WEED DYNAMICS AND EFFICACY OF HERBICIDE MIXTURES IN WET DIRECT-SOWN RICE

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In Asia, direct-sown rice (DSR) has been established as more popular than transplanted rice in many ways as it provides advantages*viz*. faster and easier planting, reduced labour and drudgery, earlier crop maturity by 7-10 days, more efficient water use, higher tolerance of water deficit, fewer methane emission (Dry-DSR<Wet-DSR<PTR) and often higher profit in areas with an assured water supply.In Wet-DSR, sprouted seeds are directly sown in puddled soil. However, among different biotic stresses, weed infestation is the most yield compromising factor in DSR which can reduce the yield up to 50-91% (Rao *et al*. 2007). Among different weed management methods, chemical method is the most easy, economical, effective and efficient one to suppress weeds(Bhurer*et al*. 2013). But the prolonged use of herbicide with same mode of action in rotation year after year leads to weed flora shift and development of herbicide resistance in weeds. Hence herbicide mixtures with different spectrum of weed control are more effective than that of their soleapplication in rice. Thissituation warrantsevaluation of different wellestablished herbicides in combination with new molecules to identify suitable dose which can control weed growth attaining potential yield in DSR. In the present investigation, cyhalofop-butyl, one of the popular post emergence herbicides among different rice herbicides from aryloxyphenoxy propionategroup having acetyl CoA carboxylase(ACCase) inhibitor mode-of-action and the new herbicide florpyrauxifen-benzyl from arylopicolinate group of synthetic auxin herbicide having disrupters of plant cell growth mode-of-action were evaluated in combination as pre-mix herbicide mixture in different doses to study the weed dynamics and bio-efficacy to get optimum yield in wet-DSR.

METHODOLOGY

The experiment on wet-DSR (cv. *Naveen*) was carried out during wet season of 2016 at the Institute Farm of ICAR-NRRI. Sprouted rice seeds were manually sown in puddle soil at 20 cm rows apart in gross and net plot size of 6.0 m x 5.0 m = 30 m^2 and 5.1 m x 4.0 m = 20.4 m^2, respectively with seed rate of 80 kg ha^{-1}. The experiment was laid out in randomized complete block design with three replications and nine treatments comprising of four herbicide mixtures i.e. florpyrauxifen-benzyl + cyhalofop-butyl in four doses [120 (20+100), 150 (25+125), 180 (30+150) and 360 (60+300) g ha^{-1}], three alone herbicides i.e. florpyrauxifen-benzyl in two doses (25 and 30 g ha^{-1}) and bispyribac-Na 30 g ha^{-1}, one weed free and weedy check. All the herbicides were applied between 12-15 days after sowing (DAS). Weed flora composition, weed densities and weed dry matter observations were taken at 30, 45 & 60 DAS and at harvest. Relative weed density, weed control efficiency and weed index were calculated. The data collected were analyzed using ANOVA.

RESULTS

The treatments significantly influenced the weed density, weed dry matter and yield (Table 1). The major weed flora observed in the experimental site, were *Echinochloacolona* and *Leptochloa chinensis* among grasses, *Cyperus difformis*, *Cyperus iria* and

Table 1: Effect of different weed management treatments on Total weed density, total weed dry matter, weed control efficiency at 60 DAS, yield and weed index

Treatments	Weed density (m^{-2})	Weed dry matter (g m^{-2})	Weed control efficiency (%)	Grain Yield (t ha^{-1})	Weed Index (%)
T1	108.70	34.66	67.26	4.68	11.20
T2	75.40	26.66	74.82	4.91	6.83
T3	109.40	40.57	61.68	4.17	20.87
T4	87.30	36.49	65.53	3.72	29.41
T5	120.90	38.73	63.42	4.46	15.28
T6	92.70	31.39	70.36	4.74	10.06
T7	131.20	40.80	61.46	4.36	17.31
T8	0.00	0.00	-	5.27	-
T9	164.20	105.87	-	3.14	40.42
SEm±	**4.87**	**3.63**	-	**0.17**	-
CD (P=0.05)	**14.59**	**8.18**	-	**0.52**	-

T_1: Florpyrauxifen-benzyl + cyhalofop butyl12% EC (w/v) 120 (20+100) g ha^{-1}, T_2: Florpyrauxifen-benzyl + cyhalofop butyl 12% EC (w/v) 150 (25+125) g ha^{-1}, T_3: Florpyrauxifen-benzyl + cyhalofop butyl 12% EC (w/v) 180 (30+150) g ha^{-1}, T_4: Florpyrauxifen-benzyl + cyhalofop butyl 12% EC (w/v) 360 (60+300) g ha^{-1}, T_5: Florpyrauxifen-benzyl 2.5% EC (w/v) 25 g ha^{-1}, T_6: Florpyrauxifen-benzyl 2.5% EC (w/v) 30 g ha^{-1}, T_7: Bispyribac-Na 10% SC 30 g ha^{-1}, T_8: Weed free and T_9: Weedy check

Fimbristylismiliacea among sedges and *Sphenocleazeylanica* and *Marsiliaquadrifolia* among broad leaves.The percentage composition of sedges at 30, 45, 60 DAS and at harvest were observed maximum in control plots followed by narrow leaf weeds and broad leaf weeds. At 30 (21.0 m^{-2}) and 45 DAS (63.8 m^{-2}) the minimum total weed density was found under florpyrauxifen-benzyl + cyhalofop butyl 360 (60+300) g ha^{-1} whereas, at 60 DAS (75.4 m^{-2}) and harvest (31.3 m^{-2}) florpyrauxifen-benzyl + cyhalofop butyl 150 (25+125) g ha^{-1} registered lowest total weed density.

In the weed dynamics study of the crop field, it was observed that up to 45 DAS almost all major weed populations increased. After 45 DAS, the populations of the early emerging weeds like *Echinochloacolona* and *Cyperus difformis* decreased at an increasing rate, as their lifespan ranges from 45 to 55 days. However the late coming weeds like *Cyperus iria*, *Fimbristylismiliacea*, *Sphenocleazeylanica* and *Marsilea quadrifolia* showed a slight increase in their populations. But at harvest, there was almost no *Echinochloacolona*, *Cyperus difformis* and *Marsilea quadrifolia* found in the field with very less populations of *Fimbristylismiliacea* and *Sphenocleazeylanica*, but with a high population of *Leptochloa chinensis* in the field followed by *Cyperus iria*.

Weed dry matter findings were in similar trend as found in weed density. Among different herbicide treated plots, lowest total weed dry matter (26.66 g m^{-2}), lowest weed index (6.83%) and highest weed control efficiency (74.82%) were recorded underflorpyrauxifen-benzyl + cyhalofop butyl 150 (25+125) g ha^{-1} treated plot at 60 DAS (Table 1). The weedy check continued to have high populations of weeds and dry matter at all stages of crop growth. The highest grain yield was recorded in weed free plots (5.27 t ha^{-1}), which was at par with florpyrauxifen-benzyl + cyhalofop butyl 150 (25+125) g ha^{-1} treatment

(4.91 t ha^{-1}). The yield was negatively correlated with weed density, relative weed density, weed dry matter and weed index.

CONCLUSION

All the herbicide mixtures performed better than sole application of herbicides. Among the herbicide treatments, florpyrauxifen-benzyl + cyhalofop butyl 150 (25+125) g ha^{-1} was found the most effective herbicide mixture to control weeds in wet-DSR showing the highest weed control efficiency and yield at par with the weed free treatment. Therefore, the herbicide mixturecan be recommendedas post emergence herbicide for effective weed control in wet-DSR.

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HARNESSING PRODUCTIVITY POTENTIAL AND QUALITY OF HIGH PROTEIN RICE THROUGH AGRONOMIC BIO-FORTIFICATION

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Rice is most important for food diet of Indian as well as world population (FAO, 2004), because it's higher nutritional quality and low price. Rice grain is a source of Fe, thiamines, niacin and riboflavin. Rice proteins content are comprised with nutritional quality, hypoallergenic and healthy for human consumption and this product have been in demand in recent years. Iqbal *et al.* (2006) reported that 170 million child and nourishing mother suffered from protein deficiencies thereafter malnutrition disorder is present in developing AfroAsian countries. Recently, considerable progress has been made in elucidating the relationships among genotypes, environmental conditions and management practices, suggesting that protein content is a variety-specific quantitative characteristic (Yu et al., 2012) and that it is substantially influenced by environmental conditions and crop management strategies. The planting of high-yielding cultivars with optimal nutritional management and water management strategies, adequate plant populations and strong seedlings are major requirements for high yields and optimal quality. Integrated nutritional management and soil temperature can influence seasonal and regional variations in the soil available N. Therefore, it is necessary to explore the relationship between agronomic management in combination with nutrient management and protein content. The objective of the present study is to improve the yield and protein quality and quantity in rice by adopting agronomic management strategies with the combination of nutrient management. The hypothesis is that the combination of agronomic management practices with nutrient management practices could be beneficial to protein quality and quantity in rice with sustainable productivity.

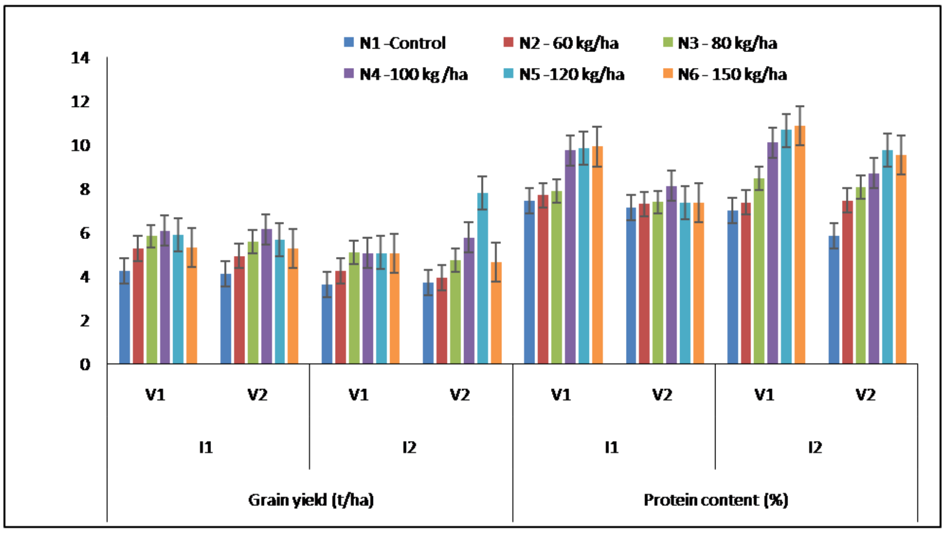
METHODOLOGY,

Two field experiments were conducted at National Rice Research Institute farm, Cuttack, Odisha, India (20°25/N, 85°55/E) at an elevation 24 m above mean sea level from 2017 to 2018 The soil of the experiment field was sandy loam containing 0.512% organic carbon and 6.29 pH Weather conditions were generally stablemaximum temperature varied from 25-36°C (average

30.8°C) and minimum temperature ranged from 14-17°C(average 24.2°C) during the study period. The field experiments were conducted during dry season of years and was laid out in split split plot design which was replicated thrice. Treatments consisted of two Main plots with Irrigation management i.e., I_1- Irrigation of ± 2 cm (Ponded water) I_2- Irrigation at hair line crack stage(-30 KPascal), Sub plots with six graded dose of nitrogen levels i.e., N_1 – 0 (No nitrogen), N_2 – 60 kg ha^{-1}, N_3 – 80 kg ha^{-1}, N_4 – 100 kg ha^{-1}, N_5 – 120 kg ha^{-1}, N_6 – 150 kg ha^{-1} and two varieties in the sub-sub plot (Varieties) V1- CR Dhan 310, V2-Naveen. ZnSO4 @ 25 kg, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} are common for all treatments.

RESULTS

Results of the experiment revealed that growth parameters, yield attributes, grain yield, straw yield, nutrient uptake by high protein rice, protein content, quality parameters and returns per rupee investment were significantly influenced by irrigation management,



I_1- Irrigation at saturated ± 5 cm, I_2- Irrigation at hair line crack stage
N_1 – Control, N_2 – 60, N_3 – 80 kg ha^{-1} N_4 – 100 kg ha^{-1} g N_5- 120 kg ha^{-1} N_6 – 150 kg ha^{-1}
V_1 – CR Dhan 301 V_2 -Naveen

Fig.1. Grain yield and protein content of rice as influenced by irrigation levels, nitrogen levels and varieties

nitrogen level and variety. Higher plant height, leaf area, plant dry weight, root dry weight and yield attributes *viz*. effective tillers m^{-2}, panicle weight, filled grains as well as grain and straw yield, available nutrients (N, P and K), nutrient uptake by high protein rice (N, P and K), quality parameters, net returns and returns per rupee investmentwas recorded with irrigation of ± 2 cm (Ponded water) and followed by irrigation at hair line crack stage (Maximum tillering and heading stage) during both the years. Among the nitrogen management treatments, application of 100 kgN ha^{-1}recorded significantly higher effective tillers, panicle weight, test weight, grain yield and available nutrients, nutrient uptake by high protein rice grain (N, P and K), hulling percent, milling percent, volume expansion ratio, kernel expansion ratio, amylose, and returns per rupee investment, which was at par with application of nitrogen 120 kg ha^{-1} during both the years and in pooled data. Higher growth parameters and N uptake by straw and protein content were recorded with 150 kg N ha^{-1}, which was at par with 120 kg N ha^{-1} and 100 kg N ha^{-1} during both the years. Among the varieties, at all growth intervals effective tillers m^{-2}, panicle weight, grain and straw yield, nutrient uptake by high protein rice, protein content and returns per rupee investment recorded higher values with variety CR Dhan 310 followed by Naveen.

CONCLUSION

It may be concluded that, appropriate agronomic management *viz*., irrigation levels along with the nutrient management strategies can enhance the productivity and quality in the high protein rice for increased nutrition and profit.

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ASSESSMENT OF DIFFERENT METHODS OF DIRECT PADDY SOWING

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Paddy is main crop grown in Bihar during *Kharif* season. Due to erratic and deficient rainfall during *Kharif* season, farmers of Jehanabad district faced water problem during last 6-7 years. In this situation, it was very difficult to grow paddy nursery timely due to delay and weak monsoon which resulted delayed transplanting and caused reduction in paddy yield. The raising of nursery and manual transplanting are both labour intensive and costly in manual rice transplanting that can be replaced by direct seeding. Halder and Patra (2007) studied performance of 8-row drum seeder in direct seeded paddy (Oryza sativa) under puddled condition. The present study was carried out as on farm trial with objective of assessment of different methods of direct sowing of paddy and to find out it's effect on cost of sowing, number of irrigation, maturity period, yield and economics of paddy cultivation.

METHODOLOGY

An on farm trial was conducted at farmer's field in Jehanabad district of Bihar for two consecutive years during *Kharif* season 2013-14 and 2014-2015. The district is situated at 25° to 25° 15' North Latitude, 84° 30' to 85° 15' East Longitude and at an altitude of 54 meter from mean sea level. It is located in the southern part of Bihar that lies in NARP Zone– III B with sub-humid, sub-tropical agro ecological system. The soil of the experimental area is leveled having a good tilth. The district's topography is alluvial plain and soil is old alluvial which varies from loam to clay. Maximum and minimum temperature of the district is 47°Cin summer month (June)and 5°C in winter month (January) whereas maximum and minimum relative humidity is 99 percent and 26.66 percent, respectively. Mean annual rainfall of the district is 1074 mm out of which most of the rain occurs during *Kharif* season (June to October). As, the district has faced uncertain and scanty rainfall situation from 6-7 years, farmers could not grow paddy nursery on time that caused delay in paddy transplanting which resulted poor yield as well as delay in sowing of next *Rabi* crops. The KVK introduced an 8-row paddy seeder (drum-seeder) made of fibre among the farmers. The experiment was laid out in Randomized Block Design with 6 and 10 replications (no. of farmers) in respective years each of 0.25 ha in 8 villages including NICRA (National Innovations on Climate Resilient Agriculture) Project village Sakrorha, Block-Modanganj along with three technological options: TO1-Broadcasting of Paddy seed without pudding (Farmer's practice), TO2- Broadcasting of paddy seed directly in puddle soil and TO3- Direct sowing of paddy by 8 row drum seeder. Short duration paddy seed var. Sahbhagi was sown in the month of July with recommended agronomical practices in which seed rate of 28 kg/ha was applied. Pre-emergence

Field operation of 8 row paddy seeder in puddle condition

herbicide has been applied within 2 days of sowing for weed management. During the study, cost of sowing, number of irrigation, maturity period, yield and economics of paddy cultivation was calculated. For direct sowing by paddy seeder, sprouted paddy seeds were filled to 3/4 level in each of 4 drums having 2 rows in each drum and the paddy seeder was pulled in the puddle field and thus direct sowing was performed in 8 rows at a time with row to row spacing of 20 cm.

RESULTS

Results revealed that during year 2013-14, saving of 2 irrigations (no.), 6 days reduction in maturity period, Rs. 300/- reduction in cost of sowing and 12.96 percent increase in yield with B:C ratio of 2.35 was observed in TO3 as compared to B:C ratio of 1.89 in farmer's practice plots whereas in TO2, 5.25 percent increase in yield with B:C ratio 2.13 besides saving of 2 irrigations (no.), 6 days reduction in maturity period and increase in cost of sowing as Rs. 300/- was found. During year 2014-15, saving of 2 irrigations (no.), 7 days reduction in maturity period, Rs. 250/- reduction in cost of sowing and 13.84 percent increase in yield with B:C ratio of 2.34 was observed in TO3 as compared to 1.86 in farmer's practice plots whereas in TO2, 6.15 percent increase in yield with B:C ratio 2.12 besides saving of 2 irrigations (no.) and 6 days reduction in maturity period and increase in cost of sowing as Rs. 400/- was found.Findings of the study indicated thatpaddy sowing directly by drum seeder has been found beneficial in terms of saving in sowing cost, irrigation, reduced maturity period, increase in yield as well as B:C ratio in comparison to broadcasting of paddy seed without puddling i.e. traditional method of direct paddy seeding after dry seed bed preparation.Shekar and Singh (1991) also stated significant improvement in yield attributes in direct seeding of sprouted seeds under puddled condition.Direct seeding method avoids raising of nursery, pulling up seedlings and transplanting so that labour requirement for crop establishment is negligible. This method can be used by farmers for paddy cultivation at any time as there is no requirement or delay of raising nursery.

CONCLUSION

Thus, findings of the study indicated that TO3 (Direct sowing of paddy by drum seeder) performed best in terms of yield and B: C ratio followed by TO2 (Broadcasting of paddy seed directly in puddle soil) as compared to TO1 (farmer's practice plot). Manually operated 8 row paddy drum seeder has been found successful for direct seeding in drought/poor monsoon situation without need of raising paddy seedlings and transplanting operation.

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EFFECT OF SALINITY ON MORPHO-PHYSIOLOGICAL CHARACTERISTICS AND ACTIVITY OF ANTIOXIDANT ENZYMES IN *AZOLLA* SP.

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Azolla is a small, water-floating aquatic fern that has a symbiotic relationship with the cyanobacterium dwelling within its leaf cavity. *Azolla* with the help of different strains of cyanobacteria fixes nearly about 20-40 kg N ha^{-1} $season^{-1}$. However, salinity causes a major trouble as it affects the nitrogen fixation rate of the plant and hampers its growth (Rai et al., 2001). Salinity in general leads to an imbalance of the cellular ions due to high exogenous salt concentrations that results in ion toxicity, osmotic stress and production of reactive oxygen species (ROS).

Plants have developed different defence strategies against salt stress like by scavenging mechanisms involves the induction antioxidant enzymes such as superoxide dismutase (SOD) and ascorbate peroxidise (APX) to counter the stress factor and also non-enzymatic antioxidant such as proline which plays a significant role against singlet oxygen and free radical damage. The two important intracellular generators of ROS are mitochondria and the chloroplast, in chloroplasts, ROS can be generated by direct transfer of excitation energy from chlorophyll to produce singlet oxygen, or by univalent oxygen reduction of photosystem I. In the absence of any protective mechanism through oxidative damage to lipids, protein and nucleic acids, ROS can seriously disrupt normal metabolism as they are highly reactive and can react with proteins and lead to denaturation of proteins and cause lipid peroxidation.

Though a considerable amount of study on the inhibitory effect of salinity on *Azolla* has been done in the past (Masood et al. 2006), but to improve the salinity tolerance in *Azolla* very few attempts have been made yet. Therefore, the present study was an attempt to identify salt-susceptible and tolerant *Azolla* strains and deciphered the stress tolerance mechanism under different levels of salinity stress after assessing the morpho-physiological and activity of antioxidant enzyme in *Azolla*.

METHODOLOGY

Altogether 102 strains of *Azolla* including 6 major species are maintained at ICAR- National Rice Research Institute (NRRI), Cuttack, Odisha. Among them, 26 strains were used for the present study. Screening of these strains for salinity stress (NaCl) was done in a 500 ml beaker-containing 250 ml IRRI nitrogen-free medium. *Azolla* fronds (0.22 g) were surface sterilized with 0.1 % mercury chloride ($HgCl_2$,) for 30 s and immediately washed with large volume of distilled water for several times and inoculated in beaker, where the salinity levels were maintained hydroponically at 40, 80 and 120 mM NaCl with a control (fronds inoculated in salt-free IRRI medium). After screening, one each salt-tolerant (*Azolla microphylla*) and salt-sensitive (*A. rubra*) *Azolla* strains were selected for the present study. Morpho-physiological characteristics *viz*. relative frond count (RFC), relative growth rate (RGR) & doubling time (DT) and antioxidant enzyme study *viz*. SOD & APX were studied.

RESULTS

Only *Azolla microphylla* was extremely tolerant to NaCl (80 mM) and *Azolla rubra* was more susceptible to salt (NaCl) (40 mM) among these species of *Azolla*. *A. microphylla*survived on 80 mM and the other 5 species and 30 strain of *Azolla* survive on 40 mM, but *A. rubra* was extremely susceptible to salt among other given *Azolla* species according to survivability. Only two species of *Azolla* were grown after screeningof *Azolla* under salt stress condition in which salt (NaCl) tolerant and susceptible *Azolla* were chosen in our research. Plant showed significant variations in salt sensitivity.

Three salt (NaCl) stress levels (40 mM, 80 mM and 120 mM) imposed on two species of *Azolla*, namely *A. rubra* and *A. microphylla*, have been found to influence several parameters of plant growth *viz.* RFC, RGR and DT. Significantly RFC in *A. rubra* reduces after 15 days of inoculation (DOI) in 40 mM NaCl and no further development was observed at greater levels salt (NaCl). However, *A. microphylla*was found to be salt (NaCl) tolerent at 80 mM NaCl but with considerably reduced RFC, at 120 mM salt concentration there was no growth in *A.microphylla*. ANOVA has shown significant varietal growth effect. Under different salt (NaCl) stressed condition (40 and 80 NaCl) the RFC of *A. microphylla*decreased by 49.25% and 68.65%, while the RFC of *A. rubra* decreased by 55% (40 mM) as compared to control. DT of *A. microphylla*(24.53% and 49.84%) was longer than *A. rubra* (28.19% and 60.97%) when subjected to 40 and 80 mM as compared to control. RGR of *A. mirophylla* (21.42% and 68.28%) and *A. rubra* (31.57% and 78.68%) was reduced considerably when the NaCl concentration (40 and 80 mM) increased relative to control. The RGR of *A. microphylla*was higher than *A. rubra* at concentrations of 0, 40 and 80 mM NaCl.

The two species of *Azolla* showed a substantial distinction in SOD content as a result of increased concentration of NaCl. SOD activity was increased in *A. microphylla*(12, 63.93 and 69.86%) when subjected to an increased in NaCl levels as compared to control. Similarly, there was an increase in SOD activity in *A. rubra* (68.33 and 73.61%) when NaCl (80 and 120 mM) was increased, but higher SOD activity in *A. microphylla* than *A. rubra*. In addition, the APX activity was considerably increased in *A. microphylla*and *A. rubra* at different levels of NaCl. In *A. microphylla*APX activity was higher in at 40, 80 and 120 mM (14.21, 32.31 and 44.74%) compared to that found in control and *A. rubra*.

CONCLUSION

The present study shows that the effect of salinity (0, 40, 80 and 120 mM) on morpho-physiological and antioxidant enzyme (SOD, APX) activities, in susceptible (*A. rubra*) and tolerant (*A. microphylla*) species of *Azolla*. Results indicated that salinity stress possessed negative impact on the production of plant cell growth in *A.rubra*. However, the scavenging mechanism of radicals activated during the course of their metabolic activity, was found to be more robust in *A. microphylla*determining the innate capability of this *Azolla* species for withstanding salinity stress. Further researches are needed to assess the biochemical and molecular mechanisms conferring salinity tolerance in *Azolla* plants to establish selection strategies.

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INTERACTIVE EFFECT OF BIOCHAR AND SLOW RELEASE NITROGEN FERTILIZER ON GROWTH AND NITROGEN USE EFFICIENCY OF RICE

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Globally on an average 90 percent of rice is developed and consumed in Asian countries. In Asia, there is still a difference between the actual and potential yield. In addition, it has been projected that by 2025, rice production would have to increase by around 60 per cent more than current productivity in order to satisfy the needs of an ever-increasing global population. The problems arising from the past years in the areas under the rice wheat cropping system are questioning the system's sustainability. Low nitrogen use efficiency and inadequate management of crop residues, are some of the major problems that impede the productivity of rice wheat cropping system. Nitrogen (N) which is an important macro nutrient element in cropping systems is required by rice in abundance quantities and is more needed than any other nutrients. Soil is central focus of agroecosystems and major concerns of its status and crop uptake. For decades,mostagricultural production system has been relying on large input of nitrogen (N)fertilizer resulting in a rapid increase in mineral (synthetic) fertilizer use over time, however N use efficiencyhas decreasein most regions. Nitrogen loss to theenvironment has many inevitable consequences, such as groundwater contamination, air pollution, and greenhouse gas emissions. Low utilization efficiency, high economic costs, and environmental pollution of mineral nitrogen is a major challenge caused its hysterical losses as nitrate leaching, ammonia volatilization and nitrous oxide emissions (Dong et al., 2013). More than 501 million tonnes (Mt) of crop residues produced in India each year out of which 70 % of total crop residues (352 Mt) come from cereals consisting of 34% rice and 22% wheat have been reported. Most straw from harvested rice plants is burning in the field, creating issues with air pollution and carbon depletion from increased fertile soil (Lohan et al., 2018). In order to preserve adequate soil fertility, this straw has to be applied on an annual basis, but applications can be made through a more sustainable to improve soil and crop quality and it should be be cost-effective. The applicability of biochar in agriculture and its impact on comprehensive climate change and the soil environment and plant growth has resulted in a growing interest in the fields of agricultural science, atmospheric science, geology, and environmental science in recent years. Application of biochar based slow or controlled-release fertilizer is being investigated worldwide as a novel approach of examining its role in efficient nitrogen nutrition.

METHDOLOGY

The experiment was conducted at GBPUAT, Pantnagar 2018. The experimental design was split-split design with three main plots (control, rice straw biochar and rice residue) and six slow release nitrogen fertilisers in subplots i.e control, 100% and 75% of Rice straw bio-urea (Intercalated urea), 100% and 75% of biochar coated urea (RDF: 150-60-40 kg N ha^{-1}). Biomass of rice straw, rice husk was collected and chopped into small pieces (0.5 - 1 cm) followed by oven-drying (70°C) for 48 hours and thereafter ground and passed through 20 mesh sieves. For the large-scale biochar production, chopped samples of 2-4 cm size while rice husk will be used as whole and subjected to sun drying. Prepared sample of biomass waste will be filled into the furnace of biochar production unit and close the lid after slight ignition. Thermal conversion of biomass produces biochar during pyrolysis: heating of biomass in limited oxygen at high temperatures (300-600°C) in a specially designed furnacethat captures all the emissions produced. Sample allowed to be charred in furnace for 45 minutes and final produce spread over the surface for cooling and filled into the container to store it. Percent biochar yield differ with feed stocks and variation in pyrolysis temperature. Biochar intercalated urea produced by dissolving urea and rice straw in 2:1 proportion. Biochar coated urea was developed by coating urea with Biochar using gum acacia and wax.Growth parameters viz., plant height, Number of tillers and dry matter accumulation was recorded at 30, 60, 90 days after transplanting of rice crops. Observations made from 2nd and 3rd row leaving 50 cm from the borders. Physiological parameters i.e NDVI and SPAD was taken at 45, 60,75 and 90 DAT. Nitrogen and uptake and efficiency was calculated in 30 days interval from sowing to harvesting by micro-Kjeldahl's method.

RESULTS

Biochar treated plots has shown a significant result over rest of the treatments. Growth parameters (plant height, no. of tillers) were significantly higher with biochar application over control. Interactive effect of biochar with slow release fertilizer was clearly noticed and reported to be one of the better combination out of all the treatment combinations. A variation in nitrogen uptake pattern throughout the crop growth period was also observed. During the initial stage the nitrogen uptake was very slow in biochar and residue incorporated plots compared to the no residue plots. With the establishment of crop at later stages nitrogen uptake and use efficiency was higher in biochar applied plots treated with slow release nitrogen fertilizers. It was significantly higher over the control plot and biochar applied-urea treated plot.

CONCLUSION

This work suggests the conversion of rice staw into a sustainable fertiliser in the form of biochar and slow release fertilizer to increase the growth of the rice plant and the nitrogen use efficiency. High surface area, CEC and porous nature of the biochar retain the nutrient and increase its supply over a long period of time. Slow release fertilisers developed using biochar are cost-effective and effective in reducing various forms of nitrogen losses that lead to poor nitrogen use efficiency. The availability of nitrogen in the required time and quantity enhanced the growth of the rice crop.

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IRC/TM-2/PP-98

VARIATION IN RICE GENOTYPES FOR NITROGEN USE EFFICIENCY UNDER VARYING N LEVELS

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Rice genotypes differ in their efficiency in utilizing the soil available N and also in their response to added N which can be explored and further utilized in the development of efficient genotypes for N limiting environments. Nitrogen Use Efficiency (NUE) is an important index in determining the way the applied N was used by rice crop. Hence, knowledge of this index is fundamental in improving NUE and consequently N management. Information generated from these type of studies help to develop best management practices for the production of high yields while minimizing N losses and costs associated with N fertilization. The development and identification of genotypes with high Nitrogen use and uptake efficiency would minimize the use of ecologically and economically expensive chemical fertilizers and encourage sustainable agriculture. Hence, to understand the genetic variation in rice genotypes for their responsiveness to nitrogen, the present study "variation in rice genotypes for nitrogen use efficiency under varying N levels" has been designed.

OBJECTIVE

To identify the genotypes with high Nitrogen Use Efficiency (NUE) by studying in terms of uptake, translocation and utilization efficiency.

METHODOLOGY

Based on earlier field phenotyping for high NUE conducted at IIRR, Hyderabad 10 rice varieties were identified as promising varieties and were tested at IIRR during Kharif (wet) season 2019 at graded levels of nitrogen (0, 50, 100 and 150 kg N/ha). Total grain weight was determined after drying it to 14% moisture content. Total straw weight was determined after drying at 70^{o} C to a constant weight. Nitrogen content in straw and grain was estimated according to Kjeldahl using block digestionand steam distillation. NUE parameters were calculated using the equations mentioned in Singh et al., 1998.

RESULTS

NUE is a complex trait influenced by genotype with a strong G X E interaction.Analysis of variance revealed significant differences among genotypes and N levels for grain yield, total biomass, HI, Grain and straw N concentration, Grain and straw N uptake, IE, NHI, AE and PFP. Rasi has greater Agronomic Efficiency (AE) at lower and higher N doses (N50 and N150) whereas at recommended dose of N (N100) MTU1010 has shown higher AE. Varadhan has lowest AE at recommended and higher N doses (N100 and N150) whereas at lower N dose (N50), IC576938 has shown least AE. Highest Physiological Efficiency (PE) was recorded by GQ-25 at recommended N dose (N100), Varadhan at higher dose of N (N150) and IC462284 at lower N dose (N50). Rasi has recorded lowest PE at N100 and N150 whereas IC576938 shown least PE at lower dose of N (N50). With regard to the Internal Efficiency (IE), GQ-25 has recorded higher IE at N100, whereas IC576938 shown higher IE at N0. IC576984 has shown least IE at N0, N50 and N100, whereas at N150 Rasi has recorded lower IE. At N100 and N150, higher Partial Factor Productivity (PFP) has recorded by MTU1010 and at N50, GQ-25 has shown higher PFP. Lowest PFP has been shown by IC576938 at N100, Varadhan at N150 and Pooja at N50 doses of N. MTU1010 has exhibited higher Nitrogen Harvest Index (NHI) at N0 and N100 levels whereas at N50 and N150 levels, Ratnasundari has shown higher NHI. At N0 level, Varadhan has recorded least NHI while IR64 shown lower NHI at N100. At N0, GQ-25 has recorded higher Harvest Index (HI), whereas at N100, Pooja exhibited the highest HI. Among the interactions between genotypes and treatments, grain yield, total biomass, harvest index, straw %N, straw N uptake, AE, NHI, PFP has shown significant difference.

CONCLUSION

Different varieties exhibited different Nitrogen Use Efficiency (NUE) values at tested N levels and no single variety was superior in all the studied indices.Hence, by averaging all the NUE parameters, it can be summarized that Ratnasundari followed by MTU1010 and GQ-25 performed better with high nitrogen use efficiency and relatively higher yield under low N dose.

IRC/TM-2/PP-99

SCREENING OF DIFFERENT RICE (*Oryza Sativa* L) GENOTYPES FOR IRON EFFICIENCY

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Rice (*Oryza sativa* L.) is a most important food staple and energy source of more than half the world population. Iron (Fe) deficiency is the most common nutritional disorder in the county and affecting nearly a third of the global population (Lopez *et al*, 2016). Low availability of micronutrients specially Zn and Fe is frequently reported for grains of cereals, resulted in insufficient amounts of nutrients (Zn/Fe) in cereal grains to meet human nutritional requirement, as majority of poor people in developing countries whose diets are dominated by maize, rice and wheat. Hence widespread occurrence of Fe deficiency is reported in human. Interrelated strategies for soil and crop management are attractive not only for improving growing conditions for different crops but also for exploiting potential of plant for Fe mobilization as well as utilization by crop. Therefore, it is necessary to identify the Fe efficient genotype having higher Fe concentration and their bioavailability in grain for improving the Fe intake in populations dependent on rice as a staple food. Keeping view of the above, the present study was conducted with the objective to identify the Fe efficient rice verities from different genotypes.

METHODLOGY

A field experiment was carried out at Anand Agricultural University, Anand with 28 white and red genotypes of rice. The treatments have consisted of three levels of Fe *viz*., Control (without Fe), medium (10 kg Fe ha^{-1} soil application through ferrous sulphate) and high (20 kg Fe ha^{-1} soil applied through ferrous sulphate + three foliar sprays of 0.5% ferrous sulphate). At the time of transplanting, recommended levels of nitrogen as urea and phosphorous were applied in addition to Fe treatment. Rice was harvested at physiological maturity and grain yield was examined. For determination of Fe content in grain and straw, samples were estimation of Fe with the help of Inductively Coupled Plasma- Optical Emission Spectrometer (ICP-OES). Following parameters were calculated (Graham, 1984):

Iron uptake in grain = Grain yield x Grain Fe content

Iron efficiency index =

$$\frac{\text{(Grain yield at low Fe)}}{\text{(Grain yield at high Fe)}} \times 100$$

Iron efficiency=

$$\frac{\text{(Grain Fe uptake at low Fe)}}{\text{(Grain Fe uptake at high Fe)}} \times 100$$

The grain yield of genotypes at low Fe ranged from 14.0 to 68.0 q ha^{-1} which an average value of 42.0 q ha^{-1}. The genotype GR-11 produced highest yield at both the Fe levels and genotype Lalkada produced lowest yield. Similarly, in case of Fe application, increasing the dose of Fe increased the grain yield of different rice genotypes. The concentration of Fe in whole grain ranged from 22.2 to 162.3 mg kg^{-1} with mean 64.9 mg kg^{-1} at low Fe level, whereas 25.2 to 171.8 mg kg^{-1} with mean of 72.8 mg kg^{-1} at high level of Fe application. Relative grain yield i.e. Fe efficiency index varied from 65.7 to 109 % and relative grain Fe uptake i.e. Fe efficiency varied from 59.4 to 104 % with a mean value of 89.7 and 79.4 % respectively. Cultivar Swarna was having the highest Fe efficiency index as well as Fe efficiency. Based on grain yield and Fe efficiency, the genotypes were classified as efficient and responsive (Swarna, SLR-51214 and GR-13), efficient and nonresponsive (GR-11, GR-12, GR-3 and Ashoka), inefficient and responsive (Lalkad, Gurjari Palkhali-203 and GR-101) and inefficient and nonresponsive (GR-9, GR-102, AAUDR-1 and K- Kamod) (Fig. 1). The efficient and responsive genotypes are most desirable as they would yield more with higher Fe content under low Fe and also respond better to Fe additions.

RESULTS

The grain yield of genotypes at low Fe ranged from 14.0 to 68.0 q ha^{-1} which an average value of 42.0 q ha^{-1}. The genotype GR-11 produced highest yield at both the Fe levels and genotype Lalkada produced lowest yield. Similarly, in case of Fe application, increasing the dose of Fe increased the grain yield of different rice genotypes. The concentration of Fe in whole grain ranged from 22.2 to 162.3 mg kg^{-1} with mean 64.9 mg kg^{-1} at low Fe level, whereas 25.2 to 171.8 mg kg^{-1} with mean of 72.8 mg kg^{-1} at high level of Fe application. Relative grain yield i.e. Fe efficiency index varied from 65.7 to 109 % and relative grain Fe uptake i.e. Fe efficiency varied from 59.4 to 104 % with a mean value of 89.7 and 79.4 % respectively. Cultivar Swarna was having the highest Fe efficiency index as well as Fe efficiency. Based on grain yield and Fe efficiency, the genotypes were classified as efficient and responsive (Swarna, SLR-51214 and GR-13), efficient and nonresponsive (GR-11, GR-12, GR-3 and Ashoka), inefficient and responsive (Lalkad, Gurjari Palkhali-203 and GR-101) and inefficient and nonresponsive (GR-9, GR-102,

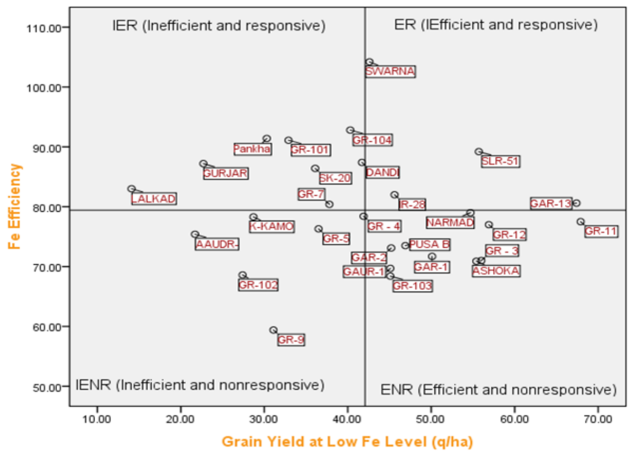

Fig.1. Classification of rice genotypes for Fe efficiency ER: efficient and responsive; IER: inefficient and responsive; ENR: efficient and nonresponsive; IENR: inefficient and nonresponsive

AAUDR-1 and K- Kamod) (Fig. 1). The efficient and responsive genotypes are most desirable as they would yield more with higher Fe content under low Fe and also respond better to Fe additions.

CONCLUSION

Overall result depicted that the agronomic bio-fortification through soil and foliar Fe application could be a better approach for enhancement of grain Fe concentration of Fe inefficient genotypes. Thus, the efficient and responsive genotypes are most desirable as they produce high yield and response to Fe fertilization and should be recommended for farmers.

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IRC/TM-2/PP-100

PROPERTIES OF BPT 5204 RICE AT DIFFERENT METHODS OF PARBOILING

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ABSTRACT

BPT also known as *Samba mahsuri* is a popular rice variety consumed among masses. It is most prominently grown in southern states of Andhra Pradesh, Telangana and Karnataka in India. Grain quality characteristics include milling, cooking, pasting properties and nutritional quality. These quality characteristics are important in determining the market prices. The quality characteristics could be influenced if certain pretreatments adopted. Hence the present study was undertaken to study about effect of different parboiling methods on the quality characteristics of BPT 5204.

METHODOLOGY

Samples of raw paddy, cold soaked and hot soaked rice at varying combinations of time and temperature were evaluated. The cold soaking was done for 14 h, while the hot soaking was done at 65ºC at 3, 4, 5 hours. The characteristics were evaluated against commercial mill sample.

RESULTS

It was observed that the milling yield was lesser for raw paddy than the parboiled paddy. The polished rice yield for raw rice was 70.8% with 19% broken and for different parboiled rice polished rice yield ranged from 72.1 to 73.5% with broken ranging from 0.3 to 1%. The amylose content was 21.7% for raw rice and the for parboiled rice it ranged from 21.2 to 23.4%. The gel consistency varied from hard, medium to soft. The pasting properties were found to be significantly different among the samples.

CONCLUSION

The observed parameters helps to understand the effect of parboling methods on properties of BPT 5204. The study also will help in application of parboling methods for the given rice variety in food industry.

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IRC/TM-2/PP-101

NITROGEN METABOLISM IN RESPONSE TO FOLIAR UREA APPLICATION IN DIRECT SEEDED RICE

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Nitrogen is the most important yield- limiting nutrient for rice. Its uptake by plants is primarily in the form of ammonium (NH_4^+) and nitrate (NO_3^-) ions. The most common source of nitrogen is urea which is a solid fertilizer that contains the highest percentage of nitrogen (46.66%) compared to other fertilizers. However, there are many serious problems concerned with the nitrogen application through soil like, nitrate (NO_3^-) leaching; surface runoff; ammonia volatilization; or microbial de-nitriûcation,, leading to water; air and soil pollution. In direct seeded rice (DSR), alternative wetting and drying of soil stimulates nitrification-denitrification processes, resulting in loss of N through N_2 and N_2O; which causes global warming. The foliar application of urea solution to rice crop is less affected by soil environmental conditions and has several potential benefits like rapid nutrient absorption by the crop and reduced N losses through denitrification and leaching compared with N fertilizer applications to the soil. Therefore, the present investigation was done to study the effect of foliar urea fertilization on enzymes responsible for nitrate and ammonia assimilation in direct seeded rice.

METHODOLOGY:

The rice crop was grown during *Kharif* 2019 in the experimental fields of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana. It was sown by drilling seed of variety PR 126 @ 20 kg/ha in rows 20 cm apart on June 6, 2019. Recommended production and protection technology was followed for raising crop except the treatments. The experiment comprised of five N treatments, viz., **T1**= 150 kg N ha^{-1} as soil application, equivalent to recommended dose of nitrogen (RDN); **T2**= 136.5 kg N ha^{-1} as 75% RDN (soil application) + 3% urea spray; **T3**= 99 kg N ha^{-1} as 50% RDN (soil application) + 3% urea spray; **T4**= 24 kg N ha^{-1} as 3% urea spray (only foliar application), **T5**=Control (zero nitrogen). Each treatment was sown in plots measuring 10.8 m^2 replicated thrice. The fertilizer was applied in the form of urea as per treatment. Samples were collected at 8 am daily so as to minimize the effect of diurnal variation. Mid portion of the leaf and root samples was used for the extraction and assay of different enzymes. Sampling was done at seedling (20 DAS), tillering (32 DAS), anthesis (62 DAS) and 15 days after anthesis (75 DAS).

RESULTS:

Maximum increase in nitrate and ammonium assimilation in roots and shoots was observed with the treatment T2 (75% RDN +3% urea spray). All N metabolising enzymes, viz., glutamine synthetase (GS), Glutamate synthase (GOGAT) and glutamate dehydrogenase (GDH) exhibited highest activity in both roots and shoots during anthesis except, nitrate reductase in roots and nitrite reductase in leaves which were found to be highest during tillering stage of growth. Activities of enzymes were found be significantly higher in leaves as compared to roots except for GDH which was observed to be higher in roots as compared to leaves. Total chlorophyll content was also found to be highest with T2. Maximum increase in grain yield was observed with treatment T2. Grain yield attributes viz., thousand grain weight of paddy, number of filled grains per panicle, ear bearing tiller per m^2 and grain weight per panicle were found to be maximum with treatment T2. Crude protein content increased in grains with treatment T2 while no significant changes were observed in ash and crude fat content. Head rice recovery was found to be maximum with treatment T2 while no effect was seen on grain dimensions with different N fertilization treatments. An overall increase of approx. 12% in grain yield over RDN was observed with treatment T2.

CONCLUSIONS:

The activities of N metabolizing enzymes with soil application of 50% RDN coupled with four foliar applications of 3% urea (T3) were found to be at par with soil application of recommended dose of urea (T1).

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IRC/TM-2/PP-102

RICE BASED CROP PLANNING FOR NORTH CENTRAL PLATEAU ZONE OF ODISHA

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The information on agro-climatology of a region is a significant tool in crop planning.The variation of monsoonal and annual rainfall in space and time are well known and this interannual variability of monsoonal rainfall has considerable impact on agricultural production. Therefore, in this study the spatial and temporal variability in rainfall along with climatic trend and LGP was analysed to prepare a rice based crop planning for North central plateau zone comprising of Keonjhar & Mayurbhanj district.

METHODOLOGY

In this study block wise rainfall and temperature data for two district (keonjhar & Mayurbhanj) were used to characterize the agroclimatology of this zone. It aimed to look at the rainfall characteristics like its spatial and temporal variability of rainfall, rainy day, onset and cessation of rainfall ,length of growing season, trend over the years, initial and conditional probabilities of dry and wet week, meteorological drought etc. over different time scale using Weather Cock and TREND software. Mean annual, seasonal and monthly rainfall variability were found out by analysing rainfall block wise period of 31 years. The data were processed by using Weather cock. "Rainy Day.exe" module was used to analyse the rainfall data. The Markov chain model is used here for the rainfall probability analysis for receiving 10, 20, and 40 mm rainfall in the 2 districts. Daily rainfall data of past 31 years were used to calculate the percentage of occurrence of drought with the help of module named as "Meteorological Drought". Since, rainfall is unimodal in North Central Plateau Zone and we are having around 25–32 weeks LGP, intercropping and sequential cropping can be taken in most of the blocks and double cropping in some of the blocks wherever irrigation facility either as groundwater or surface is available.

RESULT AND DISCUSSION

This study revealed that mean annual rainfall of North Central Plateau zone is 1450mm, with an average of 67 day .CV of annual rainfall of different blocks varies between 20-37%.This zone receives 63% & 67% of mean annual rainfall during SW monsoon in Keonjhar and Mayurbhanj district respectively. This zone receives 63% & 67% of mean annual rainfall during SW monsoon in Keonjhar and Mayurbhanj district respectively. It was also observed that annual rainfall in some of the blocks showing increasing whereas in some blocks decreasing trend. At 75% probability this zone received 1150 mm rainfall, which is good amount of rainfall for crop production. Mean annual maximum temperature of this zone was 31.5°C and minimum temperature was 20°C. By running the Mann –Kandelle Test annual temp. In both the district, it was observed that the district was showing decreasing trend over the years which is non significant in both the district (Keonjhar and Mayurbhanj). Monsoon starts effectively from 22nd week (9th June to 15th June) in North central plateau zone and remain active up to 41th week (9th October to 13th October). The initial rainfall probability {P (W)} of getting 20 mm rainfall per week was >30% during 22 SMW in this zone, hence, field preparation should be done during this period. The initial as well as conditional probability of wet week followed by wet week {P (W/W)} of getting 20 mm rainfall was more than 50% in 23rd SMW, this week is more suitable for sowing of crops. During 44th to 46th SMW (29th October – 18th November) probability of getting 10 mm rainfall per week was more than 30%. This period is suitable for land preparation and sowing of *winter* crops. Average duration of LGP is ranging between 177-258 days in different blocks of this zone.

CONCLUSION

Therefore, depending on the landform and moisture availability in the region, mono cropping, sequential cropping or intercropping of rice can be done. Rice nursery bed preparation can be started by 22nd SMW and harvesting operation can be completed by 38th-42nd week by selecting medium to long duration varieties. The amount of rainfall in the months of April and May is considered as pre-monsoon showers, helps in seed bed preparation. Since winter season gets about 7% of total rainfall, winter (toria/vegetables) crops can be planned after 44th week with assured irrigation. Rice-Sesamum, Rice-Horse gram/Green gram/Black gram, Maize-Toria, Maize-cowpea, Rice-onion, Rice-Mustard etc. are advised for this zone. Intercropping of Arhar + Groundnut (2:6), Arhar + Paddy (2:5), Arhar + Sesamum (2:4) Maize + runner bean/cowpea (2:2) can be taken. Water harvesting systems can be constructed, to store excess water during rainy season.

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Theme - II : Sustainable rice farming

IRC/TM-2/PP-103

SIMULATION OF KHARIF RICE PRODUCTIVITY IN KHORDHA DISTRICT USING DSSAT AND APSIM MODELS

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Rice is one of the major crop cultivated in Odisha. It has many unique features in terms of susceptibility and adaptation to climate change impacts due to semi-aquatic phylogenetic origin. Global climate change has potentially grave consequences for rice production and, consequently global food security. Negative effects on yields and availability of rice will directly translate into major shortages. Hence, it is essential to study the impact of climate change on *Kharif* rice yield. This study was conducted to assess the impact of climate change on productivity of rice *cv.* Hasanta in three future scenarios namely 2030, 2050, 2070 for Khordha district of Odisha, using four global climate change Representative Concentration Pathways (RCPs) scenarios namely 2.6, 4.5, 6.0 and 8.5. Also to compare the yield simulation between DSSAT and APSIM models.

METHODOLOGY

The field experiment was conducted at central research centre, Odisha University of agriculture and technology, Bhubaneswar(85° 44' E and 85° 55' E longitude and 20° 12' N and 20° 25' N latitude and 25.9 m above MSL) in Khordha district of Odisha., during kharif 2019 to simulate the growth, development and yield of four rice varieties transplanted under four different dates under climate scenarios in 2030, 2050 and 2070 using DSSAT 4.6 model and to compare the yield simulation between DSSAT and APSIM model. The experiment was laid out in split plot design replicated thrice with four dates of planting21 July, 5 August, 20 August and 4 September in main plot of four rice varieties, Mandakini, Bina-11, Swarna and Hasanta in sub-plots consisting. DSSAT 4.6 model and APSIM model was run to simulation and yield prediction. Projection of future climate scenarios was done using Marksim daily weather generator.

RESULTS

Planting rice early and mid-season on (21 July and 5 August) were more productive than delayed transplanting .The yield attributing characters like number of tillers/m² (294.07), dry matter accumulation (2573.8 g/m²), ear bearing tillers/m² (288.4), total grains/panicle (114.2), grain yield (4225 kg/ha), straw yield (4904 kg/ha) and harvest index (46.06%) were recorded maximum in 5 August planting were significantly at par with 21 July and different from other dates of planting. The leaf area index (4.22) at 60 DAT and the crop growth rate (42.16 g/m²/day) 60-75 DAT were recorded maximum in 5 August planting which was at par with 21 July planting.

Among the varieties Swarna recorded maximum grain yield of 4507 kg/ha which was 56.5% and 24.9% higher than Mandakini and Bina-11 and at par with Hasanta due to more number of ear bearing tillers(342 m^{-2}) ,115spikelets/ panicle with 80% fertile spikelets

In *cv.* Hasanta seasonal temperature increasing by 1-2^{0}C combining with increase in rainfall and solar radiation as per RCP scenarios causes increase in yield of kharif rice however, grain yield decreased with increase in temperature of more than 2^{0}C along with solar radiation more than 3.8 MJ/day. that the projected impact under RCP 4.5, RCP 6.0 and RCP 8.5

scenarios is much severe as compared to RCP 2.6 scenario on the grain yield characteristic of rice resulting in drastic decrease of the yield in future for the years 2030, 2050 and 2070. Both DSSAT-Ceres model and APSIM-Oryza model predict more rice yield than the observed yield, even DSSAT-Ceres model (4425 kg/ha) projects higher yield than APSIM-Oryza model(4251 kg/ha).

CONCLUSION

When the simulated grain yield of DSSAT model is compared with the APSIM model it was found that the yield predicted by the DSSAT model is more than that of the APSIM model.. Simulated yields were higher compared to the farm survey yields and this might be happened as both the models did not consider pest and diseases effects on yield. As in the near future years, the temperature will be increasing , so there will be reduction in the crop growth period. Accordingly the long duration paddy varieties will not be suitable for cultivation. That's why short duration paddy varieties will perform well in future scenarios and therefore more preferable.

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IRC/TM-2/PP-104

EFFECT OF INTEGRATION OF DIFFERENT SOURCES OF PLANT NUTRIENTS ON YIELD OF TRANSPLANTED RICE IN SAHIBGANJ DISTRICT OF JHARKHAND

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Rice (*Oryza sativa* L.) is a major cereal rich in nutrients, vitamins and minerals. It is an excellent source of complex carbohydrates, contribute key portion of digestible energy and protein in human intake and occupying a premium position among all food commodities It is a staple food for more than half of the world's population. Intensive cultivation of high yielding dwarf varieties responsive to fertilizer with inadequate and imbalanced use of chemical fertilizers has depleted the inherent soil fertility resulted in deficiency of many nutrients thereby declination or stagnation in crop yield. Results of long-term experiments conducted in India also indicated that continuous use of chemical fertilizers resulted in decrease in rice productivity as well as deterioration in soil health. The use of organic sources of nutrients in agriculture is rapidly gaining favour but owing to the problems related to the lack of availability of good quality and quantity of organic materials, the system may not be sufficient to achieve and sustain the production of cereal crops in the amounts required for food security. Integrated nutrient management help to achieve efficient use of chemical fertilizers integrated with organic source of nutrients. The inclusion of organic manures regulates the nutrient uptake by improving physical, chemical and biological properties of soil and producing a synergistic effect on crops. Rice is the main crop of Sahibganj district cultivated in about 45,000 ha during *kharif* season which is 49 per cent of the net sown area. Improper nutrition as well as low average NPK consumption in district results in wide yield gap and deterioration of soil quality. Hence, an on-farm trial (OFT) was designed and conducted during 2018-19 and 2019-20 to evaluate the effect of integration of different sources of plant nutrients on grain yield of rice, yield attributing characters and chemical properties of soil after harvest of crop.

METHODOLOGY

The trial was conducted at ten locations. The experimental soils were moderately to slightly acidic in nature (pH 5.7 to 6.1), medium in organic carbon status (OC 0.78 to 0.81%, medium in available nitrogen status (285 to 310 kg per ha), medium in available P status (14.5 to 16.6 kg per ha), low in available S status (8.2 to 9.5 mg per kg), low in available B status (0.32 to 0.41 mg per kg) and high in available Zn, Cu, Mn and Fe status. There were three treatments viz. (i) Farmer's Practice: Application of nitrogen and phosphorus @ 60-25 kg NP per ha, (ii) Technology Option 1: Application of 100% recommended dose of fertilizers (RDF) i.e. 80-60-40 kg NPK per ha and (iii) Technology Option 2: Application of 75% RDF + Vermicompost @ 20 q per ha + Blue Green Algae @ 10 kg per ha + Azospirillum @ 2 kg per ha. The experimental design was randomized block design (RBD) considering each location (farmer) as one block (replication). Rice var Sahbhagi dhan was taken as test crop. Standard agronomic procedures were followed during the trial. Observations on growth parameter were taken from five randomly selected plants. Soil and plant samples were analysed as per standard method.

RESULTS

Application of chemical fertilizer as per state recommendation alone or integration of chemical

Table 1 Grain yield (q/ha) and yield attributing characters of transplanted rice as affected by integration of different sources of plant nutrients

Treatments	No. of effective tillers m^{-2}			No. of grains per spike			Grain Yield (q/ha)			B:C Ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Farmer's Practice	211.6	215.5	213.6	114.9	113.9	114.4	29.91	30.42	30.17	1.42	1.41	1.41
Tech. Opt. 1	238.2	233.0	235.6	124.3	127.1	125.7	36.56	36.22	36.39	1.63	1.59	1.61
Tech. Opt. 2	**248.3**	**241.2**	**244.8**	**132.3**	**139.7**	**136.0**	**41.22**	**41.21**	**41.22**	1.92	1.87	1.90
CD at 5%	9.78	5.61	7.97	4.95	4.84	4.90	1.44	1.83	1.65	0.06	0.08	0.07
CV%	4.47	2.60	3.67	4.26	4.06	4.16	4.27	5.42	4.88	3.75	5.43	4.65

fertilizers with organic manures and bio-fertilizer significantly increased the grain yield of rice as well as yield attributing characters as compared to Farmer's Practice, except test weight of 1000 grains where no significant influence of the treatments was noticed. The significantly highest number of effective tillers per square meter (245), number of grains per spike (136) and grain yield of rice (41.22 q/ha) was recorded with application of NPK @ 75% RDF along with Vermicompost @ 20 q/ha, Blue Greean Algae @ 10 kg/ha and Azospirillum @ 2 kg/ha (Technology Option 2). Increase in yield with 100% recommended dose of fertilizer over Farmer's Practice may be due to the supply of plant nutrients in proper quantity and proportion. However beneficial effect of integration of inorganic, organic and biological sources of plant nutrients on grain yield as well as yield attributing characters might be due to the increased nutrient uptake and beneficial impact of organic manures on physical, chemical and biological properties of soil. Beneficial effect of integration of different sources of plant nutrients was also reported by Kumar *et al.* (2008).

Application of NPK @ 75% RDF along with Vermicompost @ 20 q/ha, Blue Greean Algae @ 10 kg/ha and Azospirillum @ 2 kg/ha resulted in significantly highest net return (Rs 27,506 per ha) with B:C of 1.90. This might be due to reduced use of chemical fertilizers by 25 per cent at same time increased yield by the integration of different sources of plant nutrients.

Pooled data analysis indicated that soil pH and electrical conductivity did not significantly influenced by the application of inorganic source of plant nutrients or integration of organic and inorganic sources during both the year of trial. However, integration of organic and inorganic sources of plant nutrients significantly increased the organic carbon content of soil after harvest of rice and the extent was 21.7 per cent as compared to Farmer's Practice. Application of vermicompost and blue green algae might have contributed in organic carbon content in the soil after harvest of rice.

It was found that Technology Option 1 and 2 significantly increased the available N, P_2O_5 and K_2O status of soil after harvest of rice. Significantly highest available N (341.2 kg/ha) and P_2O_5 (20.24 kg/ha) was recorded under Technology Option 2, however in case of available K_2O the observed difference was non-significant among both technological options. Addition of inorganic fertilizers along with organic manures helps in mineralization which resulted and rapid conversion of plant nutrients in available form. Favourable effect of integration of different sources of plant nutrients on available N, P and K content in soil after harvest might be the possible reason for the present findings. Favourable effect of integration of different sources of plant nutrients on available N, P and K content in soil after harvest was also observed by Kumar *et al.* (2008) and Baishya *et al.,* (2015).

CONCLUSION

On the basis of On Farm Trial conducted during the year 2018-19 and 2019-20 it can be concluded that application of NPK @ 75% RDF along with Vermicompost @ 20 q/ha, Blue Greean Algae @ 10 kg/ha and Azospirillum @ 2 kg/ha resulted in significantly highest number of effective tillers per sq meter, number of grains per spike, grain yield and B:C ratio. Significant increase in the availability of N, P_2O_5 and K_2O was also noticed under the treatment. Hence, integration of inorganic and organic sources of plant nutrients may be advantageous in case of transplanted rice in Sahibganj district of Jharkhand.

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Theme - II : Sustainable rice farming

IRC/TM-2/PP-105

HEAT USE EFFICIENCY AND RADIATION USE EFFICIENCY IN RICE VARIETIES UNDER DIFFERENT DATES OF PLANTING

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Rice (*Oryza sativa*) is a unique creation of crop plant domestication in having cultivars of maturity varying from less than 80 days to more than 180 days. The amount of biomass produced per unit of intercepted light is radiation use efficiency (RUE) determines the growth and productivity. An intercepted PAR depends on the plant's leaf area index (LAI), canopy architecture and the physiological capacity to intercept radiation. Heat use efficiency (HUE) being the efficient utilization of heat in terms of dry matter accumulation and heat unit indices viz. growing degree days(GDD), Heleiothermal unit(HTU) and phtothermal unit(PTU) helps to estimate the crop development stages as well as harvest date. Hence, the experiment was conducted to study the HUE and RUE in rice varieties under different dates of planting.

METHODOLOGY

The field experiment was conducted at the Research and Instructional Farm of OUAT (20.15^{0}N latitude, 85.52^{0}E longitude and 25.9 m above MSL), Bhubaneswar, Odisha during the kharif season of 2019. The soil was sandy clay loam with a pH of 4.5. The experiment was laid outin a split plot design with fourdates of planting 21 July, 5 August, 20 August and 4 September in main plot and four rice varieties viz. Mandakini, Bina-11, Swarna and Hasanta in sub-plots and replicated thrice. The parameters viz. Plant height, LAI, number of tillers/m^2, number of grains/panicle, grain and straw yield, harvest index along with heart units like GDD,HTU and PTU, HUE and RUE were analyzed.

RESULTS

The experiment revealed that the crop transplanted the earliest on 21 July took longer duration to achieve a particular phenological stage as compared to delayed planting. The yield attributing characters like number of tillers/m2 (295.4), LAI (4.23), dry matter accumulation (2573.85 g/m2), grain yield (4225 kg/ha), straw yield (4904 kg/ha) and harvest index (46.07%) were recorded maximum in 5 August planting which was at par with 21 July planting. The HUE (1.07g/m2 /day) and RUE (2.04 g/MJ) were highest in 5 August planting which were at par with 21 July.

The variety Swarna recorded the highest total dry matter production, LAI, grain yield (4508 kg/ha),

Heat Use Efficiency (g/m²/day) and Radiation Use Efficiency (g/MJ) of different rice varieties under different dates of planting

Dates of transplanting	LAI	Grain yield (Kg/ha) Efficiency	(HUE) Heat Use Efficiency (g/m²/day)	(RUE) Radiation Use (g/MJ)
21 July	4.18	4155	1.04	2.03
5 August	4.23	4225	1.07	2.04
20 August	3.83	3800	0.97	1.84
4 September	3.68	3217	0.82	1.54
SE(m)±	0.09	48.1	0.02	0.03
CD (p=0.05)	0.26	148.2	0.05	0.10
Varieties				
Mandakini	1.85	2880	0.60	1.14
Bina-11	3.12	3608	0.83	1.60
Swarna	5.40	4508	1.02	2.39
Hasanta	5.34	4403	0.97	2.33
SE(m)±	0.10	46.2	0.02	0.04
CD (p=0.05)	0.30	134.9	0.05	0.10

straw yield, harvest index, HUE and RUE which were at par with the variety Hasanta. GDD and PTU were recordedthe highest values in 21 July planting and decreased with delayed planting. Whereas HTU recorded higher in 5 August planting. Among the varieties, Hasanta showed higher accumulation of GDD, HTU and PTU than Swarna. Diwan et al.,2018 and Sreenivas et al., 2010 had similar observation.

CONCLUSION

Rice can be planted by 5 August to achieve the maximum yield, Variety Swarna recorded the highest yield, HUE and RUE which were at par with the Hasanta due to higher LAI under different dates of planting.

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IRC/TM-2/PP-106

EFFECT OF FERTILITY LEVELS AND SPLIT APPLICATION OF NITROGEN ON GROWTH, TOTAL DRY MATTER, YIELD AND ECONOMICS OF DIFFERENT RICE CULTIVARS

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Rice is a majour food source for a greater part of the world mass. In India, rice is cultivated in an area of 43.9 million hectares with 104.32Mt of production. Among all the nutrients, Nitrogen is a major nutrient element for rice plants . During ripening stage, almost 70% of the nitrogen taken up by the straw is shifted to the grain. When more grains are produced as compared to the size of vegetative parts, a higher amount of nitrogen will be requiredfor the grain growth to be continued and therefore the leaf nitrogen content will turn down abruptly. Under such situation some grains may suffer from nitrogen shortage (Yoshida, 1981). Hence the only way to attain a higher photosynthetic efficiency is to keep on providing nitrogen even upto heading. Application of nitrogen in splits is a well proven and accepted method of increasing the efficiency of applied nitrogen in most irrigated crops(Prasad,2007). An experiement was piloted to assess the effect of different fertiliser levels and nitrogen splits on growth,yoeld and ecocnomics of four different ricecultivars.

MATERIALS AND METHOD

An experiment was conducted during kharif season of 2017 at Agronomy Main Research Station, Odisha University of Agriculture and Technology, Bhubaneswar situated at 21015' N and 85052'E and 25.9 m above MSL. The soils of the region where experiment was carriedout was sandy loamintexturewith pH 5.6 with medium organic carbon status (0.71 %), low available nitrogen status (223 kg ha-1), medium available phosphorus status (20kgha-1) and medium potassium status(211 kg ha-1).Two fertility levels (100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1} and 80:40:40 kg $N:P_2O_5:K_2O$ ha^{-1}) each with two splitting schedules of nitrogen (¼basal+ ½tillering+ ¼PI) and (¼basal+ ½ tillering+ 1/8 PI+ 1/8 flowering) were allotted to the main plots and four varieties (Hasanta, Mrunalini, Asutosh and Swarna)wereallotted to the sub plots in a split plot design with threereplications.Observations were taken down on various growth parameters such as height of the plant, maximum dry matter accumulation, number of effective tillers and yield. Comparative economics like net return, B:C ratio were worked out for different treatments considering the market price of inputs and outputs.

RESULT

Height of the plants increased progressively and reached its maximum at harvest.The maximum plant height(116.71cm)was observed with application of 100:50:50 kg N: P2O5:K2O ha^{-1} in four splits (¼ basal + ½ tillering + 1/8 PI + 1/8 flowering). Rice variety Ashutosh recorded the maximum plant height (123.34cm) among all the varities. Contrarily Swarna variety has attained only upto 107.3 cm height during harvest.

The number of tillers m^{-2} increased significantly with increase in fertiliser levels and number of splits. The maximum number of effective tillers (340.86) were observed with application of 100:50:50 kg N: P2O5:K2O ha^{-1} in four splits. Among the varieties Mrunalini was observed with the maximum number of effective tillers (392.60).

Table.1.

Treatment	Growth parameters			Grain yield(t ha^{-1})	Net Return(Rs. ha^{-1})	Benefit: Cost
	Plant Height (cm)	Effective tillers m^{-2}	Total dry matter accumulation (g m^{-2})			
F1- 80:40:40						
S1(3 splits)	114.18	320.51	1365.35	4.03	186.20	1.48
S2(4 splits)	115.45	324.86	1369.5	4.20	198.22	1.46
F2- 100:50:50						
S1(3 splits)	115.75	336.44	1399.62	4.40	209.00	1.58
S2(4 splits)	116.71	340.86	1409.00	4.87	236.72	1.68
SEm±	0.07	0.09	0.22	0.02	0.39	0.003
CD (P=0.05)	0.25	0.29	0.66	0.04	1.34	0.01
Variety						
V1-Hasanta	114.72	309.63	1362.04	4.27	201.70	1.51
V2-Mrunalini	116.74	392.60	1481.40	5.06	237.26	1.80
V3-Ashutosh	123.34	337.10	1415.39	4.47	205.56	1.58
V4-Swarna	107.3	283.34	1284.63	3.70	185.62	1.31
SEm±	0.09	0.05	0.51	0.03	0.79	0.002
CD (P=0.05)	0.26	0.15	1.50	0.10	2.31	0.008
F x V						
SEm±	0.18	0.10	1.02	0.07	1.58	0.02
CD (P=0.05)	0.52	0.30	3.00	0.21	4.63	0.06

The amount of dry matter stored by the plant have raised significantly with increase in nitrogen doses and their split applications. The maximum accumulated dry matter 1409 g m-2 was noticed during harvest by application of 100:50:50 kg N: P2O5:K2O ha^{-1} in four splits (¼ basal + ½ tillering + 1/8 PI + 1/8 flowering). Outof the varieties, Mrunalini accumulated the maximum amount of total dry matter (1481.4 g m-2).

The grain yield of rice recorded a significant variation due to different fertility levels with split application of nitrogen and varieties. The grain yield of rice increased with increase in fertility level and split application of nitrogen. Application of 100:50:50 kg N:P_2O_5:K_2O ha^{-1}with split application of nitrogenous fertiliser S2 (¼ basal + ½ tillering + 1/8 PI + 1/8flowering stage) recorded the highest grain yield of 4.87 t ha^{-1} than S1(¼ basal + ½ tillering + ¼ PI)and less fertility level(80:40:40 kg N:P_2O_5:K_2O ha^{-1}). The fertility level of 80:40:40 kg N:P_2O_5:K_2O ha^{-1} at both the split levels recorded significantly less grain yield. Among different varieties, Mrunalini recorded the highest grain yield of 5.06 t ha^{-1} than other 3 varieties and Swarna recorded the lowest grain yield of 3.70 t ha^{-1}.

The highest net return (Rs.30735 ha-1) and B: C ratio (1.68) was observed under application of 100:50:50 kg N: P2O5:K2O ha^{-1} in four splits and among the varieties the maximum net return (Rs.35164 ha-1) and B:C ratio(1.80) was observed in Mrunalini variety.Minimumnetreturn (Rs.20128 ha-1) was observed under application of 80:40:40 kg N: P2O5:K2O ha^{-1} in three splits and the minimum B: C ratio (1.46) was also observed under same fertility level when applied in four splits.

CONCLUSION

From the above experiment it can be concluded that rice variety Mrunalini under application of

100:50:50 kg N:P2O5:K2O ha^{-1} in four splits of nitrogen (¼ basal + ½ tillering + 1/8 PI + 1/8 flowering) produced the maximum plant height, effective tillers, totaldry matter and maximum yield with the maximum net return(Rs.42,765ha-1)and B-C ratio (1.95). So the treatment can be recommended to the farmers for getting higher productivity andprofitability.

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Theme - II : Sustainable rice farming

IRC/TM-2/PP-107

PARTIAL MECHANIZATION FOR SUSTAINABLE RICE FARMING IN FRAGMENTED LAND HOLDINGS OF SMALL AND MARGINAL FARMERS

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Rice mechanization contributes to sustainable increase in rice productivity. Further, mechanization has a crucial role in this venture as it functions as a force multiplier to compensate the human labour shortage for those engaged in food production. In all rice growing, there is acute shortage for human labour which delays the operations, leading to reduced yield and lesser profit. Traditional method of transplanting can be substituted by direct seeding technique, which is not only simple to use but also has been found effective in sustaining the production of rice. Direct wet seeding of rice through drum seeder offers the advantages of avoiding nursery raising and transplanting operations. In addition, drum seeding reduces labour requirement, hasten crop maturity and increase water use efficiency, thus 25 % (250-300 man hours) of total human labour involved in rice cultivation were reduced making rice cultivation more profitable (Raghavendra *et al.*, 2015). Mechanizing transplanting and weeding operations is a pre-requisite for the labour demand areas of major rice cultivating tract. Mechanization is feasible and economical for large land holding and big farmers. However, mechanizing small fragmented land holdings of marginal farmers is not much explored. Hence, an attempt was made to develop partial mechanization package for enhancing crop productivity, profitability and labour use efficiency of rice cultivation for fragmented land holding of marginal farmers.

MATERIALS AND METHODS

Field experiment was conducted at Rice Research Station, Ambasamudram during Kar season to develop partial mechanization package for small and marginal rice growing farmers. Crop establishment treatment involves M_1 – Conventional method (Transplanting method), M_2 - Drum seeding (crop geometry tailoring with conoweeder on 10 DAS) and M_3 - transplanter. Weed control method involves S_1 - Pre-emergence herbicide (Pretilachlor 1.25 l/ha) + Hand weeding (35 DAT), S_2 - Pre emergence herbicide (Pretilachlor 1.25 l/ha) + Early Post emergence herbicide (Oxdiagryl @ 87.5 g/ha), S_3 – Cono weeder (10, 20 &30 days after transplanting)

Table 1. Effect of partial mechanization on rice grain yield (kg/ha)

Weed Control techniques	Crop establishment methods			Mean
	Transplanting	Drum Seeding	Machine planting	
Pretilachlor 1.25 l/ha + HW at 35 DAS/DAT	5588	5929	5277	5598
Pretilachlor 1.25 l/ha + Oxdiagryl @ 87.5 g/ha	5638	5974	5327	5646
Cono weeder at 10, 20 &30DAS/DAT	5805	6138	5494	5812
Power weeder at 10, 20 &30DAS/DAT	5563	5896	5252	5571
Mean	5649	5984	5338	
For	S	M	M at S	S at M
S.Em	35	115	127	62
CD (P=0.05)	75	319	336	130

* DAS - Days after sowing, DAT - Days after Transplanting, HW - Hand weeding

Table 2. Effect of partial mechanization on economics of rice (B:C ratio)

Weed Control techniques	Crop establishment methods			Mean
	Transplanting	Drum Seeding	Machine planting	
Pretilachlor 1.25 l/ha + HW at 35 DAS/DAT	2.57	2.50	2.16	2.41
Pretilachlor 1.25 l/ha + Oxdiagryl @ 87.5 g/ha	2.57	2.65	2.25	2.49
Cono weeder at 10, 20 &30DAS/DAT	2.61	2.66	2.29	2.52
Power weeder at 10, 20 &30DAS/DAT	2.52	2.60	2.20	2.44
Mean	2.57	2.60	2.23	

* DAS - Days after sowing, DAT - Days after Transplanting, HW - Hand weeding

and S_4 - Paddy power weeder (10, 20 &30 days after transplanting).

The growth and yield parameters were recorded and analyzed statistically. Energetics was calculated for the inputs and outputs in terms of Mega Joules (MJ).

Table 3. Effect of partial mechanization on energy use efficiency of rice

Weed Control techniques	Crop establishment methods		Mean	
	Transplanting	Drum Seeding	Machine planting	
Pretilachlor 1.25 l/ha + HW at 35 DAS/DAT	4.41	4.64	4.15	4.40
Pretilachlor 1.25 l/ha + Oxdiagryl @ 87.5 g/ha	4.43	4.65	4.17	4.42
Cono weeder at 10, 20 &30DAS/DAT	4.66	4.83	4.34	4.61
Power weeder at 10, 20 &30DAS/DAT	4.38	4.56	4.06	4.33
Mean	4.47	4.67	4.18	

* DAS - Days after sowing, DAT - Days after Transplanting, HW - Hand weeding

RESULTS

Partial mechanization of crop establishment and weed control methods showed significant effect on grain yield, energetics and economics of rice cultivation. Among the different crop establishment methods, drum seeding and crop geometry tailoring to single plant per hillrecorded higher grain yield (5984 kg/ha), B:C ratio (2.60) energy use efficiency (4.67). With respect to different weed management methods, weeding through cono weeder on 10, 20 and 30 DAS/DAT recorded higher grain yield (5812 kg/ha), B:C ratio (2.52) and energy use efficiency (4.61).Direct wet seeding through drum seed was reported to be better than transplanting due to higher number of filled grains per unit area, in spite of higher sterility and reduced grain weight (Bera*et al*.,2016).

CONCLUSION

Drum seeding and crop geometry tailoring to single plant per hill with conoweeder on 10 DAS and weeding through conoweeder at 10, 20 and 30 DAS is found to be economically feasible method of rice cultivation for fragmented land holdings of small farmers.

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IRC/TM-2/PP-108

EVALUATION OF SUBSTRATES FOR PRODUCTION OF *PLEUROTUS OSTREATUS*

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Pleurotus spp. are commonly known as oyster mushroom because of their oyster like structure. These are the second most popular mushroom in world after button mushroom. This is known as wood fungus and in India it is popularly known as "Dhingri". Oyster mushrooms grow naturally in the temperate and tropical forests on dead, decaying wooden logs. Therefore, a large number of agricultural forest by-products including straw of paddy, wheat, ragi; stalk and leaves of maize, jowar, bajra, cotton, sugarcane; peanut shells; dried grasses; paper; coffee waste and synthetic compost of button mushroom with rich cellulose, hemicelluloses and lignin contents are used for cultivation of oyster mushroom in large scale. However, yield of oyster mushroom largely depends upon the nutrition and nature of the substrates. Therefore, to ascertain the productivity, ten different locally available substrates were collected and evaluated in the growing room of CTMRT, Bhubaneswar.

METHODOLOGY

Ten different types of substrates such as maize stalk, sugarcane bagasse, rice husk, saw dust, banana pseudo stem, groundnut haulm, paper, finger millet stalk, sesame stalk and paddy straw were collected and dried properly. The substrates chopped and soaked in water for six hours followed by pasteurized in hot water for one hour. The pasteurised substrate was filled in a polythene bag with application of 10 per cent spawn in layer method. During spawning, 200 g of different supplements were applied separately along with untreated as control. About 10-20 small holes were made in all sides of bag for exchange of gases. Spawned bags were kept on shelves for incubation in dark room at a temperature of 20^{0}C to 30^{0}C. Once the mycelium fully colonized the substrate, the bags were then removed from polythene and arranged on shelves. Appropriate light (200 lux for 8-12 hours a day), temperature (25^{0}C) and relative humidity (70-

Table 1: Evaluation of different substrates for production of oyster mushroom (*Pleurotus ostreatus*)

Sl. No.	Ligno-cellulosic substrates	Days to spawn run	Days to pin head initiation	Days to 1st harvest	BE (%)	Average numbers of fruit bodies/ bag	Yield (g)/ 2 kg dry straw
1	Paddy straw	21.47	27.40	33.80	62.33	240.27	1246.67
2	Sugarcane bagasse	17.93	28.33	32.67	53.33	218.33	1066.67
3	Maize stalk	23.93	28.33	34.47	49.67	197.27	993.33
4	Paper	25.27	31.60	41.13	19.17	69.00	383.33
5	Sesame stalk	23.40	29.73	33.80	55.83	240.93	1116.67
6	Groundnut haulm	24.73	32.00	36.07	38.17	184.73	763.33
7	Rice husk	24.00	33.13	39.73	42.50	174.93	850.00
8	Banana pseudo stem	24.07	30.67	35.20	68.33	246.40	1366.67
9	Saw dust	28.53	36.93	43.20	43.83	153.93	876.67
10	Finger millet stalk	21.53	25.93	32.60	60.17	248.87	1203.33
	SE(m)+	0.23	0.34	0.49	1.62	2.03	32.36
	CD(0.05)	0.67	1.02	1.45	4.81	6.04	96.14

80 %) were maintained to facilitate fruiting. Observations on time taken for spawn run, pinhead initiation and first harvest along with average number of fruiting body, mushroom yield (biological efficiency) were recorded.

RESULT

Data presented in Table 1 revealed that days to spawn run in the substrate varied from 17.93 days to 28.53 days. Early pinhead initiation was observed in finger millet stalk (25.93 days) followed by paddy straw (27.40 days), sugarcane bagasse (28.33 days) and maize stalk (28.33 days) respectively. Days to first harvest of mushroom was recorded from finger millet stalk (32.60 days) which is statistically at par with that of sugarcane bagasse (32.67 days), paddy straw (33.80 days) and sesame stalk (33.80 days). The range of oyster mushroom yield varied from 1366.67 g to 383.33 g from 2 kg dry substrate. Highest yield of mushroom recorded 1366.67 g from banana pseudo stem with 246.40 number of mushrooms. The second highest yield of mushroom 1246.67 g observed from paddy straw with 240.27 numbers of mushrooms which was statistically at par with finger millet stalk (1203.33 g, 248.87 mushrooms). Similar trend was observed in biological efficiency with a range of 19.17 percent to 68.33 percent.

CONCLUSION

Oyster mushrooms have the ability to grow on a wide range of agricultural wastes with variable yield potential. From results, banana pseudo stem performed significantly the highest biological efficiency followed by paddy straw which supports the findings of Iqbal *et al*. (2005). However, paddy straw can be use as main substrate because of its cheap availability.

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EFFICACY OF HERBICIDE MIXTURES IN WET DIRECT SEEDED RICE

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Rice (*Oryza sativa* L.) is spectacularly diverse bothas an important human food crop in the world, feeding directly more people than any other crops and the way it is grown. In recent years, DSR (Direct Seeded Rice) substituted other methods of rice cultivation but weeds have been major biotic constraints and in the absence of any control measures may range from10 to 100% (Rao *et al.*, 2007). So, some weed control measures to a great degree pivots on hand weeding, in addition to herbicides though it is a tedious practice. Inspite of some herbicides show phytotoxic effect i.e. pendimethalin 2kg /ha in rice (Awan *et al*. 2016*)* and DSR fields having diverse weed community, herbicide combinations or mixtures acting as promising major strategy to manage weeds effectively.

. Hence chemical management through herbicides and/ or mixtures are one of the promising options despite of fact that some herbicides show some inimical effect like quantum of phytotoxicity, weed flora shift, herbicide resistence and deleterious effect on soil health. So, to study the effect of herbicide mixtures in rice crop for management of weeds an experiment wasconducted at Institute Research Farm of ICAR-National Rice Research Institute, Cuttack (Odisha) during kharif season of 2017.

METHODOLOGY

The experimental site was located at the Institute Research Farm of ICAR-National Rice Research Institute, Cuttack (Odisha) in 2017 with the test rice variety 'CR Dhan 203' where adequate facilities for irrigation and drainage exist. The meteorological data, recorded during experimental period showed that crop received 990.71 mm rainfall during the crop period. The soil of the experimental field was sandy clay loam in texture. The soil was neutral in reaction. It had low nitrogen, medium phosphorus and high potassium contents. The experiment was laid out in Randomized Complete Block Design consisting of twelve treatments *viz*., nine herbicide mixtures [i.e. azimsulfuron 50% DF+ bispyribac sodium 10% SC at (22+25) g/ha (T_1), flucetosulfuron 10% WDG (w/w) + bispyribac sodium 10% SC at (25+25) g/ha (T_2), penoxsulam 21.7% SC + cyhalofop-butyl 12% EC (w/v) at (25+100) g/ha (T_3), fenoxaprop-p- ethyl 6.7% EC (w/w) + ethoxysulfuron 15% WDG (w/w) at (50+15) g/ha (T_4) , bispyribac sodium 10% SC + ethoxysulfuron 15% WDG (w/w) at (25+15) g/ha (T_5), cyhalofop-butyl 12% EC (w/v) + ethoxysulfuron 15% WDG (w/w) at (75+15) g/ha (T_6), XR-848 benzyl ester 2.5% EC (w/v) + cyhalofop-butyl 12% EC (w/v) at (25+100) g/ha (T_7), flucetosulfuron 10% WDG (w/w) + pretilachlor 30.7% EC at (25+500) g/ha (T_8), bensulfuron-methyl 0.7% + pretilachlor 7% GR at (70+700) g/ha (T_9)], one herbicide check [Bispyribac sodium 10% SC at 30 g/ha (T_{10})], one weed free (T_{11}) and one weedy check (T_{12}) are applied to evaluate the efficacy of newly standardized herbicide mixtures for broad spectrum and cost effective weed control in wet direct seeded rice.

RESULTS

Data regarding the total dry matter of at 30, 60 DAS and 90 DAS are presented in Table 1. At all growth stages , the highest weed dry matter among the herbicidal treatment of other weed species was observed under Bispyribac sodium at 30 g ha^{-1} followed by bensulfuron methyl + pretilachlor at (70+700) g ha^{-1} . While lowest wed dry matter was found under fenoxaprop-p ethyl + ethoxysulfuron at

Table 1: Total dry matter production of weed (m^{-2}), Weed control efficiency (%) and Grain yield (t/ha) as influenced by different herbicide mixtures in wet direct seeded rice

Treatments	Total dry matter production of weed (m^{-2})			Weed control efficiency (%)			Grain yield(t/ha)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	
T_1	4.07(16.05)	5.60(30.85)	5.61(30.92)	72.00	68.07	65.21	4.68
T_2	4.11(16.42)	5.66(31.55)	5.67(31.62)	71.37	67.35	64.42	4.57
T_3	3.66(12.90)	5.29(27.51)	5.30(27.58)	77.50	71.53	68.97	4.75
T_4	3.57(12.21)	5.17(26.19)	5.17(26.26)	78.70	72.89	70.46	4.88
T_5	4.18(16.94)	5.75(32.55)	5.76(32.63)	70.45	66.31	63.29	4.46
T_6	4.05(15.92)	5.82(33.32)	5.82(33.41)	72.23	65.51	62.41	3.98
T_7	3.94(15.04)	5.67(31.62)	5.67(31.70)	73.78	67.28	64.34	4.20
T_8	4.35(18.43)	5.99(35.42)	6.00(35.50)	67.85	63.34	60.05	4.07
T_9	4.43(19.16)	6.11(36.82)	6.12(36.90)	66.59	61.89	58.48	3.93
T_{10}	5.15(26.03)	6.28(39.00)	6.57(42.72)	54.61	59.64	51.94	3.76
T_{11}	0.71(0.00)	0.71(0.00)	0.71(0.00)	100.00	100.00	100.00	5.23
T_{12}	7.61(57.34)	9.85(96.62)	9.45(88.88)	72.00	68.07	65.21	2.81
S.Em.±	0.22	0.23	0.17	3.68	0.41	3.32	0.33
CD (P=0.05)	0.53	0.67	0.49	8.70	1.08	7.02	0.97

*The CD (P=0.05) has been calculated based on $\sqrt{(x+0.5)}$ transformed values and values in parentheses are original values.

[1]T_1 -azimsulfuron + bispyribac sodium, T_2-flucetosulfuron + bispyribac sodium, T_3-penoxsulam + cyhalofop-butyl, T_4 -fenoxoprop-p-ethyl + ethoxysulfuron, T_5 -bispyribac sodium + ethoxysulfuron, T_6 -cyhalofop-butyl + ethoxysulfuron, T_7 -XR-848 benzyl ester + cyhalofop-butyl, T_8 -flucetosulfuron + pretilachlor, T_9 -bensulfuron methyl + pretilachlor, T_{10} -bispyribac sodium, T_{11} -Weed free and T_{12} –Weedy check, DAS- Days after sowing

(50+15) g ha^{-1} , penoxsulam + cyhalofop-butyl at (25+100) g ha^{-1}, flucetosulfuron + bispyribac sodium at (25+25) g ha^{-1} (T_2), azimsulfuron + bispyribac sodium at (22+25) g ha^{-1}, bispyribac sodium + ethoxysulfuron at (25+15) g ha^{-1} (T_5) having relationship of at par with decreasing order. At all stages highest recorded in weedy check and no weeds seen in weed free treatments.Similar findings were reported in different studies.

Weed control efficiency (WCE) computed at 30, 60 DAS and 90 DAS are presented in Table 1. At all growth stages , the lowest weed control efficiency among herbicidal treatments was observed under bispyribac sodium at 30 g ha^{-1} followed by bensulfuron methyl + pretilachlor at (70+700) g ha^{-1}. While highest weed control efficiency was found under fenoxaprop-p ethyl + ethoxysulfuron at (50+15) g ha^{-1} , which was at par with penoxsulam + cyhalofop-butyl at (25+100) g ha^{-1} , flucetosulfuron + bispyribac sodium at (25+25) g ha^{-1}, azimsulfuron + bispyribac sodium at (22+25) g ha^{-1}, bispyribac sodium + ethoxysulfuron 15% at (25+15) g ha^{-1}. Similar results were studied in different experiments.

Data with respect to grain yield is presented in Table 1. It is clear from the data that the different weed management treatments significantly influenced the grain yield. Among different treatments, the weed free (5.23 t ha^{-1}) proved significantly superior producing higher grain yield, but it was found at par with fenoxaprop-p ethyl + ethoxysulfuron , penoxsulam + cyhalofop-butyl at (25+100) g ha^{-1}, flucetosulfuron + bispyribac sodium at (25+25) g ha^{-1}, azimsulfuron + bispyribac sodium at (22+25) g ha^{-1}, bispyribac sodium + ethoxysulfuron at (25+15) g ha^{-1}. It indicates that although flucetosulfuron + bispyribac sodium at (25+25) g ha^{-1} shown highest phytotoxicity up to 60 DAA of herbicides it had no such detrimental effect on yield may be due to the phytotoxicity of the herbicide was quite less or negligible.

CONCLUSION

The result of the experiment revealed that among the herbicide treatments, fenoxopro-p-ethyl + ethoxysulfuron can be recommended as safest , cost effective and reasonable herbicide mixtures as it registered minimum weed dry matter and maximum weed control efficiency while yield being negatively related to the weed dry matter, this treatment showed highest yield among all herbicide treatments.Hence the adoption of chemical weed management option through herbicide mixtures in direct sown is quite propitious.

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SYSTEM OF ASSURED RICE PRODUCTION (*BORO*): A CLIMATE-RESILIENT METHODOLOGY

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Productivity of *boro* rice is much higher than that of *kharif* in the state of West Bengal. *Boro* rice production is still getting constrained by many factors including uneven seed germination, higher seed rate, cold injury, slow/stunted growth or even mortality of seedlings in nursery, transplanting of weak seedlings in more numbers at closer spacing in main field without micronutrient management, slow root development after transplanting, poor crop establishment, extended crop duration leading to high irrigation requirement, and Nor'wester hazards at maturity (Patra *et al*., 2018). To ensure a uniform and rapid seed germination and optimize seed rate, a low cost germinator (incubator) has been innovated and designed by the first author as 'Sampad Seed Germinator' (SSG). Timely sowing of seeds at wider spacing is another important factor to harness the yield potential of a particular inbred or hybrid. Covering of rice nursery with polythene sheet is also an effective option to overcome the adverse effects of low temperature (Singh *et al*., 2003). Avoidance of cold injury through improved management at the very beginning of crop establishment and of thunderstorms through early crop harvest is the key to successful *boro* rice cultivation. Hence, the present study was taken up to assure *boro* rice production with efficient resource conservation as well as higher productivity.

METHODOLOGY

Field experiments were conducted simultaneously at Rice Research Station, Chinsurah, Hooghly and Water Management Research Station, Ranaghat, Nadia with the use of popular rice variety '*Satabdi*' (IET 4786) in three consecutive years during dry (*boro*) season of 2016-17, 2017-18 and 2018-19. Three methods of nursery management *viz.* (i) improved method of seed germination (after nutri-priming with Zn) in SSG using seed rate of 10 kg ha^{-1} followed by nursery covering with polythene sheet (placed at about 50 cm above the ground level with four-side covering) for whole day-night (24 h) up to 15 days after sowing (DAS) and subsequent seedling hardening, (ii) improved method of seed germination (after nutri-priming with Zn) in SSG using seed rate of 10 kg ha^{-1} followed by nursery covering with polythene sheet from 3 pm to 8 am, and (iii) conventional farmers' practice with seed rate of 75 kg ha^{-1} along with three different times of sowing *viz.* (i) end of November, (ii) middle of December, and (iii) first week of January were assigned in a factorial randomized complete block design with three replications. Polythene sheets were removed after 15 DAS in day time and reused to cover during afternoon-morning (3 pm-8 am) under the method of continuous nursery covering (24 h) for hardening of seedlings. Seedlings of 20-25 days were transplanted at wider spacing (16 hills m^{-2}) using 1-2 seedling(s) hill^{-1} under improved method, whereas transplanting was done with more number (5-7) of seedlings hill^{-1} at the age of 40-45 days at closer spacing (30-35 hills m^{-2}) under the conventional practice. Two rounds of foliar spray with micronutrients (Zn and B) at active tillering and panicle initiation stages were given under improved method, whereas micronutrients were not at all applied under farmers' practice in the main field. The crop was raised with other recommended package of practices in the main field. Observations on seedling vigour, crop growth and yield attributes along with grain yield were recorded.

RESULTS

Three-year pooled data revealed that use of SSG and polythene covering in nursery (3 pm-8 am) recorded the highest grain yield (5.97 and 6.43 t ha^{-1}), which was followed by SSG + polythene covering for 24 h (5.89 and 6.42 t ha^{-1}) and conventional practice (5.61 and 5.47 t ha^{-1}) at Chinsurah and Ranaghat, respectively, regardless of sowing time. Higher yields under improved methods of crop establishment were due to good seedling vigour with cold tolerance as recorded under polythene covering with reduced frequency of irrigation in nursery, which also maintained higher level of maximum and minimum temperatures inside than the outside temperatures. No significant differences in grain yield were recorded under nursery covering for day-night (24 h) and afternoon-morning (3 pm-8 am). So far as the time of sowing was concerned, the highest grain yield was recorded under sowing in mid-December (5.92 t ha^{-1}), followed by the first week of January (5.80 t ha^{-1}) and end of November (5.75 t ha^{-1}) at Chinsurah whilst it was the highest under sowing in the end of November (6.39 t ha^{-1}), followed by mid-December (6.37 t ha^{-1}) and first week of January (5.58 t ha^{-1}) at Ranaghat. Considering results of both the locations, mid-December sowing was found to be the best for obtaining higher grain yield (6.15 t ha^{-1}), followed by the end of November (6.07 t ha^{-1}) and first week of January (5.69 t ha^{-1}). Sowing of seeds (sprouted in SSG after nutri-priming at a seed rate of 10 kg ha^{-1}) in mid-December and polythene covering in nursery (either daily for a period of 3 pm-8 am or continuously for 24 h, depending on the cold spell and its persistence with intensity) was found to reduce input requirement and shorten crop duration by about 20-25 days, ensuring early crop harvest and displaying 9.41-11.50% yield advantages, compared with conventional practice during *boro* season. The influence of low temperature prolonged the tillering phase and considerably delayed flowering, ripening as well as harvesting, thereby exposing the crop to higher temperatures at flowering/grain filling and vulnerabilities of hailstorms at harvesting time along with the problems of post-harvest sprouting and seed dormancy under the conventional practice.

