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Performance of SRI rice-mustard cropping system under system based integrated nutrient management practices

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ABSTRACT

System based integrated nutrient management practices for SRI rice-mustard cropping system was studied in a field experiment during 2013-14 and 2014-15 at RRTTS, Bhawanipatna, Kalahandi, Odisha. Application of 100% recommended dose of fertilizer (RDF-120:60:60 kg N:P $_2O_5$: K_2O ha^{-1}) + 5t FYM ha^{-1} with split application of nitrogen as ¼ at transplanting(TP) ½ at active tillering (AT) and ¼ at panicle initiation (PI) recorded maximum effective tillers m^{-2} (183), filled grains panicle^{-1} (213), test weight (26.4 g) and grain yield (7.54 t ha^{-1}) of rice under SRI. The increase in yield in this best INM treatment was 59.07% higher over existing practice of application of 100% RDF with split application of nitrogen as ⅓ at TP, ⅓ at AT and ⅓ at PI. The highest residual effect on mustard seed yield (0.81 t ha^{-1}), system productivity (9.63 t ha^{-1}), net return (Rs. 82,488/- ha^{-1}) and return rupee^{-1} invested (2.55) was noticed with this treatment. As regards to the nutrient management in mustard, higher seed yield of mustard (0.80 t ha^{-1}), system productivity (7.98 t ha^{-1}), net return (Rs 59,163/- ha^{-1}) and return rupee^{-1} invested (2.11) was recorded with application of 50% RDF (RDF-40:20:20 kg N:P $_2O_5$: K_2O ha^{-1}) + bio-fertilizer to mustard which was at par with 100%RDF treatment. The yield of mustard in this best treatment was 90.47% higher over control.

Key words: *Hybrid rice, rice-mustard crop sequence, economics, REY*

INTRODUCTION

Rice-mustard is one of the most prevalent cropping systems adopted by the farmers' of eastern India. This system is followed without proper nutrient management practices resulting in deterioration of soil fertility and crop productivity. Integrated nutrient management (INM) involves maintenance of soil fertility, sustainable crop productivity vis-à-vis improving the farmers' economic condition through the combined use of chemical fertilizers, organic manures and biofertilizers. The beneficial effect of integrated plant nutrient supply (IPNS) in rice-based cropping system has been well reported by many workers (Kumar et al., 2001; Pramanick et al., 2007 and Khambalkar et al., 2012). The rising prices and lack of availability of chemical fertilizers in right time to the farmers restricts their proper use and open the ways to search for some alternative source of plant nutrients. Integration of locally available organics like farm yard manure (FYM) and low cost inputs like bio-fertilizers as supplementary sources of nutrient not only meets the nutrient requirement of the system but also is useful for improving soil health. The beneficial effects of FYM alone or in combination with chemical fertilizers have been reported by Kumar et al. (2001). FYM has been proved to be viable component of INM for SRI (Sowmya and Venkata Ramana, 2012). Moreover the rice production in the country remains stagnant over a decade because of reduction in cultivated area, indiscriminant use of agro-chemicals and stress due to biotic and abiotic factors. System of rice intensification

(SRI) developed in Madagascar by Henri de Laulanie seems to be an alternative to conventional rice production technology for improving productivity of rice. SRI offers the opportunity to achieve the yield potential already existing in rice genome through a change in plant, soil, water and nutrient management resulting in both improvement of soil health and increased yield (Stoop et al., 2002). Nearly 82% rice fallows are located in states of Bihar, Madhya Pradesh, West Bengal, Odisha, Assam and Tripura in India. Efficient natural resource management using left over soil moisture and nutrients after the preceding rice crop can convert rice farming into profitable enterprise (Singh et al., 2014). Further, farmers are growing mustard after harvest of rice in residual soil moisture condition without any nutrient management practices leading to low yield of grain and profit. Hence, an attempt was made to develop a system based nutrient management practice for SRI rice-mustard cropping sequence using locally available organics along with inorganic fertilizer in western undulating zone of Odisha.

