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Identifying drought tolerant rice genotypes using participatory research approach for resource poor farmer's of Odisha

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ABSTRACT

To encourage rice-rice cropping system and to enhance yield and livelihood in rainfed areas, Drought Breeding Network, Cuttack conducted "Participatory Varietal Selection (PVS)" trial at Samia and Berna villages under drought prone rainfed condition during wet season 2009. The management practices were consistent with local crop husbandry used by farmers and evaluations were made by the farmers. Both male and female farmers scored each genotype for different individual traits considered important by them. The genotypes viz., CR 2624 and IR 74371-70-1-1 were stable, however IR 74371-3-1-1 was found to be suited for fragile environments. The genotypes IR 74371-70-1-1, IR 74371-3-1-1, CR 2624 and IR 55419-04 yielded maximum than best check (Khandagiri) and exhibited low drought suceptiblity index (DSI) and high drought tolerance efficiency (DTE) for grain yield also. These genotypes registered above 4.5 t ha^{-1} yield, early vegetative vigour, good drought tolerance at on-station trial. CR 2624, IR 74371-70-1-1 and IR 74371-3-1-1 genotypes were observed to be top three during participatory varietal selection.

Key words: : *Rice, yield, drought suceptiblity index, drought tolerance efficiency and PVS*

Indian agriculture is mainly dependent on the climate of India: a favorable southwest summer monsoon is critical in securing water for irrigating Indian crops. In some parts of India, the failure of the monsoon leads to water shortage, resulting in below-average crop yield. This is particularly true of major drought-prone regions such as southern and eastern Maharashtra, northern Karnataka, Andhra Pradesh, Odisha, Gujarat, and Rajasthan. Groundwater has been depleted at alarming rates. Out of a total 610 districts nationally, 278 districts in 11 states have been declared as drought-hit during *wet* season, 2009. Drought in India was also reduced production of the 2010 *Kharif* crops including rice, coarse grains and pulses in nearly half the districts of the country.

National Rice Research Institute (NRRI), Cuttack in collaboration with International Rice Research Institute (IRRI), Philippines are striving hard with pragmatic approach to develop drought tolerant rice varieties which can mitigate the changing climatic scenario and provide good stable yield in years of drought. Based on the performance of breeding materials developed for drought prone areas, a good number of lines were selected and tested on station and in farmer's field to see their performance as well as select best lines by farmers for different traits they liked. The process of conducting such activities is known as "Participatory Varietal Selection" (PVS) and thus PVS trials were conducted at *Samia* and *Berna* villages of Cuttack District, Odisha. Most farmers of these villages are resource-poor, with limited resources for irrigation facility. Low productivity is the main cause of high poverty. The coverage of land by rice crop during wet season was 99 per cent, while the coverage of rice during dry season was only 54 per cent. The early season drought occurs in most areas, affecting the time of transplanting and the growth of direct seeded rice. The irrigation source for both the villages is *Kalakala* Minor Irrigation Project which is popularly known as *Gopala Bandha* and supplies water during both wet and dry seasons. The average yield of modern varieties in upland, medium and low land was 2.86, 3.67 and 3.72 t ha^{-1} respectively at both the villages. In case of drought situation, no yield was obtained in majority of the fields. Therefore, to enhance yield and livelihood of target area, PVS trials under Drought Breeding Network, Cuttack were conducted at *Samia* and *Berna* villages to identify adaptable variety for rainfed drought prone condition with drought tolerance and high yield potential.

MATERIALS AND METHODS

Four hundred fifty genotypes received from IRRI, Philippines under IRRI-India drought breeding network (DBN) programme were tested for yield and yield attributes under irrigated and drought conditions at NRRI, Cuttack. Out of these, 11 promising genotypes were selected and evaluated along with four checks at on station NRRI, Cuttack and at four farmer's field in *Samia* and *Berna* villages of Cuttack district of Odisha under participatory varietal selection trials. These genotypes responded well under severe drought conditions and displayed good drought score, recovery and early vegetative vigour along with, substantial yield.