CONCLUSION

Using seed rate of 10 kg ha^{-1}, seed sprouting (after nutri-priming with Zn) in SSG, nursery sowing of sprouted seeds with polythene covering (either daily from 3 pm to 8 am or continuously for 24 h) in the middle of December, transplanting of 1-2 seedling(s) hill^{-1} at wider spacing and micronutrient management in main field proved to be a climate-resilient methodology.As a whole, it can be viewed as a Systemof Assured Rice Production (SARP) for efficient resource management and enhancedcrop productivity during *boro* season.

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SCREENING OF WATER USE EFFICIENT RICE VARIETIES FOR DRY DIRECT SEEDING IN EASTERN INDIA

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Water is the most important limiting factor in agriculture. Irrigation is critical to agricultural growth as it increases land use intensity and cropping intensity and allows farmersadopting modern production technologies (Vaidyanathan, 2013). Irrigated agriculture in about 48 per cent of net sown area contributes to 60 per cent of the India's food grain production. Progress of developing irrigation systems in India has been quite remarkable with an increase in irrigation potential from 22.6 M ha in 1950–1951 to about 123 M ha at present including 42 M ha under major and medium irrigation project, 14 and 67 M ha under minor surface and minor groundwater lift project. However, water available for irrigation is gradually and rapidly depleting due to fierce demand for water resources from urban and industrial sectors, and with increasing commercialization it seems that industry will receive priority over irrigation. Moreover, irrigated agriculture is facing a daunting task today to produce more crops per drop or more crops from fewer drops (Ministry of Water Resources, Govt. of India, 2017). The problems in irrigation sector in India include low irrigation efficiency (30 -35%), deteriorating physical structures, inadequate maintenance, low cost recovery, under-utilization (74%) of created potential, uncontrolled water delivery, tail-end water deprivation, seepage loss, siltation, water-logging, and soil salinity. Hence, sustainable use of irrigation water is needed in the context of currently shrinking water resources. Rice is a fundamental crop in the global stable food production and the main agricultural crop in India. Paddy water management influences rice yield and has a great effect on water resource availability. Water-saving management in rice has, therefore, been more and more recognized as an important issue, especially for agricultural sustainability and development (Bouman and Tuong, 2001). Conservation agriculture practices such as aerobic rice, SRI, direct seeded rice (DSR), zero tillage (ZT) system retain higher moisture content for longer time and are important for enhanced WUE. Exploiting the genetic potential for enhancing water productivity is very important. A number of rice varieties developed but information on efficient varieties is limited. Hence, selecting varieties that are suitable to their geographic situation appears to be a promising approach: further increases in water productivity with stability in crop performance are expected with the cultivation of improved genotypes from rice breeding.

METHODOLOGY

A pot experiment was carried out in the rainout shelter of ICAR - National Rice Research Institute, Cuttack, India to identify rice varieties with higher water productivity during the dry season 2018 - 19.The rainout shelter consisting of a sensor based automated steel frame covered with plastic sheet was used as the place of experiment for an accurate estimate of water productivity. The experiment consisted of the same 24 rice varieties used for field experimentation i.e. 12 stress tolerant/aerobic varieties *viz*. Dhalaheera, Vandana, Anjali, Sahabhagidhan, Satyabhama, Annada, Hazaridhan, CR Dhan 205, CR Dhan 202, CR Dhan 206, CR Dhan 200, CR Dhan 201 and 12 irrigated varieties Satabdi, DRR 44, Phalguni, Khitish, MTU 1010, Naveen, Abhishek, , CR Dhan 305, CR Dhan 310, Lalata, CR Dhan 304 and Khira in two moisture regime conditions i.e. Aerobic and Saturated with two replications. A field experiment was also carried out in the research farm in kharif season of the year 2019-20 to verify the water productivity. The soil was sandy clayey in texture having sand: silt:clay proportion of 66:10:24. Plastic pots of dimension 27 cm in height, 30 cm in upper diameter and 17.5 cm in lower diameter was used as an experimental unit and 13 kg of dry sieved soil was put in each pot. The soil was then irrigated to field capacity before planting. Prior to potting, the soils were mixed with a basal dressing of the following nutrients: uniform dose of 80: 40: 40 N, P_2O_5 and K_2O kg ha^{-1}. The pots were sown with three hills per pot and two seedlings per hill.

RESULTS

Grain yield of rice was higher in saturated compared to aerobic moisture regime by 23 %. The highest grain yield was recorded with CR Dhan 304 under both aerobic and saturated moisture regime which is significantly higher than rest of the irrigated and stress tolerant varieties.CR Dhan 202 and CR Dhan 205 produced higher grain yield among the stress tolerant varieties whereas CR Dhan 304 and CR Dhan 305 registered maximum yield among the irrigated rice varieties. The sterility percent was significantly higher for aerobic moisture regime but stress tolerant varieties Dhalaheera and Annada along with irrigated varieties MTU 1010 and Phalguni recorded lower sterility percentage. Aerobic water regime consumed 20 per cent less water than saturated water regime and the water productivity was significantly higher. Among the stress tolerant varieties, CR Dhan 202 and CR Dhan 205 recorded highest water productivity whereas in case of irrigated varieties MTU 1010 and CR Dhan 304 registered the same. However under field condition, CR Dhan 205 (Aerobic variety) recorded highest water productivity 0.51 kg/m^3 followed by Shabhagidhan and Satyabhama with 0.46 kg/m^3each among the stress tolerant varieties whereas higher water productivity in irrigated varieties was registered by CR Dhan 304 (0.42 kg/m^3followed by Khira(0.41) and MTU 1010. CR Dhan 304 and CR Dhan 202 were found to be superior to other irrigated and stress tolerant varieties with respect to GMP (ranged between 32.05 - 52.82 g per pot), HAR (ranged from 32.03–52.67 g per pot) and STI (ranged between 0.51- 1.40 g per pot) respectively. However, CR Dhan 201 registered the highest SSI with 1.76 followed by CR Dhan 206 (1.75) among the stress tolerant varieties and Khitish (1.69)

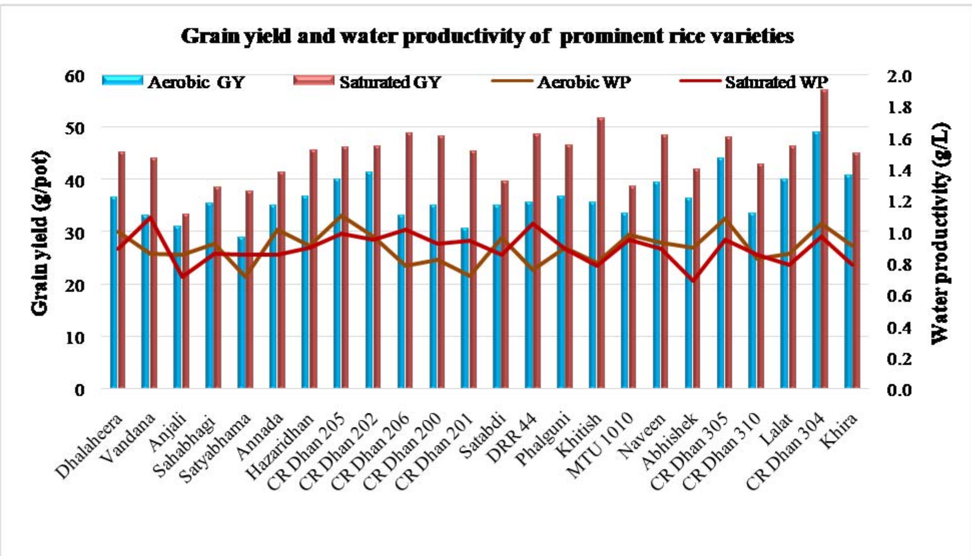

Fig.: Grain yield and water productivity of prominent rice varieties under pot experimentation

inirrigated varieties. Similarly, Khitish (16.10) and CR Dhan 206 (15.74) were found to have the highest TOL value among the irrigated and stress tolerant varieties respectively.

CONCLUSION

Short duration varieties with higher crop and water productivity may be used in rice cultivation for efficient utilization of water. The high yielding rice varieties i.e. CR Dhan 205 and CR Dhan 202 are recommended for moisture stress and CR Dhan 304 and CR Dhan 305 for irrigated condition for efficient utilization of water. Further, these varieties may be used by breeders for further increase in water productivity of high yielding mega rice varieties.

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MAGNESIUM ON PRODUCTIVITY AND NUTRIENT STATUS OF RICE IN KOLE LANDS (*ORYZA SATIVA* L.)

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Rice (Oryza sativa L.) is one of the most important staple food crop of India. Among the food grains, the demand for rice continues to grow and is projected to increase by more than 50 per cent over the next few decades. Nutrient deficiency is considered as one of the major causes of declining productivity in rice. Among the essential nutrients, Magnesium plays an important role in chlorophyll formation, photosynthesis and metabolic processes and reactions like photophosphorylation (ATP formation in chloroplasts), photosynthetic carbon dioxide (CO_2) fixation, protein synthesis etc. Consequently, many critical physiological and biochemical processes in plants are adversely affected by Mg deficiency, leading to impairments in quality, growth and yield. Many factors are responsible for increasing the yield and quality of cereals – proper and balanced fertilizer application being the most important one. Kole wetlands are low lying tracts located 0.5 to 1m below Mean Sea Level (MSL) and remain submerged for about six months in a year. It forms one of the rice granaries of Kerala, comprising of a unique rice eco system, meeting forty per cent of the rice requirement of Kerala. The data on soil analysis of kole lands for a decade revealed that there is wide spread deficiency of secondary nutrients especially Magnesium. With this background the present investigation was undertaken to study effect of different levels of magnesium sulphate on growth and yield enhancement in rice in kole lands.

MATERIALS AND METHODS

The experiment was conducted to study the effect of magnesium on yield and plant and soil nutrient status of rice crop in kole land during 2012-2014 and to determine optimum dose of Magnesium for maximum yield in rice.

The experiment was laid out in randomized block design and replicated thrice with six treatments of different levels of $MgSO_4$ viz.,

T_1 - 40 kg $MgSO_4$/ha

T_2 - 60 kg $MgSO_4$/ha

T_3 - 80 kg $MgSO_4$/ha

T_4 - 100 kg $MgSO_4$/ha

T_5 - 120 kg $MgSO_4$/ha

T_6 – control

The experiment was conducted in farmer's field of kole lands. Initial N, P, K and micro nutrients except Mg were applied as per soil test based recommendation along with all other operations as per Package of Practices (POP) of Kerala Agricultural University. Soil nutrient status was analyzed and experiment was conducted in that field which showed the deficiency of Mg in both the years. The experiment was repeated in the same season of next year.

RESULTS AND DISCUSSION

The data of Mg fertilization had significant effect on yield and yield attributes of rice. The pooled data on yield and yield contributing factors due to magnesium application revealed that the plot receiving magnesium sulphate at the rate of 100 kg/ha exhibited significantly higher number of tillers/hill (5.22), number of panicles/ m^2 (419.13) and number of grains/panicle (109.36). The application of 100 kg $MgSO_4$/ha also recorded significantly higher value compared to all other

Table: 1. Effect of levels of Mg on growth of rice

Treatments	Height (cm) 2012-13	Height (cm) 2013-14	Pooled(cm)	No. of tillers 2012-13	No. of tillers 2013-14	Pooled
T_{1}- 40 kg $MgSO_4$/ha	96.44	98.76	97.60	5.08	5.26	5.17
T_{2}- 60 kg $MgSO_4$/ha	97.33	100.80	99.06	4.55	5.01	5.13
T_{3}- 80 kg $MgSO_4$/ha	97.41	106.45	101.93	4.66	5.21	4.93
T_4-100 kg $MgSO_4$/ha	97.25	94.35	95.8	4.83	5.62	5.22
T_5- 120 kg $MgSO_4$/ha	97.50	99.90	98.7	4.91	5.23	5.07
T_6–Control	94.72	88.77	91.74	4.00	4.25	4.12
CD(0.05)	1.23	1.40	1.38	0.05	0.20	0.19

treatments with respect to thousand grain weight (28.78 g). The application of $MgSO_4$ was significant positive correlation with number of tillers/hill, no. of grains/ panicle and grain yield. Studies showed that the panicle number per square meter is the most important factor in increasing the grain yield of rice (Miller *et al*., 1991).

Yield attributing characters consequently yield of rice increased with increase in level and $MgSO_4$ and this might be due to the critical role of Mg in crop growth, with respect to photosynthesis, respiration and other biochemical and physiological activities.Straw yield also showed the same trend. No yield variation was noticed with the application of $MgSO_4$ beyond 100kg /ha.

The pooled data on the plant nutrient status after the harvest of the crop furnished that the application of magnesium sulphate had a positive relationship with the uptake of N, P, K, Ca, Mg, Fe, Mn and Zn by grain. The uptake of major and micro nutrients were enhanced with the application of magnesium sulphate @ 100 kg/ha. Correlation studies revealed that application of Mg was positively correlated with the uptake of nutrients by grain, which implies the importance of Mg nutrition for rice crop grown in kole lands. Grain yield also showed a significant positive relationship with nutrient uptake by plants at maturity across all treatments.

The effect of different levels of magnesium on soil nutrient status inferred that the highest available phosphorus content was observed with application of 120 kg $MgSO_4$/ha (T_5). Availability of P in the soil increased with increase in Mg application which may be due to the synergistic reaction of Mg with P up to certain level. The highest content of available Ca, Mg and Mn was recorded with lowest level of magnesium (T_1- 40 kg $MgSO_4$/ha). This may be due to the low uptake of manganese, magnesium and calcium by the plant. Increasing rate of Mg application had improved the uptake of nutrients by grain.

The correlation study of magnesium on plant and soil nutrient status revealed that magnesium application had a significant positive correlation with uptake of Ca and Zn and content of available P, Ca, S, Zn and B in soil.

CONCLUSION

The secondary nutrient (Magnesium) with recommended dose of N, P and K showed positive response to the availability of soil nutrients, plant nutrient content and yield and yield components in rice. The plant nutrient status after the harvest of the crop furnished that the application of magnesium sulphate had a positive relationship with the uptake of nutrients by grain. The content of major and micro nutrients was maximum with the application of magnesium sulphate

@ 100 kg/ha, resulting in higher number of tillers per hill, number of panicles per meter square, number of grains per panicle and grain yield. The study revealed that in magnesium deficient areas of kole lands, application of 100 Kg $MgSO_4$/ha was found to be optimum for correcting the deficiency in rice.

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EFFECT OF NITROGEN LEVELS ON GROWTH, YIELD ATTRIBUTES AND YIELD OF RICE VARIETY BPT 2782- BHAVATHI

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A field experiment was conducted during *kharif,* 2018 and 2019 at Agricultural Research Station, Bapatla to evaluate the effect of different nitrogen levels on growth, yield attributes and yield rice variety BPT 2782-Bhavathi. The experiment was laid out in a randomized block design with 7 treatments replicated thrice. Seven levels of nitrogen (80, 120, 160, 200, 240, 280 and 320 kg N ha^{-1}) were used as an experimental treatments. The results revealed that application of 200 kg N ha^{-1} recorded significantly the highest yield attributing characters like productive tillers plant^{-1}, panicle length, number of filled grains per panicle and grain yield (5925 and 5836 kg ha^{-1}) while lowest yield was recorded with 80 kg N ha^{-1} treatment. Highest net returns and benefit cost ratio was recorded with 200 kg N ha^{-1} during 2018 and 2019. It can be indicated that application of 200 kg N ha^{-1} is more economical to the BPT 2782 long duration variety in both the years of experimentation. A linear increase in grain yield was observed with continuous rate increase of nitrogen from 80 to 200 kg ha^{-1}.

INTRODUCTION

Rice (*Oryza sativa* L.) is the principal cereal crop of India and world. With ever increasing population, demand for rice will continue to increase. In this endeavour, in addition to high yielding rice varieties, efficient use of nutrients play an important role. Among the major plant nutrients, nitrogen is most important for augmenting rice yield. Rice is the major consumer of fertilizer nitrogen and accounts for one third of the total nitrogen consumption in the country. Nitrogen is essential nutrient element for rice growth and metabolic process (Noor, 2017). Application of optimum dose of nitrogen to rice is gaining importance because nitrogen is a key nutrient in crop production that it can never be ignored. Identification and use of high yielding potential cultivars, though ensures higher yields, the actual yield advantage depends on the agronomic management including that of nitrogen management. Yield potential of a cultivar could be exploited to a maximum extent by judicious management of applied nitrogen. Such information is lacking for the newly developed rice cultivars keeping these points in view; the present investigation was initiated to evaluate the efficiency of different nitrogen doses on rice growth and productivity of newly released rice variety

MATERIALS AND METHODS

A field experiment was conducted during *kharif,* 2018 and 2019 at Agricultural Research Station, Bapatla to evaluate the effect of different nitrogen levels on growth, yield attributes and yield rice variety BPT 2782-Bhavathi. The experiment was laid out in a randomized block design with 7 treatments replicated thrice. Seven levels of nitrogen (80, 120, 160, 200, 240, 280 and 320 kg N ha^{-1}) were used as an experimental treatments.

RESULT AND DISCUSSION

The results revealed that application of 200 kg N ha^{-1} recorded significantly the highest yield attributing characters like productive tillers plant^{-1}, panicle length, number of filled grains per panicle and grain yield (5925 and 5836kg ha^{-1}) while lowest yield (5067 and 5128 kg ha^{-1}) was recorded with 80 kg N ha^{-1} treatment. The increase in grain yield might be due to nitrogen

BPT 2782 field view

application enhancing the drymatter production, improving rice growth rate. Fertilizer application with optimum quantity had profound effect to increase the yield attributing characters which ultimately reflected on grain yield. These results are in confirmation with the findings of Ombir Singh *et al.* (2012) and Sunita Gaind and Lata Nain (2012). Highest net returns and benefit cost ratio was recorded with 200 kg N ha^{-1} during both the years 2018 and 2019. It can be indicated that application of 200 kg N ha^{-1} is more economical to the BPT 2782 long duration variety in both the years of experimentation. A linear increase in grain yield was observed with continuous rate increase of nitrogen from 80 to 200 kg ha^{-1}.

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DRUDGERY IN MANUAL BUND SHAPING FOR RICE FIELD

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Field preparation for paddy cultivation is one of the most important operations responsible for its high production. Along with puddling, field preparation also includes an operation called bund shaping which carries out at the beginning of every paddy season. During field survey, it was found that shaping of bund is carried out manually using spade in traditional way.A study (ESA 2018) shows that a significant amount of cost (Rs. 2063 per hectare) is involved in bund shaping. The cost is directly proportional to the number of plots in per hectare land. Bunds becomes distorted and undulated due to the growth of unwanted weeds, traffic of humans, animals and machinery and overflow of water over the bund over couple of days. These bunds need to be shaped into uniform sizes with desirable height and are well plastered with mud to eliminate any holes. Plastering of bunds also helps in reducing weed infestation.

The bund shaping operation remain unevaluated except Nag and Nag (2004) who reported that energy demand in bund trimming in wet and dryland condition is 19.6-35.5 kJ/min.In one more study (Nag et al., 1980) it was reported that wet and dryland condition of bund trimming requires 63.5 and 80.8%VO_{2max}based on a study on 13 subjects, respectively. Data indicated that bund shaping falls under extreme heavy work category but did not validate with the subjects of other region. Therefore, a study was taken in order to analyzethe physiological cost of manual bund shaping in paddy field in the state of Assam, India.

METHODOLOGY

Physiological cost

Under physiological, subjects were selected and measured their heart rate during manual bund shaping operations. Before it, selected subjects were calibrated in laboratory to known their maximum aerobic capacity as well as to established relation between heart rate and oxygen consumption. The established relation was used to get desired value of oxygen consumption during spading operation for bund shaping. This oxygen was sued to calculated energy expenditure of worker in the operation.

Selection of subjects

A total of 10 medically fit male subjects in the age group of 20-55 yearswere selected purposefully for the study from Lakhimpur district, Assam.All subjects were selected from one district for ease of access because work rate of subject among districts was observed non-significant. Subjects were selected randomly who were involved in bund shaping practice for paddy field.The demographicinformation like age (years), stature (cm), body weight (kg) and resting heart rate (beats/min) were recordedand given inTable 1.

Selected subjects were free from any muscular and cardio-vascular abnormalities and had at least 5 years of bund shaping activity experience. The subjectswere made acquainted with experimental protocol to enlist their full cooperation throughout the experiment.

Table 1: Physical characteristics of the selected subjects

Subject	Age, years	Weight, kg	Stature, cm	BMI	BSA,m^2	Experience, years	Resting Heart Beat (beats/min)
S1	36	57	162	21.7	1.6	20	87
S2	42	58	168	20.5	1.6	27	82
S3	40	53	170	18.3	1.6	25	74
S4	36	65	164	24.2	1.7	16	71
S5	43	66	161	25.5	1.7	22	84
S6	48	50	155	20.8	1.5	26	66
S7	39	62	168	22.0	1.7	12	76
S8	46	48	156	19.7	1.4	21	63
S9	37	56	165	20.6	1.6	11	69
S10	50	52	166	18.9	1.5	18	67
Mean	41.7	56.7	163.5	21.2	1.6	19.8	73.9
SD	4.75	5.84	4.78	2.2	0.1	5.28	7.77

Calibration of subject

Calibration of subject is a process of measuring heart rate and oxygen consumption of a subject to establish a heart rate-VO2 relationship for the subject. The selected subjects were calibrated under controlled environmental conditions. The subjects were given ample time to familiarize with the treadmill and the instruments used in the experiment. The exercise was performed on a motor driven Track master TMX425 treadmill. Before using the K4b2 (COSMED), the system was warmed up to for at least 45 minutes (as required). The portable unit was calibrated for delay, turbine and gas before calibrating a subject. For gas calibration, the cylinder having a composition of 4.95% of carbon dioxide (CO_2), 16.05% of oxygen (O_2) and rest nitrogen was used. The results of calibration should be within the acceptable range.

The sub-maximal test was performed to determine the maximum aerobic capacity of the selected subjects following Naughton protocol (Naughton et al. 1963). Each subject was allowed to walk on the treadmill and incremental load (in term of speed and inclination) was given at an interval of 3 minutes . The experiment was continued till the heart rate reached 75% of maximum heart rate which was calculated using Robergs and Landwehr (2002) equation i.e. HR_{max}=205.8-0.685*Age. The HR and VO_2 were recorded and a regression equation was developed. The developed regression equation is known as calibration curve which was used to estimate the VO_2 with reference to measured HR in the field. Further, the calibration curve was extrapolated till the maximum HR. The extrapolated VO_2 corresponding to HR_{max} was considered as VO_{2max}. A sample extrapolated curve between HR and VO_2 for calculating VO_{2max} is shown in Fig. 2.

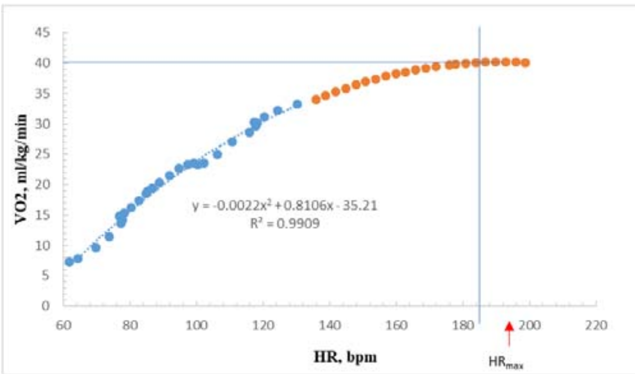

Fig. 2: A sample curve plotted between HR and VO_2 for sub-maximal exercise

The average HR_{max} and VO_{2max} were found to be 177.2 bpm and 35.99 ml/kg/min, respectively

Measurement of HR in field

The heart rate of the selected subject was recorded by polar heart rate monitor (RS 400) with wrist band. The heart rate was measured during manual bund shaping in the field . The data were taken for 30 minutes and during this period length of bund shaped was also recorded. Prior to experiment a rest of 5-10 min was given to bring the heart rate to normal range. After the experiment, a rest was given until the heart rate reached to the normal value. From the recorded average working heart rate, the volume of oxygen consumption was estimated using the calibration curve. Further, the energy consumption during manual bund shaping was calculated using Eq. 3.1.

EER = (O_2 consumption in litres x 4.8)kcal/ min.......... (3.1)

RESULTS AND DISCUSSION

It was found thatthe average resting and working HR during bund shaping process were found 74 and 133 bpm respectively. Further, the corresponding value of VO_2 and EER during manual bund shaping was calculated as 27.29 ml/kg/min and 7.37 kcal/min, respectively.The percentage of VO_{2max} consumed by the labour during manual bund shaping was 76.69% which is considered as very high. The average energy required (ER_M) for bund shaping was found 4.33 kcal per meter of bund. The average working HR of subjects S10 and S2 is quite higher than other subjects which may be because of fast pace of operation. The average energy per hectare required (ER_H) in bund shaping was found to be 77704.66kcal/ ha.

CONCLUSIONS

Physiological study indicated that bund shaping operation demands 77 percent of worker's maximum aerobic capacity and hence this operation falls under severe work load. The overall study concludes that bund shaping is expansive as well as drudgerious which demands for mechanization.

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EFFECT OF SEQUENTIAL APPLICATION OF HERBICIDES ON TOTAL DENSITY OF WEEDS IN DIRECT SOWN RICE

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Rice (*Oryza sativa* L.) is the most important staple food for more than half of the world's population, including regions of high population density and rapid growth. India has the largest area among rice growing countries and stands second in production. Critical period of crop-weed competition in rice ranges between 5 to 6 weeks. Herbicide based weed management is becoming the popular method of weed control in rice, because of lower costs involved (Singh *et al.*, 2012). But, weed shift from grasses to non-grasses and annual sedges is being observed in rice field due to continuous use of high dose of herbicides like butachlor, pretilachlor, etc. These herbicides provide effective control of annual grasses when applied as pre-emergence, rendering an effective control during the first 20 to 25 days there after the weed emerging at later stages of crop growth becomes uncontrollable results in considerable loss of crop yield besides adding weed seeds to the seed bank of the soil. Keeping in view of the above facts a field experiment is proposed to evaluate the performance of sequential application of herbicides on weed dynamics in direct sown rice

MATERIALS AND METHODS

The study was conducted at Agricultural College Farm, Bapatla, Guntur, Andhra Pradesh. The experiment was conducted during *Kharif* 2015 and 2016 and laid out in randomized complete block design with three replications and fourteen treatments. Pre emergence herbicides (Pyrazosulfuron ethyl and oxadiargyl) were applied uniformly at 3 DAS by using knapsack sprayer mixed in water @ 500 l ha^{-1}. Bensulfuron methyl + pretilachlor with safener applied uniformly at 3 days after sowing (DAS) by mixing the herbicide with dry sand at 50 kg ha^{-1} and broadcasted uniformly under thin film of water. The post-emergence herbicide *i.e.* azimsulfuron, bispyribac-sodium were applied at 25 DAS, and metsulfuron methyl + chlorimuron ethyl was applied at 45 DAS by using knapsack sprayer mixed in water @ 500 l ha^{-1}. The data were analyzed by using standard statistical procedures and comparisons were made at 5% level of significance (Gomez and Gomez 1984).

RESULTS

At 30 DAS, among the sequential application of herbicides the lowest total density of weeds was observed with treatment T_9 (pre emergence application of bensulfuron methyl @ 60 g a.i. ha^{-1} + pretilachlor with safener at 500 g a.i. ha^{-1} *fb* post emergence application of azimsulfuron @ 20 g a.i. ha^{-1}at 25 DAS*fb*post emergence application of metsulfuron methyl and chlorimuron ethyl @ 4 g a.i. ha^{-1}applied at 45 DAS) which was, however on a par with treatment T_3 (pre emergence application of bensulfuron methyl @ 60 g a.i. ha^{-1} + pretilachlor with safener at 500 g a.i. ha^{-1} *fb* post emergence application of azimsulfuron @ 20 g a.i. ha^{-1}at 25 DAS), treatment T_{10} (pre emergence application of bensulfuron methyl @ 60 g a.i. ha^{-1} + pretilachlor with safener at 500 g a.i. ha^{-1} *fb* post emergence application of bispyribac-sodium @ 25 g a.i. ha^{-1} at 25 DAS*fb*post emergence application of metsulfuron methyl and chlorimuron ethyl @ 4 g a.i. ha^{-1}applied at 45 DAS) and T_4 (pre emergence application of bensulfuron methyl @ 60 g a.i. ha^{-1} + pretilachlor with safener at 500 g a.i. ha^{-1} *fb* post

Table 1. Density of total weeds (No. m^{-2}) at different growth stages of direct seeded rice as influenced by weed management practices during *kharif* 2015-16 and 2016-17

Treatments	Dose(g ha^{-1})	Time(DAS)	30DAS		60DAS		At harvest	
			2015	2016	2015	2016	2015	2016
Pyrazosulfuron ethyl *fb* Azimsulfuron	25 *fb* 20	Pre *fb* Post	6.3 (39.7)	6.0 (36.0)	10.2 (103.3)	10.2 (104.7)	8.1 (65.3)	8.5 (72.0)
Pyrazosulfuron ethyl *fb*Bispyribac-sodium	25 *fb* 25	Pre *fb* Post	6.4 (40.7)	6.4 (40.3)	10.2 (103.3)	9.9 (97.7)	8.4 (70.3)	8.4 (70.3)
Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron	60 + 500 *fb* 20	Pre *fb* Post	4.8 (22.3)	5.0 (24.3)	8.8 (76.3)	8.9 (79.3)	6.5 (42.3)	6.9 (46.7)
Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium	60 + 500 *fb* 25	Pre *fb* Post	4.8 (22.3)	5.1 (25.7)	8.7 (75.7)	9.0 (80.0)	7.0 (48.0)	6.7 (44.0)
Oxadiargyl *fb* Azimsulfuron	75 *fb* 20	Pre *fb* Post	6.2 (38.7)	6.2 (38.0)	10.5 (109.3)	10.3 (106.0)	8.6 (74.0)	8.7 (76.0)
Oxadiargyl *fb* Bispyribac-sodium	75 *fb* 25	Pre *fb* Post	6.5 (42.0)	6.2 (37.7)	10.9 (117.7)	10.8 (116.3)	9.0 (81.3)	9.1 (81.7)
Pyrazosulfuron ethyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	5.9 (34.7)	6.2 (38.3)	7.3 (52.7)	7.6 (57.7)	6.1 (37.3)	6.0 (35.0)
Pyrazosulfuron ethyl *fb*Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	25 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	6.1 (37.3)	6.3 (39.7)	7.5 (55.7)	7.7 (58.3)	6.4 (40.0)	6.3 (38.7)
Bensulfuron methyl + Pretilachlor with safener *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	4.4 (19.0)	4.8 (23.7)	5.8 (33.0)	6.6 (43.3)	4.7 (21.3)	4.4 (19.0)
Bensulfuron methyl + Pretilachlor with safener *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	60 + 500 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	5.1 (26.3)	5.5 (29.3)	6.4 (40.7)	6.8 (45.7)	5.4 (28.3)	5.5 (29.3)
Oxadiargyl *fb* Azimsulfuron *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 20 *fb* 4	Pre *fb* Post *fb* Post	6.2 (37.7)	6.1 (37.3)	7.6 (57.3)	7.5 (56.3)	6.1 (36.7)	6.6 (43.3)
Oxadiargyl *fb* Bispyribac-sodium *fb* Metsulfuron methyl + Chlorimuron ethyl	75 *fb* 25 *fb* 4	Pre *fb* Post *fb* Post	6.5 (42.3)	6.6 (42.7)	7.8 (60.3)	7.7 (59.0)	6.4 (40.3)	6.4 (41.0)
Weed free	-	-	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)
Weedy check	-	-	10.8 (117.3)	11.2 (124.3)	13.5 (182.0)	13.2 (173.0)	10.7 (114.3)	11.3 (127.7)
SEm+	-	-	0.3	0.3	0.3	0.2	0.2	0.2
CD (P = 0.05)	-	-	0.8	0.8	0.9	0.7	0.5	0.6

Note: Data transformed to “x+0.5 transformations. Figures in parenthesis are original values

emergence application of bispyribac-sodium @ 25 g a.i. ha^{-1} at 25 DAS).Weedy check (T_{14}) recorded significantly the highest total weed density over other treatments. At 60 DAS, significantly the lowest total density of weeds was recorded with the treatment T_9, which was however, on a par with T_{10}.A similar trend of treatmental behavior was observed at harvest as well (Ajay Singh *et al.*2017).

Analysis of the data revealed that none of the herbicidal treatments could reach to the level of weed free (T_{13}) condition, which significantly recorded the lowest weed density over rest of the treatments at all stages of observation during both the years of study. The lowest number of weeds recorded in herbicidal treatment T_9 followed by T_{10} and T_7 treatments may be due to application of broad spectrum herbicides combination, which might have controlled most of the weeds effectively. This might be attributed to rapid absorption of the chemicals by roots coupled with prevention of cell division and further inhibition of protein synthesis as well as synthesis of long chain fatty acid activity.

CONCLUSION

In conclusion, the study has revealed that pre emergence application of bensulfuron methyl @ 60 g a.i. ha^{-1} + pretilachlor with safener @ 500 g a.i. ha^{-1} *fb* post emergence application of azimsulfuron @ 20 g a.i. ha^{-1}at 25 DAS*fb*post emergence application of metasulfuron methyl and chlorimuron ethyl @ 4 g a.i. ha^{-1}applied at 45 DAS (T_9) was found to be most effective in managing weeds in direct sown rice

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DIRECT SEEDED RICE- A RESOURCE CONSERVATION TECHNOLOGY FOR SUSTAINABLE RICE CULTIVATION

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Rice (*Oryza sativa* L.) is a principal source of food for more than half of the world's population. Conventional method of rice cultivation especially transplanting is not only intensive water user but also cumbersome and laborious. Different problems like looming water crisis, lowering of water table, scarcity of labour during peak periods and deteriorating soil health, demands an alternative crop establishment method to sustain productivity of rice as well as natural resources (Kaur and Singh, 2017). Direct seeded rice (DSR) is the only viable option to reduce the unproductive water flows. It offers certain advantages viz., saves labour, requires less water, less drudgery, early crop maturity, low production cost, less methane emission, better soil physical conditions for following crops and better option to fit in different cropping systems. There are several constraints associated with a shift from puddled transplanted rice to direct seeded rice, such as high weed infestation, evolution of weedy rice, increase in soil borne pathogens (nematodes), nutrient disorders, poor crop establishment, lodging, incidence of blast, brown leaf spot etc. By overcoming these constraints direct seeded rice can prove to be a very promising, technically and economically feasible alternative technology to puddled transplanted rice. Effective weed management practices are an important prerequisite in DSR culture, with herbicide application seemingly indispensable. Sustainable rice production by direct seeding therefore will critically depend on ensuring that on farm weed management technologies are implemented without the usage of water for weed suppression. Alternate wetting and drying by controlled irrigation has water saving potential yet at the same time, this procedure will have considerable impact on the germination and establishment of weeds.

Compared with conventional puddled transplanted rice, direct seeded rice is a labor-saving technology. The total labour used was 37 % higher in conventionally planted rice as compared to DSR, which was mainly because of transplanting operation. In addition to labor savings, the spread-out labor requirement helps in making full use of family labor, and having less dependence on hired labor.

Flooded rice culture with puddling and transplanting is considered one of the major sources of CH_4 emissions (Farooq *et al*., 2011). The reduction in CH_4 emissions ranged from 30 to 58% in dry-DSR compared with puddled transplanted rice. Comparative yields in DSR can be obtained by adopting various cultural practices viz., selection of suitable cultivars, proper sowing time, optimum seed rate, proper weed and water management.

IRC/TM-2/PP-117

BROWN MANURING- SUSTAINABLE WEED MANAGEMENTPRACTICE IN DIRECT SEEDED RICE

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Rice production systems are undergoing various types of changes and one such change is shift from transplanting to direct seeding. In direct seeded rice crop oftenfaces greater weed competition limiting the yield. The effective weed management is a major challenge for adopting direct seeded rice because of weed flora shift towards more competitive grasses and sedges. These diverse weed populations compete with rice and cause severe yield losses ranging from 12 to 90%. At present, brown manuring technique is gaining popularity in rice ecosystems.

METHODOLOGY

Brown manuring is a ‘no-till’ version ofgreen manuring, using an herbicide to desiccate thecrop before flowering. Direct seeded rice can be intercropped with legumes, such as *Crotalaria juncea*, *Vigna sinensis*, *Glycine max* and *Sesbania rostrata*(more suitable). Brown manuring is a practice of seeding sesbania@ 20 kgha^{-1}with rice and applying 2, 4-D @ 400–500 g ha^{-1} to knockdown the sesbania *at* 30 days after seeding. The post emergence herbicidal spray on green manure leaves results in loss of chlorophyll in leaves leading to browning and hence the same is referred brown manuring.

RESULTS

Brown manuring reducesweed pressureby smothering effect at the initial growth stage later on by shade effect and further sprayed herbicide will reduce weed growth. It alsoadds organic matter content and improves thesoil properties. Fallen sesbania leaves on the ground act as mulch and helps in conserving moisture by adding about 15 kg N ha^{-1} without adding much on cost of production.

CONCLUSION

Brown manuring results in higher grain yield with reduced weed densities by about 40-50 per cent

Fig. Stature of Sesbania and Rice crop after spraying of herbicide

Table. Effect of brown manuring on different parameters in direct seeded rice

Parameter	Impact of brown manuring	References
Weed growth	Weed infestation by 30%	Singh *et.al* (2003)
Growth and yield	Increase in plant height (1.57%),Effective tiller number (9.09%), organic carbon content (13.04%) and grain yield (7.91%) with brown manuring + 75 % fertilizer application	Sarangi*et .al* (2016)
Soil Properties	Adding about 15 kg N ha-1 along with smothering of weeds and conserving moisture.	Gaire, *et .al* (2013)
Fertilizer requirement	Nitrogenous fertilizer can be reduced up to 25 percent per cent	Sarangi*et. al* (2016)

and cost effective technology that cuts down expenses on labour, fertilizer and other inputs. Hence, brown manuring could be a viable weed management strategy in direct seeded rice conditions.

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IRC/TM-2/PP-118

METHANE EMISSION AND ITS MITIGATION IN INDIAN RICE FIELDS

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Rice is the staple diet of a large proportion of the world's population. In flooded paddy fields, where rice is grown, methane is generated by the anaerobic decomposition of organic matter in the soil. It reaches the atmosphere mainly through the rice plant's vascular system, although some does escape directly through the water column. Emission rates depend on climate, soil characteristics, the rice strain being grown and on agricultural practices such as the use of organic sources for the nutrients and the number of crops grown per year. The rice cultivation ecosystems have been classified into two categories namely, lowland and upland. The upland area is 15 % (6.35 Mha) of the total rice area and lowland area has been further categorized into rainfed and irrigated which are 32% (13.54 Mha) and 53% (22.43 Mha) respectively of the total harvested area. Further sub-classification of lowland into rainfed, irrigated and deep water areas have been done, according to the area statistics provided by IRRI. Rainfed lowland, including deep water, is a substantial portion (32%) of the rice growing area in India, where often erratic rainfall leads to drought conditions, and incessant rains create flood prone conditions. Methane emission from paddy cultivation is one of the major anthropogenic activities releasing methane into the atmosphere. Various parameters like water management, cultivars, nature of fertilizer, soil temperature and texture have been investigated and found to change the emission by a few times to orders of magnitude. When considering ways to reduce methane emissions from rice, it is essential that rice yields are maintained. The traditional nature of rice growing means that there is substantial resistance to changes in agricultural practices and even to the introduction of new cultivars. Other than emissions, agriculture also provides effective sink. Estimates indicate that soils take up about 10-20% of methane emissions globally. Well aerated paddy soils also act as a sink. The most effective sinks are in non-agricultural soils. Cultivated and fertilized soils take up less methane than less intensively managed soils. Therefore, increasing the methane sinks can also be potential mitigation options. Emissions could also be reduced by substituting inorganic fertilizers for the organic fertilizers often used. Finally, changes in water management practices could be effective. Methane production occurs only during periods of prolonged flooding, when anaerobic conditions develop in the soil. When water is drained from paddy fields during the growing season, or between crops, methane emissions decline. Shortening the proportion of time for which fields are flooded may, therefore, reduce methane emissions, *i.e.,* undertaking multiple aeration technique. Intermittent irrigation, in which the land is irrigated to give shallow flooding every 3-5 days, have shown to reduce methane emissions by up to 50 %. The mitigation options of methane from rice cultivation are a win-win situation, though emissions from rice cultivation are due to inefficient and, sometimes, unsustainable farming, leading to losses to farmers. Therefore, there is room for significant reduction of methane in all the options discussed so far.

IRC/TM-2/PP-119

BIO-EFFICACY OF PROPANIL 80 DF IN CONTROLLING COMPLEX WEED FLORA AND ENHANCING YIELD OF DIRECT SEEDED RICE

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A field experiment entitled "Bio-efficacy of Propanil 80 DF in controlling complex weed flora and enhancing yield of direct seeded rice" was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, OUAT, Bhubaneswar, during *kharif*, 2015 and *kharif*, 2016 consisting of eight treatments viz. Propanil 80DF @ 1.25 kg ha^{-1}as post-emergence, Propanil 80DF @ 2.5 kg ha^{-1}as post-emergence,Propanil 80DF @ 3.75 kg ha^{-1}as post-emergence, Propanil 80DF @ 5.0 kg ha^{-1}as post-emergence,Oxyfluorfen 23.5EC @1 kg ha^{-1}as pre-emergence, Cyhalofop butyl 10EC as post-emergence, hand weeding and weed check, which was laid out in randomized block design with three replications and with test crop rice cv. Naveen, sown under direct seeded condition. The soil of the experimental site was clay loam in textre with normal pH and medium fertility status with moderate water holding capacity.

The result of the experiment revealed that highest WCE of 91.8% & 87.7% at 45 DAS and 81.0% & 81.5% at 75 DAS in hand weeding twice treatment during *kharif*, 2015 and *kharif*, 2016 respectively. Among herbicide treatments, Propanil 80DF @ 5.0 kg ha^{-1}as post-emergence recorded highest WCE of 91.7% & 84.2% at 45 DAS and 77.6% & 78.5% at 75 DAS in both the seasons respectively, which was followed by the application of Propanil 80DF @ 3.75 kg ha^{-1}as post-emergence and Propanil 80DF @ 2.5 kg ha^{-1}as post-emergence.

All the weed management treatments gave significantly higher grain yield of rice over weedy check. The highest grain yield was recorded with hand weeding twice, with values of 41.1 kg ha^{-1} and 40.8 kg ha^{-1} during *kharif*, 2015 and *kharif*, 2016 respectively, which was found at par with Propanil 80DF @ 5.0, 3.75 and 2.5 kg ha^{-1}as post-emergence (Table-1).

On the basis of two years field study, Propanil 80DF @ 2.5 kg ha^{-1}as post-emergence can be used effectively for effective management of grassy, sedge and broad leaved weeds in direct seeded rice.

Table 1. Effect of treatments on weed control efficiency and grain yield of direct seeded rice.

Treatments	Dose(g or ml/ha)	Weed dry weight g/m^2 at 75 DAT					
		WCE (%)				Grain yield (q ha^{-1})	
		2015		2016		2015	2016
		45 DAS	75 DAS	45 DAS	75 DAS		
Propanil 80% DF	1250	62.2	57.1	65.6	63.6	36.5	35.8
Propanil 80% DF	2500	83.7	73.0	80.9	71.9	39.4	39.3
Propanil 80% DF	3750	88.9	77.6	81.8	78.4	40.4	40.2
Propanil 80% DF	5000	91.7	79.4	84.2	81.7	41.0	40.8
Oxyfluorfen 23.5% EC	1000	63.0	71.1	61.6	61.4	36.6	35.4
Cyhalofop butyl 10% EC	800	51.7	51.9	51.0	56.7	34.4	33.8
Hand weeding twice	-	91.8	81.0	87.7	81.5	41.1	40.8
Weedy check	-	0.0	0.0	0.0	0.0	31.3	32.6
CD (P=0.05)	-	-	-	-	-	1.9	1.7

PRODUCTIVITY, PROFITABILITY AND EFFICIENCY OF WEED MANAGEMENT PRACTICES IN TRANSPLANTED *KHARIF* PADDY

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Rice (*Oryza sativa* Linn.) is the principal food for more than 50% people and contributes about one-fifth to the total calory consumption of the world (Singh *et al*., 2012). Globally, rice crop occupies 158 million ha (m ha) of the arable land. The global production and productivity of rice is 744.9 million tons (m t) and 4.71 t ha^{-1}, respectively (FAO, 2014). Asia alone accounts for over 90% of the global rice production and consumption. To meet the food and nutritional requirements in these densely populated and rice dominated region, the projected demand for rice by 2030 has been estimated at 904 m t for the world and 824 m t for Asian region (Kubo and Purevdorj, 2004). India alone would require about 156 m t of rice by the year 2030 (ICAR, 2010) at an annual increment of 3 m t in the current rice production (Das *et al*., 2016). Rice is grown under different ecological conditions. Losses due to weeds are foremost important in rice production systems that interfere with all the activities involved in the field throughout the crop growing period. There is a need to reduce the weed competition in transplanted rice starting from crop emergence up to harvest and to develop a cost-effective weed control technique. A significant shift in the crop weed competition is envisaged with the change in rice cultivation practices. In transplanted rice, about 60 % of the weeds emerge in the period between one week and one month after transplanting. These emerging weeds are competing with rice during effective tillering stage and decline the quantity of panicles leading to reduction in grain yield (Soe Thura, 2010).

In most of the rice growing areas, where one rice crop is being grown per year and rest of the period, the fields are left as fallow where weeds grow enormously during off season and poses serious threat in reducing the yield. Rainfall during nursery period causes more weeds infestation and multiplication. Manual and mechanical weeding are although effective but expensive, time consuming and cumbersome. Weed management through herbicide has been gaining popularity in the recent past for many reasons. Chemical weed control is labour saving, more effective and economical. Furthermore, proper dose and time of application is critical in effective weed control and for raising healthy crop. Lower dose of herbicide may not control all weeds effectively while higher dose may result in phytotoxicity. Improper use of herbicides will have serious environmental and economic consequences. Although herbicides are much safer than other pesticides, their judicious use is very vital to the safety of the user and environment. However, more systematic research for identifying most critical crop-weed competition period, and developing the scale-neutral ecological approaches of weed control across the locations and across the environment, is highly needed to validate and demonstrate the potentials of these approaches in suppressing the weeds to impart sustainability to global rice production systems. In the view of the facts stated, an attempt had been made to assess the productivity, profitability and efficiency of weed management practices in transplanted *kharif* paddy.

METHODOLOGY

A field experiment entitled "Productivity, profitability and efficiency of weed management practices in transplanted *kharif* paddy" was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, OUAT, Bhubaneswar consisting of eight treatments viz. weedy check, weed free, pretilachlor @ 0.5 kg ha^{-1} (pre-emergence), pretilachlor

@ 0.5 kg ha^{-1} (pre-emergence) + hand weeding at 21 DAT, pretilachlor @ 0.5 kg ha^{-1} (pre-emergence) + mechanical weeding at 21 DAT, pretilachlor @ 0.5 kg ha^{-1} (pre-emergence) + pyrazosulfuron ethyl 10% WP @ 0.02 kg ha^{-1} as post-emergence at 10 DAT, pretilachlor @ 0.5 kg ha^{-1} (pre emergence) followed by bispyribac-sodium @ 0.025 kg ha^{-1} as post emergence at 21 DAT, pretilachlor @ 0.5 kg ha^{-1} followed by chlorimuron ethyl + metsulfuron methyl (Almix) @ 0.004 kg ha^{-1} at 21 DAT which was laid out in randomized block design with three replications and with test crop rice cv. Maudamani. The soil of the experimental site was loamy sand with pH 4.62, medium in organic carbon (0.53%), low in available nitrogen (188.1 kg ha^{-1}), high in available phosphorus (47.8 kg ha^{-1}) and medium in potassium (143.28 kg ha^{-1}).

RESULTS

The result of the experiment revealed the lowest total weed population and weed dry weight in weed free treatment. Among the weed management treatments, application of pretilachlor @ 0.5 kg ha^{-1} followed by chlorimuron ethyl + metsulfuron methyl (Almix) @ 0.004 kg ha^{-1} recorded the lowest weed population and weed dry weight. The highest WCE recorded at 60 and 90 DAT were 99.29% and 99.55%, respectively in weed free treatment. The tallest plants (106.6 cm), the maximum number of tillers hill^{-1} (10.3), and dry matter production (1207.4 g m^{-2}) at harvest, the highest LAI (4.15) at 60 DAT, and the maximum crop growth rate (24.9 g m^{-2} day^{-1}) during 30-60 DAT were recorded. The effective tiller count (365 m^{-2}), panicle length (25.1 cm), fertile grains panicle^{-1} (134), 1000' grain weight (25.4 g), grain yield (5.83 t ha^{-1}), straw yield (6.73 t ha^{-1}) and harvest index (46.4%) were the maximum in weed free treatment.

Among the weed management treatments, application of pretilachlor @ 0.5 kg ha^{-1} followed by chlorimuron ethyl + metsulfuron methyl (Almix) @ 0.004 kg ha^{-1} recorded the tallest plant (106.3 cm), tillers hill^{-1} (10.2) and dry matter production (1196.2 g m^{-2}) at harvest, LAI (4.02) at 60 DAT, and crop growth rate (24.5 g m^{-2} day^{-1}) during 30-60 DAT. The number of effective tillers (332 m^{-2}), panicle length (25.0 cm), number of fertile grains panicle^{-1} (130), 1000' grain weight (25.1 g), grain yield (5.39 t ha^{-1}), straw yield (6.53 t ha^{-1}) and harvest index (45.2%) were the maximum.

The maximum uptake of nutrient in grain (67.0 kg N, 18.0 kg P and 22.6 kg K ha^{-1}) and straw (39.0 kg N, 5.7 kg P and 115.7 kg K ha^{-1}) was recorded in weed free treatment followed by application of pretilachlor @ 0.5 kg ha^{-1} and chlorimuron ethyl + metsulfuron methyl (Almix) @ 0.004 kg ha^{-1} (61.4.0 kg N, 116.6 kg P and 20.8 kg K ha^{-1} in grain and 35.9 kg N, 5.4 kg P and 111.0 kg K ha^{-1} in straw, respectively). The maximum cost of cultivation (₹ 61,000 ha^{-1}) and gross return (₹ 1,08,781 ha^{-1}) were recorded in weed free treatment and application of pretilachlor @ 0.5 kg ha^{-1} + chlorimuron ethyl + metsulfuron methyl (Almix) @ 0.004 kg ha^{-1} at 21 DAT resulted in the maximum net return (₹ 54,055 ha^{-1}) and benefit- cost ratio (2.15).

CONCLUSION

Hence, application of pretilachlor @ 0.5 kg ha^{-1} followed by chlorimuron ethyl + metsulfuron methyl (Almix) @ 0.004 kg ha^{-1} at 21 DAT can effectively control weeds and hence may be recommended for getting the maximum productivity and profitability in transplanted *kharif* paddy.

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IRC/TM-2/PP-121

ENUMERATION AND CHARACTERIZATION OF PUTATIVE ENDOPHYTIC POPULATION IN SIXTEEN DIFFERENT CULTIVARS OF RICE

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Putative endophytic bacteria were isolated from the surface sterilized root,stem , leaves and pregerminated seeds of 16 cultivated rice seedlings grown from surface sterilized seed in nitrogen free sand on NFb , King's B and YEM media. The putative endophytic population varied from 1.00 x 10^3 to 1.55 x 10^7 cfu g^{-1} of fresh tissues. Seventy two isolates were selected based on the colony morphotypes. Based on the morphological, biochemical and microscopic analysis, the isolates were tentatively identified as species of *Serratia, Enterobacter, Klebsiella, Escherichia, Rhizobium, Pseudomonas, Azospirillum, Bacillus and Paenibacillus.*

Keywords:*Endophytic,cultivated rice seedlings,morphotypes,Serratia ,Paenibacillus*

METHODOLOGY

The method of isolation of endophytes from the root aswellas shoots of rice as described by Malarvizhi (1995) and Barraquio *et al.* (1997) were adopted.

The rice tissue was collected at the heading stage (milky to maturity as follows. Plants were carefully removed from the field washed to remove all soil and separated into stems and roots. The outer layer of the stem was removed and the inner layer (cortex) of the stem were washed with tap water and deionized water, cut into sections of 2-3 cm length and dried on absorbent towels. Roots were cleaned thoroughly with deionized water and dried on absorbent towels.

Surfac sterilization Technique : Ten grams of plant tissues (root and shoot tissues) was shaken for thirty minutes in a 500 ml Erlenmeyer flask containing 250 ml sterile deionoinzed water and 25 grams of glass beads and it was surface sterilized using 0.1% $HgCl_2$ (30 seconds for roots , 60 sceonds for stems).The washed 6 times repeatedly, cut into smaller pieces and homogenized in a pestle and mortar in laminar hood. Serial dilution of homogenized tissues was prepared (10^{-4}, 10^{-5} , 10^{-6}).Then the homogenized suspension were poure into the plates containing bacterial growth mediaviz., Nfb(Dobereiner, 1980), Congored Yeast extract mannitol agar (YEM) (Vincent ,1970) and King's B medium (King et al., 1954)

Biochemical characterization of the isolates such as morphological test, gram staining, colony characters, spore formation test, cellular morphology and position of spore, motility test,MRVP test.catalase test, citrate utilization test, Indole production test, starch hydrolysis, Urease test, Oxidation fermentation test, Phenylalanine deaminase testsubsurface pellicle formation test, Kovacs oxidase test, gelatin liquefaction test, Nitrate reduction test, Caesin hydrolysis, Lysozyme resistance test, utilization of different carbon sources, growth at 45˚˚C temperature and growth in NaCl

RESULT AND DISCUSSION

The putative endophytic population varied from 1.00 x 10^3 to 1.55 x 10^7 cfu g^{-1} of fresh tissues. Seventy two isolates were selected based on the colony morphotypes. Barraquio *et al.*(1997) reported that isolation of endophytes from the roots and culm of 25 highly diverse genotypes and their wild relatives wer found to have a putative endophytic population ranging from10^5 to 10^8 and 10^4 to 10^9 (MPN) g^{-1} dry weight respectively. In the present study, preliminary screening on the occurrence of endophytes in the roots, shoots and leaves of 16 highly diverse rice genotypes maintained at a Paddy Breeding station,TNAU revealed the presence of putative endophytic population ranging from1.00 x 10^3 to 1.45x10^7, 1.00 x10^3 to 9.10x 10^5 in root, shoot and leaves respectively.

In as much as there is no report on the isolation of endophytes from rice in India. The results presented here and those described by Barraquio *et al*. (1997) indicate that a large diversity of apparently diazotrophic and non diazotrphic endophytic bacteria can be isolated from rice tissues, some of which are capable of recolonizing their host when reinoculated onto sterile seedlings (Stoltzfus *et al.,* 1997).

Chaintreuil *et al*. (2000) revealed the presence of 5x10^6 endophytic rhizobia per gram of surface sterilized rice roots of African wild rice Oryza breviligulata. The highest population of putative endophytes was obtained in King's 'B' medium (1.00x10^3 to 1.38x 10^7 g^{-1} of fresh weight of roots) followed by Nfb medium (1.00x 10^3 to 1.45 x 10^7 g^{-1} fresh weight of root and YEM medium (1.00 x 10^3 to 1.28 x 10^7 g^{-1} fresh weight of root).More number of isolates were identified as diazotroph from the endophytic populations obtained in Nfb medium than in other media (57.14%).It is quite obvious to have more diazotrophs in Nfb compared to King's B because the medium do not have a nitrogen source. Therefore the bacteria has to make its nitrogen compounds by fixing the dinitrogen available in the air.The source of the nitrogen for the non nitrogen fixing bacteria is probably from the leaks of the diazotrophs. This is the reason, why early colony forming units in N free medium are mostly diazotroph.

Rice root tissue harbored more isolate than stem and leaf. Many workers use the Nfb medium for isolation of diazotrophic endophytes. Baldani (1996) used acid mannitol medium for detecting diazotrophic bacteria from banana and pineapple.

It is an accepted fact that plant is the habitat for a variety of microorganismsincluding diazotrophic bacteria and it is quite natural that in the present study , several nitrogen fixing bacteria were identified from the endophytic isolates of rice. Nfb medium isolates were tentatively identified as *Serratia* sp., *Klebsiella* sp. *Azospirillum* sp, and *Burkholderia* sp, *Serratia* sp and *Klebsiella* sp. Gyaneshwasr et al. (1995) isolated *Serratia* capable of N fixing and colonizing roots, stems and leaves of the rice variety IR 72.

In the present study the isolates from King's B medium were identified as *Pseudomonas* spp. and *Enterobacter* spp. Major proportion of the isolates obtained in YEM medium were characterized *as Klebsiella sp. Rhizobium* and *Enterobacter* sp. also observed.

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IRC/TM-2/PP-122

PERFORMANCE OF LOCAL SCENTED RICE VERITIES AT NORTH EASTERN GHAT ZONE OF ODISHA

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Rice is one of the most important grains in all over the world. A half of the world's population is dependent on rice as a main food. Rice is categorized to three types as Japonica, Javanica and indica. In general, Indica rice are narrow in grain, and Javanica ones are large-grain, while Japonica rice are small and short- grain (www.wikipedia.com). Improvement and introduction of the qualitative varieties, is one of the major important objectives of rice breeding projects in Iran (Allahgholipoor et al., 2010). Mainly, Grain appearance or marketable quality includes grain length, grain length to width ratio (grain shape), grain transparency, grain chalkiness and number of chalky grains. In terms of length, rice grains are divided into very long, long, medium and short grains. The grain shape is determined by the ratio of grain length to width and accordingly, it is classified in groups with slender, medium and rounded shape. The importance of grain size and shape is different for consumers (Yusako et al., 2001). In India, seed quality of 100 genotypes of upland rices was evaluated The land races of aromatic rice are tall, late maturing, photosensitive with short and medium grains and low yielding capacity but possess outstanding qualities like aroma, fluffiness and taste. Land races are relatively genetically more diverse than the developed varieties of a crop (Villa et al., 2005) Thus, landraces are a natural source of genetic diversity in any crop. Availability of genetic diversity is the basic requirement of any crop improvement programme (Manonmani and Fazlullah Khan, 2003) . Genetically diverse genotypes are required for selecting parents having wider variability for different characters (Nayak et al., 2004) . Genetic diversity can be estimated by the D2 analysis, metroglyph and principle component analysis using morphological traits (Manonmani and Fazlullah Khan, 2003) . Scented rice, which is grown mainly in North Indian States of Utter Pradesh, Uttarakhand, Punjab and Haryana, has assumed the status of a commercial crop in Odisha in recent years and fetching good prices in domestic and export markets.

There is also demand for local scented varieties as it is grown in different parts of the state and are acclimatized to local environmental conditions.

In order to find out suitable local scented rice varieties experiments were conducted on different scented local rice varieties during the three consecutive wet seasons of 2017, and 2018 to study the performance and its suitability at North Eastern Ghat Zones of Orissa in Regional Research and Technology Transfer Station, OUAT, G.Udayagiri, Kandhamal Odisha.

MATERIALS & METHODS

Fourteen scented rice vars. Including twelve local and two high yielding varieties with three replications were evaluated for yield performance. Fertilizers NPK @ 80:40:40 were applied in three splits. The local varieties showed fewer incidences of pest and disease than the high yielding varieties. Need based application of pesticides were given against Yellow stem borer, Leaf folder and blast based on ETL.

RESULT

Among local varieties, Khuda Kani records highest yield (3.93t/ha), Pusa Basumati (3.80)t/ha, Neelabati (3.80)t/ha and Kalajira(3.60t/ha) as against

Table – 1.Performance of different local scented rice varieties in grain yield (t /ha)

Treatment	Name of Variety	Mean(t/ ha)
T1	Acharmati	1.22
T2	Kalajira	3.60
T3	Neelabati	3.80
T4	Gangabali	3.37
T5	Badshabhoga	2.62
T6	Jaiphulla	3.60
T7	Thakura suna	3.10
T8	Nanu	2.66
T9	Lajakuli Badan	2.13
T10	Khuda kani	3.93
T11	Heera Kani	1.91
T12	Pimpudi basa	0.62
T13	ORS 199 – 5	3.65
T14	PusaBasumati	3.80
SE(m)+-		0.40
CD(0.05)		1.20
CV(%)		12.28

other eight local scented rice varities.as given in Table – 1.

CONCLUSION

This approach which is manly based on pest surveillance, monitoring and conservation of natural enemies and need based application of pesticide as last resort, if propagated by proper motivation and involvement of the farmers, may lead to substantial yield of local scented varieties which can occupy local market.

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Theme - II : Sustainable rice farming

IRC/TM-2/PP-123

TRANSLATING CLIMATE RESILIENT RICE BASED FARMING PRACTICES INTO IMPROVED PRODUCTIVITY AND REDUCED ENVIRONMENTAL FOOTPRINTS

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Climate change poses severe threats to the millions of smallholder farmers' food security and livelihoods in South Asia. In the last few decades, increased rice production left several constraints, such as stagnation in partial factor productivity, soil health degradation, environmental pollution, and increased GHG emission. Reasons are improper agronomic management, non-judicious use of agri-inputs and lack of awareness and knowledge. Multiple climate-smart practices were implemented in Odisha to build climate resilience, improved yields, better soil health, and the farming community's income and nutritional security. Our study investigated possibilities to target rice-fallow, implementing smart technologies in the rice-rice system and integrated farming practices as an option to improve livelihood and cater resilience.

MATERIALS AND METHODS

In Khordha districts, we did trials on several diversification options on residual soil moistureto target rice-fallow. In rice we use rice crop manager in Kharif season followed by best management practices for oil and pulse cultivation in Rabi season.

Fig.1. Rice-fallow diversification options in Odisha

RESULTS

Our results suggest that crop diversification through pulses and oil seeds can be used to target rice-fallow where soil moisture is available. Site suited stress tolerant varieties (drought and flood) treated with stains of trichoderma (seed treatment: antifungal and growth promoter), real time nitrogen management performs better as a package then individual's practice. An average grain yield of 5.88 t/ha (n= 10) was recorded from CSA practice vis-à-vis 4.87 t/ha (n = 08) from convention practices; thus, a yield gain of 1.01 t/ha. In monetary terms, this translated into a profit of INR 18000/ha using CSA practice. In crop diversification, best bet practices *i.e.* pulse seed treated with trichoderma yielded 8.3 q/ha as compared to non-treated seeds (6.7 q/ha), giving an additional yield benefit of 1.60 q/ha. Groundnut seeds treated with trichoderma yielded 2.6 t/ha as compared to non-treated seeds 1.85 t/ha giving an additional yield benefit of 0.75 t/ha. In economic terms, pulse and groundnut caters 9600 INR and 36500 INR, respectively.

CONCLUSION

This study evidenced climate resilient practices as better opportunity to improve crop productivity, profitability and soil health to catalyse sustainability and livelihood of the farming community.

Key words: *Site specific nutrient management, Crop diversification, Soil health, Rice-fallow, climate smart agriculture*

Theme - II : Sustainable rice farming

IRC/TM-2/PP-124

EFFICIENTWATER MANAGEMENT FOR RICE PRODUCTION

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Rice is a water intensive crop and primarily grown where rainfall is abundant. Water is primarily used by the farmers for preparing land (puddling) , continuous seepage and percolation and to also satisfy the water requirement of the crop during its growth period. By the conventional method of puddle cultivation, rice crop requires 450-700mm of water during the growing period of 90-150 days (Ref: FAO Table 5).With the ever increasing population, depleting water tables in bore-wells and open water sources, the need to use efficient methods of Irrigation like Drip-Irrigation is increasingly becoming the need of the hour to use water judiciously and also increase the productivity of rice.

OBJECTIVES:

Drip or Trickle irrigation is an efficient method of irrigation (90-95%) where the water is directly applied to root zone of the crop through a network of pipe lines consisting of Mains, Sub-mains and Emitting pipes (having in built emitters). The water is filtered by the use of appropriate filters using primary and secondary filters depending upon the water source and its quality. Water soluble fertilizers can also be easily applied to the crop with the help of an suitable fertigation injection devices like Venturi, By-pass tank or injection pumps thereby decreasing the usage of conventional fertilizers by 15-25 %.

METHODOLOGY:

The field experiment were carried out by providing drip irrigation using In-Line Drip Irrigation with emitters having a discharge of 4 liters per hour spaced at 50 cm (emitter spacing) with a lateral row spacing of 1.2m.

The details of the study carried out in the field are as under:

•The farmer Mr. Ramalingam at Velakovil (TN) tried out Drip irrigation for paddy in an area of 0.67 acres.

• Rice Koyar H3 variety from TNAU (similar to Basmati) was planted in the field.

•4lph 50 cm In line drip irrigation system was provided and laterals were laid on the surface of the paddy field.

• One row of Drip tubing catered to two rows of paddy. Lateral to lateral spacing provided was 4 feet (1.22 m)

• Initially the farmer irrigated for One hour per day for first 30 days and later forhalf an hour per day for the balance period to maintain the adequate soil moisture

RESULTS:

•Drip irrigation was found adequate for paddy and water saving observed was around 80 to 85%% in comparison to puddle irrigation.

Plate 1 Drip versus Flood

Plate 2: Premier Inline Drip Irrigation for Paddy in Velakovil (Tamil Nadu) in 0.67 acres of land

• He obtained a yield of 2600 kgs for 0.67 acre. This when extrapolated will give 3880 kg/acre.

In addition to the saving of water and increase in yield the following physiological benefits were observed:

a) More number of effective tillers was seen.

b) Pannicle length and number of grains per panicle were higher.

c) Grain weight was more.

d) Root Growth was found to be extensive and healthy.

e) Leaching loss of nutrients was prevented as water is not lost by deep percolation.

f) Good soil health is maintained and crop rotation can be easily carried out which increases the land utilization capability.

CONCLUSIONS:

Water efficient techniques like Drip Irrigation is the need of the hour and the quantity of water required to produce rice can be significantly reduced (80%) and the fertilizer to be applied can be reduced (20-25 %) with marginal increase in yield (10-15%) have been observed by field trials. The farmers need to be educated about the benefits of use Drip Irrigation for Rice and suitable subsidy interventions under PMKSY (Pradhan Mantri Krishi Sichayee Yojana) need to be provided for large scale adoption of drip irrigation systems in a phased manner. Methane gas emission reduction and reducing arsenic toxicity in rice plants are other important added benefits by adopting drip irrigation for rice.

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FAO website www.fao.org Chapter 2 : Crop water needs pp 2.4 Determination of Crop water Needs Table 5

THEME - III

Biotic-stress management in rice

HOST PLANT RESISTANCE IN RICE AGAINST BROWN PLANT HOPPER AND YELLOW STEM BORER

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Rice is an essential food commodity globally and accommodates enough variation to cope up with different climates, ecosystems, pests and provisions. India is the second largest producer of rice and contributes a lot to the global food security through rice production apart from its own. The prediction for future rice demand is towards an increasing trend and India has to prepare itself for the challenge of more rice production ahead (Milovanovic and Smutka, 2017). Insect pests are among several constraints limiting the rice production and in India and in many south and south-east Asian countries.

Host plant resistance(HPR) is considered to be an efficient, economical, eco-friendly and socially acceptable means of crop protection to manage insect pests. In Inadia, though HPR has been the focus of rice pest management since 1970s, resistant varieties at cultivation front is still meagre. The major failure was attributed to the non-availability of proper donor for strengthening the developed varieties with pest resistance through resistance-breeding programme. Identification of such donor warrents robust phenotyping which is the essential procedure to differentiate different genotypes for different traits and still it remains in the fore front of plant breeding inspite of rapid development in molecular science (Costa et al, 2019).

India is the homeland of many traditional rice varieties, particularly, the important place like Odisha state which harbours Jeypore tract, the putative secondary center of origin of cultivated rice (Ramiah and Ghose, 1951; Ramiah and Rao, 1953; Sharma et al. 2000). Land races have many inherent qualities to cope up with unfavorable circumstances and many are self protective against rice pests, like insects or diseases. In the present scenario of BPH problem in rice and related pollution and health hazards arising from pesticide application, there is an urgent need to identify the resistant donors for immediate utilization, nationally and internationally. Further, since the field infestation of BPH coincides with yellow stem borer (YSB), *Scirpophaga incertulus* Walk. which is another important insect pest of rice, there is a need to understand the reaction of BPH-resistant cultivars against this pest for better protection. Till now, no highly resistant genotypes were identified against YSB, inspite of repeated efforts worldwide. Therefore, even a low level of resistance against YSB, if found within the BPH-resistant cultivars, will provide multiple resistance to both the insect pests.

METHODOLOGY :

The present paper described the work on phenotyping, constituted of mass and replicated screening, of traditional land races of Odisha (India) against BPH and YSB under greenhouse and farm field, respectively, at National Rice Research Institute(ICAR-NRRI), Cuttack. The paper also deals with the method of force feeding as a part of robust phenotyping to identify highly resistant donors among the traditional ones. Effort was made to screen high BPH- resistant varieties against yellow stem borer of rice, so that varieties resistant/tolerant to both the pests can be identified for better utilization. Breeding lines developed by introgressing resistance from identified donors of this study, were tested in farmers' field of BPH endemic areas for their performance during the years 2017-2019 so that they can be released as high yielding varieties with resistance to BPH and other rice pests.

RESULTS :

Mass screening of 1113 varieties resulted in 46 as highly resistant with score against 100% mortality of susceptible TN1. But the replicated screening of these 46 varieties reduced the highly resistant genotypes to 27 at 100%death of susceptible check TN1. When the insect was allowed further to force feed on resistant ones , it was successful in breaking down the resistance of many genotypes at 13 days after insect release, thereby reducing the highly resistant genotypes to 10. Among the 46 BPH-resistant varieties, early stage resistance of 3 score to YSB was exhibited by 15 whereas 5 showed resistance at reproductive stage. Three varieties, CR.AC. 35181, CR.AC. 35184 and FV30, were resistant for both the crop stages. CR.AC. 35181 and 35184 were promising for both BPH and YSB and were utilized as donors at ICAR-NRRI, Cuttack in the background of popular varieties Tapaswini, Samba mashuri and Pusa 44, giving rise to high BPH resistant lines such as CR2711-76 and 3006-8-2 along with other effective ones (Jena and Sahu, 2013; AICRIP(DRR), 2009, 2011, 2012). The genotype CR2711-76 provided high resistance to BPH populations of both India and Phlippines. On-farm testing of genotypes CR2711-76 andCR3006-8-2 in BPH-endemic area of Odisha proved effective which confirmed their resistant trait further.

With the advancement of genomic tools in recent years, successful progress has been made in the area of host plant resistance to pin point insect resistance genes in rice and facilitating efforts to breed insect resistant varieties. But identification of a proper resistant donor still remains as a major challenge to researchers for achieving reliable resistance. Hence, robust phenotyping is required to produce highly resistant accessions that will withstand high insect pressure in the field conditions.

CONCLUSION:

Phenotyping of land races through SES scoring will identify BPH-resistant genotypes no doubt, but an added force feeding tool gives a powerful boost to identify a long lasting one. It is also clear from the study that some BPH resistant varieties possess resistance against YSB. These varieties can be grown as single varieties or can be utilized by researchers in resistance-breeding programme to develop high yielding BPH resistant varieties alone or along with YSB resistance which will serve the farmers' community for better future. This will also add to food security with enhanced yield and low or no protection cost against these two important insect pests of rice, leading the rice IPM at forefront to make it successful.

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ANALYSIS OF GENETIC DIVERSITY AND POPULATION STRUCTURE OF *USTILAGINOIDEA VIRENS* IN INDIA AS REVEALED BY MICROSATELLITE MARKERS

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In India, rice production per unit area needs to be increased by 3.3 ton per ha to achieve the target of 137.3 million tons by 2050 assuming the rice area under plough remains at current level. Among various production constraints rice false smut (RFs) is one of the major emerging biotic stress, has parts of role to limit the yield as well as reducing qualities of rice. The disease is caused by *Ustilaginoideavirens* (Teleomorph: *Villosiclavavirens*), an emerging and threatening pathogen reduces yield by 0.2 to 49%. Magnitude of losses will be too high if qualitative losses are taken together. It reduces filled grain (3.0-71.8%), 1000-grain weight (1.2 – 10.8%), germination (3.4 – 9.5%) and seedling vigor index (SVI-I 6.8-38.5 and SVI-II 10.8-38.5) (Bag et al., 2016). Nutritional quality like amylase, protein, antioxidant and phenol contents were also changed significantly ($p<0.01$).The disease shows a high degree of variability in the field and is very tough to manage because of its appearance in one time just before grain maturity. Adoption of resistant variety to RFs is the best acceptable method to combat the disease and its need thorough knowledge of the pathogen including genetic diversity and its population. But no information is available on its genetic diversity and population structure of the pathogen from India. Therefore, the present study was targeted to uncover thegenetic diversity and population structure of *U. virens* populations from the major rice-growing areas of India. SSR markers are preferred for genetic analyses because of theirhigher rate of polymorphism, in formativeness, reproducibility, multiallelic nature, co-dominant inheritance, relative abundance and ease ofidentification from genomic sequences.

METHODOLOGY

Altogether 113 isolates of U. virens were collected from different rice fields of different districts belongs to the states of north, east and north-east India comprises of Himachal Pradesh (HP), Uttarakhand (UK), Uttarpradesh (UP),Madhyapradesh (MP), Punjab (P), West Bengal (WB), Bihar (B), Odisha (OD), Assam (A) and Meghalaya (M). Isolation of pathogens from the samples, preparation of pure culture, DNA extraction and purification and PCR amplification were done following standard protocol.

For genotyping, 17 polymorphic SSR primers were used and similarity matrix was calculated using NTSYS 2.1 programme software. Population structure were analysed using the Structure 2.3.4 software. Optimum number of populations was envisaged using online tool structure harvester. Major allele frequency, observed heterozygosity, gene diversity (expected heterozygosity) and Polymorphic Information Content(PIC) of microsatellites were obtained by using Powermarker software. Analysis of Molecular Variance (AMOVA), Principle Component Analysis (PCoA),Mantel test and Shannon information index were donethrough GenAlEx v6.503.

RESULTS & DISCUSSION

Total 113*U. virens* isolates from three zone (north, east and north-east) of India were analyzed with 17 microsatellite markers. All the microsatellite loci were polymorphic and highly informative, and hence useful genetic tools to depict the genetic diversity and population structure of the pathogen. A wide range of diversity indices including number of observed alleles (47), effective number of alleles (47), Shannon's diversity index (0.675) and percent polymorphic loci (100) were computed to determine genetic variation within populations. A high within-populations genetic diversity (90%) was confirmed with gene diversity index and PPL values 0.46 and 100% respectively. Analysis of molecular variance (AMOVA) revealed a moderate genetic differentiation where 90% of the total genetic variation resides within populations, leaving only 10% among populations. The dendrogram showed three main clusters, cluster I comprised almost all isolates from North-India, Cluster II have all isolates from Odisha and some isolates from Bihar while Cluster III represented most of the isolates from WB and North-Eastern states of India (Fig.1).The structure analysis showed three major populations with the maximum likelihood peak observed at two places one at K=3. The Neighbor joining based Cluster (UPGMA), PCoA and Structure analyses grouped the populations geographically but not into sharpgenetically distinct clusters according to their geographical origins and this may be due to high gene flow (Nm = 4.9). The Mantel test, which is an indicator of the relation between geographical and genetic distance found that the increasing geographic distance between the isolates is proportional to the increasing genetic distance between those isolates. It proved that geographical environments have some influence on genetic variation of *U. virens*. Wang et al (2014) investigated 110 isolates from different provinces of China and reported that the isolates clustered according to geographical origin and the genetic diversity among isolates was higher between/ among the population than within geographical populations. But Zhou et al (2008) reported in contradiction that the populations among different locations were similar because of rare presence of different sexual stage of the pathogen within ecological region and the limited variation of this pathogen was mainly arisen via asexual mechanisms. The diversity analysis of V. virens from north, south and central China revealed no distinct geographical relationship among the isolates.

CONCLUSION

In conclusion, the microsatellite markers used in the present study have high quality nature data (0.562)

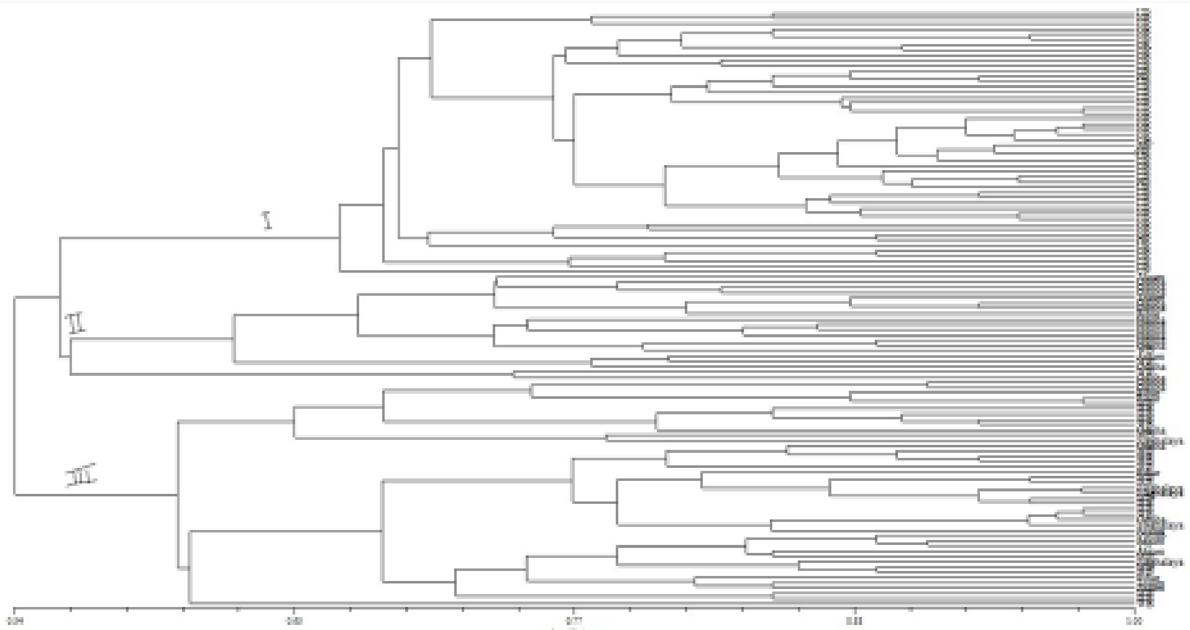

Fig.1:UPGMA-SHAN based phylogenetic analysis of 113 *Ustilaginoideavirens* isolates.

and marker index (0.491) and highly informative, thus, can help to dissect the genetic structures of *U. virens* populations in India.Present study provided the first information about genetic diversity and population structure of *U. virens* from India. Such baseline information is useful for designing and implementing durable and effective management strategies.

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IRC/TM-3/OP-5

REFINED METHOD FOR MASS MULTIPLICATION OF *USTILAGINOIDEA VIRENS* CONIDIA FOR EFFECTIVE SCREENING OF RICE GENOTYPES

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Intensive methods of rice cultivation involving widespread use of high yielding nitrogen responsive rice varieties, excessive application of chemical fertilizers and apparent changes in the climatic condition has resulted in increased incidences of many rice diseases. False smut of rice, caused by *Ustilaginoidea virens* (Cooke) Takah., has emerged as a most important grain disease in India. Disease was first reported in India (1878) and known as 'Lakshmi disease' as occurrence of this disease was recognized as a symbol of bumper harvest. It has increased substantially both in terms of its intensity and geographical spread resulting in considerable yield loss. The fungus replaces all part of kernel into powder form and causes direct economic yield loss. In severe cases up to 80 smut balls were reported per panicle. The major bottleneck in development of resistant varieties against false smut was lack of highly resistant donors due to difficulty in the artificial screening technique at large scale. Injection of conidial suspension at booting stage of the crop is the promising methodology to screen rice genotypes under field conditions. In this study we have modified and improved the mass multiplication methodology for harvesting high number of *U. virens* conidia and use them for large scale screening of rice genotypes.

METHODOLOGY

Based on our previous studies, we have selected rice leaf extract broth (RLEB) for *U. virens* conidial mass multiplication (Wang *et al.*, 2019). Mycelial disc (8 mm) of 2 weeks old culture of *U. virens* was inoculated in 100 ml of RLEB (6g rice leaf /100 ml of distilled water) in 250 ml flask and potato sucrose broth (PSB). Inoculated cultures were incubated in a shaking incubator at 120 rpm at 25 ± 2°C for 6-7 days. After incubation, the entire flask of *U. virens* culture grown in RLEB was transferred into 100 ml of freshly prepared Potato Sucrose Broth (PSB) under aseptic conditions and incubated for additional 12 hours at 120 rpm, at 25 ± 2°C for germination of the conidia. Later, conidia were harvested from RELB+ PSB and PSB and observed under microscope. For artificial inoculation the concentration was adjusted to 2.0×10^5 conidia/ml with sterile distilled water. The inoculation was performed as described previously (Ladhalakshmi *et al.*, 2019). In brief, approximately 2 ml of each conidial (2.0×10^5 conidia/ml) suspension was injected into a susceptible single rice panicle at booting stage under field conditions. Percentage of infected panicles and number of smut balls per panicle were recorded after appearance of the visible symptoms. Plants were provided shade with green shade net to enhance the disease infection.

Table 1: Details about the conidial count and artificial inoculation of false smut pathogen

Culture broth used for conidial multiplication	Number of conidia induced per ml (x 10^6 conidia/ml)	Percentage of panicle infection	Number of smut balls per panicle
Rice Leaf Extract Broth	31.83	100%	9 to 32
Potato Sucrose Broth	1.08	80%	1 to 6

Fig. 1. Severe false smutinfection produced by *U. virens* conidia cultured in RLEB and incubated in PSB

RESULTS

Rice leaf extract broth (6g/100ml) induced significantly more number of conidia production (31.83 x 10^6 conidia/ml) compared to PSB. Microscopic observation revealed that conidia produced in RLEB were of smaller size compared to PSB induced conidia. However, incubation of these conidia in PSB for additional 12 hours, resulted in increase of the size of the conidia and enhanced the initiation of germination. Results of artificial inoculation revealed that plants inoculated with germinated conidia (grown on RLEB +incubated in PSB) expressed more number of smut balls compared to conidia grown only in PSB (Table 1; Fig 1).

CONCLUSION

For large scale screening of rice genotypes, very high concentration of *U. virens* conidia is needed. The present study results revealed that instead of PSB, RLEB can be used to harvest high concentration of conidia followed by incubation of these conidia for 12 hours in PSB to enhance the conidial germination. Use of these germinated conidia for inoculation, increased the false smut infection. This methodology may serve as a full proof technique to create high disease pressure and to select the reliable false smut resistant genotypes.

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EFFECT OF ELEVATED CO_2 AND TEMPERATURE ON THE FEEDING BEHAVIOR OF RICE BROWN PLANTHOPPER, *Nilaparvata lugens* (STÅL) POPULATIONS

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Brown planthopper BPH, *Nilaparvata lugens* is one of the most destructive insect pests of rice in both temperate and tropical regions of East and South Asia and has become problematic over the past few years in India (Sunil *et al*., 2017). It is a key pest of rice and causes yield losses as high as 60% under epidemic conditions amounting to billions of dollars. In India during the recent years, several rice fields were damaged due to BPH attack. In Odisha, 2 lakh ha. and in Telangana state 7 lack acres of paddy crop was damaged by BPH.In general, in plants, exposed to elevated CO_2levels, the concentration of N decreases while the carbohydrate concentration increases. Changes in N and carbohydrate levels correlate with the performance of insects, altering their fecundity, population size, food consumption and development time (Chen *et al*.,2004). The phloem sap of plants contains high concentrations of carbohydrates and relatively low concentrations of minerals and amino acids. Host plants of high food quality are characterized by a rise in the ratio of amino acids to carbohydrates. Therefore, in order to meet the amino acid requirement, phloem feeders increase ingestion of assimilates from the phloem, leading to an increase in crop damage.In India, there is scanty information available on interactive effects of elevated CO_2 and temperature on brown planthopperpopulations. In this study, effects of different levels of CO_2 and temperature on the performance of the brown planthopper, *N. lugens*feeding on rice plants were examined using a factorial design. Three BPH populations were reared upto 10 generations on rice plants in each of the three CO_2 × temperature levels, and its effect on the feeding of brown planthopper populations and biochemical changes in the rice plant was observed.

METHODOLOGY

Three CO_2 levels and temperature combinations viz., 1. Ambient CO_2 @ 380 ppm and ambient temperature (aCO_2+aT &30°C), 2. Elevated CO_2 @ 500 ppm and ambient temperature (eCO_2+aT &30°C) and 3. Elevated CO_2 @ 500 ppm and elevated temperature (eCO_2+eT &33°C) were continuously maintained under specially designed CO_2 chambers at ICAR-Indian Institute of Rice Research, Hyderabad. Three BPH populationscollected from Ludhiana, West Godavari and Nalgonda districts were separately reared in the CO_2 chambers upto 10 generations on young rice seedlings (*cv* TN1) in flexi cages to avoid intermingling of populations. The amount of honeydew excreted by the adults and nymphs of BPH on rice plants exposed to different CO_2 and temperature levels in 1, 5 and 10 generations was measured by following methodology described by Heinrichs*et. al.* (1985). The total soluble protein, soluble sugars, reducing sugars, total free amino acids, nitrogen, potassium and phosphorous in 30 day old rice plants grown in different CO_2 levels before and after BPH infestation were estimated by standard procedures. Statistical analysis was done by 3^3 factorial Anova.

RESULTS

Elevated CO_2 levels with increasing temperature had profoundly accelerated the honeydew

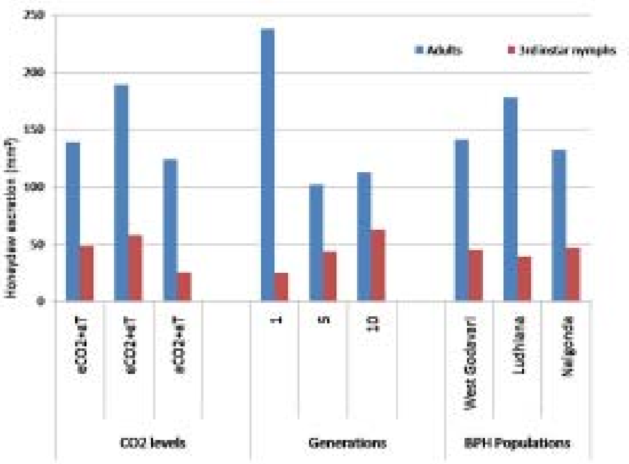

Fig 1. Honeydew Excretion of BPH populations across CO_2 levels & temperature and generations

excretion of nymphs compared to that of ambient CO_2 and temperature. Across the generations, nymphalhoneydew excretion increased in 5th and 10th generations whereas the adult honeydew excretion decreased with advanced generations. Among the BPH populations, adult honeydew excretion was more in Ludhiana BPH population compared to that of West Godavari & Nalgonda BPH populations. Thus, our results showed that elevated CO_2 and temperature had significant and positive effects on the feeding rate of BPH. Sap feeders excrete 40% of their sucked assimilates as honeydew and quantification of honeydew was directly related to the sucking rate. Thirty dayold rice plants grown under elevated CO_2 levels had higher quantities of total sugars, lower levels of reducing sugars, proteins, free amino acids, nitrogen and potassium content and higher quantities of phenols and phosphorus than those grown in ambient CO_2. Brown planthopper infested plants grown at elevated CO_2levels have reduced quantities of total soluble sugars, reducing sugars, nitrogen and phosphorus and increased levels of soluble proteins, free amino acids, and potassium compared to healthy uninfested plants.

CONCLUSIONS:

The resultsindicate effect of $CO_2$and temperature on some biological parameters of both rice plant and thedifferent brown planthopper populations and also point to an increase in planthopperpopulation size under changed climate conditions with elevated CO_2 and temperature.

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IRC/TM-3/OP-7

ORGANIC MANAGEMENT OF SHEATH ROT, AN EMERGING DISEASE OF RICE IN ASSAM

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Rice (*Oryzae sativa*) is considered as one the principal staple food for more than half of the population of the world including India. In Assam, rice accounts for more than 80% of the total cultivated area. It is a common practice among the farmers to use synthetic fertilizers as well as pesticides for rice cultivation. However, considering the hazards caused to the environment due to non judicious use of these chemicals and the growing awareness among the consumers, the modern agricultural practices are inclined towards the organically grown rice cultivation. The major constraint of organic cultivation is the high intensity of pest and diseases and the difficulty to manage those (Yadav et al., 2013).

The present study aims in the management of sheath rot, an emerging disease of rice under organic cultivation in Assam. This study also reflects about the population of the beneficial rhizospheric fungal as well as bacterial micro flora in organically grown rice.

METHODOLOGY

The current research was carried out in the experimental field of Regional Agricultural Research Station, Assam Agricultural University, Titabor, Jorhat, Assam between the year 2017-2019 in a high valued local scented rice variety namely Keteki Joha. Initially, seed treatment was carried out with an organic solution (1% cow urine + 10% *Trichoderma harzianum* amended mustard oil cake (MOC) extract) which was followed by seedling root dip treatment with *Pseudomonas fluorescence*and *T. harzianum* talc based consortia @20g/L water. The nursery bed was also amended with vermicompost @ 2t/ha (Das et al., 2018).

To test the efficacy of different organic treatments on the disease severity of sheath rot of rice, an experiment was conducted in randomized block design RBD) with eight treatment combinations in four replications. The treatment combinations are as follows: T1 (Enriched compost @ 5 t/ha + Biofertilizer consortia (BfC) and *P. fluorescence* (Pf) as root dip), T2 (Green manuring (GM) @ 5 t/ha + Azolla @ 20 kg/ha + BfC & Pf as root dip), T3 (GM @ 2.5 t/ha + Azolla @ 20 kg/ha + BfC & Pf as root dip), T4 (Vermicompost (VC) @ 5 t/ha + Rock phosphate + BfC and Pf as root dip), T5 (VC @ 2.5 t/ha + Rock phosphate + BfC and Pf as root dip), T6 (GM @ 2.5 t/ha + VC @ 2.5 t/ha + Azolla @ 2.0 kg/ha + Rock phosphate + Pf as root dip), T7 (VC @ 2.5 t/ha + Neem oil cake @ 300 kg/ha (1/2 basal + ½ top dressed) + seed soaking and Pf solution (10 g/lit/kg of seed for 12 hrs in nursery bed) + BfC as root dip) and T8 (Untreated Control).

Another experiment was carried out to study the fungal and bacterial microbial load in rice rhizosphere before and after the organic treatments. The rice rhizospheric microbes were characterized on the basis of their cultural as well as morphological characteristics and the microbial load was counted for three consecutive years after treatment.

