Yield, quality and economics of Basmati rice as influenced by different organic nutrient management practices

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ABSTRACT

A field study was conducted in Agronomy Research Farm, Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during kharif 2012-13 to study the effect of organic source of nutrients on productivity, profitability and quality of Basmati rice. Application of Azospirillum (10 kg/ha)+ PSM (10 kg/ha) + EM Spray (twice) + neem cake along with 75% N (75% FYM + 25% vermicompost) resulted in the highest grain yield (3,570 kg/ha) and maximum net returns (Rs.39,654/ha) and was closely followed by Azospirillum (10 kg/ha)+ PSM (10 kg/ha) + EM Spray (twice) with 75% N (75% FYM + 25% vermicompost). Twenty five per cent organic nitrogen source could be saved by addition of Azospirillum + PSM + EM spray or Azospirillum+ PSM + EM spray + Neem cake without any yield reduction in Basmati rice. Application of 100% N (75% FYM + 25% vermicompost) increased the soil available N (253.48 kg/ha), P_2O_5 (45.46 kg/ha) and K_2O (181.62 kg/ha) content over the initial value of available N (246.21 kg/ha), P_2O_5 (43.38 kg/ha) and K_2O (167.84 kg/ha) after harvest of Basmati rice. It was closely followed by application of Azospirillum (10 kg/ha) + PSM (10 kg/ha) + EM Spray (twice) + neem cake along with 75% N (75% FYM + 25% vermicompost) and Azospirillum (10 kg/ha) + PSM (10 kg/ha) + EM Spray (twice) with 75% N (75% FYM + 25% vermicompost). Thus, both soil fertility and grain quality could be increased by these treatments.

Key words: *Basmati rice, Azospirillum, vermicompost, EM spray, economics*

Scented rice especially Basmati rice with organic tag has huge export potential. It commands a very high premium in domestic as well as international markets due to their long slender superfine grains, pleasant aroma, soft texture and extreme grain elongation. In India, area under Basmati rice is increasing due to attractive price. It is estimated that around 700 mt of agricultural waste is available in the country every year, but most of it is not properly used. This implies a theoretical availability of 5 tonnes of organic manures/ hectare arable land/year, which is equivalent to about 100 kg NPK/ha/year (Tandon 1997). A number of organic waste materials are available, which can supply a good amount of plant nutrients, NPK to produce comparable yield (Ghosh 2005). The complexing property of organic manures influence the availability and mobility of micronutrients. Inclusion of FYM in a fertilizer regime maintains micronutrients at non limiting levels for the rice-rice system. Improvement in soil physical and chemical as well as in biological activity through continuous application of chemical fertilizers along with FYM results in a greater soil quality index (SQI) and enhanced sustainability (Shahid *et al*. 2013). Long-term balanced fertilization in the form of FYM + NPK increases P availability to the plant leading to higher P uptake and yield maintenance (Bhattacharyya *et al*. 2015).

Rice produced by organic farming had better grain quality. Grain yield of Basmati rice improved with organic source of nutrients as compared to recommended level of N and untreated control (Mahajan *et al*. 2012). Biofertilizers, an alternate low cost resource have gained prime importance in recent decades. They are cost effective, ecofriendly and renewable source of plant nutrients to supplement fertilizers for sustainable agricultural development. Phosphate solubilizing bacteria alone or in combination with Azospirillum were able to establish in the rice rhizosphere and increased the grain yield of rice in autoclaved soil by 103-256% over control (Kannaiyan *et al*. 1982).

With respect to the effect of effective microorganisms (EM) on the growth and yield of rice, visual observations indicated that the EM treated plants performed better than those without EM (Myint 1994). In most areas, Basmati rice is grown under low input management condition resulting in lower productivity. The use of organic manures in augmenting soil fertility and crop productivity is well known. Thus, efforts need to be made for suitable combination of organic nutrients and management for maintaining productivity and profitability of Basmati rice.

