Journal of Crop and Weed, 17(2): 47-51 (2021)

ISSN- O : 2349 9400 ; P : 0974 6315

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Effect of organic and inorganic nutrient sources combination on short grain aromatic rice-greengram cropping system

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Received : 12.02.2021 ; Revised : 27.03.2021 ; Accepted : 10.04.2021

DOI: https://doi.org/10.22271/09746315.2021.v17.i2.1450

ABSTRACT

The combined effect of organic and inorganic nutrient sources on short grain aromatic rice-greengram cropping system was carried out during kharif and rabi seasons in 2017-18 and 2018-19. Pooled analysis showed that nutrient management by 50% RDF + 50 % RDN through FYM recorded significantly higher grain yield (3875 kg ha^{-1}), straw yield (7233 kg ha^{-1}), hulling (75.7 %), milling (66.7%), head rice recovery (59.8%) and protein content (9.0%). Application of 50% RDF + 50 % RDN through FYM to preceding rice recorded significantly higher seed yield (806 kg ha^{-1}), stover yield (1957 kg ha^{-1}) and harvest index (29.1 %) in greengram. Application of 75% RDF+ Rhizobium+ PSB to greengram crop recorded significantly higher seed yield (697 kg ha^{-1}), stover yield (1787 kg ha^{-1}), harvest index (28.2 %). Significantly higher nitrogen uptake (165.5 kg ha^{-1}), phosphorus uptake (30.1 kg ha^{-1}) and potassium uptake (217.3 kg ha^{-1}) in cropping system were recorded with application of 50% RDF+ 50% RDN through FYM to rice.

***Keywords*:**Aromatic rice - greengram cropping sequence, yield, system productivity, nutrient uptake

Rice is an extensively grown food grain in the world which is also referred as "Global grain" due to its primary importance as staple food all around the world. India is widely regarded for its diversified aromatic rice landraces around all the states from which majority of land races area small to medium grains. Besides basmati rice, traditionally grown short grain aromatic rice is grown in small pockets in almost all parts of the country. Traditional aromatic rice varieties possess intense aroma, cooking and sensory characteristics for which they are consumed as local delicacy. Odisha as a major producer and consumer of aromatic rice has its own set of aromatic short grain rice, which are grown in different districts under various environmental conditions. Small and marginal farmers of Odisha grow aromatic rice in small localised pockets for producing different value-added products which give them higher profit. Also, these local short grain aromatic rice possesses more aroma with higher retention capacity over basmati rice in relatively warm temperature region.

Apprehension on sustainable yield of rice-based cropping system has given on to renewed interest in organic manuring by recycling of different organic wastes. Chemical fertilizers are well known for their effects on the yield increment, whereas organic nutrients enhance the quality and aroma (Kumpawat, 2010). Wider and imbalanced use of chemical fertilizers cause the degradation of soil health and soil productivity. Application of green manure, FYM or biofertilizer not only helps in supplementing requirement but also improves soil health and crop productivity (Chaudhary *et al.,* 2004). Therefore, it is needed that fertility and productivity of the soil be restored, using organic fertilizers only or in combination with chemical fertilizers.

Rice-pulse cropping system is one of the major cropping systems in rice fallow areas of the state. In rice fallow areas, farmers generally grow greengram as part of their traditional cropping pattern as reported by Mohanty *et al*. (2015). As there is higher area under rice fallow in Odisha and convergence of retreating monsoon in *rabi* season, greengram is generally grown by small and marginal farmers of Odisha as a subsidiary crop after harvesting the main crop rice. Presently there are very less studies conducted on utilisation pattern of fertilizers and its effect on residual crops in rice-based cropping system. Considering the above facts, the present study was carried out to understand the effect of organic and inorganic nutrient sources on short grain aromatic rice-greengram cropping system.

MATERIALS AND METHODS

The field experiment was conducted at Instructional Farm, Odisha University of Agriculture and Technology, Bhubaneswar (20^0 15' N latitude and 85^0 52' E longitude, 25.9 m above mean sea level) during *kharif* and *rabi* seasons in 2017-18 and 2018-19. The research farm lies within the East and South Eastern Coastal Plain agro-climatic zone of Odisha. The soil of the research field was sandy loam in texture with good water holding capacity and internal drainage. The soil was characterized by little acidic in reaction (pH value of 5.7), low in soil organic carbon (3.82 g kg^{-1}), low in available nitrogen (199.3 kg ha^{-1}), medium in available