RESULTS

The results from the organic treatments against the percent disease severity of sheath rot disease of rice indicated that all the treatments exhibited significantly higher grain yield as compared to control. However, the highest grain yield (t/ha) was obtained in T6 (GM @ 2.5 t/ha + VC @ 2.5 t/ha + Azolla @ 2.0

Table 1. Effect of organic treatments on the percent disease severity of sheath rot of rice

Treatment	Sheath rot (% of disease severity)				Grain Yield (t/ha)			
	2017	2018	2019	Mean	2017	2018	2019	Mean
T_1 Enriched compost @ 5 t/ha + Biofertilizer consortia (BfC) and *Pseudomonas fluorescence* (Pf) as root dip	6.9 (15.23)	7.0 (15.34)	10.05 18.44)	7.98 (16.32)	3.33	3.11	3.53	3.31
T_2 Green manuring (GM) @ 5 t/ha + Azolla @ 20 kg/ha + BfC & Pf as root dip	8.7 (17.16)	5.7 (13.81)	7.6 (16.00)	7.33 (15.68)	3.67	2.91	3.42	3.33
T_3 GM @ 2.5 t/ha + Azolla @ 20 kg/ha + BfC & Pf as root dip	6.25 (14.42)	5.4 (13.44)	7.17 (15.45)	6.27 (14.42)	3.63	2.53	3.14	3.1
T_4 Vermicompost (VC) @ 5 t/ha + Rock phosphate + BfC and Pf as root dip	5.75 (13.81)	6.3 (14.54)	8.2 (16.42)	6.75 (15.00)	3.01	3.11	3.34	3.15
T_5 VC @ 2.5 t/ha + Rock phosphate + BfC and Pf as root dip	8.51 (16.95)	6.8 (16.21)	8.7 (17.16)	8.00 (16.43)	3.23	2.74	3.13	3.03
T_6 GM @ 2.5 t/ha + VC @ 2.5 t/ha + Azolla @ 2.0 kg/ha + Rock phosphate + Pf as root dip	3.25 (10.31)	2.0 (8.19)	4.8 (12.66)	3.35 (10.47)	3.80	3.26	3.68	3.58
T_7 VC @ 2.5 t/ha + Neem oil cake @ 300 kg/ha (1/2 basal + ½ top dressed) + seed soaking and Pf solution (10 g/lit/kg of seed for 12 hrs in nursery bed) + BfC as root dip	9.30 (17.76)	5.7 (13.81)	8.3 (16.44)	7.76 (16.11)	3.18	2.82	3.18	3.06
T_8 Control	14.33 22.22)	19.0 (25.84)	21.42 (27.56)	18.25 (25.25)	1.98	1.30	2.08	1.79
SED(+-)	0.62	0.54	.068	0.61	0.18	0.29	0.08	0.09
CD (P=0.05)	1.82	1.58	1.98	1.79	0.54	0.42	0.21	0.27
Recommended fertilizer dose (60-20-40)	18.14 (25.18)	24.3 (29.53)	26.2 (30.78)	22.88 (28.52)	3.52	3.34	3.73	3.53

kg/ha + Rock phosphate + Pf as root dip) which was at par with the recommended dose of fertilizer (RDF) (Table 1).

The morphological observation of fungal rhizospheric microbes before and after organic treatments revealed the presence of *Aspergillus* sp., *Trichoderma* sp., *Rhizopus* sp. and *Penicillium* sp. both before and after treatment. In case of rhizospheric bacterial populations, two beneficial bacterial species were found from rhizospheric soil before treatment and three species were isolated after treatment. The bacterial species were later identified to be *Bacillus* sp. based on their cultural characteristics.

To study the effect of the organic treatments on the population of beneficial soil microbes viz. *Aspergillus* sp. and *Trichoderma* sp. in consecutive years, the best treatment (T6) was compared with untreated control (T8) and RDF. It was observed that there was significant increase in the population of both the species from 2017-2019. In T6, the percent increase in the population of *Aspergillus* sp. was 96.7, 34.04 and 25.7 and the percent increase in the population of *Trichoderma* sp. was 74.9, 36.6 and 26.8 from 2017-2019 respectively. Although there was a gradual decline in percent increase of microbial population in the second and third year than the first, it may be due to the fact that the organic amendments were appliedin the first year only and not the consecutive years.

CONCLUSION

The findings from the current study suggests that the efficient use of green manuring, vermicompost, azolla and rock phosphate ammended with *P. fluorescence* can effectively manage the sheath rot disease in organic rice cultivation without hampering the yield. Moreover, organic treatments also help in the population growth of soil rhizospheric microbes. However, further studies are required to test the efficacy of organic management on other important rice diseases too in order to develop a thorough package of practice on organic rice cultivation in Assam. Lastly, a metagenomic analysis of the soil microbial population can be done before and after use of organic amendments to have a clear idea on how the organic amendments impact the rhizospheric microbes in rice based cropping system.

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IRC/TM-3/OP-8

DISCRIMINATION OF HEALTHY AND DAMAGED RICE BY LEAF FOLDER USING HYPERSPECTRAL SENSING

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The near real time assessment of agricultural crop canopies is important to address crop health and growth for productivity modelling. In past various techniques were used to monitor crop health and growth but all were time consuming and need lots of manual interference. In last two decades, the advancement in the field of remote sensing offers an alternative approach to assess crop health and growth with minimal manual efforts. In this direction, further advancement in hyperspectral remote sensing can play a key role to discriminate crop stress using the narrow contiguous electromagnetic spectrum. In the present time efforts are going on to discriminate different disease and pest from healthy plants around the globe using hyperspectral based sensing. In this regard identification of significant spectral band width and central band is a major challenge for agricultural community. In India the Space Applications Centre in collaboration with ICAR centres carrying out different ground-based studies to identify specific spectral channel and width to discriminate healthy and stressed crops. In this regard experiment was undertaken to discriminate rice leaf folder damaged plants at different phenological stages and damage levels by using hyperspectral data (400-2500nm).

METHODOLOGY

The experiments were conducted in a rice field at ICAR-National Rice Research Institute, Cuttack with latitude at 20.45 °N and longitude 85.93°E during *kharif*2018 and 2019. Seedlings of rice variety TN1 were transplanted during the season in different micro-plots (1m x 1m) with recommended spacing and fertilizer dose. The third instar larvae of rice leaf folder were released in the microplots for creating different damage levels. The microplots were covered by nylon nets to prevent the damage from other insect pests. After attaining different damage levels *i.e*, 50 and 100 percent in the leaves, the reflectance data were recorded by ASD Spectroradiometer. Then from the raw data, the noisy bands (1350-1450nm, 1780-2000 nm and 2350-2500 nm) due to atmospheric perturbations were removed. First derivatives were calculated for spectral data of both healthy and damaged rice plants to identify the spectral channel which were having maximum change in slope. Continuum removal analysis was done for different band widths to identify significant absorption peaks and those peaks were considered as central wavelength. Further, band depth was computed and paired t-test was performed at 5, 10, 15 and 20 nm. Bio-chemical analysis such as chlorophyll, phenol, reducing sugar and non-reducing sugar was also done for rice plants for establishing relationship of these biochemical parameters with the spectral signature.

RESULTS AND DISCUSSION

The in situ electromagnetic spectral curve over healthy and leaf folder infested crop showed in Fig.1. This spectral curve was obtained after removal of noise.

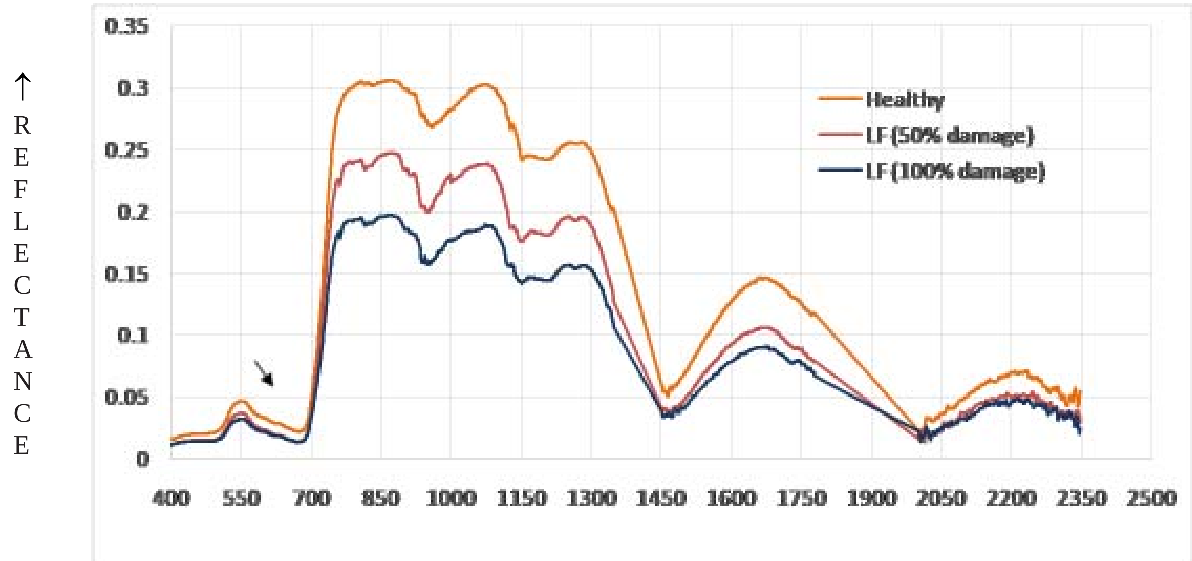

Fig 1. Spectral curve for Healthy vs Leaf folder at different damage level

A sharp peak was seen at 550nm indicating the presence of anthocyanins (Qin *et al.*, 2008).

As, from the above graph it is found that there is a slight change in magnitude in the visible range for both healthy and affected samples but the change is quite obvious in the Near Infrared (NIR) region. The maximum value is at 815nm for both healthy and affected samples on the original spectra.

On the first-order derivative spectral curves (Fig.2a), there are two reflectance peaks in the Visible and NIR spectral regions and they are at 569 and 732 nm for the healthy rice, respectively, while they are at 569 and 735 nm for Leaf folder affected samples. The maximum difference obtained between healthy and Leaf folder samples is just after the visible region *i.e* from 700 to 760 nm and to be precise, it is exactly located between 713 to 754nm.This phenomenon shows that the red edge appears in the wavelength of 680-750 nm.

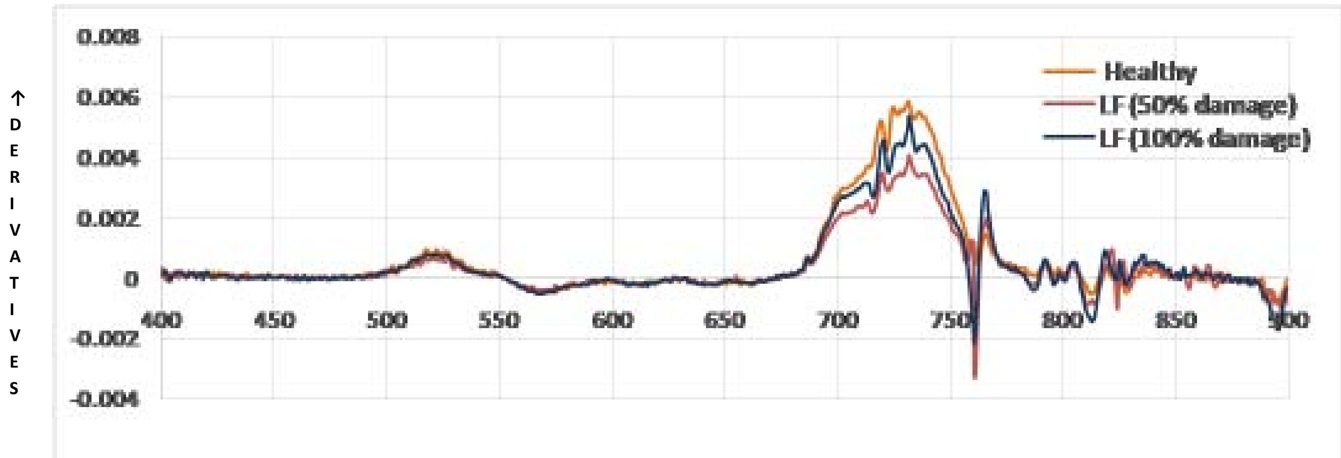

Fig 2a. First order derivative for Healthy vs Leaf folder

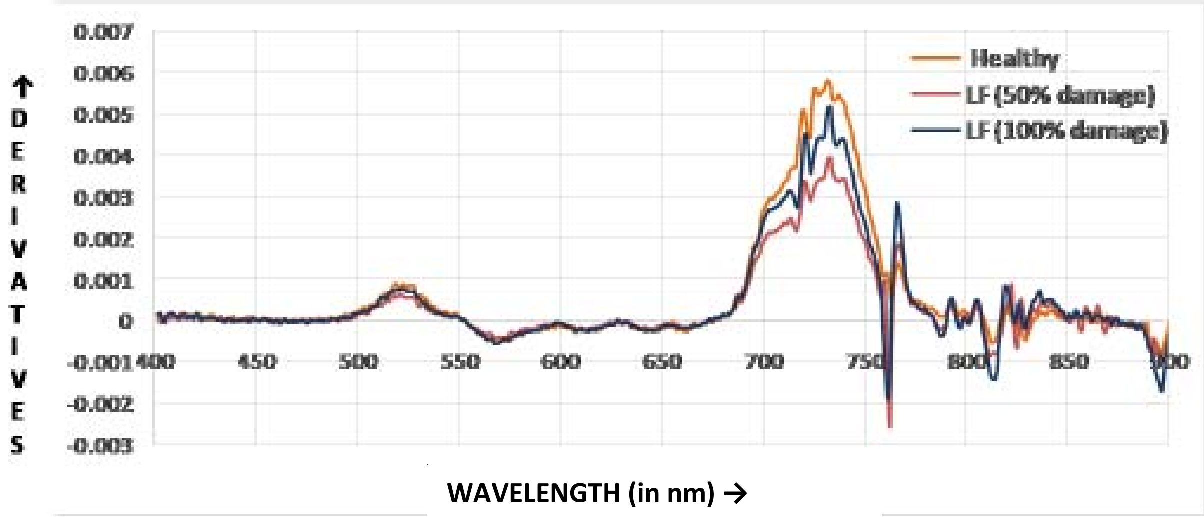

Fig 2b. Second order derivative for Healthy vs Leaf folder

For, the second order derivative spectra, considering a wavelength range from 650-800nm the maximum change in slope for Leaf folder affected samples are found at 716, 720, 733, 762 and 766nm with reflectance values 0.0021, 0.0043, 0.0051 and -0.0025 and 0.0028 respectively and for healthy samples, the reflectance values at the same wave lengths were found at 0.0049, 0.0051, 0.0056, 0.00081 and 0.0014 respectively. From the wavelength range from 800-900nm we found maximum change of slope for Leaf folder affected samples are at 814 and 896nm with reflectance values -0.0013 and -0.0016 and for healthy the reflectance values are -0.0001 and -0.00078.Summarizing the above analysis, it shows that the difference of spectral reflectance is significant for different damage levels, but they are obviously different in different spectral regions (Visible and NIR). Comparatively, the spectral difference in the NIR region is the most obvious and difference in the visible region is very negligible and hence, no significant difference is found.

The continuum removal method can normalize reflectance spectra to the range between 0 and 1, so it allows the comparison of individual absorption features from a common baseline. Continuum removal was done from band widths 486-564nm, 567-772nm, 777-834nm, 839-1017nm, 1028-1258nm and 1323-1335nm with their absorption peaks located at 505, 677, 816, 949, 1148nm, 1332nm, and values obtained from Spectral Library Plots generated by using ENVI software package, for Healthy are 0.805, 0.124, 0.993, 0.907, 0.852and 0.996, respectively and for Leaf folder samples the values are 0.766, 0.096, 0.968, 0.834, 0.793 and 0.988.Comparing the values, of the continuum removal spectra it was obtained that a Healthy sample has more spectral value as compared to leaf folder affected sample. These above absorption peaks were identified as central wavelength and an increment of 5, 10, 15 and 20nm on both sides was done and band depth, band area and normalized band depth was calculated. It was found that the normalized band depth had no effect and their values did not change irrespective of the samples.

As, from the above analysis it is clear that mainly the sensitive bands are found in the NIR region and content of chlorophyll is a major criterion for sensitive bands. In the NIR region the healthy sample has more reflectance value than a Leaf folder sample. The inclination of the graph at around 700nm is due to the presence of red edge area. Red edge defined from 690 to 750 nm is also sensitive to chlorophyll content and the movement of red edge towards shorter wavelengths during senescence or stress induced chlorosisis due to a reduction in the depth and breadth of the chlorophyll absorption feature. Hence, the bands 716, 720, 733, 762 and 766nm are sensitive bands for Leaf folder. Leaf Area Index (LAI) of healthy sample is 3.688 and that of Leaf folder affected sample is 2.12. So, a healthy sample has more LAI value as this indicates the greater area subjected to transpiration. Hence, 814 and 896nm are sensitive bands because of lower value of Leaf Area Index of Leaf folder sample as compared to Healthy. Bands identified from continuum removal *i.e.*, 505, 677 (visible range) and 816nm (NIR) are sensitive due to depletion of chlorophyll and change in the value of LAI.

CONCLUSION

Hyperspectral images provide high spectral resolution data, with many narrow contiguous spectral bands allowing for detailed applications. The results of present study has the potential to aid in monitoring damage by leaf folders in rice growing under ûeld conditions at different vegetative stages. The sensitive bands 716, 720, 733, 762, 766, 814, 816 and 896nm are mainly from the NIR region as the visible region shows no dissimilarity. Additionally, future research using image data taken from aircraft or satellite platforms are also needed to expand the study to the whole ûeld or landscape level. This will help to create hot-spots of Leaf folder with the use of hyperspectral satellite image. Thus, benefiting the farmers for taking appropriate control measures to reduce losses incur due to rice leaf folder and reduce the banket application of the pesticides.

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EVALUATING THE EFFICACY OF BACTERIAL BIOCONTROL AGENTS AGAINST SHEATH BLIGHT DISEASE IN RICE

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Sheath blight disease of rice caused by *Rhizoctonia solani* Kuhn {Teleomorph: *Thanatephorus cucumeris* (Frank) Donk} is a major biotic constraint in almost all the rice growing areas, reducing both grain yield and quality. This disease generally appears at maximum tillering stage and affects all the plant parts above water line. The yield loss due to this disease is reported to range from 5.2-50% depending on environmental conditions, crop stages at which the disease occurs, cultivation practices and cultivars used (Marchetti and Bollich,1991).Biocontrol agents are considered as one of the effective and eco-friendly means of management of diseases in different crops. Several fungi like *Trichodermaviride*, *T.harzianum*, *T.koningii (*Sudhakar *et al.*,1998*;* Das and Hazarika*, 2000), Aspergillus niger* (Kandhari*et al.*,2000), *A.terreus (*Gogoi and Roy,1993*)*, *Gliocladiumvirens* (Baby and Manibhusan Rao, 1993) in rice fields are found antagonistic against *Rhizoctoniasolani*. In the present investigation twelve strains of *Bacillus*spp were evaluated for their efficacy under *in vitro* dual culture technique and net house against rice sheath blight pathogen, *Rhizoctoniasolani*, Kuhn.

METHODOLOGY

The antagonistic microorganisms like twelve strains of native *Bacillus* sppalong with commercial formulations were evaluated for their antagonistic effect under *in vitro* conditions against sheath blight pathogen by dual culture technique. Twenty ml of sterilized and cooled PDA was poured into sterilized petriplates. Fungal antagonists were evaluated by inoculating the pathogen at one side of the petriplate and the antagonist inoculated at exactly opposite side of the same plate by leaving 3-4 cm gap. For this, actively growing culture was used. In case of bacterial antagonist evaluation, two mycelial discs of the pathogen was inoculated and bacterial antagonist was streaked in the centre of the plate. After required period of incubation *i.e.* after control plate reached 90 mm diameter, the radial growth of pathogen was measured. Per cent inhibition over control was worked out according to equation given by Vincent (1947).The *Bacillus* spp. evaluated under *in vitro*were further checked under pot experiments in the Net house during *kharif*, 2019 to know their efficacy on plant growth parameters and disease inhibition activities. All the twelve strains of *Bacillus*spp, mass multiplied under laboratory, were used as both seed treatment and foliar application during maximum tillering stage. Pure cultures of the

Table 1:*In vitro* evaluation of twelve strains of bacterial bio-control agents, *Bacillus*spp against sheath blight disease

Bacterial Strains	Mean mycelial inhibition
B. subtilis (RB-12)	58.61 (49.96) efg
B. subtilis (RB-22)	66.39 (54.57) bcde
B. subtilis (RB-23)	53.33 (46.91) fg
B. subtilis (RB-26)	60.83 (51.26) def
B. subtilis (RB-28)	63.89 (53.06) cde
B. subtilis (RB-29)	72.99 (58.68) ab
B.amyloliquefaciens(RB-30)	70.28 (56.96) abc
B. megaterium (RB-31)	72.92 (58.64) ab
B. luciferensis (RB-32)	75.00 (60.00) a
B. subtilis (RB-33)	66.94 (54.90) bcd
B.toyonensis(RB-34)	61.11 (51.42) def
B. subtilis (NIPHM)	51.39 (45.80) g
P value	P=0.000
Tukeys HSD@0.005	1.894

Plate 1:*In vitro*dual culture assay of native Bacillus strains against*Rhizoctoniasolani*Kuhn
1. Control; Lane 1. B.subtillis, RB-12, RB-22, RB-23; Lane 2. RB-26, RB-28, RB-29, RB-30; Lane 3. RB-31, RB-32, RB-33, RB-34

bacterial strains were inoculated to nutrient broth and kept in incubator shaker for 36-48 hours. The broth with maximum bacterial growth was used for evaluation. Seed treatment was done @ 5g/kg of seeds and foliar application was @5ml/lit of water.

RESULTS

The data from the *in vitro* study of evaluating twelve strains of *Bacillus*spp revealed their significant efficacy against the sheath blight pathogen, *Rhizoctonia solani* Kuhn (Table 1, Plate-1). The highest growth inhibition (75.00%) was observed in RB-32 (*B. luciferensis*-BS17) followed by RB-31 (*B. megaterium*-BS11), RB-29 (*B.subtilis* -BS39) and RB-30 (*B. amyloliquefaciens*-BS5).All these three strains were significantly observed on par with each other with more than 70% inhibition of mycelial growth,whereas least inhibition of 51.39% was recorded in *Bacillus subtilis* (NIPHM).

The results from the pot experiments were found that, there was a significant variation among the twelve strains of *Bacillus*sppwith respect to plant growth, disease reduction and yield increase. Maximum germination was found in RB-31 (94%) and 17.67 tillers in RB-32, whereas, 14.33 panicle bearing tillers, mean panicle length of 21cm, highest mean panicle weight of 2.13g and maximum grain number of 220.67 were observed in RB-31.

CONCLUSION

Significant inhibition of mycelia growth ofsheath blight pathogen, *RhizoctoniasolaniKuhn* was observed by treating with twelve strains of *Bacillus*spp under in vitro dual culture technique. These strains of *Bacillus*spp were evaluated under pot experiments as seed treatment and foliar application. All the treatments significantly increased growth parameters such as germination, vigour, tiller number, panicle bearing tillers, panicle length, grain number and reduced disease incidence.

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LIGHT TRAP CATCHES OF BROWN PLANT HOPPER OF RICE IN RELATION TO METEOROLOGICAL FACTORS

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The Brown plant hopper (BPH), *Nilaparvata lugens* (Stal) (Hemiptera: Delphacidae) is an important insect pests of rice (*Oryza sativa* L.). BPH is a serious pest in Asia today, primarily because of the unpredictability of the infestation and the dramatically severe damage it causes. They damage plants directly by sucking the plant sap, causing plant wilting or hopper burn (Turner et al., 1999). Damage to the rice crop is caused directly by feeding on the phloem and indirectly by transmitting plant viral diseases (Powell et al., 1995). Meteorological factors play an important role in seasonal abundance, distribution and population build up of insect pests, it is difficult to find direct cause and effect relationship between any single factor and pest activity because the impact of meteorological factor on pests in usually compounded. The present study was undertaken to find out the influence of meteorological parameters namely temperature (Maximum and Minimum), relative humidity (Morning and Evening), rainfall and sunshine hours on light trap catches of BPH so that active period may be ascertained for controlling the BPH in the field conditions.

METHODOLOGY

The present study was conducted at Agricultural Research Station, Nellore during kharif, 2018-19. Assessment of BPH population was done by light trapping. 200-watt electric light source was used for the trapping of insects. Light trap was installed in ARS farm long ago, 6 m above the ground level with collection pan below the light source. The trap was operated from 18.00 to 6.00 hours. The trap catches have been recorded daily throughout the year. The daily meteorological data were collected from Agro-meteorological observatory, Department of Agronomy at ARS, Nellore. These observations were compiled and averaged to weekly.

RESULTS

During the study period twoPeaks of BPH and WBPH catches were observed, first peak during 33rd standard week (1015, 367 insects/week, respectively) and second peak was recorded during 45th standard week (4000, 4450 insects/week, respectively)

Correlation analysis revealed that there is a significant negative correlation between BPH and WBPH catches and temperature where as non-significant positive correlation with relative humidity, rainfall. Light trap catches of BPH and WBPH had significant negative correlation with maximum temperatures with correlation coefficient r=0.582 (P= 0.006), r=0.678 (P= 0.001), respectively, and minimum temperature was also negatively correlated with BPH and WBPH catches (r=0.434, P= 0.049 and r=0.498, P= 0.021, respectively). There is non-significant negative correlation was recorded with sunshine hours (r=0.030, P=0.869; (r=0.0101, P=0.664). The morning relative humidity recorded positive correlation with BPH and WBPH catches with correlation coefficient r=0.276 (P= 0.225) and r=0.290 (P= 0.203), respectively and evening relative humidity was also positively correlated (r=0.283, P= 0.215; r=0.334, P= 0.139). Rainfall also positively correlated with BPH and WBPH catches (r=0.112,

Table: Seasonal occurence of BPH and WBPH of Rice through light trap catches and correlation with weather factors.

Std. wk	catches/week		Temperature (0C)		Relative humidity (%)		Sunshine hours	Rainfall (mm)
	BPH	WBPH	Max	Min	RHM	RHE		
27	0	10	35.5	27.3	34.3	27.3	2.4	29.6
28	45	50	33.2	25.9	33.5	25.9	5.0	6.6
29	90	90	34.4	26.0	34.5	25.9	3.5	17.6
30	110	100	36.5	27.3	36.4	27.3	4.7	4
31	175	95	34.1	25.6	66.7	54.1	4.9	53
32	256	71	33.6	25.9	79.7	61.0	4.2	3.2
33	1015	367	34.3	25.5	70.7	59.7	6.1	8.3
34	105	43	32.5	24.8	88.9	74.7	4.4	76
35	152	102	33.4	25.6	84.4	65.0	1.2	44.4
36	130	35	34.0	25.4	80.7	65.4	4.8	46.2
37	100	10	33.8	25.9	77.7	68.6	6.7	0.2
38	50	0	32.2	25.2	79.0	60.4	6.2	68.2
39	155	100	31.4	24.2	86.6	68.0	2.9	74
40	80	70	32.6	26.0	84.4	64.6	3.1	19.6
41	0	0	32.8	26.3	79.7	73.0	6.5	0
42	0	0	32.8	25.1	80.6	67.1	2.4	32.4
43	0	0	33.1	25.2	78.4	73.9	5.6	0
44	570	1140	28.9	22.9	91.0	93.1	1.9	87.7
45	4000	4450	28.7	23.9	91.0	73.9	3.6	47.3
46	1390	1905	29.6	24.6	83.1	85.1	5.5	13
47	135	135	31.2	24.4	85.1	70.7	4.5	0
Correlation co-efficient (r)-BPH		—	-0.582 (P=.001)	-0.434 P=(.049)	0.276 (P=.225)	0.283 (P=.215)	-0.030 (P=.896)	0.1122 (P=.628)
WBPH		—	-0.678 (P=.001)	-0.498 (P=.021)	0.290 (P=.203)	0.334 (P=.139)	-0.101 (P=.664)	0.169 (P=.465)

P= 0.628; r=0.169, P= 0.465). Sam and Chelliah (1984), Murugeson (1987) and Suthamasamy (1989) also reported that temperatures had no significant effect on light trap catches of BPH. Relative humidity and rainfall were positively correlated to the BPH trap catches where as temperature and sunshine were negatively correlated with to the BPH catches. In contrast, krishnaiah et al.m (2006) and Chaudary et al (2014) reported a positive correlation with temperature and sunshine.

CONCLUSIONS

Among six weather factors (Maximum temperature, Minimum temperature, Morning relative humidity, Evening relative humidity, Rain fall and Sunshine), maximum and minimum temperatures has significant negative correlation with BPH and WBPH light trap catches.

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IRC/TM-3/PP-3

INCIDENCE OF RICE LEAF MITE IN RELATION TO WEATHER FACTORS

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Rice, *Oryza sativa* L., is a staple food crop in India, which is attacked by many insect pests out of which leaf mite, *Oligonychus oryzae* Hirst (Acari: Tetranychidae) attack heavily during summer season (Early kharif) causing yellowing of leaves. Meteorological factors play an important role in seasonal abundance, distribution and population build up of insect pests it is difficult to find direct cause and effect relationship between any single factor and pest activity because the impact of meteorological factor on pests in usually compounded.

Considering the severity of leaf mite on rice during summer the present investigation was under taken and information gathered is presented hereunder.

METHODOLOGY

The present course of investigation was conducted at Agricultural Research Station, Nellore, and Andhra Pradesh during Early kharif season (April –August) of 2018. Rice varieties NLR 40024 and TN 1 (Susceptible check) were selected for the study and normal agronomic practices were followed during the crop growth under unprotected conditions. The observation on leaf mite incidence were made at weekly intervals throughout the crop season, total number of leaves and damaged leaves were counted and per cent damage or per cent incidence was calculated. The meteorological data were collected from Agro-meteorological observatory, Department of Agronomy at Agricultural Research Station, Nellore.

RESULTS AND DISCUSSION

The study revealed that the incidence of mite found to build up from second fort night of June (6.9 %) and this trend continued up to last week of July (91.3 %). The peak incidence was associated with rise in temperatures. Correlation coefficient studies indicated that the temperature and relative humidity have significant effect on the rice leaf mite incidence. The leaf mite incidence was positively correlated to temperatures and negatively correlated to the relative humidity. There is no significant correlation with rainfall.

CONCLUSION

Abiotic factors play important role on incidence of leaf mite on rice during Early kharif season.

Table : Seasonal occurrence of insect pests of Rice through light trap catches

Std week	Leaf mite (%) Leaf damage NLR 40024	TN 1	RF (mm)	Temp ($_0$C) Max.	Min.	RH (%) Morn.	Even.	SSH
28	6.9	4.6	6.6	33.2	25.9	33.5	25.9	5.0
29	31.19	42.69	17.6	34.4	26.0	34.5	25.9	3.5
30	92.1	74.7	4	36.5	27.3	36.4	27.3	4.7
31	88.3	83.8	53	34.1	25.6	66.7	54.1	4.9
32	91.3	88.2	3.2	33.6	25.9	79.7	61.0	4.2
33	79.3	74.9	8.3	34.3	25.5	70.7	59.7	6.1
34	80.1	76.8	76	32.5	24.8	88.9	74.7	4.4
35	—	48.8	44.4	33.4	25.6	84.4	65.0	1.2

IRC/TM-3/PP-4

RESPONSE OF RICE CULTURES OF BAPATLA TO STORED GRAIN INSECTS

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The rice weevil *Sitophilus oryzae* (L.), the lesser grain borer *Rhyzopertha dominica* (F.) and the Angoumois grain moth *Sitotroga cerealella* (Olivier) are referred as primary insect pests of stored grains; are the most common and destructive insect pests of rough rice. The red flour beetle *Tribolium castaneum* (Herbst) is a major pest commonly found in stored cereal grains, processed grain products, oilseeds, nuts and dried fruits. It is predominant throughout the year in raw rice stored at warehouses in spite of all the prophylactic and control measures taken up by the management on schedule basis. Researchers observed that the infestation by *R. dominica* varied across the paddy varieties. The varieties of paddy with low amylose content tend to be more susceptible to infestation by *S. cerealella* than those with high amylose content (Ashamo and Khanna, 2006). Similarly, significantly higher numbers of rice weevil and grain moth adults were found in BPT 5204, while the bold varieties with thicker husk were less prone to infestation than the varieties having fine grain with thinner husk (Swamy *et al.*, 2019). Hence, it is essential to understand the preferences of insects to paddy grains of different cultures under storage to formulate pest management strategies and to know the influence of physico-chemical characters of grains in the selection process.

METHODOLOGY

A total of ten different cultures of rice including released and pre-released culturesobtained from Agricultural Research Station, Bapatla, Andhra Pradesh were screened against lesser grain borer and red flour beetle with rough rice and milled rice, respectively under free-choice conditions at Post Harvest Technology Centre, Bapatla during 2020. For this, grain (100 g) of each individual culture was taken in plastic containers and arranged in a circle in a small storage bin (45 cm diameter and 55 cm height) and a total of 200adults of test insects were released in the centre so that the insects get equal opportunity to secure the food grains of their choice. Then the setup was closed with lid and allowed for three days. After three days of insect release, the grains along with the insects were transferred individually into plastic jars (250 ml). Thus, experiments were conducted in three replications. The progeny development was observed in terms of adult emergence at 60 days after release of insects. Thousand grain weight was also measured. Further, in an attempt to understand the role of biochemical constituentsfor preference or non-preference of the test insects, proteins, phenols and total sugars in milled rice were analysedusing standard methods of estimation. The data on insect population and biochemical parameters were subjected to statistical analysis of variance by completely randomized design for the test of significance.

RESULTS

There were significant differences in the population buildup of lesser grain borer and red flour beetle in rough rice and milled rice, respectively (Table 1). Significantly higher number of lesser grain borer adults were found in BPT 2766 (336.67 no.s) while the red flour beetles were more in BPT 3111 (59.0 no.s) compared to the remaining paddy varieties. BPT 2411 recorded very less population of both lesser grain

Table 1: Response of grain insects to certain rice cultures along with the physical and biochemical factors

Tr. No.	BPT cultures	Adult population (no.)		1000 grain weight (g)	Biochemical constituents		
		Lesser grain borer	Red flour beetle		Protein (%)	Phenols (mg GAE /100g)	Total Soluble Sugars (%)
T_1	BPT 5204	196.33 (13.98)	36.33 (6.0)	13.87	8.90	43.67	60.31
T_2	BPT 2295	223.33 (14.91)	44.33 (6.66)	13.91	6.20	46.0	59.78
T_3	BPT 2411	13.0 (3.58)	18.67 (4.31)	18.69	5.14	28.0	60.47
T_4	BPT 2595	217.0 (14.73)	52.0 (7.18)	13.92	6.51	55.67	59.98
T_5	BPT 2782	97.67 (9.87)	49.0 (7.0)	14.26	6.39	46.0	60.79
T_6	BPT 2766	336.67 (18.30)	54.0 (7.35)	14.56	5.36	43.0	54.91
T_7	BPT 2776	195.0 (13.95)	41.33 (6.42)	13.82	6.12	42.33	53.30
T_8	BPT 2846	208.33 (14.37)	40.67 (6.37)	13.85	11.39	83.33	52.38
T_9	BPT 2841	278.0 (16.67)	46.67 (6.84)	12.66	10.62	272.33	53.22
T_{10}	BPT 3111	90.33 (9.50	59.0 (7.68)	16.94	10.92	87.33	51.70
	SEm±	0.59	0.26	0.02	0.14	7.06	0.30
	CD(p=0.05)	1.73	075	0.06	0.42	20.81	0.87

The values in parentheses are square root transformed values

borer and red flour beetles (13.0 and 18.67 no.s, respectively), indicating it is the least preferred grain compared to other cultures. All the tested rice cultures are categorized under medium slender grain type. BPT 2841 is a variety with black colored kernels while BPT 3111 is with red colored kernels. The thousand grain weight of these cultures ranged from a minimum of 12.66 g (BPT 2841) to a maximum of 18.69 g (BPT 2411). Proteins and phenols were found at lowest in BPT 2411 (5.14% and 28.0mg GAE /100g, respectively). The presence of total sugars was also significantly higher in BPT 2782 (60.79%) followed by BPT 2411 (60.47%). The content of phenols was exceptionally high in BPT 2841 (272.33 mg GAE / 100g), however it recorded significantly higher populations of *R. dominica* and *T. castaneum*adults (278.0 and 46.67 no.s, respectively).

CONCLUSION

Though there were significant differences in the contents of biochemical constituents of rice in the test varieties, they could not exert significant influence on insect development. The physical factors such as grain hardness and husk thickness probably contribute for insect preference. However, BPT 2411 was the least susceptible culture as it allowed the development of very less population of *R. dominica* and *T. castaneum*insects.Knowledge of insect preferences and susceptibility of varieties is useful in early detection of infestations so that timely control measures can be taken in order to reduce losses both in terms of quantity and quality of stored produce.

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IRC/TM-3/PP-5

CONTROL POTENTIAL EVALUATION OF BACTERIAL BIO – AGENTS IN RICE INFESTED WITH *MELOIDOGYNE GRAMINICOLA*

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Rice (*Oryza sativa*) is the most important food crop of the developing world and the staple food of more than half of the world's population. Over 200 species of plant parasiticnematodes have been reported to be associated with rice (Prot, 1994).Among them *Meloidogyne graminicola* is the predominant species of rice causing substantial yield loss. Under the immense concern for environmental hazard and other negative impacts of chemical pesticides, the bio control of nematode pest using potential bio agents is gaining popularity among the farmers day by day. *Pseudomonas fluorescens* and *Bacillus* spp. are among the most commonly used bacterial bio-control agents (BCAs) against plant parasitic nematodes. With this background three bio-agents viz. *Bacillus pumilus*, *Bacillus subtilis* and *Pseudomonas fluorescens* were compared along with a standard nematicide Carbofuran and untreated control to evaluate their control potential and effect on growth parameters of root-knot nematode infested rice.

METHEDOLOGY

The experiment was carried out during *Kharif*, 2018 following Completely Randomized Design (CRD) in net house of Department of Nematology, O.U.A.T, Bhubaneswar. Well pulverised sandy loam soil was collected from sick plots of AICRP on Nematodes with pathognic level of *M. graminicola* poupaltion. Earthen pots of 15 cm diameter were cleaned and surface sterilized and Pots were then filled with infested soil (1 kg). Bio-agents were added to the pot soil as per the treatment requirements given below

Treatments -

T_1 = Sowing of seeds in infested soil enriching with *Bacillus pumilus* @20mg/pot (kg soil)

T_2 = Sowing of seeds in infested soil enriching with *Bacillus subtilis* @20mg/pot (kg soil)

T_3 = Sowing of seeds in infested soil enriching with *Pseudomonas fluorescens* @ 20mg/pot (kg soil)

T_4 = Sowing of seeds in infested soil with application of Carbofuran @60mg/pot (kg soil)

T_5 = Untreated check

Three to four seeds of susceptible variety of rice *i.e.* Naveen were taken and sown in each pot. After 10 days of germination one plant per pot was maintained by thinning.. 45 DAS the observations on plant growth parametersrice plant and nematode population parameters of were recorded & subjected to statistical analysis

RESULTS

Among all treatments T_4 (Soil application of Carbofuran @ 60 mg/pot) exhibited highest shoot length (42.37cm) followed by T_3 (41.32 cm) with Soil application of *Pseudomonas fluorescens* @ 20mg/ pot (kg soil). Maximum enhancement of root length was observed in T_4 (32.72%) followed by T_3 (21.91%). In case of fresh shoot weight T_1 & T_2 were at par but significantly inferior than T_4 which exhibited the highest value. Maximum change of dry shoot weight over control was 59.49% in case of T_4 followed by 39.54% in case of T_3 and T_1 (24.29%) being the lowest.. Maximum fresh root weight (4.07g) was observed in

Table 1: Effect of bio – agents and carbofuran on plant growth parameters of rice plant

Treatments	Shoot Length (cm)		Root Length (cm)		Fresh shoot weight (g)		Fresh root weight (g)		Dry shoot weight (g)		Dry root weight (g)	
	Mean	% increase over control	Mean	% increase over control	Mean	% increase over control	Mean	% increase over control	Mean	% increase over control	Mean	% increase over control
T_1	37.12	1.69	13.37	2.45	7.07	24.69	3.45	25.45	2.20	24.29	1.62	15.71
T_2	38.37	5.12	14.50	11.11	7.15	26.10	3.40	23.63	2.25	27.11	1.67	19.28
T_3	41.32	13.20	15.91	21.91	7.50	32.27	3.70	34.54	2.47	39.54	1.80	28.57
T_4	42.37	16.08	17.32	32.72	8.52	50.26	4.07	48.00	2.77	59.49	2.02	44.28
T_5	36.50	-------	13.05	-------	5.67	-------	2.75	-------	1.77	-------	1.40	--------
SEm(±)	0.67	-------	0.43	-------	0.17	-------	0.08	-------	0.08	-------	0.05	-------
CD(0.05)	2.01	-------	1.29	-------	0.50	-------	0.23	-------	0.26	-------	0.14	-------

T_1 = *Bacillus pumilus* @20mg/pot (kg soil); T_2 = *Bacillus subtilis* @20mg/pot (kg soil); T_3 = *Pseudomonas fluorescens* @20mg/pot (kg soil); T_4 = Carbofuran @60mg/pot (kg soil); T_5 = Untreated check

T_4 followed by T_3 (3.70g). Maximum dry root weight was noticed in T_4 (2.02g) followed by T_3 (1.80g). Number of galls/root system was found to be minimum in T_4 (Carbofuran). Among the bacterial antagonists *Pseudomonas fluorescens* (T_3) exhibited lowest number of galls/root system (10.50). The final root-knot nematode population both in soil as well as plant root was minimum (77.25 J_2/200 cc soil & 8.00/root system) in T_4 followed by 96.75 J_2/200 cc soil and 12.25/root system in T_3. The reproduction rate was also minimum in T_4 (0.3). Among bio-agents T_2 (*Bacillus subtilis*) and T_3 (*Pseudomonas fluorescens*) were found to have equal effect on the multiplication of root-knot nematode with reproduction rate 0.4 each while T_1 (*Bacillus pumilus*) reduced the nematode multiplication with reproduction rate of 0.5.The overall

Table – 2 : Effect of bio-agents and Carbofuran on root-knot nematode multiplication

	No. of galls/root system	% decrease over control	No. of egg masses/ root system	% decrease over control	INP/ 200cc soil	FNP/ 200cc	NP In Root Soil	Total NP	% decrease over control	Rf = Pf/Pi
T_1	12.0	68.00	7.75	65.16	216.33	107.50	15.75	553.25	53.81%	0.5
T_2	14.0	62.00	7.50	66.29		102.50	17.5	530	55.75%	0.4
T_3	10.50	72.00	5.0	77.52		96.75	12.25	496	58.59%	0.4
T_4	7.75	79.33	3.75	83.14		77.25	8	394.25	67.09%	0.3
T_5	37.50	–	22.25	–		230.25	46.75	1198	–	1.1
SEm(±)	0.94	–	1.81	–	–	1.17	0.60	–	–	–
CD(0.05)	2.82	–	2.44	–	–	3.53	1.79	–	–	–

T_1 = *Bacillus pumilus* @20mg/pot (kg soil); T_2 = *Bacillus subtilis* @20mg/pot (kg soil); T_3 = *Pseudomonas fluorescens* @20mg/pot (kg soil); T_4 = Carbofuran @60mg/pot (kg soil); T_5 = Untreated check ; INP - Initial Nematode population/200 cc soil; FNP - Final Nematode population/200 cc soil; NP - Nematode Population; Rf - Reproductive factor increased shoot length, root length, fresh shoot weight, dry shoot weight, fresh root weight and dry root weight by $T_4$was 16.08%, 32.72%, 50.26%, 59.49%, 48.00% and 44.28% respectively which is very close to the result of T_3. It also decreased the number of galls, number of egg massesand total nematode population in soil and root by 79.33%, 83.14% and 67.09% respectively.The reduction in root galling and increase in plant growth parameters by *Pseudomonas fluorescens* may be due to increased colonization, competition for nutrition, change in host response, release of toxic chemicals etc. Our findings also corroborates with the facts of Compant *et al.* (2005), that root colonization by *Pseudomonas sp* frequently enhances root growth, development, crop productivity, resistance to abiotic stress and uptake of nutrients.

CONCLUSION

From this experiment it was concluded that that soil application of Carbofuran @ 60mg/pot with 1 kg soil at the time of sowing exhibited maximum increase in growth parameters of rice and maximum decrease of *M. graminicola* population in plant over untreated check followed by soil application of *Pseudomonas fluorescens* @ 20mg/pot with 1 kg soil.

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IRC/TM-3/PP-6

BIO-INTENSIVE APPROACHES FOR MANAGING STEM BORER IN AROMATIC RICE IN ASSAM

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Rice *(Oryza sativa L.)* is one of the most significant cereals and is the staple food for more than 2 billion people.The aromatic rice of Assam is a unique class under *Sali* rice traditionally known as 'Joha' which is known for its unique aroma, superfine kernel, good cooking qualities and excellent palatabilityand has a tremendous scope as a cash crop for earning foreign exchequer (Das *et.al.*, 2010).During the last decades, there is stagnancy in rice yield due to various limiting factors. Rice is attacked by a number of pests, the stem borer being the major one which cause losses up to 90 per cent if not managed timely.Globally, yellow stem borer alone causes yield losses of 10 million tones and accounts 50% of all insecticides used in the rice field. The excessive use of chemical insecticides created many ill effects, such as reduction of biodiversity, high pesticide residues, secondary pest outbreak, environmental pollution and imbalanced ecological diversity. It is of prime importance to conserve natural enemies to restore ecological balance in the ecosystem. As an alternative to chemical control, bio-intensive approaches have been gained momentum in managing the pest in recent years which help in bio-ecological conservation. *Keteki Joha* is an aromatic rice variety and no information is gathered on the new approach till now.

Therefore, the present study was undertaken in the aromatic rice to gather information on managing stem borer using bio-intensive approaches considering the growing demand of organic aromatic rice.

MATERIALS AND METHODS

Seed treatment was done by soaking the seeds in a solution of *Pseudomonas florescense* prepared @10g/litres of water per kg of seed for 12 hours. Root dipping was done by dipping the seedlings in a solution containing *Azospirillum* and Phosphate solubilising bacteria (PSB) @10g /litre of water. Nursery bed was prepared by applyingvermicompost @500g/sqm and rice husk ash @100g/sqm and mixing well with the soil at the time of preparation of the field.The thirty days old seedlings were transplanted into the main field in two blocks, Biointensive pest management (BIPM) and Farmers' practices (FP) block. In BIPM block, vermicompost @2.5 tonnes and 300 kg mustard oil cake per hectare half as basal and half as top dress at active tillering stage were applied and Mass trapping of stemborer by placing pheromone traps @20 Nos/ha was retained throughout thecrop season by replacing 3-4 times @5mg lure at 20 days interval.The tricho cards of*Trichogramma japonicum* @5cc egg card were placed six timesweekly from first week after transplanting. The arahar plant and marigold were planted in the rice bunds of BIPM plot to attract natural enemies and pollinating agents. Neemazal1% EC was applied when the population of stem borer attained economic injury level. The farmer's practices was the untreated control. The stem borer incidences as well as population of the major predators and the parasitoid which effect the stem borer population were recorded on the 10 hills selected randomly from each plot at weekly interval. To assess stem borer, observations were recorded on total tillers (TT), dead hearts (DH) at 30 and 50 DAT, while stem borer damage at heading stage was expressed as percent white ears based on counts of panicle bearing tillers (PBT) and white ear heads (WEH).The data of different parameters were analyzed using ANOVA. The different

Table 1. Stem borer incidences and population of natural enemies during *kharif*, 2019-20

Parameter	DH %		WEH% % damage		Coccinellid Nos /hill		Ground beetles Nos/hill		Spider No/hill	
	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP	BIPM	FP
Mean	3.25	16.56	4.38	15.33	5.39	1.57	8.56	2.34	17.5	12.3
t- value	8.34**	9.98**	3.17**	2.41**	0.83NS					
P-value	<0.01	<0.01	<0.01	<0.01	<0.01					

** Significant

treatment means were separated by least significant difference test (LSD) at p = 0.05.

RESULTS AND DISCUSSION

The stem borer incidencewas significantly lower in BIPM plots as compared to FP plot.The dead heart was observed in BIPM(3.25%) plots lower than FP plots (16.56%DH) and white ear head was observed in BIPM (4.38%) which was lower than FP (15.33%). The natural enemies were found to be higher in BIPM than that of FP. The population of coccinellid and ground beetle were significantly higher in BIPM than that of FP, but the population of spider in BIPM was non-significantly higher than that of FP. The grain yield was significantly higher (4.4 ton/ha) in BIPM than that of FP plots (3.3 ton /ha).

Sharma *et al.* (2018) also reported similar results where management module comprising alternate spraying with neem-based formulation coupled with release of egg parasitoids and monitoring of stem borer with sex pheromone traps significantly reduce incidence of dead hearts and white ear heads as well as higher population of natural enemies in BIPM fields in comparison to conventional plots in aromatic rice.

CONCLUSIONS

Lower incidences of stem borer may be due to non use of insecticides as because of which stem borer population could not be able to develop resistance against insecticides rather they are repelled by the use of neem products. As the flowering plants attract the natural enemies, because of which there were higher population of predators in BIPM plot. Higher yield was obtained in BIPM plot indicating a period of three years for stabilization of yield in organic practices in aromatic rice variety.The present work substantiates the fact that bio-intensive integrated pest management technologies provide a sustainable system for the ecofriendly management of insect pests in rice.

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IRC/TM-3/PP-7

EFFICACY OF *TRICHOGRAMMA JAPONICUM* IN COMPARISON TO CHEMICAL CONTROL AGAINST RICE YELLOW STEM BORER

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Rice (*Oryza sativa* L.) is one of the most vital staple foods for more than half of the world's population influencing the livelihoods and economics of several billion people. Among the various pests infesting rice, stem borer is chronic and widely distributed pest which occurs in every rice field in every season. Globally, yellow stem borer alone causes yield losses of 10 M t accounting for 50 per cent of all insecticides usage in rice field (Huesing and English, 2004). The farmers depend upon a great deal of insecticide applications to manage this pest, even though a lot of insecticide applications are not effectual. The over reliance on chemicals may leads to numerous undesirable consequences like disrupting natural enemy complexes, secondary pest outbreak, pest resurgence, development of insecticide resistance and environmental pollution. It is imperative to adopt the alternate methods or integrated methods to manage the rice stem borer effectively without any menace to the ecological niche. One such biological based pest management strategy is inundative release of egg parasitoid, *Trichogramma japonicum* to suppress the menace of rice stem borer damage both in terms of per cent dead hearts and per cent white ears during vegetative and reproductive stages, respectively. Hence, a extension research study was undertaken in farmers field to aware them on benefits of ecological based pest management in comparison to insecticidal application.

METHODOLOGY

An extension research study was conducted in farmer's fields of Krishna district (three locations), Andhra Pradesh for a period of three successive *kharif* (2016, 2017 & 2018) seasons and three successive *rabi* (2016-17, 2017-18 & 2018-19) seasons to evaluate the effectiveness of release of *T. japonicum* in reducing the damage of yellow stem borer in comparison to chemical control. The tricho cards *i.e.*, *T. japonicum* @ 1 lakh ha^{-1} were released in selected field (one ha) for 6 times starting from 15 DAT at 7-10 days intervals as biological control. For chemical control, foliar spray of chlorantiniliprole 18.5 SC 200g a.i. ha^{-1} thrice at tillering, active tillering and panicle initiation stage were practiced n one ha area of selected farmers field. Both the bio control based and chemical based control treatments were imposed in the same fields for all the seasons *i.e.*, three *kharif* and *rabi* seasons from 2016-2018. All the agronomic practices were adopted as per recommendations but no plant protection chemicals were imposed in bio control plots. The per cent dead hearts and white ears caused by rice stem borer during vegetative and reproductive stages were recorded in both the treatments imposed plots and evaluated their efficacy. Starting from 15 days after transplantation (DAT), observations on stem borer incidence both in terms of per cent Dead Hearts (DH) and White Ears (WE) was recorded on randomly selected 100 hills at 15 days interval as per the formulae here under.

$$\text{DH per cent} = \frac{\text{Total number of dead hearts in 25 hills}}{\text{Total number of tillers in 25 hills}} \times 100$$

$$\text{WE per cent} = \frac{\text{Total number of white ears in 25 hills}}{\text{Total number of panicle bearing tillers in 25 hills}} \times 100$$

RESULTS

The results upon data analysis revealed that there was no significant difference of stem borer damage among the treatments during *kharif* 2016 and *rabi* 2016-2017 with 2.79 & 2.36 and 3.25 & 2.36 per cent dead hearts in bio-control plots and chemical control plots, respectively. Similarly, with respect to white ears also there were no significant results in bio-control plots and chemical control plots encompassing 4.63 & 4.12 and 3.94 & 3.23 per cent white ears. It was quite interesting to notice that from third season *i.e*., *kharif* 2017 there was a significant difference in damage levels between both the treatments. The per cent dead hearts in *T. japonicum* released plots was 2.18, 2.09, 2.36 and 1.95 during *kharif* 2017, *rabi* 2017-18, *kharif* 2018 and *rabi* 2018-19, respectively as against comparatively higher dead hearts damage in chemical treated plots with the corresponding values of 3.28, 4.15, 4.65 and 4.35, respectively. The analogues results were also documented with respect to per cent white ears in *kharif* 2017, *rabi* 2017-18, *kharif* 2018 and *rabi* 2018-19 seasons. The per cent white ears in bio control imposed plots were 2.85, 1.87, 2.05 and 1.65 as against higher in chemical based plots with 3.55, 3.15, 2.98 and 3.84 per cent during *kharif* 2017, *rabi* 2017-18, *kharif* 2018 and *rabi* 2018-19 seasons, respectively. The predators (spiders and mired bugs) population was enhanced in biocontrol treated plots and declined in chemical applications imposed plots. Further, studies on recovery of *T. japonicum* from the bio control fields were monitored by releasing unparasitized tricho cards (*Corcyra* eggs) of nearly 1 lakh per hectare. The results clearly showed the natural subsistence of *T. japonicum*population in the bio control plots where in 35-40 per cent of the *Corcyra* based cards were parasitized by *Trichogramma* spp. under natural conditions. The farmer's perceptions were change and motivated to adopt these biological based management practices by viewing the above results in their own fields.

CONCLUSION

Keeping in view the deleterious nature of insecticides in unbalancing the ecosystem, disturbing the ecological niche and effectiveness of bio control agents in suppressing the rice yellow stem borer damage both in terms of per cent dead hearts and white ears, it is the need of the hour to encourage the farmers in adopting biological based pest management approaches in managing rice yellow stem borer damage. Besides, effective pest management the inundative release of egg parasitoid, *Trichogramma japonicum* had exhibited increased natural enemy fauna without any harmful tribulations leading to sustainability in rice production.

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EFFICACY OF NEW COMBINATION FUNGICIDE AZOXYSTROBIN 5.6% + TEBUCONAZOLE 10% + PROCHLORAZ 20% EC AGAINST RICE SHEATH BLIGHT

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Sheath blight is one of the most wide spread and important fungal disease of rice world-wide. Sheath blight is caused by a fungus (*Rhizoctonia solani*) one of the destructive diseases across the rice growing regions of the world, specifically, East and South-East Asian countries. The disease is endemic to areas where temperature and relative humidity are high and cultivation is intensive, common during *kharif* season in Andhra Pradesh. Yield losses of 5-10% have been estimated in tropical lowland rice in Asia (Savary *et al*. 2000). Yield losses due to sheath blight disease are reported to the range from 5.2-50% depending on various factors. A modest estimation of losses due to sheath blight disease alone in India has been up to 54.3%. The pathogen is challenging to manage because of its extensively broad host range and high genetic variability and also due to the inability to find any satisfactory level of natural resistance among the available rice germplasm. Hence, the disease is being managed by changing cultural practices and use of chemical fungicides.

The disease is more pronounced in delta soils of Andhra Pradesh where rice-rice cropping system is predominant. Fungicides with multifaceted effects on the sclerotial germination, mycelia growth inhibition and hampering the disease spread will have an ideal inhibitory effect on the pathogen as well as disease spread. Several new molecules are available in the market and farmers are going for 3-4 sprays for the control of sheath blight under field conditions. Keeping in view, with the advent of new fungicides, the present investigation was undertaken to assess the efficacy of new combination fungicide Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC (MAFRM-13) at different doses against sheath blight of rice.

METHODOLOGY

The efficacy of new combination fungicide Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC (MAFRM-13) was tested at different doses against sheath blight of rice variety, Swarna (MTU-7029) under field conditions during *kharif* 2017 and 2018 seasons. The other fungicides azoxystrobin 23% SC, tebuconazole 25.9% EC, prochloraz 45% EC and azoxystrobin 11% + tebuconazole 18.3% SC were also included in the study. In total, there were 8 treatments and four replications. A standard fungicide azoxystrobin 23% SC was used for comparison along with control. A pure culture of a virulent isolate of *Rhizoctonia solani* was multiplied on typha leaf bits. Artificial inoculation with *R. solani* was carried out at maximum tillering stage with colonized typha bits placed between the tillers of rice plant, 5-10 cm above the water level. Twenty days after inoculation, sheath blight was assessed by Standard Evaluation System (IRRI, 2014) for rice.

RESULTS

During 2017, the combination fungicide Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC was found effective against rice sheath blight disease @ 3.0 ml/l followed by 3.5 ml/l showing least sheath blight incidence (12.03%, 12.97%) and severity (15.81%, 15.65%), respectively as against 92.70% and 60.74% in control. The standard fungicide Azoxystrobin 23% SC @ 1.0 ml/l was also found highly effective recording sheath blight incidence (1.55%) and severity (3.01%) respectively. The other fungicide, Azoxystrobin 11% + Tebuconazole 18.3% SC @ 1.5 ml/l was also found effective recording the lowest sheath blight incidence and severity (5.78%, 7.50%), respectively.

During 2018, the combination fungicide Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC @ 3.5 ml and 3.0 ml was found effective against rice sheath blight recording low disease incidence (2.18%, 3.82%) and severity (3.73% and 7.93%), respectively as against 34.91% and 50.13% in control. The standard recommended fungicide, Azoxystrobin 23% SC @ 1.0 ml/l was also found highly effective showing disease incidence and severity of 1.78% and 2.17% respectively. The other fungicide, Azoxystrobin 11% + Tebuconazole 18.3% SC @ 1.5

Table 1. Efficacy of Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC in the management of rice sheath blight disease

Treatments	Dose/l	Sheath blight incidence (%)			Sheath blight severity (%)			Yield (Kg/ha)		
		2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC (MAFRM-13)	3.0 ml	12.03 (20.04)	3.82 (9.18)	7.92 (16.25)	15.81 (23.17)	7.93 (13.44)	11.87 (20.07)	6704	5400	6052
Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC	3.5 ml	12.97 (19.44)	2.18 (8.20)	7.57 (14.95)	15.65 (21.47)	3.73 (11.04)	9.69 (17.35)	7051	5211	6131
Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC	4.0 ml	21.21 (27.12)	5.91 (11.54)	13.56 (20.35)	23.09 (28.09)	11.02 (15.98)	17.06 (24.24)	6460	4915	5687
Azoxystrobin 23% SC	1.0 ml	1.55 (6.88)	1.78 (7.03)	1.67 (7.22)	3.01 (9.67)	2.17 (8.47)	2.59 (9.17)	6515	5426	5970
Tebuconazole 25.9% EC	1.5 ml	34.71 (36.09)	9.66 (17.05)	22.19 (28.05)	34.50 (35.86)	15.68 (22.35)	25.09 (29.92)	6634	5053	5844
Prochloraz 45% EC	2.0 ml	60.57 (51.59)	18.02 (24.82)	39.30 (38.78)	45.76 (42.55)	26.64 (30.65)	36.20 (36.97)	5018	4033	4526
Azoxystrobin 11% + Tebuconazole 18.3% SC	1.5 ml	5.78 (13.40)	2.00 (6.08)	3.89 (11.36)	7.50 (14.87)	3.73 (8.53)	5.62 (13.70)	6957	5062	6010
Untreated control (Water spray only)	-	92.70 (74.40)	34.91 (36.20)	63.81 (53.02)	60.74 (51.28)	50.13 (45.08)	55.44 (48.13)	4098	3437	3768
		*Sig	*Sig	*Sig	*Sig	*Sig	*Sig	*Sig	*NS	*Sig
	CV	17.60	40.33	13.67	13.96	34.88	12.71	12.56	15.96	7.87
	SEm+/-	2.74	3.03	1.63	1.98	3.39	1.58	388.13	386.81	216.94
	CD(0.05)	8.31	9.18	4.95	6.01	10.29	4.81	1177.40	1173.40	658.09

*Mean of three replications, Figures in the parentheses are arc sine transformed values.

ml/l was also found effective showing the disease incidence (2.0%) and severity (3.73%) respectively.

The pooled data revealed that Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC @ 3.5 ml/l and 3.0 ml/l was found effective against sheath blight showing least disease incidence (7.57%, 7.92%) and disease severity (9.69%, 11.87%), respectively as against 63.81% and 55.44% in control. The standard fungicide Azoxystrobin 23% SC @ 1.0 ml/l was also found highly effective showing disease incidence and severity (1.67% and 2.59%), respectively. The other fungicide, Azoxystrobin 11% + Tebuconazole 18.3% SC @ 1.5 ml/l was also found effective recording the disease incidence and severity (3.89% and 5.62%) (Table1).

CONCLUSION

Azoxystrobin 5.6% + Tebuconazole 10% + Prochloraz 20% EC @ 3.5 ml/l could be useful for the management of sheath blight of rice.

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NOVEL STRATEGIES TO COMBAT RICE BLAST DISEASE

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Rice (*Oryza sativa* L.) is major cereal crop that constitutes staple diet for more than 3.5 billion people around the world (CGIAR, 2016) and it has major role in global food and nutritive security. India accounts for 20 per cent of the world's rice production, thus standing in second position (172.58 million tonnes) following China and the productivity in India is 3878.2 kg/ha (FAO, 2018). An account of 70 different diseases caused by fungi, bacteria, viruses or nematodes have been reported on rice. An account of 70 different diseases caused by fungi, bacteria, viruses or nematodes have been reported on rice (Zhang et al., 2009). Among all diseaseses of rice, blast disease is most devastating causing significant economical loss each year. It has been estimated that 60 million people could have been fed with the amount of rice it destroys every year. Rice blast disease is caused by a fungus *Magnaporthe grisea*, causes lesions on leaves, stems, peduncles, panicles, seeds. An integrated approach with more emphasis on novel strategies is the need of the hour to combat with rice blast disease. Objective of this summary is to cite some novel components contributing towards disease resistance.

Identification and pyramiding of blast reistance genes- The genetic basis of the resistance to rice blast is explained by more than 86 dominant R genes and approximately 350 QTLs out of which twenty three R genes have been molecularly characterized till date.Each of these R genes act only against a subset of existing pathogen races, the identification of new R genes/alleles is still essential to the breeding of endurably resistant varieties by different strategies such as pyramiding of different resistance genes. Some major genes cloned till date in rice are Pib, Pb1, Pita, Pi9, Pi2, Pizt, Pid2, Pi33, Pii, Pi36, Pi37, Pikm, Pit, Pi5, Pid3, Pikh, Pish, Pik, Pikp, Pia, PiCO39, Pi25, Pi1, pi21, Pi50. Marker assisted backcross breeding is currently in trend for transferring blast resistant genes to target cultivars.

Understanding the molecular basis for rice-Magnaporthe interaction-

The major part in rice *M. oryzae* interactions include resistance R genes and PRRs from rice, as well as effectors and PAMPs from *M. oryzae*. R genes and effectors are well studied in gene for gene resistance. However fewer PRRs and PAMPs have been identified till now in rice" *M. oryzae* pathosystem.

Proteomic analysis-

PR proteins come into action after infection for plant defence. Recent advancement in mass spectrometry (MS) and apoplastic and plasma membrane protein isolation methods facilitated the identification and quantification of subcellular proteomes during plant-pathogen interaction. Biological pathways involved in pathogen infection, plant response, and disease progression can be effectively studied by using this tool. Proteomic studies conducted during rice"M. oryzae interaction have led to the identification of several proteins positively involved in pathogen perception, signal transduction, and the adjustment of metabolism to prevent plant disease. Some of these proteins include receptor-like kinases (RLKs), mitogen-activated protein kinases (MAPKs), and proteins related to reactive oxygen species (ROS) signaling and scavenging, hormone signaling, photosynthesis, secondary metabolism, protein degradation, and other defense responses. Moreover, gene expression and alteration in allele can also be analysed by using real time PCR. Thus proteomics research can provide an insight into molecular interaction and protein responsible for disease resistance in rice.

Systemic acquired resistance and Induced systemic resistance-

Upon infection with pathogen some novel molecules inside plant induce synthesis of phenolics and enzymes responsible for degrading pathogen structures. Phenyl ammonia lyase, peroxidase, poly phenol oxidase play major role in disease resistant response.Phenyl propanoid pathway is mainly involved in synthesis of the above. Salicylic acid (SA), Jasmonic acid (JA), Ethylene (ET) have been well studied for their role in inducing systemic resistance in plants. These use multiple signaling pathways to activate defence related compounds. Some other signal transducing molecules are Benzothiadiazole (BTH), Cupric chloride, cycloheximide. Some PGPR like *Pseudomonas fluorescens* can also be used for ISR reponse.

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ASSESSMENT ON BPH RESISTANT VARITIES OF RICE IN GANJAM DISTRICT

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Rice is the primary staple food of more than two billion people of Asia and for about hundreds of millions of people of Africa and Latin America. It is noted from the report that 4180.22 thousand ha area of the total agriculture area of Odisha is occupied by rice cultivation (Anon, 2017). It is projected that the demand for rice will increase by 1.1% per year and to meet this demand, the rice production should grow at the rate of 2.9% per year. In order to meet the increasing demand for rice it is recommended to use high yielding varieties and increase cropping intensity (Anon, 2017). These practices can't be long lasting in increasing the rice production as they promote the development of phytophagous pests. The brown planthopper (BPH) is an economically important and widespread insect pest of rice (*Oryza sativa* L.). Incidence of BPH infestation in Odisha has been drastically rising in the recent years and more hopperburn incidences had been reported. The damage caused to the rice plants could be in the form of direct and indirect damage. Direct damage is caused from the injury due to oviposition and from the excessive sucking of the rice plant sap (Heong and Hardy, 2009). Dehydration due to sap removal caused the leaves of heavily infested plants to turn yellow, wilt and die, a symptom known as hopperburn. Heavy infestation results in significant yield loss and deterioration of the quality of grains. Hopperburn could usually be observed on crops at the maximum tillering stage or around 80 days after sowing (DAS) which usually coincided with the emergence of the third generation of the invading population in the field.The indirect damage could result from untimely application of insecticides could provide effective control against BPH. However, large scale chemical control is usually difficult and expensive. Repeated sprayings of broad spectrum insecticides could also affect the natural balance existing between the insect pest population and their natural enemies. It could also lead towards resistance development to a particular insecticide used. Considering the undesirable effects of pesticides, a logical approach to BPH management would be to use biologically based alternative such as the use of host plant resistance, which is also more in line with the integrated pest management programme concept.

METHODOLOGY :

An On-Farm Testing experimant on "Assessment On BPH tolerant varities Of rice In Ganjam district" was conducted on farmers' field in different parts of Ganjam district under supervision of Krishi Vigyan Kendra, Ganjam-I, Bhanjanagar during *kharif* 2018 and 2019. The soil was texturally sandy loam with low in available N (198.36 kg/ha), medium in available P (18.74 kg/ha) and high in available K (289.36 kg/ha) and low in organic carbon (0.32 %). The experiment consisits of 3 treatments i.e. TO1: Farmers' practice (Cultivation of Swarna), TO2: Cultivation of Hasanta and TO3: Cultivation of Pooja with seven replications.The seedlings of all varieties were transplanted after 25-30 days in nursery. Recommended package of practices were followed in all treatments. Yield parameters of all treatments were recorded on treatment basis.

Hasanta and Pooja varieties are both longer duration in nature (140-150 days) with semi dwarf plant height. Pooja variety is photosensitive in nature, suitable to shllow land and performs better under late planting

Treatments	No. of BPH/hill		Chaffy grain (%)		Grain Yield (q/ha)		Gross return (Rs./ha)		Net return(Rs./ha)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
FP : Farmers' practice	7.3	16.4	27.3	38.4	38.6	37.4	65620	63580	31620	29580
TO1: Cultivation of Hasanta	-	-	8.1	6.4	43.2	44.2	73440	75140	39440	41140
TO1: Cultivation of Pooja	4.2	12.3	10.4	12.8	40.4	41.6	68680	70720	34680	36720

with aged seedlings with yield potential about 5 t/ ha.Hasanta variety is resistant to BPH with yield potentail of about 5.5 t/ha.

RESULTS:

Among the three treatments tested in farmers' field, the treatment consisting of cultivation of Hasanta variety showed 0 (zero) BPH/hill indicating complete resistance to brown plant hopper than farmers' variety (7.3 and 16.4) and cultivation of pooja (4.2 and 12.3) in both the years. Significantly lesser number of chaffy grains (8.1 and 6.4 in 2018 and 2019 respectively) were observed in Hasanta variety than farmers' variety (27.3 and 38.4) and cultivation of pooja (10.4 and 12.8) respectively in both the years. Significantly higher grain yield (43.2 and 44.2 q/ha respectively) was obtained in cultivation of Hasanta variety and lowest grain yield was obtained in farmers' practice i.e. cultivation of Swarna variety (38.6 and 37.4 q/ha respetively)in both years.Highest gross returns (Rs. 73440 and 75140 /ha respectively) and net returns (Rs.39440 and 41440/ha respectively) were obtained from cultivation of Hasanta variety and lowest returns were obtained from farmers' practice.

CONCLUSION

From on farm testing experiment , it was concluded that Hasanta variety performed better in Ganjam disrict than cultivation of Swarna and Pooja variety in both the years. So the BPH resistant variety Hasanta woud be priortised for cultivation in the district with various front line demonstration programmes.

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CHARACTERIZATION OF BLAST RESISTANCE IN CSSLS DERIVED FROM WILD ACCESSIONS USING STANDARD DIFFERENTIAL BLAST ISOLATES

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Wild species are known to be innately diverse and carry important donor genes for genetic improvement of cultivars. Blast disease is one of the major threats to rice crop production worldwide.The pathogen can infect every part rice plant and across the crop stages from seedling to panicle development causing devastating damages up to 80%. The present study was designed to detect genetic variation of blast resistance in a set of wild introgression lines developed in the background of Indian popular cultivars Swarna and MTU1010. The introgression lines under this study showed an extensive variation for blast resistance across the different isolates tested. Standard differential monogenic lines with different resistance genes along with the susceptible genotypes were used as control in blast screening.

In the present study, chromosome segment substitution lines derived from cultivar/ wild accessions developed under ICAR National Professor Project, IIRR (Rao et al., 2018) were shared with JIRCAS. CSSLs were screened against blast isolates using standard differential system to characterize the resistance to various isolates. The lines were phenotyped at the seedling stage with twenty-four blast isolates collected from geographically distinct rice growing regions. The goal was to determine if theses CSSLs contained resistance genes effective against diverse blast isolates.

METHODOLOGY

Two populations involving 396 chromosome segment substitution lines along with parents of Swarna /*Oryza nivara* IRGC81832 (BC_2F_{10}) (90 Lines), MTU1010 / *Oryza rufipogon*IC 309814 (BC_4F_4) (306 lines) along with their recurrent parents were used in the studywere screened at TARF, JIRCAS, Ishigaki, Japan for blast resistance.

The I population Swarna /*Oryza nivara* IRGC81832 (BC_2F_{10}) was subjected to blast screening in the month of June 2019at TARF, JIRCAS, Ishigaki, Japan. Set of 24 virulent isolates from11 countries across Asia and Africa were used to test the resistance in glass house conditions. Isolates JPF507, JPF500, JPF509, JPF574, JPF494 (Japan), PHL4, PHL8, PHL14, PHL16 and PHL11 (Philippines), LAO12, LAO3 (Lao PDR), KNY135(Kenya), CHN125 (China), IDN280 (Indonesia), NIG1 (Nigeria), VTN64, VTN119 (Vietnam), BAN440, BAN491 (Bangladesh), CAM116, CAM106 (Cambodia) BEN60, BEN54 (Benin) were used in this study.The population of MTU1010 / *Oryza rufipogon* was screened with only one isolate JPF517 for blast resistance characterization during July 2019.

Plant material was raised in glasshouse along with parents susceptible checks like LTH and US2.The plant material preparation, spore isolation, cultivation, inoculation of blast disease were carried out with following protocols for evaluation of blast disease in rice (Hayashi et al., 2009).

RESULTS

The CSSL population, Swarna/*O.nivara*, were phenotyped at the seedling stage with twenty four blast isolates collected from geographically distinct rice growing regions. Phenotyping or evaluation of blast resistance on 8th day of inoculation showed wide variation in the resistance pattern across the genotypes as well as isolates.

Most of the isolates showed a minimum score of zero among the CSSLs, except BEN54, JPF494, PHL4, VTN64 and JPF507. Four isolates showed a maximum score of less than 5 viz., JPF500 (4.5), JPF507 (4.5, JPF 509(3.5) and JPF514 (4.5). Highest average disease score was sby JPF494 followed by VTN64 and lowest by JPF 509 among the genotypes. 20 lines showed resistance reaction below an average score of 2 with four lines NPK32, NPK4, NPK56 and NPK86 with less than 1.5 disease score.

306 CSSLs along with parents MTU1010 / *Oryza rufipogon* IC309814 (BC_4F_4) were screened using one virulent isolate JPF517.The average disease score of two replications varied from 2.9 to 3.3 with a mean of 3.13 disease score in the population showing a greater number of lines towards susceptible reaction. LinesMTU4, MTU17, MTU37, MTU138, MTU249, MTU250 and MTU283 showed highly resistant reaction in both the replications.

CONCLUSION

Wide variation in blast resistance was observed among the CSSLs, varying from highly resistant to highly susceptible lines were detected while screening with different isolates. Same lines showed different resistant reaction to various isolates This shows the existence of a monogenic or few gene combinations in various lines. Broad spectrum resistance to multiple isolates are observed in lines viz., NPK32, NPK4, NPK56 and NPK86. This may be either due to the presence of multiple resistance genes or due to hotspot regions in genome which has a pleotropic resistance reaction pattern to various isolates. These lines are potential source as a donor in resistance breeding programmes and also to develop mapping populations to detect novel genes with broad spectrum durable resistance.

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IRC/TM-3/PP-12

SCREENING OF RICE GENOTYPES AGAINST SHEATH ROT

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Sheath rot (Sarocladium oryzae) of rice emerged as one of the major diseases in almost all rice-growing ecosystems of India. The disease become a highly destructive with a high variability in yield loss levels varying from 20 to 85% (Pushpam *et al*., 2019). The disease occurs on the upper leaf sheath enclosing the young panicles. Under sever conditions the sheaths become rotten, discolored and the grains of the partially emerged panicles shows chaffiness and sterility. It is a serious problem during south west monsoon in India. Host plant resistance is an ecofriendly and economical alternative for the management of the disease. Pal *et al.* (2015) have reported 10 lines of rice as moderately resistant against sheath rot. Pushpam *et al*. (2019) have also reported 4 resistant and 6 moderately resistant lines against the disease. The present study was carried out to find out resistant source against sheath rot.

METHODOLOGY

The screening trial was carried out with 60 rice genotypes including 2 susceptible checks (1 NC + 1 LC) showed resistance against sheath rot during previous years trials. These selected genotypes were again evaluated for three years (*Kharif*-2015 to 2017) against the disease under natural conditions in the field to find out the source of stable resistance at Main Rice Research Station, Anand Agricultural University, Nawagam, Kheda , Gujarat, India. The field was prepared for sowing by leveling thoroughly. Care has been taken that water should not be stagnant in the field because of rainfall. Nursery was grown on raised beds. All the recommended agronomical practices were adopted for raising the nursery of all genotypes. The experiment was established under transplanting conditions in the spacing of 20x15 cm. The row length of each genotype was 1.5 m along with two replications. The one row of each susceptible variety *i.e.* TN-1 and Gurjari was transplanted after every 5 tested genotypes. In addition to this the experimental plot was surrounded by border rows of susceptible variety Gurjari. The basal application of NPK at 40:25:00 Kg/ha was applied at the time of transplanting. Whereas 60 kg/ha nitrogen was applied as top dressing in two splits at 25 days after transplanting and at panicle initiation stage. Ten metric tones of FYM was applied per hectare, while 300 kg/ha castor cake was also applied. Manual weeding was adopted to keep the experimental field free from weeds. Plant protection measures adopted only to prevent insect-pests damage to the crop. The need based irrigation was applied. The observations were recorded through screening by adopting 0–9 SES (Standard Evaluation System).

RESULTS

The results showed that out of 60 rice genotypes including 2 susceptible checks (1 NC + 1 LC), none of the genotype was found immune towards the disease. Whereas only one genotype was showed resistant reaction, twenty five genotypes were showed moderately resistant reaction and twenty three genotypes showed moderately susceptible reaction and eleven genotypes including susceptible checks TN-1

SES Scale (2013) for sheath rot

Rating Score	Description
0	No disease observed
1	Less than 1%
3	1-5%
5	6-25%
7	26-50%
9	51-100%

Disease rating scale	Response	No. of entries	Germplasm/ Genotypes
0	Immune	Nil	Nil
1	Resistant	1	IET-25611
3	Moderately resistant	25	IET-24438, IET-24486, IET-25390, IET-25196, IET-25400, IET-25421, CR DHAN-201, IET-25654, IET-25655, , IET-24709, IET-25332, IET-24735, IET-24744, C. Muthyalu, IET-25089,TaraoriBasmati, Sabita, IET-24797, IET-25669, IET-25673, Ranjit, Bahadur, IET-24935, PJTSAU-BR-155-2, IET-25671
5	Moderately susceptible	23	IET-25394, IET-25114, IET-25126, IET-25584, IET-25618, IET-25637, IET-24721, IET-24395, IET-25324, IET-24331, IET-25520, US-312, IET-24122, IET-24427, Imp. Samba Mahsuri, IET-24401, IET-24904,TNRH-282, PJTSAU-BR-14,PJTSAU-BR-16, DRRBL-155-2, PJTSAU-BR-155-2, VL-31802
7	Susceptible	11	IET-25523, IET-24424, CSR-36, IR-64, IET-24040, IET-24737, IET-25676, PJTSAU-BR-126, PJTSAU-BR-165-1, TN-1(NC), Gurjari(RC)
9	Highly susceptible	Nil	Nil

and Gurjari were showed susceptible reaction. The consistent resistant reactions found in the genotype IET-25611 against sheath rot. The genotype can be used in breeding programme for developing glume discolouration resistant varieties.

CONCLUSION

Growing concern about the health issues due to pollution, minimized use of fungicides is being discussed, which for some reason is not practical. Host plant resistance is most promising to combat sheath rot of rice. Based on above findings it is concluded that the consistent resistant reactions observed in the genotypes IET- 25611against the sheath rot of rice. The genotypes can be used in breeding programme for developing sheath rot resistant varieties. Further the study and time to time field evaluation of rice genotypes against sheath rot is entertained.

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IRC/TM-3/PP-13

FIELD SCREENING OF DIFFERENT GENOTYPES AGAINST YELLOW STEM BORER AND LEAF FOLDER IN RICE

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Rice (*Oryza sativa* L.) is the world utmost importantcrop and a main food for half of theworld's population.India is the second largest rice producing country in the world. In Indian environment more than 100 species of insect-pests are known to attack and about 20 are of economic importance and considered to be major insect-pests. Among them yellow stem borer is a monophagous pest of paddy. The infestation of this pests in rice from seedling to maturity stage of the crop,their larvae bore in to stem, feed on the inner tissue and habitually one larva occurs per tiller. The feeding of larva cause 'dead heart' symptoms at the vegetative stage and during reproductive stage, feeding of larvae particularly in panicle initiation and earhead emergence, cause 'white ear' symptoms. The foliage feeders in rice, leaf folder has become a major threat to rice production in India. Larva fold the leaves by stitching with silken threads and feed on the green mesophyll tissue resulting in white membranous patches that are visible from a distance in the rice field.Rice growers are choice to use hazardous pesticides for managing insect-pests that leads to numerous undesirableconsequences. Host plant resistance enables plants to avoid, tolerate or recover from the effects of insect-pests attack and has proved to be aneffective tool against insect-pests. In some cases, the combined nutritional and allelochemical alterations either improve the quality of the host plant as a source of food and can therefore be considered favorable to herbivorous insects or make the quality of host plant as source of food unfavorable to phytophagous insects.Using resistant varieties is an important component for integrated pest management in rice. Hence, conducted field screening trial for multiple resistant of different genotypes against yellow stem borer and leaf folder in rice.

METHODOLOGY

The screening experiment consisted of twentytwo genotypes of ricewere screened under field condition at MRRS, AAU, Nawagam during *kharif* 2018.The nursery of thesegenotypes was sown on well prepared raised beds and around Thirty days old healthy seedlings were transplanted with 2 seedling per hill. Each genotypes contained two rows with 20 plant andafter two raw of test entry one raw of local susceptible check GR 11 were transplanted. Transplanting was done at a spacing of 20 × 15 cm with two replications. No plant protection treatment was applied and more nitrogenous fertilizer were applied in the screening trial to create ideal condition for insect-pests development.Incidence of yellow stem borer and leaf folder was recorded on randomly selected 10 hills per culture. Observations on infestation of yellow stem borer were assessed by total tillers and number of dead heartsat vegetative stage and number of panicle bearing tillers and white earsat pre harvest stage were noted. Similarly, for leaf folder incidence, total number of leavesanddamaged leaves were recorded in each genotype. Finally, the per cent damaged leaves, dead heartand white earwere calculated using following formula, per cent DH/WE/DL=total number of DH/ WE/DL/number of TT/PBT/TLx100. Based on the damage rating and scale the status of rice culture was determined by the IRRI Standard Evaluation System (SES) for rice.

RESULTS

The result revealed that the rice genotype KAUPTB 0627-2-15 found least per cent damaged leaves (9.90%/hill) and found resistant against leaf folder. Whereas, genotype BPT 2766 (11.0%/hill), NWGR 12048 (11.9%/hill), NWGR 8001 (13.1%/hill), IC 466451 (13.5%/hill), Suraksha (13.9%/hill), SinnaSivappu (14.5%/hill),BPT 2795 (14.6%/hill), KAUPTB 0627-2-11 (15.2%/hill), MSM-3 (15.6%/hill), KAUPTB 0627-2-14 (15.7%/hill), BPT 2782 (15.7%/hill), RP 2068-18-3-5 (16.0%/hill), WGL 825 (17.1%/hill), W 1263 (18.4%/hill), BPT 2611 (18.9%/hill) and MSM-1 (19.0%/hill)were found moderately resistant with 3 damage score against leaf folder.While, GR 11 were found susceptible with Seven damage score against leaf folder(Table 2 and Fig. 1). The result of the present screening experiment interrelated with Chintalapati *et al.*, (2019)revealed that genotypes MP114 and MP108 with lower damage area and damage score against leaf folder.

The result on white ear headrevealedthat the lowest per cent white ear head damaged were observed in BPT 2611 (2.1%/hill), BPT 2782 (2.2%/hill), NWGR 12048 (3.3%/hill),MSM-3 (4.3%/hill) and KAUPTB 0627-2-15 (5.4%/hill)with one damage score and found resistant against yellow stem borer.While, Kavya (21.2%/hill), IC 466451 (19.0%/hill) KAUPTB 0627-2-11 (23.7%/hill)and RP 2068-18-3-5 (33.8%/hill)GR 11 (38.5%/hill)with 7 and 9 damage score andfound susceptible and highly

TABLE: Screening Of Different Entries Against Leaf Folder And Yellow Stem Borer During Kharif-2018.

Sr. No.	Name of genotypes	Leaf folder			Yellow stem borer					
		% DL	DS (0-9)	Status	% DH	DS (0-9)	Status	%WE	DS (0-9)	Status
1	BPT 2766	11.0	3	MR	4.8	1	R	7.5	3	MR
2	**BPT 2782**	15.7	3	MR	2.1	1	R	2.2	1	R
3	BPT 2795	14.6	3	MR	6.9	1	R	6.5	3	MR
4	RP 2068-18-3-5	16.0	3	MR	11.2	3	MR	33.8	9	HS
5	KAUPTB 0627-2-11	15.2	3	MR	11.3	3	MR	23.7	7	S
6	KAUPTB 0627-2-14	15.7	3	MR	6.6	1	R	14.0	5	MS
7	**KAUPTB 0627-2-15**	9.9	1	R	5.3	1	R	5.4	1	R
8	**NWGR 12048**	11.9	3	MR	2.2	1	R	3.3	1	R
9	NWGR 8001	13.1	3	MR	2.8	1	R	6.2	3	MR
10	SinnaSivappu	14.5	3	MR	4.4	1	R	13.0	5	MS
11	WGL 825	17.1	3	MR	5.1	1	R	6.5	3	MR
12	WGL 1062	21.1	5	MS	3.9	1	R	9.2	3	MR
13	IC 466451	13.5	3	MR	5.2	1	R	19.0	7	S
14	MSM-1	19.0	3	MR	3.8	1	R	13.8	5	MS
15	MSM-2	21.7	5	MS	3.3	1	R	12.7	5	MS
16	**MSM-3**	15.6	3	MR	2.3	1	R	4.3	1	R
17	Kavya	24.1	5	MS	4.5	1	R	21.2	7	S
18	**BPT 2611**	18.9	3	MR	2.0	1	R	2.1	1	R
19	W 1263	18.4	3	MR	1.0	1	R	20.0	5	MS
20	Suraksha	13.9	3	MR	3.4	1	R	14.7	5	MS
21	TN1	21.5	5	MS	4.4	1	R	12.9	5	MS
22	GR 11	36.2	7	S	15.7	3	MR	38.50	9	HS

Note: R- Resistant, MR-Moderately Resistant, MS- Moderately Susceptible, S- Susceptible and HS- Highly Susceptible

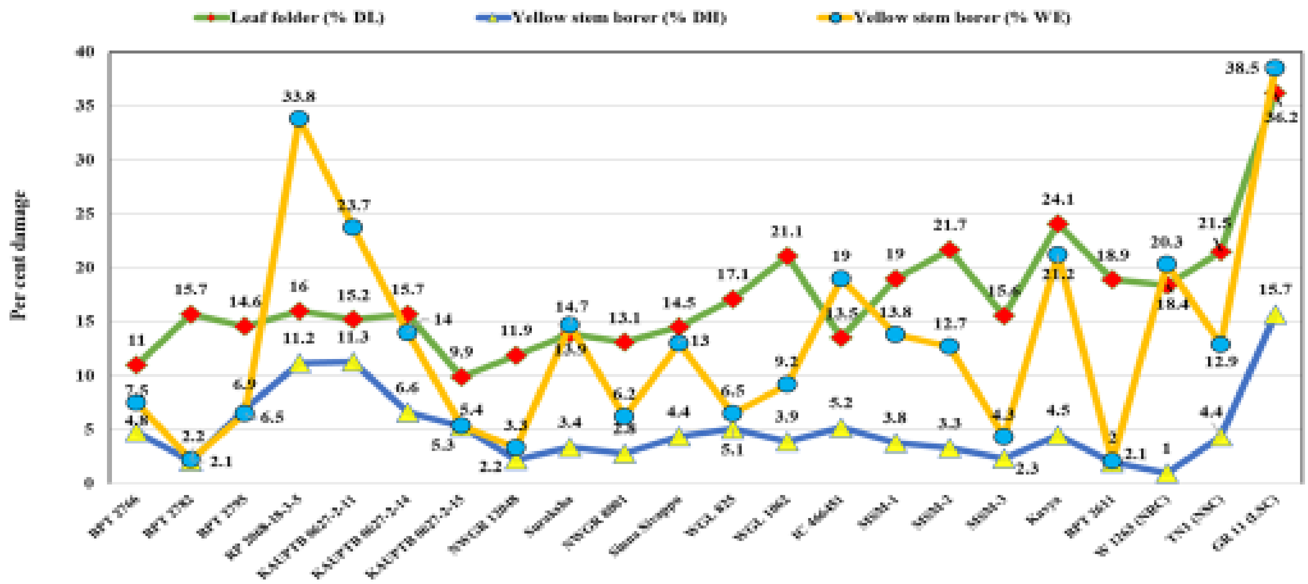

Fig. 1 Evaluation of different rice genotypes against leaf folder and yellow stem borer during *Kharif* 2018

susceptible, respectively(Table 2 and Fig. 1).Present findings are similar findings with Mandloi*et al.*, (2018) recorded lowest white ears in genotypes IR 36, R 1700- 302-1-156-1 and Shymlawere moderately resistant to yellow stem borer.

CONCLUSION

Rice yellow stem borerand leaf folderare important pests causing serious damage to rice crop. The result of this screening experiment revealed that therice genotype KAUPTB 0627-2-15 recorded lowest per centdamaged leaves dead heart and white ear head with one damage score and found multiple resistant against leaf folder and yellow stem borer. While, rice genotype BPT 2782, NWGR 12048, MSM-3 and BPT 2611 recorded least per cent dead heart and white ears and found resistant against yellow stem borer. The rice genotype shows multiple resistant it may be used as donors in resistant breeding programmes against leaf folder and yellow stem borer in rice.

INTRODUCTION

Therefore, present experiment concluded that rice genotype KAUPTB 0627-2-15 have multiple resistance traits against yellow stem borer and leaf folder. While, BPT 2782, NWGR 12048, MSM-3 and BPT 2611 show resistant against yellow stem borer.

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IRC/TM-3/PP-14

POTENTIAL DISTRIBUTION OF BROWN PLANTHOPPER, *NILAPARVATA LUGENS* (STAL) (HEMIPTERA: DELPHACIDAE) UNDER PROJECTED CLIMATE CHANGE SCENARIO

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Climate change is the key factor to regulate habitat distribution, species migration, seasonal population dynamics etc. of insect pests and diseases. The brown planthopper (BPH), *Nilaparvata lugens* (Stal) is one of the major insect pest of rice in Indian subcontinent. Being the world's second largest producer of rice, India suffers a severe loss due repetitive outbreaks of *N. lugens* in many part of the country. *N. lugens* has the capability of damaging rice cultivation from vegetative stage to reproductive stage and its infestation leads to "hopper burn" symptom (Pandi et al., 2017). The present study attempted to understand the potential suitable geographical areas for population dynamics and spread of BPH in India.

METHODOLOGY

A species distribution model, MaxEnt (maximum entropy modelling program was used to map a suitable habitat for BPH under current climate and future climatic scenarios for 2050 and 2070 (Elith et al., 2006). The annual mean temperature, precipitation of coldest quarter and precipitation seasonality are predicted the most important environmental variables determining the potential distribution of BPH. Model predictions of each location were imported to geographic information system (GIS) and maps were generated using ArcMap. Four approximate categories, low (<0.265), mild (0.265-0.4), moderate (0.4- 0.6) and high (0.6- 1) of BPH occurrence at current and future scenarios were defined based on the predicted habitat suitability. Spatial analyst tool in ArcGIS was used for computing the area (km^2) under each polygon. Absolute and percentage areas under each category of an index for current and future scenarios were calculated.

RESULTS

Our model suggested that approximately 30% area of India is currently suitable for *N. lugens*. Highly suitable habitats of BPH are predicted in the states of Tamil Nadu, Andhra Pradesh, Telangana, Odisha and Punjab. States like Chhattisgarh, West Bengal, Bihar, Jharkhand, Haryana, southern parts of Karnataka and coastal regions of Kerala have moderate suitability, while states like Maharashtra, Gujarat, Rajasthan, Madhya Pradesh, Himachal Pradesh, north eastern states, Jammu and Kashmir are unsuitable for BPH distribution. The Southern and Eastern rice-growing areas of Indian mainland are particularly predicted with high risk of *N. lugens* spread and dispersion due to better adaptability of the pest species to these regions climate as against very low to nil risk in the western India.

Our results revealed that total area under high risk was 7.5% (i.e. ~238192.6 KM^2) at present climatic scenario, which expected to increase into the tune of 15 to 27 % (i.e. ~519046.905.1 to 887744.5 KM^2) at 2050 and 15 to 58% (i.e. ~ 481090.5 to 1899556 KM^2) at 2070 (Fig. 1). The predicted percentage of high habitat suitable area for *N. lugens* at present is less than 10% in India, whereas in the projected climate scenario high habitat suitable area of *N. lugens* was doubled up at 2050 and tripled up at 2070. Likewise moderate habitat suitable area also

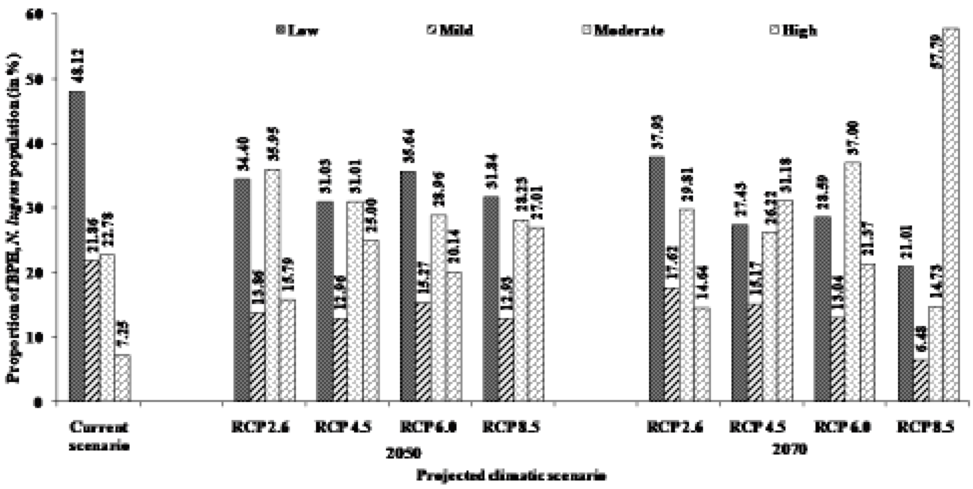

Figure 1. Proportion of BPH, *N. lugens* in India during current and projected (2050, 2070) climatic scenario.

increased from 20% at present to 30-40 % in near future at 2050 and 2070 (Fig. 1). Percentage changes of area suitable for *N. lugens* over current scenario exhibited a unique trend as low and mild habitat suitable area was found in negative trend, whereas moderate and high habitat suitable area was increased for both the projected scenario of 2050 and 2070 in all four RCP (RCP 2.6, RCP 4.5, RCP 6.0, RCP 8.5) (Fig. 1).