Eleven selected genotypes were grown under rainfed conditions representing a sample of environments during wet season, 2009 at four farmer's field. The rain fall during the cropping season was less and erratic in these parts of Odisha and faced early and late season drought stress. Rice genotypes at farmer's field 1: upland area (F_1) were directly sown at 2-3 cm soil depth in dry and pulverized soil by hand plough with the seed rate of 60 Kg ha^{-1} to maintain 3-4 seeds per hill. This method gave uniform seedling emergence for all the plots in 6-8 days. Each plot was 4 m long and 5.0 m wide with row to row distance was 15 cm and plant to plant distance was 10 cm in each plot. Fertilizer was applied at the rate of 60, 30 and 30 kg ha^{-1} of N, P_2O_5, and K_2O, respectively. One third of nitrogen and entire dose of P_2O_5 and K_2O were given as basal dose and remaining N was applied in split doses at maximum tillering and flowering stages. Weeds were controlled by treating plot with pre-emergence herbicide (Pretilachlor) after three days of sowing followed by two hand weeding. At farmer's field 2: lowland (F_2) and farmer's field 3 and 4: medium land (F_3 and F_4), seeds were sown in the nursery and 21-day-old seedlings were transplanted to the main field. One seedling was transplanted per hill at a spacing of 15 cm between rows and plants in each plot of 18 m^2. Inorganic NPK fertilizer was applied at the rate of 80:40:40 kg ha^{-1}. Weeds were controlled by application of pre emergence herbicide Pretilachlor 4 days after transplanting. The other trial management practices were consistent with local crop husbandry used by the farmers and evaluation was made by both male and female farmers.

However, under irrigated control condition at NRRI, Cuttack, 25 days old seedlings were transplanted following randomized block design with three replications. Inorganic fertilizer NPK was applied at the rate of 80:40:40 kg ha^{-1}. Weeds and insect/pests were managed by general recommended practices.

Observations on days to 50 per cent flowering (DFF) and grain yield (GY) were recorded on plot basis. The effect of drought was assessed as percentage reduction in mean performance of characteristics under rain-fed condition relatively to the performance of the same trait under irrigated condition. Drought susceptibility index for grain yield and other characters was calculated using the formula of Fischer and Maurer, (1978). Drought tolerance efficiency was estimated by the equation of Fischer and Wood (1981).

RESULTS AND DISCUSSION

Khandagiri, CR 2624 along with other three high yielding rice varieties Lalat, Satabdi and Naveen recorded high grain yield (>4.5 t ha^{-1}) under irrigated control condition. However, in farmers field under water limited condition, the relative yield reduction was more in these varieties (>30.0%) except CR 2624. Among the tested advanced lines average yield performance over four farmers field conditions, the genotype IR 74371-70-1-1 recorded highest grain yield (3.80 t/ha) with lowest yield reduction percentage (5.83%) followed by CR 2624 (3.78 t/ha) and Khandagiri (3.48 t/ha) (Table1). Details of DSI and DTE for grain yield are explained in Table 2.

Differences in DSI between genotypes were estimated for days to 50 per cent flowering and grain yield under stress in this study (Fig. 1) and large values of DSI indicates greater drought susceptibility (Winter *et al*., 1988). The mean values of DSI for grain yield

Table 1. Performance of rice genotypes for grain yield and relative yield reduction grown under irrigated control and four farmer's field (F_1 to F_4)