MATERIALS AND METHODS

The field experiment was conducted during 2013-14 and 2014-15 in randomized block design during *Kharif* season to rice and split plot design in *Rabi* season to mustard with three replications. The eight treatment combinations *i.e.,* 120: 60:60 kg $N:P_2O_5:K_2O$ ha^{-1} (⅓ N each at TP, AT and PI) *i.e.,* 100% RDF, 50% RDF (⅓ N each at TP, AT and PI) + FYM 5t ha^{-1}, 75% RDF (⅓ N each at TP, AT and PI) + FYM 5t ha^{-1} , 100% RDF (⅓ N each at TP, AT and PI) + FYM 5t ha^{-1}, 100% RDF (½ N at TP, ¼ N at AT, ¼ N at PI) + FYM 5 t ha^{-1}, 100% RDF (¼ N at TP, ½ N at AT, ¼ N at PI) + FYM 5 t ha^{-1}, 50% RDF (? N each at TP, AT and PI) + FYM 10 t ha^{-1} and FYM 5 t ha^{-1} + vermicompost 2.5 ha^{-1} + Azosporillum 5 kg ha^{-1} + PSB 5kg ha^{-1} were imposed in RBD during *Kharif* to hybrid rice (hyb. Ajay) grown under SRI method. During *Rabi*, the eight *Kharif* treatments were taken as main plot and three nutrient management treatments *viz.,* 100% RDF (40:20:20 kg $N:P_2O_5:K_2O$ ha^{-1}), 50% RDF + Azotobacter and PSB @ 5 kg ha^{-1} each (Biofertilizer-BF) and control (no fertilizer) taken in subplot comprising twenty four treatment combinations were imposed in split plot design during *Rabi* season to mustard (cv. Anuradha) crop. The soil of the experimental site was silty clay with almost neutral pH (6.6), high in organic carbon content (0.705%), low in available N (132.5 kg ha^{-1}), medium in available phosphorus (11.8 kg P ha^{-1}) and high in available potassium (338.7 kg K ha^{-1}). All the standard procedures were followed for rice grown under SRI. Twelve days old seedlings were transplanted in square pattern with a spacing of 25cm x 25cm and mustard was sown with row to row spacing of 30cm and plant to plant 10cm. FYM, vermicompost and bio-fertilizers were applied before transplanting of rice crop as per treatment. Full does of phosphorous and potassium were applied as basal before transplanting (TP) and nitrogen was applied as basal and two top dressing at active tillering (AT) and panicle initiation (PI) stage of rice as per treatments. The biofertilizers Azosporillum/ Azotobacter 5kg ha^{-1} + PSB 5kg ha^{-1} were inoculated with FYM two days prior to transplanting rice or sowing of mustard as per treatment. The bio-fertilizers and chemical fertilizers were applied to mustard at the time of sowing as per the treatment. The source of N, P_2O_5 and K_2O were urea, di-ammonium phosphate and muriate of potash. Observations recorded in the two years experiment on yield attributes and yields were pooled together. System productivity in terms of rice equivalent yield (REY), net return and return rupee^{-1} invested were also calculated on pooled data. The economics and REY were calculated as per the prevailing market price of the produce. The prices of paddy grain and straw was Rs.13,100.00 and Rs.900.00 t^{-1} during 2013-14 and Rs.13,600.00 and Rs.1000.00 t^{-1} during 2014-15, respectively. The price of mustard seed and stover was Rs.34,000.00 and 300.00 t^{-1} during 2013-14 and Rs.35,000.00 and 400.00 t^{-1} during 2014-15, respectively.

RESULTS AND DISCUSSION

Integrated nutrient management (INM) brought about a significant variation in crop yield, yield attributing traits and economics for both the crops of rice and mustard. Highest effective tillers m^{-2} (183), filled grains panicle^{-1} (213), test weight (26.4 g) and grain yield (7.54 t ha^{-1}) of hybrid rice (hyb. Ajay) grown under SRI was recorded with the application of 100% RDF (N as ¼, ½ , ¼)+ FYM 5 t ha^{-1} (Table 1). This treatment recorded grain yield, effective tillers m^{-2} and filled grains panicle^{-}

Table 1. Effect of different nutrient management treatments on yield attributes and yield of rice under SRI during *Kharif* season (pooled for two years).