CONCLUSION

Present study is the first attempt to understand the *N. lugens* distribution and habitat suitability under the changing climate scenarios in India based on MaxEnt model with 10 climatic variables. The current study have produced clear and more accurate potential distribution map of *N. lugens* under current and future climate with more environmental factors, hence could more clearly reveal the survivability of the pest. Results from present study will be used by researchers, agriculture departments and policy makers for designing national-level *N. lugens* management strategies.

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CANDIDATE SCREENING FOR BROWN PLANTHOPPER, *NILAPARVATA LUGENS* RESISTANCE DONORS FROM FARMERS VARIETIES OF ODISHA FOR RICE BREEDING

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Globally, rice production is severely affected by brown planthopper, *Nilaparvata lugens*. Management of this pest with resistant genotypes is effective, environmental friendly and sustainable strategy and has received considerable attention worldwide. As far as BPH resistance, till now 39 genes/quantitative trait locus (QTLs) have been identified in both cultivated varieties and wild species of rice, of which only 14 genes were functionally characterized (Du et al., 2020). Understanding the genetic basis for *N. lugens* resistance and identification of new donors is vital to develop BPH resistant rice genotypes owing to resistance breakdown. Resistance to BPH has not yet been explored in Odisha farmer varieties (FVs) of rice; hencethe present investigation assessed the BPH resistance status through various phenotypic and genetic parameters.

OBJECTIVE

Main objectives were to identify and characterize BPH resistance genes specific to Indian biotype of BPH, which will be useful for the development of new BPH resistant rice varieties. In addition, these studies will also provide new insights into the host-plant interaction and molecular mechanism of BPH resistant genes.

METHODOLOGY

In the present work, a total of 600 farmer's varieties (FVs) were screened against *N. lugens* and subsequently 104 panel populations were genotyped using 87 molecular markers linked to 34 different *N. lugens* resistance genes for marker-trait association and genetic diversity. A total of 34 BPH resistant genes linked with 87 selected markers were analyzed for both GLM and MLM using TASSEL 5.0 software. Similarly, the estimates of gene diversity, major allele frequency, allele per locus, heterozygosity, polymorphism information content (PIC) values of the tested markers were calculated with the help of POWER MARKER Ver3.25 program. Besides, Structure Harvester Ver.0.6.193 software was used to find out the optimal K-value by using ÄK method. Darwin5 software was used to draw an unweighted neighbor-joining (NJ) unrooted tree (https://darwin.cirad.fr/). The principal coordinate analysis (PCoA), molecular variance (AMOVA) and population assignment was determined from the markers generated binary data/allelic data with the GenAlex 6.502.

RESULTS

The average polymorphism information content was 0.354 for 34 genes with 0.018 to 0.750 threshold level. 104 FVs were categorized into three main genetic groups according to cluster analysis (Fig. 1) and population structure. Resistant and moderately resistant FVs were separately distributed according to principal co-ordinate analysis. Analysis of molecular variance results displayed within population had maximum diversity (83%) and between populations had minimum (17%) diversity. In both generalized linear model (GLM) and Multi linear model (MLM), eight markers

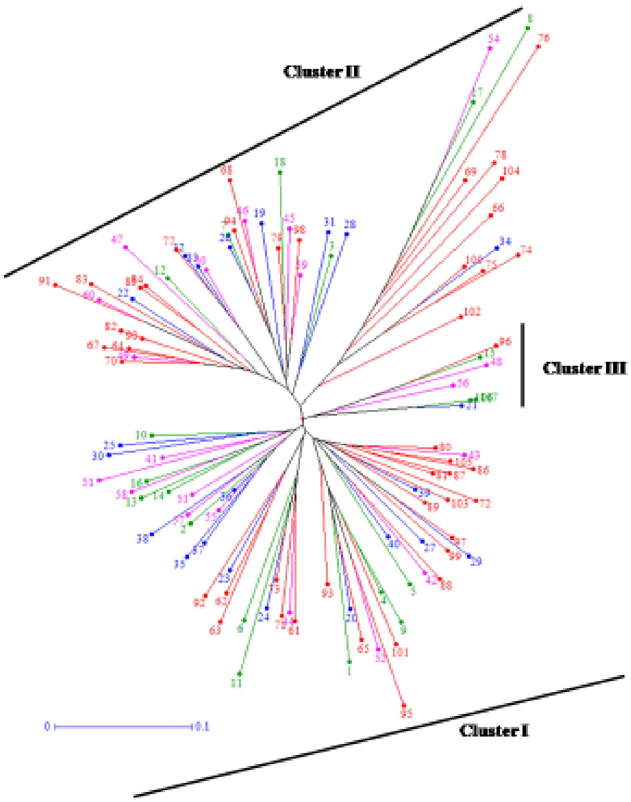

Figure 1. Unrooted neighbor-joining tree based on molecular markers linked to BPH resistance in 107 FVs. These FVs are represented corresponding to BPH resistance reaction (resistant, green; moderately resistant, blue; susceptible, red).

linked to Bph genes viz., RM222 (*Bph30*), RM6997 (*Bph6*), RM17006 (*Bph33*), RM6308 (*bph19*), RM463 (*bph2*), RM28561 (*Bph21*), RM586 (*bph4*), RM309 (*Bph26*) were found to be common for four different phenotypic parameters and RM5479 (*Bph25*) was significantly associated with honey dew excretion under GLM, whereas RM551 (*Bph33*) was found to have significant association with nymphal survival, percent damage, and feeding mark under MLM.

CONCLUSION

Our study strongly indicated that only 10 SSR markers *viz.*, RM222, RM6997, RM17006, RM6308, RM463, RM28561, RM586, RM309, RM5479, and RM551 were significantly linked to 9 BPH resistant genes namely, *Bph30*, *Bph6*, *Bph33*, *bph19*, *bph2*, *Bph21*, *bph4*, *Bph26*, and *Bph25*, respectively in relation to resistance reaction against Indian biotype of BPH, *N. lugens*. Out of reported nine associated BPH resistant genes only *bph4, Bph6, Bph21* and *Bph26* were functionally characterized and others needs to be characterized and has potential to be used in BPH resistant breeding programs. Thus, reported resistance genes either alone or in combination could be introgressed into elite varieties with genomic approach to develop robust resistant rice varieties against *N. lugens* biotype 4.

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STATUS OF RICE DISEASES IN *KONKAN* COASTAL ZONE OF MAHARASHTRA

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Rice is an important crop contributing approximately 23% of theper capita energy for six billion people worldwide. It is not just agrain; it is the lifeline and the second most important crop next towheat at global level (Tonnycisse 2005)]. It has been under cultivation from timeimmemorial, being grown under varying climatic conditions. It is widely affected by many diseases caused by fungi, bacteria, virusesand mycoplasma that results in significant yield losses (Ou 1985).The *Konkan* region of Maharashtra is pre-dominant rice growing belt of Maharashtra with an average productivity is 33.52q ha^{-1}. The farmers of this region cannot grow any crop other than rice in *Kharif*, because of high rainfall and geographically low land area, hence to know the present situation of the crop and disease incidence of this region the survey was undertaken with the following objective.

OBJECTIVE:

To know the status of diseases of rice prevailing in the konkan region of Maharashtra

METHODOLOGY:

The production oriented survey of was organized at dough to maturity stage of crop during the month of October-November 2019. With the introduction of high yielding new varieties of rice and imbalanced use of chemical fertilizers and pesticides it has been a change in the pattern of occurrence of several diseases. Hence the Production oriented survey for rice diseases was under taken and district wise disease prevalence of rice was recorded in this survey.

RESULTS:

The production oriented survey was undertaken during October 2019 in five districts viz., Palghar, Thane, Raigad, Ratnagiri and Sindhudurg of Konkan region of Maharashtra. The total area under rice cultivation in *kharif*, 2019 season in the region was 392392 ha out of these 89 % area were sown under rice during this year.it was found that blast incidence was very low at Palghar, Thane and Raigad districts. However it was medium in Sindhudurg and Ratnagiri districts of *Konkan* region. False smut incidence was very low in all the five districts, whereas, incidence of Sheath rot was medium range in Palghar, Thane, Raigad and Ratnagiri. In Sindhudurg district Sheath rot incidence was very low. Bacterial leaf blight disease was medium to severe in some part of Raigad and Thane district, whereas, it was not noticed in Sindhudurg district during the survey. Incidence of bacterial leaf blight disease was found severe in balegaon village of Murbadtahsil of Thane districts and severe in Antore village and nearby villages of Pen tahsil of Raigad districts. Sheath blight incidence was low to medium in Raigad and Ratnagiri districts. Grain discolouration was also noticed in all the districts but the range was very low.

CONCLUSION:

During the survey it was noticed that bacterial blight disease of rice is becoming severe followed by blast , sheath sheath rot and sheath blight.

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DETERMINATION OF THE PATHOGEN CAUSING GRAIN DISCOLOURATION IN RICE

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Grain discolouration is gradually evolving as an important disease of rice in India. The disease causes yield loss and deteriorates the quality of rice. Many researchers reported the disease to be caused by complex pathogens like bacteria, fungi, viruses and environmental factors etc. For efficient management of a disease, correct identification of the pathogen is essential. Therefore, an attempt was made to determine the causal pathogen of rice grain discolouration based on its morphological and molecular characteristics.

MATERIALS AND METHODS

Infected rice seeds were obtained from NRRI, Cuttack and were used for isolation of the pathogen using potato dextrose agar (PDA) following standard protocol. The inoculated plates were incubated at 26±2!. The isolation of the fungus from infected grain sample was repeated more than five times to make sure same organism was obtained in each isolation.

Morphological identification

The colour and growth diameter of the fungal colony was observed for preliminary identification. The morphological characters studied under the compound microscope were the appearance of the hyphae and conidia. These are important preliminary parameters in identification of a fungus.

Molecular identification

The DNA was extracted from fungal mycelium following standard CTAB method described by Murray and Thompson, 1980 with some modification. About 0.5 gm mycelium was ground with liquid nitrogen and further processed to obtain DNA which was then stored in TE buffer at -20!. The ITS1-5.8S-ITS2 regions of candidate fungus was amplified by PCR using primers ITS1 (5'-TCCGTAGGTGAACCTGCGG - 3') and ITS4 (5'-TCCTCCGCTTATTGATATGC - 3') (White et al, 1990). The amplified single specific band was eluted, consequently purified using gel extraction kit (Bangalore Genei, India) and sequenced (AgriGenome Pvt Ltd, India). The generated sequences were BLAST analyzed in NCBI for identification.

RESULTS

Colonies were fast growing, brown to greyish black with a black reverse. The colony diameter measured about 11 mm and 82 mm after one day and seven days of inoculation respectively. The conidia were often curved (lunate), the sub terminal cell enlarged and conspicuously larger than the remaining cells, pale brown at both ends with 3–5 septa. The size of the conidia measured 17-21 x 10-12 µm.

The amplification product of ITS regions was S 600 bp. The ITS regions of the fungus was sequenced and upon identity search in NCBI database revealed 100% similarity match with that of*Curvularia lunata*. The ITS sequence was submitted to NCBI having the accession number, **MN372449**.

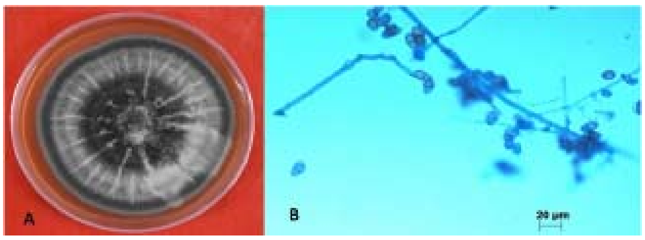

Fig. A 10-day-old *Curvularia lunata* grown on potato dextrose agar media (A) and its conidial structure as seen under compound microscope (B).

CONCLUSION

Grain discolouration is emerging as an important rice disease. Based on the morphological and molecular assays, the pathogen was identified as *Curvularia lunata*, (Wakker) Boedijn. The future research may focus on management of the disease by fungicides, biological control or by use of resistant genotypes.

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IRC/TM-3/PP-18

IDENTIFICATION OF RICE GALL MIDGE BIOTYPE AT NELLORE, ANDHRA PRADESH

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Rice is one of the major food grain crops in India.A study carried out by Rockfeller foundation (Herdt, 1991) revealed that seven out of 20 major challenges in rice production are biotic factors thatinclude insect pests and diseases. Among the biotic factors, insect pests cause about 10-15 per cent yield losses, accounting for an estimated yield loss of 21-51 per cent. Yellow stem borer, brown plant hopper and gall midge are thekey pests in rice causing 25-30 per cent, 10-70 per cent and 15-60 per centyield losses respectively. Rice crop is attacked by a number of insect pests of which gall midge continues to be one of the key biotic stresses constraining rice production across different rice ecosystems in India.

Due to wide cultivation of high yielding varieties over years resulted in the emergence of new virulent population capable of overcoming resistance. The study on characterization of gall midge biotype at field level is urgently needed. Hence, the present study was taken up to identify the rice gall midge biotype in Nellore.

METHODOLOGY

Seventeen differentials along with two checks (TN-1: susceptible check and NLR 34449: local check) were evaluated against the rice gall midge during rabi, 2019 to identify the gallmidge biotype in farmer's field at Varigonda village, Nellore. Single seedlings of 25 numbers in each row were transplanted per each differential with a spacing of 15x15 cm. After every 10 entries, the susceptible check (TN-1) was transplanted. No weedicide was applied during the experimentation. All the agronomic practices were followed as per the recommended package of practices.

The observations on damaged plants on hill basis and number of healthy and infested tillers (Silver shoots) per 20 hills were recorded at 30 and 50 days after transplanting.The percent damaged plants and percent silver shoot damage was calculated. Each entry under 5 groups was rated either resistant (R) with less than 10% plant damage or susceptible (S) with higher damage. Based on their pattern of resistance or susceptibility, the biotypes in test location was differentiated as biotype 1 (R-R-R-S-S), biotype 2 (S-R-R-S-S), biotype 3 (R-S-R-S-S), biotype 4 (S-S-R-S-S), biotype 4M (S-S-S-R-S), biotype 5 (R-R-S-S-S) and biotype 6 (R-S-S-S-S) (Vijaya Lakshmi *et al.*,2006).

RESULTS AND DISCUSSION

Gall midge incidence at Varigonda was very low at 30 DAT, highest per cent plant damage was observed at 50 DAT in TN 1 (75.00%) and nil damage was recorded in Kavya, W 1263 and ARC 6605 of group I, Madhuri L9 of group II, RP 2068-18-3-5, Aganni and B 95-1 of group IV. From the table 1, it is evident that all the entries in the group I were found to be resistant to existing unknown biotype of rice gall midge population at Nellore and it is following the pattern nearer to Biotype VI (R-S-S-S-S) as in the revised group of differentials given by Vijaya Lakshmi *et al.* (2006).

The reaction pattern observed in the differentials tested at Varigonda, Nellore is quite different from the prescribed pattern. In contrary, perfect reaction

Table 1. Reaction of differentials in GMBT during *rabi* 2019-20 (30 DAT) at Varigonda, Nellore

Group	Entry No.	Differential	Gene	TP	30 DAT		50 DAT		Reaction pattern
					%DP	%SS	%DP	%SS	
I	1	KAVYA	*Gm 1*	*20*	0	0.00	0	0.00	R
	2	W 1263	*Gm 1*	*20*	0	0.00	0	0.00	R
	3	ARC 6605	*(?)*	*20*	0	0.00	0	0.00	R
II	4	PHALGUNA	*Gm 2*	*20*	0	0.00	5	1.20	R
	5	ARC 5984	*Gm 5*	*20*	0	0.00	5	1.32	R
	6	DUKONG 1	*Gm 6*	*18*	0	0.00	5	1.31	R
	7	RP 2333-156-8	*Gm 7*	*20*	5	1.35	15	3.26	S
	8	MADHURI L 9	*Gm 9*	*20*	0	0.00	0	0	R
	9	BG 380-2	*Gm 10*	*19*	0	0.00	10	5.88	S
III	10	MR 1523	*Gm 11*	*20*	10	2.60	25	8.79	S
IV	11	RP 2068-18-3-5	*gm 3*	*20*	0	0.00	0	0	R
	12	ABHAYA	*Gm 4*	*20*	5	1.08	15	5.26	S
	13	INRC 3021	*Gm 8*	*20*	0	0.00	10	2.35	S
	14	AGANNI	*Gm 8*	*20*	0	0.00	0	0	R
	15	INRC 15888	*Gm 8*	*20*	0	0.00	5	2.82	S
	16	B 95-1	*None*	*20*	0	0.00	0	0	R
V	17	TN1	*None*	*20*	10	1.72	35	7.03	S
		TN 1			20	6.31	75	14.28	S
		NLR 34449			10	1.46	25	5.88	S

pattern was recorded by Vijay kumar (2008) who reported the presence of biotype I in Madikeri and Ponnampet, Kodagu, Mysore and Hassan districts of Karnataka with R-R-R-S reaction pattern when studied with 14 rice differentials.

CONCLUSION

Further investigations have to be carried out to confirm the existence of Biotype VI in Nellore or a new gall midge biotype has emerged in Nellore. Continuous biotype monitoring studies will aid in finding the resistant donors to develop resistant cultivars and to pyramid or stack two or more resistant genes in a variety and also to monitor the change in the biotype over a period of time in a particular area.

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CAN ELEVATED CO_2 AFFECT OFF SEASON SURVIVAL AND EMERGENCE OF YELLOW STEM BORER?

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Insect pest infestation serve as a key factor in order to obtained maximum production and productivity of any crop. Rice, an important food crop grown throughout the world, is known to be attacked by a number of insect pests. Among them, yellow stem borer (*Scirpophaga incertulas*, Pyralidae, Lepidoptera) is major one and responsible for huge economic losses to farmers throughout the World (Muralidharan, 2005). The pest is well known for its occurrence starting from seedling to harvesting stage. Being a monophagous pest, it feed only on rice. During offseason, the pest is known to hibernate in larval/pupal stage near the base of the stem. Climate change, a phenomena arises due to natural variability and anthropogenic variability, is known to affect each and every organisms. Because of this, there is gradual increase in the average temperature of earth and atmospheric CO_2 concentration. It is known to affect the insect both directly as well as indirectly. Hence, this investigation was carriedout in order to find out the possible effect of elevated CO_2 on offseason survival and adult emergence of yellow stem borer.

METHODOLOGY:

The experiment was conducted under the Open Top Chamber (OT Chamber) located at Research Farm, ICAR-National Rice Research Institute, Cuttack, Odisha during kharif 2018 which is situated at 20^0 N latitude, 86^0 E longitude and is at an elevation of 23.5 m above the mean sea level (MSL). The experiment comprises of three OT Chambers having different concentrations (700 ppm, 550 ppm and ambient condition) of CO_2. In each OT Chambers, 10 numbers of plant (Variety TN 1) were grown in pot with recommended package of practices and are covered with a mylar cage in order to prevent the infestation of inset pest. When the crop is of three month old (i.e during reproductive stage), five numbers of first instar larva were released in each pot and again covered with mylar cage. The larva were allowed to grow and feed, subsequently to cause white ear head. After formation of white ear head, the plants were oboserved regularly for adult emergence. The number of adult emerged were counted and recorded. As the cropping season was over, the infested plants along with pot were brought to the laboratory and cut 20 cm above from the ground level. After that, the remaining stem along with roots were splited in order to observe the hibernating stage. The expriment consists of three tratments and ten replication (each plant is considered as one replication), each comprises of five numbers of larvae.

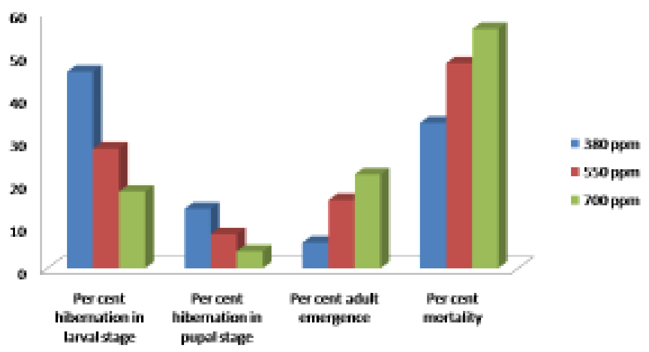
RESULTS AND DISCUSSION:

The effect of elevated CO_2 on off season survival and adult emergence was embodied in figure 1. From this investigation, it was observed that, under ambient concentration of CO_2, maximum population (46 %) of yellow stem borer hibernate in larval stage whereas only 14 % population hibernate in pupal stage. Similarly in 550 ppm and 700 ppm concentration of CO_2, 28 % and 18 %population was found to be hibernate in larval stage followed by 8 % and 4%

population in pupal stage. As per as adult emergence was concerned, maximum percentages of adults were emerged under elevated concentration of CO_2 (22 % in 700 ppm, 16 % in 550 ppm) as compared to ambient conditions (6 %). It was also observed that maximum mortality occurs under elevated concentration of CO_2 (56 % in 700 ppm, 48 % in 550 ppm) as compared to ambient condition (34 %).

In our studied we observed that, increase in concentration of CO_2 lead to decrease in hibernation of yellow stem borer, subsequently increase the rate of adult emergence. This is because increase in temperature under elevated CO_2 concentration. Again hibernation is a temperature dependent phenomenon observed among the organisms, which usually occurs under the condition of low temperature. As the temperature under elevated CO_2 concentration is usually higher than the ambient CO_2 conditions, minimum percentage of hibernation was observed. In contrast, maximum population mortality was also observed under elevated concentration of CO_2. This is because of reduction in quality of plants in terms of nutrient composition that were grown under elevated CO_2 concentration (Ujiie et al. 2019).

Fig: 1. Effect of elevated CO_2 on off season survival, emergene and mortality of Yellow Stem Borer



CONCLUSION:

Increase in atmospheric CO_2 concentration leads to increase in average temperature of earth which provides a congenial environment for emergence of adult in case of yellow stem borer. Earlier studied reported that, as winter arrives, yellow stem borer hibernate in larval stage. As under ambient condition, there is no changes in temperature, maximum population hibernate in larval stage followed by few in pupal stages. In contrast, under elevated condition, the larvae moult into pupa which in turn moults into adult because of congenial temperature. Hence we can say that, increase in concentration of atmospheric CO_2, reduces the per cent hibernation and increases the percentage of adult emergence in case of yellow stem borer. In practical agriculture, this above study helps to farmers in minimising the yield losses by adopting appropriate management practices particularly in rabi rice. This is because under current scenario, the residual population (hibernating population) of yellow stem borer infesting kharif rice were usually emerged during the beginning of February, hence there is no population of yellow stem borer during the month of November and December. If there is increase in concentration of CO_2, then this hibernating population may emerge during the month of November itself because of increase in temperature and started causing damage during the initial stages of crop. This may cause huge economic losses to rice growers.

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IRC/TM-3/PP-20

SCREENING OF RICE GENOTYPES FOR RESISTANCE TO BROWN PLANTHOPPER POPULATION OF KHAMMAM DISTRICT OF TELANGANA STATE AND ITS MORPHOMETRICS

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The brown planthopper (BPH), *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae) is one of the most serious insect pests of rice and directly damages the plant by sucking phloem sap, causing hopper burn, and also by transmitting viral diseases such as grassy stunt and ragged stunt. It causes yield losses as high as 60%. Chemical control is the principal method of controlling BPH but indiscriminate use of chemicals leads to environmental hazards. Host-plant resistance is the most desirable and economic strategy for the control of BPH (Vanisri *et al*., 2020). Till date, forty BPH resistance genes have been identified from rice cultivars. The BPH resistance genes from *Bph1* to *Bph9*, *Bph19*, *Bph25*, *Bph26*, Bph28, *Bph31*-*Bph33*, Bph33(t) (Bhaskar *et al.*, 2018), *Bph37*, *Bph38* are from cultivated rice, *O. sativa* as gene source, whereas *Bph10* to *Bph18*, *Bph20 to Bph24* and Bph 27 to Bph31(t), Bph34 to Bph36 and bph39(t) and bph40(t) (Akankshha *et al*., 2019) are from wild rice species. Resistant and moderately resistant varieties keep the pest densities below economic threshold levels. Planthopper populations in different countries and different regions within the same country differ in their response to rice varieties with same resistance genes. Due to lack of precise studies under controlled conditions, information on performance of identified sources of BPH resistance carrying specific genes for resistance against various BPH populations across India is lacking. Hence, an attempt was made to study the response of 30 BPH gene differentials with known genes along with resistance mechanisms against BPH population collected from Khammam district of Telangana state, India which is endemic to BPH.

METHODOLOGY:

Thirty rice gene differentials were mass screened for resistance to brown planthopper collected from Khammam district of Telangana state in greenhouse through standard seed box screening test on 0-9 scale at the ICAR- Indian Institute of Rice Research, Rajendranagar, Hyderabad. The mechanism and components of host plant resistance i.e. non-preference (probing marks, honeydew excretion and fecundity); antibiosis (nymphal survival, nymphal duration, growth index, macroptery etc) and tolerance (days to wilting) were studied in the gene differentials by following standard procedures. Different morphological parameters of brown planthopper like total body length, total body width, length of abdomen, width of abdomen, length of wing, width of wing, antennal length, inter occular distance, length of tibial spur and length of rostrum of all five nymphal instars as well as both forms of females and males (macropterous and brachypterous) of adult brown planthoppers have also been recorded under stereo zoom binocular microscope.

RESULTS:

Of the thirty one gene differentials screened, four gene differentials viz., PTB 33 with bph2+Bph3+unknown factors (DS 1.3), RP 2068-18-3-5 with Bph 33t gene (DS 1.2), RP Bio 4018-230S with bph39 and bph40 genes (DS 2.7) and IR 62 with

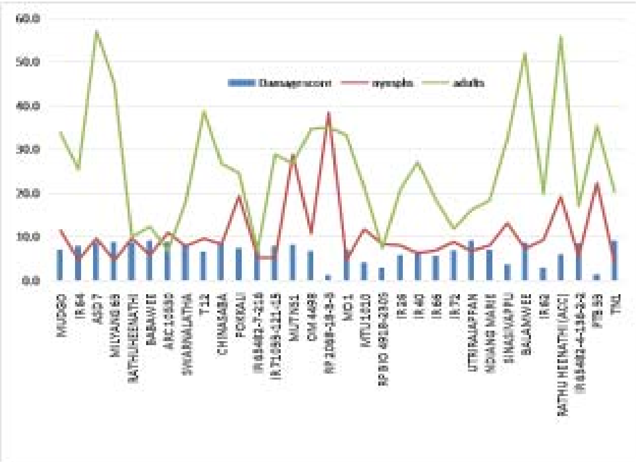

Fig. : Damage score and probing marks in the adults and nymphs on different genotypes

(DS 2.8) are resistant with a damage score of 1.1-3.0. Two gene differentials Sinasivappu with unknown genetics (DS 3.5) and MTU 1010 with unknown genetics (DS 4.1) are moderately resistant with a damage score of 3.1-5.0. Brown planthopper probed more number of times, fed more and excreted less honeydew on the resistant gene differentials, compared to others. The nymphal survival was less on the resistant gene differential PTB 33 and more number of winged insects compared to wingless insects emerged on resistant gene differentials. More number of males emerged and sex ratio was in favour of males in the resistant gene differentials. Growth index was less on resistant gene differentials. The gene differentials took 5-15 days for wilting after infestation with BPH (Fig 1).

The 1st instar BPH measured 1198 µm in length and the last instar measured measured 3323 µm. The antennal length was 473 µm in 1st instar to 1049 µm in the last instar. Tibial spur measured from 82 µm in 1st instar to 352 µm in winged male. The length of the rostrum was 346 µm in 1st instar to 1191 µm in wingless female. The wing span was 3227/715 µm in the winged female adults.

CONCLUSION:

The genes which are found resistant to Khammam brown planthopper population can be used in the breeding programme to develop brown planthopper resistant varieties for that region.

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Theme - III : Biotic-stress management in rice

IRC/TM-3/PP-21

DEVELOPMENTAL STIMULATION IN A PARASITOID, *HABROBRACON HEBETOR* BY INSECTICIDE HORMESIS IN IT'S HOST, *CORCYRA CEPHALONICA*

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Pesticides are a necessary evil. Agricultural insects are generally exposed to inordinate amounts of pesticide through direct application or ingestion through food or residual contact (Stark and Banks, 2003). Often pesticide exposure through indirect routes is neglected. The effects of pesticides on target and non-target insect populations depend on several factors, nonetheless dose being a key factor of response (Cutler 2013). Pesticides are generally applied at sufficient concentrations to kill target insect pests, but spatio-temporal changes in concentrations due to abiotic and biotic factors leads to altered targeted dose. Most often these altered doses are sublethal, which stimulate metabolic processes and finally the growth of organisms (Calabrese 2010), this biological phenomenon is termed as 'hormesis'. Hence, sublethal effects should be considered while estimating the total effect of any pesticide.

The rice moth, *C. cephalonica* is an important insect-pest of stored rice and other products in tropical region (Harita et al., 2000). The larvae cause damage to grains by forming silken webs and feeding inside them. To manage this pest, deltamethrin is being widely used. Food Corporation of India has recommended treating produce with Deltamethrin once in every three months as prophylactic measure (FCI, 2020). *Corcyra cephalonica* is also one of the most preferred hosts of choice for mass production of several egg and larval parasitoids. Habrobracon hebetor Say, 1836, (Hymenoptera: Braconidae), is a cosmopolitan, gregarious, larval ectoparasitoid important insect pests of field crops and stored produce including *C. cephalonica* (Farahani et al. 2016; Yu et al. 2003). Several Studies have reported stimulatory effects or hormesis directly in the parasitoid, but our study for the first time attempts to understand host (*C. cephalonica*) mediated sub-lethal effects in parasitoid (*H. hebetor*). Therefore, in the current study, effects of sublethal concentrations of deltamethrin (a pyrethroid insecticide) over generations on host, *C. cephalonica*, and developmental performance of parasitoid, *H. hebetorvia* its host was investigated.

METHODOLOGY

Study was carried out in Biocontrol laboratory, Division of Crop Protection, ICAR-National Rice Research Institute (NRRI), Cuttack, India (20°27'14.0"N 85°56'06.0"E) under controlled conditions (Temperature 25±1°C; relative humidity 70±5%; and 14 h light:10 h dark). Host, *Corcyra cephalonica* and parasitoid, *Habrobracon hebetor* were reared as per the procedure of Lalitha and Ballal (2015) and Ghimire and Phillips (2014), respectively. Commercial formulation of insecticide, Deltamethrin 2.5% WP (Delthrin®; Hemba industries limited) was used in experiments. The sublethal concentrations (LC_{10}, LC_{15}, LC_{20}, LC_{25} and LC_{30}) effect along with LC_{50} and control on *C. cephalonica* were assessed for consecutive three generations.

Habrobracon hebetor females (< 24 h post-eclosion) were paired with males for 24 h in a plastic container (500-ml) separately for mating. It was observed that more than 80% of *H. hebetor* virgin females mate within the first 15 min (Ode et al. 1995). After 24 h of pairing, individual mated females

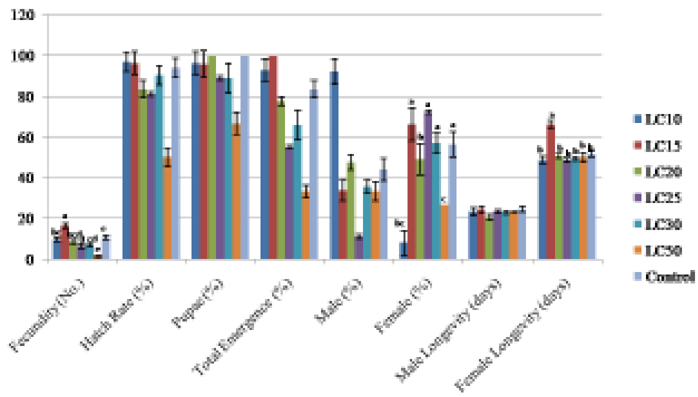

Figure 1.Developmental parameters of the parasitoid, *H. hebetor* following its development on multigenerational sub-lethal concentration exposed factitious host, *C. cephalonica*

introduced (Chen et al. 2011; Ghimire and Phillips, 2014) into plastic containers containing a three generations sub-lethal concentration treated host larvae (5 larvae for each female *H. hebetor*) for 48 hrs as per the sandwich method described earlier. Twelve replications were maintained per treatment. After parasitization of host larvae, eggs were counted at 40 X magnifications under a trinocular microscope (Nikon SMZ-745T) and fecundity (eggs laid/female) was recorded. Also, observations on larval hatch rate (%); pupation (%); sex-wise emergence (%) and longevity (days) were recorded.

RESULTS

The performance of parasitoid, *H. hebetor* on the multigenerational sub-lethal concentrations treated factitious host *C. cephalonica* in terms of fecundity, larval hatch rate, pupation rate, sex-wise emergence rate, sex-wise longevity is shown in Figure 1. A significant increase in parasitoid fecundity by 65.33% was found when host larvae were treated with LC_{15} compared to control ($F_{6,21}$= 40.00; P<0.0001). But non-significant differences were noticed between the treatments and control in terms of hatch rate, pupation rate, total emergence, male emergence and male longevity. Compared to control, the female emergence rate of *H. hebetor* was significantly different ($F_{6,21}$= 2.9; P=0.0003) among the treatments and was highest in LC_{15} treatment (100 % emergence). Among the sex-wise longevity, male longevity was non-significant among the treatments, whereas, female longevity was significantly influenced ($F_{6,21}$= 14.48; P<0.0001).

CONCLUSION

In the current study, fecundity, emergence and female longevity in *H. hebetor* have significantly differed when reared on sub-lethal deltamethrin treated factitious host for three generations. Hormesis induced by sublethal doses of insecticides was exploited in the current study for *C. cephalonica* which is generally used to mass rear *H. hebetor*. The sub-lethal effect of pesticide was considered in a different approach to harness its benefits. However, long-term experiments are required to whether these stimulations could translate into economic benefits during mass culturing of beneficial insects and if at all to understand any trade-offs that do occur. We propose for additional research to confirm whether or not the trend holds across several generations.

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IRC/TM-3/PP-22

PREPARATION OF NOVEL INSECTICIDE MIXTURES EFFECTIVE AGAINST BROWN PLANT HOPPER AND YELLOW STEM BORER

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Insect pests and diseases are major constraints in increasing the productivity of rice in all ecosystems in the tropics. To control rice insect-pests 67 pesticide formulations and 11 combination products are recommended by Central Insecticide Board and Registration Committee (CIB&RC) till date. Insecticide resistance and pest resurgence are reported in India and the invention of new molecules is not that fast to manage the pest populations. Hence, tank mixtures of existing molecules can serve as a viable option to manage the rising pest populations and emerging pest complexes and can delay the build-up of resistance. Hence, the present study investigates the compatibility of different group of insecticides i.e., chlorantraniliprole, flonicamid, pymetrozine and triflumezopyrim in mixtures, and their combined toxicity against Brown Plant Hopper (BPH) and Yellow Stem Borer (YSB).

METHODOLOGY

Mixtures of chlorantraniliprole (Coragen 18.5 SC) with flonicamid (Ulala 50 WG), pymetrozine (Chess 50 WG) and triflumezopyrim (Pexalon 10.6 SC) were checked for physical compatibility using jar test (ASTM E1518-05, 2005). Pesticide formulations were mixed at different ratio and 100 mL of aliquots were poured into three polyethylene bottles and allowed to stand at room temperature overnight. Phase separation, foam, layer and sludge formation were observed. The pH and EC of the aliquots were compared to that of the stock solutions of individual pesticides using a pH and EC meter. Phytotoxicity of the mixtures was checked. The symptoms of chlorosis, necrosis, hyponasty and epinasty upon pesticide application were noted down. LD_{50} values were determined to evaluate the susceptibility of BPH and YSB to the individual insecticides (analytical standards) by topical application method using Hamilton's repeating dispenser. Insecticide treated BPH were released onto 7-10 days old seedlings were placed in hydroponics media. Ten 4th instar BPH insects were considered to be one replicate and five replications were taken (Liu et al., 2003). Mortality count was recorded after 24 hrs. Ten third instar pesticide applied YSB larvae were released into petri dishes containing ten paddy stem bits comprising as one replicate and a total of three replications were taken. Mortality count was recorded after 48 hrs. Both tests were performed in ambient conditions. Combined toxicity of mixtures of different combinations was tested against BPH and YSB following the above methods.

RESULTS

The pesticide mixtures of chlorantraniliprole with flonicamid, pymetrozine and triflumezopyrim, respectively indicated no observed phase separation, foam, layer and sludge formation implying that the mixtures were physically compatible. The pH and EC of the mixtures did not differ significantly than that of the individual insecticides justifying that the mixtures are chemically compatible. Similarly, there were no signs of chlorosis, necrosis, hyponasty and epinasty on the plants after spraying these mixtures signifying that these mixtures have no phytotoxic effect. The LD_{50} were 17.22 ng/insect for chlorantraniliprole, 0.059 ng/insect for flonicamid, 0.18 ng/insect for pymetrozine and 0.047

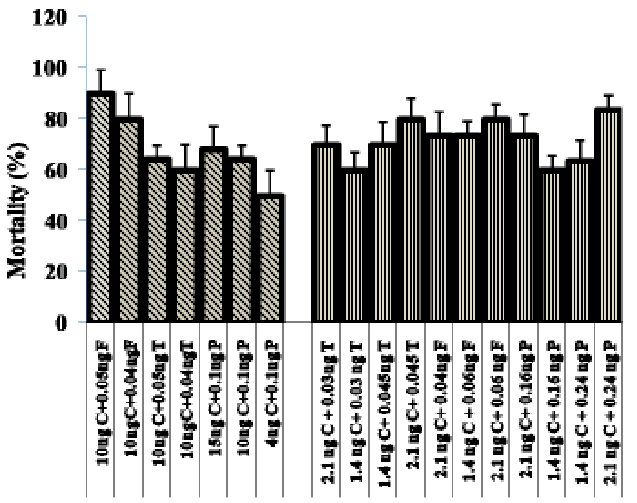

Figure 1Efficacy of different insecticidal mixtures against BPH and YSB

ng/insect for triflumezopyrim against BPH. The LD_{50} were 2.737 ng/larva for chlorantraniliprole, 0.073 ng/ larva for flonicamid, 0.313 ng/ larva for pymetrozine and 0.061 ng/ larva for triflumezopyrim against YSB. In combined toxicity studies against BPH, the total mortality was ranged from 50-90 % among different mixtures, among which combination of 10 ng chlorantraniliprole (C) + 0.05 ng flonicamid (F) per insect had shown maximum mortality of BPH i.e., 90 %. It was followed by 10 ng C + 0.04 ng F per insect with 80% mortality. In case of YSB, the mortality was ranged between 60-83.33 % where the highest mortality was recorded in the dose of 2.1 ng C+ 0.24 ng P per larva (83.33%), followed by 2.1 ng C+ 0.45 ng T per larva. The results suggested insecticides when applied in combinations are more efficacious than the solo applications against both YSB and BPH.

CONCLUSION

The insecticidal mixtures of chlorantraniliprole along with flonicamid, pymetrozine and triflumezopyrim were physically and chemically compatible and had shown no phytotoxic effect on plants. These mixtures have higher efficacy as compared to their efficacies when applied in solo. Hence, these mixtures can be applied in field conditions as tank mix to manage BPH and YSB in a single application, when they are present in the late tillering stage of paddy by reducing the doses of the individual insecticides.

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A NOVEL SEED TREATMENT FORMULATION (CHLORANTRANILIPROLE 625 G/L FS) FOR STEM BORER AND LEAF FOLDER MANAGEMENT IN RICE

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Many biotic and abiotic constraints limit the rice productivity in India. Nearly 300 species of insect pests infest rice crop from sowing to harvest and among them only 23 species causes notable damage. The average yield losses in rice had been estimated to vary between 21-51 per cent. Among major insect pests of rice, yellow stem borer (YSB) *Scirpophaga incertulas* (Lepidoptera: Crambidae), a monophagous pest is considered as most important pest in different rice ecosystems and rice leaf folder, *Cnaphalocrocis medinalis* (Guenée) (Pyralidae: Lepidoptera), has recently emerged as an important major insect pest of rice in many Asian countries. As there is no full proof method to get rid of these two pests either through a resistant variety or through certain biological agents, the use of insecticides becomes unavoidable to control this pest.

Always there exists a thrust to search for a viable and cost-effective alternative strategy to manage the insect pests, paving way for reduced use of insecticide without compromising the pest suppression. One such management tactic is the seed treatment which is very much successful in cotton and other commercial crops. Even though we select good quality seeds for sowing, it is advised to go through seed treatment process for better germination and to prevent crop from seed and soil borne diseases and insect pests. Seed treatment enhances the seed viability and vigor which are the two most important factors in plant health management. Apart from that seed treatment results in early growth and uniform crop establishment. In legumes seed treatment enhances nodulation resulting in uniform crop stand especially in adverse/ stress situations like low moisture conditions.

The tested product Chlorantraniliprole 625 g/ L FS (Lumivia)developed by Dupont India Pvt. Ltd for seed treatment is presumed to have effect on rice yellow stem borer and rice leaf folder. In foreign countries for early season protection of corn (field, seed, pop) from feeding damage by wireworms, cutworms, armyworm (*Mythimna unipuncta*) and seed corn maggot and larvae of Asiatic garden beetle, masked chafers, European chafer, May/June beetles, Japanese beetle similar product, DuPont™ Lumivia™ seed treatment formulation (a flowable suspension) is applied as a seed treatment component. Chlorantraniliprole seed treatment is now used in approximately 80% of the rice-producing area in southwest Louisiana (Wilson et al., 2019). Chlorantraniliprole persists in the plant long enough to affect later-season pests. In fact, a greenhouse study conducted by Sidhu *et al.* (2014) reported 70–80% mortality on sugarcane borer larvae in chlorantraniliprole-treated rice plants at the mid-tillering stage of development

Currently, the most widely used management tactic for insect pests in rice is insecticidal seed treatments. The primary target for seed treatments is the rice water weevil. There are three seed treatments registered for control of rice water weevil in the USA. In India not even a single insecticide seed treatment formulation is recommended by CIB and RC against rice insect pests. In this context, the present work formulated to explore the possible utilization of the product for the management of stem borer (*S. incertulas*) and leaf folder (*C. medinalis*) in paddy.

METHODOLOGY

The field experiments were carried outduring *Kharif* 2018 and Rabi 2018-19 seasons in a RBD design with 4 replications at the Crop Protection Division fields (K & L Block), ICAR-National Rice Research Institute (NRRI), Cuttack (Odisha). Seed treatment was done to test the bio-efficacy of test chemical on Variety (CR Dhan 304) and Hybrid (28P67) as per the standard protocol given by the Company and Crop management was done as per standard package of practice including the control of non-target insect and diseases.

RESULTS

It was evident from the studies undertaken during *Kharif* 2018 and Rabi 2018-19, that Chlorantraniliprole 625 g/L FS (Lumivia) provided excellent control over stem borer and leaf folder control in conventional variety of rice (CR Dhan 304) and hybrid rice (28P67). Amongst all the concentrations of Chlorantraniliprole 625 g/L FS (Lumivia), Chlorantraniliprole 625 g/L FS @ 75 g ai/ha recorded best result in terms of dead heart control. Similarly, treatment Chlorantraniliprole 625 g/L FS @ 75 g ai/ha also recorded highest yield (both in variety and hybrid rice). Again, all the dose rates of Chlorantraniliprole 625 g/L FS (Lumivia) recorded *at par* result with the market standard and the untreated check in terms of natural enemy count (dragonfly, spider and damselfly). Even the highest dose rate of Chlorantraniliprole 625 g/L FS (Lumivia) i.e Chlorantraniliprole 625 g/L FS @ 150 g ai/ha did not record any phytotoxicity symptoms like chlorosis, wilting, stunting, hyponasty and epinasty and 100 % germination was recorded at 7, 14 and 21 days after sowing.

CONCLUSION

The studies indicated that Chlorantraniliprole 625 g/L FS (Lumivia) a seed treatment formulation provided excellent control of stem borer and leaf folder in conventional variety of rice (CR Dhan 304) and hybrid rice (28P67). Seed treatment with Chlorantraniliprole 625 g/L FS (Lumivia) @ 75 g ai/ha can be recommended for managing stem borer and leaf folder in paddy.

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IRC/TM-3/PP-24

RICE GERMPLASM ACCESSIONS POSSESSING RESISTANCE TO WHITEBACKED PLANTHOPPER, *SOGATELLA FURCIFERA* (HORVARTH) (HOMOPTERA:DELPHACIDAE)

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The whitebacked planthopper (WBPH), *Sogatella furcifera* (Horváth) (Hemiptera: Delphacidae) is a major pest in rice throughout Asia and causes damage to rice by sucking phloem sap and transmitting Southern rice black-streaked dwarf virus. The main method used to control the planthopper is the application of chemicals. However, the long-term application of chemicals will inevitably lead to resistance, planthopper resurgence, and environmental pollution (Jena *et al*., 2006). Alternatively, development and cultivation of resistant cultivars has generally been considered to be the most economic and environmentally sound strategy for management of whitebacked planthopper. It is considered, that a resistant plant variety that reduces the insect population by 50 per cent in each generation is sufficient to eliminate an insect of economic importance within few generations (Painter, 1951). The necessity to identify suitable new resistant donors for whitebacked planthopper from different sources is important in order to combat the pest and develop varieties resistant to WBPH. It is also necessary to understand the mechanisms responsible for manifesting resistance into the selected cultures with desirable characters, so that these can be utilized effectively in the breeding programme. Keeping this in view, present investigation was planned to evaluate the germplasm accessions for their resistance to whitebacked planthopper and to study the antixenosis mechanism of resistance for feeding.

METHODOLOGY:

Whitebacked planthopper was reared on rice plants. One thousand germplasm accessions collected from various parts of India were mass screened at the ICAR- Indian Institute of Rice Research, Rajendranagar , Hyderabad in greenhouse under artificial infestation through standard seed box screening test on 0-9 scale. The mechanism and components of resistance (antixenosis-feeding preference-probing marks and honeydew excretion) were studied in the selected resistant and susceptible accessions. The highly resistant, resistant and moderately resistant entries along with some susceptible accessions, susceptible and resistant checks were selected to find out the feeding behaviour of one day old adult female and third instar nymphs of whitebacked planthopper expressed in terms of feeding marks or probing marks on the leaves and stems of the rice entries (Naito 1964).The amount of honeydew excreted by the adults and nymphs of WBPH on the selected germplasm accessions was measured by according to Nanthakumar *et. al.* (2011).

RESULTS:

Out of these, two accessions viz., IC75864, IC215298 were resistant with a damage score of 1.1-3.0 and 32 accessions viz., IC216620, IC75877, IC216897, IC216632, IC216901, IC75737, IC75955, IC210765, IC216563, IC216612, IC216710, IC540676, IC540644, IC216908, IC211233 and IC216628 etc. were moderately resistant with a damage score of 3.1-5.0 to whitebacked planthopper. 204 accessions were moderately susceptible, 329 accessions were susceptible and 434 germplasm accessions were highly susceptible (Fig 1). The resistant check MO1 was resistant with a damage score of 1.4 and PTB 33 was moderately resistant with a damage score of 3.4. The

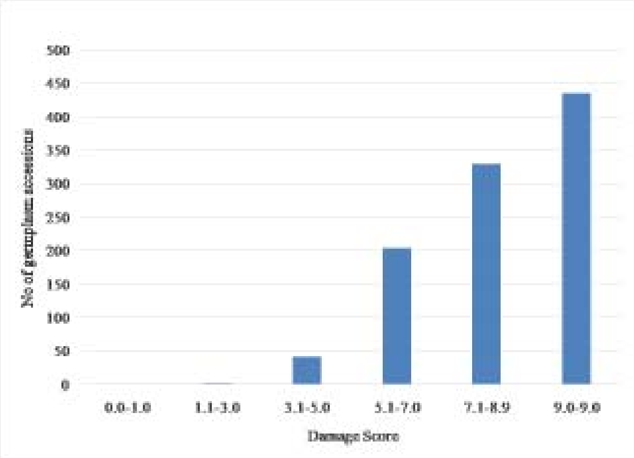

Fig. Frequency distribution of whitebacked planthopper damage score in germplasm accessions

WBPH probed more number of times and excreted less honeydew on resistant accessions. Adults probed more number of times compared to nymphs. The number of probing marks in nymphs were more on resistant check MO1 (31) followed by PTB 33 (19.4) and lowest number of probing marks were observed on IC216479 (1.8). In adults highest number of probing marks were observed on MO1 (31.6) followed by IC 540644, IC75735, PTB 33 and 216693. Honeydew excretion was highest in the susceptible check TN1 (185mm^2), and in the resistant check MO1 it was 35 mm^2. Nymphs fed less and excreted less amount of honeydew compared to adults on the germplasm accessions. In some of the resistant germplasm accessions whitebacked planthopper nymphs and adults probed more number of times, fed less and excreted less amount of honeydew.

CONCLUSION:

In the present study, the germplasm accessions resistant to WBPH and with more number of probing marks and less amount of honeydew excretion which are not preferred for feeding can be used in the breeding programme to develop whitebacked planthopper resistant varieties.

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IRC/TM-3/PP-25

NEW REPORT OF ASIAN GALL MIDGE *ORSEOLIA ORYZAE* (WOOD-MASON) (DIPTERA: CECIDOMYIIDAE) IN PADDY AT TUNGA-BHADRA COMMAND AREA OF KARNATAKA

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Rice (*Oryza sativa*) is the most widely consumed staple food for a large part of the world's human population, especially in Asia and Africa. Among different countries of the world, India stands second in production and productivity. Among the different states in India, Karnataka is one of the important states which contribute maximum to rice production. In Karnataka rice growing areas were divided into 6 regions *viz.*, coastal area, hilly area, transitional area, tankfed area, the irrigated maiden area South and irrigated maiden area North (T-B command area and UKP). In Tunga-Bhadra command area about 4.5 lakh ha area is under rice in both *kharif* and *summer* season. For the higher rice production, these areas are likely to intensify through new high yielding varieties and improved cultivation practices. With the increasing numbers of new rice genetic material being offered to rice farmers for cultivation and adoption of new and improved agricultural and plant protection practices, the pests status of certain rice-associated insects is expected to change.However, a major threat to low productivity is due to biotic and abiotic stresses. Among the biotic stress, insect pests constitute one of the major yield reducing factors and among the abiotic factors temperature, relative humidity, rainfall were the major yield reducing factors in rice. It is reported that about 20 major insect pests causing economic yield loss in Karnataka.

In current season (*kharif* 2020), the Asian rice gall midge, *Orseolia oryzae* (Wood- Mason) (Diptera: Cecidomyiidae) was reported for the first time from Tunga-Bhadra command area during August 2020 at Muddapur, Itagi and Sanapur villages of Kampli taluk, Bellary district and from Danapur, Mushtoor villages of Gangavathi taluk of Koppal district in the first week of September 2020. Earlier the insect was observed only in the coastal area and irrigated maiden area of South Karnataka districts only (Vijay Kumar *et al.*, 2008). Hence, study was carried out to confirm the presence of asian gall midge in TBP area by taxonomists and also conducted rapid roving survey to know the level of infestation in rice in the same area.

METHODOLOGY

During *kharif* 2020 the infestation of this gall midge in the TBP command area was very high which may led to heavy economic loss. Based on insect damage symptoms and presence of maggots and pupae in the different varieties, insect samples (maggots and pupa) and rice plants along with soil was collected and reared in cages for adult emergence at Department of Entomology, AICRP on Rice, ARS, Gangavathi. After adult emergence the sample were collected and stored in 70 per cent ethanol, packed and samples sent to IIRR, Hyderabad, Dept of Agril. Entomology, UAS, Bangalore and Dept of Agril. Entomology, UAS, Raichur for re - confirmation along with necessary information.

Table 1. Roving survey of Asian gall midge incidence in different talukas of TBP command area during *kharif* 2020

Sl No	Taluk	Villages surveyed	variety	Number of Healthy tillers/hill*	Damaged tillers/hill (Silver shoot/ onion tubes)*	% Infected/ damaged/hill
1	Gangavathi	Siddapur	Sona mahsuri, RNR	35.5	9.2	25.92
		Mushtoor	RNR, Janani sona,	36.4	11.3	31.04
		Hosalli	Sona masuri	32.1	2.9	9.03
		Sharanabasaveshwar camp	RNR, sona masuri	34.2	9.4	27.49
		Chikkadankanakal	Sona masuri	37.0	7.5	20.27
		Kalgudi	RNR, sona mahsuri	41	9.4	22.93
		Danapur	RNR, sona mahsuri	38.3	11.6	30.29
	Averge	**36.36**	**8.76**	**23.85**		
2.	Kampli	Muddapur	Sona masuri, thayi sona, Janani sona	38	11.4	30.00
		Itagi	Janani sona, sona masuri, RNR	34	11.9	35.00
		Sanapur	Sona masuri, thayi sona, Janani sona	38	12.3	32.37
		Kampli	Janani sona, sona masuri, RNR	35.2	8.4	23.86
	Averge	**36.30**	**11.00**	**30.31**		
3.	Karatagi	Hanchinal camp	sona masuri, RNR	31.4	3.2	10.19
		Karatagi	RNR, sona mahsuri	35.1	6.4	18.23
	Averge	**33.25**	**4.80**	**14.21**		
4	Sindhanur	Sindhanur	sona mahsuri	29.6	3.4	11.49
		Shreepuram	sona mahsuri	27.6	2.8	10.14
		Dhadesuguru	sona mahsuri	30.3	4.6	15.18
	Averge	**29.17**	**3.60**	**12.27**		
5	Shirguppa	Shirguppa	RNR, sona mahsuri	35.9	12.8	35.65
		Deshanoor	RNR, sona mahsuri	37.2	13.1	35.22
	Averge	**36.55**	**12.95**	**35.44**		

· *** average of 5hills**

The rapid roving survey was conducted in different villages of Kampli, Gangavathi, Karatagi, Shirguppa and Sindhanur taluka during September first week in farmer's fields to know the intensity of the infestation (Fig. 1). A mobile based electronic pest surveillance application; eSAP (Electronic Solutions against Agricultural Pests) was employed while conducting the survey. From each taluka 2 to 6 villages were selected and from each village five farmers were selected for the survey. The observation was taken on gall fly damage by counting the total number of tillers and number of damaged tillers (silver shoot/Onion shoot) from randomly selected 5 hills and it was averaged to the single hill and the damage was expressed in per cent infestation.

RESULTS AND DISCUSSION

Infestation of rice gall midge was noticed during August 2020 at Muddapur, Itagi and Sanapur villages of Kampli taluk, Bellary district and from Danapur, Mushttor villages of Gangavathi taluk of Koppal district in the first week of September 2020. The infestation by gall midge was confirmed through the external symptoms of damage such as the production of a silvery-white, tubular leaf sheath gall called a silver shoot or onion tubes (Fig. 2). This renders the tiller sterile and cause the yield loss. As per the experts from IIRR, Hyderabad, Dept of Agril. Entomology, UAS, Bangalore and Dept of Agril. Entomology, UAS, Raichur, it was cinfirmed that the samples sent are Asian Gall Midge *Orseolia oryzae* (Wood- Mason) (Diptera:

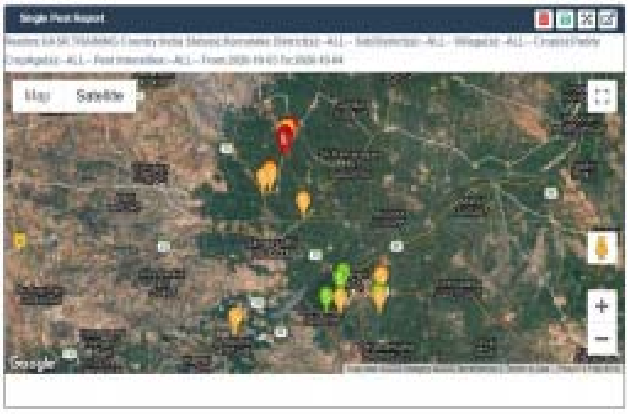

Fig. 1. GIS map indicating the survey points raised in rice fields through eSAP

Cecidomyiidae). From the survey it was observed that among all talukas, the average maximum of 12.95 damaged tillers per hill was observed in Shirguppa taluk with 35.44 per cent damaged tillers per hill followed by Kampli taluk with 11.00 damaged tillers per hill with 30.31 per cent, Gangavathi taluk with 8.76damaged tillers per hill with 23.85 per cent respectively, whereas lowest damaged tillers and per cent infected tillers per hill was observed in Sindhanur taluk with 4.80 and 12.24 per cent respectively (Table 1). The reports pertaining to occurrence of Asian gall midge at Tunga – Bhadra command area is nil but new biotype of the Asian rice gall midge *Orseolia oryzae* (Diptera: Cecidomyiidae) was characterized from the Warangal population in Andhra Pradesh by Laxmi, P.V *et al*., 2006 and probable reasons for the outbreak of the gall midge in TBP area may be due to occurrence of intermittent rain during early stage of the crop, continuous cultivation of paddy crop, availability of new varieties brought from gall midge infected regions, variation in planting dates by farmers, increased fertilizer application which makes the plant more succulent etc,might have lead to the occurrence and outbreak of the gall fly in Tunga – Bhadra Command area during current season (*kharif* 2020). Still there is lot need to study the type of gall midge biotype, gall midge resistant genotypes adoptions and integrated management practices against gall midge in this region.

Fig. 2. Silver shoot symptoms expressed by rice plants due to infestation by gall midge

ACKNOWLEDGEMENTS

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 IRC/TM-3/PP-26

LOOP MEDIATED ISOTHERMAL AMPLIFICATION (LAMP) FOR THE RAPID AND SENSITIVE DETECTION OF *FUSARIUM FUJIKUROI* CAUSING BAKANAE DISEASE OF RICE

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Rice (*Oryza sativa* L), being an important staple food crop of the world contributes significantly to the food and nutritional security of more than 60% of the people. The crop suffers from a number of diseases caused by fungi, bacterial, virus and nematodes. Among the diseases, blast, sheath blight, bacterial blight, brown spot and tungro continues to cause more damage under changed climatic conditions. On the other hand, number of minor diseases like bakanae, false smut, sheath rot, early seedling blight emerged as major problems. In recent years, bakanae /foolish seedling disease is emerging as major problem in eastern India (Raghu et al., 2018). Most of the popular varieties are suffering a great loss due to the disease. The pathogen, *Fusarium fujikuroi*, a seed borne fungal pathogen causes the disease. The pathogen produces conidia on infected rice plant and easily spread by wind and water. In addition, pathogen can also overwinter in rice seeds, and these contaminated seeds become the main source of infection in subsequent seasons (Rong et al., 2018). The pathogen is capable of producing Fusaric acid and Gibberellic acid (GA_3) which results in different kinds of symptoms. Since the disease can occur at different growth stages, the management of the disease is very difficult once it establishes in field. Thus a reliable, simple, specific and sensitive method for surveillance and detection is urgently needed to screen infected seeds and seedlings at early developmental stages to manage the disease to minimize further losses.

METHODOLOGY

In our study, a rapid and efficient loop-mediated isothermal amplification (LAMP) method was developed to detect *Fusarium fujikuroi* in contaminated seeds, seedlings and soil for diagnosis of bakanae disease. TEF-1á gene target being specific genes of *Fusarium* spp. was adopted as target for LAMP primer design. The LOOP primers were designed using Primer Explorer V5 software ((http://primerexplorer.jp/e/) for TEF-1á sequences. Total of 20 primer sets were designed and synthesized by outsourcing at Sigma and validated in the experiment. The DNA from infected seeds, symptomatic plants and rhizosphere soil using modified CTAB method. The LAMP reaction was performed in a volume of 26 µl containing 2.5 µl 10X ThermoPol buffer, 4µl betain (5m), 4µl MgSo4 (50 Mm), 3.5µl dNTPs (10Mm), 2µl of the primers FIP and BIP (20µm), 0.5 ìlof the primers F3 and B3 (10 ìm), 1 ìl of the primers LF or IF andLB (10 ìm), 2 ìl hydroxynaphthol blue (HNB; 2.4 mm), 1 ìl Bst DNApolymerase (8 U/ìl) and 2 ìl DNA template.The LAMP reaction was optimal at 62°C for 60 min in 0.2µl tubes. Following the amplification, LAMP products were visualized directly by the unaided eye. The positive reaction showed a sky blue colour and the negative reaction remained purple colour. Template DNA from *Helminthosporium oryzae*, *Rhizoctonia solani* and *Magnoporthe oryzae* served as negative control and template DNA from *F. fujikuroi* was positive control.

RESULTS

Our results showed that, successful detection of *F fujikuroi* from infected seeed, symptomatic plants and rhizosphere soil was made using LAMP assay. Positive or negative results were confirmed by adding hydroxynapthol blue (HNB) to the reaction system prior to amplification. After the reaction completes, the colour of the positive samples changed to sky blue, and the colour of the negative samples remained purple. Three replications were maintained for each sample and results were reproduced.This LAMP assay could detecteven 10 fg of genomic DNA per reaction, while that of conventional PCR was 100 pg. We found no reaction in other pathogenic fungi infecting rice (*Rhizoctonia solani*, *Magnoporthe oryzae*, and *Helminthosporium oryzae*). Our results show that, this LAMP assay is useful and convenient tool for detecting *F. fujikuroi* and can be useful tool in quarantine and further minimizing losses.

CONCLUSION

In this study, based on the LAMP technology, we developed and TEF-1á LAMP assay for Fusarium fujikuroi assay which is successful in directly detecting and rapidly diagnosing the pathogen in rice seeds, diseases plant and rhizosphere soil so that, huge losses can be minimized.

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IRC/TM-3/PP-27

EFFECT OF RICE WEEVIL *Sitophilus oryzae* (L.) INFESTATION ON SEED QUALITY PARAMETERS OF RICE GENOTYPES

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Seed is the critical determinant of the agricultural production. Nearly 30 per cent of such seeds are deteriorated during storage period due to insects, rodents and microorganisms.Germination and seedling vigour are two important attributes which decide the quality of the seeds. Infestation by stored pests may deter the quality of seeds which may adversely affect germination and vigour. In the present investigation, seed quality parameters of rice genotypes were assessed before and after infestation by *S. oryzae*, so that, the best genotypes can be known.

MATERIAL AND METHODS:

The present investigation was carried out during 2019-20 at Seed Research and Technology Centre (SRTC), PJTSAU, Rajendranagarto assess the performance of 25 rice genotypes before and after infestation by *S. oryzae*.The selected genotypes after disinfestationwere used for further studies.

2.1 Screening of test genotypes:

Ten grams of seed from each treatment (three replications) was taken in small plastic tubes (7.5 cm x 5 cm) with tiny punctures on the lid. Freshly emerged weevils (eight females and four males) were introduced into each tube to infest ten grams seeds of each test genotype. They were incubated at a temperature and relative humidity of 26±2p C and 70±5 per cent, respectively. The weevils were allowed to oviposit in the seeds for two weeks and then removed. The number of adults that emerged from each replication of the treatments were counted and discarded daily from the respective tubes until they cease to emerge from the seeds and mean adult emergence was worked out by pooling the data. Similarly, the number of damaged seeds by the weevils were counted at the end of the experiment and converted into per cent damaged seeds.

2.2 Seed germination percentage

Seed germination per cent of test genotypes was recorded before and after infestation by using paper towel method as per the ISTA.

Seed germination percentage =

$$\frac{\text{No. of germinated seedlings}}{\text{Total no. of seeds}} \times 100$$

2.3 Seedling vigour index

Seedling vigour index of test genotypes was determined by selecting ten healthy germinated seedlings from each replication of the treatment. Shoot and root length of each of ten seedlings was measured in centimeters and average length of the seedlings was calculated.

Seedling length = shoot length+ root length

Seedling vigour index was calculated by multiplying germination percentage with seedling length as suggested by Abdul Baki and Anderson (1973).

Seedling vigour index = Per cent seed germination x Seedling length

2.4 Statistical analysis:

The data obtained was analysed for ANOVA (5% probability level) following completely randomized design by using INDOSTAT statistical software. Percentage data obtained was subjected to angular transformation.

Table 1. Seed quality parameters assessed in rice genotypes before infestation by *S. oryzae*.

S.No.	Name of the treatment	Mean adult emergence	Seed damage (per cent)	Germination percentage (Before infest)	Seedling vigour index(Before infestation)	Germination percentage (After infestation)	Seedling vigour Index (After infestation)
1	JGL 384	09.67	5.11 (13.07)	94.67 (76.70)	1139	79.33 (63.00)	913
2	JGL 1798	04.00	1.69 (7.47)	98.67 (83.23)	1746	94.00 (75.95)	1504
3	JGL 3828	07.00	3.89 (11.37)	97.33 (80.73)	1184	84.00 (66.45)	831
4	JGL 11470	08.00	5.73 (13.85)	96.67 (79.60)	1305	82.67 (65.40)	942
5	JGL 3855	11.67	5.84 (13.98)	98.67 (83.23)	1437	83.33 (64.92)	1027
6	JGL 11727	07.00	5.03 (12.97)	95.33 (77.58)	1271	86.67 (68.63)	1166
7	JGL 11118	17.33	10.82 (19.20)	98.00 (81.87)	1551	73.33 (58.92)	810
8	JGL 17004	11.67	7.57 (15.97)	97.33 (80.73)	1401	81.33 (64.43)	905
9	JGL 18047	11.00	7.52 (15.91)	98.67 (83.23)	1668	83.33 (65.91)	1222
10	JGL 24423	08.00	5.91 (14.07)	99.33 (84.59)	1474	88.67 (70.34)	1356
11	JGL 3844	03.00	1.38 (6.74)	96.00 (78.46)	1504	92.67 (74.32)	1279
12	KNM 118	06.00	3.84 (11.30)	96.00 (78.46)	1638	89.33 (70.95)	1241
13	RNR 18833	16.00	8.62 (17.07)	96.67 (79.60)	1437	78.00 (62.04)	991
14	RNR 10754	11.67	6.63 (14.92)	98.67 (83.23)	1397	82.00 (64.92)	1088
15	RNR 15048	08.67	5.49 (13.55)	96.00 (78.46)	912	83.33 (65.91)	747
16	MTU 7029	04.37	2.25 (8.62)	100.00 (85.95)	1566	94.00(75.82)	1419
17	MTU 1001	04.00	2.56 (9.21)	100.00 (85.95)	1440	94.67 (76.70)	1243
18	RDR 7555	06.67	3.81 (11.25)	98.67 (83.23)	1617	90.67(72.23)	1254
19	RDR 763	12.67	7.67 (16.08)	99.33 (84.59)	1277	76.00 (60.68)	775
20	RDR 355	08.00	5.91 (14.07)	100.00 (85.95)	1650	89.33 (70.95)	1396
21	RNR 1446	10.37	6.30 (14.53)	100.00 (85.95)	1566	80.67 (63.92)	1126
22	RNR 2458	04.00	1.76 (7.62)	100.00 (85.95)	1650	92.67 (74.32)	1220
23	RNR 2465	07.67	2.54 (9.16)	100.00 (85.95)	1103	86.67 (68.63)	791
24	*MTU 1010	04.00	0.86 (5.28)	100.00 (85.95)	1260	93.33 (75.07)	1182
25	**BPT 5204	09.33	4.08 (11.65)	98.00 (81.87)	1323	84.67 (66.96)	982
	SEm±	0.26	0.22	0.89	43.13	0.81	34.63
	CD(P=0.05)	0.73	0.63	2.52	122.50	2.31	98.38
	CV (%)	5.28	3.91	1.86	5.26	2.07	5.47

*Resistant check
**Susceptible check

RESULTS AND DISCUSSION

3.1 Mean adult emergence

The mean number of adults emerged from various test genotypes ranged from 3.00 to 17.33 (Table1). Significantly less number of adults had emerged from JGL 3844 (3.00) followed by JGL 1798 (4.00), MTU 1001 (4.00),RNR 2458 (4.00) and MTU 1010 (4.00) which were on par with MTU 7029 (4.37). While, significantly highest number of adults had emerged from JGL 11118 (17.33) followed by RNR 18833 (16.00). The adult emergence recorded in rest of the genotypes varied from 6.00 to 12.67.

3.2 Seed damage (per cent)

Seed damage in rice genotypes ranged from 1.38 to 10.82 per cent (Table 1). Lowest seed damage was recorded in JGL 3844 (1.38%) which was on par with JGL 1798 (1.69%) and RNR 2458 (1.76%). While seed damage was significantly highest in JGL 11118 (10.82%) followed by RNR 18833 (8.62%).

3.3 Seed quality parameters recorded before infestation

3.3.1 Germination percentage and Seedling vigour index: Initial germination per cent of different rice genotypes ranged from 94.67 to 100 per cent and Initial seedling vigour index of rice genotypes varied from 912 to 1746. (Table 1),

3.4 Seed quality parameters assessed after infestation by *S. oryzae*

3.4.1 Germination percentage: Germination percentage of rice genotypes after infestation by *S. oryzae* ranged from 73.33 to 94.67 per cent (Table 1). Significantly lowest germination percentage was recorded in JGL 11118 (73.33%) followed by RDR 763 (76.00%) which was on par with RNR 18833 (78.00%). While, highest germination percentage was recorded inMTU 1001 (94.67%) which was on par with JGL 1798 (94.00), MTU 7029 (94.00%), MTU 1010 (93.33%), JGL 3844 (92.67%) and RNR 2458 (92.67%).

Results obtained are in accordance with Borah and Mohon (1982) who reported that the paddy varieties *viz*., Ahom sali and Jahinga which were least susceptible to infestation by *S.oryzae* showed highest germination rates (92.8 and 93.1%, respectively).While highly infested ones *viz.*, Monoharsali and Karsali showed lowest germination rate (86.2 and 85.5%, respectively).

3.4.2 Seedling vigour index : Seedling vigour index of different treatments varied from 747 to 1504 (Table 1). Lowest seedling vigour index was recorded in RNR 15048 (747) which was on par with RDR 763 (775), RNR 2465 (791), JGL 11118 (810) and JGL 3828 (831). While, highest vigour index was recorded in JGL 1798 (1504) which was on par with MTU 7029 (1419).

Singh *et al*. (1975) observed that the viability of maize seed was drastically affected due to *S.oryzae* infestation. While, the seedling vigour was less affected in the genotypes that recorded least adult emergence coupled with less seed damage *i.e* MTU 1010 (1260 to 1182), MTU 1001 (1440 to 1243),JGL 3844 (1504 to 1279), MTU 7029 (1566 to 1419),RNR 2458 (1650 to 1220) and JGL 1798 (1746 to 1504).

CONCLUSION:

Among the genotypes evaluated, it is evident that, JGL 1798, RNR 2458, MTU 7029, JGL 3844, MTU 1001and MTU 1010 recorded good germination and seedling vigour even after infestation by *S. oryzae*.Hence these varieties can be recommended for farmers to cultivate so that the losses caused due to *Sitophilus oryzae* can be for minimized to some extent.

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IRC/TM-3/PP-28

ANALYSIS OF ADOPTION OF INTEGRATED PEST AND DISEASE MANAGEMENT PRACTICES IN RICE CROP IN VISAKHAPATNAM DISTRICT OF A. P.

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Integrated Pest Management (IPM) is an effective and environment-friendly pest management system. It is an ecological approach to pest management in which all available effective techniques are deployed in a unified programme so that the pest populations can be managed to avoid economic damage and minimize adverse side effects .Adoption is a mental process of an individual; it is a decision of full use of an innovation as the best course of action available. The aforementioned study was conducted in Visakhapatnam district of Andhra Pradesh during the year 2018.The objective of the study is to analyse the adoption of integrated pest and disease management practices in Rice crop.

METHODOLOGY

Visakhapatnam district was selected for this study .In the Visakhapatnam district 4 mandals were selected purposively and from each mandal 25 rice growing farmers were selected randomly The primary data was collected from 100 respondents by following personal interview method and using structured interview schedule. Descriptive statistics such as frequencies and percentages were used to analyse the data.

RESULTS

The results of this study reveals that majority of the rice growing farmers (60%) were adopting the IPM practices moderately and fallowed by low (28%) and High (12%) adoption levels. It has been observed that among selected farmers, various cultural practices have widespread adoption as against very low adoption of biological practices . In cultural practices, more than two-thirds farmers were found practising deep summer ploughing, trimming of bunds, destruction of crop residues, etc. Among the mechanical practices, pheromone traps were being used by only four per cent of farmers in paddy, mainly because of farmers' poor knowledge about its use and non-availability of pest-specific lures. Use of biological control methods for pest control was observed at low level(10%) . *Trichogramma* was the major bio-agent used in paddy IPM, but its adoption was found abysmally low in paddy. The major problems reported in its adoption were its slow action against the target pest, lack of easy availability, short shelf-life and low survival of these bio-agents on farmers' field. Similarly, use of neem-based pesticide was also found very low (14 %), mainly because of its slow action and lack of availability at local pesticide dealers. Only 28 per cent farmers reported using pesticides on the basis of economic threshold levels of pest infestation in paddy growing areas .While coming to IDM practices 28%of the farmers are practicing seed treatment and 18% of the farmers reduced usage of high doses of Nitrogen fertilizers.

CONCLUSION

Table 1 : Categories of farmers based on adoption levels of IPM practices in Rice

Adopter categories	Frequency	Percentage
Low	28.0	28
Medium	60.0	60
High	12.0	12

Table 1I : Item wise analysis of adoption of IPM practices in Rice

Items/components of IPM practices	Percentage	Rank
Deep summer ploughing	60	I
Trimming of bunds and destruction of crop residues	20	VII
Making alley ways	24	IV
Use of pheromone traps	4	IX
Seed treatment for the control of diseases	28	II
Reduced usage of N fertilizer	18	V
Use of neem based pesticides	14	VI
Use of biological control measures	10	VIII
Using pesticides on the basis of economic threshold levels	28	II

IPM is a holistic approach of pest control, based on sound ecological factors. It was obvious from the results that the farmers faced various problems that discouraged them to adopt IPM practices for rice cultivation.The study recommends that extension services should be strengthened with necessary inputs for improved adoption of rice production technologies by respondents.

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IRC/TM-3/PP-29

SCREENING OF VARIOUS GERMPLASM/VARIETIES AGAINST SHEATH BLIGHT OF RICE CAUSED BY *Rhizoctonia solani* Kuhn

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Rice (*Oryza sativa* L.) is the world's second most important cereal crop grown throughout the world and is a staple food crop of 60% of world's population. In India, rice occupies a pivotal place as the primary source of calories for more than 70% population. It is grown across the world on an area about 163.62 million hectares with annual production of 501.4 million tons. In India, it is grown in 44.5 million hectares in desired ecological conditions with an annual production of 116.0 million tons and productivity 3.91 tons/ha (Anonymous, 2019). Whereas in Bihar it covers the area of 3.306 million hectares with production of 8.1 million tons and productivity 2.45 tons/ha. To meet the food needs of ever growing population (1.8%) in India, there is a need to raise rice production around 130 million tons by 2030. Sheath blight disease of rice caused by *Rizoctonia solani* Kuhn is one of the major disease constraints in rice production areas of the world. In India it causes up to 50% economic loss under sever infestation. An experiment was conducted in respective screening of varieties/germplasm including susceptible check MTU 7029 against sheath blight of rice at Pusa centre, Bihar during *Kharif* 2019. The main objective of the study was to identify the source of resistant in available germplasm lines. These germplasm were supplied from IIRR, Hyderabad in AICRP for screening trials. Out of 146 germplasm/ varieties only two germplasm IR-64 and Ajaya were disease free, 81 were resistant, 43 were moderately resistant, 18 were susceptible, and 2 were showed highly susceptible reaction to sheath blight disease.

METHODOLOGY:

Under field condition total of 146 germplasm/ varieties were screened against sheath blight of rice. Highly susceptible variety MTU 7029 was used as infector row. 25 days old seedlings were transplanted in two rows of 2 m length with spacing of 20×15cm. Pure culture of pathogen was multiplied on corn, rice culm bits (5-7 cm) and rice hull (1:3) media. Inoculation was done at tillering stage by placing the inoculum between the tillers just above the water line. Fresh sheath blight infected material with active lesions was also used as inoculum.

Screening trial observations were recorded based on SES Scale (1996) for sheath blight disease as given bellow:

Rating scale	Description
0	No infection
1	Vertical spread of the lesions up to 20% of plant height.
3	Vertical spread of the lesions up to 21-30% of plant height.
5	Vertical spread of the lesions up to 31-45% of plant height.
7	Vertical spread of the lesions up to 46-65% of plant height.
9	Vertical spread of the lesions up to 66-100% of plant height.

RESULTS:

There is generic variation among the lines as far as response sheath blight disease is concerned. In highly susceptible check *i.e.* MTU 7029 disease severity was 77.88 % indicating that the environmental

Table 1. Reaction of various germplasm/varieties to sheath blight disease

Rating scale	Total no. of entries	Breeding No./Varieties
0(No infection)	2	IR-64, Ajaya
1(R)	28	CR 4053-24-40-1, CR 4054-26-6-3, CR 4054-26-6-5, CR 4055-11-28-1, CR 4055-11-28-5, CR 4656-4-21-7, NWGR 12016, V-MSM 142, V-MSM-143, LR 202, Satya-LT, RNR 21278, RNR 2360, UBKVR-15(IET-24173), RP-Bio patho-3, ISM, C 101 LAC, Tetep, HR-12, RMS-R-6, RMS-R-7, RMS-R-8, RMS-R-18, Benibhog, Co-39, IR-50, Rasi, IET 25692.
3(R)	53	CR 4051-7-14-2, CR 4054-26-2-1, CR 4054-26-6-1, CR 4055-11-2-7, CR 4055-11-40-3, CR 4210-2, CR 4210-3, NWZR 11048, NWGR 12002, KNM 7633, KNM 7660, KNM 7759, V-MSM 145, V-MSM 146, ISM-3G-6, ISM-3G-7, LR 203, RP-Patho-1, RP-Patho-2, RP-Patho-11, RP-Patho-12, RP-Bio Patho-4, RP-Bio Patho-5, RP-Bio Patho-8, RP-Bio Patho-9, BPT 5204, C 101 A51, IET 26451(CR 3516), XL18WS-23-18, XL18WS-22-16, XL18WS-22-2, XL18WS-20-8, XL18WS-20-5, XL18WS-39-24-22, RMS-R-1, RMS-R-2, RMS-R-4, RMS-R-5, RMS-R-10, RMS-R-15, RMS-R-16, RMS-R-17, GSY-4-1, GSY-4-2, GSY-4-4, GSY-4-6, Whazhuopek, CB 15569, CB 16585, Nidhi, CH-45, RP-BIO-226, Swarnadhan,
5(MR)	43	CR 4209-1, NWGR 8001, NWGR 14035, NWGR 14084, KNM 7629, KNM 7777, KNM 7785, MSM-SB-6, MSM-SB-52, MSM-SB-87, V-MSM 141, ISM-2G-5412, ISM-3G-4, ISM-3G-5, RP-Patho-3, RP-Patho-4, RP-Patho-5, RP-Patho-8, RP-Patho-9, RP-Patho-10, RP-Bio Patho-1, RP-Bio Patho-7, RP-Bio Patho-11, RP-Bio Patho-12, IET 26463 (CR 3511), HL18WS-23-30, HL18WS-20-4, HL18WS-39-24-19, RMS-R-3, RMS-R-11, RMS-R-12, RMS-R-13, GSY-4-3, GSY-4-9, GSY-4-11, RP 2068, Phoghak, Gonalasha, SM-801, Gumdhan, CB 16512, CB 16570, Vikramarya.
7(S)	18	CR 4209-2, NWGR 11002, KNM 7631, KNM 7632, KNM 7786, KNM 7787, MSM-BB-61, RP-Patho-6, RP-Bio Patho-10, HL18WS-23-51, RMS-R-9, RMS-R-14, GSY-4-7, GSY-4-8, Pankaj, CB 15138, CB 15530, T(N)1
9(HS)	2	RP-Patho-9, Swarna.

conditions were favourable for disease development. Below table 1 showing that out of 146 breeding lines, 2 were free from infection (0 rating), 81 breeding lines were showed resistant reaction (1 to 3 rating), 43 were showed moderately resistant reaction (5 rating), 18 were showed susceptible reaction (7 rating) and 2 breeding lines were showed highly susceptible reaction to sheath blight disease (9 rating).

CONCLUSION:

Out of 146 gemplasm/varietal lines only two germplasm IR-64 and Ajaya were disease free, 81 were resistant, 43 were moderately resistant, 18 were susceptible, and 2 were showed highly susceptible reaction to sheath blight disease.

ILLUSTRATION:

Same work was done by Pavani *et al.* (2018) and screened 196 germplasm under natural conditions after inoculation with virulent isolate of *R. solani* (RS 49). None of the entries were found immune or resistant. Fifty seven entries were found moderately resistant, moderately susceptible and rest of the entries showed highly susceptible reaction.

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ISOLATION OF PLANT GROWTH PROMOTING RHIZOBACTERIA FROM RHIZOSPHERIC SOILS OF *CHAKHAO ANGANGBI* AND *CHAKHAO WAIRI* (UNIQUE BLACK RICE VARIETIES IN MANIPUR), BIOCHEMICAL CHARACTERIZATION AND ANTIFUNGAL ACTIVITY AGAINST FIVE RICE FUNGAL PATHOGENS

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A group of rhizosphere bacteria that exert beneficial effect on plant growth is referred as PGPR (Kloepper, J.W. 2003). PGPR may induce plant growth promotion by direct or indirect modes of action (Beauchamp, 1993). The rice variety black rice (Chakhao) endemic to Manipur is rich in nutritional values and renders antioxidant property due to its high anthocyanin content and presence of vitamin E and so needed to enhance its productivity. Biological control neither eliminates the pathogen nor the disease, but brings them into natural balance. Antagonistic activity may be due to production of antifungal metabolites, volatile compounds and cell wall degrading enzymes such as chitinase, glucanase and some reported for their ability to solubilize phosphate, and production of indole acetic acid (IAA), siderophores, 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase and cell wall degrading enzymes such as chitinase, glucanase and protease .

Objectives of this work are given below:-

(a) Isolation of rhizobacteria from the rhizospheric soils of *Chakhao Angangbi* and *Chakhao Wairi.*

(b) Selection of isolates having biocontrol activities against pathogenic fungi by dual culture method.

(c) Characterization of PGPR such as ammonia production, HCN production, ACC deaminase production, siderophore production, IAA production, etc.

Table 1. Inhibition percentage of *Rhizoctonia solani*, *Fusarium oxysporum*, *Pyricularia oryzae*, *Curvularia oryzae*, *Aspergillus niger* by PGPR isolates in Dual culturemethod

Sl. No.	Isolates	Percentage of inhibition (%)				
		Rhizoctonia solani	*Fusarium oxysporum*	*Pyricularia oryzae*	*Curvularia oryzae*	*Aspergillus niger*
1	CAng1	68	46	64	47	65
2	CAng5	60	45	58	63	46
3	CAng12	84	75	72	82	85
4	CAng17	63	37	36	59	39
5	CAng23	56	53	29	35	46
6	CW2	45	62	70	30	64
7	CW6	67	56	49	45	70
8	CW10	70	37	55	67	50
9	CW11	75	84	76	78	83
10	CW20	55	67	54	58	60

Table 2. Production of NH3, HCN, ACC Deaminase, Siderophore and IAA production by PGPR isolates from rhizospheres of Chakhao angangbi (CAng) and Chakhao wairi (CW) .

Sl. No.	Isolates	Plant Growth Promoting Traits (PGP Traits)				
		NH3 Production	HCN Production	ACC Deaminase Production	Siderophore Production	IAA Production
1	CAng1	+	++	-	+	++
2	CAng5	-	+	++	++	+
3	CAng12	+++	++	+++	++	+++
4	CAng17	-	+	++	+	++
5	CAng23	++	+	-	+++	+
6	CW2	-	++	+	++	++
7	CW6	+++	-	++	+	++
8	CW10	+	+	-	++	+
9	CW11	++	+	+++	+	+++
10	CW20	+	-	+	++	++

- = No production; + = Weak production; ++ = medium production; +++ = high production

(d) Screening of extracellular enzyme activities like amylase activity, protease activity, cellulose activity, catalase activity, etc.

(e) Selection of potent isolates and further studying under pot trial method.

MATERIALS AND METHODS

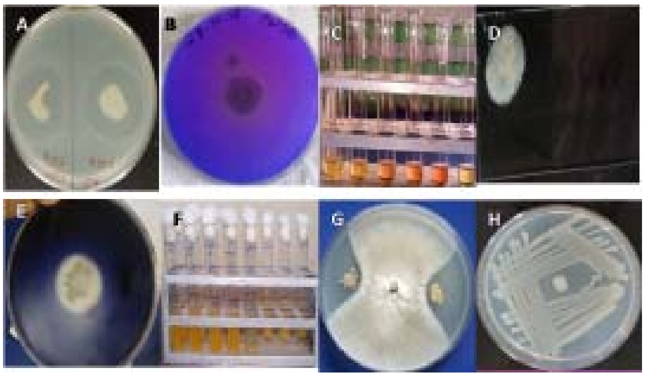
2.1. ISOLATION OF RHIZOBACTERIA:

The soil samples were air-dried for 1 week, crushed and sieved. Rhizospheric bacteria were isolated using 1g soil was suspended in 99ml sterile distilled water and shaken (150 rpm) at room temperature for about 10 minutes. This suspension was then serially diluted (10^{-2} to 10^{-6}) and plated on Starch Casein Nitrate Agar medium, Nutrient Agar medium and Gauze's Medium No. 1. Bacterial colonies were picked up and subcultured to obtain pure cultures. The purified cultures were preserved as agar slants (4 degree C) and glycerol stocks (20 p.c v/v, -20^0 C) for further use.

Table 3. Extracellular enzyme activity of selected rhizobacterial isolates from Chakhao angangbi (CAng) and Chakhao wairi (CW) rhizospheres.

Sl. No.	Isolates	Phosphate solubilization	Catalase activity	Protease activity	Cellulose activity	Amylase activity
1	CAng1	+	-	++	+++	+
2	CAng5	++	+	-	++	++
3	CAng12	++	+++	+++	+	+++
4	CAng17	-	++	+	++	++
5	CAng23	+	-	++	+	+++
6	CW2	++	+	++	-	+
7	CW6	+	++	-	+	+++
8	CW10	++	-	+	++	++
9	CW11	+++	++	++	+++	++
10	CW20	++	+++	+	++	-

- = No production; + = Weak production; ++ = medium production; +++ = high production



Figures: A. Protease activity; B. Phosphate solubilization; C. IAA Production; D. Catalase activity; E. Amylase activity; F. Ammonia Production; G. Antifungal activity against *Rhizoctonia solani*; H. ACC deaminase production activity.

2.2. SCREENING OF PGPR FOR ANTAGONISM ASSAY AGAINST PHYTO PATHOGENIC FUNGI IN DUAL CULTURE PLATE METHOD:

All the 43 PGPR isolates were screened for antagonism against RS, FO, PO, CO and AN using potato dextrose agar medium by dual culture assay.

2.3. CHARACTERIZATION OF PGPR:

(a) Production of ammonia: It was done by growing the isolates in peptone water (Dye 1962) at 30°C for 4 days. Ammonia production was tested according to Cappucino & Sherman, 1992 method.

(b) HCN Production: The isolates were streaked on King's B medium amended with 4.4 g/l glycine (Bakker and Skipper 1987) and then HCN production was tested.

(c) Aminocyclopropane-1-carboxylic acid (ACC) deaminase production: ACC deaminase activity was screened accordingly to Dwarkin M., Foster J. 1958.

(d) **Siderophore production:** Siderophore production was assayed accordingly to Payne S.M. 1994.

(e) IAA Production: IAA production was done by Luria Bertani (LB) broth medium enriched with tryptophan method.

2.4. EXTRA CELLULAR ENZYME PRODUCTION:

(a) Phosphate solubilization: Phosphate solubilisation was done by Pikovaskya, 1948 method.

(b) Catalase activity: Catalase test was performed by Schaad, 1992 method.

(c) Protease activity: Protease activity was determined by clear zone in protease medium (Chaiharn, 2008).

(d) Cellulose activity: Cellulose degrading enzymes were screened by using Miller and Samanta et al.

(e) Amylase activity: Amylase activity was performed by Collins, C. H 1995.

EXPERIMENTAL RESULTS

Over all 43 bacterial strains were isolated from the rhizospheric soils of Chakhao angangbi and Chakhao wairi from selected regions by serial dilution method. The Rhizobacteria have been screened for antifungal activity against RS, FO, PO, CO and AN and zone of inhibition was taken as an indicator of antifungal property in the dual culture method. Among the 43 isolates, only 10 were antagonistic to the pathogens. The inhibition percentage was calculated using the formula described by Idris et al. (2007) which is $(R - r) / R \times 100$ (r: radial growth of the fungal colony opposite to the bacterial colony, R: the radial growth of the pathogen in control .Among antagonistic isolates CAng12, CW2, CW6, CW10 and CW11 exhibited significant antifungal activity. Isolate CAng12 has shown high level of inhibition against RS, CO and AN. Isolate CW11 has shown high level of inhibition against FO and PO. All the 10 antagonistic isolates were tested for growth promotion traits.

Among 10 antagonistic isolates only two isolates CAng12 and CW11 can produce NH3, HCN, ACC deaminase, Siderophore and IAA but the rest of the 7 isolates cannot show activity in one or the other PGP traits.

In view of the significance of extracellular enzymes all the 10 PGPR isolates selected from the antifungal and growth promotion screening were tested for their extracellular enzyme production like phosphatases, catalase, protease, cellulase and amylase activity. The bacterial isolates CAng12 and CW11 showed all extracellular enzyme activities, but the rest of the isolates showed negativity in one or the other extracellular enzymes.

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BIOLOGICAL CONTROL IN RICE CULTIVATION OF ARAKU VALLEY, VISAKHAPATNAM DISTRICT, ANDHRA PRADESH - A BOOST TO ORGANIC FARMING BY TRIBAL FARMERS

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Rice is a major crop in tribal areas ofnorth coastal zone of Andhra Pradesh. Tribal farmers cultivate paddy under natural conditions with local varieties without adopting nutrient and pest management practices which resulted in very low yields . Organic cultivation in rice is very much a feasible proposition in tribal areas of Andhra Pradesh state where chemical use is absolutely nil. Arakuvalley tribal farmers with small land holdings of half an acre to one acre are benefited from ICAR- Tribal Sub Plan programme implemented by All india coordinated research project on Biological Control working under Acharya N.G.Ranga Agricultural University, Andhra Pradesh from the year 2015-16 to 2019-20. The main objective of the programme is to increase the net incomes of small and marginal as well as women tribal farmer with the popularization of biological control as frontline demonstrations, training programmes, exposure visits, fields days and rythusadassu. The Tribal farmers are exposed to ecofriendly low cost biological control techniquesin rice cultivation which AICRP Biological control believes is a stepping stone for sustainable agriculture. Tribal farmers realized the use of Biological control in preventing pests and diseases in rice cultivation and expressed willingness to adopt the technology for achieving higher yields.

MATERIALS AND METHODS

Rice organic farming techniqueswere adopted in pest management using Biocontrol agents and Biopesticides and nutrient management using biofertilizers by tribal farmers through Fronline large scale demonstrations, farmers training programmes, method demonstrations . Exposure visits , Field days and Rythusadassus's were organiswed for the promotion of the technology in adjacent tribal villages. Biocontrol agents, *Trichogramma chilonis* @ 1,00,000 egg parsitoids / ha /release against rice leaf folder and *Trichogramma japanicum* @ 1,00,000 egg parsitoids / ha /release against rice stem borer as Trichocards , 3 timeseach at weekly interval from 25 days after transplanting was demonstrated. Biopesticides, *Pseudomonas fluorescence* as seed treatment @ 10 g/kg seed and as foliar spray @ 5 g/lt for management of rice blast and sheath blight was conducted. Educated the farmers on Liquid biofertilizers,*Azospirillum* and *Phosphobacteria* each @ 500 ml/ acre mixed with 25 kg FYM and broadcasted at the time of transplanting .