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phosphorus (17.3 kg ha^{-1}) and medium in available potassium (269.1 kg ha^{-1}). Short grain aromatic rice (cv. Nua Acharamati) was grown during *kharif* season in randomized block design comprising six treatments *viz*. 100% RDF (60 – 30 – 30kg ha^{-1} of N: P_2O_5: K_2O), 75 % RDF+25% RDN through FYM, 50 % RDF+50% RDN through FYM, 50 % RDF+25% RDN through FYM, 75 % RDF+ green manuring and 50% RDF+ green manuring. In green manuring treatment plots, dhaincha (*Sesbania aculeata*) @ 25 kg $ha^{-1}$was sown and incorporated at 40-42 DAS and then rice transplanting was done. *Azospirillum* and PSB were applied to all the treatments in rice field. During *rabi* season of both the years, greengram (cv. IPM-02-03) was grown in split-plot design taking nutrient management in rice as main plots and three nutrient management practices *viz*. 100% RDF (20: 40: 40 kg $ha^{-1}$of N: P_2O_5:K_2O), 75% RDF, 75 % RDF+ *Rhizobium*+ PSB as sub plots.The fertilizers based on treatments were applied as basal in furrows keeping 30 cm between row to row and 10 cm between plant to plant. The *Rhizobium* cultures@ 200 g *Rhizobium* 10 kg^{-1} seed was mixed with 10% sugar solution or a little water and kept in air shade without sunlight. PSB culture @ 200 g 12 kg fine $soil^{-1}$ was mixed properly and applied to the treatment plots.Yield parameters of both aromatic rice and greengram were recorded at the time of harvest of respective crops.

Rough rice samples were dehulled by a laboratory sheller and the resulting brown rice was weighed to determine hulling recovery (%)

$$\text{Hulling \%} = \frac{\text{Weight of brown rice(g)}}{\text{Weight of rough rice(g)}} \times 100$$

The whole grains were separated from broken with a rice sizing device and head rice recovery (%) was expressed as

Head rice recovery (%) =

$$\frac{\text{Weight of whole milled rice(g)}}{\text{Weight of rough rice(g)}} \times 100$$

Alkali spreading value was determined in alkali digestion test using as suggested by Dela Cruz and Khush (2000). Duplicate sets of six whole milled kernels without cracks were kept in petriplate which contains 1.7% KOH solution at 30 ± 1 ^{0}C for 23 hours and those were evaluated using a 7-point rating scale.

System productivity (kg $ha^{-1}day^{-1}$) is expressed by the following formula:

System productivity (kg $ha^{-1}day^{-1}$) =

$$\frac{\text{Total system yield}}{365}$$

(where the system yield indicates the rice equivalent yield)

At the time of harvest of both rice and greengram, plant samples were collected randomly and analysed for nitrogen, phosphorus and potassium content of grain and straw of rice and seed and stover of greengram separately. The oven-dried samples were finely ground and analysed for estimation of nitrogen, phosphorus and potassium content using the appropriate methods. Total nitrogen content in plant material was determined by modified micro Kjeldahl distillation method (Jackson, 1973) after digestion of 0.1 g of oven-dry finely ground haulm samples and 0.2 g of oven-dry seed sample. The total phosphorus and potassium content was determined after digestion of 0.1 g straw and 0.2 g of grain in nitric acid (HNO_3) and perchloric acid ($HClO_3$) and diluting the digested material after filtering to a standard solution. Phosphorus content was determined by spectrophotometer and potassium by flame photometer method (Jackson, 1973).The nutrient content in grain and straw obtained from plant analysis were multiplied with the grain and straw yield to get the nutrient uptake (kg ha^{-1}).

RESULTS AND DISCUSSION

Yield performance of short grain aromatic rice

Yield attributes of short grain aromatic rice were significantly varied by the treatment combination of organics and inorganics applied. Pooled data showed that application of 50% RDF + 50 % RDN through FYM produced significantly higher number of panicles m^{-2}(318.4), filled grains $panicle^{-1}$ (180.6), 1000 grain weight (18.4 g), grain yield (3875 kg ha^{-1}), straw yield (7233 kg ha^{-1}) and harvest index (34.9 %) followed by the treatment comprising of 75% RDF+ green manuring. The lowest values were obtained from the 50% RDF+ 25% RDN through FYM treatment (257.9, 128.9, 16.2 g, 2638 kg ha^{-1}, 5870 kg ha^{-1} and 31.0 % respectively) (Table 1). It could be due to additional supply and availability of nutrients through FYM and improved soil environment, maintaining soil health, and keeping pace with sustainable productivity of aromatic rice. Besides, farmyard manure improves the soil physical condition, *i.e*., soil structure, water-holding capacity, soil porosity and numerous microbial activities that increase balance nutrition, development of root and crop morphological characters, which ultimately increases the yield of rice. This result is in confirmatory with Aasif *et al*. (2018) and Ali *et al*. (2009).