Treatments	Effective tillers m^{-2}	Filled grains panicle^{-1}	Test weight(g)	Grain yield (t ha^{-1})
100% RDF (N as ⅓+⅓+⅓)	127	168	25.1	4.74
50% RDF (N as ⅓+⅓+⅓)+5 t FYM	132	178	25.4	5.17
75% RDF (N as ⅓+⅓+⅓)+5 t FYM	143	190	25.6	6.04
100% RDF (N as ⅓+⅓+⅓)+5 t FYM	166	196	26.2	6.90
100% RDF (N as ½+¼+¼)+5 t FYM	159	192	25.9	6.75
100% RDF (N as ¼+½+¼)+5 t FYM	183	213	26.4	7.54
50% RDF (N as ⅓+⅓+⅓)+10 t FYM	136	187	25.5	5.87
5 t FYM+2.5 t VC + BF	119	164	25.0	4.18
LSD0.05	13	15	0.8	0.40
CV(%)	7.7	7.0	2.6	5.7

The prices of paddy grain and straw was Rs.13,100.00 and Rs.900.00 t-1 during 2013-14 and Rs.13,600.00 and Rs.1000.00 t-1 during 2014-15, respectively.

^{1} significantly higher than all other treatments. The increase in rice grain yield due to FYM incorporation might be attributed to release of nutrients from soil slowly for longer duration after decomposition resulting in better plant growth and yield attributing characters. The findings are in confirmation with the observations of Das et al. (2001) and Singh et al. (2009). The increase in yield due to supply of ½ N at active tillering stage was attributed to better uptake of nutrients resulting high biomass production with efficient translocation of photosynthates to grains (Dwivedi et al., 2006 and Naidu et al., 2013). The lowest yield attributes and yield were recorded with application of organic nutrients only to SRI rice (Table 1).

The application of organics and inorganics to rice and their residual effect and the direct effect of fertilizers and bio-fertilizers to mustard significantly

Table 2. Effect of different nutrient management treatments on yield attributes and yield of mustard under SRI rice-mustard cropping system (pooled for two years).

Treatments	Number of siliquae plant^{-1}	Number of seed siliqua^{-1}	Test weight (g)	Seed yield (t ha^{-1})
Kharif treatment				
100% RDF (N as ⅓+⅓+⅓)	56.8	5.8	3.66	0.47
50% RDF (N as ⅓+⅓+⅓)+5 t FYM	63.4	7.1	3.72	0.62
75% RDF (N as ⅓+⅓+⅓)+5 t FYM	69.5	7.7	3.77	0.67
100% RDF (N as ⅓+⅓+⅓)+5 t FYM	87.4	9.1	3.87	0.79
100% RDF (N as ½+¼+¼)+5 t FYM	85.9	8.8	3.83	0.75
100% RDF (N as ¼+½+¼)+5 t FYM	89.5	9.7	3.90	0.81
50% RDF (N as ⅓+⅓+⅓)+10 t FYM	73.2	8.1	3.81	0.69
5 t FYM+2.5 t VC + BF	61.4	6.6	3.68	0.57
$LSD_{0.05}$	5.6	0.4	0.2	0.05
CV(%)	14.0	11.6	5.8	9.5
Rabi treatment				
100% RDF	82.6	8.7	3.80	0.79
50% RDF + BF	88.6	9.3	3.84	0.80
Control	48.9	5.5	3.69	0.42
$LSD_{0.05}$	4.2	0.4	0.10	0.03
CV(%)	14.0	11.6	5.8	9.5

The price of mustard and stover was Rs.34,000.00 and Rs.300.00 t^{-1} during 2013-14 and Rs.35,000.00 and Rs.400.00 t^{-1} during 2014-15, respectively.

Table 3. Effect of different nutrient management treatments on system yield and economics of SRI rice-mustard cropping system (pooled for two years).