RESULTS AND DISCUSSION

During first year, 2015-16, Front line demonstrations, training programmes, method demonstrations, field days on rice Organic farming techniques was conducted in 40 acres area at two villages i.e., Kothavalasa and Gunjariguda, Dumbriguda mandal, Araku valley, Visakhapatnam district, Andhra pradesh benefiting 50 farmers. Tribal farmers realized the use of biofertilizers application with good tillering and more productive tillers (8-10 tillers/hill) without zinc deficiency symptoms in organic farming block compared to check plot with poor tillering severe zinc deficiency in organic farming compared to traditional practice without using any fertilizers (4 tillers/hill) and observed nil incidence of stem borer as deadhearts and white ears and also leaf folder damage and severe incidence of stemborer as deadhearts and white ears and leaf folder damage . Tribal farmers recorded higher yields (4025 kg/ ha) with biological control practices compared to 2100 kg / ha in farmers practice. Additional yield recorded by organic rice farmers was 1925kg/ha with additional income of Rs. 19,250.00 and incremental benefit cost ratio of 1:4.4 compared to farmers practice of no fertilizer and no plant protection.

During 2016-17, improved rice varieties , MTU 1075, RNR 15048 wereintroduced along with biopesticides, Biofertilizers and Biocontrol agents for 45 farmerscovering 43 acres. Biological control in rice recorded higher yields (4500 kg/ ha) with incremental benefit cost ratio of 1:5.63 compared to farmers practice of no fertilizer and no plant protection(2300 kg / ha). Training imparted to 40 tribal of Asarada, GK veedhi mandal, Chinthapalli farmerson *Trichogramma chilonis* production using Eri silkworm eggs and Corcyra eggs at AICRP on Biological control, Anakapalle. Trichocard production unit constructed under ICAR Tribal sub plan programme was handed over to Trichocard rythumitra group (15 Tribal farmers) of Asarada village and motivated tribal youth for production of trichocards from kharif , 2018. Potential successes of advanced biocontrol based IOM systems was realized in rice in farmer field (Dirk Babendreie*et al.*, 2020)

Adoption of biological control in rice recorded higher yields (4625 kg/ ha) with incremental benefit cost ratio of 1:5.4 compared to farmers practice of no fertilizer and no plant protection(2450 kg / ha) in 2019-20. Transferred Biological control techniques through rice organic farming covering 165 acres of ricein Chinthapalli and Arakuvalley divisions of Visakhapatnam district, Andhra Pradesh through front line demonstrations, farmers trainings, method demonstrations, exposure visits, rythusadassus's, Exposure visit and created awareness on biocontrol agents, biopesticides and biofertilizers. Around 280 Tribal Farmers of 11 villages are benefited from ICAR-Tribal Sub Plan Programme implemented by AICRP on Biological Control Scheme, ANGRAU for improving the livelihood of tribal farmers through organic farming cultivation in rice . Farmers perception on importance of biological control in rice was collected from FLD farmers. Majority of farmers expressed biological control as effective method providing satisfactory control of rice pests and diseases in tribal areas .

The feed back from Killo Bhimala, tribal women farmer from Kothavalasa expressed that use of yellow cards (Trichocards) in paddy 4 times by clipping to paddy leaves prevented deadhearts and white ears by stem borer and leaf damage by leaf folder and happy to use trichocards for pest control as it is easy technique compared to severe incidence of deadhearts and white ears and leaf folding symptoms in traditional rice

Table 1. Reduction of pest and disease incidence in biological control of rice cultivation

Year	Percent reduction in stem borer damage	Percent reduction in leaf folder damage	Percent reduction in sheath blight incidence	Percent reduction in blast incidence
2015-16	89.4	88.2	36.9	68.82
2016-17	87.2	89.4	47.6	81.63
2019-20	88.1	82.80	40.52	88.25
Average	88.23			

Table 2. Advantages of biological control in rice cultivation by tribal farmers

Year	Yield (kg/ha)		Yield increase with biological control (%)	Monitory benefit with biological control Rs. / ha	Incremental Benefit Cost with biological control
	Biological control rice cultivation	Traditional rice cultivation			
2015-16	4025	2100	91.67	19,250	1:4.4
2016-17	4500	2300	95.65	22,000	1:5.63
2019-20	4625	2450	88.78	23,925	1:5.4
Average	4383.3	2283.3	92.03	21,725	1:5.14

cultivation. Pangi Narasayya, tribal farmer from Kothavalasa said that paddy cultivation became profitable . B.Krishna, tribal farmer from Gunjariguda expressed happiness in showing the healthy paddy crop with the application of biofertilizers and interested to adopt the technology in his total cropped area for achieving higher yields. The tricho cards, they say, do not have any biological side-effects, and the use of artificial pesticides being avoided, the paddy thus produced can be labelled as organic. This study indicate that rice production systems in tribal areas offer great scope to reduce pesticide use inturn improve human and environmental health. Similarly, case study reported biological Control of lepidopteran pests in rice (Gurr et al. 2016 and Horgan 2017).

CONCLUSION

Tribal farmers realized the use of Biological control in preventing pests and diseases in rice cultivation and expressed willingness to adopt the technology organic farming for achieving higher yields. Indian tribes set an example of sustainable agriculture. The benefits organic fertilisers have transformed the practice of traditional natural farming into adoption of organic farming practices by the tribal farmers. The change noticed was preparation of organic fertilisers using cow dung, cow urine, jaggery as well as organic pesticides using the leaves and kernels of neem (Azadirachta indica).The best part of the story is that the tribal women prefer to use Trichocards and Pseudomonas for the management of pestsa dn disesases in rice. Tribal farmers of arkuvalley and chinthapalli , visakhapatnam district of andhra pradesh state have chosen to produce safe and nutritious food, achieving food security with better livelihood through organic farming.Based on the experience gained Tribal sub plan programme , there is a scope for introduction of more number of programmes for effective, sustainable biological control programs.

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BIOCONTROL AND RICE GROWTH PROMOTING POTENTIAL OF ENDOPHYTIC BACTERIA ACCESSED FROM MEDICINAL PLANTS IN MANIPUR

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The rise of drugresistant bacteria (superbugs) has prompted a search for new and better antibiotics (National Institutes of Health, 2001; Raviglione *et al*., 1995; Pablosmendez *et al*., 1997). There is also an urgent need for novel antimycotics due to increasing incidence of opportunistic infections in HIV/AIDS and organ transplant patients (Walsh, 1992). The search is also on for environmentally friendly ways to grow the world's food through microbial plant growth promoting (PGP) and plant protection (PP) agents (Overton *et al*., 1996).

A relatively untapped source of microbial diversity for use in agriculture as well as medicine is the microbial endophytes (Bacon & White, 2000). They may produce antimicrobial agents that may be involved in symbiotic associations with host plants (Yang *et al*., 1994). Endophytic bacteria have been recognized as potential sources of drugs and agrochemical compounds (Zhao *et al*., 2007; Qin *et al*., 2009; Saikonnen *et al*., 2004; Taechowisan *et al*., 2003).

There is great promise for survey of bioactive endophytic bacterial strains in Manipur for potential applications in medicine, agriculture and industry. Manipur (Indo-Burma biodiversity hotspot) is rich in unique and underexplored ecosystems. As floral diversity is linked with microbial diversity, it is expected that the state may harbor rich microbial diversity including actinobacterial diversity in her varied biotopes. However, microbial diversity especially of actinobacteria has been poorly studied so far. Major actinobacterial niche habitats could be wetlands (rivers, lakes and streams), limestone habitats, caves, pristine forests and most importantly, medicinal plants of Manipur (for endophytes).

OBJECTIVES

- Ø To isolate endophytic bacteria from selected medicinal plants of Manipur and screen for biocontrol activities.
- Ø To screen for PGP traits (qualitative & quantitative) of the selected bioactive strains.
- Ø To study plant growth promotion and biocontrol potential of selected pathogens by most potent strains in agricultural crops under nethouse and field conditions.

METHODOLOGY

Isolation: Endophytic bacteria were isolated from selected ethnobotanically important medicinal plants using Qin et al. method (2009) with a few modifications.

Biocontrol Activity: Dual culture technique (Khamna et al., 2009) was used for antifungal screening.

In vitro tests for PGP traits were also performed as outlined below:

(i) Indole acetic acid (IAA) production: According to the method of Bano and Musarrat (2003).

(ii) Siderophore production: According You et al. (2005) with some modifications.

(iii) Phosphate (P) solubilization: According to (Mehta and Nautiyal, 2001).

(iv) 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase production: According to EL-Tarabily (2008).

(v) Fungal cell wall degrading enzyme production:

Chitinase production: According to Reid and Ogrydiazk (1981) with some modifications.

B-1,3-glucanase and β-1,4-glucanase production: Aaccording to Renwick et al. (1991). â-1,4-glucanase production was assayed according to Ariffin et al. (2006) using Congo red dye.

Lipase and protease production: According to Cappuccino and Sherman (1992).

(vi) Ammonia production: Estimated in peptone water (Cappuccino and Sherman, 1992)

In vitro Seed Vigor index testwas performed according to Baki and Anderson (1973).

Growth promotion under nethouse (pot trial) conditions and limited field trial will be done. Different parameters (root and shoot lengths, fresh root and shoot weights, and dry root and shoot weights) will be measured.

RESULTS

Isolation: 167 endophytic bacteria were isolated from 9 ethnomedicinally important medicinal plants of Manipur, India.

Biocontrol activity: Of 167 endophytic bacterial strains screened, 48 showed antifungal activities against one or more fungal test pathogens (*Curvulariaoryzae*, *Rhizoctoniasolani*, *Bipolarisoryzae*, *Fusariumoxysporum*, *Pyricularia oryzae*).

In vitro test for plant growth promoting (PGP) traits: Of 48 bioactive endophytic bacterial isolates, 29 endophytic isolates were found to show good PGP activities.

In vitro seed (*Jatra* Rice) germination test (*Vigor Index*): Twenty-nine(29) endophytic isolates having potent antifungal and promising PGP activities were selected for seed germination test.All the 29 isolates enhanced seedling growth of rice plants over the control. Four (4) isolates (Endo1, Endo2, Endo3, Endo4) showed the highest vigor indices (Table 1).

Table 1. Seed germination test (Vigor index) of the 4 endophytic isolates on *Jatra*Rice

Treatments	Seed Germination Percentage	Root Length (cm)	Shoot Length (cm)	Vigor Index
Control	70.7	1.94 ± 2.22	0.84 ± 1.09	196.55
Endo1	92.4	2.40 ± 1.84	1.34 ± 1.02	345.57
Endo2	70	2.30 ± 1.90	1.20 ± 1.04	245.21
Endo3	96.7	3.13 ± 0.84	1.20 ± 0.53	418.71
Endo4	90	2.05 ± 1.38	1.27 ± 0.86	298.80

In vitro seed (*Chakhao* Rice, unique black rice of Manipur) germination test (Vigor Index) : 3 potent isolates with good PGP activities were selected for further screening for seed germination test of black rice **(*Chakhao*)** plant growth promotion under nethouse condition. Of these 3 PGP strains, AcRz3 significantly promoted growth and grain yield of black rice plant. The strain significantly protected the lesions caused by *Rhizoctonia solani*(Table 2).

Rice growth promotion under pathogen challenged conditions (Field Trial, *Jatra* Rice): Four (4) shortlisted endophytic isolates showing highest vigor indices were further evaluated for plant growth promotion and biocontrol potential against selected rice

Table 2. Seed germination (Vigor Index) of the 3 endophytic isolates on *Chakhao* Rice

Treatments	Seed Germination Percentage	Root Length (cm)	Shoot Length (cm)	Vigor Index
Control	93	1.80±1.23	0.98 ± 0.74	258.54
Endo5	97	2.19 ± 1.17	1.37 ± .098	345.32
Endo1	93	1.78 ± 1.14	1.56 ± 1.13	310.62
Endo4	93	1.75 ± 1.09	1.95 ± 1.38	344.10

fungal pathogens under field conditions.Rice plants treated with the endophytic isolates showed significant increases in root lengths, shoot lengths, fresh shoot and dry shoot weights over the control **(**details not shown here**).**

CONCLUSIONS

Excessive application of chemical fertilizers, pesticides and other anthropogenic agrochemicals in agriculture is increasingly unpopular due to environmental and health concerns. Therefore, finding alternative eco-friendly strategies especially the use of microbial bioinoculants, biofertilizers, biocontrol agents (BCAs) and biostimulants to reduce harmful effects of farming practices is urgentlywarranted.The present study indicates that endophytic bacteria have promise for agricultural applications as PGP/PP agents. The 4 most promising endophytic bacteria (Endo1, Endo2, Endo35, and Endo42) associated with ethnomedicinal plants could be exploited for application as biocontrol and biofertilizing agents for rice production.

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COMPATIBILITY OF NEW INSECTICIDES, FUNGICIDES AGAINST MAJOR INSECT PESTS AND DISEASES OF RICE

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Rice (*Oryza sativa* L.) is the staple food crop of more than half of the world's population. Occurrence of insect pests and diseases together in rice crop needs insecticidal and fungicidal application to control these pests and diseases. Occurrence of stem borer, brown planthopper (BPH) together with sheath blight during *kharif* season is a common phenomenon. Therefore application of insecticides in combination with fungicides is effective and also minimizes the cost on spraying. In Andhra Pradesh, Godavari delta farmers go for sprayings up to 3-5 times during kharif season based on the intensity of occurrence of pests and diseases. The farmers usually tank mix the insecticides and fungicides indiscriminately to control both insect pests and diseases at a time. Keeping this in mind the study was under taken to evaluate the compatibility of selected insecticides and fungicides against major insect pests and diseases under field condition.

METHODOLOGY

The experiment was conducted at Regional Agricultural Research Station, Maruteru, West Godavari District during 2015-2016 in *kharif* seasons. The field experiment was laidout with nine treatments and three replications. All the standard agronomic practices were followed during the crop seasons. The treatments were T1-Chlorantraniliprole 20 SC @ 0.3 ml/l, T2- Flonicamid 50 SG @ 0.4 g/l, T3 - Azoxystrobin 25 SC @ 1.0 ml/l, T4- Tebuconazole 25.9 EC @ 2.0 ml/l, T5- T1+T3, T6-T1+T4, T7-T2+T3, T8 -T2+T4 and T9 is Untreated control. The treatments were imposed at 45 and 60 days after transplantation. The insecticides and fungicides were tank mixed and spray fluid @ 500 litres per hectare was used in order to thorough coverage of the crop. The data on insect pests stem borer, brown plant hopper along with sheath blight collected at before and 15 days after the imposition of the treatment. The mean data so obtained from the field data was analysed statistically by ANOVA.

RESULTS

Flonicamid 50 SG @ 0.4 g/l in combination with tebuconazole 25.9 EC @ 2.0 ml/l recorded lower incidence of plant hoppers 24.00/10 hills during *kharif*, 2015 and 46.00/10 hills during *kharif*, 2016 followed by flonicamid 50 SG @ 0.4 g/l in combination with azoxystrobin 25 SC @ 1.0ml/l recorded plant hoppers per 10 hills 36.33 and 107.00 and flonicamid 50 SG @ 0.4 g/l alone recorded 54.67 and 136.00 plant hoppers per 10 hills respectively.

Among the treatments chlorantraniliprole 20 SC @ 0.3 ml+azoxystrobin 25 SC @ 1.0 ml/l recorded low incidence of stem borer in terms of percent white ears 5.26 and 2.23 during *Kharif*, 2015 and 2016 respectively followed by chlorantraniliprole 20 SC @ 0.3 ml/l alone recorded 7.44 percent white ears during *kharif* 2015 and 2.59 percent white ears during *kharif*, 2016 and chlorantraniliprole 20 SC @ 0.3 ml+tebuconazole 25.9 EC @ 2.0 ml/l recorded 8.96 % white ears during *kharif*, 2015 and 3.00% white ears during *kharif*, 2016.

Against sheath blight incidence the treatments flonicamid 50 SG @ 0.4 g/l in combination with azoxystrobin 25 SC @ 1.0 ml/l recorded lowest incidence of sheath blight incidence 29.10% during

Theme - III : Biotic-stress management in rice

Table 1: Efficacy of new insecticides, fungicides combinations against planthoppers, stem borer and grain yields during *Kharif* 2015 and 2016.

Treatments	Planthoppers (Number/10hills)		Stem borer incidence(% white ears)		Sheath blight incidence (%)		Grain yield (Kg/ha)	
	2015	2016	2015	2016	2015	2016	2015	2016
T1=Chlorantraniliprole 20 SC@ 0.3 ml/L	494.00(20.65	200.00(14.09)	7.44(15.80)	2.59(9.17)	38.05(38.08)	36.96(37.39)	3396	1820
T2=Flonicamid 50 SG @ 0.4 g/L	54.67(6.00)	136.00(10.41)	16.46(23.90)	6.03(14.00)	44.58(41.88)	42.32(40.56)	5247	2459
T3=Azoxystrobin 25SC @ 1.0 ml/L	236.33(14.79	181.00(13.41)	11.84(17.83)	5.57(13.54)	31.63(34.18)	35.23(36.37)	4135	2484
T4=Tebuconazole 25.9EC @ 2.0 ml/L	66.00(8.12	271.00(16.34)	21.04(26.86)	4.03(11.55)	37.85(37.91)	30.76(33.59)	3004	1948
T5=T1+T3	431.00(20.35	545.00(23.33)	5.26(13.25)	2.23(8.20)	30.22(33.33)	29.20(32.64)	4245	2314
T6=T1+T4	242.33(13.65	370.00(19.22)	8.96(17.10)	3.00(9.87)	42.65(40.75)	36.77(37.19)	4013	2514
T7=T2+T3	36.33(5.92)	107.00(10.05)	9.79(17.78)	4.03(11.55)	29.10(32.63)	26.16(30.72)	5738	3104
T8=T2+T4	24.00(4.82)	46.00(6.50)	11.05(19.19)	4.81(12.62)	40.14(39.31)	31.07(33.84)	5197	2295
T9=UTC	356.00(18.26)	378.00(19.42)	24.39(29.55)	5.65(13.74)	41.62(40.16)	36.90(37.39)	2609	1618
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
CD	10.16	4.48	9.49	3.19	5.76	5.15	1724	572.37
CV (%)	47.04	17.54	27.23	15.89	3.75	8.37	23.85	14.48

kharif, 2015 and 26.16% during *kharif*, 2016 followed by chlorantraniliprole 20 SC @ 0.3 ml/l in combination with azoxystrobin 25 SC @ 1.0 ml/l recorded 30.22 % and 29.20 % sheath blight incidence and azoxystrobin 25 SC @ 1.0 ml/l alone recorded 31.63 % and 35.23 % sheath blight during *kharif*, 2015 and *Kharif*, 2016 respectively.

The higher grain yield (5738 kg/ha) was recorded in flonicamid 50 SG @ 0.4 g/l in combination with azoxystrobin 25 SC @ 1.0 ml/l followed by flonicamid 50 SG @ 0.4 g/l alone which recorded 5247 kg/ha during *kharif* 2015. During *kharif*, 2016 flonicamid 50 SG @ 0.4 g/l in combination with azoxystrobin 25 SC @ 1.0 ml/L recorded higher yield 3104 kg/ha.(Table. 1)

CONCLUSIONS

Among the combinations new insecticides and fungicides evaluated **c**hlorantraniliprole 20 SC @ 0.3 ml+azoxystrobin 25 SC @ 1.0 ml/l against stem borer (white ear), flonicamid 50 SG @ 0.4 g/l in combination with tebuconazole 25.9 EC @ 2.0 ml/l against planthoppers and flonicamid 50 SG @ 0.4 g/l in combination with azoxystrobin 25 SC @ 1.0 ml/l against sheath blight &grain yield were fund best.

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IRC/TM-3/PP-34

COMPONENTS OF SLOW BLASTING RESISTANCE TO NECK BLAST DISEASE (*PYRICULARIA ORYZAE* CAVARA) IN BASMATI RICE

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Blast disease of basmati rice caused by *Pyricularia oryzae*, is highly destructive and has worldwide distribution. Over the past few decades, huge yield losses ranging from 20-100 per cent have been reported from India(Vasudevan *et al* 2014).. The disease can be managed effectively through the use of systemic fungicides but late application of fungicides particularly near to maturity of the crop leads to build-up of harmful residues in rice grain. In the recent past, Indian basmati consignments containing residues of tricyclazole have been rejected by European Union and had larger impact on Indian economy as 50-80 per cent of basmati is exported to the international and domestic market. The complete resistance or vertical resistance to blast disease is of qualitative nature, controlled by one or few major genes and is highly race specific. Moreover, rice blast pathogen is highly variable and resistant varieties remain effective only for a few years. Therefore, the study was planned in order to study interaction among various components responsible for slow blasting type of resistance (partial resistance) which is more durable and race non-specific.

METHODOLOGY:

Rice crop: A set of 3 Near Isogenic Lines (NILs) viz., IRBL 22, IRBL 8 and IRBL 14 having single blast resistance gene developed by International Rice Research Institute (IRRI), Manilla, Philippines; 2 Introgression Lines (INGR 15001 and INGR 15002); 2 local cultivars (Pusa Basmati 1637 and Punajb Basmati-5); 2 susceptible checks (Pusa Basmati 1401 and Pusa Basmati 1121) and 1 resistant check (Tetep) were grown under field conditions for two consecutive years i.e. *Kharif* 2018 and 2019 following standard cultivation practices at Punjab Agricultural University, Ludhiana.

Pathogen isolates: Five Plants and five necks per plant were artificially inoculated with highly virulent isolate (NB7) and least virulent isolate (NB51) of the fungus (Singh 2018). Artificial inoculations were carried out at 0, 3, 6 and 9 days after 50 per cent flowering stage using bit wrap technique (Jain et al. 2017). Following observations were recorded:

a). Morphological parameters: Ten morphological parameters viz., Panicle Diameter (PnD), Flag leaf length (FLL), Flag leaf width (FLW), Flag Leaf Angle (FLA), Days to 50 per cent flowering (DF), Node ageing, Degree of exsertion of panicle, Panicle length (PnL), Panicle Axis (PnA) and Culm length (CL) were recorded at different growth stages of rice plant .

b). **Disease parameters:**Lesion length, Panicle blast severity (PBS), Area under disease progress curve (AUDPC), Disease incidence (DI), Incubation period (IP50) and Apparent rate of infection (R) were six disease parameters recorded for each cultivar after inoculating the cultivar with isolate NB7 as well as NB51.

Correlation coefficients among resistance components were determined by Pearson correlation analysis. Statistical analysis of the data was performed using SPSS 20 software.

RESULTS:

The test genotypes exhibited high variability in various architectural features such as flag leaf angle, flag leaf length, flag leaf width, panicle axis, panicle diameter, degree of exertion of panicle, culm length, 50% flowering and node aging. On inoculation with NB7 (most virulent) isolate, maximum lesion length was recorded in genotype IRBL 14 and maximum panicle blast severity was recorded in cultivar Pusa Basmati 1121. Lowest lesion length and panicle blast severity was noted in resistant check Tetep. Area under disease progress curve (AUDPC) was calculated based on panicle blast severity which ranged between 86.4 to 349.2 with a mean value of 214.04. Disease incidence ranged from 80 per cent to 96 per cent with a mean value of 87 per cent. Least disease incidence was observed for the resistant cultivar Tetep whereas maximum disease incidence was observed for the highly susceptible cultivar Pusa Basmati 1121. All ten basmati rice genotypes had different incubation period ranging from 7.3 days (Pusa Basmati 1121) to highest 9.6 days (INGR 15002) with a mean of 8.17 days. Apparent rate of infection varied from 0.30 for resistant check tetep to 0.48 for Pusa Basmati 1401. On the other hand, when the test genotypes were inoculated with NB51 (least virulent) isolate, the lesion length was recorded ranging from 3.6 mm to 16.48 mm with a mean of 10.61 mm. Maximum lesion length was recorded in IRBL 22 and lowest lesion length was recorded in resistant check Tetep.

Significant positive correlation between flag leaf angle and disease incidence was observed with correlation coefficient of (r=0.758*) when the genotypes were inoculated with isolate NB7. When the same genotypes were inoculated with NB51, there was no correlation between the above two parameters but another significant negative correlation was observed between Panicle axis and apparent rate of infection with correlation coefficient r equal to -0.668*. A decreasing trend in the lesion length was observed when the necks were inoculated at a later stage of panicle development (increased node ageing). This decrease in lesion length, irrespective of the isolate with which it was inoculated, was related to decrease in the AUDPC and thus decrease in susceptibility index and increasing resistance of plant towards the disease.

CONCLUSIONS:

In this study, three components viz., flag leaf angle, panicle axis and node ageing emerged out to be important components contributing towards partial resistance. These findings are of vital interest and can help as morphological markers in resistance breeding for neck blast.

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MORPHOMETRICS OF *NILAPARVATALUGENS* POPULATIONS COLLECTED FROM DIFFERENT LOCATIONS OF INDIA

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Rice is one of the main cereal crops and a staple food for over half of the world's population. It provides up to 50 per cent of the world's dietary caloric supply and a substantial part of the protein intake for a large portion of people in various regions of the world. More than 100 insect species attack rice, of these 20 are major pests. Particularly, the brown planthopper (BPH) *Nilaparvatalugens*(Stål) (Homoptera: Delphacidae), is one of the notorious sucking pest. The *N. lugens* damage is more often seen in well irrigated, densely planted fields with high doses of nitrogen and frequent insecticide application. The insects immigrate into the freshly planted crop and colonize. Crop loss is usually considerable and complete destruction of the crop occurs in severe cases. BPH displays two wing forms in adult stage: long (macropterous) and short (brachypterous). Macropterous adults fly long distances and invade rice-growing areas, whereas brachypterous adults cannot fly long distance. Bey-Bienko (1985) noted that in many organisms' changes in the ecological and physiological traits of the species are frequently followed by subtle changes in its morphological characteristics. Morphology as the end product of physiological activities is initiated by the genome and modified by the environment. A physiological change at the immature stage would likely result in a morphological change at the adult stage (Eastop, 1973). Brown planthopper populations were collected from different parts of India to know the variation in the bioefficacy of insecticides and to monitor the insecticide resistance status in different populations. Morphometrics i.e. morphological variations in different BPH populations was also studied to know whether the exposure to insecticides or the insecticide resistance in the population has any effect on the morphology of BPH and also to know whether any morphological variations are there in BPH populations of different regions in India. Morphometric studies also help us to know whether any subtle change occurred due to the changes in biology and elevated detoxification enzymes in different BPH populations. Keeping these facts in view the investigations have been carried out to study the morphometrics of *N. lugens* populationscollected from few locations of India.

METHODOLOGY

The investigations were carried out in the greenhouse at ICAR-Indian Institute of Rice Research, Rajendranagar and at the Instrumentation Cell, College of Agriculture, PJTSAU, Rajendranagar during 2016-2018. One day old adults of all forms and the different instar nymphs immediately after moultingwere used for measurement. Total length of the body, width of the body, length of wings, width of the wing, length of head, inter ocular distance and tibial spur length of adult barchypterous and macropterous forms of females and males along with length and width of the body of all the five instar nymphs of BPH were measured.

The BPH populations collected from Kampasagar (Telangana), Gangavathi (Karnataka), Raipur (Chhattisgarh), Bargarh (Odisha) and Ludhiana (Punjab) and glasshouse BPH population(IIRR) were used for the study. The morphologicalcharacters were examined under the Lawrence and Mayo stereoscopic

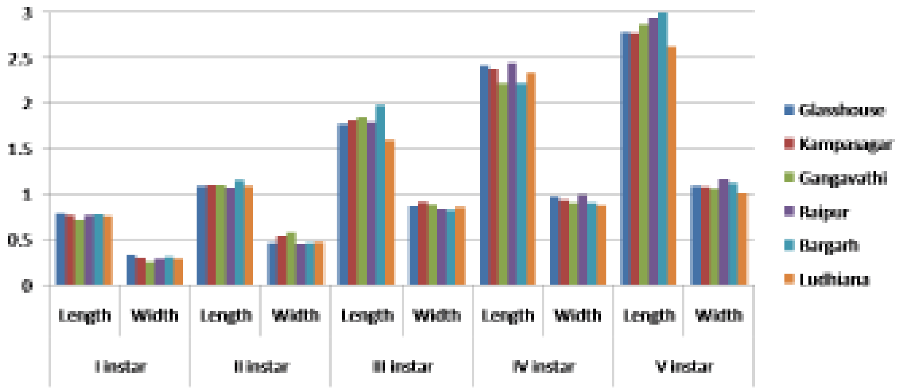

Fig1: Morphometrics of brown planthopper nymphs collected from different locations

binocular microscope, Model: LM-52-3611 (ZTX-3E) with 2X zoom. The samples from each stage from each region comprised of twenty individuals of the test insect. Results were analyzed with T capture software version 3.9 build 500 and statistically analyzed in Completely Randomized Block Design.

RESULTS

Body length of brachypterous female BPH from Kampasagar was more *i.e.* 3.356 mm and length of the head of the brachpterous female was more 0.847 mm in Raipur BPH population compared to that of other BPH populations. The body length of the adult macropterous female BPH from Kampasagar was more (3.448 mm) and tibial spur was longest (0.456 mm) in Bargarh macropterous females compared to that from other locations. Maximum length of the head (0.777 mm) of the brachpterous male BPH was observed in Raipur population as compared to the other geographical regions. Interocular distance in adult macropterous male was significantly more in the Kampasagar BPH population (0.810 mm). The tibial spur was the longest in the glasshouse macropterous males (0.320mm) (Fig1).

The body length of the first instar BPH nymphs was more in Gangavathi BPH population (0.716 mm), the body length of second instar nymph was more in Bargarh BPH population (1.153mm). The body length and width of fourth instar BPH nymphs were more in Raipur BPH population (2.447mm and 0.988mm, respectively) and the body length of fifth instar BPH nymphs was more in Bargarh BPH (2.996mm).

CONCLUSION

Morphometric studies revealed that slight variation existed among different BPH populations. There is further need to studythe genital characters to conclude accurate deviation among the distant BPH populations.

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IRC/TM-3/PP-37

INFLUENCE OF RAINFALL & STANDING WATER ON DISSIPATION OF IMIDACLOPRID FROM A SIMULATED RICE ECOSYSTEM

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Climate change is real and its effects has given permanent scars to our planet. Unpredictable rainfall and vagaries in temperature will certainlydisturbthe balance of ecosystem. Agricultural yields firmly rest on crop protection measures and pesticides are integral part of agriculture. Once applied in field, pesticides underwent many changes through abiotic and biotic factors. Among abiotic factors, rainfall (intensity and amount) plays significant role in governing the distribution and dissipation of any pesticide. High intensity rainfall will produce rapid flow pathway and macropore flow in soil (Chen *et al.* 2019). This will cause heavy loss of pesticides through leaching and runoff,particularly, those pesticide which are feebly attached to soil thus, contaminating water resources (surface and groundwater). Understanding the fate of pesticides in environment is important to evaluate the potential risk associated with pesticide use. No real time information is available on quantity of pesticide lost through leaching and runoff and how much quantity of pesticide taken up by plants after a sudden rainfall. Imidacloprid granule formulation is recently recommended in rice by Central Insecticide Board and Registration Committee, India. Imidacloprid is prone to leaching. Looking above facts, this study aims (a) to study the effect of rainfall on imidacloprid losses through leaching and runoff from a simulated rice ecosystem (b) role of standing water (saturated, 5, 10 cm standing water) on persistence and dissipation of imidacloprid.

METHODOLOGY

Influence of simulated rainfall was conducted in lysimeter (length 90 cm and diameter 55 cm) made up of polyethylene plastic. Soil was filled up to height of 60 cm from bottom of lysimeter. Simulated rainfall treatments were imposed at once by applying equivalent water of rainfall events 40 mm (rainfall/day) and 100 mm (rainfall/day) rain water to simulate varied climatological rain events. The water equivalent to rainfall amounts was imposed at 4, 8 and 24 h after pesticide application.Soil column (PVC) pipes of 60 cm length and diameter of 10.5 cm were used to study role of standing water on dissipation and persistence of imidacloprid. PVC columns were filled with soil up to height of 45 cm and leachates were collected from bottom of each column. To maintain different water regimes conditions (saturated, 5 cm and 10 cm standing water) in soil columns, water was supplemented twice daily equivalent to water lost through leaching and evaporation throughout the experiment. Both experiments were set up in Completely Randomized Design with four replications. Soil, plant and water samples were collected at different intervals to study the dissipation of imidacloprid. The methodology to study the dissipation of imidacloprid was followed as per Mahapatra *et al.* 2017. SANTE guidelines (SANTE/11813/2017) (SANTE, 2017) were followed for method validation of imidacloprid.

RESULTS

The dissipation of imidacloprid from soil and plants under two simulated rainfall events followed first order kinetics (Table 1). Under 40 mm simulated rainfall, imidacloprid was dissipated 82.83, 78.85 and 75.66% of initial deposits at 10 days after pesticide application when rainfall happened at 4, 8 and 24 h

Table 1: Linear regression equations and half-life of imidacloprid in soil exposed to 40 mm & 100 mm simulated rainfall conditions

Treatments (Gap between pesticideapplication and rainfall events)	40 mm rainfall		100 mm rainfall	
	Regression Equation	Half-Life (days)	Regression Equation	Half-Life (days)
4 h	$y = -0.0629x + 1.9133 R^2 = 0.9674$	11.02[a]	$y = -0.0682x + 1.2887 R^2 = 0.886$	9.69[a]
8 h	$y = -0.0612x + 1.9787 R^2 = 0.975$	11.32[a]	$y = -0.0651x + 1.3165 R^2 = 0.942$	10.28[a]
24 h	$y = -0.0608x + 2.0427 R^2 = 0.9815$	**11.55[b]**	$y = -0.0643x + 1.3809 R^2 = 0.938$	**11.55 [b]**
p- value	<0.0003		< 0.0003	

p- value:
rainfall: 0.0348
rainfall*time: 0.6217 (non-significant)
*Means with at least one letter common are not statistically significant using Tukey's minimum significant difference test at p< 0.05
a, b means with different superscripts are significantly different with p <0.05

after pesticide application, respectively. While, under 100 mm simulated rainfall event, imidacloprid was dissipated 82.83, 77.45 and 76.06% of initial deposits at 10 days after pesticide application, when rainfall happened at 4 h, 8 h and 24 h after pesticide application, respectively.

Under 40 mm rainfall event, the highest concentration of imidacloprid in leachate was observed on day 1 after pesticide application and were 37.87, 53.15 and 72.48 ng mL^{-1} when rainfall occurred 4 h, 8 h and 24 h after pesticide application, respectively. Similarly, under 100 mm rainfall event the highest concentration of imidacloprid in leachate was observed on day 1 after pesticide application and were 26.36, 35.43 and 48.32 ng mL^{-1} when rainfall occurred 4 h, 8 h and 24 h after pesticide application, respectively. Water runoff was observed only in 100 mm simulated rainfall event. The highest concentration of imidacloprid in runoff water was detected from treatment when rainfall event occurred at 4 h (79.17 ng mL^{-1}) followed by 8 h (51.58 ng mL^{-1}) and 24 h (28.98 ng mL^{-1}) after pesticide application (Fig 1).

Dissipation of imidacloprid in soil and plants followed first order kineticsunder different standing water conditions.At day 7 after pesticide application, there was a loss of 63.39, 68.84 and 61.41% imidacloprid from saturated, 5 cm and 10 cm standing water conditions, respectively. Half-life values of imidacloprid in soil were 10.5, 8.6 and 8.1 days under saturated, 5 cm and 10 cm standing water conditions, respectively.Highest concentration of imidacloprid in plants were detected on day 1 after insecticide application and were 24.21, 18.01 and 14.71 ng g^{-1} of leaves under different water regime conditions i.e., saturated, 5 cm and 10 cm standing water, respectively. While, in water samples highest concentration of

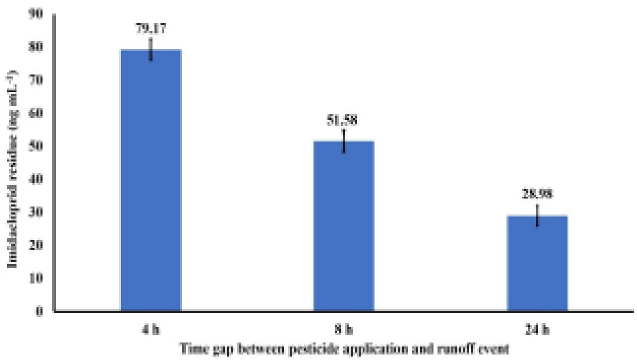

Fig 1: Concentration of imidacloprid residues in runoff water of 100 mm rainfall (error bars represent standard deviation of four replications)

imidacloprid was detected on 2nd day after pesticide application and it was 31.56, 44.30 and 60.39 ng mL^{-1} from different treatments viz., saturated, 5 cm and 10 cm standing water, respectively. Imidacloprid residues were not detected in leachates at 21 days after pesticide application.

CONCLUSION

Heavy rainfall and stagnant water conditions just after pesticide application cause considerable pesticide loss from applied area. These losses might result into ineffective functioning of pesticides. Imidacloprid lost through leaching and surface runoff may enter into various matrices of environment and can pose threat to the environment.

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Theme - III : Biotic-stress management in rice

IRC/TM-3/PP-39

EVALUATION OF RICE GERMPLASM FOR BROWN PLANTHOPPER, *NILAPARVATA LUGENS* (STÅL) RESISTANCE USING GENE SPECIFIC MARKERS AND PHENOTYPIC METHODS

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Brown planthopper (BPH), *Nilaparvata lugens* (Stål) (Hemiptera: Delphacideae) is the serious insect pest of rice in India. It sucks the plant sap, causing wilting and death of the plants in patches causing severe yield losses. Host plant resistance is the important control method and there is a need to search for new resistant donors for BPH by systematic phenotyping and genotyping. Assessment of genetic diversity using DNA based molecular markers is considered as a powerful tool for determining genetic variation in rice varieties. Among various PCR based markers, SSR markers are more popular in rice because they are highly informative and also cost effective. Forty BPH resistance genes of rice have been identified till now in different cultivars and in wild species (Akanksha *et al* ., 2019). But many of the molecular markers reported so far are not tightly linked to the genes of interest and hence, they are difficult to use for molecular marker assisted selection. In order to develop resistant varieties for the biotype 4 present in India, identification of highly resistant donors is essential to strengthen resistance breeding. Therefore, the present study was undertaken to evaluate different germplasm accessions collected from Establishment of National Rice Resource database (ENRRD) for their resistance to BPH through phenotyping in relation to genetic divergence.

METHODOLOGY:

1110 ENRRD rice germplasm accessions were mass screened under greenhouse conditions at ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad following the Standard Seedbox Screening Test method. The mechanisms and components of resistance i.e. antexenosis (non-preference for feeding probing marks and honeydew excretion); antibiosis (nymphal survival, duration, sex ratio, growth index, macroptery); tolerance (days to wilting) were studied in the selected resistant germplasm accessions. The highly resistant germplasm accessions were genotyped to know the presence or absence of known major genes, using the reported markers. Genomic DNA of twenty four rice genotypes including sources for the BPH resistance was isolated by CTAB method of Murray and Thompson (1980). A set of 17 SSR markers were used for this study which were reported linked markers to nine BPH resistant genes *viz., Bph1, Bph2, Bph 3, Bph 6, Bph 7, Bph 17, Bph 18, Bph 20* and *Bph 32*. The isolated DNA of each genotype was analyzed by PCR using BPH resistant gene specific SSR markers. The PCR products was separated on agarose gel electrophoresis and results were recorded. The presence or absence of amplicons was scored as 1 and 0 as a binary data. This binary data was fed into diversity software using Unweighted Pair Group Method with Arithmetic Mean (UPGMA) method using DARwin V6.0. to generate the dendrogram. Based on the dendrogram, the relationships existing among the genotypes were identified.

RESULTS :

Out of 1110 rice germplasm accessions tested, 3 accessions *viz.*, IC Nos. 343457 (DS 0.3), 300168 (DS 0.6)and 377051 (DS 0.9) were as highly resistant, while, 24 entries *viz.*, IC Nos. 319799, 343394, 301181, 449821, 343392, 464944, 450041, 341334, 300166, 377527, 300167, 319350, 346927, 343515, 300202, 577624, 545441, 497079, 461801, 377423, 554787, 354787, 321833 and 252243 were resistant and 19 were moderately resistant. Brown planthopper probed more number of times, fed less and excreted less amount of honeydew on resistant entries, nymphal survival was low, more males emerged and growth index was low on resistant entries. Resistant germplasm accessions took more days to wilt. In this study, 17 gene based markers associated with BPH resistance classified all the genotypes into four major clusters (Fig1). Cluster II was the largest and included 10 genotypes, while clusters I, II and IV included the rest of the 14 cultivars out of which 9 belonged to cluster II and cluster I comprised of single genotype and cluster IV comprised of 4 genotypes. The average similarity matrix value was found to be of 0.31. Maximum genetic similarity was 0.86 between IC 3 77527 and IC 301181, whereas least genetic similarity was 0.06 between T 12 and IC 343457. Cluster I and Cluster II consisted of both resistant donars and susceptible checks having reaction to BPH from score 1-9 whereas Cluster III and IV each are represented by highly resistant and resistant genotypes except Sampada having susceptible reaction. The genotypes IC 300167 was observed to have *Bph 6* gene. Similarly, IC 301181, IC 319799, IC 450041 IC 343392, IC 343457 and IC 449821 were observed to have *Bph 18* gene (Table 7). Lines IC 300168, IC 450041 and IC 343394 for RM19291 and IC 343394, IC 343457, IC 377051, IC 449821, IC 577624 for RM8072 showed entirely new alleles. These new alleles might be source for BPH resistance in these lines.Only for *Bph6 and Bph18*, both flanking markers showed the presence of donor alleles which could be considered for putative indication of presence of these genes.

CONCLUSIONS:

The phenotypic screening studies indicated that IC 343457, IC 343394, IC 450041, IC 577624, IC

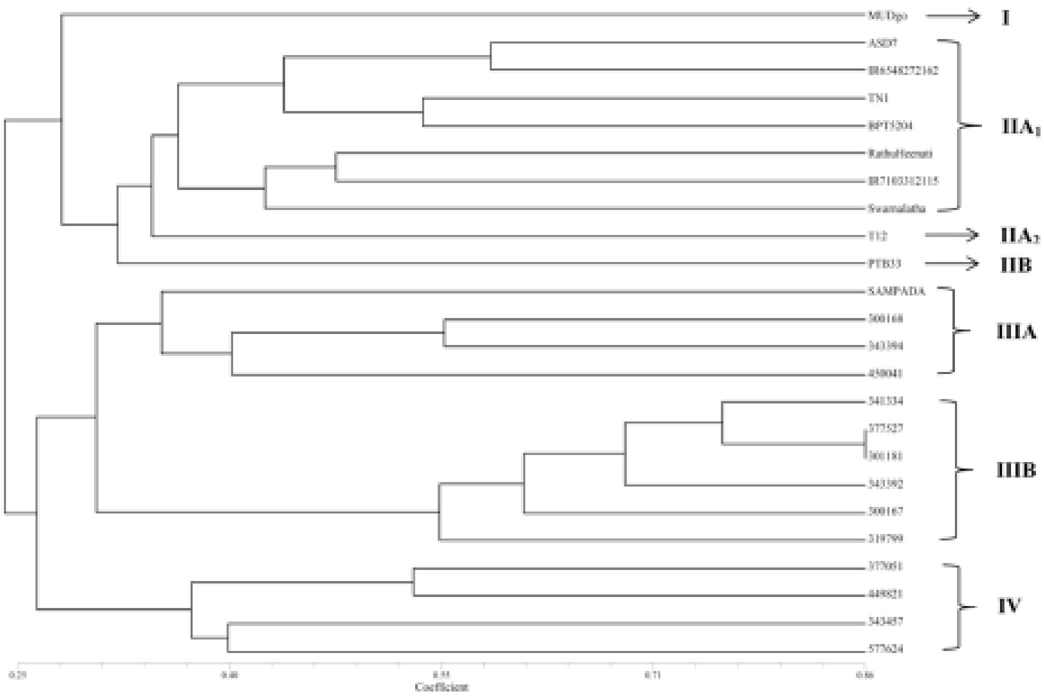

Fig 1. Dendrogram based on similarity coefficients calculated from 24 rice genotypes

341334, and IC 300168 are good resistant sources. These genotypes would be used in future for genetic studies to identify the gene(s).The accession IC 343457 possessed more number of resistant genes as it showed five positive detections for five *Bph* resistant genes.

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EFFECT OF CHLORANTRANILIPROLE ON SOIL MICROBES

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Increase in rice production is hampered due to insect-pests and diseases in rice which cause significant yield losses. In the tropical environment major rice insect-pests are stem borers, hoppers, leaf folder etc. Till date, the yellow rice stem borer is most important insect-pest in rice and it causes yield loss in pan-India. Farmers use number of insecticides against this pest. Two chlorantraniliprole (CAP) formulations namely, chlorantraniliprole 0.4 G @ 10 kg/ha and chlorantraniliprole 18.5 SC @ 150 g/ha are recommended for efficient control of yellow rice stem borer (CIBRC, 2018). Pesticide molecule itself or its transformed products can alter the activities of soil-associated microbes. These may impact nutrient cycle and soil quality at large. In our study, we generated basic information about the dissipation of CAP and microbial activity in rice planted soil.

METHODOLOGY

Dissipation of chlorantraniliprole and its effect on non-target organisms were studied in rice (var. TN1, *Indica* type) soil at ICAR-National Rice Research Institute, Cuttack. The pesticide chlorantraniliprole (Ferterra 0.4G) was applied at 40g a.i./ha as farm recommended dose (FR). Control had not been applied with any pesticides. Soil samples were collected at different intervals after pesticide application for quantification of residues and microbial activities from soil. Microbes number namely, heterotrophic bacteria, actinomycetes, fungi, phosphate solubilising bacteria and asymbiotic nitrogen fixer were counted. Similarly, soil enzymes namely, dehydrogenase, fluorescein diacetate hydrolase, phosphatases, glucosidase were estimated (Sahu et al. 2019).

RESULTS

The studied soil was alluvial and the soil texture was sandy loam. The physico-chemical properties of the soil were pH 5.68, electrical conductivity 0.67 ds m^{-1}, organic carbon 0.7% and total nitrogen 0.7%. When chlorantraniliprole was applied at farm recommended dose (FR) @40g a.i./ ha, no residues could be recovered from the soil 30 days' post application. Dissipation half- lives of chlorantraniliprole was 23.8 days.Chlorantraniliprole (FR) did not have any significant negative effect on soil microbes namely, bacteria, fungi, actinomycetes,phosphate solubilising bacteria and assymbiotic nitrogen fixer (BNF) population compared to control. Soil enzymes did not respond negatively upon chlorantraniliprole application as compared to control. Minor disturbances in soil enzyme activities occurred upon pesticide application, were also recovered 15 days after pesticide application. Urease activity was higher in chlorantraniliprole treatment as compared to control. Soil microbial biomass content did not vary significantly between the treatments. As stated earlier, if recovery of soil microbial parameters takes place within 30 days post-application of a pesticide, then the pesticide may not be termed as harmful. Our study corroborates that chlorantraniliprole

Table 3. Effect of chlorantraniliprole on microbial biomass carbon(µg g^{-1} soil) in rice planted soil

Dose	Duration (days)						
	BS	0	3	7	15	21	30
FR	75.84	71.62	99.69	103.62	82.29	86.23	89.26
Control	75.84	88.59	91.77	105.40	83.55	82.41	86.93

Where, BS: Before pesticide application, FR: Farm Recommended dose.

as a reduced risk pesticide as stated by the Environmental Protection Agency (EPA).

CONCLUSION

Application of the farm recommended dose of chlorantraniliprole is non-toxic to soil microbes. Therefore, recommended dose of CAP in rice has less chance of environmental contamination. It can be a useful tool for insect pest management in rice.

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IRC/TM-3/PP-41

BROWN PLANT HOPPER, *NILAPARVATA LUGENS* (STAL.) DYNAMICS IN SEMI DRY SYSTEM OF RICE

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In North Coastal Zone of Andhra Pradesh most of the rice growing area is under rain fed conditions. Semi-dry system is getting wide acceptance among the farmers of the Zone which is sown on dry condition as a rain fed crop taking advantage of monsoon rains prior to canal water release and after canal water release the crop will be maintained as lowland rice with standing water. In recent years the BPH problem is increasing in NCZ especially in semidry system. To develop sustainable management systems, it is important to find out the influence of different cultivation practices followed by the farmers on the incidence of BPH and its natural enemies.

OBJECTIVE

To study the incidence of BPH and its natural enemies in semi dry rice system as influenced by seed rate, nitrogen levels and irrigation water levels.

METHODOLOGY:

Design	:	Randomized Block Design
Replications	:	3
Treatments	:	9
Plot size	:	5 m X 4 m (20 m^2)
Season	:	*kharif* 2017
Variety	:	BPT5204

BPH and WBPH populations of both nymphs and adults on 10 hills at random was recorded from 30DAS at 10 days interval throughout the crop period. Natural enemy populations *viz.*, predatory mirid bugs (Green), spiders and coccinellid beetles was recorded simultaneously on the crop from 30DAS at 10 days interval on 10 hills. the plots were harvested replication wise and yield per plot was recorded and expressed as kg $plot^{-1}$ based on which yield per hectare was calculated. The data on the incidence of BPH, WBPH and its natural enemies was subjected to ANOVA in Randomized block design.

RESULTS:

During tillering stage of rice, the incidence of BPH population was observed highest (6.93/hill) in RSDS + higher seed rate (T2) followed by T8 and lowest BPH population (4.39/hill) was observed in transplanted rice (T9) followed by RSDS (T1). The highest incidence of coccinellid population (3.28/hill) was observed in RSDS (T1) followed by T6 and lowest coccinellid population (2.96/hill) was observed in transplanted rice (T9) followed T7. The highest incidence of spiders population (3.31/hill) was observed in transplanted rice (T9) followed by T5 and lowest spiders population (3.00/hill) was observed in RSDS + higher seed rate + higher nitrogen+ water stagnation (T8). The highest incidence of mirid bugs population (3.09/hill) was observed in RSDS (T1) followed by T2 and lowest mirid bugs population (2.89/hill) was observed in T8 followed by transplanted rice (T9).

During reproductive stage of rice, the incidence of BPH population was highest (42.72/hill) in RSDS + higher seed rate + water stagnation (T6) followed by T8 and lowest BPH population (13.46/hill) in transplanted rice (T9) followed by RSDS (T1). It is supported by studies of Dharmasena *et al*. (2000). The highest incidence of coccinellid population (4.65/hill) was observed in RSDS (T1) followed by T2 and

T.No.	Treatments	Particulars of the Treatments
T1	Recommended Semi Dry system (RSDS)	75kg seed/ha + 120:60:50 NPK kg ha^{-1}
T2	RSDS + Higher Seed rate	100kg seed/ha + 120:60:50 NPK kg ha^{-1}
T3	RSDS + Higher Nitrogen	75kg seed/ha + 150:60:50 NPK kg ha^{-1}
T4	RSDS + Water stagnation	75kg seed/ha+ 120:60:50 NPK kg ha^{-1} + Stagnation of water from 45DAS.
T5	RSDS + Higher Seed rate + Higher Nitrogen	100kg seed/ha + 150:60:50 NPK kg ha^{-1}
T6	RSDS + Higher Seed rate + Water stagnation	100kg seed/ha + 120:60:50 NPK kg ha^{-1} + Stagnation of water from 45DAS.
T7	RSDS + Higher Nitrogen + Water stagnation	75kg seed/ha + 150:60:50 NPK kg ha^{-1}+ Stagnation of water from 45DAS.
T8	RSDS + Higher Seed rate + Higher Nitrogen + Water stagnation	100kg seed/ha + 150:60:50 NPK kg ha^{-1} + Stagnation of water from 45DAS.
T9	Recommended Transplanted system (RT)	35kg seed/ha + 120:60:50 NPK kg ha^{-1} (Transplanted)

lowest coccinellid population (3.74/hill) was observed in RSDS + higher seed rate + water stagnation (T6) followed by T7.The highest population of spiders was observed (4.09/hill) in RSDS + higher nitrogen (T3)followed by T2 and lowest spiders population (3.38/hill) was observed in RSDS (T1) followed by T7. The highest population of mirid bugs (3.76/hill) was observed in RSDS (T1) followed by T2 and lowest population (3.67/hill) was observed in RSDS + higher seed rate + higher nitrogen + water stagnation (T8) followed by transplanted rice (T9).

During maturity stage of rice, the highest incidence of BPH population (22.40/hill) was observed in RSDS + higher nitrogen (T3) followed T8 and lowest BPH population (9.36/hill) was observed in RSDS (T1) followed by transplanted rice (T9).The highest coccinellid beetles population (4.65/hill) was observed in RSDS (T1) followed by T2 and lowest coccinellid population (3.74/hill) was observed in RSDS + higher seed rate + water stagnation (T6) followed by T3.

Among the treatments, transplanted rice (T9) was significantly superior over the other treatments and recorded grain yield of 5084 kg ha^{-1} which was followed by RSDS (T1) and recorded grain yield of 4947 kg ha^{-1}. RSDS + higher seed rate + water stagnation (T6) was significantly lower yield over the other treatments and recorded grain yield of 3592 kg ha^{-1} followed by T7 and recorded grain yield of 3973 kg ha^{-1} are in agreement with findings of Soni and Tiwari (2016).

CONCLUSION:

RSDS (T1) and transplanted rice (T9) were the most effective treatments with minimum incidence of BPH and WBPH. RSDS (T1) and transplanted rice (T9) recorded highest seed yield of 5084 kg ha^{-1} and 4947 kg ha^{-1} respectively. The higher seed rates, nitrogen levels and stagnation water adopted individually and in combinations recorded higher pest incidence and lower seed yield in semi dry rice system.

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IRC/TM-3/PP-42

IMPACT OF WEATHER VARIABLES ON RICE SHEATH BLIGHT DISEASE

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Rice production and productivity is affected by many biotic and abiotic factors. Among the different biotic constraints, sheath blight caused by fungal pathogen ie *Rhizoctonia solani* Kuhn is the most important one. It occurs in all rice growing areas of the world (Savary *et al*. 2006) and has become a serious threat to rice cultivation after the introduction of high-fertilizer responsive varieties. The disease occurs frequently in the intensive rice cultivating areas of Indo-Gangetic plains, Coastal plains and deltaic areas of India (Prakasam *et al*., 2013). Sheath blight pathogen can cause significant reduction in grain yield (up to 70%) and quality.

It is generally known that the availability of susceptible host, virulent pathogen and prevalence of favorable weather condition play important role in the process of disease development.The spread of sheath blight is largely dependent on inoculum density, warm and high humidity conditions and varietal resistance (Groth and Lee, 2003). Little was known regarding the influence of weather factors that influence the continuous build- up of sheath blightin the field. Weather-based prediction models have been usedto forecast rice disease like, blast and bacterial leaf blight but there wasvery little initiative to model sheath blight incidence usingepidemiological parameters, particularly in Indian condition. The objectiveof this study was toestimate the effect of weather variableson severity of the disease and epidemics under field condition.

MATERIALS AND METHODS

To study the effect of weather parameters on sheath blight was observed through staggered sowing with an interval of ~20 days. Eight rice entrie with different level of disease reaction (Tetep, Wazophek (WZP), Pankaj, Swarnadhan, NDR 350, IR-50, Swarna, IR-64, TN-1, PBT 5204) were sown and observed the disease initiation and spread under field condition during *Kharif* -2019. The plot size was about

Table 1: Effect of weather parameter on sheath blight spread under different date of sowing

Entries	Early Planting		Normal Planting		Late Planting	
	Vertical spread in inoculated plant (cm)	Horizontal spread in uninoculated plant (No)	Vertical spread in inoculated plant (cm)	Horizontal spread in uninoculated plant (No)	Vertical spread in inoculated plant (cm)	Horizontal spread in uninoculated plant (No)
NDR350	55	2	35	-	25	-
Pankaj	47	3	25	-	30	-
Wazhophek	45	3	22	-	20	-
Swarnathan	50	4	27	-	20	-
Swarna	70	5	42	2	25	-
IR50	85	5	55	5	30	-
PBT5204	75	4	27	2	45	-
TN1	95	5	60	5	45	-
Mean	**65.25**	**3.9**	**36.62**	**3.5**	**30**	-

Table 2: Mean weather data of disease period (pathogen infection) in staggered rice planting for sheath blight spread.

Disease period in stagger planting	Temperature (°C)		R.H. (%) (mm)		Rain fall (No/Ag)	Rainy Days (hrs.)	Sunshine (km/h)	WindSpeed (mm)	Evaporation
	Max.	Min.	I	II					
Early	30.05	16.86	93.38	68.86	7.88	16/0.38	5.29	0.15	2.92
Normal	29.68	17.74	90.10	56.29	1.16	5/0.12	7.03	0.12	2.95
Late	28.50	16.02	91.24	50.10	0.21	1/0.02	7.14	0.03	2.78

$3m^2$ with three replications. Disease was established with typha bit method of inoculation. The disease severity was observed with vertical lesion spread in relation to plant height.The spread of disease was observed based on horizontal movement of pathogen from inoculated plant to uninoculated plant by plant through plant conduct and/or pathogen propagule movement (Table 1).Relative lesion height was calculated as per SES scale (IRRI, 2014) for both inoculated and uninoculated plants. Disease severity was correlated with daily weather data (Table 2).Weather variables such as temperature, rain fall, rainy days, rain fall, sunshine, wind speed and evaporation were observed with automatic weather station.

RESULTS

The disease severity and spreads were observed in ten days interval for forty days from the day of artificial inoculation by typha bits method (Fig. 1). Maximum disease severity in inoculated plants was noticed in early planting (65.25%) followed by normal (36.62%) and late planting (30%). The disease severity was reduced from the early planting to late planting and correlated with the monsoon withdrawal period. Similarly maximum horizontal spread also noticed in un-inoculated plants of sheath blight differentials from early planting (up to 4 plant) and normal planting (3-4 plants) (Fig. 1). There was no disease spread to the

Fig 1: Sheath blight severity and horizontal spread in TN1 at early planting

adjacent uninoculated plants in late planting. Tolerant genotypes *viz*., Tetep, Wazophek (WZP), Pankaj, Swarnadhan, NDR 350 showed the slow and less disease progress in inoculated plants and low disease incidence at uninoculated plants. Among four tolerant entries Wazophek showed less disease severity and spread in all three planting followed by Pankaj and Swarnathan. Among the susceptible entries very high disease severity and spread was observed in TN-1 follwed by IR-50. This disease severity and spread is positively correlate with the weather parameters like relative humidity, rainfall and rainy days and negatively correlate with the sunshine hours(Amandeep et al 2015).

CONCLUSION

In the present study, relative humidity evening (RH-II) and rain fall was positively correlated with the sheath blight progression in inoculated plant and spread to uninoculated plants. Sun shine hour was negatively correlated with sheath blight disease during the study period.

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PROTEOMIC ANALYSIS OF RICE PLANTS IN RESPONSE TO INOCULATION WITH *BACILLUS AMYLOLIQUEFACIENS*

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Bacillus amyloliquefaciens managesplant pathogens through different mechanismssuch as production of various antibiotics, direct inhibition of pathogens, plant growth promotionand induced systemic resistance (Elanchezhiyan et al., 2018). But the interaction between rice plants and *B. amyloliquefaciens* is yet to be clearly defined which can be studied by way of molecular techniques *viz*., proteomics approach. Proteomic studies provide the basic knowledge on the gene(s) and pathways induced during host-PGPR interaction. In this study, efforts were made to elucidate the molecular response of rice plants to *B. amyloliquefaciens* throughprotein profiling.

MATERIALS AND METHODS

The seeds of rice cultivar (Naveen) were surface-sterilized using 2% sodium hypochlorite and rinsed with sterile distilled water. After surface-sterilization, the seeds were treated with a liquid formulation of *B. amyloliquefaciens*(5 ml / L). Twenty days after transplanting 5 ml of *B. amyloliquefaciens* was applied as soil application and foliar spray. Sampling of leaf and root tissues from control and treated plants were collected at 72 h after bio-agent treatment, the experimentwas repeated twice (biological replications) withadequate replications.

2D-PAGE analysis and protein identification

The protein was extracted using lysis buffer and protein quantification was done using the Bradford method. Immobiline pH Gradient (IPG) strips (pH 4–7, 17 cm) was used for the experiment. A system protein i12 IEF cell (Biorad) was used for Isoelectric focusing (IEF) with the following running conditions; 500 V for 30 min followed by 1000 V for 30 min and finally 9000 V for 50,000 Vhr. The 12% polyacrylamide gels were used for the separation of proteins in second dimension. The gels were silver stained and scanned using GS-900 Calibrated Densitometer (Biorad). Image analysis was performed by PD Quest (Bio-Rad) software. A minimum 1.5-fold change was considered for upregulated proteins and 0.5-fold for down-regulated proteins. The abundance of protein spots showing significance differences (Student's *t*-test at 90% confidence with p-values < 0.1) was used for further analysis. The differentially expressed proteins were sent to Sandor Lifesciences Pvt Ltd, Hyderabad, India for MALDI-TOF MS/ MS analysis. The software MASCOT search engine was used to identify the proteins with the following database searches: Taxonomy: Viridiplantae, 1 missed cleavage was allowed with trypsin, Peptide tolerance for fragment ions (100–300 ppm); modifications allowed, oxidation of Met (variable) and Cys Carbamidomethyl (fixed). The scoring of peptide mass fingerprinting of the proteins was done with the Mowse score (Prabhukarthikeyan et al., 2019).

RESULTS

A total of 400–500 protein spots were resolved and their locations were similar in all the replications. In our study, seventeen proteins were found to be differentially expressed. Out of these, seven proteins were found in leaf and ten proteins were found in root tissue. A total of seventeen proteins were excised and protein identification was carried out by MALDI-TOF mass spectrometry. MASCOT search demonstrated homology for the following proteins *viz*.,

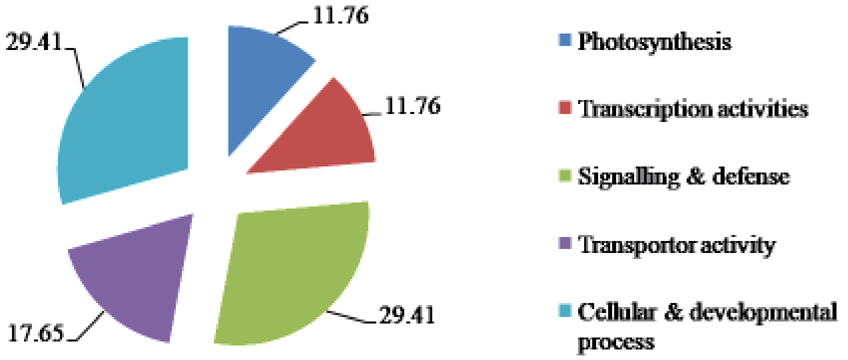

Fig.1. Functions of differentially expressed proteins identified during rice-BS5 interaction

Ribulose bisphosphate carboxylase, Transcription initiation factor IIB, Copper transporter 6, Protein phosphatase 2C, Bidirectional sugar transporter SWWET 7d, Hypersensitive induced response protein , Histone acetyltrasferase, Signal peptide peptidase-like 3, DNA damage-binding protein 1, Hexokinase-6 , Thioredoxin , Kinensin-like protein KIN-12F, MADS-box transcription factor 17, Probable thiamine biosynthetic bi-functional enzyme, chloroplastic, Probable Calcium-binding protein CML7, Magnesium-chelatase subunit Chloroplastic and Probable ethylene response sensor 2. The functions were identified by comparing the protein sequences to the public protein database NCBInr (Fig 1).

CONCLUSION

Our study clearly established that *B. amyloliquefaciens* induces up-regulation of the signaling, defense, disease resistance and plant metabolic proteins which might play a major role in the bio-protection mechanism of the strain *B. amyloliquefaciens* in rice plants.

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IRC/TM-3/PP-44

STUDIES OF BIOLOGICAL AGENT USED FOR CONTROL OF RICE DISEASES IN DIFFERENT AGRO CLIMATIC CONDITION: AN OVERVIEW

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This study refers to the importation, introduction and establishment of a non-native natural enemy population for the suppression of plant pathogen. Biological protection against infection is accomplishby destroying the existing inoculum by preventing the formation of active inoculum, or by weakening and displacing the existing virulent pathogen population. Biological control was achieved through protection of plant material and roots with biological seed treatments, or suppression of pathogens by the introduction of plant associated antagonists into the rhizosphere. A number of fungus, bacteria, virus, nematode and mycoplasma-like organisms cause disease to rice plants. Among these the fungal diseases viz. blast (*Pyricularia grisea*), brown spot (*Bipolarisoryzae*), stem rot (*Sclerotium oryzae*), sheath blight (*Rhizoctonia solani*), sheath rot (*Sarocladiumoryzae*), bacterial disease such as bacterial blight (*Xanthomonas oryzaepv. oryzae*) and viral disease such as tungro (ricetungro virus) are most important. Biocontrol assumes special significance being an eco-friendly and cost-effective strategy which can be used in integration with other strategies for a greater level of protection with sustained rice yields.*Bacillus spp.*,*Pseudomonas spp*., *Serratia spp.* and*Erwinia spp.* inhibit mycelial growth of *R. solani*, *Sclerotium oryzae* (stem rot), *B.oryzae* (brown spot), *P. grisea* (blast), *Sarocladiumoryzae*(sheath rot) and *Fusariumfuijkuroi* (bakanae).Fungalantagonists include *Trichoderma spp.*,*Penicillium spp.*, *Myrotheciumverrucaria*, *Chaetomium globosum* and *Laerisariaarvalis* were the important biocontrolagents of major rice diseases control.

Keywords: biological agent, bacterial and fungal antagonist, control diseases

IRC/TM-3/PP-45

MOLECULAR IDENTIFICATION OF AVR GENES IN RICE BLAST PATHOGEN (*MAGNAPORTHE ORYZAE*) FROM ODISHA

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Magnaporthe grisea is one of the important destructive pathogen worldwide by causing blast disease in rice. The rice blast fungus is a model organism which follows gene-for-gene concept. According to hypothesis plant resistance (R) gene product interacts with the complementary avirulence (Avr) gene and triggers the defense response. Based on this concept the use of resistant varieties is always found to be an efficient method for management of rice blast disease. However, due to rapid evolving nature of the Avr genes and increasing of genetic diversity of the pathogen it poses a risk of resistant breakage. Hence, a study was carried out to find presence/absence of Avr genes in natural populations from diverse rice-growing regions of Odisha and which may be useful to breeders attempting to develop resistant varieties.

MATERIALS AND METHOD

Fungal isolate and DNA extraction

In total, 58 rice blast isolates were isolated from the infected leaves of rice with typical blast disease symptoms from different parts of Odisha. Each fungal isolates were cultured in Oat meal agar medium at 25±2°C. Fungal genomic DNA was extracted from 10 day old fungal mycelium using liquid nitrogen and CTAB method (Doyle and Doyle, 1987). DNA quality and concentration were determined by electrophoresis on 0.8 % agarose gel.

DNA marker analysis

The *M. oryzae* isolates were screened for the presence of avirulence (Avr) genes, Avr-Piz-t, Avr- Pita, ACE1, Avr-Pia, Avr-Pit, Avr-Pi7, Avr-Pi15, Avr- pib1, Avr-PWL2 and Avr-Pii using a set of ten specific molecular markers. The amplified fragments were scored as presence (1) or absence (0) of amplicon linked to each gene DNA fragment.

RESULTS

A total of 58 *M. oryzae* isolates were used for the identification of ten Avr genes. The markers for different Avr genes detected varied size of amplicons and confirms the presence of particular Avr gene. The isolates possessed minimum of four to many avirulence genes and the frequency of their distribution varied in the tested isolates. Among the isolates three isolates possessed only 4 Avr genes whereas 1 isolate possessed all the 10 Avr genes. Twenty five isolates possessed eight Avr genes and another 8 isolates possessed six Avr genes. Avr-PWL 2 had the highest frequency of 100 % (Fig. 1), while Avr-Pi15 had the lowest (15 %). Frequencies of other Avr genes varied from 17 to 96 %.

CONCLUSION

From this study we could able to conclude that the molecular marker detection of ten Avr genes in the *M. oryzae* population had an average of 15 % to 100% of avirulent genes were available in the sampled location. However, previous studies have reported the high instability of several *Avr* genes, which are closely located to unstable chromosomes in telomere regions including *Avr-Pita*, *Avr-Pik*, *Avr-Pia* and *Avr-Pii* (Chuma et al., 2011). The less frequency of Avr-*Pi15 gene in* rice blast isolates indicated changes of the genome in the fungal population. Finally, this

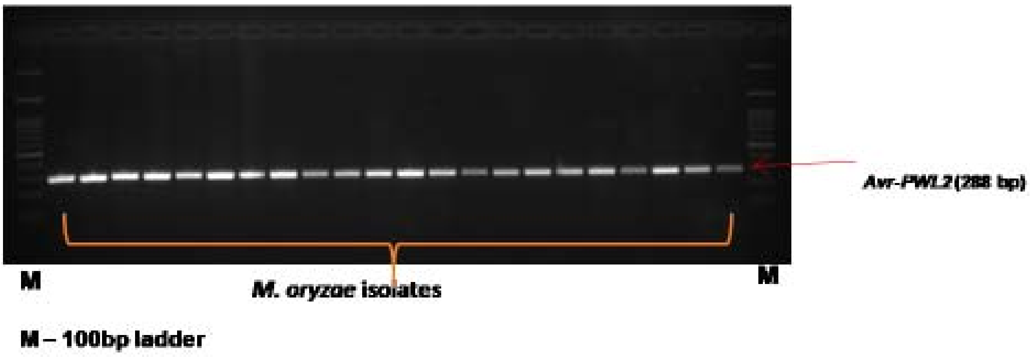

Fig. 1. Agarose gel electrophoresis of PCR products from *M. oryzae* isolates tested for Avr-PWL 2

information will be crucial for understanding the AVR gene diversity of pathogenic populations and pathogenic selection, which can lead to novel strategic development for a co-evolutionary relationship between the R and Avr genes in rice breeding programs.

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Theme - III : Biotic-stress management in rice
IRC/TM-3/PP-46

IDENTIFICATION OF RICE ROOT KNOT NEMATODE (*Meloidogyne graminicola*) RESISTANCE QTLs IN RICE THROUGH QTLseq APPROACH

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Rice root knot nematode is one of the emerging risk for rice production especially in current scenario of ricecropping intensification and increasing scarcity of water.Grain yield losses of 97% and 31% have been reported at highest initial population density (Pi) and even at low population density of 0.1 J2 per gram of soil, respectively (Prasad *et al* 2010). The management practices to lower root knot nematode population densities fromdamaging to threshold levels are inadequate at this moment.Therefore, identification and exploitation of *M. graminicola* resistantgenotypes offer an effective and economic option to diminish the crop yieldlosses caused by nematode.

OBJECTIVES

Ø Phenotypic evaluation of *O. glaberrima* accessions, *O. sativa* and their derived population for *M. graminicola* resistance

Ø Identification of *M. graminicola* resistance QTLs through BSA-QTL seq approach.

METHODOLOGY

Screening of *O. glaberrima* accessions for rice root knot nematode resistance

Forty two accessions of *O. glaberrima* obtained from International Rice Research Institute, Philippines, and maintained at Punjab Agricultural University, Ludhiana were screened against rice root knot nematode, *Meloidogyne graminicola* in nematode infested soil along with *O. sativa* cultivar PR121 as check.

Development and Screening of Experimental Population: *O. glaberrima*accessionswere crossed with *O. sativa* cultivar PR121 to generate F_1's. Backcrossing was attempted between F_1's and PR121 to generate BC_1F_1's. Backcross progenies were screened in nematode infested soil at initial inoculation density of 1 juvenile per gram of soil. The moderate resistant BC_1F_1 plants were further backcrossed to generate BC_2F1's. Resistant BC_2F_1 plants were again backcrossed to generate BC_3F_1's.

QTL identification through BSA-QTLseq analysis

a) Development of bulk segregants from BC_1F_1 population : After screening of BC_1F_1 population, resistant and susceptible bulks were prepared by mixing equal amount of DNA from 10 individuals of highest gall number (30-100) and lowest gall number (1-10), respectively.

b) Whole genome re-sequencing : The resistant and susceptible bulks along with parental DNA were subjected to whole genome re-sequencing through Illumina paired-end sequencing.

c) Next generation sequencing based BSA analysis : The SNP index and G statistics values for individual SNPs were calculated as described by Takagi *et al* (2013) and Mansfeld and Grumet (2019).

RESULTS

Out of 42 accessions of *O. glaberrima*, 3 accessionswere found to be highly resistant (Immune), 33 accessions were resistant and 6 accessions were moderately resistant. While *O. sativa* cultivar PR121 was found to be susceptible with characteristic hook shaped galls (Figure 1). The resistant *O. glaberrima* acc. IRGC102206 was crossed with PR121 for identification and transfer of root knot nematode resistance from African into Asian cultivars of rice.

Figure 1: Root knot nematode infestation results in no or few root galling in *O. glaberrima* accessions (a) and hook shaped galling in *O. sativa* cultivar PR121 (b).

The bulked segregants of BC_1F_1 population along with parents were subjected to next generation sequencing based bulked segregant analysis. Illumina sequencing of genomic libraries for each of the parent and two bulks (2 X 150bp) produced 33 to 35 million reads per sample for a total of 273 million reads. Maximum number of low quality reads were trimmed through Trimmomatic 0.39 in *O. sativa* cv PR121 (0.41%) followed by resistant parent IRGC102206 (0.34%), resistant bulk (0.33%) and susceptible bulk (0.27%). Trimmed high quality short reads were aligned using bowtie2 software. *O. sativa* L. ssp indica cultivar 93-11 having genome size 395.4 Mb was downloaded from Ensembl Plants and used as reference genome for alignment. Susceptible parent PR121 showed 96.12% overall alignment rate with reference genome while IRGC102206 exhibited 87.71% overall alignment rate.

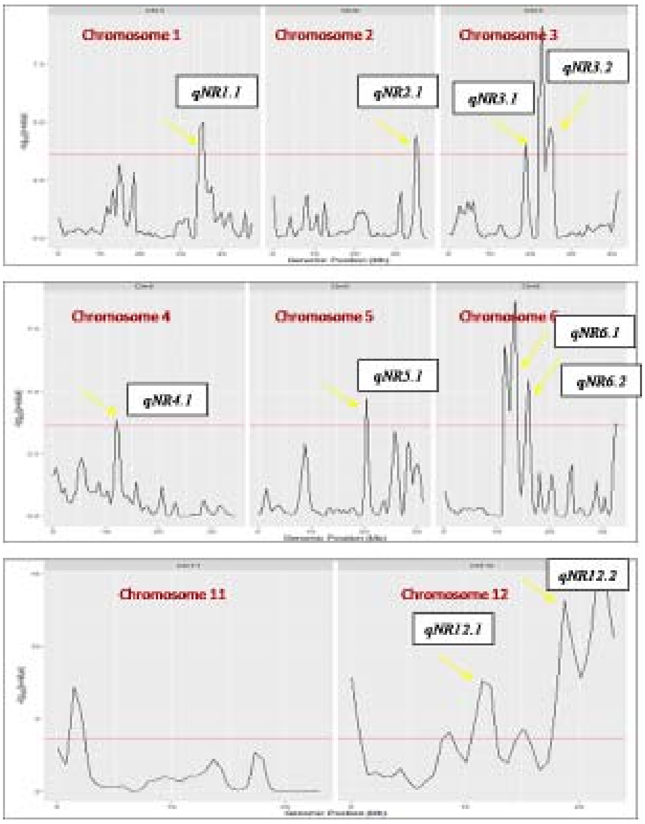

Figure 2: QTL likelihood plots showing putative QTLs on chromosomes 1, 2, 3, 4, 5, 6 and 12 on the basis of derivative of G' ($-\log_{10}$p value).

All four samples underwent joint variant calling using the HaploTypeCaller program from GATK pipeline. SNP calling generated a combined VCF file for all samples. VCF file was filtered through VCF tools to remove InDels and variants having quality score less than 30, 100% missing data and keep variants having minimum mean depth of 5. Raw VCF file contained a total of 3692066 sites, after removing 100% missing data and kept variants having minimum mean depth of 5, only 1608420 sites were remained. These sites were further filtered to remove indels and a total of 1416115 sites were generated. Filtered VCF file in table format used as input for QTL-seqr package. SNP index value was calculated for all SNPs. The chromosomal regions representing the expected allele frequency or SNP index value close to 0.5 means equal representation of parental genome in bulk whereas deviation from expected allele frequency means unequal representation of parental genome in bulk which might contain a QTL or candidate region associated with nematode resistance. G' analysis used absolute "SNP index values greater than a set threshold (default = 0.1) to filtered out potential QTLs. TheplotQTLStats function used a direct derivative of G' *viz*. "log10 (p-value) to plot individual graphs of chromosomes for a close up figure of QTLs of interest (Figure 2). The G' analysis showed significant G' peaks on chromosomes 1, 2, 3, 4, 5, 6 and 12 above the FDR (q) of 0.001 suggesting that these genomic regions most likely contain the QTL for root knot nematode resistance.

Each chromosome 1, 2, 4 and 5 has only one significant QTL and designated as qNR1.1, *qNR2.1*, *qNR4.1* and *qNR5.1* respectively. Chromosome 3 has two significant QTLs and were named as *qNR3.1* and *qNR3.2*. Similarly, chromosome 6 has two significant QTL as *qNR6.1* and *qNR6.2*. Two significant QTLs were identified on chromosome 12 as *qNR12.1* and *qNR12.2*. Among all QTLs, *qNR6.1* and *qNR12.2* showed the highest G' peaks indicating the major QTL region for root knot nematode resistance. The average number of SNPs per QTL varies from 27 (*qNR6.1*) to 345 (*qNR2.1*).

CONCLUSION

The development of SNP based molecular markers from identified QTL regions will fasten the marker assisted breeding for nematode resistance in rice.

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IRC/TM-3/PP-47

FALSE SMUT : MOLECULAR DIAGNOSTICS, VARIABILITY OF PATHOGEN AND DISEASE MANAGEMENT UNDER CHANGING CLIMATIC SCENARIO

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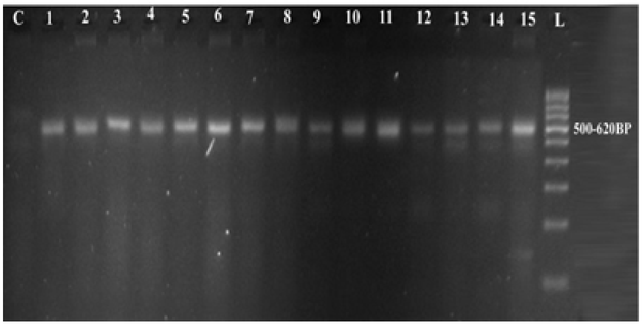
Climate change is predicted to have a direct impact on the occurrence and severity of diseases in crops, which will have a serious impact on our food security. Climate change will result in rise in temperature and carbon dioxide levels and will also have a varied effect on moisture. In many cases, temperature increases are predicted to lead to the geographic expansion of pathogen, bringing pathogens into contact with more potential hosts and providing new opportunities for pathogen hybridization. Rice is one of the important staple food crops of India and in recent years, false smut caused by *Ustilaginoidea virens* becoming major disease of rice crop by causing yield losses in Karnataka as well as in the country and has worldwide importance and widely prevalent in the eastern states of India. As such there is no systematic work on the pathogen as management of the disease in Karnataka. There is a need to develop and know the molecular diagnostics and variability of pathogen as well as its management of disease under changing climatic scenario for the benefit of farming community.

METHODOLOGY

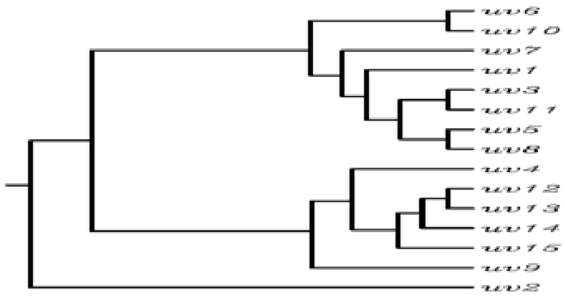
In the present study,infected false smut showing typical smut balls were collected from different districts of north Karnataka. Fifteen isolates (Uv-1, Uv-2, Uv-3……..Uv-15) were obtained from such sample and subjected for cultural, morphological and molecular characterization as well as variability. The morphological characters *viz.*, colour and branching of mycelium, growth and morphology of colony, colour and shape and size of chlamydospore by using standard methods and procedures. Molecular identities of fifteen isolates of *U.virens* from were studied by sequencing ITS rDNA conserved region by extracting genomic DNA (Zhou *et al.*,2003). The extracted DNA was quantified and later its quality ws assessed by following standard methodology. The rDNA gene cluster, consisting of ITS-1, the 5.8 S rDNA and ITS-4, was amplified with primers homologous to conserved sequences within the small subunit (SSU) rDNA gene. The general ITS primers (ITS-1 and ITS-4) and as well as specific (UVR1- and UVR-4) (White *et al.*, 1990) were used for the study. Fifteen isolates of pathogen were subjected for sequencing of 5.8S rDNA using *Sangersequencing* method. For management of the disease, new fungicide molecules were tested under in vitro by poisoned food method. The fungicides which were found most effective under *in vitro* were evaluated for their field efficacy with nine treatments by following statistical procedures and package of practices. The farm and large scale trials were also conducted for two seasons at research station and in farmers fields. The observations on disease incidence were recorded and finally the economics were worked out.

RESULTS

The results indicated that the variability was observed among the isolates with regard to mycelial characters, colony characters and chlamydospore character. Mycelial colour was predominantly white in all isolates and branching type was acute in all the isolates. The isolate Uv-6 recorded maximum mycelial width followed by Uv-7 and Uv-8. Chlamydospore shapes varied among the isolates and were globular, round irregular and ovoid. The size of the



PCR amplification using specific universal ITS1 primers. LaneM-1000 bp DNA ladder, Lane N is negative and 1 to 15 *U.virens*



Internal transcribed spacer 1 and 4 based and ITS4 phylogenetic tree of U.virens isolatesLane N is

chlamydospore ranged from 5.45 (Uv-13) to Uv-6 (7.10 ìm). DNA of fifteen isolates of *U. virens*was successfully amplified with general ITS-1 and ITS-4 primers and specific UVR1- and UVR-4 primers. The size of amplified DNA ranged from 500-620 bp in general primers and 280- 320 bp in specific primers. BLAST results revealed that all the isolates belonged to the*Ustilaginoidea virens*. Further, the dendrogram constructed from the pooled dataclearly showed two major clusters A and B. At 75 per cent similarity coefficient, all isolates clearly clustered into five clusters. Cluster-I included twoisolates (Uv-6 and Uv-10), Cluster-II six isolates (Uv-1, Uv-8, Uv-3,Uv-4, Uv-5 and Uv-7), Cluster-III included five isolates (Uv-4, Uv-12, Uv-13, Uv-14 and Uv-15) and finally Cluster-IV had isolates Uv-9 and Uv-2. Trifloxystrobin 25 % + Tebuconazole 50 % WP among combi-fungicides were highly effective in inhibiting the mycelial growth of *U. virens*.Two sprays of new combi-fungicide molecule that is Ttrifloxystrobin 25 % + Tebuconazole 50 % EC@ 0.4 g/lit at 50 and 70 days after transplantingwas highly effective in the management of disease with lesser disease severity and highest yield apart from higher BC ratio under in vitro and in-vivo trails.

CONCLUSION

The studies indicated the there was variability in *Ustlaginoidea virens* with respect to morphological as well as cultural characters. The DNA of fifteen pathogen isolates belonging to different geographic regions can be successfully amplified with general ITS and specific UVR primers and the size of amplified DNA ranged from 500-620 bp in general primers and 280-320 bp in specific primers and all isolates belonged to the*U. virens* with BLAST results. Phylogenetic analysis of fifteen pathogen isolates using UPGMA-NJ online software and dendrogram clearly showed two major clusters (A and B).Foliar application of new combi-fungicide molecule that is Ttrifloxystrobin 25 % + Tebuconazole 50 % EC@ 0.4 g/lit at 50 and 70 days after transplantingwas highly effective for the management of disease there by increased yield and cost benefit ratio. Hence, foliar sprays of Trifloxystrobin 25% + Tebuconazole 50% EC @ 0.4 g/lit at 50 and 70 DAS has been recommended and included in the university package of practices of University of Agricultural Sciences, Raichur, Karnataka for the farmers of region to manage the disease.

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IRC/TM-3/PP-48

EFFICACY OF BOTANICALS AS RODENTICIDES AND REPELLENTS AGAINSTLESSER BANDICOOT, *BANDICOTABENGALENSIS* IN RICE

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Rodents are the well-known ubiquitous pests in crop and human habitations. Rodents often pose a challenge to the humans and their control is a unsolved task so often due to theirbehavioural adaptability and reproductive elasticity. They can cope up with new environments, new foods and adjust to new associateship with a striking swiftness.Among the field crops, rice is the more vulnerable to the rodent attack irrespective of its method of cultivation and crop stage. The lesser bandicoot rat, *Bandicota bengalensis* Gray is the most destructive rodent species in Indian agriculture, particularly in rice cultivation. Poison baiting using synthetic rodenticides is the most commonly practiced rodent control method by the farmers due to cost economics and easy large scale coverage. However, large scale use of toxic synthetic rodenticides in crop and human habitations will contaminate the ecosystem, besides developing resistance in target pests and leaving hazardous residues in the environment.Plant substances were traditionally used as rodenticides or repellents, but have now been almost completely replaced by chemicals. Botanicals with potent anti-rodent properties can be the best alternative to these toxic synthetic rodenticides and identification of such botanicals is the need of the hour to reduce the pressure on the synthetic rodenticides. Considering the importance of the botanicals, the present study has been undertaken to identify the potent botanicals for their anti-rodent properties against lesser bandicoot rat,*B. bengalensis*.

METHODOLOGY

*Laboratory Studies:*Field trapped bandicoots were acclimatized individually in cages of 36×23×23cm size eachfor15 daysbefore the commencement of experiment. Food and water were provided albitum. Food consisted of broken rice coated with edible oil in ratio 98:2 was given along with water before treatment. After acclimatization, healthy and mature rats of both sexes were weighedandselectedforexperimentation.

Matured fruits of test botanicals were shade dried and finely grounded into powder. These botanical powders are mixed with wheat flour w/w to prepare the 10 and 20 per cent baits using little amount of edible oil. Five test animals weighing 150-180 g. were used at each concentration. 15 g of botanical bait was offered to the each acclimatized animal individually in the laboratory under no choice condition. Fresh broken rice and water was given till the end of the experiment, once the test animal completely ate the botanical bait. Data on food consumption, debilitating effects and mortality, time period mortalitywere recorded daily up to 30 days and expressed asmean ± SD.

Field Studies: Botanicals with pungent odour were tested for their repellent effect under field conditions. Garlic and ginger were finely ground and allowed to ferment for a week in sizable water. Later the 10% aqueous extracts were prepared by required dilutions and imposed as bund sprays using battery operated hand sprayer. Crude castor oil mixed in surf water is used solo and in combination with other botanicals. Along with these extracts, two commercially available botanical based formulations (Ecodon^R and Biorepel^R) were also tested for their repellent efficacy. Treatments were imposed on 50 m linear field bunds showing more or less uniform rodent infestation and located apart. Each treatment was replicated thrice

Table 1. Feeding deterrent and rodeticidal properties of botanicals against lesser bandicoot

Treatment	Mean bait consumed (g)	Mean animal weight after treatment	% body weight gain	% weight gain over control	% Mortality 15DAT	Mean time mortality
Datura 10%	6.09±0.76	164.57±5.46	-7.08	-3.04	20.0	13.5±4.9
Datura 20%	2.37±2.51	177.21±5.86	-8.18	-9.96	60.0	12.0±2.8
Castor 10%	5.80±7.80	161.93±13.30	-12.62	-11.41	0.0	—
Castor 20%	4.57±2.72	145.07±11.00	-13.61	-20.63	0.0	—
Neerium 10%	6.80±1.24	164.00±8.96	-12.86	-8.92	60.0	8.75±1.5
Neerium 20%	3.97±2.12	152.36±8.72	-13.48	-12.89	80.0	9.4±2.4
Custard apple 10%	10.94±1.80	181.71±9.65	-5.08	-1.46	0.0	—
Custard apple 20%	7.38±3.05	164.29±6.04	-7.16	-10.12	0.0	0.0
Jatropa 10%	5.80±1.95	167.00±17.65	-12.00	-8.63	20.0	18.0
Jatropa 20%	4.57±3.14	151.36±12.77	-13.11	-17.19	60.0	10.3±1.5
Control(Atta	13.90±1.90	182.79±8.51	5.32	-	—	-

and pre- treatment rodent population was recorded in terms of live burrows. The live burrows were covered with paper and mud paste before imposition of treatments and post treatment infestation was recorded at5,10 and 15 days after treatment. The percent rodent control success was worked out (Mathur and Prakash, 1984) aspercent control success = 100 (1- ((T2 X C1)/ (T1 X C2)). Where, T1- pre-treatment population of rodents (LBC) T2- post treatment population of rodents (LBC) C1- pre-treatment population of rodents (LBC) in control bund (T9) C2 - post treatment population of rodents (LBC) in control bund (T9). The data was statistically analysed using DMRT.

RESULTS

Botanical baits inhibited the consumption in the test animal and the consumption decreased with increased bait concentration in all the treatments. All the botanicals has showed potent feeding deterrence and the test animals lost their body weight considerably after feeding. The weight loss was more in castor followed by Jatropaand Nerium. Baits containing Datura, Nerium and Jatropacaused the mortality in the test animal and per cent mortality is high with 20% baits. The highest mortality of 80% was recorded with Nerium 20% bait material followed by datura and Jatropawith 60% mortality at 20% concentration. Though the percent mortalities were significant, the mean mortality times were found higher when compared to existing chemical rodenticides. The mean mortality period were low at higher bait concentrations. The mean mortality periods varied between 8.75 to 13.5 days and it was lowest with Nerium (8.7 to 9.4 days) among the potent botanicals. The anti-feedant properties of Datura was

Table 2. Repellent effect of 10% aqueous botanical extracts against field rodents in rice

S.N	Treatment	Live Burrow Counts/ acre			
		PTC	% reduction over control		
			5 DAT	10 ADT	15 DAT
T1	Garlic extract 10%	6.00	26.2d	26.8c	12.5e
T2	Ginger extract 10%	4.00	18.3e	7.7e	9.8ef
T3	Castro oil 10%	5.00	27.5d	24.2c	18.3d
T4	Ga+Ca (1:1)-10%	6.00	42.0b	37.0b	26.8bc
T5	Gi+Ca (1:1)-10%	4.33	20.9de	18.3d	12.5e
T6	Ga+Gi+Ca (10%)	4.67	37.2c	36.2bc	24.2c
T7	Ecodon	6.00	65.0a	58.0a	42.0a
T8	Bio-repel	5.00	45.0b	40.0b	35.6b
T9	Control	5.33	-	-	-
CD 5%		NS	Sig.	Sig.	Sig.

well established by the studies of Rakesh and Sharma (2005) against *Mus musculus*. Baglari and Borah (2014) were also evaluated the several botanicals for their anti-rodent properties against lesser bandicoot rat.

In field studies, among the treatments, garlic extract+ castor oil (1:1)- 10% recorded the 42, 37 and 27 per cent reduction in rodent incidence compared to control at 5,10 and 15 DAT. The commercially available botanical based Ecodon^R performed relatively superior over all the treatments with 65,58 and 42 per cent reduction in live burrows over the control at 5,10 and 15 days after treatment. Similarly, Sudharani and Narasimha Rao (2014) also reported that the castor based Ecodon^R was effective in containing the rodent infestation in rice field bunds.

CONCLUSION

The present studies reveal the potential of Nerium, Datura and Jatropa for their anti-rodent properties in the laboratory. These botanicals can provide an alternatives to the existing rodenticides if the substances (flavonoids, glycosides, alkaloids, tannins, sterols etc) responsible for anti-rodent properties are identified and extracted using various solvents.Further, studies may be conducted to retain the field efficacy of botanical sprays by adding certain substances so as to increase their persistence for a longer period of time.

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Theme - III : Biotic-stress management in rice

IRC/TM-3/PP-49

NEW GENERATION COMBI-PRODUCTS FOR THE MANAGEMENT OF MAJOR PESTS OF PADDY *Oryza sativa* L.