Genotypes	Grain Yield (t ha^{-1})						Relative Yield Reduction (%)				
	Irrigated condition	F_1	F_2	F_3	F_4	Mean	Pooled	F_1	F_2	F_3	F_4
IR 72267-16-B-B-1	4.05	3.12	3.25	3.35	3.25	3.24	19.94	22.96	19.75	17.28	19.75
IR 74371-46-1-1	4.37	3.27	3.09	3.28	3.10	3.18	27.12	25.17	29.29	24.94	29.06
IR 74371-3-1-1	4.26	3.17	3.28	3.36	3.54	3.23	21.65	25.59	23.00	21.13	16.90
IR 79906-B-192-2	4.29	3.06	3.71	3.10	3.08	3.34	24.53	28.67	13.52	27.74	28.21
IR 78875-53-2-2-2	4.24	3.01	3.19	3.15	3.23	3.14	25.83	29.01	24.76	25.71	23.82
IR 55419-04	4.31	3.42	3.44	3.44	3.45	3.44	20.24	20.65	20.19	20.19	19.95
IR 74371-70-1-1	4.03	3.83	3.65	3.81	3.89	3.80	5.83	4.96	9.43	5.46	3.47
IR 78875-131-B-14-1	4.39	2.80	3.11	2.90	2.70	2.88	34.45	36.22	29.16	33.94	38.50
IR 78877-181-B-1-2	3.77	3.10	3.62	3.15	3.52	3.35	11.21	17.77	3.98	16.45	6.63
IR 79906-B-5-3-3	3.94	3.13	3.08	3.09	3.12	3.11	21.19	20.56	21.83	21.57	20.81
CR 2624	4.75	3.70	3.84	3.78	3.79	3.78	20.47	22.11	19.16	20.42	20.21
Khandagiri (check)	4.90	3.32	3.62	3.38	3.59	3.48	29.03	32.24	26.12	31.02	26.73
Lalat	4.55	3.02	2.95	2.99	3.17	3.03	33.35	33.63	35.16	34.29	30.33
Satabdi	4.99	2.75	2.88	2.72	2.96	2.83	43.34	44.89	42.28	45.49	40.68
Naveen	4.67	2.81	3.08	3.07	3.02	2.99	35.87	39.83	34.05	34.26	35.33
Mean	4.37	3.17	3.32	3.24	3.29	3.25	25.51	27.46	24.03	25.86	24.71

Table 2. Mean yield, Drought Susceptible Index (DSI) and Drought Tolerance Efficiency (DTE) of 15 genotypes grown at four farmer's field (F_1 to F_4)

Genotypes	Mean yield (t ha^{-1})	Drought Susceptibility Index (DSI)					Drought Tolerance Efficiency (DTE)				
		Pooled	F_1	F_2	F_3	F_4	Pooled	F_1	F_2	F_3	F_4
IR 72267-16-B-B-1	3.24	0.87	0.85	0.82	0.66	0.82	80	77	80	83	80
IR 74371-46-1-1	3.18	1.18	0.93	1.22	0.96	1.21	73	75	71	75	71
IR 74371-3-1-1	3.23	0.47	0.37	0.60	0.41	0.36	89	90	86	89	91
IR 79906-B-192-2	3.34	1.07	1.06	0.56	1.07	1.18	75	71	86	72	72
IR 78875-53-2-2-2	3.14	1.13	1.07	1.03	0.99	0.99	83	79	81	83	88
IR 55419-04	3.44	0.88	0.76	0.84	0.78	0.83	80	79	80	80	80
IR 74371-70-1-1	3.80	0.74	0.79	0.78	0.64	0.51	74	71	75	74	76
IR 78875-131-B-14-1	2.88	1.50	1.34	1.21	1.31	1.60	66	64	71	66	62
IR 78877-181-B-1-2	3.35	0.48	0.66	0.17	0.63	0.28	89	82	96	84	93
IR 79906-B-5-3-3	3.11	0.92	0.76	0.91	0.83	0.87	79	79	78	78	79
CR 2624	3.78	0.89	0.82	0.80	0.79	0.84	80	78	81	80	80
Khandagiri (check)	3.48	1.26	1.19	1.09	1.19	1.11	71	68	74	69	73
Lalat	3.03	1.45	1.25	1.47	1.32	1.26	67	66	65	66	70
Satabdi	2.83	1.88	1.66	1.76	1.75	1.70	57	55	58	55	59
Naveen	2.99	1.56	1.48	1.42	1.32	1.47	64	60	66	66	65
Mean	3.25	3.25	1.00	0.98	0.98	1.01	75	73	77	75	76

below 1, indicates the relative tolerance of this trait to drought where genotypes showed delay in flowering and more prone to drought stress. Based upon the value and direction of desirability, ranking was done for different genotypes as highly drought tolerant (DSI<0.50), drought tolerant (DSI: 0.51-0.75), moderately drought tolerant (DSI: 0.76-1.00) and drought susceptible (DSI>1.00). Seven genotypes (63% of total) at all farmer's field were identified as drought tolerant genotypes (DSI<1) while, rest of the