Treatments	REY (t ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Return $rupee^{-1}$ invested
Kharif treatments				
100% RDF (N as ⅓+⅓+⅓)	5.95	84,332	35,519	1.73
50% RDF (N as ⅓+⅓+⅓)+5 t FYM	6.76	95,568	45,530	1.91
75% RDF (N as ⅓+⅓+⅓)+5 t FYM	7.77	109,710	58,034	2.12
100% RDF (N as ⅓+⅓+⅓)+5 t FYM	8.93	126,014	72,702	2.36
100% RDF (N as ½+¼+¼)+5 t FYM	8.69	122,690	69,377	2.30
100% RDF (N as ¼+½+¼)+5 t FYM	9.63	135,801	82,488	2.55
50% RDF (N as ⅓+⅓+⅓)+10 t FYM	7.66	108,235	53,697	1.98
5 t FYM+2.5 t VC + BF	5.66	79,905	20,242	1.34
$LSD_{0.05}$	0.40	5,537	5,537	0.10
CV(%)	2.1	2.1	4.1	2.1
Rabi treatments				
100% RDF	7.94	1,11,929	57,872	2.08
50% RDF + BF	7.98	1,12,513	59,163	2.11
Control	6.98	98,903	47,061	1.91
$LSD_{0.05}$	0.07	905	905	0.20
CV(%)	2.1	2.1	4.1	2.1

increased yield attributing characters and yield of mustard over control. The highest number of siliquae $plant^{-1}$ (89.5), seeds $siliqua^{-1}$ (9.7), test weight (3.90 g) and seed yield (0.81 t ha-1) were recorded with 100% RDF (N as ¼, ½, ¼) + FYM 5 t ha-1 applied to rice. But it was at par with 100% RDF (N as ⅓, ⅓, ⅓) + FYM 5 t ha^{-1} in terms of number of siliquae $plant^{-1}$ and seed yield (0.81 t ha^{-1}) (Table 2).

Highest number of siliquae $plant^{-1}$ (88.6), seeds $siliqua^{-1}$ (9.3), test weight (3.84g) and seed yield (0.8 t ha^{-1}) were recorded with application of 50% RDF + BF to mustard which was at par with 100% RDF only for test weight and seed yield (Table 2). The percent increase in number of siliquae plant-1, seeds $siliqua^{-1}$, test weight and seed yield was 81.2, 69.1, 4.1 and 90.5, respectively over control. This increase in yield components might be due to carry over effects of applied nutrients to the preceding rice crop and bio-fertilizers to mustard which resulted in higher availability of macro and micronutrients. Similar finding were also reported by Paikray et al. (2001), Munda et al. (2008) and Singh et al. (2009). Application of Azotobacter to mustard plays greater role in enhancing the yield attributing characters owing to fixation of atmospheric nitrogen, production of siderophores which regulates the availability of nutrients to the crop (Narula et al., 1993).

The system productivity of rice - mustard cropping sequence also varied significantly with different integrated nutrient management treatments (Table - 3). Highest rice equivalent yield (REY) of 9.63 t ha^{-1}, was recorded with 100% RDF (N as ¼, ½, ¼) + FYM 5 t ha^{-1} which was significantly superior to all other treatments imposed on *Kharif* rice with respect to REY. The INM treatment *i.e.,* 50% RDF + BF to mustard registered higher REY yield (7.98 t ha^{-1}) which was at par with 100% RDF (7.94 t ha^{-1}). The increase in REY of INM and 100% RDF treatment to mustard was 14.3 and 13.7 percent higher over control, respectively. The residual effect of the *Kharif* nutrient management treatment with 100% RDF (N as ¼, ½, ¼) + FYM 5t ha^{-1} recorded highest gross return (Rs. 1,35,801/- ha^{-1}), net returns (Rs. 82,488/- ha^{-1}), return $rupee^{-1}$ invested (2.55) for the rice-mustard sequence which is significantly superior from all other treatments imposed on rice. Among the different nutrient management approaches to mustard, 50% RDF + BF (INM treatment) registered highest gross return (Rs. 1,12,513/- ha^{-1}), net return (Rs. 59,163/- ha^{-1}) and return $rupee^{-1}$ invested (2.11) than 100% RDF and control in SRI rice- mustard cropping system but remained at par with respect to REY, gross return and return $rupee^{-1}$ invested with application of 100%RDF to mustard. This result confirms with the findings of Munda and Islam

(2006).

Thus the integrated nutrient management treatment of 100% RDF + FYM 5 tha^{-1} (N as ¼, ½, ¼) to hybrid rice (hyb. Ajay) grown under SRI method and 50% RDF + Azotobacter and PSB 5 kg ha^{-1} each to mustard found to be beneficial is terms of REY, net return, return rupee^{-1} invested for SRI rice-mustard cropping systems in western undulating zone of Odisha.

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