Grain quality of short grain aromatic rice

Pooled data analysis of quality parameters of rice showed that significantly higher hulling % (75.8), milling % (68.1), head rice recovery % (59.8) and protein content (9.0%) were achieved with 50% RDF+ 50% RDN through FYM treatment followed by the treatment

Table 1: Effect of organic and inorganic nutrient sources on yield parameters of short grain aromatic rice (cv. NuaAcharamati) during *kharif* season

Treatment	No. of panicles m^{-2}	No. of filled grains $panicle^{-1}$	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
100 % RDF (60-30-30 kg $ha^{-1}$of N: P_2O_5: K_2O)	277.6	138.1	16.5	3048	6207	32.9
75% RDF + 25% RDN through FYM	299.2	149.3	16.7	3337	6692	33.3
50% RDF + 50% RDN through FYM	318.4	180.6	18.4	3875	7233	34.9
50% RDF + 25% RDN through FYM	257.9	128.9	16.2	2638	5870	31.0
75% RDF + Green manuring	309.0	162.2	17.9	3489	6595	34.6
50% RDF + Green manuring	281.9	141.0	17.4	3203	6390	33.4
SEm (±)	**4.45**	**1.94**	**0.09**	**60.6**	**105.3**	**0.42**
LSD (0.05)	**12.39**	**5.42**	**0.26**	**168.8**	**293.2**	**1.18**

Table 2: Effect of organic and inorganic source of nutrients on quality parameters of short grain aromatic rice (cv. NuaAcharamati)

Treatment	Hulling (%)	Milling (%)	Head rice (%)	Alkali spreading value (score)	Amylose content (%)	Protein content (%)
100% RDF (60-30-30 kg $ha^{-1}$of N: P_2O_5: K_2O)	70.2	62.4	54.1	4.2	21.2	8.0
75% RDF + 25% RDN through FYM	71.4	64.6	56.6	4.3	21.5	8.2
50% RDF + 50% RDN through FYM	75.8	68.1	59.8	4.4	21.7	9.0
50% RDF + 25% RDN through FYM	70.7	63.4	54.3	4.3	21.0	7.9
75% RDF + Green manuring	75.3	66.3	59.1	4.3	22.2	8.6
50% RDF + Green manuring	72.3	63.6	55.2	4.3	21.3	8.1
SEm (±)	**0.29**	**0.35**	**0.15**	**0.02**	**0.15**	**0.03**
LSD (0.05)	**0.80**	**0.99**	**0.42**	**NS**	**NS**	**0.09**

Table 3: Effect of organic and inorganic nutrient sources on yield attributes of greengram (cv. IPM-02-03) during *rabi* season

Treatment	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	1000 seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Nutrient management in rice						
100 % RDF(60-30-30 kg $ha^{-1}$of N: P_2O_5: K_2O)	6.4	6.8	29.3	525	1444	26.6
75% RDF+25% RDN through FYM	8.5	9.0	30.3	620	1648	27.3
50% RDF+50% RDN through FYM	11.1	10.8	31.3	806	1957	29.1
50% RDF+25% RDN through FYM	5.7	6.4	28.6	487	1393	25.8
75% RDF+ Green manuring	10.3	10.7	30.9	717	1814	28.3
50% RDF+ Green manuring	8.0	9.1	29.2	539	1566	25.7
SEm (±)	**0.14**	**0.10**	**0.16**	**16.0**	**27.9**	**0.34**
LSD (0.05)	**0.39**	**0.28**	**0.47**	**46.5**	**81.1**	**0.98**
Nutrient management in greengram						
100% RDF (20-40-40 kg $ha^{-1}$of N: P_2O_5: K_2O)	8.2	8.8	30.0	613	1644	27.0
75% RDF	7.4	8.2	28.8	537	1500	26.2
75% RDF+ *Rhizobium*+ PSB	9.4	9.4	30.9	697	1767	28.2
SEm (±)	**0.08**	**0.04**	**0.13**	**5.**	**14.1**	**0.21**
LSD (0.05)	**0.22**	**0.12**	**0.37**	**15.4**	**40.2**	**0.61**

Table 4: Performance of organic and inorganic source of nutrients on system uptake in rice-greengram cropping system