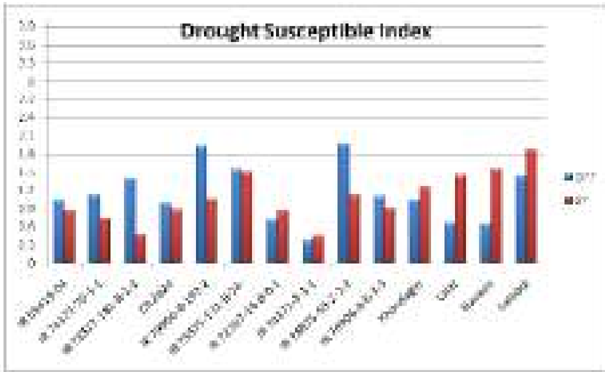

Fig. 1. Drought Susceptibility Index (DSI) for days to 50 per cent flowering (DFF) and grain yield under stress (SY)

genotypes were identified as susceptible genotypes (DSI>1) for grain yield. An overall appraisal revealed that IR 74371-3-1-1 and IR 78877-181-B-1-2 observed as highly tolerant genotypes while six genotypes *viz*., IR 79906-B-5-3-3, IR 72267-16-B-B-1, IR 55419-04 and CR 2624 grouped into moderately tolerant group. Furthermore, IR 74371-70-1-1 (0.74) recorded as drought tolerant on pool basis. Comparison across the farmer's field indicated that the genotype IR 74371-3-1-1 emerged as highly tolerant for grain yield. Earlier Prakash (2007) and Bandyopadhyay (2008) reported similar findings. The reduction in grain yield was observed under farmer's field for the different genotypes while experimental mean reduced up to 30.43 per cent. The similar findings were found by Wonprasaid *et al*., 1996. Differences among genotypes in yield under stress were partitioned into differences in yield potential, drought escape and drought tolerance. Phenotypic traits related to yield under stress were divided into those reflecting drought escape and those reflecting drought tolerance. However, the field data also indicated that considerable progress in yield under stress would be possible by selection for earlier flowering and improved yield potential alone (Fussell *et al*., 1991). In present study, depletion of soil moisture, which was associated with forced maturity during dough stage, might have resulted in decreased grain yield. The present study revealed that among the eleven tested genotypes, seven genotypes observed as drought tolerant genotypes, as indicated by their relatively low DSI values for grain yield at farmer's field. Genotypes with lowest DSI, particularly for grain yield would serve as useful donors for drought breeding programme. The use of DSI is likely to be most beneficial in selecting parents for development of drought tolerant populations, especially when yield potential vary greatly among the tested genotypes.

Drought tolerance efficiency value which was one of the drought resistance parameters were ranged from 55-90 per cent in F_1, 58-96 in F_2, 55-89 in F_3 and 59-93 per cent in F_4. Thus, IR 74371-3-1-1, IR 78877-181-B-1-2, IR 78875-53-2-2-2, CR 2624, IR 55419-04, IR 72267-16-B-B-1 and IR 79906-B-5-3-3 showed high DTE at all four farmer's field. On the other hand, IR 74371-3-1-1 and IR 78877-181-B-1-2 had lowest DSI. Results of this study have showed a parallelism with Parameshwarappa *et al*. (2008) findings. They reported that minimum yield reduction was realized in the genotypes which had the highest DTE and the lowest DSI. In this study IR 74371-3-1-1, CR 2624 and IR 74371-70-1-1 were observed to be drought resistant genotypes with the minimum yield reduction with higher DTE and lower DSI. IR 78875-131-B-14-1 and IR 74371-46-1-1 and all the checks were observed to be drought susceptible genotypes with maximum yield losses having low DTE, also the high DSI values. Desmukh *et al*. (2004) reported that the drought resistant genotypes had highest DTE, minimum DSI and minimum reduction in grain yield due to moisture stress.