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Rice (*Oryza sativa* L.) is the most important and staple food crop for more than two third population of India and more than 65% population of the world population (Mathur *et al.*, 1999).A decrease in the productivity of rice has been attributed to various biotic and abiotic factors. Among biotic factors loss caused by insect pests is considered as one of the prime factors.More than 100 species of insects are known as important pests of rice crop, out of which 20 are of major national economic significance and causes about 24% of damage (Pathak and Dhaliwal, 1981).Insect pests that are of major economic significance in Karnataka are yellow stem borer (*Scirpophaga incertulas*Walker), leaf folder (*Cnaphalocrocis medinalis* Guenee), brown planthopper (*Nilaparvata lugens* Stal.), white backed planthopper (*Sogatellafurcifera*Horvath), case worm (*Nymphuladepunctalis*Guenee) and green leafhopper (*Nephotettix virescens* Dist.), etc. Several cultural practices such as planting of rice with wider spacing, nutrient and water management and conservation of natural enemies, etc., have been suggested for effective management of these insect pests. However, the intensive and continuous cultivation of rice with excessive use of nitrogenous fertilizers has paved the congenial conditions for pest population outbreaks thus compelled the farmers to use insecticides for their suppression.The scenario of resistance has forced farmers to apply these broad-spectrum insecticides in heavy doses against recommended due to which diversity of natural enemies has been reduced and led to the resurgence of pests of rice. So for the effective control of these pests, it is better use single chemical that should control both sucking pests and leaf-eating caterpillars rather than using two or more chemicals. Keeping these points in view, an experiment was conducted in Agriculture Research Station, Gangavathi, University of Agricultural Sciences, Raichur, Karnataka to evaluate theefficacy of combi product tolfenpyrad 15% + bifenthrin 7.5% SE against planthoppers, stem borer and leaffolder.

Nursery of rice variety BPT- 5204 transplanted after 25 days of sowing at 20 cm x 10 cm hill spacing. All the agronomic practices were followed during crop growth period. The treatments were: T_1- Tolfenpyrad 15% + bifenthrin 7.5% SE) @ 500 ml/ha; T_2- Tolfenpyrad 15% + bifenthrin 7.5% SE@ 625 ml/ha; T_3- Tolfenpyrad 15% + bifenthrin 7.5% SE@ 750 ml/ha; T_4- Tolfenpyrad 15 % EC @ 1000 ml/ha; T_5- Chlorantraniliprole 18.5% SC@ 150 ml/ha; T_6- Bifenthrin 10%EC @ 500 ml/ha; T_7- Untreated check. The treatments were applied at 30 DAT and 50 DAT. The observations for hoppers were recorded one day before application of treatments and at 1, 3, 7 and 14 days after each spray on randomly selected 10 hills per plot at each observation time. The incidence of stem borer was recorded in terms of dead hearts at 10 days after each spray and also in terms of white ear heads at 10 days after last spray and at harvest time. The leaf folder damage was recorded based on total number of leaves and number of leaves damaged per 10 hills before each spray and after 10 days of each spray. The yield per plot was recorded at harvest. The data were analyzed statistically after subjecting to appropriate transformation. From the result it is confirmed that tolfenpyrad 15% + bifenthrin 7.5% SE @ 750 ml/ha, tolfenpyrad 15% + bifenthrin 7.5% SE @ 625 ml/hacan be used for the effective management of brown plant hoppers, stem borer and leaf folder. And this treatment recorded maximum yield compared to other treatments

Keywords: *Bifenthrin,Brown plant hopper, Chlorantraniliprole, Dead heart, Leaf folder, Tolfenpyrad, White ear head.*

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BIO-EFFICACY OF ACEPHATE 50% + FIPRONIL 5% WDG AGAINST PLANTHOPPERS OF PADDY *Oryza sativa* L.

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Rice is the seed of the grass species *Oryza glaberrima* (African rice) or *Oryza sativa* (Asian rice). It is the agricultural commodity with the third-highest worldwide production (Anon., 2018).India's yields are too low (4.2 t paddy ha1) even under irrigated condition compared to other countries (6.1 and 9.3 t ha1for China and Egypt, respectively). Again, only 51% of the total rice area is under irrigation. A decrease in the productivity of rice has been attributed to various biotic and abiotic factors. Among biotic factors loss caused by insect pests is considered as one of the prime factors.More than 100 species of insects are known as important pests of rice crop, out of which 20 are of major national economic significance and causes about 24% of damage (Pathak and Dhaliwal, 1981). Among the major insect pests, brown planthopper *Nilaparvatha lugens* (Stal) (BPH) andwhite backed planthopper Sogatella furcifera (Hoverth) (WBPH) are predominant in the Tungabhadra project area of North Karnataka.Presently,chemical control is considered as the first line of defense against insect pests in any crop ecosystem. Keeping in the view the importance of rice as a cereal crop in the state of Karnataka and the intensity of damage by the planthoppers in this crop the present investigation was undertaken to know the bio-efficacy of combined insecticides acephate 50%+fipronil 5% WDG against insect pests of paddy along with older insecticides against planthoppers to come up with promising potential insecticides.

The experiment was conducted in the experimental farm of Agricultural research station, Gangavathi, during *kharif* 2016 and *Kharif* 2017 in Randomized Block Design (RBD), having 8 treatments which were replicated thrice in a net experimental area of 5 m x 5 m each.The treatments were: T_1- acephate 50% + fipronil 5% WDG @ 800 ml/ha; T_2- acephate 50% + fipronil 5% WDG @ 1000 ml/ha; T_3- acephate 50% + fipronil 5% WDG @ 1200 ml/ha; T_4- acephate 75% SP @ 1000 ml/ha; T_5- fipronil 5% SC @ 1500 ml/ha; T_6- deltamethrin 0.72% w/w + buprofezin 5.65% w/w EC @ 1500 ml/ha; T_7- ethofenprox 10% EC @ 750 ml/ha; T8-untreated control.The treatments were applied thrice during the experimental time based on ETL. The insecticides were applied as high volume sprays @ 500 liters of spray fluid/ha.

Observation on the hopper (brown planthopper and white backed planthopper)population per 10 hills was recorded 7 days after the second and third spray.The lowest BPH population was recorded in acephate 50%+fipronil 5% WDG @ 1200 g/ha (4.46, 3.48 and 1.71) with 64.70%, 83.66% and 93.44% reduction over controlafter first, second and third spray respectively.The lowest WBPH population was recorded in acephate 50%+fipronil 5% WDG @ 1200 g/ha (3.56, 2.78 and 1.28) with 71.83%, 86.96% and 94.35% reduction over controlafter first second and third spray respectively.The test compound acephate 50%+fipronil 5% WDG @ 1200 g/ha harvested a maximum yield of 65.16 q/ha followed by acephate 50%+fipronil 5% WDG @ 1000 g/ha (64.59 q/ha) which were on par with each otherand untreated control which harvested lower yield of 28.26 q/ha.

Keywords:*Acephate, Brown planthopper, Buprofezin, Deltamethrin, Ethofenprox, Fipronil, White backed planthopper.*

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BACTERIAL PANICLE BLIGHT: RECURRENCE OF MINOR DISEASE AS MAJOR DISEASE DUE TO GLOBAL WARMING

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India occupies significant position in both area under rice cultivation and its production. By adopting improved technologies and high yielding varieties/ hybrids and crop management practices the countries rice supply has kept pace with the incremental demand for the crop. However Biotic factors like pest and diseases have always been a hindrance to the increasing production and cause significant crop loss. In India diseases like Bacterial blight, Blast, Stem rot, Sheath blight and Rice Tungro contribute to the substantial reduction in rice yield.

In the current scenario climate changes have led the recurrence of certain minor diseases as major disease and one such emerging threat is Bacterial Panicle Blight of Rice. The optimal temperature for *B. glumae* is quite high 30 -35 ^{0}C and thus global warming can make it more pervasive for Panicle blight causing bacteria. During past few years this diseases have caused epidemic in rice growing areas of north Indian states especially affecting the panicles and leaf sheath of major basmati and non- Basmati varieties**.** Bacterial panicle Blight was first reported in Japan in 1950s and then in other countries like United States. Initially the symptoms were considered to be the consequence of water stress, high temperature or toxic chemicals but later it was confirmed that the disease is caused by bacteria, *Burkholderia glumae* and *Burkholderia gladioli* similar to grain rot reported in Japan.

SYMPTOMOLOGY:

Prominent feature of this disease is that, the rachis of the infected panicle remains green while affected florets turn brown or gray at their bases and abort the developing kernels. Infected florets are grey brown discoloured, usually on the half of the emerging panicle, with a clear, profound boundary followed by sterility or partial filling of grains. In severe infection, panicle stands steadfast as the grain does not fill. Grain filling of the diseased panicles is altered with the development of chaffy grains.The host range of B. glumae mainly includes *Oryza sativa (L), Eleusine coracana (L) Lycopersicon esculentum (Mill), Solanum melongena (L), Sesamum indicum***.**

EPIDEMIOLOGY:

Infected seeds serve as the source of primary inoculum. The bacteria is capable of inhabiting surface plants and soil under a wide range of environment. Soil and irrigation water serve as secondary source of infection. High temperatures in combinations with high humidity or frequent rain are essential for the development of BPB epidemics.

CURRENT STATUS OF THE PATHOGEN AND DISEASE:

The panicle blight pathogen has undergone rearrangement in taxonomic terms in last few decades. *Burkholderia glumae*. Currently, there are evidences of rapid evolution of *B. glumae* all over the world because the pathogenically and genetically dissimilar strains of *B. glumae* have been isolated from symptomless rice plants which produce symptoms, analogous with bacterial panicle blight.

Presently, the disease scenario witnesses that paddy crop in several countries is under arrest of Bacterial Panicle Blight. This disease presents an emblematic illustration of the status shifting from minor to major disease due to the climate change. Toxoflavin, lipases and type III effectors have been identified as virulent factors of *B. glumae* (Zhou, 2016). Due to lack of strict quarantine, non-availability of resistant cultivars and efficient management practices and higher yield loss due to BPB has been observed at various locations.

DISEASE MANAGEMENT:

This disease has the potential to limit the rice production and therefore there is a need of pertinent and reliable measure for disease management under current climatic conditions.*In vitro* and *in vivo* screening of chemicals and biocontrol agents in for the management of Panicle Blight Disease of Paddy are major practices to manage bacterial panicle blight disease are to use pathogen free seeds and application of antibiotics.The disease is seed borne and therefore it's important to monitor its dissemination to different geographical regions of major rice growing areas in India through infected seeds.

Ham and Groth, 2011, report oxolinic acid, is practically the only effective chemical agent for the disease in the fieldbut it's long-term and sustainable efficacy is doubtful due to the frequent occurrence of antibiotic-resistant strains. Other reports recommended 3 sprays of Streptocycline @ 100 pg a.i/l, or Agrimycin-I 00 @ 100 pg a.i./l, Oxolinic acid @ 300 pg a.i/l or streptomycin sulfate @ 100 pg a.i/l, glycocide B @ 700 pg a.i/l, kasugamycin @ 80 pg a.i/l, at 10 days interval starting from the earliest appearance of the disease for effective disease management.

Shahjahan (2000) found the use of copper-oxy-chloride, antibiotics viz. - streptomycin sulphate, kanamycin, ampicillin trihydrate, tetracycline and biocontrol agents for the management of bacterial panicle blight of rice.

Biological control could be an alternative approach in managing bacterial panicle blight.Shrestha *et al.,* 2016 isolated 26 strains of *Bacillus* spp. that exhibited high levels of antagonistic activity to both *B. glumae* (bacterial blight pathogen) and *Rhizoctonia solani* (sheath blight pathogen) from rice plants in the field, and they tested their biological control activities with the five selected strains in the field for two years. All five strains tested significantly suppressed both bacterial panicle blight and sheath blight.Miyagawa and Takaya, 2000 observed in a field test that avirulent strains of *B. gladioli* (the other species causing bacterial panicle blight) effectively suppressed the symptom development that is caused by the inoculation of a virulent *B. glumae* strain.

HOST RESISTANCE:

Besides chemical and biological approach state that breeding of elite disease resistant lines is imperative to mitigate the problem of bacterial panicle mite. Recently two tropical japonica cultivars, Kale and Jaguary, are identified with a high level of resistance and several indica cultivars with moderate levels of resistance. Resistant cultivars and lines have also been reported in other countries like in Brazil, three cultivars were found to be resistant to BPB in the field evaluation.

Twelve quantitative trait loci associated with partial resistance has been identified Few reports of quantitative trait loci for Bacterial panicle blight disease resistance(Pinson *et al*., 2010) are given in Table 1.

Cultural control for the disease management that includes elimination of infected seeds by salt water selection with a specific gravity of 1.18.

BURKHOLDERIA GLUMAE AND STENEOTARSONEMUS SPINKI (PANICLE MITE) COMPLEX:

Rice panicle mite, *Steneotarsonemus spinki* Smiley found to be an emerging pest infesting paddy fields in India especially at flowering stage when temperature ranged 26-30 oC and relative humidity above 80%, Its incidences in India have been reported

Table 1: Quantitative Trait Loci (QTL) for Bacterial panicle blight disease resistance:

Chromosome	QTL	Source of Resistance Allele	Material Used for QTL Analysis	Flanking markers	Phenotypic variance(%)
1	qBPB-1-1	TeQing	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	RG472-C131 (2year average)	2.7 (2year average)
1	qBPB-1-2	TeQing	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	CDO455-CDO118 (2002)	4.6 (2002)
1	qBPB-1-3	Lemont	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	RG236-C112x (2001) RZ14-RZ801 (2002)	3 (2001) 3.4 (2002)
2	qBPB-2-1	Lemont	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	C624x-RG139 (2001)	2.5 (2001)
2	qBPB-2-2	TeQing	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	On end at RG520 (2002)	2.1 (2002)
3	qBPB-3-1	TeQing	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	C515-RG348x (2year average) C515-RG348x (2001) C515-RG348x (2002)	13.8 (2- year average) 12.7 (2001) 9.8 (2002)
3	qBPB-3-2	Lemont	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	G249-RG418 (2year average) G249-RG418 (2001) G249-RG418 (2002)	3.6 (2- year average) 3.5 (2001) 3.2 (2002)
7	qBPB-7	TeQing	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	BCD855-CDO497 (2001)	2.8 (2001)
8	qBPB-8-1	TeQing	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	on end at C424x (2year average)	2.9 (2- year average)
8	qBPB-8-2	Lemont	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	C825x-G104 (2year average) C825x-G104 (2002)	3.8 (2- year average) 2.8 (2002)
10	qBPB-10	TeQing	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	RG214x-CDO98 (2year average) CDO98x-Y1065La (2001)	3.6 (2- year average) 5.7 (2001)
11	qBPB-11	TeQing	300 Recombinant inbred lines from a cross of TeQing(R) and Lemont (S).	RZ900-G44 (2year average) RZ900-G44 (2002)	2.9 (2-year average) 4.6 (2002)

from Andhra Pradesh and West Bengal, more severe during September and October where congenial conditions of temperature and humidity prevailed, resulting considerable yield losses in term of sterility (20- 50%) in rice.

Rao and Prakash, 2003 reported *B. glumae* and other pathogens to be the possible primary cause of damage or crop loss that are associated with *S. spinki.*

Based on these observations and photographs from other fields worldwide, some scientists believe that the majority of damage attributed to *S. spinki* is actually caused by the bacteria.

CONCLUSION:

The disease Bacterial Panicle Blight has risen to be a matter of great concern in countries like Japan, US as well as India. The disease is highly destructive and can cause complete loss of yield under favaourable conditions. As the optimum temperature for the pathogens is high, with global warming the disease is more likely to cause severe damage in epidemic regions in future. Therefore with global warming Bacterial panicle blight could be one of the most destructive disease of rice within the next few decades.

Oxolinic acid is claimed to be an effective antibacterial compound for control of BPB claimed by scientists in Japan, but it is not labeled for use on rice in the USA and many other countries. Since there is no standardized management methods scientists, agronomist should contrive a more sustainable method of management and plan for a resilient future inrice production. Considerable research efforts have been conducted globally to develop resistant cultivars as an effective and sustainable strategy for management of BPB of rice. Unfortunately, no single genes or quantitative trait loci (QTLs) for complete resistance to BPB have been found so far. Since there is no standardized treatment methods and most commercially available varieties are susceptible the only sustainable control of BPB relies on integrated use of available management strategies of exclusion, genetic resistance, chemical control, biocontrol, and cultural practice. Developing and use of resistant cultivars is the best strategy to minimize the damage caused by BPB and maximize rice production in the long term.

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A LOOK INTO THE GENETIC DIVERSITY AND POPULATION STRUCTURE OF THE *USTILAGINOIDEA VIRENS* IN RICE-GROWING REGIONS OF NORTHERN INDIA

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Rice, a unique food crop, has wide adaptability to climate, edaphic and cultural conditions. Rice False Smut (RFS) is now one of the most emerging disease of rice under changing climate condition. At the beginning the disease appears to be white, later turns to yellow, yellowish-green and finally greenish-black ball like structure, known as false smut ball. The individual grains converted into mass of sclerotia which leads to loss of rice yield and grain quality. About 44% yield loss reported in Uttar Pradesh, 0.2 - 49% reported in pan India. The many popular high yielding and multiple disease resistant varieties used to show susceptibility to this pathogen. Large number of plants can't be screen because of peculiarity and toughness of artificial inoculation procedure.Study of genetic diversity of pathogen gave very precise result about the population structure of the pathogen, more quickly than other methods, helps in building better management strategy and checking the possibility of evolution of new race of pathogen. In addition, temporal and spatial information on genetic diversity and population structure of plant pathogen are highly important to understand the evolutionary adaptability and the pathogen's potentiality to overcome the potential resistance of the host plant.

OBJECTIVE:

The present study was to elucidate the population genetic diversity and structure of the *U. virens* isolates in the major rice growing areas from northern India, using RAPD and SSR markers.

METHODOLOGY

1. **Sampling, Isolation and Purification of *U. virens* isolates-** Total 50 samples were collected from the region of U. P., M. P., Uttrakhand, and H. P. where the disease was more prevalent during 2017-2018 further isolation of pathogen from individual balls and purification were done in the potato sucrose media (PSA).

2.DNA Isolation- For isolation of DNA individual spore was inoculated in to the Potato Sucrose Broth (PSB). After 20 days mycelium was harvested and subjected to isolation of DNA. The isolated DNA was purified with RNAase treatment.

3. **RAPD and SSR Genotyping-** Total 32 RAPD primers and 50 SSR markers were selected from different literatures and tested for amplification of *U. virens* isolates. 10 random decamer RAPD primers and 21 SSR primers were able to produce reproducible bands and were used for further assessment and survey of the isolates. Polymorphic bands were manually scored as binary data basis on presence (1) or absence (0) of each amplicon. The similarity matrix was then subjected to the unweighted pair group method with arithmetical mean (UPGMA).

4. **Population structure, Gene flow, Genetic diversity analysis and AMOVA (Analysis of Molecular Variance) -** On the basis of binary scoring the cluster analysis was made using the NTSYS-pc program 2.1 software. Population structure were

analysed using the Structure 2.3.4 software. Major allele frequency, observed heterozygosity, gene diversity (expected heterozygosity) and Polymorphic Information Content(PIC) of microsatellites were obtained by using Powermarkersoftware.The number of subpopulations obtained through Structure v 2.3.4 taken as basis for AMOVA and for Nei's genetic distance in GenAlEx v6.503. Other supporting information like Fst and gene flow, also obtained from AMOVA. Further extractions of important information from genotyping of isolates and to express this information as a set of summary indices Principle Component Analysis (PCoA) were made GenAlEx v6.503.

RESULTS

Markers informativeness and DiscrimanativeCapasity-Expected heterozygosity (GD) ranged from 0.166 to 0.38 with an average of 0.260 while unbiased heterozygosity showed 0.167 to 0.384 with an average of 0.262. Shannon's informativeness of an ava. of 1.432. The PIC value of markers was an average of 0.243. The PIC value ranged from 0.04 to 0.2516 except monomorphic markers with an average of 0.2680. All the SSR markers significantly deviated from the HWE. Polymorphic information content (PIC) and qualitative nature of data (QND) was high in SSR markers (0.312 & 0.14) than RAPD markers (0.234& 0.046).

Population Structure analysis- When genotyping done by the RAPD markers the maximum likelihood peak observed at two places one at K=2 and another peak at K=3 (Fig.1). When analysis done with SSR markers the best value for the structure distribution of the *U. virens* isolates shows ("K) peak at K=3 which means optimal predicted number of population clusters K for the dataset is 3 when analysis done in the structure harvester (online tool). Combine marker study also showed the K=2 as well as peak at K=3.

Fig.1. Rice False Smut (RFS) on Panicle of rice and growth of the RFS fungi at Potato Sucrose Media (PSA)

Principal Component Analysis (PCoA)- Analysis with RAPD markers showed the % of variation from first two axis were 92.79% of the total observed variation, suggesting a distinct genetic structure exist between the subpopulations 1 and subpopulation 2. When analysis for PCoA was done with SSR markers the first two axes shows the 82.89% variation of the total, while the combined markers (RAPD+SSR) studies showed 84.53% variation which was at par with the SSR markers studies.

Analysis of the molecular variance of the populations : A low level of variance was observed among the populations as 14%, 9% and 5%when analyzed with RAPD, SSR and combined (RAPD+SSR) respectively, whereas very high variation was observed within population e" 85% for RAPD, SSR and combined (RAPD+SSR).Coefficient of genetic variation (PhiPH) was also calculated and it was found 0.14, 0.09 and 0.05 for RAPD, SSR and combined markers respectively.

Mantel test- Negetive coorelation were observed.

RAPD, SSR and Combined analysis- Main two cluster were observed when analysis were done with RAPD, SSR and Combined.

Conclusion: The following study would help in understanding the population biology of the pathogen in terms of population structure and dissimilarity % between the isolates of different regions. We observed low genetic differentiation in the regions due to high gene flow and genetic drift in fungi. These information's further lead to develop better understanding building for management strategies.

IRC/TM-3/PP-53

MANAGEMENT OF RICE SEEDLING ROT DISEASE CAUSED BY *SCLEROTIUM ROLFSII* SACC. UNDER SUMMER NURSERY CONDITIONS

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ABSTRACT:

Rice seedling blight or rot disease caused by *Sclerotium rolfsii* Sacc. in the rice seedbeds of the summer season from November April. Typically, the rice seedlings are weakened or killed by the fungi. Environmental conditions are important to seedling mortality due to this fungi. In the present climate change scenario rice crop is facing the tough competition of new diseases which were otherwise not touching the economical threshold. Rice seedling disease is emerging as one of the potential threats to rice cultivation under South Gujarat conditions. *S. rolfsii* pathogenwas isolated from infected rice seedlings from Regional Rice Research Station N.A.U., Vyara farm nursery and farmers field nurseries. The pathogen was purified and maintained on potato dextrose agar (PDA) medium. Pathogenecity of *S. rolfsii* was proved by active mycelium incorporate in the soil under pots conditions. Initial infection was started before seed emergence to 3-4 leaf stages of growth. Fungus completely colonized seeds which were failed to emerge and later became rotted. Pathogen infect seedling after emergence showed discolored brown to black colored on infected roots near crown region and shoots were suddenly died and turned to straw colored. Seedling rot of rice was most prevalent disease in summer rice nurseries then *kharif* season under south Gujarat conditions. *S. rolfsii* was most important fungus to caused seedling rot in cold, wet soil conditions. In view of the importance of the fungi caused high seedling mortality under nursery condition on farmers field, there is urgent need to develop management strategies to better crop production. Eight fungicides evaluated under *invitro* condition out of them Trifloxystrobin 25% + Tebuconazole 50%, Mancozeb 63%+ carbendazim 12% 75 WP, Azoxystrobin 18.2%+ Difenconazole 11.4%SC, Thiram 75WP and Azoxystrobin 11.5% + Mancozeb30.0% gave complete mycelia growth inhibition at 50 ppm concentration. Whereas Tebuconazole 2SD and Azoxystrobin 23SC were also found good mycelia growth inhibition ability by 83.33 and 90.74% respectively. Carbendazim was fail to inhibit the mycelia growth under *invitro* condition. New fungicides was evaluated under field condition and found that rice seeds treat with Azoxystrobin 23SC @0.046% solution (1ml /kg seeds) soaked in 500 ml water for 2 hrs and soil application with *T.harzianum* @ 1g/m^2 or alone seeds treat with Azoxystrobin 23SC and Azoxystrobin 18.2%+ Difenconazole 11.4%SC for better plant population with minimum seedling mortality and good seedling vigour. Also improved seedling height and root length.

BIOCHEMICAL BASIS OF RESISTANCE IN RED RICE GENOTYPES AGAINST BROWN PLANTHOPPER

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Rice (Oryza sativa L.) is an essential cereal crop consumed by millions of people both as a staple food as well as processed products. Rice ranks second in consumption after wheat throughout the world. Among the rice varieties pigmented rice varieties have gained much popularity in almost every country due to the presence of flavonoids and antioxidant compounds (Zhang *et al*., 2005). Brown planthopper (BPH) *Nilaparvata lugens* (Stal) is one of the most destructive monophagous insect pests in rice and causes huge yield losses every year throughout tropical, subtropical and temperate areas in Asia (Park *et al*., 2008) . The commonly practiced measure is the use of insecticides. Chemical insecticides are extensively usedfor the control of BPH, which has resulted in many problems, including toxicity to natural enemies, pest resurgence (Wang et al, 2008).To overcome above problem, rice resistance is a cost-effective and environmentally friendly strategy for BPH management.In contrast, host plant resistance (HPR) is the key to integrated pest management as this approach is eco-friendly, provides cumulative protection against insect pest and is often compatible with other pest management methods (Kogan, 1998).Plants contain certain anti-nutritional chemicals that may be in toxic levels to insects but are harmless to man as it gets degraded by cooking. Resistant rice varieties appear to have higher levels of phenolic compounds, lower levels of free amino acids, and lower concentrations of reducing sugars (Thayumanavan *et al* 1990).So, understanding the mechanism of resistance is important before evolving resistant varieties. Hence, the present study was conducted for knowing the biochemical basis of resistance in promising red rice accessions.

MATERIALS AND METHODS

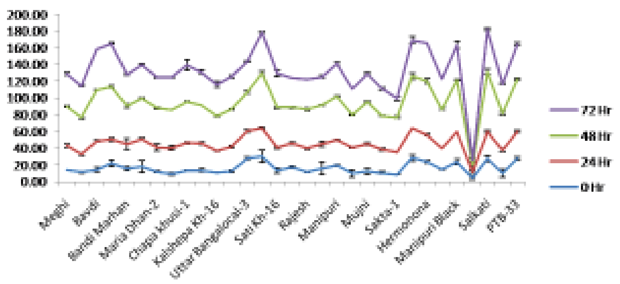
Samples were collected from 28 resistant red rice accessions along with TN1, Salkathi and PTB-33 to study the total phenol content and changes in phenol content in response to brown planthopper attack under greenhouse conditions. Leaves from different accessions were collected in early morning in ice cold box andused for analysis.Phenol content was estimated as per the procedure given byS. Zilic et al 2011) and (Modification of Hagerman et al 2000).After 40 minutes the absorption of the developed blue color was measured using UV-visible spectrophotometer at 725 nm. The content of the total soluble phenols was calculated according to a standard curve obtainedfrom a Folin-Ciocalteau reagent (FCR) with a phenol solution (C_6H_6OH) and expressed as catecholequivalentsmg-1 tissue weight.The total soluble sugar was measured by anthrone method as described by Hedge and Hofreiter (1962)and change in colour from green to dark green was measured at 630 nm in a spectrophotometer. Standard curve was drawn by plotting the concentration of the standard on the X-axis versus the absorbance on the Y-axis. From the graph the amount of carbohydrates and the amount of total sugar present in the sample tube was calculated.

Amount of carbohydrate in sample =

Sugar value from graph(mg) X Total Vol of extract (ml)X100 Aliquot sample used (0.5 ml) X Wt of sample (mg)

RESULTS AND DISCUSSION

In the present investigation, we estimated phenol quantity of uninfested plants as well as 24, 48, 72 h after BPH infestation. We observed that, the phenol quantity significantly increased in all the tested genotypes with maximum activity in Mata Meher which is a highly resistant germplasm. Similarly the phenolic content in all the highly resistant germplasm was more compare to resistant and moderately resistant germplasms. Our results were in support of the previous researchers Thayumanavan et al., (1990) who reported that resistant varieties had significantly higher total phenolic content compare to susceptible varieties. After 24hours of BPH feeding, the phenol quantity increased significantly and reached its peak at 48h after BPH feeding. Thereafter, the phenol content started decreasing gradually.In the present investigation, we estimated the quantity of total soluble sugars in response to BPH infestation in 31 selected rice accessions at different durations. We observed that, the total soluble sugar content tends to decrease at 24, 48 and 72 h after BPH infestation. The reduction in sugar content was more in highly susceptible genotype TN-1 followed by moderately resistant genotypes. The quantity of sugars was less in resistant and highly resistant accessions. These accessions had shown slight decrease in sugar content. The decrease in sugar content may be attributed to the BPH feeding. Our results are supported by previous workers. Ashrith et al. (2017) observed, higher infestation of brown planthopper in transplanted rice than in direct seeded rice.



Total Phenols (µg/gm of fresh sample) in red rice genotypes

CONCLUSION

The overall results revealed that resistant red rice accessions have higher phenol and lower sugar content as compare to TN1. Phenol content was increased in resistant accessions up to 48hr of infestation of BPH. Similarly sugar content was lowered in all resistant accessions as infestation prevails.

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IRC/TM-3/PP-55

INCIDENCE OF STEM ROT (*SCLEROTIUM ORYZAE* CATT.) OF RICE IN MAJOR RICE GROWING STATES OF SOUTHERN INDIA

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Rice serves as a staple food for more than two-thirds of the world's population. Rice production is affected by a number of biotic and abiotic factors. Among the biotic constraints, diseases caused by fungal pathogens such as leaf blast, neck blast, sheath blight, sheath rot, false smut and stem rot cause significant damage in irrigated rice. Stem rot of rice caused by *Sclerotiumoryzae*is becoming a serious problem and is known to cause substantial quantitative and qualitative losses due to increased lodging, smaller panicles, production of light chalky grains and poor milling quality particularly in waterlogged areas. Stem rot caused by *Sclerotium oryzae* which was considered as a minor disease earlier, is now one of the major constraint in rice cultivation (Cother and Nicol 1999). The information on the disease status is limited. Therefore, present investigation was undertaken to ascertain the disease incidence in different rice growing states of southern India.

METHODOLOGY:

The roving survey was conducted to assess the incidence of stem rot in major rice growing states of southern India*viz*., Andhra Pradesh, Tamil NaduandTelanganain *kharif* 2019.In each stateprominent rice growing areas were chosen for assessment of disease and the data regarding, per cent stem rot incidence, stage of the crop, variety grown, cropping pattern were recorded.

RESULTS:

The mean disease incidence was in the range of 2.2 to 5.5 per cent in three states. In Andhra Pradesh the mean per cent disease was varied from 2.2 to 12.3 per cent with a highest incidence of 12.3 per cent in Akividu mandal of west Godavari district. In Telangana the mean per cent disease was varied from 0 to 5.7 per cent with a highest incidence of 5.7 per cent in Miryalaguda mandal of Nalgonda district. In Tamil Nadu the mean per cent disease was varied from 0 to 4.1 per cent with a highest incidence of 4.1 per cent in Kumbakonam block of Tanjavur district. All the prominent growing rice cultivars are susceptible to stem rot in the surveyed areas. The incidence of disease is in coupled with stem borer and brown plant hoppers infestation.

CONCLUSIONS

Stem rot of rice is an emerging disease posing to great threat to the rice cultivation in southern India.

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IRC/TM-3/PP-56

EVALUATION OF BPH RESISTANT RICE GENOTYPES AGAINST YELLOW STEM BORER, S. INCERTULAS (WALKER) THROUGH ARTIFICIAL SCREENING METHOD IN RAINFED RICE FIELD SYSTEM

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Increasing population with squeezing cultivable land is the biggest challenge of 21st century. The challenge multiplies for the agricultural researchers, when a major portion of crop loss occurs due to pest attack. Among all the pests, yellow stem borer (*Scirpophaga incertulas*, YSB) is one of the important insects, which attack rice plants in both vegetative and reproductive stage. It produces 'dead heart' (DH) at vegetative stage and white ear head (WEH) during panicle initiation stage. If the infestation is not treated from the early stage of the crop, it may lead to major yield loss. This can be avoided by identifying multiple insect pest resistance varieties. It can be only be achieved through rigorous screening procedure.

METHODOLOGY

A total of 250 BPH resistant genotypes, which had already been screened against brown plant hopper during seedling stage through standard procedure, were transplanted in experimental field of ICAR-National Rice Research Institute(NRRI), Cuttack, for screening against YSB during two cropping seasons, i.e., Rabi andkharifseason of year 2019. Screening was done under artificial inoculation of YSB egg masses, implanting them @ one egg mass/ 2 hills. The number of dead hearts against total tillers was recorded at the vegetative stage of the crop separately in each variety, during Rabi, 2019 and screening for WEH was conducted at the reproductive stage during kharif, 2019 by implanting eggmasses at the panicle initiation stage. The recorded data was transformed to percent DH and WEH for different genotypes, were subjected to statistical analysis and scored according to the SES technique of IRRI(2013) for comparison of efficacy.

RESULTS

In vegetative stage screening, 10 genotypes found highly resistant to YSB with score 1 (1-10% DH) whereas 85 scored 3 with 11-20% DH and 86 were of score 5. In reproductive stage screening, 40 genotypes were devoid of any WEH. Six genotypes recorded score 1 and 20 genotypes scored 3 whereas 12 genotypes scored 5 against YSB for WEH formation (ref. Table-1). The comparative study of screening showed 14 genotypes as having resistance against YSB at both vegetative as well as reproductive stage. They were, AC 38449,CR 2711-149, CR 2711-76, CR3006-8-2, FV-267, Abhay,IRWH 9, IR 113050-3-51(P1), IRWH 30, IRWH 44, IRWH 26, IRWH 27 and IRWH 41(ref. Table-2).

Table 1

DH scoring	No. of varieties infested with YSB on early stage	WEH scoring	No. of varieties infested with YSBon reproduc-tive stage
0 (no infestation)	0	0 (no infestation)	40
1(HR, 0-10%)	10	1 (HR,1-5%)	6
3(R, 10-20%)	85	3(R,6-10%)	20
5(MR, 20-30%)	86	5(MR,11-15%)	12
7 (S, 50-70%)	19	7(S,16-25%)	16
9(HS, Above 70%)	99	9(HS, Above 25%)	177

@HR- Highly Resistant, R- Resistant, MR- Moderately Resistant, S- Susceptible & HS- Highly Susceptible

Table 2

Varieties	Total tiller	DH	% of DH	DH score	% of WEH	Score WEH
IR WH -9	161.5	24	14.86	3	0	0
IRII3050-3-51(P1)	110	17	15.45	3	0	0
IRWH-30	125	21	16.8	3	0	0
IRWH-44	155.5	28.5	18.3	3	0	0
IRWH-27	134.5	21	15.61	3	0	0
IRWH-26	71	11.5	16.2	3	0	0
IRWH-41	74	14	18.92	3	0	03
FV-267	45	6	13.33	3	10	3
CROSS-204 (CR2711-149)	137	17	12.41	3	6.666667	3
IR-64	25	3	12	3	5	1
AC-38449	103.5	17.5	16.91	3	10.13	3**
CR2711-76	125.3	22	17.56	3	0	0
CR 3006-8-2	69.5	12.5	17.99	3	0	0
ABHAYA	55	9.5	17.27	3	0	0

**Percentage of EBH values are closer to 10%, so they can be considered as resistant varieties

Rabi or dry season rice generally suffers heavy damage due to early stage infestation of YSB. Even scheduled based application or immediate application of pesticides fail to protect the crop. The study showed a group of genotypes which can resist the infestation of the pest to a considerate level. Even the genotypes having 3 or 5 score can manage the pest suitably with minimum chemical application or with integrated pest management technique. Likewise, YSB attacks the kharif or wet season rice mostly at the reproductive stage. The genotypes having resistance against WEH formation can be of immense help to rice farmers. Above all, the genotypes resistant to YSB at both the stages of the cropcan serve as a boon to the rice farmers. Since many identified genes are breeding lines, derivatives of land races or wild rice, they can be utilized in resistant breeding programme to develop YSB-resistant varieties.

CONCLUSION

Yellow stem borer is a damaging pest of rice and hence, a dread to farmers. At present, rice farmers apply more pesticides for this single pest. But still, they suffer yield loss due to the internal feeding habit of the pest and improper use of management strategy. Host palnt resistance against the pest has not been properly explored till date as a result identified resistant genotypes are meagre at present. This study will provide opportunity for the farmers and researchers to screen the effective genotypes in large scale areas of different locations to re-evaluate their efficiency against YSB in different climatic conditions. The molecular evaluation will further enable to explore the functional genes and narrow down the search for highly resistant donor/ genotype for YSB for benefit of rice farmers.

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IRC/TM-3/PP-58

STUDY OF GENETIC CONTROL OF FOOT ROT DISEASE IN BASMATI RICE

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Among aromatic rices, 'Basmati rice' regarded as the queen of rice is a nature's gift to Indian sub-continent, where it has been grown in the foothills of Himalayas from ancient times. The rice grown in this area has unique quality features and pleasant aroma which is endowed by climate of this region. For a variety to qualify as basmati, along with aroma it has to meet specific physio-chemical characteristics like minimum raw grain length of 6.61 mm, Kernel length upon cooking more than 12.5 mm, minimum elongation ratio of 1.7 etc. India is the leading exporter of basmati rice in the world.

The sustained production of basmati rice is threatened by many biotic stresses. Among these the foot rot disease also known by different names like "elongation disease", "white stalk", "bakanae" disease in the different regions of the world has emerged as an alarming problem in the past few years. The disease is seed as well as soil-borne and infection becomes easily taken place when infected seeds are sown in non-infested fields or healthy seeds in fungus infested fields or the infected seeds in infested fields. There is no chemical control available for the control of disease and seed treatment is the only recommended option. But, the use of chemicals also raises concerns of pesticide residues and meeting MRL (minimum residue limits) specified by different importing countries is nowadays a chief concern for trouble free basmati export. Development of new foot rot resistant basmati cultivars is the highly effective, efficient, eco-friendly strategy for its sustained production along with maintaining the sanctity of basmati rice. For initiating a sound breeding program, there is a need to completely understand the genetics of the disease which is a basic step towards identification and genes/QTL's associated with the disease and their use for development of foot rot resistant/tolerant varieties. Keeping the above facts in view the research was planned to study the inheritance of foot rot resistance and identify gene(s)/QTL(s) in the F_2 population derived from the cross of susceptible basmati elite genotype RYT 3677 developed at Punjab Agricultural University, Ludhiana and aromatic rice variety Punjab Mehak-1 which was found to be moderately resistant to the disease in one of the in previous studies (Puyam *et al* 2017).

OBJECTIVES:

To study the genetic control of foot rot disease by screening F_2 population derived from the cross of susceptible basmati genotype RYT 3677 and moderately resistant aromatic rice variety Punjab Mehak-1.

METHODOLOGY:

The screening for foot rot resistance was done according to a high throughput screening protocol developed by Fiyaz *et al* (2014). For this purpose artificial inoculations were done by using, culture of virulent isolate of *Fusarium moniliforme* (1x 10^6 spore suspensions) by treating the seed for 48 hours. The inoculated seeds of the F_2 population were sown on beds in rows, by allowing space planting to maintain the individuality of each plant. The resistant and susceptible parents were also planted as control with and without inoculations as one row each (50 plants) after every 10^{th} row of F_2 population. Observations were recorded starting from seventh to twenty fifth day after inoculation. Observations were recorded on number of discolored, elongated, stunted and dead seedlings and the plants showing these type of disease symptoms were classified as susceptible while the plants with normal appearance were recorded as resistant.

RESULTS:

Among the parents, the plants of inoculated lines showed clear cut differences for disease reaction. RYT 3677 genotype behaved as susceptible while the reaction of Punjab Mehak 1 was found to be moderately resistant. A total of 1390 F_2plants were screened to study the genetic control of foot rot disease by following the procedure described above. From these 1302 plants showed completely resistant reaction towards foot rot while 88 plants were found to be susceptible to this disease. The preliminary studies indicate that the resistance against foot rot in Punjab Mehak 1 is governed by complementary genes as the ratios fit well into 15:1 genetic ratio with chi square values of0.016. The confirmation of the results will be made in the next season by taking observations on the freshly generated F_1's and F_3 generations. As the genetic control of resistance in Punjab Mehak 1 is unknown, it may be due to undescribed genes.

CONCLUSION:

The preliminary studies indicate that the resistance to foot rot disease in Punjab Mehak 1 is showing complementary gene action as the observed ratios shows good fit into 15:1 genetic ratio and can be utilized as potential donor for foot rot resistance in basmati breeding programmes.

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IRC/TM-3/PP-59

INCIDENCE OF GRAIN DISCOLORATION OF RICE IN NELLORE AND CHITTOOR DISTRICTS OF ANDHRA PRADESH

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Rice (*Oryza sativa* L.) is the primary staple food in many countries.Rice can be grown in different environments depending upon wateravailability as low land-rainfed which is drought prone, low land-irrigated,deep water or floating rice, coastal wetland and upland rice which is known fordrought tolerance. Rice crop suffers from many biotic and abiotic stresses thatincites diseases.Some plant diseases, which were less significant earlier, are nowgradually gaining importance and posing a serious threat to the cropproduction. Among these, the rice grain discoloration disease is one, which isalso known as "Glume discoloration" or "Dirty panicle" etc. The disease is distributedthroughout Asia, Africa and America. It is presently posing a serious threat inrice growing areas of India.The grain discoloration or dirtypanicle or black panicle disease was first observed in Navsari, (Gujarat)caused due to various saprophytic and pathogenic fungi predominantly. The early and medium rice cultivars grownparticularly in wet seasons are generally exposed to high humidity and warmenvironmental conditions during flowering and post flowering stages, whichsignificantly induced the disease.

Grain discoloration of rice is a complex disease occurred, due toinfection by certain microorganisms on glumes, kernels or both. These fungiindividually or in combination were demonstrated to be infectious (Dash andNarain, 1988).Seed (or) grain discoloration is an early indication of poor seed or grainquality which is generally associated with micro-organisms and sometimesinsect pests. Such grains are of poor market value and low consumption qualitydue to degradation in nutritional value. It was reported as an independentdisease in the literature causing significant yield losses (Ashfaq et al., 2013; Chandramani and Awadhiya, 2014). The information on the disease status is limited and it has been found most serious for the last fewyears in Andhra Pradesh. Therefore, present investigation was undertaken.

METHODOLOGY:

The roving survey was conducted in two districts *viz;* Nellore and Chittoor districts of Andhra Pradeshduring kharif 2017 and from each district prominent rice growing areas were chosen for sample collection and assessment of the disease. In Nellore district, four mandals *viz;* Nellore Rural, Indukurpeta, Atmakur, and Sangam, and where as in Chittoor district, four mandals *viz;* Tirupati rural, Yerpedu, Nagiri and Srikalahasti were surveyed with a sample size of three villages in each mandal and five fields in each village. Rice panicles showing typical symptoms of grain discoloration disease were collected to record the severity of rice grain discoloration according to the severity scale given by IRRI.

RESULTS:

Thedisease severity was observed more inNelloredistrict, vary from 36 to 20 per cent and from 34 to 19 per cent in Chittoor district. The highest disease severity was observed in Atmakur mandal of Nellore district and least severity was observed in Nagiri mandal of Chittoor district. In Nellore district, the Vasili village of Atmakur mandal shows the highest disease severity of 36.85 per cent and the least disease severity of 20 per cent was observed in Kovur village of Nellore rural mandal. In Chittoor district Yerpedu village of Yerpedu mandal shows the highest disease severity of 32.26 per cent and the least severity of 19.79 per cent was observed in Nagiri village of Nagiri mandal. All the growing rice cultivars are susceptible to grain discoloration in the surveyed areas.

CONCLUSIONS

Grain discoloration of rice is an emerging disease posing a great threat to the rice cultivation. It is caused by a fungal complex and also coupled with insect damage as a secondary infection. The disease is causing both qualitative and quantitative losses of grain yield and also results in seedling mortality, reduction in germination and seedling vigour in Andhra Pradesh.

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IRC/TM-3/PP-60

SCREENING OF CERTAIN RAJENDRANAGAR RICE CULTURES UNDER PROTECTED AND UNPROTECTED CONDITIONS AGAINST LOCATION SPECIFIC INSECT PESTS

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Rice is the staple food of over half of the world's population.It is grown in 158 million hectares with a production of more than 700 million tonnes. Out of which 90 per cent of global production is produced in Asia. India accounts for 44 million hectares of land area for cultivation of rice. The production and productivity of rice is highly affected by biotic and abiotic stresses of which insects play a major role.

More than 100 species of insects attack rice crop. Out of these 20 can cause economic damage (Pathak and Khan,1994) and necessitating the growers to opt chemical control. The over reliance on insecticides for the management of insects is an important factor for the escalating cost of cultivation and environmental pollution. Breeding multiple resistant cultivars is quintessential to manage different insect pests. These cultures are compatible with other methods of integrated pest managementin general and chemical control in particular. This helps reaping better yields with reduced input use. The evaluation of multiple resistant cultures against different insect pests and their yield potential is the vital step before releasing them as varieties for the farmers. With this backdrop the present studies were conducted with a view to evaluate the rice cultures developed at Rajendranagar under protected (P) and unprotected (UP) conditions against major insect pests of the region.

METHODOLOGY:

The experiment was conducted in RBD with six rice cultures (RNR - 14956, 15028, 15038, 15048, 15069 and 15170) and a check (BPT – 5204) at Rice Section Farm, Agricultural Research Institute, Rajendranagar, Hyderabad. Under protected conditions, nursery and main field were protected with carbofuran 3G @ 10 kg ha^{-1} and cartap hydrochloride 4G @ 20kg ha^{-1} one week before pulling of nursery and 20 DAT respectively. All other agronomic practices were followed as per package of practices (Jagadeeshwar et. al. 2014). The treatments were replicated thrice with a net plot area of 10.71 m^2 and the seedlings were planted at a spacing of 20 X 15 cm. The data pertaining to population / damage counts were recorded at 30 and 50 DAT and one pre – harvest count for the white ear data were taken. Total tillers and damaged tillers due to stem borer incidence were counted on 20 hills selected by stratified random sampling. Total leaves and damaged leaves of 10 plants were selected at random for calculation of *Hispa* and whorl maggot damage at 30 DAT. Grain yield from each plot excluding two border rows was collected. The data recorded was subjected to statistical analysis.

RESULTS:

The results presented in table-1 indicated that among the six RNR rice cultures evaluated under P and UP conditions, RNR 15038 recorded significantly lower white ear incidence of 1.79 and 1.56 and was followed by RNR 15170 with a white ear incidence of 1.54 and 2.09, respectively. The grain yield was higher in BPT 5204 (8.04 t ha^{-1}) but was on par with RNR 15038. The yield data indicated that there is a significant difference in yield between P & NP conditions. The Third best in yield was RNR 15069 with 7.90 t ha $^{-1}$

Table : 1. Percent damage caused by different insect pests and yield.

Treatments		% HDL	% WMDL	% DH	%DH	%WE	Yield
RNR 14956	P	3.75(12.32)	3.48(17.82)	1.77(6.83)	1.95(6.75)	1.85(9.07)	6.49
	UP	0.99 (11.36)	2.54(18.99)	0.27(7.53)	8.52(20.04)	4.21 (10.18)	6.16
RNR 15028	P	3.63(11.09)	6.09(20.99)	3.13 (8.92)	6.44(11.82)	3.10(7.41)	7.53
	UP	1.57 (12.16)	5.69(19.76)	0.72(11.42)	9.03 (27.34)	4.37 (8.05)	6.40
RNR 15038	P	2.03(11.81)	0.96(19.67)	2.19(7.93)	5.76(13.50)	1.79(6.11)	8.01
	UP	4.03 (12.95)	3.92(23.45)	3.64 (8.64)	2.61(26.68)	1.56(5.76)	6.59
RNR 15048	P	2.22(9.80)	1.55(20.74)	2.51(12.34)	3.08(9.84)	3.10(9.55)	7.84
	UP	5.11(10.78)	2.09(21.31)	4.51(13.43)	4.05(23.31)	4.73(9.44)	7.24
RNR 15069	P	1.58(11.65)	2.92(21.22)	2.05 (12.52)	7.28(13.93)	0.97(5.13)	7.90
	UP	2.83(10.32)	2.8(18.25)	3.77(12.26)	4.63(19.88)	3.26(9.36)	7.29
RNR 15170	P	3.40(11.95)	2.48(20.04)	4.18(7.69)	4.60(12.88)	1.54(7.28)	7.53
	UP	3.87(9.32)	2.75(19.72)	1.29(10.49)	4.82(22.60)	2.09(5.26)	7.12
BPT 5204	P	1.19 (10.48)	4.69(15.98)	6.76 (9.65)	5.63 (11.69)	2.92 (5.74)	8.04
	UP	1.41(11.79)	4.53(18.35)	6.92 (14.10)	6.76 (25.69)	2.63 (8.74)	6.99
SEM		2.37	2.98	2.68	2.64	1.47	
CD		5.17	6.49	5.83	5.74	3.20	NS
CV%		25.71	18.72	34.85	28.11	25.05	

and was followed by RNR 15048 (7.84 t ha^{-1}). However, there is no significant difference in yield between these four varieties. The need based protection followed didn't show any influence on the white ear data as the white ear count was taken before harvest and the granules applied at 20 DAT might lost the lethality. The incidence of *Hispa* and whorl Maggot also followed the similar trend.

CONCLUSION:

This study indicated the superiority of RNR 15038 in response to insect pests particularly stem borer.

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IRC/TM-3/PP-61

TRANSCRIPTOMIC PROFILING OF PR114-XA38 LINE (*ORYZA NIVARA*) RESISTANT TO THE BACTERIAL BLIGHT DISEASE

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The diseases arise when agriculture moves toward higher productivity. Rice bacterial blight (BB) and bacterial leaf streak (BLS) are caused by gram negative bacteria *Xanthomonas oryzae* pv. *oryzae* (*Xoo*) (Arshad et al., 2015) and *Xanthomonas oryzae* pv. *oryzicola* (*Xoc*), respectively. Thereare46*Xa* genes identified till date from which only nine genes have been characterized at molecular level (Chen et al., 2020). To overcome this disease some resistance genes, including *Xa4*, *xa5*, *Xa7*, *xa13*, *Xa21*,*Xa38*and *xa45*have been incorporated into rice cultivars in order to develop new resistant varieties (Hsu et al. 2020). A novel BB resistance gene *Xa38*identified from *Oryza nivara*, and the gene was mapped on the long arm of chromosome 4 (Cheema et al., 2008). The gene size is 38.4 kb region and has provided a high level of resistance against BB pathogen (Bhasin et al., 2012). The *Xa38* locus spans seven loci (LOC_Os04g53030, LOC_Os04g53050, LOC_Os04g53060, LOC_Os04g53070, LOC_Os04g53080, LOC_Os04g530110 and LOC_Os04g530120) on rice genome (Lore et al., 2012). However, it is still not clear which of these is the candidate resistance gene. Cloning of *Xa38* will provide to develop gene specific markers. In addition, identification of genes working downstream of *Xa38* will be important for its effective utilization and designing strategies to combat BB. For better understanding of *Xa38* resistance mechanism in rice it is essential to study rice-Xoo interaction mechanisms as well.

OBJECTIVE:

Transcriptomic sequencing and identification of downstream signaling components of *Xa38* gene followed by quantitative real time analysis.

MATERIALS AND METHODS:

Plant material and pathogen inoculation

Two recombinants inbred lines of rice, resistant (PR114-*Xa38*) and susceptible (PR114), were used in this study. Xoo pathotype 7 and 10 infection was performed using a wild-type strain of *Xanthomonas oryzae* grown at 27±1ÚC on wakimoto media and incubated for 72-96 h. Plants were kept in a growth room at 24ÚC with 16 h light and 8 h dark for 24 h. After incubation the clean and autoclaved scissor is used for the sample collection. Plant tissue was sampled by insertion of clean scissor inside the broth and then cutting the leaves diagonally below 2-3 cm. After the cut is made the plant has been left for collection in different time intervals (0, 24 and 48 h). Tissue samples were then immediately frozen in liquid nitrogen prior to RNA extraction and transcriptomic analysis. Samples from non-inoculated leaf tissues were served as a control. The experiment was performed with three biological replicates for each treatment.

RNA extraction

Total RNA was extracted from rice leaves tissues collected in different time intervals after infection using modified IRIS method.

cDNA synthesis

RNA from the infected rice leaf tissues was extracted by IRIS method. The contaminating DNA from the RNA sample was removed by DNase treatment using RNase free DNase (GE Healthcare UK Limited, Little Chalfont (UK) (1 unit/ 25-50 µg of RNA). DNA-free RNA was used for cDNA synthesis. verso thermo scientific kit (United states) was used to synthesize the cDNA following the protocol mentioned by the manufacturer.

Quantitative Real-time PCR

The cDNA was synthesized following (verso thermo scientific kit) manufacturer's instruction. Fast start Universal SYBR Green master (Thermo scientific) was used for quantification. qRT-PCR was performed with three biological and experimental replicates. Prior to qRT-PCR, RT-PCR was performed with the tobacco actin gene, an endogenous control to ensure that there was no primer dimer in the amplification. Relative expression of mRNAs was quantified using the $2^{\text{"ÄÄCT}}$ method (Livak and Schmittgen, 2001).

RESULTS:

The RNA was extracted from different time intervals in triplicate, further the cDNA was synthesized. The primers were used for the reverse transcriptase PCR to confirm the amplification of *loc30*, *loc50*, *loc110* and *loc120*. The expected amplification band of 151 bp, 195 bp, 100 bp and 200 bp for *loc30*, *loc50*, *loc110* and *loc120*, respectively, was obtained. The same primers were used for the quantitative real time analysis. *Loc120* showed 1-fold changes at 24 h. *p value* achieved is not *<0.05* indicates *Xa38*and PR114 were not significantly different for *loc30*, *loc50*and *loc110*.

Differentially expressed genes (DEGs)

A comparative analysis of differentially expressed genes (DEGs) was performed during the course of infection in both the resistant and susceptible lines as well as between these two lines at the specified time points. In the PR114-*Xa38* line infected with *Xoo7* as well as *Xoo10*, the observation showed maximum number of DEGs at 48 h followinginoculation against 0 h (2768 genes) followed by 24 h control (1181 genes). In case of infection with *Xoo10* at 0 h 3822 genes and with 24 h control (1080 genes) get expressed differentially. In contrast, the maximum DEGs in the PR114 line also occurred during 48 h against 0 h post inoculation with 3819 genes and against 24 h, 837 genes were differentially expressed. Interestingly, at 48 h against control (0 h post inoculation), the number of DEGs in the PR114 line (2413 genes) was markedly higher than *Xa38* line (386 genes) in case of *Xoo7*. On the other hand, *Xoo10* resulted maximum number of differentially expressed genes at 48 h against 0 h control in PR114 line (2083 genes) against PR114-*Xa38* line (581 genes) whereas, at 48 h infection against 24 h control the resistant (PR114-*Xa38*) line counted to be higher than the susceptible (PR114) line. Among these, 1526 genes were differentially regulated in both PR114 and PR114-*Xa38*lines when infected with *Xoo7*, while 1838 genes weredifferentially regulated in both PR114 and PR114-*Xa38*lines when infected with *Xoo10* (Table 1). These results indicate that the strains of *Xanthomonas oryzae*(*Xoo7* and *Xoo10*) infection causes a substantial change in gene expression in rice

Table 1: Statistics of the comparison data of differential expressed genes in both susceptible and resistant lines

Susceptible Vs Resistant	Total DEGs	DEGs at log2FC	DEGs log2FC and pal0.05
PR114 Uc C Vs 48 h Treatment	37849	10042	3819
PR114 24 h C Vs 24 h Treatment	37849	2164	311
PR114 24 h C Vs 48 h Treatment	37849	3084	837
Xa38 Uc C Vs 48 h Treatment Xoo7	37849	8550	2768
Xa38 24 h C Vs 24 h Treatment Xoo7	37849	4481	915
Xa38 24 h C Vs 48 h Treatment Xoo7	37849	5078	1181
Xa38 Uc C Vs 48 h Treatment Xoo10	37849	11052	3822
Xa38 24 h C Vs 24 h Treatment Xoo10	37489	4617	743
Xa38 24 h C Vs 48 h Treatment Xoo10	37849	4969	1080

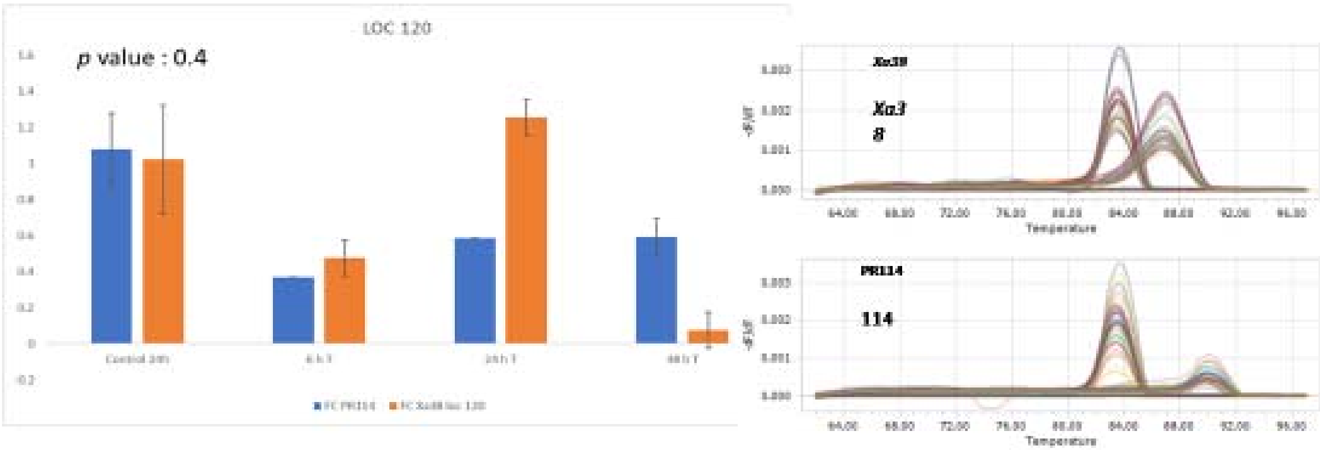

Fig.1. Relative gene expression of *LOC* 120 with Xa38 and PR114

and also suggests the substantial differences between the resistant and susceptible lines used in this study. The increased number of differentially expressed genes in *Xoo10* strain compared to *Xoo7* also indicates that these can be resolved as quicker.

Expression analysis of the locus present in the *Xa38* region and RNA sequence analysis of both susceptible (PR114) and resistant (*Xa38*) lines

Towards this, the infection was made at two different time intervals 24 and 48 h and the sample was collected for expression and transcriptomic analysis. The expression of *loc30*, *loc50*, *loc110* showed down regulation of resistant lines compared to susceptible lines. Whereas, with *loc120*only one-fold upregulation was observed at 24 h infected sample in resistant lines. Moreover, not the single gene locus of *Xa38* region was found to be present in transcriptomic profiling from both time interval (24 h and 48 h) as shown in Fig.1.

CONCLUSION

The study is underway to study differential expression analysis at 72 h of post inoculation to get insights of plant-*Xoo* interaction. Moreover, we have obtained metabolic profiling of both lines under *Xoo* infection. The data analysis is being in process. Both transcriptomic and metabolic profiling will provide platform to decipher the putative candidate gene of *Xa38* locus and helps in understanding the resistance mechanism.

IRC/TM-3/PP-62

AN INTEGRATED APPROACH FOR MANAGEMENT OF STEM ROT DISEASE OF RICE

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Integrated disease management strategy against stem rot of rice was attempted with thirteen treatments using rice cultivar MTU- 3626 in pot culture maintaining three replications under glasshouse conditions and the results revealed that the disease index was lowest (0.42%) in the treatment T10 (Propiconazole @ 0.1%+ Pseudomonas sp.(T11) @ 10 ml kg-1 + Bispyribac sodium @ 0.5 %) followed by 0.97 % in T11 (Trichoderma sp.(T11) @ 10 g kg-1 + Pseudomonas sp.(B1) @ 10 ml kg-1 + Bispyribac sodium @ 0.5 %) were found on par with each other in reduction of stem rot incidence under glasshouse conditions. All the treatments were effective in improving plant growth parameters viz., root length, shoot length, shoot and root weights of rice plant over pathogen inoculated control.

An integrated approach involving fungal antagonists along with plant protection chemicals has gained considerable attention and appears to be a promising alternative to chemical control alone (Natarajan and Rao, 1996). Integrated seed treatment with chemicals and compatible antagonists not only protect the seed and seedlings from soil borne infection but also provides protection from seed borne inoculum. Compatible fungicides are therefore essential for integrated disease management, keeping this in view to determine the efficacy of fungicide, antagonist and herbicide individually and in combination, a replicated trial was conducted atDepartment of PlantPathology in collaboration with Indian Institute of rice research, Rajendranagar, Hyderabad- 30, Telangana state, India

MATERIALS AND METHODS

Studies were taken up to develop an effective management module by integration of potential antagonists, fungicides and herbicide against stem rot disease incited by *S. oryzae* with thirteen treatments and three replications under glass house. Plastic pots of 3 kg capacity containing un-sterilized red soil @ 3 kg per pot were used for this experiment. 22 days old seedlings of susceptible rice cv. MTU -3626 grown in plastic trays were transplanted in plastic pot @ six seedlings per pot. Fifteen days after transplanting of rice seedlings, thirty days old culture of *Sclerotium oryzae* (containing mycelium and sclerotia) grown on sand maize meal medium was inoculated into the soil @ 50 gm kg^{-1} and mixed in upper layers of 1-2 cm soil and then the pots were moistened with water. The fungicides were sprayed by using automizer just at the appearance of the disease at mid tillering stage (55-60 days old seedlings. The fungal bioagent *T. harzianum*multiplied on sorghum grains was added to the top 1-2 cm of soil @ 10 g kg^{-1} just at appearance of disease followed by incorporation of seven day old culture of *P.fluorescens* multiplied on nutrient broth was added @ 10 ml kg soil. The herbicide Bispyribac sodium @ 0.5 % was added to the soil 8-10 days after inoculation by the pathogen after moistening the pots. Inoculated control was maintained by mixing of unsterilized soil with *S. oryzae* mycelial mat along with sclerotia @ 15 g per pot along with uninoculated control pots.

Disease incidence was recorded at the time of maximum disease development (i.e.,at mid tillering to booting stage) by following disease index formula given by Krause and Webster (1973).The growth parameters *viz.*, plant height (cm), root length (cm), dry shoot weight (g) and dry root weight (g) were also recorded to know the inhibitory or stimulatory effect of the treatments imposed.

RESULTS AND CONCLUSION

The results indicated that all the treatments involving bioagents were found significantly superior when compared with control in reducing stem rot with disease index of 0.42 % to2.8% as compared to inoculated control (6.72%). The initial symptoms due to *S. oryzae* were observed at mid tillering to booting stage and disease incidence was recorded by following disease index formula.

The disease index (0.42 %) was lowest in the treatment Propiconazole at 100 ppm + *P. fluorescens* @ 10 ml kg^{-1} + Bispyribac sodium @50 ppm followed by (0.97%) in the treatment *T. viride*@ 10 g kg^{-1}+ *P. fluorescens* @ 10 ml kg^{-1} + Bispyribac sodium @50 ppm which were found on par with each other. Propiconazole was used in the treatments T5,T8 and T10 due to low disease index of 1.07 % when compared with hexaconazole (2.8 %) under glass house conditions. The present results are in accordance with the results of Gopika *et al*.,2011 who reported low disease index in the treatment of propiconazole at 100 ppm + *T. viride* and *P.fluorescens* + Butachlor at 400 ppm indicating that combination of fungicides, antagonist and herbicide which showed high efficacy in controlling the stem rot disease under glass house conditions. The other treatments were found on par with each other in their disease index per centage.

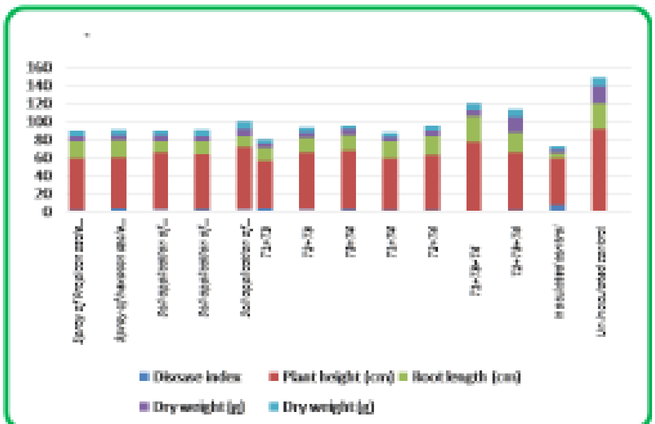

Fig 1: Efficacy of fungicides, herbicides and antagonists against stem rot disease and plant biometrics in rice cv. MTU 3626 under glasshouse conditions.

Maximum plant height (75.33 cm) and root length (29.27cm) was recorded in the treatment Propiconazole at 100 ppm + *P. fluorescens* @ 10 ml kg^{-1} + Bispyribac sodium @50 ppm when compared to inoculated control which recorded a plant height of 57.40 cm and root length 5.07 cm respectively.

Maximum dry shoot weight (17.69 g) and dry root weight (8.29 g) was recorded in the treatment *T. viride* @ 10 g kg^{-1} + P. *fluorescens* @ 10 ml kg^{-1} + Bispyribac sodium @50 ppm when compared to 4.34 g and 3.14g dry weights in inoculated control

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IRC/TM-3/PP-63

INFLUENCE OF ALTERED DATES OF SOWING ON DEVELOPMENT OF SHEATH BLIGHT AND BACTERIAL LEAF BLIGHT IN PADDY

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Rice yields are majorly limited by the development of diseases during different stages of crop growth. Disease manifestation is primarily influenced by prevailing weather conditions, crop growth stage and presence of virulent pathogen. It was often observed that temperature and rainfall pattern influence the severity of losses due to two major diseases of ricei. e, Sheath blight caused by *Rhizoctonia solani* and bacterial leaf blight caused by *Xanthomonas oyzae* pv. *oryzae* in the Godavari zone of Andhra Pradesh. Earlier studies indicate the importance of weather on development of diseases in rice (Amandeep Kaur *et al.*, 2015). Keeping in view and importance of weather on development of two most important diseases *viz*., sheath blight and BLB and lack of effective chemical management options against BLB, the present trial was undertaken to study the influence of different sowing dates on the development of diseases in paddy.

METHODOLOGY

The trial was conducted in sheath blight sick plots of Plant Pathology Section, Regional Agricultural Research Station, Maruteru during *kharif* 2020-21 to study the influence of dates of sowing on the development of major diseases prevalent in the Godavari zone i.e., sheath blight and BLB. Popular varieties *viz*., BPT 5204 (Samba mashuri) and MTU 7029 (Swarna) sown at three different dates viz., IV week of June (23/06/2020); II week of July (09/07/2020) and IV week of July (23/07/2020)were transplanted on 18/07/2020, 06/08/2020 and 04/09/2020 respectively for the study. Standard package of practices (ANGRAU) pertaining to Godavari zone were adopted during the trial. Data on sheath blight incidence (infected tillers x 100/total tillers) and severity and bacterial leaf blight incidence and severity (0=No incidence; 1=1-5% leaf area; 3=6-12%; 5=12-25%; 7=26-50%; 9=51-100%) were recorded and presented following SES, 2014.

RESULTS

Sheath blight

The selected varieties (BPT 5204 and MTU 7029) planted at different dates varied in their response to development of two major diseases (sheath blight and bacterial leaf blight). Early sown crop (June IV week) of MTU 7029 recorded 86.3% sheath blight incidence at 80 DAS in comparison to 25.5% recorded in BPT 5204. Whereas, late sown crop (July IV week) recorded low sheath blight incidence (7.0%) in BPT 5204 (crop at panicle emergence stage) in comparison to 100% sheath blight incidence at similar growth stage in crop sown one month earlier (June IV week). Sheath blight severity as measured by extent of spread at the end of crop growth was found to be more in early sown crop of BPT 5204 (67.5%) in comparison to late sown crop (6.2%), whereas 41.6% and 37.6% sheath blight severity respectively was recorded in *var*. MTU 7029. Data suggests that irrespective of the variety, late sown crop (July IV week) was more resistant to sheath blight development. The escape of var. BPT 5204 from sheath blight disease in the late sown crop could be attributed to resistance of the variety to sheath blight pathogen during early stages of crop growth coupled with lack of favourable weather conditions for development of sheath blight during later stages of crop growth.

Table : Effect of Variety x Date of sowing on development of sheath blight and bacterial leaf blight in paddy (*kharif* 2020-21)

Variety & Date of sowing	18.09.2020		08.10.2020		31.10.2020		20.11.2020	
			Sheath blight					
BPT-5204	I*	S*	I	S	I	S	I	S
IV week of June	25.5	15.4	44.4	25.8	100.0	58.1	100.0	67.5
II week of July	16.7	9.9	88.2	18.6	100.0	27.8	100.0	41.6
IV week of July	0.0	0.0	0.0	0.0	5.9	3.7	7.0	6.2
MTU-7029								
IV week of June	86.3	48.9	93.3	52.8	99.7	64.9	100.0	41.6
II week of July	41.0	20.0	94.7	41.3	100.0	47.2	100.0	50.0
IV week of July	0.0	0.0	0.0	0.0	37.4	26.8	40.7	37.6
				Bacterial leaf blight				
BPT-5204	I	Score	I	Score	I	Score	I	Score
IV week of June	0.0	0.0	68.3	6.6	78.3	6.6	82.6	8.5
II week of July	0.0	0.0	10.7	2.1	58.8	6.4	59.2	6.1
IV week of July	0.0	0.0	0.0	0.0	33.6	5.8	53.2	5.7
MTU-7029								
IV week of June	0.0	0.0	5.0	1.1	36.6	5.1	53.2	6.9
II week of July	0.0	0.0	0.0	0.0	18.9	3.3	23.5	4.2
IV week of July	0.0	0.0	0.0	0.0	7.8	1.6	17.8	3.4

* I = Disease Incidence; S= Disease Severity; Score = Disease severity values (SES, 2014)

Bacterial leaf blight (BLB)

In the location under study, weather conditions (periodic cyclonic rains during September-October) during the season were favourable for the development of bacterial leaf blight. At 90-100 DAS, BLB incidence of 5.0% was recorded in MTU 7029 in comparison to 68.3% in BPT 5204. Delay in sowing resulted in lower BLB incidence and severity in the varieties evaluated. In the variety BPT 5204, disease severity score of 8.5 was recorded in early sown crop in comparison to 6.1 score in crop sown during July II week. In the late sown MTU 7029, 17.8% tillers were infected in comparison to 53.2% tillers of BPT 5204. Severe incidence of BLB on resistant cv. MTU 7029 could be attributed to the highly favourable weather conditions or introduction of new *Xanthomonas oryzae* pv. *oryzae* pathotypes into the location under study.

CONCLUSION

In a study to evaluate the effect of dates of sowing (IV week of June, II week of July and IV week of July) in two most popular varieties viz., BPT 5204 (samba mashuri) and MTU 7029 (Swarna) on development of two diseases most prevalent in the Godavari zone of Andhra Pradesh i.e., sheath blight and bacterial leaf blight of paddy, delayed sowing of BPT 5204 resulted in lower sheath blight (7.0%) and BLB (53.2%) incidence. Favourable weather conditions during the year resulted in BLB incidence of 17.8% in the late sown MTU 7029. The influence of crop growth stage and weather parameters on development of diseases reemphasizes the need to explore options for sheath blight and BLB management through altered dates of sowing.

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Theme - III : Biotic-stress management in rice

IRC/TM-3/PP-64

TO STUDY THE EFFECTIVENESS OF SOME BOTANICAL INSECTICIDES FOR THE MANAGEMENT OF RICE STEM BORER *Scirpophaga incertulas* (Walker)

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Rice is major staple food crop in india but its yield is greatly affected by no. of insect pests. Rice stem borer, *Scirpophaga incertulas* (Walker) is the major devastator causing economic damage by producing characteristics symptoms of 'dead heart' and 'white ear'during vegetative and reproductive stages respectively (Satpathi *et al*. 2012). Yield loss due to stem borer varied from 11.2 to 40.1% due to dead heart and 27.6 to 71.7% due to white ears, respectively (Krishnaiah and Varma, 2012). Conventionally control of rice stem borer is generally done by uses of different insecticides but due to indiscriminate use of it, create problem like pesticide resistance, pest resurgence, environmental hazard, residual toxicity. Hence, Keeping these facts in view the present investigation was proposed to study effectiveness of some botanical insecticides for the management of rice stem borer *scirpophaga incertulas* (walker)

METHODOLOGY:

A field study was conducted at Regional Agril. Research Station, Karjat under AICRP during *Kharif* 2017 to study efficacy of different botanicals insecticides against rice stem borer. Karjat 3 variety was transplanted in plot size 2m X 2.5m with spacing 20cm X 15cm under. Total eight treatments were evaluated against stem borer under randomized block design. The observations were recorded at 30 Day and 50 Day after spraying. The observation was recorded by counting damage done by yellow rice stem borer i.e. dead hearts (DH) during vegetative stage and white ear heads (WEH) during panicle initiation stage, leaf folder and case worm damage were recorded on the basis of total no. of leaves and damage leaves. Pre-treatment observation was recorded 24 hrs before first spray. Commencing pest incidence on rice spraying was undertaken. The data thus obtained was subjected to appropriate transformation and analyzed statistically. The per cent damage was calculated by using following formula :-

$$\text{Per cent damage for Stem borer} = \frac{\text{No. of deadhearts/ White ear heads}}{\text{Total no. of tillers/panicle per hill}} \times 100$$

RESULTS:

The overall mean per cent result revealed that in case of dead hearts most effective treatment was treatment treatment T7 Rynaxypyr 20SG@ 200g/h was found most effective treatment for management of rice stem borer fallowed by treatment T6 Dinotefuran 20SG@ 200g/ha with 0.45% incidence .In case of botanicals the treatment T5 Neemazal@1000 ml/ha was found most effective treatment for management of rice stem borer fallowed by T2,T1,T4& T3. The In case of White ear head, treatment T7 Rynaxypyr 20SG@ 200g/ha was found effective with 0.28% incidence followed by treatment T6 Dinotefuran 20SG@ 200g/ha 0.45% incidence. All the remaining treatments were found significantly superior over untreated control.The maximum White ear head incidence was recorded in treatment T8 untreated control i.e. 2.99%. Rajpoot *et al*. (2020) reported that Neem azal @ 1.0 ml/l was found most effective against yellow stem borer of rice with lower dead heart 3.5% (30 DAT), 3.2% (50 DAT) and white ear 1.9 % followed by Lemon grass oil @ 1.0 ml/l with lower dead heart 6.2% (30 DAT), 5.3 %(50 DAT) and white ear 3.3% . Ganeshwari *et al*. (2018) reported that Rynaxypyr @ 0.3 ml/l was most effective with overall mean 12.17 percent dead heart and 18.38 percent white ear head.

CONCLUSION:

It can be concluded that treatment treatment T7 Rynaxypyr 20SG@ 200g/h was found most effective treatment for management of rice stem borer fallowed by treatment T6 Dinotefuran 20SG@ 200g/ha. Treatment T7 Rynaxypyr 20SG@ 200g/ha was found effective with 0.28% incidence for white ear head.In case of botanicals the treatment T5 Neemazal@1000 ml/ha was found most effective treatment for management of rice stem borer. Hence uses of botanical insecticides is an alternative approach to different harmful chemical to control the yellow stem borer incidence without harming the ecological niche.

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IRC/TM-3/PP-65

SCREENING OF RICE GENOTYPES FOR BROWN PLANTHOPPER (*NILAPARVATA LUGENS* STAL.) RESISTANCE

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Rice (*Oryza sativa* L.) is a staple food for more than half of the world's human population with a total harvested area in India of 44 m ha, with an annual production of 118 mt and productivity 4 t/ha. In Karnataka, rice is cultivated in command areas of Kaveri, Tungabhadra and Upper Krishna area of 1.45 m ha with an annual production of 3.6 m t and the productivity is about 2729 kg/ha (Anon, 2019). The rice productivity is constrained by numerous biotic and abiotic factors.Approximately 52 per cent of the total global rice production is lost annually owing to thedamage caused by biotic factors, of which nearly 21 per cent is attributed to the attack ofinsect pests. More than 100 species of insects are known to attack rice crop, where 20 are ofeconomic importance.

OBJECTIVE

Among the different insect pests of rice, the brown planthopper (BPH), *Nilaparvatalugens*(Stal.) (Homoptera: Delphacidae) has long been known a pest of rice in South Asia and South-east Asia. It is one of the most destructive monophagous insect pests, causing yield losses every year in rice. The mechanism of resistance found in host-plant interaction was known to be antibiosis. To avoid yield losses due to this pest identification of resistant genotypes for brown planthopper was carried out. For this phenotypic screening for assessing the levels of resistance to BPH for 28 promising rice genotypes was conducted at ARS, Gangavati.

METHODOLOGY

The 28 genotypes used for BPH screening included PTB-33 and TN-1 as resistant and susceptible checks. The experiment was carried out by Modified Seed-box Screening Test (MSST) developed by Velusamy*et al.*, (1986) in wire mesh cages. Seeds of each genotype were sown in rows in trays with border check genotype as susceptible check around the periphery of each tray. Manual release of BPH nymphs was done after 10 days after sowing. The wilting symptoms was observed and recorded at 30 DAS, 50DAS and 80 DAS using Standard Evaluation System (SES) by IRRI.

RESULTS

In the screening, the genotypes BA-13 and BA-19 had shown resistant scores, six genotypes showed moderate resistance (BA-03, BA-15, BA-20, BA-33, GNV1921, GNV1979) and eighteen genotypes (BA-04, BA-17, BA-28, BA-3, HR-01, HR-02, HR-03, HR-04, HR-13, HR-26, HR-30, GNV1914, GNV1918, GNV1937, GNV1938, GNV1971, GNV1972, GNV1978) had shown susceptible scores.

CONCLUSION

Among 28 genotypes only two genotypes (BA-13 and BA-19) were found resistant to BPH and can be used in further crop improvement.

Keywords: Rice, Modified Seedbox

Screening Technique, Brown planthopper, PTB-33, TN-1, Productivity, insect damage, SES, DAS, host plant resistance, Antibiosis.

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IRC/TM-3/PP-66

NEW RECORDS OF PARASITOIDS OF RICE LEAF FOLDER, *CNAPHALOCROSIS MEDINALIS*FROM CUTTACK

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Rice production is influenced by several yield limiting abiotic and biotic factors. Besides, intensification of agriculture has resulted in visible changes in the rice insect pest complex in Asia and many species that were considered as minor pests earlier, have now become major like paddy leaf folder , *Cnaphalocrosis medinalis* (Guenee) (Ahmed *et al*., 2010). Indiscriminate use of insecticides has led to several undesirable effects including development of insecticide resistance and mortality of natural enemies. Biological control is an important tool for sound IPM. Therefore the need for exploration of potential parasitoids for use in biological control.

OBJECTIVE

To explore the naturally occurring biological control agents of paddy leaf folder.

METHODOLOGY

Exporations were conducted in the rice fields of ICAR- National Rice Research Institute, Cuttack, Odisha to find native biological control agents especially parasitoids of paddy leaf folder*C.medinalis*. Infested larval stages were collected from the fields and brought to the laboratory for rearing. The infested larvaewasreared in glass tubes under laboratory conditions of 26.4± 2 ˚C and 43±5% RH. Daily observationswere taken and parasitoids were collected as and when they emerged.The parasitoids were identified based on morphological characters with available keys.Photography was done with the help of Leica Stereo Zoom Microscope M205 FA along with digital camera Leica DFC425 C.

RESULTS

A total of 10 species of parasitoids belonging to the following Hymenopteran families *viz*., Braconidae, Elasmidae, Chalcididae, Torymidae, Bethylidae, Eurytomide, Eulophidae and Ceraphronidae were found to be parasitizing various stages of the leaf folder.A total of 10 species were collected and identified out of which six species were recorded for the first time from Cuttack in Odisha viz.,*Elasmusclaripennis*, *Spathiushelle* ,*Hormius sp*. and *Braconunukii*were identified as larval parasitoids whereas *Brachymeriaeupoleae* and *Podagrioncalopeplum*as pupal parasitoids on paddy leaf folder. Four of the remaining parasitoids viz.,*Apantelesglomerata*, *Macrocentrus*sp., *Cardiochilesnigricollis*,*Myosoma chinensis* have been reported earlier by (Anonymous 1970-1980).Among the parasitoids *Apanteles glomerata* was the most dominant parasitoid (Fig.1).

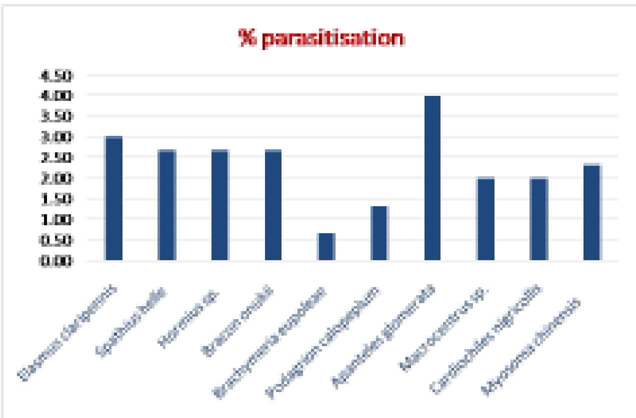

Fig 1. Percent Parasitisation of Leaf folder at NRRI, Cuttack

Over all 23.33% parasitisationwas recorded on the Leaf folder in the rabi crop 2019.

CONCLUSION

Parasitoids have the potential tocontrol paddy leaf folders in the field hence efforts should be directed towards their conservation for a better IPM approach in rice agro ecosystem.

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IRC/TM-3/PP-67

EFFECT OF ORGANIC PLANT PROTECTION MANAGEMENT ON MAJOR PEST IN RICE

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Rice (*Oryza sativa* L.) is one of the most important staple foods for the people of South East Asia including India.Around 40% of the world's population prefers rice as their major source of food and 1.6 billion people in Asia take rice as their mainstay food. Further, in many of the South East Asian countries, rice cultivation is an important source of livelihood for small and marginal farming households. It is estimated that global demand for rice is increasing day by day from 511 MT in 2020 to 536-551 MT in 2030. Securing sustainable rice production by protecting environment is one of the challenges in future.Indiscriminate use of chemicals breaks down the natural ecological balance by killing the beneficial and antagonistic soil microbes. Use of eco-friendly management practices may help in avoiding environmental pollution as well as save foreign currency used for importing costly chemicals from abroad. Use of bio-control agents, botanicals, plant extracts and chemical inducers is an ecofriendly measure in controlling pest and pathogens is relatively a new approach. It may be economically beneficial to our farmer, as well as, it may increase the production of rice.Keeping these in view the present research work was carried out with the objective to study the effect of various organic package of practices on major pest management in rice crop.

METHODOLOGY

The field experiment was conducted in model organic farm at "C Block farm" of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia during the period of *Kharif* 2013 and *Kharif* 2014, under New Alluvial Zone of West Bengal. The field is maintained as completely organic since 2007. The soil of the experimental field was Gangetic alluvium (Entisol) type with sandy clay loam in texture having good water holding capacity and moderate soil fertility status. The experiment was laid out in strip plot design with 24 numbers of treatment combinations replicated thrice, the treatment details includes N_1: Vermi compost @ 60 kg N equivalent ha^{-1} (Basal & Top dressing), N_2: Mustard cake @ 60 kg N equivalent ha^{-1} (Basal & Top dressing), N_3: Vermi compost @ 30 kg N equivalent ha^{-1} (Basal) + Mustard cake @ 30 kg N equivalent ha^{-1} (Top dressing), N_4: Sesbania green manure @ 20 kg N ha^{-1} + Vermicompost (Top dressing) @40 kg N ha^{-1} N_5: Sesbania green manure @ 20 kg N ha^{-1} + Mustard cake @ 40 kg N ha^{-1}(top dressing), N_6: Sesbania green manure @ 20 kg N ha^{-1} + Vermicompost @ 20 kg N ha^{-1}+ Mustard cake @ 20 kg N ha^{-1} and plant protection treatments includes P_1: Seed treatment with Brahmastra + Foliar spray with Brahmastra (at 15, 30, 45, 60, 75 DAT), P_2: Seed treatment with Brahmastra + *Trichoderma harzianum* application @ 130 kg ha^{-1}, P_3: P_1 + P_2 (Seed treatment with Brahmastra + Foliar spray with Brahmastra (at 15, 30, 45, 60, 75 DAT) + *Trichoderma harzianum* soil application @ 130 kg ha^{-1}) & P_4: Control. Brahmastra is a product preparing from various natural sources like Water, Cow dung, Cow urine, Neem leaves, Castor leaves, Calotropis leaves, Custard apple leaves, Pongamia leaves, Bitter gourd leaves and

Parthenium leaves. All these mentioned plant and animal products collected in a container mix it and boiled for 20 - 30 minutes time after that cool it and kept it for 30 days for fermentation. This was used as seed treatment and foliar spraying according to their respective treatment plots. Rice cultivar used in the experiment is IET 4786 (Shatabdi), recommended dose of fertilizer for rice was 60: 30: 30 kg N, P_20_5 and K_20 ha^{-1} respectively. Green manure was sown and incorporated in their respective plots at the time of puddling. Remaining organic nutrient sources *i.e*., mustard cake and vermicompost were divided in to two parts and applied as basal and top dressing in their respective plots according to treatment combination. The plant protection inputs *i.e., Trichodermaharzianum* mixed with soil as 1:40 ratio according to treatment, and applied in their respective plots after land preparation.

RESULTS

Leaf folder attack was observed during both the years of experimentation. By the pooled data of both the years the no. of leaf folder $hill^{-1}$ was significantly influenced by plant protection treatments measures, however organic nutrient treatments were not influenced significantly. The lowest number of leaf folderswas observed under the treatment P_1 (Seed treatment with Brahmastra + Foliar spray with Brahmastra) and it was statistically not comparable with P_3 (Seed treatment with Brahmastra + Foliar spray with Brahmastra + *Trichoderma harzianum* soil application @ 130 kg ha^{-1}) and the highest number of leaf folders were observed in control plot.This may be due the brahmasta containing different type of plant leaf extracts, the presence of some specific alkaloid compounds in the plant extract having biopesticidal potential to reduce the sucking insect population. This is because some biologically active organic ingredients derived from plants have pesticide and repellent properties used for the management of pest organisms was also observed by Asogwa*et al.* (2010). When nutrients are made available to crop plants in required quantities in balanced proportion these may aid formation of such substances that impacts resistance to disease-pathogens and insect-pest.Similar results were also found by Anand Prakash *et al*. (2008), who reported that direct spray applications of various extracts of biologically effective plant products like leaves, stem, roots and whole plants especially for the control of soft bodied insect pests, which feed on the leaves and tender plant parts as flowers and developing grains.

CONCLUSION

The number of leaf folder $hill^{-1}$ was influenced significantly by the organic plant protection management treatments only. The least number of leaf folder $hill^{-1}$ was recorded with combination of seed treatment and foliar spray with brahmastra and it was statistically at par with seed treatment and foliar spray with brahmastracoupled with *Trichoderma harzianum* soil application @ 130 kg ha^{-1}.

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THEME - IV

Rice for livelihood security, equity and profitability

BOON OF BINA DHAN 11 FOR YIELD AUGMENTATION IN FLOOD PRONE RICE ECOLOGY OF ODISHA

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Rice in Odisha makes up a major contribution (24.4%) to the total annual value of agriculture output to the extent of INR 75000 crore (State Agriculture Policy, 2019). Yet, the state records a low and stagnant rice productivity of just 1.5t/ha (Pathak et al., 2020) and it compares poorly with the national average and other major rice-producing states like Punjab (3.97t/ha), Tamil Nadu (3.92t/ha), and Andhra Pradesh (3.5 t/ha). Slow varietal replacement is a major reason for this productivity gap. Besides, this major staple in the state suffers a setback of submergence for a considerable period in the wet season as 1.15 million ha (31% of total rice area) is prone to recurrence of the flood that constraints harvesting an assured yield. Eventually, the strategic end of strengthening the state's food security through rice yield augmentation remains far from actualization.

Odisha State Seed Corporation (OSSC) through its dealers' network sells seeds of about fifty rice varieties every year. Additionally, farmers in Odisha grow several other traditional varieties suitable for a specific ecology or season but doesn't offer many varietal preferences. Moreover, three ruling varieties (Swarna, Pooja, MTU1001) in the state are more than 20 years old now and developed susceptibility to many biotic stresses. Thus there exists a reported dearth of varieties for better productivity, flood tolerance, seasonal adaptability, and preferred grain size, and grain quality.

BINAdhan 11 (Ciherang-Sub 1, IR09F436) - a newly bred high yielding and submergence tolerant variety was field evaluated in Odisha from 2017 to 2019 by IRRI with support from state government. Subsequently, a longitudinal study was undertaken with the following objectives of (a) estimating yield superiority of BINA dhan 11 over major traditional varieties across different rice ecologies, (b) field-validation of submergence tolerance trait of BINA dhan 11 in flood-prone rice tract, (c) comprehending farmers' perceptions and adoption decision about this variety and (d) mapping the diffusion rate of BINA dhan 11, as reflected through seed sale increase of state seed corporation

METHODOLOGY

The study evaluated BINA dhan 11 in both wet and dry season from 2017 to 2019. Head to Head demonstration-a unique on-farm trial was deployed with selected farmers who were provided Minikits of this variety and this was grown adjacent to their traditional variety under the same management practices. Since management of both BINA Dhan 11 and adjacent (traditional) variety remains same; any differential gain observed can be attributed to the variety exclusively. During the wet season, 18 districts proportionally represented medium land (12) and shallow low (6) were selected. From each district, three blocks were included in the demonstration plan, thus 54 blocks (17% of all blocks) made up the experimental site. Ten farmers from each of these blocks were randomly selected to constitute 540 units for the experiment.

The same framework was followed for the evaluation in the irrigated crops during *rabi* season. Since only 10% of the total rice area is sown this season, hence the experiment was limited to 24 blocks of 8 districts comprising 120 farmers. 15 from each block were sampled for study for same period of 2017 to 2019.

For assessing submergence tolerance trait, varietal performance from reported submerged experiment plots was evaluated. Further, participating farmers were interviewed to understand if this variety fits into their requirement and their adoption decision. To estimate the demand increase of this variety-indicative of adoption and diffusion-OSSC seed sale data of the last three years were analysed and interpreted.

RESULTS

An impressive yield gain of 0.5 t/ha is recorded over popularly grown varieties which are older than the standard norm of 10 years. Also, BINA dhan 11 averted yield penalty in submergence condition as observed from farmers' fields in experimental districts. In respect of farmers' preferences about the variety, 69% of farmers who took part in trials in the first year, have adopted BINA dhan 11 in 2019, establishing better adaptability and adoption of the variety. OSSC has registered 278% CAGR in seed sale for BINA dhan 11 between 2017-2019 and this upswing concludes the superiority of BINAdhan 11 and its acceptance amongst farmers.

CONCLUSION

The assured higher yield vis-à-vis other prominent varieties, is an impactful trigger for farmers to test and adopt this variety. Besides, BINAdhan 11 being a medium duration variety and suitable in medium, shallow lowland, and irrigated ecosystems, can strategically find its place in the cropping pattern of Odisha. Institutional support and planning will be crucial for this varietal advancement. In addition to higher yield, BINA dhan 11 shields farmers substantially from yield loss when the crop is submerged for a certain period. Deployment of this variety can step up farmers' (small and marginal farmers in particular) resilience to this weather shock. Since the initial trend showcased the popularity of this variety, a further coordinated fillip will trigger its spread for the benefits of farmers.

The state of Odisha relies on other states for a significant portion of its pulse requirement. One of the feasible options, advocated by the scientific community is to introduce more pulse crops after rice of shorter duration. BINA dhan 11 with its ideal duration contributes to this strategic approach of boosting pulse production by a sustainably intensifying cropping pattern.

Given the suitability and host of advantages of BINAdhan 11, the seed system should further stimulate the promotion and diffusion of this variety for larger uptake.

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IRC/TM-4/OP-2

SUSTAINABILITY OF RICE CULTIVATION IN INDIA

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Rice is the most widely consumed staple food for a large part of the world's human population. Nearly 90% of the world's rice is produced and consumed in Asia (Van Nguyen & Ferrero, 2006). The crop occupies largest area in India followed by China and Indonesia, whereas China has the highest production, but Australia has the highest productivity. It is the agricultural commodity with the third-highest worldwide production, after sugarcane and maize, according to (FAOSTAT, 2018).