Treatment	SREY (kg ha^{-1})	System productivity (kg ha^{-1}day^{-1})	System N uptake (kg ha^{-1})	System P uptake (kg ha^{-1})	System K uptake (kg ha^{-1})
Nutrient management in rice					
100% RDF (60-30-30 kg ha^{-1}of N: P_2O_5: K_2O)	4711	12.9	132.2	18.9	119.7
75% RDF+25% RDN through FYM	5303	14.5	151.8	22.5	136.9
50% RDF+50% RDN through FYM	6431	17.6	189.1	28.7	162.2
50% RDF+25% RDN through FYM	4161	11.4	121.6	15.3	108.9
75% RDF+ Green manuring	5763	15.8	165.1	26.5	144.4
50% RDF+ Green manuring	4906	13.4	137.6	20.6	127.0
SEm (±)	**115.5**	**0.32**	**2.58**	**0.42**	**1.97**
LSD (0.05)	**336.4**	**0.92**	**7.52**	**1.21**	**5.73**
Nutrient management in greengram					
100% RDF (20-40-40 kg ha^{-1}of N: P_2O_5: K_2O)	5214	14.3	149.6	22.2	133.4
75% RDF	4975	13.6	140.6	21.0	127.6
75% RDF+ *Rhizobium*+ PSB	5450	14.9	158.6	23.1	138.5
SEm (±)	**18.7**	**0.05**	**0.71**	**0.05**	**0.45**
LSD (0.05)	**53.3**	**0.15**	**2.01**	**1.14**	**1.29**

comprising 75% RDF+ green manuring. Lowest values were recorded in the 100 % RDF treatment (Table 2). Farmyard manure provides macro and micronutrients in optimal quantity resulting in increasing quality parameters of rice. Higher protein content in grain in 50% RDF + 50% RDN through FYM is due to synchrony in nitrogen demand and supply and its efficient translocation from source to sink which increases nitrogen content in grain. The variation in the chemical composition of rice seed may be also due to differential release of nutrients from organic sources. Cooking characteristics of rice like alkali spreading value and amylose content remain unaffected by agronomic management practices as these are governed by genetic characters. However there was little increase in alkali spreading value (4.4) and amylose content %(21.7) due to 50 % RDF + 50 % RDN through treatment.These results are in confirmatory with Sravana and Singh (2019) and Davari and Sharma (2010).

Yield performance of rabi greengram

During *rabi* season, application of 50% RDF + 50 % RDN through FYM to preceding rice crop recorded significantly higher pods plant^{-1}(11.1), seeds pod^{-1} (10.8), 1000 seed weight (31.3 g), seed yield (806 kg ha^{-1}), stover yield (1957 kg ha^{-1}) and harvest index (29.1 %) in greengram followed by the treatment comprising of 75% RDF+ green manuring (Table 3). Application of 75% RDF+ *Rhizobium*+ PSB to greengram crop recorded significantly higher pods plant^{-1}(9.4), seeds pod^{-1} (9.4), 1000 seed weight (30.9 g), seed yield (697 kg ha^{-1}), stover yield (1787 kg ha^{-1}), harvest index (28.2 %) in greengram followed by the treatment comprising of 100 % RDF + 75 % RDF. This might be due to the combined effect of residual effect of FYM application with synchronized effect of application of *rhizobium* and phosphorus solubilizing bacteria to greengram crop. Combined application of organic and inorganic fertilizers could attribute synchronisation of nutrient demand and supply to the greengram crop resulting in better biomass production leading to higher yield attributes. These results are also in confirmatory with Singh *et al*. (2017) and Sudhagar Rao *et al*. (2019).

Performance of short grain aromatic rice – greengram cropping system

Performance of short grain aromatic rice – greengram cropping system was significantly affected due to integrated nutrient management practices applied to rice and greengram. Pooled analysis showed that significantly higher system rice equivalent yield (6431 kg ha^{-1}), system productivity (17.6 kg ha^{-1}day^{-1}), system nitrogen uptake (189.1 kg ha^{-1}), system phosphorus uptake (28.7 kg ha^{-1}) and system potassium uptake (162.2 kg ha^{-1}) were recorded with application of 50% RDF+ 50% RDN through FYM to rice followed by the treatment comprising 75% RDF+green manuring. Lowest values were recorded in the 50% RDF + 25% RDN treatment only (Table 4). Similarly, application of 75% RDF+*Rhizobium*+ PSB to greengram showed significantly higher system rice equivalent yield (5450 kg ha^{-1}), system productivity (14.9 kg ha^{-1}day^{-1}), system

nitrogen uptake (158.6 kg ha^{-1}), system phosphorus uptake (23.1 kg ha^{-1}) and system potassium uptake (138.5 kg ha^{-1}) than 100% RDF and 75% RDF treatments. Similar results were also obtained by Guadhade *et al.*(2020).

From the above experiment, it is concluded that application of 50 % RDF + 50 % RDN through FYM to short grain aromatic rice significantly increased yield and yield attributes as well as nutrient uptake of rice and has residual effect on succeeding greengram crop. Also, the treatment receiving 75 % RDF + *Rhizobium* + PSB in greengram increased the yield and yield parameters of greengram.

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