Participatory varietal selection is a farmer participatory approach for identifying farmer-preferred varieties. However, in the formal testing system varieties are identified for their superiority over the existing released varieties and much attention is given to grain yield and adaptability in the target area for promotion or release (Virk and Witcombe, 2008). Farmer-relevant traits other than yield are rarely considered while, promoting an entry although farmers are known to tradeoff multiple traits while selecting a variety. Participatory approaches that relied on focus group discussions (FGD) provided farmers' perceptions that were not obtained in the on-station trials and researcher managed FFTs, particularly those from women members of farming households. The grain yield of CR

2624, IR 74371-70-1-1 and IR 74371-3-1-1 were higher than the local check and farmers preferred CR 2624 for a range of other pre and post-harvest traits even though they disliked its late maturity (Table 3). Farmer's of target environments selected cultivars on the basis of duration i.e. mid early/or medium duration (up to 110 days), grains panicle^{-1}, effective tillers hill^{-1}, less number of chaffs and grain type.

Grain yield selection is based on results from multi-location trials and more attention is given to testing under on-farm conditions. Farmer participatory plant breeding approaches have been integrated into the on-farm testing program to ensure that farmers will accept new cultivars. The visual combined assessment of performance and its stability is an important advantage, and adds confidence in the decision to promote a superior genotype. In the view of above discussion, the genotypes IR 74371-70-1-1 and CR 2624 recommended for cultivation under target environment in drought condition. In a joint variety development programme by International Rice Research Institute, Philippines with National Rice Research Institute, Cuttack IR 74371-70-1-1 is released as Sahbhagi dhan for drought prone areas and CR 2624 is released as Pyari for aerobic conditions (water shortage areas).

Table 3. Ranking of varieties in Participatory Varietal Selection (PVS) trial at *Samian* and *Berna* village

Varieties	First	Second Figures in per cent	Third
CR 2624	30	12	33
IR 74371-70-1-1	23	38	5
IR 74371-3-1-1	17	20	17
Khandagiri	7	2	12
IR 55419-04	7	2	8

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REFERENCES

Bandyopadhyay BB 2008. Genetic variation in wheat upon water deficit stress to a range of low temperature regime at high altitude. *Indian Journal of Genetics.* 68 (1): 26-32.

Deshmukh DV, Mhase LB and Jamadagni BM 2004. Evaluation of chickpea genotypes for drought tolerance. *Indian Journal of Pulses Research.* 17: 47-49.

Fischer RA and Maurer R 1978. Drought resistance in spring wheat cultivars: I. Grain yields responses. *Australian Journal of Agricultural Research.* 29: 897-907.

Fischer KS and Wood G 1981. Breeding and selection for drought tolerance in tropical maize. In: Proc. Symp. on Principles and Methods in Crop Improvement for Drought Resistance with Emphasis on Rice, IRRI, Philippines.

Fussell LK, Bidinger FR and Bieler P 1991. Crop physiology and breeding for drought tolerance: research and development. *Field Crops Research.* 27 (3): 183-199.

Parameshwarappa SG and Salimath PM 2008. Field Screening of Chickpea Genotypes for Drought Resistance. *Karnataka Journal of Agricultural Science.* 21(1): 113-114.

Prakash V 2007. Screening of wheat (*Triticum aestivum* L.) genotypes under limited moisture and heat stress environments. *Indian Journal of Genetics.* 67 (1): 31-33.

Virk DS and Witcombe JR. 2008. Evaluating cultivars in unbalanced on-farm participatory trials. *Field Crops Research.* 106: 105-115.

Winter SR, Musick JT and Porter KB 1988. Evaluation of screening techniques for breeding drought resistance winter wheat. *Crop Science.* 28: 512-516.

Wonprasaid S, Khunthasuvon S, Sittisuang P and Fukai S 1996. Performance of contrasting rice cultivars selected for rainfed lowland conditions in relation to soil fertility and water availability. *Field Crops Research*. 47: 267–275.