India achieved self-sufficiency in rice since green revolution. Nevertheless, India still ranks low in productivity despite being the highest in production. World-wide efficiencies in operations in production cycles have a high correlation with productivity. The major gaps in productivity in India has been inefficiencies during operations in the production cycle. It requires high energy input particularly for seed bed preparation, transplanting, spraying, irrigation and harvesting. It undergoes tremendous wastage in terms of water loss and inputs because of holding on to the age-old practice of cultivation. Current scenario requires maximum output in minimum expense and "sustainability…… in rice" is a pursuit to achieve the excellence in the same with help of progressive farmers as pioneers.

Demand for agricultural commodities is linked to their requirement as final human consumption and intermediate consumption in the supply chain in addition to their requirement as seed and feed for animal consumption. The National Sample Survey (NSS) data pertaining to consumption of food grains shows that in rural areas, rice consumption dominates the food basket, consuming on an average 6 kg per individual per month. In urban areas, milk and rice dominates the food basket. Assuming a static behaviour in household consumption, i.e., tastes and preferences remain constant with the rise in income an increase in projected population to 1.5 billion by 2030, demand for rice is expected to increase to 9 billion kg. In addition to direct demand for household consumption, there is demand of food grains for seed, feed and industrial uses and also some wastages in the process of harvesting, collection.

With the growing demand for rice, both at the global and national level, the required rice production in India by 2030 is estimated to be 138 million tonnes. This implies rice production need to grow by 17% from the current level of 118 million tonnes in 2020 to reach 138 million tonnes by 2030. With the current level of productivity, total area under rice would be 52 million hectares covering almost 38% of the total cropped land. The requirement of land under rice can be a major constraint to the growing need for crop diversification for both economic securities of the farmers and nutritional security for the larger population. Therefore, there is a strong need to increase rice production by enhancing productivity levels of rice without area expansion.

Further, rice is highly labour-intensive crop which has led to high operational cost of cultivation. Thus, the need to reduce costs of farming and arrest the decline of soil fertility has been an endeavour in Rice based farming systems of India. Among the various rice establishment systems, puddled transplanted Rice (PTR), Direct Seeded Rice and System of Rice Intensification (SRI) are being practiced mostly in India.

Out of these PTR occupies more than 90% of the area under rice and gains popularity amongst farmers because of higher yield and lesser weed infestations. Scientifically, it is found that organic matter increases in flooded fields along with making certain nutrients available like Fe and Zn more available in flooded conditions. Also, well managed irrigated rice ecosystems are masterpieces of ecological vitality and sustained productivity.

METHODOLOGY

With an objective to identify the factors impacting sustainability of PTR, an effort was made to collect data from a representative set of farmers on operations, its expenses and challenges from 6 different locations in 3 states, viz. Mohania and Kaimur in Bihar, Deverkonda and Miryalguda in Telangana, E Soos, Hoshiarpur in Punjab.

The various operations performed are categorised as dry land preparation, wet land preparation, nursery management, transplanting, spraying, irrigation, fertilisation, crop care, harvesting and post harvesting. Out of all these operations the most expensive is transplanting, followed by wet land preparation and harvesting for all three locations. The most challenging operation was transplanting followed by spraying in terms of labour availability and monitoring.

Adoption of new farming practices is key to the shift towards sustainable rice farming. In this paper, we have identified the key factors that impact the inefficiencies in the operations of production. The theoretical grounding of the approach is based on stochastic production frontiers as defined in Aigner, Lovell and Schmidt, 1977.

Stochastic frontier analysis is based on the standard production function approach, which relates the quantity of output of a given farm 'i'(q_i), to the quantity of inputs used (x_i) through the production technology f (.) The study is based on farm level data collected from about 552 rice producing households. Stochastic frontier analysis is used to measure the effects of farm input expenditure and technology on the value of rice production.

$$q_1=(fx_i).exp(v_i-u_i)$$

The inclusion of a random error term (v_i-u_i), takes into account the random shocks which may lead to differences between the observed production and the theoretical output based on production technology.

Within this framework, the measure of technical efficiency is the ratio between the output assuming technical efficiency and the technically inefficient output.

$$IE_1 = (fx_i).exp(v_i)/(fx_i).exp(v_i-u_i)=exp(u_i)....$$

On the modelling of inefficiency term, it is assumed that inefficiency is a linear function of a set of explanatory factors (Z_i), such as agro -climatic conditions, input management, etc, and individual characteristics related to farm workers, such as, education, age which may influence the farm operations.

$$log(q_i)=log\ (fx_i)-g(z_i)+v_i.....$$

Where,

$f(x_i)$ is the production function

$g\ (z_i)$ – set of factors assumed to explain inefficiency

The relationship is estimated using standard single equation technique, i.e., Least Squares Estimation

RESULTS

Preliminary statistical tests based on likelihood ratios show that the value of production is impacted by the inefficiencies in production system. Mechanisation in farm operations can significantly reduce inefficiencies in production system. Transplanting is highly labour-intensive farm operation. Usage of rice-transplanters can reduce inefficiency by 12%. Similarly, introduction of machines in the harvesting stage will be key to improving productivity and returns. Again, surface irrigation system which is highly labour intensive is likely

Table 1.Inefficiency models for paddy cultivation

Dependent Variable = logarithm of value of output of rice		
Variable	Coefficient	Significance level
Translog production function log f (.)		
Fertilizer	0.16	***
Labour	-0.05	**
Technical inefficiency model		
Use of chemical fertilizers	-0.14	***
Transplanting by machines	-0.22	***
Harvesting by machines	-0.12	***
Surface irrigation systems	0.02	**
Age: <40 yes	-0.05	*
Education: above matriculate	-0.03	*
Institutional cdit	-0.99	**
Extension services	-0.69	**
Small size farm	0.22	***

Source: Author's own estimates

to increase inefficiency in production. Drip/ Sprinkler irrigation can play a significant role in improving the production efficiency. Apart from production techniques, other key factors associated with inefficiency include – age of the farmer, education level, availability of credit and extension services.

CONCLUSION

The analysis identifies multiple factors impacting the adoption of new age farming practices. These include, land holding size, credit availability, extension services availability and age. Age of the farmer is likely to have positive or negative effect on the size of inefficiency. The older farmers are likely to be more conservative in adopting the new techniques and practice in farming, thereby having more inefficiency; on the contrary the older farmers have more farming experiences, so they use the resources efficiently at their disposal. Education have a strong negative impact on inefficiency. it is expected that greater years of formal education will reduce inefficiency. Similarly, the access to institutional credit and extension contacts are expected to have negative impact on inefficiency.

However, the most significant factor that can reduce inefficiency in the production process is the introduction of machines at every stages of production. This requires initial capital investment and extension services to equip the farmers to use machines effectively.

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IMPACT OF RICE VARIETAL IMPROVEMENT RESEARCH IN DIFFERENT STATES OF INDIA

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Research managers, policymakers and donors are interested in knowing the outcomes and impacts of investments in agricultural research (Renkow and Byerlee, 2010). Agricultural research investments yield different types of outputs and only a few of them are adopted by the farmers. In crop research institutes and agricultural universities, the development of crop varieties is one of the major research outputs. The adoption of a variety by farmers is a necessary condition to have an impact of research. Therefore, the estimation of area under different modern varieties (MVs) provides the intensity of adoption and impact of research. The estimation of area under different varieties not only helps to compute returns to research investments but also aids in selecting parents from among the popular cultivars to transfer desirable traits to the new generation of varieties in varietal improvement programs. This paper aims to estimate the area under popular rice varieties in different states of India.

METHODOLOGY

The paper usedcertified seed distribution, MV area coverage and other information that was collected from 27 states and one union territory (UT). These states and UT accounted for 99.4% of the total rice area of India. The certified seed distribution method developed by Samal and Behura (2019) was used to compute the area under different MVs in each state. The states were divided into two categories viz. major rice-growing states (area coverage > 1 million ha) and minor rice-growing states (area coverage < 1million ha) and analysis carried out. Varieties released up to 2013 were considered for area estimation in this paper and the area estimates obtained were for the year 2014-15.

RESULTS AND DISCUSSION

The coverage of MVs in the study states was 39.5 million ha (Mha) by 2014-15, which was computed to be 91%. On average, about 705 thousand tonnes of certified seeds per year were distributed to farmers in the study states and UT. The number of varieties released for general cultivation by state and central varieties release committee up to 2013 was 1006. Out of that 354 varieties were found in the seed chain. Estimation of the area at the country level revealed that 235 varieties covered more than 5000 ha each. Among these 235 varieties, ninety-six varieties occupied more than 50,000 ha each. MTU-7029 topped the list covering about 5 Mha, which was computed to be 11.4% of the total rice area. The other prominent varieties that covered more than 500 thousand ha in the country were, MTU-1010, BPT-5204, MTU-1001, IR-64, Ranjeet, Pusa Basmati - 1121, Sarjoo-52, NDR-359, Lalat, Pusa-44, Pooja, Shatabdi and IR-36 and accounted for 7.1, 5.5, 5.3, 3.0, 2.5, 2.1, 1.8, 1.6, 1.6, 1.6, 1.5, 1.4 and 1.2 percent of total rice area, respectively. The adaptability of varieties to different states revealed that seven varieties covered ten or more states and seventeen varieties covered five to nine states. IR-64 had covered the maximum number of states (17) followed by Swarna (14), MTU-1010 (14), BPT-5204 (12), MTU-1001 (11), IR-36 (11) and Swarna Sub-1 (10). Older varieties like Jaya and Mahsuri was popular in 9 and 7 states, respectively.

State-wise, the top ten varieties of the major rice-growing states and the top five varieties of minor rice-growing states were identified. Comparison in 14 major rice-growing states revealed that MTU-7029 occupied the first rank in four eastern states (Bihar, Jharkhand, Odisha, and West Bengal) and second rank in two states (Chhattisgarh and Madhya Pradesh). MTU-1010 occupied the first position in Chhattisgarh and second position in Andhra Pradesh and Maharashtra. BPT-5204, Ranjeet, Pusa Basmati-1121, MTU-1001, Indrayani, IR-64, Pusa-44, ADT-45, and Sarjoo-52 were the first rank varieties in the states of Andhra Pradesh, Assam, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Punjab, Tamil Nadu and Uttar Pradesh, respectively. Varieties like NDR-359, Pooja, Shatabdi, Pusa Basmati-1121 and Rajendra Mahsuri-1 occupied the second rank in the states of Uttar Pradesh, Odisha, West Bengal, Punjab and Bihar, respectively and covered sizeable area. The older varieties like IR-64, IR-36, Jaya and Mahsuri also occupied some rank or the other in different states. Varieties of PR series, Pusa-44, and basmati varieties were popular in northern states. The analysis also revealed that the top five varieties accounted for 41 to 86 percent and the top ten varieties accounted for 56 to 95 percent of total MV area in different states. This implies that some states cultivated few MVs while in some states more varietal diversification was there. Prominent among the states where varietal concentration was more were Andhra Pradesh, Assam, Odisha, Punjab, and Tamil Nadu. The states where varietal diversification was more were Maharashtra, Madhya Pradesh and Uttar Pradesh.

The top five varieties of minor rice-growing states were also identified. They accounted for 54 to 99 percent of the total MV area in different states. Varietal concentration was more in the states of Arunachal Pradesh, Goa, Himachal Pradesh, Jammu and Kashmir, Kerala, Manipur, Meghalaya, Nagaland and Tripura where the top five varieties accounted for 90 or more percent of total MV area. The varietal concentration was least in Gujarat, where the profile of varieties was much more than other minor states. Hill states like Himachal Pradesh and Jammu and Kashmir adopted a different set of varieties than other states. Gurjari was the single most dominant variety in Gujarat while MTU-7029 was found most popular in Tripura. IR-36, Jyothi, HPR-1068, Jhelum, Uma, IR-64, Arize-6444, IR-64, Ranjeet, Improved White Ponni, Pusa Basmati-1121, MTU-7029 and PR-113 was the first rank variety in the states of Arunachal Pradesh, Goa, Himachal Pradesh, Jammu and Kashmir, Kerala Manipur, Meghalaya, Mizoram, Nagaland, Puducherry, Rajasthan and Uttarakhand, respectively. Older verities like Jaya, Mahsuri and IR-36 were popular among farmers and occupied some rank or the other in these states.

CONCLUSIONS

The impact of rice research in terms of area coverage under MVs in different states of Indiawas estimated. The information generated will help in selecting parents for the development of superior varieties as well as computing returns to research investments in rice research by various institutions in the country.

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EVALUATION OF SCIENTIFIC PRODUCTION PACKAGE VS. FARMERS' PRACTICES IN RICE FARMING

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Adoption of scientific management practices are the key to boost rice production on a profitable basis. However, its implementation at farmers' level is inadequate, mainly due to the unawareness of the options available, limited resources and economic feasibility. In order to circumvent this situation, the improved options confirmed from various research investigations and approved for field adoption have to be compared with the prevalent practices adopted by farmers of the locality through demonstration in a large area. Accordingly, the package of scientific crop production technologies on soil amelioration, nutrient management, planting methods and weed control strategy were selected for evaluation in comparison with farmers' practices of the locality.

METHODOLOGY

Large area demonstration plots were laid out in the paddy fields of Regional Agricultural Research Station, Pattambi during *rabi* season of 2019-20 for comparison between the two packages. The two sets of packages included improved crop production practices as well as farmers' practices of the locality. Two blocks of 1 ha each were used for demonstration of the two packages with transplanted crop of Kanchana, a local popular high yielding variety.

Improved practices involved lime application @ 600 kg/ha in two splits (first dose of 350 kg/ha as basal and second dose @ 250 kg/ha as topdressing at one month after transplanting), recommended nutrient dose of 70:35:35 kg NPK /ha (Full P as basal application of Rajphos; N as urea in two split doses of 2/3 as basal, 1/3 at panicle initiation stage; K as Muriate of Potash in two equal splits as basal and at panicle initiation stage); improved planting method viz. paired row planting with 40 hills per m^2 (plant to plant distance: 10 cm; row to row distance: 15 cm; distance between paired row: 35 cm); weed management through application of pre emergence herbicide, Sathi 10 WP (Pyrazosulfuronethyl) @ 300 g/ha at 6 days after transplanting followed by cono-weeding at one month after transplanting.

Farmers practices involved single application of lime @ 130 kg/ha as basal; basal application of Factamfos @ 125 kg/ha; random planting with an average of 30 hills per m^2; top-dressing of Urea and Muriate of Potash @ 50 kg/ha and 37 kg/ha, respectively at 30 days after transplanting; hand weeding at one month after transplanting.

Each block was divided into fiveequal sized unitsand observations on weed population, weed dry weight, yield and yield attributes were recorded and the data were subjected to statistical analysis. Benefit-cost analysis of the two practices were also worked out.

RESULTS

The data on grain and straw yield, panicle observations and weed parametersunder the two management practices are given in Table 1. Results showed that adoption of improved package resulted in grain yield of 7.05 t/ha, which was significantly higher than the yield realised through adoption of farmers' practices (6.38 t/ha). Straw yield, panicles per m^2 and panicle weight also showed higher values in the improved package. The increased yield can be attributed to higher number of plant hills (40 per m^2) through adoption of paired row planting along with other scientific management practices viz. liming and

Table 1. Effect of management practices on grain and straw yield, panicle observations and weed parameters

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Panicle number / m²	Panicle weight / m² (g)	Weed population at 30 DAT	Weed population at 60 DAT	Weed biomass at 30 DAT	Weed biomass at 60 DAT
Improved package	7.05	4.73	391	845	37.4	17.8	21.2	12.8
Farmers' practices	6.38	4.51	359	741	70.0	41.4	39.4	16.6
C.D.	0.58	N/A	N/A	100.99	N/A	7.99	N/A	N/A
SE(m)	0.14	0.36	12.08	25.05	8.88	1.98	6.75	2.62
SE(d)	0.20	0.51	17.09	35.43	12.55	2.80	9.55	3.71
C.V	4.81	17.45	7.20	7.07	36.96	14.98	49.85	39.87

NPK application in adequate quantity and appropriate splits which ensures adequate nutrition at critical growth stages of the crop as well as cono-weeding which improves soil aeration and enhanced root growth of rice. Mahajan et al. (2014) has reported superiority of paired row planting in rice owing to the border effect through better sunlight infiltration.

Observations also showed that weed population and weed biomass at all stages of crop growth was low in plots receiving improved agronomic practices. The population was significantly low at 60 DAT (17.8 per m^2), whereas in plots of farmers' practice it was 41.4 per m^2. The predominant weed species were *Isachnemiliaceae*, *Cyprus iria*, *Fimbristylismiliacea*, *Monochoriavaginalis* and *Sphenocleazeylanica*. Hand weeding is becoming tougher and expensive because of labour scarcity and increased wage rates. Paired row planting itself facilitates weed suppression by maintaining rice plant's dominant position over weeds through modification in canopy structure; Apart from herbicide, cono-weeding also contributes much to weed control as well as yield increase. The planting method of paired row planting facilitates cono-weeding which ensures that the weeds incorporated become manure for the existing crop. Verma et al. (2017) has reported that cono-weeding combined with pre emergence herbicides, increases weed control efficiency to a considerable extent and yield of direct seeded rice increases.

The net returns through adoption of improved package was Rs.1,05,215/- per ha whereas from farmers' practice it was Rs. 89267/- per ha and the benefit: cost ratio was 1.95 and 1.83, respectively under the two practices.

CONCLUSION

Adoption of scientific crop production practices helps to improve yield and can help to achieve the goal of sustainable rice production on a profitable basis. These technologies have to be popularised among farmers and the constraints in adoption have to be documented and carried forward for further refinement.

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AROMATIC RICEOF WEST BENGAL: VARIETY REGISTRATION, VALUE-CHAIN, GEOGRAPHICAL INDICATION AND EXPORT ISSUES

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The diversity and traditional cultivation of non-Basmati aromatic rice in Bengal have been documented in ancient *punthi*, district gazetteers, books, etc. Among these, some small-grained scented rice (Gobindabhog, Radhunipagal and Badshabhog) of South Bengal and a few medium-grained ones (Tulaipanji, Kataribhog and Kalonunia) of North Bengalare popular in domestic market for their excellent quality features and different end-uses. The farmers grow these aromatic rice landraces in their native areas mainly for their own use and small-scale marketing. The non-remunerative nature of cultivation due to inconsistent output prices, lack of market study, inadequate approach for fine-tuning in processing, packaging, labeling and pricing indicate that there is no integrated and long-term effort for 'Bengal Aromatic Rice' to link up all the stakeholders in production-to-consumption system.

METHODOLOGY

With a view to develop value-chain systems of premium aromatic rices of West Bengal, a multi-Institutional RKVY Project on 'Bengal Aromatic Rice' was started since 2009 involving farmers' groups in native regions. The morphological and related characteristics of traditional aromatic rice varieties were determined following 'DUS Test Guidelines for Rice' of Protection of Plant Varieties and Farmers Rights Act, Government of India (PPV&FRA, 2007). The RKVY Project started seed production of small and medium-grained aromatic rice of South Bengal in 'C' Block Farm, BCKV, Kalyani, Nadia, West Bengal during*kharif* season since 2009 and the testing of seed quality was done at State Seed Testing Laboratory, Government of West Bengal, Tollygunge, Kolkata.Grain quality parameters like millimg recovery, kernel size and shape, amylose and protein content, and aroma were determined following standard procedures at Aromatic Rice Laboratory, Department of Agronomy, BCKV, West Bengal.

RESEARCH-BASED STRATEGIC ACTIVITIES

Farmers' variety registration under PPV&FR Act, 2001

With the advent of World Trade Organization (WTO) and India becoming a member of it, the RKVY Project on 'Bengal Aromatic Rice' of BCKV took initiatives and extended technical guidance to different farmers' organizations of the native areas for registration of traditional scented rice varieties of West Bengal under 'Protection of Plant Varieties and Farmers' Rights Act, 2001'. Gobindabhog (233 of 2014) has been registered as a farmers' variety, while four other varieties (Radhatilak,Lal Badshabhog,Harinakhuri and Radhunipagal) are in the process of registration.

Technology-supported group-cultivation and value-chain

More than 5,600 farmers of about 70 farmers' organizations cultivated eight non-Basmati aromatic rice varieties (Gobindabhog, Radhatilak, Lal Badshabhog, Radhunipagal, Harinakhuri, Tulaipanji, Kataribhog and Kalonunia) in about 40 blocks of 15 districts in West Bengal under technical supervision of the RKVY Project on 'Bengal Aromatic Rice' of BCKV and UBKV during 2013-2016 (Table 1).

Table 1. Technology-supported group cultivation and development of value-chains of aromatic rice under State Agricultural Universities of West Bengal

Aromatic Rice	University	Number of Farmers				Packet of Product	Date of Release
		2013	2014	2015	2016		
Gobindabhog	BCKV	1124	533	722	556	Milled rice	27 May, 2010
Radhatilak	BCKV	47	81	97	148	Milled rice	28 February, 2015
Lal Badshabhog	BCKV	-	7	35	56	Milled rice	15 December, 2015
Radhunipagal	BCKV	-	10	51	71	Milled rice	20 January, 2017
Harinakhuri	BCKV	-	-	62	27	Milled rice	12 January, 2018
Tulaipanji	UBKV	693	-	175	280	Milled rice	
Kataribhog	UBKV	148	84	120	185	Milled rice	
Kalonunia	UBKV	78	-	70	152	Milled rice	

Gobindabhog (8 districts), Radhatilak (4 districts), Lal Badshabhog (2 districts), Radhunipagal (2 districts), Harinakhuri (1 district), Tulaipanji (2 districts), Kataribhog (3 districts) and Kalonunia (2 districts)

With such technology-supported group cultivation during last 10 years, BCKV has developed model value-chains for these premium aromatic rices, which need active support and cooperation from the Government,agro-based companies, farmers' organizations, etc. for long-term sustainability.

Enrollment of farmers' organizations under State Marketing Agencies

A total of 90farmers' organizations associated with RKVY Project of both BCKV and UBKV have already been enrolled under Paschimbanga Agri. Marketing Corporation Limited (PAMCL) and Sufal Bangla under Department of Agricultural Matrketing, Government of West Bengal during 2015-2017 for supply of aromatic rice (Table 2). The farmers' groups have already developed the value-chain systems at their levels with great hope and economic sustainability in future.

Organic aromatic rice

Organic Bengal Aromatic Rice-based Cropping System (BCKV-BARCS) has been developed in 6 Farms (1 University farm and 5 farms/ farmer's fields) in 2 districts (Nadia and PurbaBurdwan) in South Bengalalong with Paddy Processing Centre, BCKV, since 2010 under National Programme for Organic Production (NPOP). The RKVY Project developed the packets of 'certified organic' aromatic paddy seeds of 3 varieties (Gobindabhog, Radhatilak and Radhunipagal) during 2017, and milled rice packets of these 3 varieties having 'India Organic' logo during 2018 and 2019, which need to be promoted for commercialization.

Geographical indication

The Geographical Indication (GI) of goods reveals an indication, which identifies the agricultural

Table 2. Farmers' organizations enrolled under State Marketing Agencies for supply of aromatic rice

Government Organization	Aromatic Rice	No. of Farmers' Organization	No. of Districts	Year of Enrollment
PAMCL	Gobindabhog and Radhatilak	17	5	2015
	Tulaipanji	27	1	2015
Sufal Bangla	Gobindabhog, Radhatilak, Radhunipagal, Lal Badshabhog and Harinakhuri	25	7	2016 and2017
	Tulaipanji, Kataribhog and Kalonunia	21	8	2016

Table 3. Geographical indication of aromatic rice of West Bengal

Aromatic Rice	Geographical Area	Applicant / Authorized User	Present Status
Gobindabhog	South Bengal	SAMETI, Government of West Bengal and Bidhan Chandra Krishi Viswavidyalaya	Registered (531/2017)
Tulaipanji	North Bengal	SAMETI, Government of West Bengal and Uttar Banga Krishi Viswavidyalaya	Registered (530/2017)

goods as produced in the native region of a country, where a given quality, reputation or other characteristics of such goods essentially attributable to its geographical origin. The Patent Information Centre (PIC), Government of West Bengal prepared the technical and legal documents on Gobindabhog and Tulaipanji rice based on the Status Papers and Logos provided by BCKV and relevant information from Rice Research Station (RRS), Department of Agriculture, Government of West Bengal, and subsequently submitted to the Intellectual Property Office, Government of India during July, 2015. With completion of necessary official and technical formalities, both Gobindabhog (South Bengal) and Tulaipanji rice (North Bengal) have been registered under 'The Geographical Indication of Goods (Registration and Protection) Act during October, 2017 (Table 3).

Export issues

With response to a public notice issued by Rajya Sabha, the BCKV prepared and submitted a Proposal on 'Promotional Strategy for Export of Bengal Aromatic Rice (Gobindabhog and Tulaipanji)', during October, 2010.The Standing Committee on Commerce of Parliamentof India finalized 98th Report on 'Export of Foodgrains–Premium Non-Basmati Rice & Wheat.', wherein Gobindabhog and Tulaipanji rice of West Bengal were identified and recommended for export. The Report was accepted in the Rajya Shabha on 11 August, 2011 for future export promotional activities (BCKV, 2011).

CONCLUSION

With comprehensive research-based extension activities on traditional non-Basmati aromatic rice varieties during last 10 years, farmers' variety registration and geographical indication (GI)tagginghave been done for two premium varieties (Gobindabhog and Tulaipanji), and model value-chains have been developed with the involvement of farmers' organizations in native districts.

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IRC/TM-4/OP-6

IS RICE FARMING PROFITABLE? A FARM-LEVEL APPRAISAL FROM EASTERN INDIAN STATES

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Rice is the major staple food crop, feeds about 65% of Indian population and remains the major source of living for about 58% of the households. Among the food grain crops, rice is most important in terms of area coverage (35%) and contribution to total food grains production (41%). The production has grown steadily in recent years from increasing productivity due to high yielding varieties, better agronomic methods, and increase in irrigated area. However, India's overall rice yields (2.46t ha^{-1}during 2018-19; DES, 2020) are still much below than the world average (4.07 t ha^{-1}) (Statista, 2020). Low productivity coupled with increasing input prices results eroding the profit margin in rice cultivation and making the enterprise as unattractive (Samal et al., 2018). State wise data for the year 2018-19 indicates the typical concentration of rice cultivation in the eastern and southern Indian states (DES, 2020). Also, the eastern states, though accounts for the greater area and production but with the lowest average yield (Yadav et al., 2017). Therefore, increase in production, productivity and profitability of rice is a major concern to the policy makers and other stakeholders in the development process in this region. Against this backdrop, we have collected field level data and estimated cost of rice cultivation across eastern Indian states, to aid appropriate policies for boosting rice productivity and profitability in eastern region.

METHODOLOGY

Data on entire rice cultivation practices were collected from 30 farmers each from predominantly rice growing states of eastern region comprising Bihar, Chhattisgarh, Jharkhand, Odisha and West Bengal during the cropping season of 2018-19 and 2019-20. Based on primary data collected from farmers, both fixed and operational expenses associated in rice cultivation were estimated.Operational expenses are the expenditure on recurring inputs that are used up during the cultivation, whichcomprises expenditures on material inputs like seeds, fertilizers, micro-nutrients, manure, plant protection chemicals, etc., human labour – both hired and owned, machine labour for various farm operations, etc. Fixed costs refers the value of services from capital assets, which are fixed in nature and not related to the quantity of output, which includes rent, interest, depreciation, etc.Costs of cultivation were also estimated using other cost concepts(Raju and Rao, 1990) that are widely adopted in farm management research (Nirmala and Muthuraman, 2009; Pushpa et al., 2017; Agarwal et al., 2018). The concepts used were: (i) Cost A_1= All recurring expenses incurred to procure the material inputs and expenditure on hired labour, all types of machine labour and including land revenue, depreciation and interest on operational expenses, (ii) Cost A_2= Cost A_1 + land (leased in) rent paid, (iii) Cost B_1= Cost A_2 + interest on value of permanent assets, (iv) Cost B_2= Cost B_1 + imputed rent of owned land, (v) Cost C_1= Cost B_1 + imputed value of ownedlabour, (vi) Cost C_2=Cost B_2 + imputed value of owned labour, and (vii) Cost C_3= Cost C_2 + 10 per cent of cost C_2 to account for managerial input of the farmer. Likewise, income concepts used were as: (i) Gross return = Total value of the produce (main product and by product), (ii) Net income = Gross return - Cost C_3, (iii) Managerial income = Gross return - Cost C_3, (iv) Family labour income = Gross return – Cost B_2, and (v) Farm business income = Gross return – Cost A_2.

Table 1.Extent (rupees per hectare) and share (per cent) of various categories of costs in total cost of cultivation of rice

Particulars	Bihar	Chhattisgarh	Jharkhand	Odisha	West Bengal
Material costs	9392 (15.11)	8096(14.71)	8521(16.16)	10060 (15.58)	14221 (18.23)
Human labour	16440 (26.44)	10700(19.45)	23016 (43.64)	27758 (42.99)	25208 (32.32)
Machine labour	9280 (14.93)	7008 (12.74)	9479 (17.97)	7683 (11.90)	11667(14.96)
Total variable costs	35112 (56.48)	25804 (46.90)	41016 (77.77)	45501 (70.48)	51096 (65.50)
Fixed costs	27060 (43.52)	29217(53.10)	11727 (22.23)	19062 (29.52)	26908 (34.50)
Total cost	62172 (100.00)	55021 (100.00)	52743 (100.00)	64563 (100.00)	78004 (100.00)

Note: Figures in parenthesis indicates percent of total cost

RESULTS

The various categories of expenditure incurred in cultivation of rice are presented in Table1. Material costs included the expenses incurred on inputs like seeds, fertilizer, manure, micro-nutrients, plant protection chemicals and this categories of costs accounted for 14 to 18% of total costs of cultivation of rice in different states. Human labour accounted largest share among individual cost items and accounted about 19% in Chhattisgarh to 44%in Jharkhand. Expenses on machine labour though less but gaining importance now-a-days and ranged between 12 to 15% and total variable costs together accounted about 47 to 78% of rice cultivation expenses. The fixed costs items included were land rent, taxes, interests and depreciation on permanent assets and worked out to be Rs.11727 in Jharkhand to Rs.29217in Chhattisgarh. On average, a total expenditure ranged from Rs.55021 to Rs.78004 per hectare was incurred in various states.

Different costs were categorized as per various cost concepts used in farm management research and presented in Table 2. The returns were calculated by considering both the main products and by-product (i.e. straw) of rice. Cost C_3comprises all the likelyexpenses and is measured as the actual cost of cultivation of crops in farmer's field and it ranged between Rs.58017 in Chhattisgarh to Rs.85804 in West Bengal. If we calculate net returns by deducting all the estimated costs, rice cultivation becomes a loss

Table 2.Cost of cultivation and income from rice production (rupees per hectare)

Particulars	Bihar	Chhattisgarh	Jharkhand	Odisha	West Bengal
Cost A_1	34932	27246	30899	38197	46187
Cost B_1	40532	32013	32638	39132	48920
Cost B_2	55532	50013	40138	49132	65379
Cost C_1	47172	37021	45243	54563	61545
Cost C_2	62172	55021	52743	64563	78004
Cost C_3	68389	60523	58017	71019	85804
Gross Returns	65516	67993	66990	88638	86500
Farm business income	30584	40747	36091	50441	40313
Family labour income	9984	17980	26852	39506	21121
Managerial income	3344	12972	14247	24075	8496
Net income	-2873	7470	8973	17619	696

Note: There were no leased in farm, so Cost A_2 not calculated making venture for some states like Bihar, and negligible for other states. However, imputed rent of owned land and managerial inputs for the farmer can be left out in a marginal profit situation and Cost C_1/C_2 can be considered as the usual cost of cultivation that covers all genuine expenditure made in cash and kind, the imputed rentfor owned capital resources and imputed value of ownedlabour (Nirmala and Muthuraman, 2009). If we deduct Cost C_2 from gross returns, we will get farmer's managerial income, which is also very meagre amount that remain at their hand and ranged between Rs.3344 to Rs.24075 for various states. Family labour income, which is gross return less cost B_2 is remunerative in some states and ranged between as low as Rs.9984 in Bihar to Rs.39506 in Odisha. When we calculate the farm business income by deducting Cost A_1, i.e. mainly paid out costs from the gross return, then only farmer seems to get a handsome returns ranging from Rs.36091 per hectare in Jharkhand to Rs.50441 per hectare in Odisha.

CONCLUSIONS

Results indicated that expenditure on human labouraccounted a major share in the total costsof rice cultivation. So, the cost of cultivation can be curtailed by restricting the expenses on labourinput in small farms by embracingupgraded production technologies. Cost ofcultivation estimated using various cost concepts indicated that farmers received a handfulmargin only when income was calculated over expenses made in paid-out costs and remains nothing literally when calculated over all costs estimated.Development efforts including massive production and supply of quality seed, supply of fertilizer, micro-nutrients and plant protection chemicals on time, widespread transfer of technologies through appropriate extension mechanism, extension of irrigation facilities, extended credit facilities, favourable price policy and other support measures, etc. are important aspect for achieving the desired goal for providing a level playing field for the farmers for earning a higher and remunerative profit.

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ADOPTION AND DIFFUSION OF SWARNA *SUB1* RICE VARIETY AND NEW *SUB1* RICE VARIETY IN DEKHATA VILLAGE, PURI, ODISHA: A STUDY BASED ON GPS MAPPING

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Swarna (MTU 7029) is a high yielding (5.5t/ha) popular rice variety in India with many desirable agronomic and quality traits.But the variety lacks tolerance of complete submergence and cannot tolerate inundation beyond 4 to 5 days. Swarna s*ub1* (SS1) was developed by introgressing the submergence tolerance gene (*Sub1*) into Swarna using marker assisted backcross (MABC) breeding. Swarna s*ub1*, which was commercialized in India in 2009, shares all desirable traits of Swarna with the added advantage of submergence tolerance for 10-17 days. In same way s*ub1* gene was also introgressed in CR1009 rice variety. CR1009 *Sub1* is released in 2015 and also has submergence tolerance for 10-17 days but provide more yield (5.8t/ha) as compared to SS1. CR1009 *Sub1* is longer duration (155-160days), whereas SS1 is of 145 days.

Village Dekhata (20^0 05' 58'' N, 85^0 55'59'' E) is located in Puri district, which forms part of the East Coast Plains. The village is located on the bank of Dhanua river, prone to flood and submergence almost every alternate year. The eastern part of the village regularly experiences short-duration flash-floods (15 days or less), whereas the north-western part has longer durations (about 20-30 days) of stagnant waterlogging. Pooja, a high yielding rice variety was grown by most of the farmers in the flash-flood prone area. In the case of crop damage by early season flood, re-transplanting was a common practice, using older seedlings. The village Dekhata covers 119 ha area, net sown area is 84 ha and irrigated area is 81.2 ha. Main source of irrigation in village is canal that assures irrigation up to 97% of the irrigated area. The cropping pattern of the village is rice-rice/pulse and rice-pulse. Average yearly rainfall in the village is 1450 mm and the elevation form mean sea level is 10 meter. As per 2011 census the village had 395 households with total population of 1501. In past 10 years, the flood occurred during 2008, 2011, 2013, 2014, 2015 and 2018. Normally the duration of flood is about 5-15 days between July to October. Flood effects the crop during its vegetative to flowering stage. A GPS based mapping study carried out to assess the geo-spatial pattern of adoption of *Sub1* varieties.

METHODOLGY

International Rice Research Institute (IRRI) distributed 2 kg SS1 seed in 2008 as trialin the village under Stress Tolerant Rice for Africa and South Asia (STRASA) project. SS1 was targeted in the area where submergence limited to ≤ 17 days and no water stagnation for a longer period. In the same village, two farmers were given 20kg CR 1009 *sub1* seed to grow in lowland area as trial basis in 2017.

Mapping of all the Swarna-Sub1 fields in Dekhata village was carried out during the wet season (June- November). Coordinates were taken in middle of the Swarna *sub1* field by help of farmers and the coordinates are overlaid on cadastral map of the village. Mapping of Swarna*sub1* fields was done in different years starting with the year of its introduction (2008,

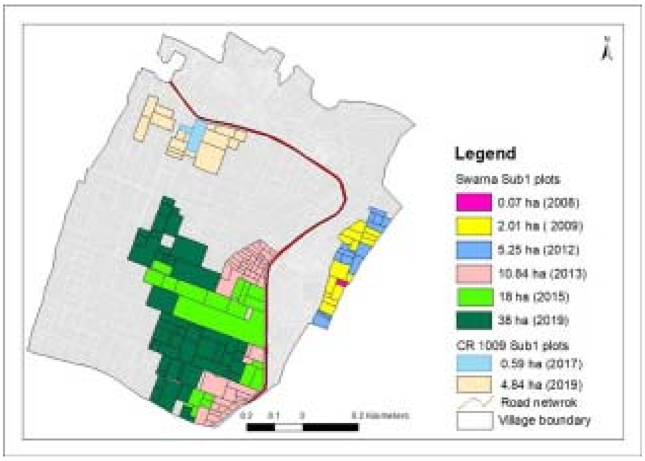

Fig. 1. Depicting adoption and diffusion of *sub1* rice variety and introduction of new Sub1 rice variety in Dekhata village, Puri

2009, 2012, 2013, 2015 and 2019) in the village and subsequently in following years to record the changes in area and its spatial and temporal expansion. As same procedure, mapping was also done for CR 1009 *sub1* in 2017 and 2019. While conducting GPS based mapping of Swarna-Sub1 and CR 1009 *sub1* adoptions, farmers were interviewed about the performance of this variety, possibility of adoption and diffusion in the village as well as adjoining villages.

RESULTS

It is observed that from 2008 to 2019, the Swarna*sub1* growing area in Dekhata village increased from 0.07 ha to 38 ha (45%) (Fig. 1). Whereas, CR1009 *sub1* growing area increased from 0.59 ha (2017) to 4.48 ha in 2019, which is about 6% of net sown area.

CONCLUSION

It is concluded that the older rice varieties like Puja, Swarna, Sarala are being replaced by Swarna *sub*1 and CR 1009 Sub1 in Dekhata village. Farmers are adopting the submergence tolerant rice varieties and according to the farmers of the village, the *sub1* rice varieties are spreading with the adjoining villages also. In the north-west part of Dekhata village is lowland, where water stagnates for longer period, farmers prefer to grow CR 1009 *sub1* because its longer duration.According to the farmer's observations, more than 17days of complete and continuous submergence does not occur in the village, so, CR 1009 *sub1* performs better in lowland as compared to SS1.The trend of adoption shows that farmers would be continuing these varieties and also helps diffusion of adoption process from one village to adjoining villages.

IRC/TM-4/PP-2

ATTRACTING RURAL YOUTH TOWARDS RICE FARMING- A FEASIBILITY CASE OF CUSTOM HIRING IN ANDHRA PRADESH

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Various constraints in rice cultivation were identified in Andhra Pradesh state like lack of small scale farm machinery for various operations including post-harvest handling suitable for small and marginal farmers and acute shortage of labour during peak operations leading to delay in timely operation and escalation of cost of production (ICAR, 2016). Due to abundance of irrigation water, rice is cultivated almost throughout the year. As there is acute shortage of labour in peak time of sowing, introduction of mechanized system of rice intensification is very profitable and will be a boon to the farmer (Prasad, 2020). Andhra Pradesh is a riverbank state and as much of the area is canal fed, two season cultivation is going on and hence the custom hiring units can be operated in both *kharif* and *rabi*. Hence a study has been undertaken during 2018-19 to test the feasibility of establishing a Mechanized System of Rice Intensification (MSRI) unit and consequently attracting youth towards agriculture.

METHODOLOGY

Both quantitative and qualitative data collected from already established enterprises for the above said elements and sub components from Andhra Pradesh. Based on the collected data, ex-ante analysis was conducted by conceiving the above prospective enterprises in new location in East Godavari District. Various project appraisal techniques viz., NPW, BCR, IRR, profitability index (PI) along with SWOT analysis were used.

RESULTS

A feasibility study is used to determine the viability of an idea in terms of legal, technical and economic viability. The elements of project feasibility viz., market and its sub components such as market size and potential, detailed competition review, customer research and need assessment and routes to market, technology and its sub components such as proto type development, legal assessment, technical feasibility and product road map, operations such as manufacturing requirement, operational costs, sales resources and support were considered and discussed here under.

The total cost for initial establishment of MSRI Unit is Rs.18.84 lakhs. The trans-planter cost contributes maximum share that is 90.21% out of the total investment anticipated for the proposed MSRI unit in East Godavari District as shown in Table 1.

Table 1. Investment for proposed customer hiring unit (Lakh Rupees)

Item	Fixed cost	Variable cost	Total	Per cent in total cost
Land	0.40	-	0.40	2.12
Shed construction	0.50	-	0.50	2.65
MSRI Unit	17.0	-	17.00	90.21
Diesel	-	0.20	0.20	1.07
Repairs and maintenance	-	0.30	0.30	1.33
Labour	-	0.50	0.50	2.61
Total	**17.90**	**1.00**	**18.90**	100.00

The net present value of the proposed custom hiring unit is Rs.1,56,015 representing its viability at 25% discount rate. Since the banking sector is offering start up loans much below the interest rate of 25% per annum. But the industry appears to be non-viable at higher interest rates (Table 2) showing its inability to make its services available at competitive rates

Table 2. Net present value at various discounting factors for the proposed MSRI unit(Lakh Rupees)

Year	Fixed cost	Variable cost	Returns	Net income	Discounting factor(20%)	NPV @ 20%	Discounting factor(25%)	NPV @ 40%
1	22.9	0.95	6.00	-17.85	0.83	-14.81	0.8	-14.28
2	0	0.97	64.00	5.43	0.69	3.75	0.64	3.48
3	0	1.00	6.75	5.75	0.57	3.28	0.51	2.93
4	0	1.20	6.85	5.65	0.48	2.71	0.4	2.26
5	0	1.70	7.00	5.25	0.4	2.10	0.32	1.68
6	0	2.00	5.75	3.75	0.33	1.24	0.26	0.98
7	0	2.50	6.60	4.10	0.27	1.11	0.21	0.86
8	0	3.00	6.80	3.80	0.23	0.87	0.16	0.61
9	0	3.15	6.95	3.80	0.19	0.72	0.13	0.49
10	0	3.30	7.00	3.70	0.16	0.59	0.1	0.37
Total	22.9	19.76	123.70	23.38		31.18		27.93

particularly to small and marginal farmers. Institutional innovations and government interventions are the need of the hour to scale up custom hiring as an attractive proposition for the youth to take up as an employment.

BENEFIT COST ANALYSIS

A perusal of the Table 4 revealed that an IRR of 36.5 per cent which is reasonably higher than the IRR in the case of traditional business model. This indicates that the newly proposed unit is a feasible and economic one. Backward integration of providing quality seeds and avoiding maintenance of seedlings at the unit site could be differed to reduce the cost of

Table 3. Cost Benefit analysis of proposed custom hiring unit (Lakh Rupees)

Total cost	Gross income	Discount rate (35%)	Discounted costs	Discounted benefits
18.85	6.00	0.74	13.95	4.44
0.97	6.40	0.54	0.52	3.46
1.00	6.75	0.4	0.50	2.70
1.20	6.85	0.3	0.36	2.06
1.75	7.00	0.22	0.39	1.54
2.00	5.75	0.16	0.32	0.92
2.50	6.60	0.12	0.30	0.79
3.00	6.80	0.09	0.27	0.61
3.15	6.95	0.06	0.19	0.42
3.30	7.00	0.04	0.13	0.28

Table 4. Ex – ante project appraisal of the proposed MSRI unit

Type of Appraisal	RESULT
BCR	1.11
NPV	1.56 Lakhs (25%)
IRR	36.5%

inventory and fixed capital requirements during the initial periods.

Sensitivity analysis

To reduce fixed costs of a purchased tractor, instead of buying the tractor which is costing around 5 lakhs, the farmer can be asked to bring tractor. Seedling should be grown and maintained at the farmer by

Table 4. Result Matrix of SWOT Analysis of the proposed custom hiring unit in Pithapuram of Andhra Pradesh

Strengths	**Weaknesses**
Present at a good location; modern machinery;wider working area; skilled man power.	Rising cost of capital; scarcity of capital;inadequate skill training.
Opportunities	**Threats**
Good monsoon; more area of rice cultivation; government subsidies.	Market competition; drought;repair and maintenance; growing area.

providing the trays, so that the cost of raising and maintaining seedling can be reduced.

SWOT analysis

The results of the SWOT analysis are presented in Table 4, which could be useful for planning and monitoring of the proposed custom hiring unit as viable alternative for unemployed youth of Andhra Pradesh.

CONCLUSIONS

From the above analyses, it could be concluded that MSRI unit that is going to established in the new proposed place is a feasible one having IRR touching towards 36 per cent, positive NPV at 25% discount rateand BCR greater thanone. There is also scope to reduce cost by doing various sensitivity analyses and consequently putting them to operation.

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Theme - IV : Rice for livelihood security, equity and profitability

IRC/TM-4/PP-3

ON FARM EVALUATION OF CROP NUTRITION ON AGRONOMIC USE EFFICIENCY IN RICE –HORSE GRAM CROPPING SYSTEM IN KONKAN

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Nutrient use efficiency (NUE) in India has always been major issue. In the last 35 years, fertilizer response in irrigated areas of the country has declined almost three times from 13.4 kg grain/kg NPK in 1970 to 3.7 kg grain/kg NPK in 2005. However, its use efficiency in agriculture is in general low and ranges between 20% and 50%. Imbalanced application of essential nutrients (secondary and micro) is one of the reasons for low nitrogen use efficiency. Improved nitrogen management will certainly save the nitrogen loss with increasing in NUE. Time and rate of application is a key for higher profitability and productivity. Proper scheduling of nitrogen is necessary for improving its use efficiency depending on climatic situation, rainfall pattern and soil type (Dahiphale et al., 2018). In Maharashtra, rice is cultivated on 15.56 lakh ha area. In Konkan regions rice was grown on 3.69 lakh ha with the highest productivity of rough rice was in Konkan region 4.25 t/ha. In Konkan region, traditional rice based cropping systems followed under residual moisture situations. Inclusion of horse gram crop in intensive rice based system is step towards integrated plant nutrient supply system. Therefore, horse gram has become viable alternative to improve the soil health and improve nutrient management efficiency in south Konkan region.Considering this fact, a farmer's participatory research was carried out at farmers' field to quantify response of the nutrients in rice-horse gram cropping system in south Konkan region.

METHODOLOGY

An experiment was conducted in (6) six different villages of two blocks of Lanja and Rajapur in Ratnagiri district, situated in south costal Konkan Zone of Maharashtra to assess the response of rice – horse gram system to different nutrients combinations during the year 2017-18 at farmers' field. The seven treatments, *viz.*, T_1-Control, T_2-Recommended N alone, T_3- commended N and P, T_4-Recommended N and K, T_5-Recommended N, P and K, T_6-Recommended NPK with ZnSO4 and T_7-Farmers' practice were taken for study on each selected farmers field. The soils of the experimental sites were red laterite with pH 5.24, Electrical conductivity was 0.08 (dS m^{-1}), organic carbon was 12.5 (g kg^{-1}) and available N, P and K was 290.25, 14.05 and 96.8.16 kg ha^{-1}, respectively.

Table 1. Agronomic use efficiency (AUE) of Nitrogen of rice –horse gram cropping system in Ratnagiri district of Maharashtra.

Location	***Kharif Rice***						***Horse gram***					
	Agronomic use efficiency (AUE) of N (in %)											
	N alone	With P	With K	With PK	With PK & Zn	WithFP	N alone	With P	With K	With PK	With PK & Zn	With FP
Veral	5.06	6.50	6.60	16.11	21.58	14.67	5.63	9.30	8.42	13.08	14.89	15.34
Asage	5.50	9.87	8.74	13.53	23.22	12.61	6.96	10.34	9.03	14.23	14.26	17.38
Panhale	7.10	12.60	11.09	14.69	26.48	13.96	7.01	10.56	9.12	12.94	15.03	18.42
Unhale	8.45	11.24	11.41	17.96	24.04	16.21	6.63	10.06	8.01	14.40	15.58	17.38
Parule	5.94	8.56	8.30	15.16	22.19	14.50	7.16	10.29	8.01	13.75	14.69	18.74
Shedhe	6.86	8.75	8.69	16.59	21.97	13.22	7.90	10.09	7.87	13.89	15.16	19.95

In case of nutrient use efficiencies (NUE) of the system it was measured and calculated in terms of agronomic use efficiency (AUE); $AUE_n = (GY_n - GY_0)/F_n$ Where, (AUE_n), are the agronomic use efficiency of N. In case of the GY_0 and GY_n are the yields of respective treatments (control and N alone) and F_n are the amounts of nitrogen applied to particular treatment. Thereafter, the Randomized Block Design was used to compare treatment means within and between the locations.

RESULTS

Agronomic efficiency (AE)

Estimation of an incremental efficiency from applied Nitrogen, over control, was done in our study, it was noticed that apart from fertilizer treatments, calculated agronomic use efficiency of applied N (AUE_n) is greater in rice than in horse gram at all locations. In study area it was observed that farmers are habitual of applying N fertilizers only. AUEn can be increased from 26.48% to 21.58% in *kharif* rice crop and 15.58% to 14.26 % in horse gram crop when treatment T_6 was impose to the rice -horse gram cropping system as compared to application of nitrogen alone, combination of NP and combination of NK in rice- horse gram cropping system in all villages of study area. Data indicated that application of NP or NK had recorded considerable increase in AUE of N at all the locations of study area as compared to application of N alone, the magnitude of increase in AUE was meager than the balanced application of NPK+micronutrient. Singh et al(2017*)* recorded similar findings which are in conformity with results noted.

CONCLUSION

With aim to improve agronomic use efficiency in rice-horse gram cropping system in Konkan region an appropriate balanced application of recommended quantity of NPK with micronutrients is essential.

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IRC/TM-4/PP-4

RED RICE (LAL CHAWAL) OF KASHMIR HIMALAYAS: FROM REVIVAL TO RECOGNITION

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In Kashmir valley, the red rice is under cultivation since time immemorial in tehsil Tangdar of district Kupwara. Till 1960, only red rice was under cultivation in this niche area. Red rice (Zag rice) refers to the rice variety having red kernel colour due to the deposition of anthocyanin in pericarp, aleurone layer, etc. As per the reports, 1000 hectares of land had been under red rice cultivation in the area before the introduction of different high yielding varieties (HYVs). After introduction of HYVs, the area under red rice was reduced to few 100 hectares. The survival of this valuable indigenous red pearl is only because of the efforts of progressive, futuristic and broad- visioned farmers. Presently red rice, locally known as *Lunda*, is cultivated in 100 % area of Gomal village,50%area of Bagibella village and 30% area of Hajinad village of district Kupwara at an altitude of 1650-1750 m amsl under irrigated conditions fed by melting snow. Revival programme of red rice cultivation on scientific lines was initiated in the niche areas by SKUAST– Kashmir in 2015 involving the farming community of the afore-mentioned villages. The main objective of the revival programme was to conserve the valuable gene repository of the high altitudes of Kashmir for enhanced income,food and nutritional security of farmers. SKUAST-Kashmir under the flagship programme of *"Genetic purification, in-situ conservation and utilization of indigenous landraces of rice"* carried out the genetic purification and developed the production and protection technologies for this endangered landrace.The word 'purification' was highly indispensablebecause a lot of admixture was found in the farmer's variety. The reason of lot of admixture was due to continuous cultivation of the variety in several isolated pockets of Kashmir inherited from their forefathers. As a result the variety had lost its identity.Besides purification, the variety was characterized for agro-morphological,physico-chemical and cooking quality traits. Some farmers' self help groups were also created for the strengthening of the seed supply system for commercial exploitation in its niche areas

METHODS

During 2017, 10.0 q pure seed of red rice variety (*Lunda*) produced in the niche area was demonstrated on 12 ha land encompassing more than 100 farmers from villages of Gomal and Hajinad as the beneficiaries (Table 1).

RESULTS

Red rice variety *Lunda*(Lal chawal) has been characterized for the most of traits needed for registration with PPV and FRA, GoI (Table 2). The variety was found to contain high Zn in brown (26.5ppm) as well as in polished rice(24.5ppm) [Table 3], thus has a great scope in ameliorating micronutrient deficiency in rice consumers. Despite the fact that the yield of the variety is around 60 to 70% in comparison

Table 1.Details of quality seed production (truthfully labeled) of red rice variety *Lunda* during 2015-2017 along with area demonstrated

2015	2016	2017	2018
Seed quantity distributed(kg)	seed production(q)	Seed production(q)	Area covered (ha)
10.0	2.6	10.0	12

Table 2.Important DUS characters of the local red rice (Lal chawal) variety, Lunda

Characteristics.	Lunda	Jhelum
Panicle : number per plant	8-10	12-15
Panicle :Awns	Present	Absent
Time maturity (Days)	120-125	135-145
Leaf senescence	Early	Medium
Plant height (cm)	130	115
Grain yield (t/ha)	4.5-5.0	6.5-7.0
Grain weight of 1000 Fully developed grains	24.0 g	27.0g
Rough grain : length	7.4mm	8.5mm
Rough grain width	4.0mm	3.8
Decorticated grain length	6.3mm	7.9
Decorticated grain width	2.5mm	3.2

Table 3.Micronutrient contents in red rice germplasm of Kashmir

Genotype	Micronutrient content in brown rice (ppm)		Micronutrient content in polished rice(ppm)	
	Iron	*Zinc*	*Iron*	*Zinc*
MushkBudji	12.1	20.6	0.9	13.4
Kamad	10.8	19.7	0.9	10.6
Uri Zag	13.5	23.4	3.1	20.0
GS 599	16.1	24.5	2.9	18.5
GS 604	11.5	24.0	2.3	18.9
TangdarZag (*Lunda*)	9.6	26.5	2.1	24.2
Jhelum*	10.4	12.9	1.4	9.4

Analysis done at IIRR, Hyderabad, using XRF method; *Popular rice variety used as check

to high yielding variety but the benefits in terms of socio-economic and nutritional are manifolds. The minimum price per kg of rice is around ₹ 200.00 which is 6-7 times higher than other varieties. The scope of variety for horizontal expansion is about 1000 ha. If the same area is brought under the cultivation of red rice the minimum returns from the niche areas shall be around ₹ 6.0million/year. This can completely transform the economy of region. The significant achievement was that the farming community of Tangdar was selected for the prestigious Plant Genome Saviour Community Award 2019 and same was conferred to the group on Nov.2019.

CONCLUSION

The characterization of the red rice variety shall be useful for registration (application already submitted) with PPV and FRA,GoI. The technology developed and used is the benchmark for the horizontal expansion beyond niche areas. Identification and promotion of red rice for high Zn and Fe could mitigate the malnutrition and other health issues of rural areas. Further scope of expanding the area under such rice has been estimated upto 1000 ha in tehsil Tangdar and equivalent ecologies for raising farm income.

Exploring sustainable market linkages seems to be the need of the hour for socio-economic development and livelihood security of the farmers. Farmers need to be grouped in clubs who will undertake the responsibility from production to market and can be strengthened and promoted as farm producer's organization using the support of state government and banks. Above all to promote the cultivation of such high valued rice, capacity building of farmers groups need to be given due consideration.

IRC/TM-4/PP-5

GROWTH PERFORMANCE AND ECONOMIC FEASIBILITY OF RICE PRODUCTION IN INDIA

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About 65 per cent of Indian population consume rice as it is an important staple food of the country. It contributes around 10 per cent of the agricultural GDP and its production generates 3.5 billion mandays of employment (Kumar *et al.*, 2018). Its consumption by a large proportion of people, contribution in agricultural GDP and generation of employment are self-explaining its role in food security, income and employment generation of the nation.The major rice producing states with respect to share in total rice production of the nation were West Bengal (13.79%), Uttar Pradesh (13.34%), Andhra Pradesh including Telangana (12.84%), Punjab (11.01%), Odisha (6.28%), Chhattisgarh (5.61%), Tamil Nadu (5.54%), Bihar (5.19%), Assam (4.41%), Haryana (3.88%) and Madhya Pradesh (3.86%) during 2018-19. Keeping these facts in consideration, the present study investigated growth and instability in area, production, productivity, cost of cultivation and profitability of rice in major rice producing states and nation as whole.

METHODOLOGY

The secondary data was used for the present investigation.The compound growth rates (CGRs) of area, production and productivity of rice in major rice producing states of India was computed both for states and for India as a whole, using the following formula:

CGR = (Anti log of b – 1) x 100

Where, b is the regression coefficient.

The instability index was calculated using better measure of variability suggested by Cuddy- Della Valle index (Cuddy and Della, 1978).

$$\text{Instability Index} = CV \times \sqrt{1 - R^2}$$

$$CV = \frac{\text{standard deviation of the variable}}{\text{Mean of the variable}} \times 100$$

Where, CV is Coefficient of Variation and R^2 is the Coefficient of Determination from a time series trend regression adjusted by the number of degrees of freedom.

Apart from Cuddy Della Valle index, this study also calculated Coppock instability index.

$$\text{Coppock's instability index} = \text{Antilog}(\sqrt{\log V} - 1) \times 100$$

$$\log V = \frac{\sum \left(\log \frac{X_{t+1}}{X_t} - m^2 \right)}{n}$$

X_t = area/production/productivity of rice

t= number of years

m=mean of the difference between logs of X_{t+1}, X_t

Log V = Logarithmic variance of the series

Cost C_2 was used as total cost of cultivation which includes all actual expenses in cash and kind incurred in production as well as interest on value of owned capital assets (excluding land), rental value of owned land and rent paid for leased-in land. Profitability/ loss in rice cultivation was estimated using following methods.

Farm business income = Gross income -costA_2

Net income = Gross income - Cost C_2

RESULTS

The results of growth performance revealed that the area under rice for Andhra Pradesh including Telangana (0.47%), Assam (0.01%), Haryana (1.05%), Madhya Pradesh (0.83%), Punjab (0.50%) and Uttar Pradesh (0.11%) were positive whereas, the states like Bihar (-0.22%), Chhattisgarh (-0.02%) Odisha (-0.44%), Tamil Nadu (-0.09%) and West Bengal (-0.29%) showed negative growth rates. Growth rates of production and productivity in almost all the states and nation as whole was positive and significant. The increase in production and productivity could be attributed to the adoption of new technologies of rice cultivation like use of high yielding varieties, improved package and practices, improved infrastructural facilities for farming. Another reason may be the rice intensification programme of government.

The result exhibited that instability index of area under rice was comparatively less than that of production and productivity at national level revealing area under rice was more or less stagnant during the period under investigation. No doubt, production and productivity of rice has increased during the period of investigation due to technological changes in production of rice. However, instability indices of production and productivity was more because production and productivity are influenced by climatic conditions and during study period the monsoon was very erratic which may have created variation in production and yield. State-wise instability indices of area, production and productivity of rice also showed that instability in area was less than that of production and productivity in all the major rice growing states. Instability indices of production and productivity were comparatively high in the Madhya Pradesh, Bihar, Tamil Nadu and Chhattisgarh as these states have not benefited from technological changes during Green revolution.

The results revealed that net income was comparatively high in case of Punjab followed by Haryana, Tamil Nadu and Andhra Pradesh and in rest of the state net income was negative. The reason may be that the productivity of Punjab, Haryana, Tamil Nadu and Andhra Pradesh was comparatively high as compared to Assam, Bihar, Chhattisgarh, Odisha, Madhya Pradesh and West Bengal. The other reason may be that Punjab, Haryana, Tamil Nadu and Andhra Pradesh have regulated markets and farmers might have sold their produce at minimum support price (MSP).

CONCLUSION

From the above findings, it can be inferred that compound growth rate of area under rice was almost constant in the country during the period of investigation and it was fluctuating across the states but growth rates of production and productivity was positive and significant indicating the production of rice has increased during the period under study. Instability indices of area were less as compared to production and productivity due to technological changes in cultivation practices. Most of the states registered negative profitability in rice cultivation. Only the farm business income was found to be positive. Since rice is an important staple food of the country, therefore, to achieve food security, policy makers, planners and stakeholders should frame policies to restrict sale and purchase of rice below MSP so that farmers may not shift to other crops or quit rice farming.

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IRC/TM-4/PP-6

IMPACT OF FRONT LINE DEMONSTRATION OF RICE VARIETY SWARNA SHREYA AT KATNI DISTRICT OF MADHYA PRADESH

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Rice is one of the oldest cultivated crop and staple food for world's half population. Area under rice crop in Katni district is 172.10 thousand ha which covered about 91.5% of the*kharif* area in the district. The crop grown under wide range of climatic condition but non availability of high yielding medium duration rice variety is the main concern among farmers. The continued use of same variety for long period also leads to the low yield. Keeping this in view, KVK Katni made an attempt to substitute existing variety with improved rice variety Swarna Shreya. Afront line demonstration programme was conducted against the local variety to evaluate the production potential and increase the knowledge level of the farmers.

METHODOLOGY:

The FLD on improved variety Swarna Shreya was carried out during the two consecutive years 2018 and 2019 in Village Banda and Jarwahi, Block: Katni of Katni district. Scientific package of practice were followed and for popularization different extension approaches (supply of bioagent, training, field visit, field day etc) were conducted. Observation on various growth and yield parameters were taken from the demonstration and farmer practices plot. Economic analysis was done by calculating cost of cultivation, gross return, net return and BC ratio. Further technology gap, extension gap and technology index were calculated following Samui et al. (2000).

RESULTS& DISCUSSION:

Result from the 20 conducted FLD indicated that improved variety Swarna Shreya exhibited mean grain yield of 43.70 q/ha which is 26.11% higher than the farmer practices. This might be due to knowledge and adopting of improved variety Swarna Shreya coupled with the scientific package of practices. Thus the FLD might have a positive impact on farming community in the district. The technology gap of the demonstration plot were 5.85 q/ha and 6.75 q/ha during 2018-19 and 2019-20, respectively with an average of 6.30 q/ha. This may be attributed to the dissimilarity in soil fertility status and variable climatic condition. Extension gap of 9.10 q/ha and 9.00 q/ha were observed during 2018-19 and 2019-20, respectively with an average of 9.05 q/ha. This emphasized the need to educate the various extension means. Appropriate use of latest production technologies with the high yielding variety will subsequently change this alarming trend of galloping extension gap (Girish et al., 2020). The technology index varied from 11.70% to 13.50% with a mean value of 12.60%. This shows the efficacy of demonstrated technology improved variety Swarna Shreya coupled with scientific package of practices. This will accelerate with the adoption of demonstrated technology to increase the yield of rice.

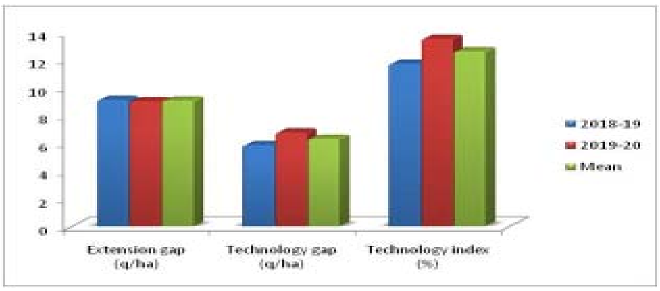

Fig.1.Technology gap, Extension gap and Technology Index under FLD on Improved variety Swarna Shreya

The cultivation of improved variety Swarna Shreya gave higher net return of Rs. 39117 and Rs. 39999 per ha during 2018-19 and 2019-20, respectively as compared to farmer practices with Rs. 25202 and Rs. 26314. The benefit cost ratio of demonstration was 2.02 and 2.04 as compared to 1.69 and 1.72 of existing practices. This showed the significant change in income of farmers by adopting of improved variety Swarna Shreya coupled with scientific package of practices. This variety found to be suitable since it fits well to the existing farming situation and also it had been appreciated by the farmers.

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IRC/TM-4/PP-7

VARIETAL IMPROVEMENT OF RICE IN GUJARAT FOR IRRIGATED CONDITION

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Rice occupies about 8.0% of the gross cropped area of the Gujarat and accounts for around 26% of the total food grain production. The total rice occupying area in Gujarat is 8.26lakh hectares, production is 19.0lakh tons and yield is 2249 kg/ha (Anonymous, 2019). The rice research improvement work in Gujarat was initiated with the establishment of the Rice Research Stations at Nawagam (Kheda) in the year 1945 by the Department of Agriculture of the Bombay State under the scheme 'Research and Extension work on Rice'. Subsequently, on formation of the Gujarat state in 1960, this station was upgraded as Main Rice Research Station of the state and presently it isunder the set-up of Anand Agricultural University, Anand.This station has made a great impact and influence in changing the whole scenario of rice production in Gujarat (Patel and Mehta, 2010). The concerted research efforts were made with major objective to develop high yielding rice varieties suitable to different rice growing regions of the state and possess multiple tolerances in field conditions.

METHODOLOGY

The rice improvement work during early phase (1945-1969) was initiated by the collection of rice germplasm including traditional cultivars and landraces from different regions of the state and the country. The pureline selection method was implemented for varietal improvement during this phase.During 1969 to 1986, the hybridization followed by pedigree selection method was followedfor varietal improvement programme using traditional or local or basmati cultivars and new type dwarf donors like TN-1, IR series varieties of IRRI, Phillipines and entries of AICRIP trials. The promising genotypes were evaluated in the station and multi-location trials at different locations of the state to identify suitability of genotypes for different regions. The high yielding genotypes having biotic stress tolerance were recommended for farmers of Gujarat.

RESULTS

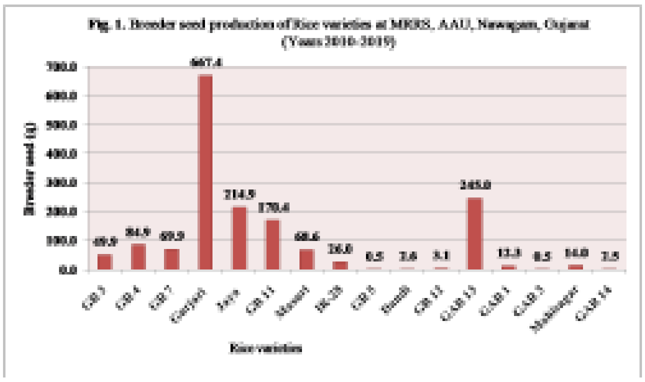
The efforts for rice improvement using pure line selection method were resulted in the release of improved varieties *viz*., Sukhwel-20, Early Sutarsal-39 (EST-39), Jirasal-280, Kamod-118, Pankhali-203, Early Kolam-70, Zinnia-31, Kolhapur scented and Nawagam-19 during year 1949 to 1969. These included early, mid-late and late maturing varieties having medium and long slender, coarse and medium coarse grained varieties. Some of the varietieswith strong aroma and good cooking quality are still popular in the state.The variety Nawagam-2-6 (1965) was developed from EST-39 x Jirasar-275 hybridization followed by pedigree selection method.

The rice improvement programme was reoriented to develop high yielding varieties with short stature, dark green and erect leaves, non-lodging habit and fertilizer responsiveness using the introduction material of TN-1and IR-varieties from IRRI, Philippines. The varieties *viz*., GAUR-1 (Zinnia-31 x IR-9-60), GAUR-10 (Zinnia-31 x IR-9-60), GAUR-100 (Zinnia-31 x IR-8-246), GAUR-2 (IR-8 x Kada-176-12), GR-3 (Nawagam-19xIR-9-60), GR-4, GR-11 (Zinnia-31 x IR-8-246), GR-101(IR-8 x Pankhali-203) and GR-102 (IR-8 x Pankhali-203) were developed during 1970 to 1990 using hybridization followed by pedigree method of selection. The early maturing varieties GAUR-1, GR-2 (GAUR-2) and GR-3 mature almost in 100 days. The variety GR-4 was early maturing (100-110 days) with clustered spikelet and very fine grains. The early maturing varieties GR-6 (GR-3 x Pusa-33), Gurjari (Asha x Kranti), GR-7 (GR-3 x Basmati-370) and GR-12 (GR-4 x IR-64) were developed during 1997 to 2008 for irrigated transplanted ecosystem. The GR-6 and GR-7 became popular in south Gujarat due to their moderate resistance to BLB and stem borer and mild aroma. The Gurjari (IET-10750) was isolated in 1988 from AICRIP multi-resistant trials and released in 1997, have high yielding ability with inbuilt resistance to WBPH and higher popped and flaked rice recovery. Further due to its early maturity it fits well in the prevailingcropping sequences to facilitate timely planting of *rabi* crops followed after paddy.It became most popular variety in coarse grain segment and replaced the variety Jaya. The early maturing, long slender grain and mild aromatic variety GAR-1 (Narmada x IET-14708) was released in 2010. The medium slender grain, early maturing and disease-pest tolerant rice variety Mahisagar (CN-540 x IR-50)(2016) is become popular among farmers of the middle Gujarat.

The mid-late maturing varieties were GAUR-10 and GR-11. Because of profuse tillering, clustered panicle type with high panicle density, very fine translucent grains, high yielding ability and fertilizer responsiveness, the variety GR-11 was become most popular variety of the Gujarat. In recent years it has succumbed to major diseases and pests. Thusconcerted efforts were made to incorporate multiple resistance in GR-11.The variety GAR-13 (2009) was developed from GR-11 x IET-14726,having high yielding ability with multiple pest and disease tolerance, good grain and cooking quality. Itbecomeone of the popular varietyof Gujarat. For salt affected and coastal saline areas of the state the salt tolerant, short bold grained high yielding variety Dandi (PNL-2 x IET-8320) was developed. The variety GR-103 derived from GR-11 x Mahsuri having mid-late maturity, dwarf stature, golden coloured husk is popular as mini Mahsuri. The varieties GAR-2 and GAR-3 (Gurjari x IET-14714) were released in 2011 and 2013, respectively having mid-late maturity and non-lodging habit.

The GR-101, GR-102, GR-104, Narmada and GAR-14 are the aromatic short grain varieties. Thevariety GR-101 popularly known as scented Basamati in middle Gujarat.The GAR-14 (GR-7 x Mahisugandha) released through CVRC in 2018, is having biotic stress tolerance, non-lodging habit and strong aroma.

The breeder seed demand of last ten years (2010-2019) indicated that the coarse grain early maturing variety Gurjariand mid-late maturing fine grain variety GAR-13 have maximum popularity and cover majority of rice cultivated area in Gujarat. The recently



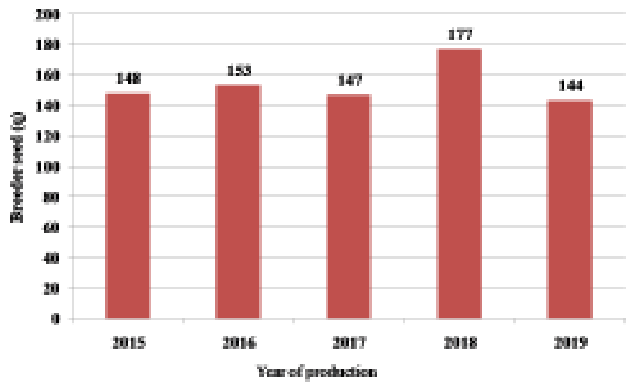


Fig. 2. Breeder seed production of Rice at MRRS, AAU, Nawagam

released varieties Mahisagar and GAR-14 are covering more acreage in the state.

CONCLUSION

The early maturing rice varieties GR-3, GR-4, GR-6, GR-7, Gurjari and Mahisagar, mid-late maturing GR-11, GAR-3 and GAR-13 and ASG varieties GR-101, Narmada and GAR-14varieties are the major contributors for increasing area, production and productivity of rice in Gujarat.

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Theme - IV : Rice for livelihood security, equity and profitability

IRC/TM-4/PP-8

RICE EXPORTS FROM INDIA-PRODUCT AND GEOGRAPHIC DIVERSITY-IMPLICATIONS

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In India rice is a prominent food crop cultivated in 43.79 million hectares in 2018-19. India occupied second rank in global rice production with average annual production of 107.25 million tonnes during 2012-2017. India is also a major player in global rice market with average annual export of 9.79 million tonnes during 2010-11 to 2019-20. In 2019, India contributed 28 percent in global rice export quantity and 32 percent in global rice export value. In the present research work an attempt is made to analyse product and geographical diversification of rice exports from India in the recent decade i.e., during 2010-11 to 2019-20 and implications derived.

METHODOLOGY

Secondary data collected from published sources viz., Agricultural Statistics at a glance (various years) published by Ministry of Agriculture and Farmers' Welfare, Government of India. Data accessed from website of Agricultural and Processed Food Products Export Development Authority (APEDA) of Government of India has also been utilized in the current study. Descriptive statistics is used for analysis and drawing inferences.

RESULTS

Rice exports from India increased from 2.43 million tonnes in 2010-11 to 9.49 million tonnes in 2019-20 with much fluctuations in between. Out of ten years considered in the study, rice exports from India was highest (12.69 million tonnes) in 2017-18. India exports two types of rice viz., Basmati rice and non-basmati rice. Basmati rice is protected under Geographical Indications (GI) IPR (Intellectual Property Rights) system. Basmati rice exports of India increased from 2.33 million tonnes in 2010-11 to 4.45 million tonnes in 2019-20. In the year 2010-11, share of Basmati rice was 96 and 98 percent in total Indian rice exports quantity and value, respectively. This high share was due to ban on Non-basmati rice export till later part of the year 2011 and Minimum Export Price (MEP) policy. There after share of non-basmati rice in total rice exports increased and stood at 53 percent in total quantity and 32 percent in total rice export value in 2019-2020. In 2010-11, India exported Basmati rice to 105 countries and it increased to 149 countries in 2019-20. On the other hand, the share of top 5 destination in quantity of Indian basmati rice export, which was 84 percent in 2010-11 declined to 71 percent in 2019-20. This clearly indicates increasing diversification in basmati rice exports. However, there was not much dynamics in terms of the countries appearing in top 5 destination list.

In Indian non-basmati rice exports, there are six product categories viz, parboiled rice, (husked) brown rice, broken rice, other rice semi milled or wholly milled rice whether or not polished or glazed,other rice in the husk (Paddy/Rough), and rice in the husk (Paddy/Rough) of seed quality. Out of these, share of parboiled rice was highest in total quantity of non-basmati rice exports, 50 percent in 2010-11 and 62.1 percent in 2019-20.The share of other rice semi milled or wholly milled rice whether or not polished or glazed, was 37.4 percent in 2010-11 but decreased to 27.3 percent in 2019-20. In 2010-11, rice in the husk (Paddy/Rough) of seed quality occupied third place out of 6 product categories with 9.3 percent share but fell down to 5th rank in 2019-20 with only 0.5 percent share in total non-basmati rice exports from India. Similar trend was also observed in share of the six products in total value of non-basmati rice exports.

The number of countries to which non-basmati rice was exported from India ranged between 49 to 144 countries across the ten years. In all 6 non-basmati rice product categories, the number of export destinations increased over the 10 years. But the number of countries to which brown rice, and rice of seed quality were exported was below 35 across all the years. Similar to the case of Basmati rice, in the case of non-basmati parboiled rice, other rice semi milled or wholly milled rice whether or not polished or glazed, broken rice and non-basmati brown rice, share of top 5 destinations of Indian rice exports declined in 2019-20 compared to 2010-11 indicating increased diversification of exports. In the case of other two product categories i.e.,rice in the husk (Paddy/Rough) of seed quality andother rice in the husk (Paddy/ Rough),the reverse is the trend.

A look into per unit value (price) of exports across different rice product categories in the last decade, yielded the following insights. Basmati rice price was much higher (two to three times) than non-basmati price for 10 years. But when looked across all product categories highest per unit value was observed in the case of Basmati rice in only one out of ten years. In the rest nine years,rice in the husk (Paddy/Rough) of seed quality was the leader in terms of highest unit value (price) of exports. Accordingly, in all the 10 years, share of rice in the husk (Paddy/Rough) of seed quality category was higher in total export value compared to total export quantity of rice. In the other product categories reverse is the trend.

Analysis using measure of Coefficient of Variation (CV) indicated that dispersion around mean was higher in case of non-basmati rice exports quantity (41 percent) and value (44 percent) compared to basmati rice exports quantity (17 percent) and value (29 percent). Within non-basmati rice category, CV was maximum in the case of brown rice export quantity (122 percent), and was minimum (38 percent) in the case of parboiled rice export quantity. Similar trend was observed in the case of export value also. Besides the policy ban on export of non-basmati rice till later part of the year 2011 and MEP policy, the policy of 5 percent Merchandise Exports from India Scheme (MEIS) from 26-11-2018 to 25-03-2019, increase in domestic MSP (Minimum support price), strengthened stringent sanitary and Phyto-sanitary Measures (SPS) in some countries, were some drivers of high fluctuations in non-basmati rice exports.

CONCLUSIONS

Basmati rice export was stable compared to non-basmati rice exports from India in recent decade. There is diverse global market for different rice product categories of non-basmati rice. India needs to harness these opportunities together with risk spreading through appropriate strategies.

EVALUATION AND ASSESSMENT OF EARLY MATURING RICEMAHISAGARTHROUGH ON-FIELD DEMONSTRATION

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Area under rice in India is 44.79 million hectares with production of 116 million tones (GOI 2019).Worldpopulation is expected to increase to 8.5 billion by 2025 and to maintain the self-sufficiency in rice, an increaseof 2% - 3% per year in rice production had to be maintained within limited land. Rice occupies about 7-8% of the gross cropped area in the Gujarat state and it is being grown on an average about 7.5 to 8.5 lakh hectares of land, comprising nearly 60-70% of transplanted and 32-40% direct seeded rice and rainfed area. The major constraint for low productivity of rice in the rice growing area in Gujarat is non-adoption of recommended package of practices and lack of awareness about the improved rice variety. The agricultural technology is not generally accepted by farmers completely. As such, their always appear to be a gap between the recommended technology by the scientist and its modified form at the farmer's levels. To replace this traditional package of practices, main rice research station, AAU, Nawagam conducted 247 and 110 front line demonstrations on high yielding early variety 'Mahisagar' under the State and ICAR FLD program during *kharif* season 2017, 2018 and 2019, respectively. An evaluation study was made to know the gaps between potential yield and demonstration yield, extension gap and technology index for extension of Mahisagar variety through the FLDs.

METHODOLOGY

In present study, performance of rice variety Mahisagar against local check was evaluated through Front Line Demonstration conducted at farmer's fields. In this study, number of demonstration conducted under state program 104, 90 and 53 whereas, 40, 50 and 20 in ICAR program in the year of 2017, 2018 and 2019, respectively. The total 128.5 ha field area covered in this study in which total number of 357 demonstrations were conducted on the selected farmer's field of middle Gujarat and South Gujarat rice growing area*viz*, Ahmedabad, Kheda, Anand, Gandhinagar, Navsari, Valsad, Surat, Baroda and Dahod.

The data on output of rice cultivation were recorded from FLD plots, besides the data on local variety adopted by the farmers of this region were also collected. The difference between FLD and local check were observed in Mahisagarvariety. However, other critical inputs such as recommended dose of fertilizers, agrochemicals and rest of the agronomical practices was similar. The demonstration farmers were facilitated by MRRS scientists in performing field operations i.e. sowing, spraying, weeding, harvesting, grading etc. during the course of training and visits. The technologies demonstrated are maintained and compared with local variety. The technology gap, extension gap and technological index (Samui et al., 2000) were calculated by using following formula as given below equations [Eq. 1-4]:

Percent increase yield=

$$\frac{\text{Demonstration yield} - \text{Local check yield}}{\text{Local check yield}} \times 100$$

.........Eq. 1

Technology gap= Potential Yield–Demonstrated yield..........................Eq. 2

Extension gap= Demonstrated yield – Yield under existing practice ....Eq. 3

Technology index =

$$\frac{\text{Potential yield} - \textit{Demonstrated} \text{ yield}}{\text{Potential yield}} \times 100$$

……Eq. 4

RESULT

Results of frontline demonstrations conducted during three year in*kharif* 2017, 2018 and 2019 in 26, 36 and 26.5 ha area on farmers field in the state FLD program indicated that the cultivation practices under FLDs viz. demonstrated high yielding variety (Mahisagar) recommended spacing (20 x 15 cm), recommended dose of fertilizer (N:P:K @ 80:25:00 kg/ha), timely inter culturing operations like weeding and control of pest and diseases through recommended chemicals at economic threshold level. The average FLDs yield was recorded 4806, 5275 and 4403 kg/ha in the year of 2017, 2018 and 2019, respectively, which were found 09,10 and 09 per cent increase over local check. While, in ICAR FLD program average FLDs yield was obtained 4914, 5496 and 4900 kg/ha during 2017, 2018 and 2019, respectively, which were found 12,09 and 11 per cent increase over local check (Table 1).The results indicate that FLDs has given a good impact on rice growing farming communities and they were motivated by the new recommended and new high yielding early maturing rice varietyMahisagar.

The technological gap in state FLD program was 1194,725 and 1597 kg/ha and technological gap in ICAR FLD program was 1086, 504 and 1100 kg/ha, in the year of 2017, 2018 and 2019, respectively, it is clearly reflected that farmer's cooperation, in carrying out such demonstrations with encouraging results. The technology gap observed may be attributed to variability in the soil fertility status and agro climatic conditions. The existing gap in State program which is ranged from 414, 469 and 371 kg/ha whereas, 524, 470 and 468 kg/ha in ICAR program during three-yearperiod of study. We emphasized the need to educate the farmers through various means for the adoption of improved agricultural technologies to reserve this trend of wide extension gap. More adoption of recent production technologies with high yielding varieties will subsequently change this alarming trend galloping the extension gap.

The technology index shows the feasibility of the evolved technology at the farmer's field. The lowest value of technology index which indicate the more feasibility of the technology. As such, decreased the technology index range from 08 to 27% indicated that the demonstrated technology was feasible (Table 1).

Table1. Productivity, technology gap, technology index, extension gap of rice variety Mahisagar under FLD program

Year	Area	No. of FLD	Demo. Yield kg/ha			Local check yield kg/ha			Potential yield kg/ha	Increase yield (%)	Extension Gap kg/ha	Tech. gap (kg/ha)	Tech. index (%)
			High	Low	Avg.	High	Low	Avg.					
State FLD													
2017	26	104	7200	3200	4806	6560	2880	4392	6000	09	414	1194	20
2018	36	90	6300	4250	5275	5980	3590	4806		10	469	725	12
2019	26.5	53	6000	2500	4403	5360	2480	4032		09	371	1597	27
Avg.		4828		4410		9.30	418	1172	19.60				
ICAR FLD													
2017	10	40	6800	3600	4914	6320	3360	4390	6000	12	524	1086	18
2018	20	50	6350	4620	5496	5770	4120	5026		09	470	504	08
2019	10	20	6000	4000	4900	5360	3680	4432		11	468	1100	18
Avg.		5103		4616		10.60	487	897	14.60				

CONCLUSION

The present study of front line demonstrations produces a significant positive result and give researchers an opportunity to demonstrate the productivity potential and profitability of the recent developed technology under real farming situation, which they have advocating for long time. The results of front line demonstrations convincingly brought out that the yield of rice could be increased 10 per cent to 12 per cent with intervention on high yielding variety. From the above findings it can also concluded that use of high yielding variety of rice cultivation reduced the extension and technology gap to a great extent.

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IRC/TM-4/PP-10

CONSTRAINTS FACED BY THE FAMILY FARMS IN COASTAL ODISHA: AN EXPLORATIVE STUDY

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Family farming is a means of organizing agricultural, forestry, fisheries, pastoral and aquaculture production, which is managed and operated by a family and predominantly reliant on family labour, involving both men and women. The United Nations (UN) declared the year 2014 as International year of Family Farming to provide an opportunity to reflect on the status of family based agriculture throughout the world in relation to food security, socio-ecological sustainability and equitable economic development. Many of these smallholder family farmers are poor and food insecure and have limited access to markets and services. Their choices are constrained, but they cultivate their land and produce food for a substantial proportion of the world's population. This research study provides a detail analysis about various constraints faced by the family farmers of small family farms in eastern coastal district of Odisha.

METHODS

The study was explorative in nature and the data was collected from Balasore district of coastal region of Odisha through personal interview of 120 numbers of respondents selected through non-probability random sampling procedure, using structured interview schedule. In this study majorly four constraints were taken, socio-economic constraints, technological constraints, bio-physical constraints and institutional constraints.

RESULTS

Three major socio-economic constraints faced by the family farmers were low land holding (30%), inadequate expertise in handling new and advanced technology (28.33%), and inadequate income from this family farms (20%). The three major technological constraints faced by them were high cost of technology (41.36%), complex nature of technology (30%) and lack of on-farm trials on technology usage and application (18.33%). Three major bio-physical constraints faced by farmers were loss due to natural calamities (90%), lack of space for piggery and poultry (70.83%), and frequent occurrences of theft cases (39.16%). The major three institutional constraints were non-availability of inputs (38.33%), irregularity of getting loan facilities (22.50%) and lack of insurance coverage to the enterprise (21.66%). Various suggestions were received from the respondents to improve the existing condition of the family farmers and encouraging family farming approach to attain both food and income security of the world agricultural scenario. Three major suggestions which were received from the respondents were: (i)more economic policies and programmes should be formulated for regular financing (78.18%), (ii) partnership between urban companies with rural farmers to improve farmer's production and personal security (77.27%), and (iii) to increase availability of marketing infrastructure to avoid distress sale (72%).

CONCLUSION

At national level, there are a number of factors that are key for a successful development of family farming, such as: agro-ecological conditions and territorial characteristics; policy environment; access to markets; access to land and natural resources; access to technology and extension services; access to finance; demographic, economic and socio-cultural conditions; availability of specialized education among others. Co-ordinated extension efforts may be made to convince the rural people to practise this family farming system along with timely availability of credit and input, provision of crop insurance to all the crops and enterprises. Uplifting the status of family farming system is possible by collaborative efforts between government officials and corporate organizations and by addressing the constraints perceived by the respondent farmers.

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GENDER ROLE ANALYSIS FOR INSTITUTIONALIZING A WOMEN-CENTRIC RICE VALUE CHAIN MODEL

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Rice is the staple food of Asia and part of the Pacific. Over 90%of the world's rice is produced and consumed in the Asia-Pacific Region. With growing prosperity and urbanization, per capita rice consumption has started declining in the middle and high-income Asian countries. A population projection made for the year 2025 shows an average increase of 51%, and in certain cases up to 87%over the base year 1995. So far the annual growth rate for rice consumption in the Asia-Pacific Region over a period of 45 years (1950 to 1995) has kept pace with the demand, more through yield increase rather than area expansion. India is one of the world's largest producers of rice and brown rice, accounting for 20% of all world rice production.

Women comprise, on average, 43% of the agricultural labour force in developing countries. Women are farmers, workers and entrepreneurs, but almost everywhere they face more severe constraints than men in accessing productive resources, markets and services. This "gender gap" hinders their productivity and reduces their contributions to the agriculture sector and to the achievement of broader economic and social development goals.

Closing the gender gap in agriculture would generate significant gains for the agriculture sector as well as society for whole by increasing agricultural productivity, reducing poverty and hunger and promoting economic growth. Rice is a major diet in whole India and it can be a profitable entrepreneurship/ business for women. The main objective of the present study was to make women's work visible which they perform in value addition and also to analyze the role performance, training needs of women farmers in different activities of rice cultivation and developing a refined gender sensitive entrepreneurial model of rice value chain.

METHODOLOGY

The study was conducted in Sankilo and Tentalpur villages under Nischintakoili block of Cuttack district. The primary data was collected by interacting with women rice growers using a well-structured and pretested interview schedule. Stratified random sampling technique was adopted for the study of socio-economic status. For the study, 40 women rice farmers from 2 SHGs groups of these two villages were taken up. To minimize the errors, the quantitative data were collected in local units but later on they were converted into standard units. The major focus was on gender participation and their role performance in paddy farming. Analysis of an existing rice value chain was also done and later refined as per the findings.

RESULTS

The findings relating to role performance of women farmers showed that the involvement of women farmers was more in case of preparation of value addition products (95%), storage (92.50%), weed management (87.50%), nursery raising/sowing (65 %), transplanting (60%) andthreshing (57.50%), where the involvement of women was significantly more than men. Whereas, in procurement of inputs (72.50%), pesticide application (60%), fertilizer application (55%) and marketing (47.50%) the involvement of men was found to be more. The ranking of the training needs among the respondents showed that 'pesticide application' and 'disease management' for safe and profitable farming were ranked at the top followed by 'fertilizer application' and 'summer ploughing' which were ranked as II and III, respectively. The awareness level among the women paddy growers was highest in terms of storage, preparation of value added products, line transplanting, weed management and seed treatment with 100% beneficiaries, followed by summer ploughing by 80% beneficiaries. Interestingly the awareness on paddy varieties and disease management was the least with 62.50% and 60.00% beneficiaries, respectively.

The major findings on access to resources indicated that 70% of women respondents had access to FYM, on the contrary on 15% of women had sole access to fertilizers. Again while 82.5% of women had access to family income and savings only 10% of women had access to bank credits and expenditure in critical inputs against 52.5% of men for the same. While establishing a correlation between the dependent and independent variables, it is noteworthy that occupation was alone found to have positive relation with all the three variables of role performance, training needs and awareness level.

A modified, refined and women-centric value chain was also developed during the study for maximum benefit of the paddy growing women farmers. The chain starts form pre-production phase where the role of research organizations (central govt. state govt. and private players) have been defined in which the research organizations play the role of breeder seed provider for the seed companies. After the multiplication of breeder seeds the seed is then supplied to the WFGs (Women Farmer Groups) or farmer groups for grain production purpose in large scale. Once the production is done the WFGs (Women Farmer Groups) and farmer groups would directly sell the produce to government procuring agencies, millers and traders. The government procuring agencies and the traders thereby can again transfer or sell the produce to the millers for milling activities further only to be bought by government distributing agencies, traders and food processing industries. While the government distributing agencies through public distribution system make it reach to the end user i.e., the consumers, the food processing industries through their retail chain market reach the product to the consumers and the traders indirectly reach the consumers through open retail market which further goes down to small shops and outlets before reaching the consumers. This value chain provides a win-win situation for every stakeholder. While the information flow is also very crucial which first flows from the consumer side creating demand and reaches to the research organizations for consumer specific breeder seed and thus consumer specific end product reaches the consumer ensuring fair an profitable business for all the stakeholders and also avoiding unusual unforeseen losses from over stocking at the retail and market level.

CONCLUSION

The role of female farmers in field is same as men except transport and procurement process. There is joint involvement in access of resources, credit and others but control of men was more over them. Women farmers were fully aware of summer ploughing,time line of fertilizer application and stages of value addition as these were ranked highest among the awareness level ranking followed by suitable variety of paddy for their location but least aware about the critical periods and dough stage of paddy cultivation.

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ON FARM DEMONSTRATIONS TO TEST THE EFFICACY OF HERBICIDES IN DIRECT SOWN PADDY WITH EIGHT ROW DRUM SEEDER

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In Telangana state rice is the major food crop grown in an area of 14 lakh ha during *kharif*, with an average productivity of 3277 kg ha^{-1}. Decreased availability of water, late receipt of rains and increased production costs are the different kinds of problems faced by the farmers. As a result, the farmers in the state are shifting from manual transplanting to direct-seeded rice systems. But in direct-seeded rice, weeds are the number-one biological constraint to the production. Weeds equally compete with the crop plants and reduce the yields. One of the major causes for low yields of direct seeded puddled rice is inadequate weed control measures. The competition is more severe in direct seeded rice, as crop and weeds emerge simultaneously starting from early period of growth of crop and in turn cause reduction in the rice yield. The yield loss due to weeds varied from 40 to 100% in direct seeded rice (Choubey et al., 2001).

METHODOLOGY

On farm evaluation trials were conducted during *kharif*, 2013 in farmer's fields to assess the best pre emergence herbicide for the effective control of weeds under direct seeding with eight row drum seeder. In five different villages and mandals i.e., Puppalaguda village of Rajendranagar, Jaganguda of Shamirpet, Kummera of Chavella and Ethbarpally of Moinabadmandals of Telangana state. The fields in different locations were thoroughly puddled, perfectly leveled and entire water from the field is drained out of the field a day prior to sowing. The treatments consist of three different kinds of herbicides viz., T1- Pyrazosulphuronethyle 80-100 g/acre, T2-Pretilachlor with safener @ 600 ml/acre T3: Oxadiargyl @30-40 g/acre. All the herbicides are applied 3- 8 days after sowing. The crop was fertilized with 120 kg N, 60 kg P_2O_5 and 25 kg zinc sulphate/ha. Full dose of P_2O_5 and zinc sulphate and one third dose of N were applied at the time of sowing, whereas the remaining N was top-dressed in 2 equal splits at 30 and 50 days after sowing (DAS). The crop was irrigated as and when required to maintain the wet condition in the field. The yield attributes were recorded to know the efficacy of the herbicides under directed seeded conditions.

RESULTS

The weed flora identified in the farmers' fields across the district was *Echinochloacolona,Cyperus iria, Alternatherasessilis, Commelinabenghalensis, Eclipta alba* and*Dactyloctenounaegyptium* Among the grassy weeds *Echinochloacolona*was the most dominant species which constitutes about 20% of the total weed flora. All the herbicides are effectively managed different weed flora and reduced the density and intensity of the weeds. Since, it is an on farm trial, weedy check was not maintained and comparative evaluation between the treatments was done by taking into account the yield attributing characters and yield of rice.

All the treatments influenced the yield and yield attributing characters of the rice crop the highest no of panicle/ m^2, no. of grains per panicle and grain yield were highest (2450 kg/acre) with application of Pyrazosulphuronethyle @ 80-100 g/acre at 8-10 DAS.

Table 1. Effect of herbicides on yield and yield attributes and grain yield of direct seeded rice(average of 5 locations)

Treatment	Dose (ml/acre)	No. of panicles/m^2	No. of grains/ panicle	Grain yield (kg/acre)
Pyrazosulphuran Ethyle	80-100	236	170	2450.0
Pretilachlor	600	225	158	2300.0
Oxadiargyl	30-40	215	136	2240.0

While the lowest yield was recorded with application of Pretilachlor. Similar kinds of results were reported by Dixit et al. (2008). It can be concluded that herbicide usage is very important where there is a morphological similarity between weeds and rice, especially in a direct seeded crop. Though there are, various kinds of pre-emergence herbicides available in the market and all are giving promising results in the farmers' fields. Among the different kinds available application of PyrazosulphuranEthyle @ 80-100 g/acre at 8-10 days after sowing found to be effective in controlling weeds.

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Theme - IV : Rice for livelihood security, equity and profitability
IRC/TM-4/PP-13

SUSTAINABILITY OF QUALITY SEED PRODUCTION THROUGH FARMERS' GROUPS: A CASE STUDY

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In the context of agricultural development, a major concern is that good quality seed of improved varieties are not always readily available to farmers. By 2050, country need to double its production of food to meet the diversified and ever increasing demand. development of new varieties is essential to enhance the production and productivity of crop, similarly, the adoption and replacement of varieties (VRR) is associated with seed replacement rate (SRR) is important for current increasing population demand (Singh, 2015). As a result, varietal performance and productivity has gradually declined. Decentralized distribution of seed can lead to the availability of good quality seed to farmers and boost total production and therefore increases the food self-sufficiency, keeping other production factors constant, by increasing the seed and VRR (Joshi, 2001).

Apart from government institutions, there are farmers' groups or organization who were also involved in the seed business (seed production and marketing). Strengthening and sustaining these farmer's groups or organizations could aid in meeting the local demand as well as supply quality seed to fulfil the national demand. There is always a doubt with farmer skills and their abilities to produce quality seed which had been one of the limiting factor for the production and supply of seed besides poor market infrastructure is another limiting factor, although some farmers' groups have been successful in producing and marketing the quality seed. One such good example is the farmers' group of Rajawaram village in the Warangal District of Telangana. The Rajawaram farmers club of Rajawaram village of Ghanpurmandal, is one of the better-known independent seed producing group. Technical and financial support for seed production to the group is provided by the Agricultural Department of Telangana and Regional Research Stations under Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad. An exercise was made to determine the effectiveness and sustainability of the quality seed system in the seed business through the medium of farmers' groups. The strength and weakness of farmers' group involved in the seed business were also assessed.

METHODOLOGY

A meeting was organized for in field for discussion regarding the seed study. A focus group discussion was carried out with members of the Rajawaram farmers club and seed-producer farmers to collect relevant information. Neighbouring farmers were also interviewed to verify the information collected. Other organizations, such as State Agricultural Department were also contacted to gather relevant information on any technical and financial support they provided. Secondary data (e.g. from reports) were reviewed. Visit was made to the study area to directly observe farmers' group activities and for informal discussions with the members of the group on telephone.

RESULTS AND DISCUSSION

Group formation andmobilization

The Rajawaram farmers club was formed initially with a Group of 15 members in the year 2016 and the farmers of the village was motivated by the State Agriculture Department with the idea of quality seed production and increase their income besides being self-sufficient in the seed availability. They got trained in improving the quality in terms of germination and genetic purity. The Farmers club was legally registered under MAX society of the district in the year 2018, and were mobilized and formed into FPOs of 500 members with the support of NABARD in the year of 2019. The members of the group formed a committee and shareholder membership was provided to those who met certain criteria. The group raised funds through various means. Few of them are procuring paddy and from the village farmers and providing fertilizers and pesticides by getting license. Charging entry fees (initially Rs.500 per member and later increased to Rs.2000) of members, commission from seed sales, etc. Foundation seeds of KNM 118 variety were produced and marketed followed by breeder seed production of rice varieties such as RNR 15048.

Supports in the form of technical backstopping, training and seed assistance to the group were provided by; PJTSAU and Research stations, the District Agriculture Development Office, Warangal, State Agriculture officers and Seed Village Programme, Seed certification agencies, Primary Agriculture Cooperative Societies of district, and the Markfed, IFFCO and Mahindra seeds Private Ltd., JVRDS (Janavikas Rural Development Society) (NGO), etc.

Evaluation of the costs and benefits

The seed producers' group of Rajawaram obtained a good return from the seed business. However, the cost of production was also higher because of the high quality of the seed and lower levels of mechanization in production, supervision, cleaning and grading. In addition, the group had developed its own identity in seed production and management (tagging, bagging etc). The group had its own fund to provide future procurement centers for paddy and seed processing units to aid farmer in the village. Group members fixed the price on the basis of the actual costs of production, grading, storage and marketing. In the year 2018-19, quantity of seed sold under the Rajawaram Farmers club was 368 qtls. With sale price of Rs. 3,600 per qtls. (Rs.900 per 25 kg bag), the gross amount earned was Rs.13,25,800 with cost of cultivation for one acre as Rs.27,616, this group in the year 2018-19, seed produced for 16 acre, therefore the cost of cultivation was Rs.4,51,616. The Net profit for the year was Rs. 8,75,184

There are few strengths of the group like: the members were well-trained in technical aspects of seed production and management, the group had developed its own identity in seed production and management (tagging, bagging with logo) and the group provided aid for other farmers in the village in seed production. Likewise, there are weakness also likefarmers often have insufficient cash to purchase inputs, including seed from the market because of high prices. Lack of mechanization in seed production, transportation, profit percentage of middle-men/ all increase the price of seed beyond the purchasing power of ordinary farmers.

CONCLUSION

The Rajawaram farmers club was successful in producing, managing and marketing of quality seed, and was running smoothly. The main reasons for its success were the constant technical and financial support from government offices and other external agencies with which the group had strong links. The group placed great importance on the quality of seeds produced in terms of seed purity, vigor and germination. The best results were with the production of rice seed due to the higher demand, effective marketing channels, seasonal advantage and quality of seed production. The group had, therefore, placed more emphasis on seed production of rice than on other food grains. However, low purchasing capacity of group sometimes was the limiting factors for rice seed production and supply.

Although the group had strong links with government and nongovernment institutions, communication with private seed agencies was seemed to be week. Hence, farmers club needs to develop better communication between farmers and linkages with the private sector for effective seed marketing. Further, the group was marketing most of the produce; it had not conducted a proper market survey of seed requirements. They need to do this in order to identify which crops, varieties and in what quantity were sold/ purchased by other agencies in one year.

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IRC/TM-4/PP-14

DEEP WATER RICE VARIETY: A BOON FOR FLOOD PRONE AREAS OF ASSAM UNDER CHANGING CLIMATE

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As per the climate change projection for India up to the year 2100, there will be an overall increase in temperature of 2-4^0 C with no substantial change in precipitation. However, the spatial and temporal variation of precipitation will also be observed in the coming decades (Kavikumar, 2010). This change will impact all the dimensions of natural and human interventions. Among all, agriculture of entire country is going to be highly affected due to its closeness to climatic parameter. As far as Assam is concerned, the composite vulnerability index of Assam is 0.72, which ranks them the most vulnerable state in the Indian Himalayan Region to climate change. The geographic position of Assam is such that more than 40% of land surface of state is susceptible to flood damage (Deka *et al*, 2013). The climate change made it more serious as over the years the state has been experiencing an increased number of precipitation driven flash floods and long duration floods. Rice being the staple food crop of the state, occupying 2.54 mha of the gross cropped area of 4.16 mha (61% of the gross cropped area) and contributes 95.51% of the total food grain production of the state. The changing climate is also threatening the sustainable production of paddy to feed the ever increasing population. But, deep water paddy can sustain the water stagnation up to fifteen days and is the only crop giving some economic relief to the flood prone poor farmers. Substantial rice growing areas of the state are very low-lying where no other rice except *baodhan* (deep-water and floating rice) can be grown, whichcan withstand submergence up to 3- 4 meter water depth in low lying areas with water stagnation beyond 50 cm for more than a month in the season. The *bao* rice varieties are known to rich in mineral contents, but the productivity is low (1.6 to 3 t/ ha). Enhancing rice productivity in these areas requires demonstration of suitable varieties that can withstand flash floods and support climate resilient agriculture. Keeping in view the above facts, Krishi Vigyan Kendras under Assam Agricultural University, Jorhat under the guidance of ICAR-ATARI, Guwahati has demonstrated stress tolerance rice varieties for enhancing the adaptive capacity of farmers to flood hazards under NICRA since 2012.

METHODOLOGY

Assam is located in the tropical latitudes of 24^{0}08´ N to 27^{0}59´ N and eastern longitudes of 89° 42´ E to 96° 01´ E. The Brahmaputra in the northern part and the Barak flowing through the southern margins of Assam along with their numerous tributaries are the main river systems that have created a very dynamic and powerful hydrologic regime in NE India causing flood.Considering the major contingencies 'flood' during *kharif* season, different climate resilient rice varieties such as submergence tolerant Ranjit *sub1*, Bahadur *sub1*and Swarna *sub1* were demonstrated in the farmer's field according to different agro-ecological situations of Assam under NICRA since 2012. The performances of these varieties and farmers adoption were observed. Weather parameters were recorded based on secondary data and analyzed as per standard procedures.

RESULTS

The results indicated that the submergence tolerant rice variety 'Swarna *sub1*' can tolerate submergence condition up to 13 days with an average yield of 44.42 q/ha, which was up to 27.93 per cent higher over that of local variety. The variety was demonstrated in 387.89 ha covering 1012 farmers of 11 districts of Assam. Data of rice variety 'Ranjit *sub1*' demonstrated in 16 districts covering 2640 farmers in an area of 1090.71 ha and recorded an average yield of 47.09 q/ha, which is 29.31 per cent higher over local varieties. Another submergence rice variety 'Bahadur *sub1*' was demonstrated in 528.81 ha covering 1452 farmers of 13 districts of Assam. It has been observed 26.30 per cent increased in yield over local varieties with an average yield of 46.77 q/ha. Farmers could earn a net return of Rs.30304, Rs.35643 and Rs.34264 per ha with a benefit to cost ratio 1.76, 1.92 and1.89 in case of rice variety 'Swarna *sub1*', 'Ranjit *sub1*' and 'Bahadur *sub1* 1', respectively.

CONCLUSION

Withchanging climate, extreme events are likely to increase in the country in general and in the north eastern region in particular resulting into more drought and floods. Floods during the entire *kharif* season hinders in achieving achievable yield and production threatening food security of majority of small and marginal farmers of the state (85%). To enhance the resilience to agriculture in flood affected and submergence prone area, high yielding rice varieties with certain specialties like'Swarna *sub1*', 'Ranjit *sub1*', 'Bahadur *sub1*' could be introduced which will certainly be adopted by farmers as per their agro-ecological situations.

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TREND ANALYSIS OF RICE PRODUCTION IN ODISHA

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Rice is the major crop of the Odisha state. It is fifth largest rice producer state of the country contributing 6.64% of rice production. It ranks third in rice area only after West Bengal and Uttar Pradesh occupying about 9% rice area of the country. During last 25 years rice production in Odisha increased only 1.17 times, while rice area decreased to 0.85 times its area. As major workforce of the economy of the state is engaged in rice cultivation for their livelihood and rice area is reducing day-by-day; higher growth of rice yield is vital for the state. The quantitative assessment of the contribution of different factors of agricultural output growth is important for reorienting the programmes and prioritizing the agricultural development. Hence, a study was undertaken to estimate the growth rate of area, production and yield of rice in the districts of Odisha state and to decompose the rice production into area, yield and their interactions.

METHODOLOGY

The district wise data of Odisha state from 1993-94 to 2016-17 was collected from Directorate ofEconomics andStatistics,Department ofAgriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India. The data has been categorized into three periods viz. 1993-94 to 1999-2000, 2000-01 to 2009-10, 2010-11 to 2016-17 and one overall period i.e. 1993-93 to 2016-17 to estimate the growth rate and decomposition of production growth into area and yield effect.

The growth rate of area, production and yield for the districts of Odisha for each period were computed using the following compound growth model.

$$Y = ab^t$$

$$\text{Log } Y = \log a + t \log b$$

$$CGR(r) = [\text{Antilog}(\log b) - 1] \times 100$$

where,

CGR = Compound growth rate

t = time period in year

Y= area/production/productivity

a and b = Regression parameters

To measure the relative contribution of area and yield to the total output change for the major crops, the following decomposition model (Minhas,1964) was used.

$$\Delta P = A_0\Delta Y + Y_0\Delta A + \Delta A\Delta Y$$

Change in Production = Yieldeffect+ Area effect+ Interaction effect

where,

$P_n - P_o = \Delta P$, $A_n - A_o = \Delta A$ and $Y_n - Y_o = \Delta Y$

A_0, $P_0$and $Y_0$are therespectively area, production and productivity in base year and A_n, $P_n$and $Y_n$are values of the respective variablein nthyear:

Thus, the totalchange in production can be decomposed into threecomponents i.e. yieldeffect,area effect and theinteraction effectdue to change inyieldand area.

RESULTS

The growth rate of area under rice for most of the districts was negative. During period II, growth rate of 16 districts were negative which increased to 22 during period III. But during overall period, only 10 districts showed negative growth rate for area. The lowest growth rate for area was observed in Ganjam district during period I and highest was observed in

Puri during period I and Boudha during period IV. The production growth rate of all the districts was negative during period I except for four districts Nawarangpur, Phulbani, Rayagarh and Sambalpur. In growth rate for production was positive in other period for all the districts except Gajapati in period II and Gajapati, Jajpur and Phulbani during period III. The highest growth rate for production was found in Deoghar during period III and lowest was found in Ganjam during period I. The growth rate of yield was negative for most of the districts during period I, but it was positive for all the districts during other periods II, III and overall period IV. The highest growth rate for yield was observed in Angul during period III and lowest was observed in Kendrapada during period I.

During period I, yield in all districts and state contributed positively for rice production, while the contribution of area and interaction were negative for some districts. In all districts yield contributed positively except for Balasore and Jharsaguda during period II, Kalahandi and Bargadh during period III and Puri during overall period IV. The decreasing trend was observed for the districts in which area contributed positively for rice production. Number of districts decreased during each period from 25 in period I to 5 in period IV. Similar decreasing trend was observed for interaction effect also in the contribution of rice production. The districts contributed positively reduced from 19 in period I to 5 in period IV.

CONCLUSION

The rice area in Odisha was observed to be reducing day by day over the last few year so some steps are required to contain the decreasing trend. The study indicated district-specific direction of changes in area, production and productivity, which can be used as a base for crop planning for individual district as well as Odisha as a whole. The existing policies can also be reoriented as per the requirement of the rice stakeholders of the Odisha state.

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Theme - IV : Rice for livelihood security, equity and profitability
IRC/TM-4/PP-16

EMPOWERING WOMEN FARMERS THROUGH CLIMATE RESILIENT RICE CULTIVATION PRACTICES TO ACHIEVE SDGS AND COMBAT CLIMATE CHANGE

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Women farmers in Telangana state, India, constitute a formidable agricultural work force of 64.5%, comprising of agricultural labour (48.14%) and women cultivators (16.43%) as per Census Report (2011). Rural women are critical to the success of almost all the 17 Sustainable Development Goals (SDGs). The immense role of women farmers in agriculture can help reduce poverty and achieve SDG1. Technological empowerment of women farmers would help to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture (SDG 2). Enabling women farmers' access to skills, tools, inputs, and knowledge will help in attaining quality education (SDG 4). Gender equality, (SDG5) could be achieved through equal access to and use of resources to produce food and reduce global hunger. Knowledge and adoption of water saving technologies in agriculture could enable the women farmers to contribute to the SDG 6.Dissemination of energy efficient agriculture practices, direct seeded rice, cultivation of crops for biofuels and laser land leveller etc. can help achieve the goal of affordable and clean energy (SDG 7). Moreover, empowering women farmers can enable the achievement of decent work and economic growth (SDG 8). Training in water and energy saving practices in crop cultivation and responsible consumption and production practices to reduce waste could enable women farmers to contribute towards the SDG 12.The SDG 13, to combat climate change and its impact could be achieved through the adoption of climate resilient rice cultivation practices like system of rice intensification (SRI).The objectives of the study were to identify the extent of participation of women in SRI, analyse the problems in adoption of SRI and to conduct training programs for imparting knowledge and skills in adoption of SRI. The knowledge networks of women farmers were targeted as focal points for dissemination of SRI practices in rice cultivation. Institutional and peripatetic training programs were organized for women farmers for imparting knowledge and skills in adoption of SRI.

METHODOLOGY

Gender disaggregated data on participation in cultivation of rice through the System of Rice Intensification (SRI) method was collected from 261 farmers of thirteen villages in YadadriBhongir, Jangaon and Siddipet districts of Telangana State. The district and farmers were selected purposively as SRI was being promoted by an NGO, BLESS in these villages. Semi structured interview schedule was used to collect data from farmers.Two focus group discussions(FGDs) were conducted to verify the survey data.The household survey and FGDs were conducted during 2017/ 2018.The operations in SRI cultivation method were listed and the farmers were asked to indicate against each operation their participation and a score of 1 and 0 for participation and non-participation were assigned.Training needs assessment for successful implementation of SRI was also undertaken. A ranking exercise was done to identify the major problems faced by farmers in adopting SRI. Respondents were asked to grade the problems on a three-point continuum of 0-3(0-no problem, 1- low, 2- moderate and 3-major) and the problem confrontation index (PCI) was worked out as follows.

$$PCI = Pn x\ 0 + Pl\ x\ 1 + Pmo\ x\ 2 + Pma\ x3$$

PCI = Problem Confrontation Index;

Pn = Number of respondents who graded the constraint as no problem;

Pl = Number of respondents who graded the constraint as low;

Pmo = Number of respondents who graded the constraint as moderate*;*

Pma= Number of respondents who graded the constraint as major.

RESULTS

The findings of the study indicated that the operations *viz.* nursery bed preparation (77.8%), seed selection (93.5%), irrigation management (95.7%), fertilizer application (96.5) and weed management (61.3%) were being carried out extensively by male farmers. Activities like, single seedling selection (93.8), transplanting (97.4), gap filling (98.5%) and harvesting (81.9%) were being carried out by women farmers. Weeding in rice is predominantly carried out by women farmers but in SRI system, mechanical weeding by cono-weeder was being undertaken by male farmers, endorsing the fact that mechanized tasks are mostly taken over by male farmers.The women farmers expressed the training needs for adoption of SRI as, selection of young seedlings (89%), square planting (76%), transplanting single seedlings (72%) and use of mechanical weeder (34%). Based on the training needs assessed both institutional and peripatetic training programs were organized for imparting skills in the adoption of SRI practices. The problem confrontation index analysis indicated the ranking of problems in SRI adoption as high labour requirement(1), highly skilled activities(2),high labour costs(3), high input cost(4),time consuming(5) and unwilling labour(6) as the major problems in adopting SRI method of rice cultivation.The SDG 13, to combat climate change and its impact could be achieved through the adoption of climate resilient rice cultivation practices like system of rice intensification (SRI). The cultivation and promotion of SRI can be targeted through women's knowledge networks and collective actions through SHGs and FPOs.

CONCLUSION

The participation of women in the critical operations of SRI is very high and they expressed the need for training in selection of young seedlings, square planting and transplanting single seedlings and use of mechanical cono-weeder.It is highly imperative to train farm women in different aspects of SRI method to build their knowledge and skills to ensure widespread adoption of SRI. It is also necessary to conduct intensive training programs for imparting skills in these activities of SRI. The major problems in adoption of SRI were related to the labor. Therefore, the essential requirement in SRI promotion is incentivizing the farmers and labor to shift to a new method of rice cultivation. There is a need for policy intervention to promote SRI as a climate resilient practice for saving labor water and energy. Therefore, empowering women farmers to adopt climate resilient rice cultivation practices would enable the achievement of SDGs and ensure food and nutritional security. The creation of a highly skilled women-SHG-task force for promotion of SRI needs to be promoted for widespread adoption of SRI.

IRC/TM-4/PP-17

THE CRITICAL CHALLENGES AND BENEFITS ASSOCIATED WITH SUSTAINABLE DEVELOPMENT OF AGRICULTURE BY NATURAL FARMING: AN EMPIRICAL STUDY IN ODISHA

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India has been witnessing a blinding pace of growth and development in recent times. Recently pandemic Covid 19 situation has taught the world that all progress can stop if agriculture stops. In the last few years, the Indian economy has emerged as one of the fastest growing economies in the world. However, the vulnerability of the Indian economy with respect to the performance of the agricultural sector despite other macroeconomic indicators and sectors gaining in strength is well known. Over the past two decades, there has been an increasing awareness of the potential damages that climate change, air and water pollution and inadequate natural resources management could induce upon human health, natural ecosystems and the economy. To address these concerns, considerable emphasis has been placed on sustainable development by many countries and international organizations. Accordingly, sustainable agricultural development has become a major issue of the 21st century.

Odisha is primarily an agrarian economy having nearly 30% contribution to the Net State Domestic product (NSDP) with 73% of the work force engaged in this sector. The cropped area is about 87.46 lakh hectares out of which 18.79 lakh hectares are irrigated. Climate and soil play a vital role in Odisha's agriculture economy. The total cultivable land exploited for cropping is about 40% of the total geographical area and the exploitation is comparatively more in the coastal districts of Odisha, that is, Balasore, Bhadrak, Cuttack, Ganjam, Jajpur, Jagatasinghpur, Kendrapara, Khurda, Nayagarh and Puri.

With the accelerating population growth, diminishing arable land surface, especially in developing countries, declining non-renewable energy supplies and an increasing awareness of potential environmental degradation, there is now much greater demand for sustainable management in the agricultural sectors of the world's economies.

In particular, agricultural production is highly dependent upon weather, climate and water availability, and sustainable agricultural development needs to incorporate weather and climate information in order to be most effective. In addition, weather and climate information are critical for real-time monitoring and long-term risk assessment of natural disasters, such as droughts, floods, grassland and forest fires, severe weather and tropical cyclones, which can induce very strong impacts on natural and environmental resources.

We can grow healthy food without depending too much on toxic chemicals and chemical fertilizers with Natural Organic and Biological Farming systems. We also encourage the adoption of the latest improved technology and farming systems that are environmentally and ecologically friendly. We encourage farmers to adopt practical Integrated Pest Management (IPM). There is a worldwide shift for safe, chemical free food and a demand for organically grown food crops. The alarming increase in the use of toxic chemicals to control pests and diseases on both farm animals and plants has endangered the environment and reduce bio diversity as well as the health of consumers.

METHODOLOGY

It is an exploratory study, as it has focused on particular aspects or dimensions of the problem studied. Convenience sampling method has been used to select 481 respondents and both qualitative and quantitative information have been collected from them.

RESULTS

There are many benefits of sustainable agriculture, and overall, they can be divided into human health benefits and environmental benefits. In terms of human health, crops grown through sustainable agriculture are better for people. Due to the lack of chemical pesticides and fertilizers, people are not being exposed to or consuming synthetic materials. These limits the risk of people becoming ill from exposure to these chemicals. In addition, the crops produced through sustainable agriculture can also be more nutritious because the overall crops are healthier and more natural.

Sustainable agriculture has also had positive impacts of the environment. One major benefit to the environment is that sustainable agriculture uses 30% less energy per unit of crop yield in comparison to industrialized agriculture. This reduced reliance on fossil fuels results in the release of less chemicals and pollution into the environment. Sustainable agriculture also benefits the environment by maintaining soil quality, reducing soil degradation and erosion, and saving water. In addition to these benefits, sustainable agriculture also increases biodiversity of the area by providing a variety of organisms with healthy and natural environments to live in.

CONCLUSION

The concept of sustainable agriculture is somewhat vague and ambiguous in its meaning, which renders its use and implementation extremely difficult. In this research, we aim to understand the innovations in natural farming through sustainable agriculture development from a social science and governance perspective by identifying areas of complementarity and concern between emerging definitions of sustainable agriculture. There is need to integrate paradigms and conceptualization of sustainable agriculture demands that knowledge is integrated between scientific disciplines. Indeed, such integral solutions address a range of different challenges all at once instead of seeking different isolated solutions for single aspects.

IRC/TM-4/PP-18

RICE RESEARCH IN INDIA: ASCIENTOMETRIC ANALYSIS OF RESEARCH OUTPUTS DURING 2000-2019

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Scientific performance is essentially a multidimensional concept which can be measured by various indicators. Publication has been the one of the most important indicators for measuring the research performance. The study analyses the research outputs related to rice from India during 2000-2019 on different parameters including growth, global publication share, authors, institutions, and pattern of research communication in most productive journals. SCOPUS Citation database has been used to retrieve the data for 20 years (2000-2019) by searching relevant keywords. A total of 18767 papers published during the period 2000-2019 were downloaded and analysed.

The publication productivity has recorded 5 fold increases during 2000-2019. From merely 380 papers in 2000, it has gone up to 1830 papers in 2019. The growth of publication output in this field was low during the period 2000-2004. But since 2005, an exponential growth was observed which indicating sustained impetus received for rice research during 2005-2019. Among the top 10 most productive countries in the rice research, China and USA remain the first and second position, India ranks 3rd with 18676 papers with global publication share 13.31%. Ninety percent of the papers were research articles, whereas reviews, conference papers, book chapters, notes, letters- etc. constitute the rest. ICAR-IARI published the highest number of papers (1440) followed by ICAR-NRRI (859 papers), Punjab Agricultural University (849 papers) and Tamil Nadu Agricultural University (665 papers). SCOPUS H-index of major R & D institutes were also worked out. IRRI got the highest h index (73) followed by ICAR-IARI (70) and Punjab Agricultural University (57). Indian Journal of Agricultural Sciences emerged as the most preferred journal by the researchers with 640 papers. This is followed by Indian Journal of Agronomy with 492 papers, Current Science with 272 papers, Plant Archives with 229 papers and Journal of Food Science and Technology with 215 papers, respectively. In terms of the NAAS Score (IF) for the current year (2020), Field Crop Research has got the highest NAAS Score (9.87) followed by Journal of Food Science and Technology (NAAS Score 7.85) and Current Science (NAAS Score 6.76), respectively. The highly cited publications and funding sponsors have also been identified.

SYSTEM OF RICE INTENSIFICATION (SRI) – AN EMERGING ALTERNATIVE TO TRADITIONAL RICE CULTIVATION METHOD IN TRIPURA, INDIA

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Rice is the principle crop of Tripura, which plays a significant role in improving food security in North-Eastern states of India (Harish et al., 2018). The area under paddy in Tripura occupies 78.1% of the cultivated area with major rice growing seasons being April to June *(Aush)*, July to November *(Aman)* and December to March *(Boro)*. However, increasing trend of cost of cultivation calls for special efforts to adopt innovative alternative rice production methods, which can use the limited resources efficiently and produce more from the same piece of land (Choudhary and Suri, 2018). Under these circumstances, the SRI may be an appropriate practice to produce more food with fewer inputs. Though farmers adopted rice cultivation through the SRI method in the state, the practice is new and some farmers still using the conventional method of rice cultivation. The fact that the SRI techniques requires very less water and less seed in comparison to the traditional method which reduced costs to a significant level that attracts the farmers primarily. The SRI practices known as 'more from less' is articulated as: *Beej kam, saarkam, jalkam, aushadhkam, kharchakam, phalanbishi, aaybishi* (reduced quantity of seed, fertilizer, water, pesticides, costs, with increased output and income).The state government has also played a very decisive role in influencing farmers to adopt the SRI method for rice cultivation. They have brought about many demonstrations and schemes for the farmers so that they can enhance their knowledge upon every minute details of the SRI method. An attempt has been made to assess the SRI technique in terms of profitability over traditional methods of rice cultivation.

METHODOLOGY:

A multistage random sampling technique was employed to select the ultimate sample unit, the rice farmer. Samples of 120 units were selected fromNalchar, Bishalgarh, Boxanagar and Mohanbhogblocks of Sepahijala districts. Data collected through a primary survey of the respondents on entire farming activities using a structured interview schedule. Suitable statistical methods were used to analyze the data like calculation of compound growth rate, use of various costs concepts, fitting and estimation of Cobb-Douglas production function and logit regression model.

RESULTS:

The results of the study revealed that there was significant growth in area, production and productivity of rice under SRI in the state. The main product and by-product obtained in SRI method was 72.33 q/ha and 18.08 q/ha, respectively, whereas, in the traditional method, these were 42.11 q/ha and 10.52 q/ha, respectively. Cost A, Cost B, and Cost C for SRI method were Rs.27474, Rs.59756 and Rs.60421, respectively and the same were recorded as Rs.29077/ha, Rs.47872/ha and Rs.49039/ha, respectively in the traditional method. The gross return and net return in SRI wasRs.122969/ha and Rs.62549/ha, respectively and the return over cost (based on gross return) over total costs (Cost C) was 2.03. The gross return and net return for the traditional method was Rs.71591/ha and Rs.22553/ha, respectively and the return over cost (based on gross return) over total costs (Cost C) was 1.46.

An analysis of the impact of the production variables on rice productivity revealed that human labour, machine labour, fertilizers, plant protection chemicals, irrigation and farmyard manure were found to have a highly significant and a positive impact upon the gross return of rice production both under SRI and traditional method. A logistic analysis showed that the age of the respondents and land holding, had a negative impact, whereas the literacy level, number of extension contacts and occupation had a positive effect on the adoption of SRI.

CONCLUSION:

The study concludes that SRI has a tremendous potential to increase the production of rice. It has got dual advantages for the marginal farmers i.e. reduced costs and increased returns. Moreover, the adoption of this technique by the farmers would give them higher yields, which in turn will help them to earn more and improve their socioeconomic situation. Further, to increase the adoption rate of SRI techniques in the states, the government should provide more appropriate policy measures such as awareness campaign, capacity building programmes and input subsidies to farmers.

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 IRC/TM-4/PP-20

ENHANCING CROP PRODUCTIVITY AND FARMERS' PROFIT INRICE BASED PRODUCTION SYSTEM: A SUCCESSFUL CASE STUDYOF NRRI FARMER FIRST PROGRAMME

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The Farmer FIRST Programme of ICAR-NRRI, Cuttack started in 2016-17 by adopting four villages of Salipur block in Cuttack district of Odisha with the aim of increasing productivity and profitability of rice based cropping system. Need based technological interventions were undertaken through four modules, namely, (i) crop-based module (rice, pulses, mechanization), (ii) horticulture-based module (vegetables, fruits, poly house), (iii) animal husbandry-based module (poultry, duckery& fishery) and (iv) enterprise-based module (mushroom, vermi-composting). Crop-based module (rice, pulses, mechanization) is extensively adopted among the farmers as majority of them follow rice based cropping pattern. Various package demonstration of new improved rice varieties suitable for the local ecosystem were conducted and the impact of technological interventions in terms of increment in crop productivity and profitability were assessed.

METHODOLOGY

In the adopted village cluster,four villages namely, Biswanathpur, Satyabhamapur, Laxminarayanpur and Ganeswarpur of Salipur block, Cuttack district, Odisha were selected purposively for undertaking the ICAR-sponsored Farmer FIRST Programme since November, 2016-17 by adopting over 800 farm families from among the 1800 odd farm families in the cluster. The region is mostly dominated by rice and has a major hold among thefarmers of selectedvillage cluster. Therefore, the most important and comprehensive project interventions undertaken included: (a) introduction of high yielding and hybrid rice varieties including package demonstration, (b) mechanization of rice farm, (c) introduction of high yielding varieties in rice-pulse cropping system, and (d) capacity building through training, demonstration, field days and farmers meets. Information collected from the beneficiary farmers on adoption of technologies and profitability of rice-based cropping system and analysed.

RESULTS

Adoption of introduced high yielding and hybrid rice varieties

Introduction of high yielding and hybrid rice varieties among the rice farmers of the four adopted villages was conducted through varietal demonstration of over 25 newly released rice varieties including two hybrids suitable for different ecologies with complete package of practices. Field demonstrations were conducted for three years (2017-2019) during wet seasons involving over 450 selected rice farmers of the four adopted villages. Significant demonstrated varieties included CR Dhan 304, CR Dhan 307 (Maudamani), CR Dhan 409 (Pradhandhan),and hybrids like Rajalaxmi& CR Dhan 701. The crop cutting results showed an average grain yield advantages of 20-30% over the popular varieties like Swarna, highest being for CR Dhan 307 (Maudamani) with 63% yield advantage. As critical inputs, farmers were provided with seed minikits of about 10 kg and partial amount of fertilizers and pesticides. Based on the findings of baseline survey, they were trained and motivated particularly in seed treatment, nursery management, line transplanting with young seedlings, fertilizer management, seed production technologies for producingquality seeds for future use and post-harvest technologies. Other interventions included application of need-based pesticides, seed treatment with bio-agents, pest monitoring and surveillance using pheromone traps, tricho-cards &bracon cards, nitrogen management with NRRI-developed customisedleaf colourchart (CLCC), green manuring with sesbania (*dhaincha*), training and capacity development programmes,continuous monitoring and technical backstopping.

Mechanization of rice farms

Mechanization of rice farm was conducted through extensive training-cum-demonstrations programmes on over 20 different types of implements like 8-row power operated mechanical rice transplanter, raising mat-type nurseries on trays & cemented floors for rice transplanter, 8-row tractor driven fertilizer-cum-seed drill, 6-row drum seeder, finger weeder, cono-weeder, power tiller with cage wheel, power reaper, power thresher-cum-winnower, manual pedal thresher, rice husk combustor, rice parboiling unit, battery-operated power sprayer and Knapsack sprayers. Mechanization of rice farms helps in reducing the cost of production and drudgery among farmers and thereby effectively reducing the farm operational time.

Adoption of high yielding varieties in rice-pulse cropping system

High yielding varieties of pulses namely, black gram (var. PU-31, IPU-02-43) and green gram (var. IPM-02-03) were introduced in the less-favourable rice-fallow areas and in the rice-pulse cropping system to make use of residual soil moisture after *kharif* rice, for additional income and maintaining soil health. Theaverage yield of black gram(var. IPU-02-43) in adopted villages was found to be 6.27 q/ha against the local check of 4.35 q/ha with the increment of 44.14%, while the average yield of green gram(var. IPM-02-03) in adopted villages was found to be 4.85 q/ha as against the local check of 3.80 q/ha with 27.63% increment.

Table 1. Average net returns over inputs from rice cultivation during pre and post FFP period

	Items	Pre-FFP period (2016-17)	Post-FFP period (2018-19)	Change	% Change
A. Inputs (Rs./ha)					
1.	Seed*	1000	0	-1000	-100.00
2.	Fertilizer	3990	2980	-1010	-25.31
3.	Agricultural operation	15630	3310	-12320	-78.82
4.	Machinery(tractor and thresher)	3500	3100	-400	-11.43
5.	Marketing	2000 (Rs.1000/trip)	2200(Rs.1100/trip)	200	10.00
	Total	26,120	11,590	-14,530	-55.63
B. Returns (Rs./ha)					
1.	Main produce (grain)**	55,860(@3.8t/ha)	98,875(@5.65t/ha)	43,015	77.00
2.	Bye-product (straw)	2490	2760	270	10.84
Gross return		58,350	1,01,635	43,285	74.18
Net return		32,230	90,045	57,815	179.38

*Seed rate: 50kg/ha, post of seed: Rs.20/kg. Straw yield: 4.15t/ha (2016-17), 4.46 t/ha (2017-18), 4.60 t/ha (2018-19), price of straw= Rs. 600/t**MSP during 2016-17: Rs.1470 per q; during 2017-18: Rs.1550 per q; during 2018-19: Rs.1750 per q

Capacity building through training, demonstration, field days and farmers meets

Extensive training-cum-demonstration programmes and continuous technological backstopping on commercial production and marketing were provided. Demonstration of the superior high yielding and hybrid varieties and farm mechanization over the farmers own-managed crop and traditional cultural practices always facilitates technological adoption and diffusion in a social system. Therefore, farmers field days at various stages of crop growth, and crop cutting experiments (CCEs) at the time of harvesting were organized in the presence of both beneficiary & non-beneficiary farmers, local line department officials and project staff. These CCEs were followed by farmers meets for experience sharing and participatory evaluation of the performance of introduced rice varieties and demonstrated technologies.

It is evident from the Table 1 that the average grain yield of paddy in pre-FFP was only 3.80t/ha, while during post-FFP period, the average grain yield was found to be 5.65 t/ha.Thus a quantum jump of average 48.68% in rice productivity was observed in the adopted village cluster. In monetary terms, the net return from rice alone has increased from Rs.32,230 per ha to Rs.90,045per ha with an increase in income by over 179% among the beneficiary rice growers. However, from rice-pulse cropping system, it is calculated an increase of 112% in income over only rice crop, with an indirect benefit of increasing soil fertility.

CONCLUSION

The overall analysis of the study concluded that with thedemonstration of new improved rice varieties, there is a significant increase in average grain yield of paddy during post-FFP periodover the pre-FFP period.The average grain yield was found to be increased from 3.80t/ha to 5.65t/ha, with rangesfrom 15-63% grain yield advantage. In monetary terms, the income of the farmers adopted under ICAR Farmer FIRST project has increased significantly with an average of 144% with the adoption of HYVs of rice alone, 19% with the adoption of pulses only and 112% increase in farmer's income with the adoption of rice-pulse cropping system. So, it is concluded that the ICAR-sponsored Farmer FIRST Programme created significant impact on profitability and earning of rice growing farmers in the adopted villages.

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SMALL MILLETS IN RICE FALLOW: ABENEFICIAL CHOICE FOR PROMOTION OF *'NUTRI-CEREALS'*

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Rice (*Oryza sativa* L.) fallow areas are left as fallow during the winter season due to lack of rainfall or for want of additional irrigation, late harvesting of long-duration high yielding rice varieties, moisture stress at sowing during *rabi* as a result of early withdrawal of monsoon, water logging and excessive moisture during December and /orpoor nutrient management practices which are the major constraints for low yield in the following crop. The second crop in rice-fallow is a great challenge as post-rainy season often confronts a series of abiotic and biotic stresses. But intensification of existing agricultural systems is the need of the hour to take care of the rising demand for food grain production with limited land resources availability in the country. In this perspective, there is an enormous opportunity to increase the total cropping area through strategic research in rice-fallow.

Small Millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops under marginal conditions of soil fertility and moisture. There is a growing demand for these nutri-cereals. However, the area under these crops are in declining trend for the past 10 – 20 years. To increase the area under small millets has become a big challenge. Utilization of rice – fallow area for growing small millets is the best alternative choice in the state like Tamil Nadu, where rice is grown in larger area. Moreover, there is a decline in productivity of paddy due to continuous monocropping system, adding small millets can partially solve the problem for sustainable crop intensification and increased income generation. Based on these facts, this experiment was planned to assess the suitability of small millets and evaluation of specific crop based traits to be used as rice fallow small millets. The small millets like Foxtail millet, Little millet, Proso millet and Banyard millets which have just 75 to 90 days of duration were taken for performance study. An experiment was conducted to assess the suitability of small millets under rice fallow condition and evaluate genotypes of small millets with special reference to rice fallow condition.

METHODOLOGY

As a preliminary evaluation, four crops of small millets viz., Foxtail millet, Little millet, Proso millet and Banyard millet of short duration were selected. In each crop, along with the ruling varieties one or two advanced high yielding cultures were also included in the analysis in Randomized block design with three replications at Tamil Nadu Rice Research Institute, Aduthurai during rabi 2018 -19. The data on germination on 6th, 9th and 12th day after sowing were recorded. The length of seedling, root length, shoots length and vigour indices were noted for further analysis. A good crop was raised as per the standard operation procedure.

The seeds were broadcasted in standing rice 4 days before rice harvest. A higher seed rate of 25 kg/ ha against 10 kg/ha of normal seed rate was adopted. Seed treatment with biofertilizers and biocontrol agents was done before sowing. Mobile sprinkler irrigation was given at 7 DAS and 25 DAS for better crop establishment. The status of weeds was also recorded.

RESULTS

The results showed that all the four small millet crops showed significant variation in performance under rice fallow condition. In addition, there is a significant variability in genotypes within the crop also. Out of the four crops, the germination (%) was found to be high in Barnyard millet followed by Little millet. Due to high vigour indices of Barnyard millet followed by Prosomillet, the weed competition was also recorded as less in Barnyard millet followed by Proso millet. The seedling length, shoot and root length and vigour index were the least for Little millet followed by Foxtail millet. Hence the weed growth was recorded as high in Little millet and Foxtail millet.

CONCLUSION

There is a very good scope for rice fallow small millets such as Barnyard millet (TNEf 317) and Proso millet (TN Pm 238) to increase the area under these '*Nutri-cereals*'. After validation of the results, Plant Genetic Resources of small millets could be suitably utilized for screening the accessions for specific traits to grow under rice fallow condition. In addition, précised technologies for weed control, integrated nutrient management and population maintenance could be planned to reap a good harvest in rice fallow small millets. Continued ward and watch is essential to manage pest and diseases in small millets under this new cropping system. The success in this cropping system will boost the area and production of small millets in future.

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IRC/TM-4/PP-22

ACHIEVING SUSTAINABLE PROFITSFROM PADDY PRODUCTION IN INDIA:ASSESSING THE EFFECT OF POLICY FACTORS IN MAJOR STATES

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Paddy is one of the major staple food for the mankind since time immemorial. It is grown nearly 120 countries across the length and breadth of the globe. As per FAOSTAT (2020), during 2018, paddy is cultivated in an area of 167.13 million hectares (Mha) with 782 million tonnes (Mt) of production, resulting in world paddy productivity as 4.68 tonnes per hectare (t/ha). In India, paddy is cultivated in 44.50 Mha of area (26.6% of world area), with 172.58 Mt of production (22.0% of world production) with 3.88 t/ha of productivity (82.9% of world's productivity). Among the countries in the world, India was ranked first in area and second in production, but, ranked 58th in productivity. It clearly indicates that production in India was driven more by area expansion policies than by technology spread policies. Leading states in paddy cultivation in India are Uttar Pradesh, West Bengal, Andhra Pradesh, Odisha, etc. Profitability depends on the difference between gross returns and cost of cultivation. Production in-turn depends upon magnitude of area and productivity. To decompose the effects of area expansion policies, technology spread policies and price policies on the profitability of paddy production, present study was taken up to measure the magnitude of growth and extent of instability in area, production and productivity; to assess the influence of area expansion policy, technology spread policy and price policy on farm profitability; and to suggest the sustainable way of dealing with paddy profitability.

METHODOLOGY

The study pertains to all states and union territories of India. Data for the period 2000-01 to 2018-19, on area, production, productivity and farm harvest prices of paddy were collected from published sources. Data period was divided into two periods' *viz.* Period – I (2000-01 to 2009-10) and Period-II (2010-11 to 2018-19). Analytical tools like compound growth rates, Coefficient of variation and three-way decomposition analyses were conducted separately for each period. The area, productivity and farm harvest prices were taken as proxy variables for area expansion policy, technology spread policy and price policy, respectively.

RESULTS

Magnitude of Growth: In India during the period-1, increase in price (7.6%) contributed more towards growth in returns (9.3%) than by area expansion (-0.02%) and growth in productivity (1.65%). In all states, increase in price contributed more than growth in area and productivity towards increase in returns. During the period –II, similar trend was noticed.

Extent of Instability: During the period -I, in majority of states fluctuations in price in relation to variability in area and productivity had more effect on profitability fluctuations. Similar trend was noticed in period –II also. From period I to II, profitability was more stabilized among many states andproductivity fluctuations in many states are higher in period –II than period –I.

Table 1. **Effect of different components on profitability of paddy (%) in major states of India**

States	Period -1(1991-92 to 2000-01)				Priod-2(2001-02 to 2010-11)			
	Area effect	Tech effect	Price effect	Interaction effect	Area effect	Tech. effect	Policy effect	Interaction effect
Uttar Pradesh	-0.5	5.2	92.9	2.4	-4.9	1.2	104.6	-0.9
West Bengal	-1.8	7.8	91.8	2.2	-20.2	5.4	135.4	-20.6
Madhya Pradesh	-3.7	26.3	66.5	10.9	-3.6	14.7	76.1	12.8
Bihar	-2.3	14.6	82	5.7	-129	-61.9	454.3	-163.4
Odisha	0.1	24.7	60.5	14.7	-4.9	1.4	108.5	-5
Andhra Pradesh	19	7.5	58.1	15.4	17.9	1.4	63.5	17.2
Punjab	9.1	19.5	62.4	9	20.8	12	53.3	13.9
Tamil Nadu	13.6	6	72.5	7.9	-10.2	-6.6	132.3	-15.5
Other States	9.7	11.9	67.7	10.7	8.9	1.8	78.5	10.8
INDIA	2.75	16.22	72.4	8.63	-4.84	8.22	94.32	2.3

Effect of policy factors on profitability: During period –I, price policy measures (72.4%) had higher effect on farm profitability than area effect (2.75%), technology effect (16.22%) and interaction effect (8.63%) in India. Similar trend was noticed in all states (Table 1). Among the states, magnitude of price effect was highest in Uttar Pradesh (92.9%) and lowest in Andhra Pradesh (58.1%). Influence of technology on profitability was highest in Madhya Pradesh (26.3%) and lowest in Uttar Pradesh (5.2%). During the period –II, in all states, price policy measures had dominance over area expansion policy and technology spread efforts on profitability differential. Highest technology effect (14.7%) was noticed in Madhya Pradesh and least in Bihar (-61.9%). Thus, regardless of time periods, price policies had predominant effect than area expansion policy and technology in all the states.

CONCLUSIONS AND POLICY IMPLICATIONS

Paddy production was more influenced by productivity than area. This indicates the growth in production should come from yield attributing factors like development of high yielding varieties and improvement in input use efficiency.Farm profitability was more influenced by the policy (price) than area expansion policy or technology (productivity). So, immediate concern is to how to transfer the '*technology know-how*' to '*farmer's do-how*'.

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IRC/TM-4/PP-23

EVALUATION OF MEDIUM DURATION FINE GRAIN RICE MINIKIT CULTURE MTU 1271 IN FARMERS' FIELDS DURING *KHARIF* 2019

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Rice is the major food crop of our country. Different rice varieties with varying quality parameters are consumed in different rice growing areas of the country. In Southern India, generally fine grain rice varieties with good cooking quality are preferred. In view of the above, breeding for fine grain rice varieties was initiated at RARS, Maruteru during last decade and a series of fine grain cultures were developed for the benefit of rice farming community of Andhra Pradesh. An evaluation was made to test the performance of MTU 1271 culture in farmer's field.

METHODOLOGY

MTU 1271, is a fine grain rice culture developed by crossing MTU 1075 and MTU 1081 as parents. After the material was stabilized, the rice culture was tested in station trials viz., OYT, PYT and AYT at RARS, Maruteru, followed by multi location testing in 7 locations during *kharif*, 2017 and 8 locations during *kharif*, 2018. The data was summarized and the rice culture MTU 1271was given for testing in farmer's fields in all the rice grown districts of the state in 330 locations.

RESULTS AND CONCLUSIONS

The rice culture MTU 1271, recorded an average yield of 5881 kg/ha in station trials in comparison with best check (5671 kg/ha) with 3.70 percent increase over the best check. In multi location trials conducted during *kharif*, 2017 and *kharif*, 2018 in 15 locations, the rice culture MTU 1271 recorded an average yield of 6736 kg/ha in comparison with best check (5243 kg/ha) with an yield advantage of 28.47 percent. Owing to the superior performance of the culture, it was decided to test the culture MTU 1271 in farmers' fields with the help of DAATTC coordinators and Joint Director of Agriculture (JDAs) in different districts of Andhra Pradesh during *kharif*, 2019. Accordingly, the culture was tested in 330 locations in different districts during *kharif*, 2019 and MTU 1271 rice culture recorded an average yield of 6695 kg/ha with an yield advantage of 12.03 percent over the check varieties (Tables 1 and 2).

MTU 1271 has L/B ratio of 3.23 with 67% of milling percentage and 62% of head rice recovery with good cooking quality. With an average yield advantage

Table 1.Evaluation of MTU 1271 rice culture in station trials and multi location trials

Name of the trial	Year &season	Grain yield(kg/ha)	Best check yield(kg/ha)	Percent increase over best check
OYT (medium)	*Rabi* 2015-16	5943	5935	-
PYT (medium)	*Kharif* 2016	5919	5531	7.02
AYT (medium)	*Rabi* 2016-17	5780	5547	4.20
Mean in station trials		5881	5671	3.70
MLT-SG (I year) Overall (7 locations)	*Kharif* 2017	7040	5401	30.35
MLT -SG (II year)Overall (8 locations)	*Kharif* 2018	6431	5084	26.50
Mean in MLTs		6736	5243	28.47

Table 2.Evaluation of MTU 1271 rice culture minikits in different districts of Andhra Pradesh during *kharif*, 2019

Name of the DAATTC/JDA	Number of locations	Local check entry	Minikit yield (kg/ha)	Local check yield (kg/ha)	Percent increase over check
DAATTC, Nellore	3	NLR 34449	9743	8367	16.45
DAATTC, Krishna	5	BPT 5204	7035	6330	11.13
DAATTC, Guntur	4	BPT 5204	6985	6188	12.88
DAATTC, Kurnool	5	MTU 1061	6650	5325	24.88
DAATTC, Srikakulam	5	BPT 5204	6250	5800	7.70
DAATTC, Vizianagaram	5	BPT 5204	5497	5260	4.51
DAATTC, Visakhapatnam	5	RGL 2537	5902	5210	13.28
DAATTC, West Godavari	5	BPT 5204	6050	5550	9.00
DAATTC, East Godavari	3	BPT 5204 /RP Bio 226	7182	6064	18.44
JDA, Nellore	30	BPT 5204	8561	7907	8.27
JDA, Vizianagaram	30	BPT 5204	5707	4724	20.81
JDA, Visakhapatnam	30	BPT 5204 / RGL 2537	5604	5083	10.24
JDA, West Godavari	50	MTU 7029	6937	5988	15.85
JDA, East Godavari	50	MTU 7029	5560	4930	12.77
JDA, Krishna	50	BPT 5204	6511	6391	1.88

of more than 12 percent over the check variety along with good grain quality and cooking quality, the rice culture MTU 1271 can be a good rice culture for the state of Andhra Pradesh.

Theme - IV : Rice for livelihood security, equity and profitability

IRC/TM-4/PP-24

DRR DHAN 45:SUSTAINABLE WAY TO ATTAIN NUTRITIONAL SECURITY

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Andhra Pradesh is rice bowl of India. In Andhra Pradesh 31% of the children below five years are stunted and 32% are underweight and 60% women in reproductive age group are anaemic. Such nutritional deficiencies adversely affect the health of the mothers and the children. ICAR has started Nutri-sensitive Agricultural Resources and Innovations (NARI) programme for promoting family farming linking agriculture to nutrition. Indian Council of Agricultural Research (ICAR) has initiated bio fortification in crops as sustainable and cost-effective solution to alleviate malnutrition. Nutrition Sensitive Agriculture (NSA) places nutritionally rich food, dietary diversity and food fortification at household level in the centre for holistic nutritional security of the communities. NSA ensures food production in adequate quantity and quality to meet the dietary requirements of populations in a sustainable manner. The approach also stresses the importance and social significance of the food and agricultural sector for supporting rural livelihoods. The recent 'National Nutrition Strategy' by the NITI Aayog, Government of India, would also provide impetus to utilize these biofortified varieties more effectively towards achieving 'Kuposhan Mukt Bharat ' means to attain nutrition secured India. DRR Dhan 45 introduced at KVK farm and created awareness among the farmers and farm women for its adoption.

METHODOLOGY

Krishi Vigyan Kendra Ghantasala is located in Krishna District of Andhra Pradesh in Southern part of India. Major crops cultivated are rice in *kharif* and blackgram in *rabi* season. ICAR-Indian Institute of Rice Research (IIRR) released biofortified rice variety DRR Dhan 45 in 2016. About 2 kg seed of DRR Dhan 45 was procured from ICAR-Indian Institute of Rice Research, Hyderabadand direct sown in an area of 0.03 ha in KVK farm in *kharif* season of the year 2018 under NARI programme. Krishi Vigyan Kendra, Ghantasala created awareness among farmers about the DRR Dhan 45 biofortified crop and farm women about the value added products with biofortified DRR Dhan 45 rice to combat zinc deficiency among vulnerable groups. The study was conducted in Ghantasala village of Ghantasala Mandal of Krishna District. A sample of 60 pregnant and lactating women were given awareness about the zinc rich biofortified variety DRR Dhan 45 in daily diet through direct consumption and value added products.

RESULTS

Krishi vigyan Kendra, Ghantasala has introduced Rice Dhan 45 variety under NARI programme of ICAR and ATARI Zone X, Hyderabad. Awareness was created about the variety among the farmers and farm women for adoption. DRR Dhan 45 is high in zinc content (22.6 ppm) in polished grains in comparison to 12.0- 16.0 ppm in popular varietiesand 20.4 ppm in Kalanamak and 20.7 ppm in Chittimutyalu varieties (Yadava et Al., 2017).Micronutrients though required in small amounts, are essential for proper growth and development of the human body. Micronutrient deficiencies also referred to as 'Hidden Hunger' affects the health, learning ability as well as productivity owing to high rates of illness and disability contributing to vicious cycle of malnutrition, underdevelopment and poverty.Zinc is a trace element that is necessary for a healthy immune system. Lack of Zinc can make a person more susceptible to disease and illness. Zinc is responsible for a number of functions in the human body and it helps to stimulate the activity of at least 100 different enzymës. Only a small intake of Zinc is necessary to reap the benefits. Currently the recommended dietary allowance (RDA) of Zinc is 5-


Demo plot maintained at KVK farm, Ghantasala village


Awareness programme to farm women

9mg for children one to 12 years of age, 10-11mg for 13-17years of age, 12 mg/day for pregnant and lactating women (Dietary Guidelines for Indians, 2011).

In the present study awareness was given about the importance of zinc in daily dietary requirement and value added products introduction to regulate immune function, boosting learning &memory, useful for treating cold, wounds and diarrhoea. Among the sample 85% were interested in using Dhan 45 as brown rice, flaked rice and puffed rice. Ninety-two percent interested in utilizing it in the form of breakfast items like *dosa, idli and upma*. About 73% interested in makingspecial items like Hot pongal, sweet pongal in the festive season of Makara Sankranthi and Kanuma in the month of harvesting time in January month. Rice flakes can be made into *poha, chiwda* for consumption in breakfast or snacks. Puffed rice can be made as chat or can be consumed as snacks. Women with gestational diabetes during pregnancy are interested in consuming directly as Dhan45 variety is having low glycemic index number and hence good for diabetic patients.

In the present study awareness was created among women about the benefits of Zinc in preventing cellular damage in the retina which helps in delaying the progression of Age related Macular Degeneration (AMD), vision loss, prevention of acne, attention deficit hyperactivity disorder (ADHD) and osteoporosis. Further an attempt was made to introduce the rice variety rich in zinc for controlling stunted growth, poor cognitive development and reduced immunity among children. For this method demonstrations and trainings programmes were organized in making value added products like *ariselu, boorelu, chakralu, janthikalu* etc. with rice atta, which can be stored for 25 days to one month.

CONCLUSION

Biofortified varieties rich in micro nutrients are very much essential for proper growth and development of children, pregnant and lactating women in the society. It can be concluded that from present study that children and women require some time for direct consumption of Dhan 45 as boiled rice but in the form of snacks, breakfast items and special items not feeling much difference in consumption. But milling of rice is little difficult as the grain is little harder than normal rice varieties.

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IRC/TM-4/PP-25

ECONOMICS AND ENERGETICS OF DIRECT SEEDED RICE: A CASE STUDY OF ANDHRA PRADESH

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Rice is the staple food crop of India accounting for 40 per cent of the total food grain production. At the global level, India stands first in rice area with 44 million hectares and second in rice production with 111.52 million tons (Ministry of Agriculture, 2018). Rice production needs to be increased to meet future food requirements amid strong competition for limited resources. Rice cultivation is in crisis the world over and India is no exception, with a shrinking area, fluctuating annual production, stagnating yields and escalating input costs. The cost of cultivation of paddy has consistently been increasing owing to the escalating costs of seeds, fertilisers and labour. There is a need to grow more rice but with less water and fewer inputs.

Rice, being a semi- aquatic crop, is generally cultivated through transplanting of seedling in submerged field which is a labour intensive practice. This technique requires growing rice in puddle soils and involves high water consumption. On an average, 2500 L of water is used, ranging from 800 to 5000 L to produce 1 kg of rough rice (Bouman 2009). Increasing water scarcity and labour costs demand for alternative management methods to increase water productivity in rice cultivation. Direct seeded rice (DSR) has received much attention because of its low-input demand.

Energy use in agricultural production has become more intensive due to the use of fossil fuel, chemical fertilizers, pesticides, machinery and electricity to provide substantial increase in food production. Hence, energy efficiency has been crucial for sustainable development in agriculture systems. Thus, the energy analysis in rice in general and DSR in particular is essential because of the direct link between energy and rice yields, and food supplies. Among the different indicators of crop performance, the energy analysis is one of the important one.

Rice is the dominant food crop of Andhra Pradesh, cultivated in an area of 22 lakh ha in *2018-19*. Rice cultivation in Andhra Pradesh is facing the challenges of water and labour scarcity. This necessitates adoption of water saving technologies like DSR by the rice farmers of Andhra Pradesh. Of late, many farmers of Guntur, East and West Godavari districts of Andhra Pradesh have been adopting DSR. Hence, the present study was undertaken to study the economics and energetics of DSR.

METHDOLOGY

The study used field survey data of two hundred and twenty DSR adopter farmers from three districts *viz.*, Guntur, East Godavari and West Godavari districts of Andhra Pradesh, in 2018. Primary data were obtained through survey with structured questionnaire, key informant interviews, focus group discussions, and field observations.

Based on the energy equivalents of the inputs and outputs, the energy ratio (Energy use efficiency), energy productivity, specific energy and the net energy were calculated by using the following formulae:

$$\text{Energy use Efficiency} = \frac{\text{Total Energy output (MJ/ha)}}{\text{TotalEnerg yinput (MJ/ha)}}$$

$$\text{Energy productivity (kg/MJ)} = \frac{\text{Grain yield (kg/ha)}}{\text{Total Energy input (MJ/ha)}}$$

Specific Energy (MJ/kg)=

$$\frac{\text{(Total Energy input (MJ/ha)}}{\text{Grain yield (kg/ha)}}$$

Net Energy (MJ/ha) = Energy output (MJ/ha) –Energy input (MJ/ha)

The energy consumption for DSR and conventional method was estimated. From the literature review, equivalent energy inputs were determined for all input and output parameters for rice energy sources. Total energy input was calculated based on energy inputs for various operations from land preparation to harvest and energy output was based on grain and straw yields. Energy calculations like Energy use efficiency, Energy Productivity, Specific energy and Net energy benefit were worked out for DSR and conventional method of rice cultivation.

RESULTS

The adoption of DSR has resulted in reducing the total cost of cultivation per hectare by 15%. The net returns obtained by the sample farmers for conventional and DSR method were Rs.21,916/ha and Rs.29,780 /ha respectively. The BC ratio for conventional and DSR methods was 1.2 and 1.32 respectively.

The adoption of DSR ensured higher productivity with higher energy efficiency and returns. The energy use efficiency obtained for DSR method was 7.5, while for the conventional method it was 5.8. The average energy productivity was 0.24 kg/MJ for DSR method and 0.19 kg/MJ for conventional method, which means 0.24 kg of paddy is produced per unit energy in DSR method and 0.19 kg of paddy is produced per unit energy in conventional method.

The results of the specific energy indicate that the conventional method requires 5.37 MJ of energy to produce a kilogram of paddy while with the DSR method, about 4.13 MJ of energy is consumed to produce one kilogram of rice. The conventional method has a net energy gain of 1,68,812 MJha^{-1}, whereas DSR method has a net energy gain of 1,71,657 MJha^{-1}. The results indicated that the DSR method is more energy-efficient as compared to conventional method.

CONCLUSION

The higher energy efficiency in DSR is due to a significant reduction in inputs. Such methods of energy efficient production result in reduced energy consumption and the environmental impacts associated with rice production. DSR can play an important role in enhancing the agricultural productivity and sustainability, besides saving the energy. Hence, there is a strong need to upscale the technology through demonstrations and awareness programs.

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1st Indian Rice Congress 2020

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THEME

Resilience

Theme: Resilience

RICENXPERT: A DIGITAL SOLUTION FOR REAL TIME N RECOMMENDATION FOR ENHANCING NITROGEN USE EFFICIENCY AND YIELD OF RICE

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Nitrogen is the most essential element which helps in enhancing and stabilizing the crop growth and yield. A sustainable management of nitrogen fertilizer requires the knowledge of nitrogen nutrition status of crops. Greenness of leaves indicate the plant nitrogen status and help determine the need for nitrogen fertilizer application. Nitrogen is directly related to leaf color which has been recognized as one of the most sensitive indicators to know the nutrient status.The SPAD meter is used to make an optimum fertilizer N-rate decision by measuring nitrogen stress relative to an optimum N-rate strip within a field. Digital image processing has been used in crop management and monitoring. Smartphone cameras are relatively inexpensive; require little technical expertise and the images could allow sampling a greater leaf area than that used for SPAD measurements. All the visible spectral index based methods working on the assumption that plants display a clear high degree of greenness, and soil is the only background element. In fact, the brightness and contrast of an image coming from outdoor environments are seriously affected by the weather conditions and the capture time. The color of the plant varies from dark green to yellowish green. These environmental factors always make the visible spectral index based methods unable to work correctly.

The main objective of this study was to develop a low cost android based application to develop nitrogen recommendation using android mobile phone based digital colour image analysis.

METHODOLOGY

A field experiment was conducted with six rice varieties with six nitrogen fertilizer levels (i.e. 0, 40, 60, 80, 100 and 120 kg ha^{-1}) in three replications for creating all the possible variations in the green colour starting from yellowish green to dark green. Android smartphones were used to capture the images of ten second topmost leaves from maximum tillering stage (21 to 28 days after transplanting) to panicle initiation (45 to 55 days) stage at 7 days interval during 8-10 AM by keeping a distance of 15-20 cm from the camera lens to leaf. The SPAD readings were also taken for the same leaves. The following smartphones were used for the experiment; (1) Vivo Y81i, (2) Samsung Galaxy A9, (3) Samsung Galaxy J4 and (4) Samsung Galaxy J6. The leaf photographs were taken from all the plots with white background by placing a white sheet below the leaf during 8-10 AM under the shade of body. The images were captured by keeping a distance of 15-20 cm from the camera lens to leaf. The SPAD (used as a proxy indicator of leaf color) readings for these photographed images were also taken at the same time for all the treatments.

A programme in MATLAB was written to extract RGB colour codes from the leaf image by averaging the pixel values. Various greenness indices such as Normalized green red difference index (NGRDI), Excess green minus Excess red(ExGR), Green-red vegetation index (GRVI), Red Green Ratio Index (RGRI), Visible Atmospherically Resistant Index (VARI) and Principal component analysis index *(*IPCA) greenness indices were estimated using these RGB values. Principal component bivariate analysiswas done to observe the relationship between greenness indices and nitrogen as well as pantone colours and nitrogen. A principal component analysis uses a few linear combinations of a set of variables to explain their variance-covariance structure. PCA often reveals relationships not previously suspected, allowing new interpretations (Johnson and Wichern, 2007). The principal component scores were used to form clusters of leaf nitrogen content with greenness indices and leaf nitrogen content with pantone colour. The Principal component analysis (PCA) plot shows that four clusters are visible. There are four clusters with only two dimensions explaining the 63.6% variability. PCA analysis of pantone colours with nitrogen content were performed. Based on the PCA clusters, the pantones were categorized into four standard pantone categories. A code was written for matching the test pantones to standard pantones.

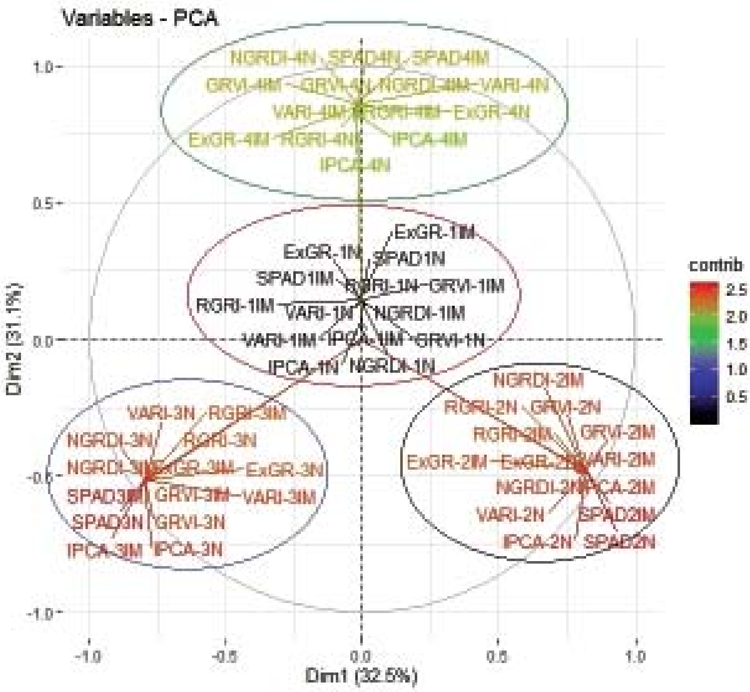

Fig.1: Relationship between greenness indices with Nitrogen content by Principal Component Analysis. NGRDI: Normalized green red difference index, SPAD: SPAD reading, GRVI: Green-red vegetation index, VARI: Visible Atmospherically Resistant Index, RGRI: Red Green Ratio Index, ExGR: Excess green minus Excess red, IPCA: Principal component analysis index, N: nitrogen, IM: digital image, 1: pantone category-1, 2: pantone category-2, 3: pantone category-3 and 4: pantone category-4.

RESULTS

A program was written in Matlab for extracting the RGB colour codes from pixels rice leaf images and averaging was done to get the RGB colour codes for a leaf. Pantones were extracting based on colour distance. Principal component analysis (PCA) was performed to reduce the dimensionality in the data on greenness indices and leaf nitrogen content (Fig. 1). In case of PCA on greenness indices with nitrogen content (Fig.1), the green oval shows occurrence of greenness indices belonging to category-4, the red oval shows occurrence of greenness indices belonging to category-1, the blue oval shows occurrence of greenness indices belonging to category-3 and the black oval shows occurrence of greenness indices belonging to category-2.

The principal component analysis clearly indicated four clusters based on the pantones and rice leaf nitrogen content hence the pantones extracted from the rice leaves of different greenness were categorized into four standard pantone categories. The RGB colour codes were used to calculate the greenness indices i.e. NGRDI, ExGR, GRVI, RGRI, VARI and IPCA using normalized RGB and chromatic coordinate. The greenness of leaves from four pantone categories. Correlation analysis between the greenness indices with SPAD and leaf nitrogen content indicated a significant correlation between leaf nitrogen and greenness indices and SPAD.

Matching technique: A set of ten rice leaf images from different pantone categories were retrieved from leaf image library for generating pantones and histograms were constructed using the pantones. Using the vector matching technique, the histogram of the testing data was compared with the standard pantone category histogram by "Euclidean distance" technique. The minimum Euclidean distance between the test and standard pantone categories data depicts the closeness or similarity. The generated value for testing data of lighter yellow closer to Category-1, testing data of yellowish green closer to Category-2, testing data of green closer to Category-3, testing data of dark green closer to Category-4, shows a successful matching, whereas any other cross combination when used it mismatched.

Soil Plant Analysis Development (SPAD, meter Minolta Camera Co., Osaka, Japan) chlorophyll meter provides a rapid and non-destructive approach that enables users to measure chlorophyll content in the field. Considering the strong positive relation between N and chlorophyll content of leaf this method has been widely recommended to monitor leaf N status and guide top dressing of fertilizer N using SPAD threshold. Based on the SPAD reading and standard pantones categories, N fertilizer was recommended for different ecologies.

CONCLUSION

The study shows that a simple image capture digital advanced technology can be used to extract the greenness as well as N stress on lowland rice leaves. In this study android phones were used to capture the image if rice leaves and provide the nitrogen recommendation based on the different shades of greenness of rice leaves.

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Theme: Resilience

ICT MEDIATED AGRICULTURE EXTENSION SERVICES IN STRENGTHENING RESILIENCE OF SMALL FARMERS

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INTRODUCTION

Climate change is a major challenge to the agriculture sector and the impacts are highly adverse for small farmers. Studies have proven that combination of human and social capital can support farmers in building resilience to the impacts of climate change by accessing reliable agriculture extension services and farmers networks respectively. Though efforts have been taken to promote both the capitals together by the agriculture extension systems, two important areas need attention while reaching small farmers. The first one is necessity for a paradigm shift in the current agriculture extension systems from "providing technological packages" to "enhancing the skills and information necessary to make informed decisions" with a farmer centric and demand driven approach. Second one is building the capacities of individuals, organizations and systems level in a comprehensive manner to deal with risks and bring changes.The IPCC also reiterated that the ability of decision-makers to manage information as an important factor determining farmers to adapt to climate change. Also, in natural disaster prone areas it is essential to reach quickly in a cost effective manner among small farmers with reputable information which can strengthen resilience.

In this backdrop, Information and Communication Technologybased Village Knowledge Centers (VKC)approach has the potential to create an access to need based, locale-specific information and build capacity to use the information among small holders. Two unique points makes VKCs as prime institution atvillage level in building resilience: one is basket of field testedinformation sharingtools such asmobile based audio advisories, Farmers' helpline services, audio-video conferences, phone-in programmes, social media, video including multimedia-based learning, plant clinics etc.which helps to disseminate dynamic information within a short span to reach more farmers to manage the risks. The second one is its partnership and convergence approach with KrishiVigyan Kendra, state agriculture extension systems and agriculture research institutions to mobilize reliable contents to deal with risks and adapt to changes. The present paper aim to validate and develop evidences on how ICT based farmer-centric extension services helps in building resilience to address climatic risks at individual level, VKCs and other institutions at organization level and KVKs at system levels.

METHODOLOGY

The study has been conductedin two different climate risk scenarios: flood and drought prone casesin two states namely Odisha and Assam. Paddy based cropping system is the main livelihood among small holders in all the study sites; apart from paddy other minor crops cultivated during rabi are maize and vegetables. FiveVKCs have been established during June 2019 in these sites to provide the need-based locale-specific, demand-driven information and knowledge and build farmers' capacity. Currently 3000 farm families have been covered under this program. The VKCs played a major role in need assessment, need based content creation, capacity building, dissemination of the content through various ICT tools in collaboration with the KVKs, Agriculture departments and Agriculture research stations. Even though it uses different ICT tools, the present study mainly focuses on plant clinics, farmer's helpline services and mobile-based audio advisories as key extension service delivering tools. In addition, farmer field schools have been facilitated on important climate smart practices among farmers through field demonstration with a cadre of 200 lead farmers.

RESULTS AND DISCUSSION

Building the capacity of farmers to address climate risks requires a concerted level of preparedness among individual farmers, organization and systems. The initial need assessment indicated farmer's access to extension services in general is very limited. Pest management is the main service farmers look for during cropping season and input suppliers are primary source. There general framework adopted by KVKs and state agriculture extension system are largely restricted to implementing government schemes, conducting frontline demonstrations on improved technologies andconducting training programmeswith less importance to the process of co-creating knowledge.

In this pilot study, individual and organization level capacity building initiatives have been facilitated at the VKC level involving local panchayats, farmer groups and producer organizations. At KVK level, key experts have been oriented to resilient framework by involving them in the process of capacity building as resource organizations. Itprovided an opportunity to strengthen lab to land and land to lab linkages through closure network with farmers. At the farmer's level, capacity building programmes on main climate smart agricultural practices has been facilitated using ICT tools and field demonstrations. Apart from technical inputs, knowledge and skills, linkages with different institutions were facilitated to access services. The final paper will provide the detailed processes, data and the results.

The feedback from the farmers indicated that there has been a positive change in their knowledge and access to extension services especially in using flood/drought tolerant varieties, diversification at the farm level by change in the cropping systems, pest management practices etc. Now there is a change in their pest management practices, they diagnose the symptomsand get advisories from plant doctors and adopting it. By this way, they shifted their practices from blanket approach after seeing symptoms to preventive measures using non-chemical based inputs. Some of the illustrations shared by them helps us to understand the benefits realized in the approach (box 1.):

- The results indicated that 45% of the farmers realized reduction in economic loss during the production process and 32 % of yield loss has been prevented.
- The timely alert on the prevalence of pest in Paddy helped 68% of Paddy farmers to adopt the preventive /control measures and saved the plant protection costs up to Rs 1500/ ha.
- The voice SMS on the endemic disease bacterial leaf blight in Paddy alert the farmers to adapt prophylactic measure such as cow dung spray helped to check the disease and saved the crop. This improved the yield up to 875 kg/ ha.
- The farmer are linking with expert and clarify the issues, thus the travel time and cost to block extension centre is completely saved here.

CONCLUSION

It is evident that ICT tools are working well in building the resilience capacity of farmers by strengthening human and social capitals. Farmers realised the importance of VKCs in meeting knowledge needs and timely agriculture extension services. The collaboration with KVKs strengthens the ICT mediated intervention due to mutual strengths and resources. Continuous efforts to build the capacity and increase the reach in convergence with KVKs and other line departments in reducing climate risks and building adaptation skills.

Theme: Resilience

ENVIRONMENT IMPACT ANALYSIS OF RICE VARIETIES UNDER TWO ECOLOGIES IN GANJAM DISTRICT, ODISHA

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The agricultural sector is a large contributor to economic development of our country: contributing to 5.3% of its GDP and employing more than 53% of the population. Rice has a very wide range of adaptation, growing 3 m below sea level in Kerala in India and more than 3000 m elevation in Nepal and Bhutan. It is cultivated in regions with more than 3000 mm rainfall, but also in desert regions with less than 50 mm rainfall during its growing season. For optimum growth and yield, rice requires (i) evenly distributed water during the growing season but relatively dry during the grain-filling period, (ii) temperatures that are sufficiently high throughout the growing season but with somewhat lower night temperatures during the grain-filling period, and (iii) ample solar radiation throughout the growing season (Rahman *etal.,* 2017). Based on several criteria such as water regime, drainage, soil and topography the rice-growing environments are classified into categories such as irrigated, rainfed, upland and flood prone etc.

Our country is vulnerable to the impacts of the global environmental phenomenon. Therefore, developing measures that can ensure food and livelihood security, especially in the face of accelerating extreme climate events such as droughts, erratic rainfall patterns, cyclones and floods, is a priority. In recent years, extreme weather patterns have resulted in unseasonable biotic and abiotic stresses in agricultural sectors. Rice is grown thrice in a year in various agroecological landscapes with different temperatures and rainfall profiles. Rice production has increased tremendously in last decade due to technological development such as new varieties and management technologies. However, non-technological events such as drought, flood and prevalence of pests are creating threat to agricultural development in some parts of the world. Climate change in terms of increasing temperatures and uncertainty of precipitation is expected to adversely affect agriculture production in coming years. Although it is said that rice production is at vulnerable condition due to climate change, the quantification of yield loss due to variation of rainfall and temperature is not well documented. Taking note of this concern, this study was designed to understand climate change trends at a regional level, with a specific focus on temperature and rainfall. The objective of this work package is to carryout farmer-led climate smart agriculture (CSA) technology validation and farmer-to-farmer (F2F) knowledge exchange. The outputs from this work package will promote climate resilient technologies in rice crop. The outcomes will be increasing the adaptation measures and productivity of smallholder rice farmers in this region.

MATERIALS & METHODS

The field experiments were carried out in participatory mode on farmers' field during *Kharif* seasons of 2019 at Lathipada, Chikarada, Sorisaballi, Sasanapadar villages of Ganjam district of Odisha under the RESILIENCE project. The Ganjam district is located under North Eastern Ghat Zone and East & South Eastern Coastal Plain Zone of Odisha, India. The fields are experiencing hot dry summer with an average annual rainfall of 1056-1307 mm and the mean minimum and maximum temperature was 21.0ºC and

33.5ºC, respectively.The soil of experimental site was shallow depth, well drained, sandy loam in texture, nearly neutral reaction, and variable soil status in both places.

RESULT & DISCUSSION

This study examines climate variability and its impacts on rice productivity for different ecosystems in Ganjam. The annual rainfall trend shows much variation in different locations. The major differences were observed between demonstration package and farmer's practices with respect to recommended varieties; under upland conditions Swarna-Shreya performed better among all varieties with 22.4-23.4% more yield compared to farmer's practice and under medium land conditions CR-1009 Sub-I gives 16.8% higher yield over farmers practice. Corroborative reports relating to changes in yield due to varietal adaptation to that particular environment was given by Sandhu *et al*., 2019. There was no significant difference in yield of rice varieties under different locations of both the ecologies. However, in upland ecology rice varieties performs better under Lathipada condition than Chikarada due better climatic as well as soil conditions (higher OC, N,P,K content) for rice growth. In medium land ecology Sorisaballi shows higher yield attributes as well as grain yield than Sasanapadar due to better edaphic conditions. Significant differences among the varieties and environments for yield trait suggested the presence of wide variability. Both components of varieties × environment interaction were significant. Similar reports were given by Salim *et al.,* 2016.

CONCLUSION

Relationship between rainfall and yield through correlation and regression analysis showed that upland ecologies had higher determination factor indicating a comparatively strong relationship than medium land ecologies. Therefore, in order to enhance productivity of rice varieties rainfall is an important factor. While under medium land condition genotypic character shows differences in yield than rainfall because of the storage of water in the soil for a longer period than upland ecology which needs high frequency of rainfall that may be due to low ground water table depth.

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Theme: Resilience

EFFECT OF ADAPTATION STRATEGIES ON HOUSEHOLD VULNERABILITY IN RICE BASED FARMING SYSTEM OF EASTERN INDIA

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Climate change is a growing global threat to agriculture with serious implications for food security and poverty reduction, especially in the context of expected 50 % increase in food demand by 2050. For developing countries like India, the threat of climate change on agriculture is very serious. Agriculture is highly vulnerable to increasing weather variability and shocks, which are often manifested in extreme weather events like floods and droughts. Arid and semi-arid areas, where agriculture is already constrained by water scarcity are disproportionately at risk of climate change and weather hazards. To adapt to climate change, climate smart agriculture (CSA) practices and coping strategies are increasingly and widely being promoted and up scaled. However, prioritizing CSA practices is required to optimize financial and human resources investments. There is need to understand how different coping strategies build farmers resilienceand what are the farmer characteristics that affect this. In this study, we assess household level vulnerability based on different household characteristics and how alternative CSA practices and coping strategies of farmers reduce vulnerability in rice based farming system in Eastern India. Our study is based on data collected in villages from 4 districts in Assam and Odisha. Analysis from this aims to inform the choices of CSA practices that can be promoted as part of government and non-governmental programs and policies.

METHODOLOGY

In this study we define household level vulnerability, as the probability of falling below a threshold income level. We estimate an econometric model for the level and variability in income as a function of household level characteristics and climatic shocks faced by farmers. This estimated model is then used to determine the probability of a household falling below a threshold poverty line and to see how these probabilities are affected under different adaptation strategies. The estimation procedure uses the three stage Feasible Generalized Least Square (FGLS) method to estimate vulnerability following closely the approach developed by Chaudhuri et al. (2002) and similar analysis undertaken by Palanisami et al. (2015).

The household level vulnerability analysis is based on primary survey data, obtained from smallholder farmers in 30 villages of two districts each of Assam (Sibsagar and Golaghat) and Odisha (Ganjam and Cuttack). In each district both rainfed and irrigated agriculture are represented. Total sample size was 1627 households; 825 in Odisha & 802 in Assam.

RESULTS

In our sample, overall 67.3% sampled farmers had faced at least one major agricultural shock affecting their production in the last 10 years. In Odisha, 54% had faced at least one cyclone in the last 10 years, while 53% have faced drought. In Assam, pest attack was the most important factor negatively affecting the production of 45% of farmers.

In the face of these agricultural shocks farmers adopted different coping strategies both in their farming activities and outside their farm also. Overall, the three most important farm based coping strategies were: increased use of fertilizer/ pesticide (23%), shift to alternative crops (13.6%) and changing the sowing/ harvesting time (10%). Other than the farming-based activities, farmers mainly relied on their own savings (16.1%), borrowed from friends/relatives (7.6%) or had to sell their household equipment to tide over the agricultural shocks. Overall 20.1% could do nothing in the face of climate shocks and it was more common for smaller farmers with less access to resources and risk-taking abilities.

For the factors affecting per capita income, we find that livestock ownership, changing crop-type and increased use of HYV seeds had significant positive effect. On the other hand, higher family size, low education level, pest attack, drought, cyclone and flood were related with negative impact on per-capita income. In Odisha, we find that "livestock" and "livestock + change crop type + saving", are most likely to move households from vulnerable to less vulnerable, followed by "improved storage + livestock" and "farm yard manure + bio fertilizer + livestock". In Assam, there are much fewer cases of moving from vulnerable to less vulnerable category, but it is most likely to happen if the farmer happens to "apply bio-fertilizer + livestock", "farm yard manure + livestock + increased fertilizer use" and "livestock".

Using laser land levelers for field levelling and ownership of electric/ diesel pumps results in lowest probability of falling below poverty threshold and it is significantly lower than farmers who do not have these. Practicing SRI (Systemic rice intensification) and using bio-fertilizers also results in significantly lower vulnerability. Finally seed treatment and use of certified seeds by farmers also result in significantly lower probability of falling below poverty line. Interestingly, in our sample we could not find significant difference in vulnerability through practice of direct seeded rice, alternate wetting and drying and farm yard manure. Although given the fact that very few farmers are practicing these improved methods in their agriculture, power of the test is low. But still the analysis very clearly identifies irrigation, field levelling and use of better seeds and bio fertilizers as primary technologies which can substantially reduce farmer's vulnerability in terms of expected probability of falling below the poverty threshold.

CONCLUSION

Household level vulnerability analysis identified that smaller farm size, larger family size, lower education, climatic shocks are some of the factors that significantly decreases the level of per-capita income of households and thereby increase their vulnerability. Also, through our analysis it was found that better access to irrigation, access to better seeds and bio fertilizers can substantially reduce farmer's vulnerability in terms of expected probability of falling below the poverty threshold. This highlights some of the socioeconomic characteristics and adaptation strategies that can be prioritized by government and nongovernmental schemes and extension activities.

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Theme: Resilience

ROLE OF CLIMATE SMART RICE VARIETIES IN BUILDING RESILIENCE OF SMALL FARMERS IN THE CLIMATE CHANGE SCENARIO OF ASSAM: AN IMPACT STUDY

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Rice is a staple for Assam, the crop has been a major produce for many years now. It is the most commonly cultivated and occupies about 60 per cent of the total area under cultivation. Approximately 2.54 million hectares of the 4.16 million hectares cultivated in Assam are occupied by this crop. The production of rice has seen a rapid increase in productivity, with many high-yielding varieties being introduced over the years. Produce, however are not marketed through proper marketing channels; they are usually sold by farmers on the local markets or sold to local vendors; hence the price is generally much lower than the MSP. Due to the high price gap, the crop is not considered lucrative to date and is only grown for consumption purposes in most areas.

To alleviate climate-adverse impacts, the RESILIENCE project was set up in the districts of Sivasagar and Golaghat. The project implemented climate-resilient rice varieties in the region, analyzing the value of the crops and the losses experienced by farmers as a consequence of climate change. Ranjit Sub-1 and Bahadur Sub-1 varieties were introduced which are long duration high yielding varieties and have a ability to withstand complete submergence for 10-12 days. Along with that two other varieties Shraboni and Luit were also introduced to the areas which are medium and short duration varieties respectively. The idea was to enable the farmers to prepare for any changes to the crop season without affecting the cropping pattern.

The present study is based on the changes in yield as an introduction of the new high-yielding climate resilient varieties and the effects of the SSPS in the annual income of the farmers in the project area. The study also reveals the technology gap and the extension gap in the area.

METHODOLOGY

The study was carried out in the Climate affected districts of Golaghat and Sivasagar in Assam. The area grows paddy as the most important crop; its crop season in the areas has been highly affected by the changes in the rainfall pattern, the introduced varieties is a way to mitigate those problems. The present study is carried out with data recorded from the beneficiary farmers of both the sites, for Kharif 2018-19 and Kharif 2019-20. The data were collected and the extension gap, technology gap, technology index; economics of demonstration along with the benefit cost ratio were worked out.

RESULTS AND DISCUSSION

Changes to climatic factors have affected the farmers to quite an extent. Though the effects cannot be fully mitigated the study revealed that the introduction of the varieties have brought about positive changes to the income and yield of the farmers in the area.

The analysis evidently reveals the enhancement in yields after the introduction of the Climate Resilient Varieties. It is evident that there has been significant increase in the yield over the previous year. The yield for the year 2019 was recorded at 44.93 Quintals per hectare in comparison to 33.98 Quintals per hectare for 2018. The results clearly speak of the positive effect of introduction of new climate resilient variety over existing variety towards enhanced the yield of paddy in demonstrated area.

The difference between potential yield and the yield for the variety cultivated was found to be 26.02 quintals per hectare when grown with local varieties during 2018-19, whereas during Kharif 2019-20 the technology gap was found to be 15.11quintals per hectare. It indicates that there is still a technology gap in the yield as the potential yield couldn't be reaped by the farmers. The extension gap was found to be 10.91 quintals per hectare whereas the technology index was found to be 25.18 percent.

To ascertain the economic feasibility of the demonstration over the general practice, certain economic indicators were calculated. The B: C ratio for Kharif 2018-19 was 0.54 and for Kharif 2019-20 was 1.34. The data revealed that the return from the newly introduced variety has been significantly higher than the local varieties.

The impact of introduction of the new varieties on the farmers was calculated and a 67.92 percent change was noticed. Horizontal spread was also calculated and it revealed that there was an increase in 27.68 hectares of crop area with a 20.81 per cent impact change.

The overall impact will be explained in details in the final paper

CONCLUSION

A substantial increase in the yield of selected Paddy varieties was obtained as compared to local varieties, along with a high rate of horizontal spread of the varieties. The study also reveled positive changes in the economic factors. Thus, there is ample scope for creating climate resilience among farmers through the distribution of climate resilient varieties backed up by demonstration and trainings. The results from the present study clearly suggests that the a awareness regarding climate resilient varieties has been developing among the farmers due to better performance as compared to local varieties. Therefore it can be concluded that climate resilient varieties play a significant role in building climate resilience of the farmers.

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Theme: Resilience

IMPACT OF THE SMART SEED PRODUCTION SYSTEM OF RICE IN AUGMENTATION OF CLIMATE SMART AGRICULTURE

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INTRODUCTION

Rural communities are the most vulnerable to the adverse impacts of climate change andvariability because of their low adaptive capacity (Adger et al. 2003:179–195).Adaptation to climate change is the adjustment of a natural or human system tomoderate the impacts of climate change, to take advantage of new opportunities or to cope withthe consequences (Adger et al. 2003:179–195).Flash flood and erratic submergence regimes are the major limitations in increasing the productivity of rice cultivated in rainfed situation in Assam. Farmers are generally satisfied in producing grains from "source seeds" collected from readily available local paddy varieties which are "farm saved seeds" of the farming community. And such free access to locally available seed varieties results in reluctance in adoption of new climate resilient varieties suitable for large scale seed and grain production. However, lack of knowledge and awareness of benefits of seed production create a hindrance in farmers' adoption. Farmers usually cultivate paddy for grain rather than seed for commercial purpose because farmers don't receive adequate forward and backward linkage to evolve as successful seed producers in commercial grounds.

As per the Indian Seed System, a variety enters into the seed system only after the notification of a variety. Certified seeds are produced subsequently from Breeder seed and Foundation seed which requires a minimum time span of 3-4 years. Thus, it takes an ample amount of time to reach farmer's field. In order to shorten the seed production cycle, attempt has been made to establish a Smart Seed Production System in Assam. Under this system multiple stakeholders are involved in the process of seed production system right from the developmental stage of a variety. The process adopt a Participatory Varietal Selection (PVS) Approach in which desired lines are selected by different stakeholders. The variety selected by them is subsequently notified and released. During the process of notification also seed multiplication of the potential varieties are carried out and immediately after notification mass multiplication of seed is carried out with the help of Private Sectors seed agencies with the direct monitoring of the breeder. By this method the newly notified variety is available for cultivation to farmers within a time span of 1-2 years. Thus, to promote small holding farmers as "Seed Producers" Assam Agricultural University in collaboration with M.S. Swaminathan Research Foundation has launched the Smart Seed Production System in 2018 at RESILIENCE project site ChawdangPothar, Golaghat. Hence, the main objective of the study was to examine, via a case study investigation conducted in Assam was to study effectiveness of the introduced seed production system.

MATERIALS AND METHODS

Commercial scale seed production of this system was initiated under Norwegian Government funded AAU and NIBIO Collaborative project in

Golaghat district of Assam. Two climate resilient recently notified rice varieties, Ranjit Sub-1 and BahadurSub-1were considered for the study. The primary and secondary data has been collected from a Farmer Producer Organization involved in the seed production; Allied Crop Care Ltd, a private seed company involved in marketing and Government organizations involved in marketing and seed distribution. The seed multiplication factor was considered as seventy in calculating the total seed production for further data interpretation.

RESULT &DISCUSSION

Generally a variety comes to Indian seed production system after its notification by the Government of India. The seed available at the time of notification is only around 1 ton seed for further seed multiplication. During the second year, the required Breeder Seed; during the third year the foundation seed and in the subsequent years certified seed is produced. Therefore time required to reach a variety to farmers field around 3-4 years. Hence, it always affect the genetic gain and therefore it is essential to reduce the time in reaching a variety after notification which intern helps in accelerating genetic gain.

In this introduced Seed Production System, initiated in Golaghat district RESILIENCE project site we have been attempting to shorten the time required for a variety. We tried to involve other stakeholder during the breeding process itself through participatory varietal selection. We have provided the nucleus seed of the newly notified varieties to multiply during the year of notification of the varieties itself to the Farmer Producer Organization associated in the RESILIENCE project to multiply at the Golaghat site and successfully produced 111.32 tons, which was certified by the Assam State Seed Certification Agency as Foundation Seed. The whole process seed production was constantly monitored by the scientists involved in the development of these varieties and other scientists from Assam Agricultural University.For, the marketing of the produce, a Letter of Agreement was signed between the Farmer Producer Organization and the Seed Company. This was facilitated by the Assam Agricultural University and MS Swaminathan Research Foundation.

During 2019, around 80 tons of seed the FPO sell it to the Allied Crop Care Limited, the private seed Company and the remaining around 30 tons of foundation seed kept for further multiplication. The Allied Crop Care Limited successfully marketed 469.28 tons Bahadur Sub-1 and 1532.68 tons of Ranjit Sub-1 Certified Seed and the certified seed was marketed by the Allied Crop Care Limited in the 2nd year seed was all cultivated through contact farming and a major part of that also produced by the FPO during 2019. The small and marginal farmer involved in the seed production through the FPO was benefited and also help in producing a good quantity of certified seed of these climate resilient varieties. By utilizing seed lot produced, the varieties covered an area of around 50 thousand hectares. Further, due to the seed produced through the University system and the 82.72 tons of foundation seed marketed during year one, that

Table1: Foundation/Certified Seed marketed by Allied Crop Care Limited during 2018-19 and 2019-20

Year	Paddy Variety	Area (Ha)	Total Production (tonnes)
2018-19	Bahadur Sub 1	9.5	38.00
	Ranjit Sub1	18.33	73.32
2019-20	Bahadur Sub 1	117.32	469.28
	Ranjit Sub1	383.17	1532.68

is 2018 had also helps in further increasing of area of these varieties by various other seed organizations and farmers contributing total area spread of around 1 lakh hectare.

CONCLUSION

Climate change threatened the agrarian economy of Assam and caused considerable social and economic impacts on farming communities. Usually the farmers are getting around Rs 14/ kg on an average with their traditional varieties. But under the Smart Seed Production System the farmers received Rs 20/kg. A considerable increased in income is reflected which will further accelerate the farmer's interest as "Seed growers" among the farming community which will also help in minimizing the reluctant behavior of farmers in adopting a new technology to certain extent. Further, due to reduction of time needed to reach the submergence tolerant rice varieties help farmer to cope with the vagaries of climate change in the changing climatic situation of Assam and which intern helps in accelerating genetic gain in rice. Documentation of such Smart seed production system will help to develop and replicate such smart seed production system in other similar regions and also help the policy makers to develop more appropriate policies regarding seed production for the state.

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