MATERIALS AND METHODS

A field experiment was conducted to study the "effect of organic source of nutrients on productivity, profitability and quality of Basmati rice" during *kharif* season of 2012 at Agronomy Research Farm, Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar. The mean annual rainfall of the center was 1471.6 mm received in 100 days. Nearly 75 % of the annual rainfall is received between June to September. The soil was sandy loam and slightly acidic with pH 5.7, medium in organic carbon (0.51%), low in available N (246.21 kg/ha), high in available P_2O_5 (43.38 kg/ha) and medium in K_2O content (167.84 kg/ha). The experiment was conducted in randomised block design with three replications. The field experiment was laid out in a randomised block design with twelve treatments as T_1 : 100% N (75% FYM + 25% vermicompost), T_2 : 75% N (75% FYM + 25% vermicompost), T_3 : 50% N (75% FYM + 25% vermicompost), T_4 : T_2 + Azospirillum (10 kg/ha), T_5 : T_2 + Azospirillum + PSM (10 kg/ha), T_6 : T_2 + Azospirillum + PSM + EM Spray (two times), T_7 : T_2+ Azospirillum + PSM + EM Spray (two times) + Neem Cake (250kg/ha), T_8 : T_3 + Azospirillum, T_9 : T_3 + Azospirillum + PSM, T_{10} : T_3 + Azospirillum + PSM + EM spray (two times), T_{11} : T_3 + Azospirillum + PSM + EM spray (two times) + Neem Cake (250 kg/ha) and T_{12} : Control (no manure). The Basmati rice variety utilized in the experiment was Geetanjali aromatic. Seedlings were raised in wet nursery bed. Dhaincha seeds were sown @ 25 kg/ha and after 40 days ploughing was done to incorporate the plants into the soil for green manuring purpose. Sixteen days old seedlings were transplanted in the main field at a spacing of 20cm x 15cm. Biometric observations were recorded at fortnight interval starting from 15 days after transplanting upto the harvest on randomly selected and pegged five hills from every treatment plots (Kumar *et al*. 2017). After harvest, yield and quality parameters of rice were observed. The data collected from field observations and those recorded in laboratory were subjected to statistical analysis by standard analysis of variance techniques (Gomez and Gomez 1984).

Analysis of quality parameters

Kernel length and breadth (mm)

Ten milled kernels from each plot were taken at random and were placed on graph paper for their length breadth using a "Photo Enlarger" with a magnification of 3*. The mean length and breadth were expressed in mm.

Hulling per cent

Well dried rough rice sample from each plot weighing 100g were hulled in a mini "Satake Rice Medium" and the weight of brown rice was recorded. Hulling percentage was worked out as:

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

Milling per cent

The hulled brown rice samples were milled in a "Satake Rice Whitening and Caking Machine" for 5 minutes. The polished rice was weighed and milling percentage was calculated as:

$$\text{Milling}\ (\%) = \frac{\text{Weight of milled rice}\ (\text{g})}{\text{Weight of rough rice}\ (\text{g})} \text{ x } 100$$

Head Rice Recovery (HRR)

The head rice yield was determined by separating whole grains and 3/4th grains manually and percentage was expressed as:

$$\text{HRR}\ (\%) = \frac{\text{Weight of wholed milled rice}\ (\text{g})}{\text{Weight of rough rice}\ (\text{g})} \text{x100}$$

Amylose content

Representative samples containing 20-30 seeds for each sample were taken and graded to a very fine powder. Each sample was transferred in a commercial filter paper envelope. They were defatted for six hours with approximately 300 ml of hexane per balloon in a Soxhlet type continuous extractor. Samples were air dried so as to evaporate all hexane. Then extract solution and standard solutions were prepared by adding reagents following the procedure of Galicia *et al*. 2008.

Readings were taken at 620 nm in a spectrophotometer and standard curve was made. Percentage of amylose was calculated by using following formula. $Y_g = a(x) + b$

where, Y_g is the absorbance units at 620 nm, a is the slope, x is the amylose content and b is the intercept. % AM = (x.d) (100/f)

where, x is the amylose amount (mg), d is the dilution factor and f is the original weight of flours.

Volume expansion ratio (VER)

Volume expansion ratio was determined from the rate of cooked volume rice to that of the uncooked rice (Zhang and Shao 1999). 5g of rice was added to 15ml of water in a test tube and rise in volume (x ml) was noted. Rice was cooked and 15ml of water was added. Then rise in volume (y ml) was noted VER = y/x.

Elongation ratio (ER)

Kernel elongation is the linear expansion of the kernel after cooking which is being used in the quality evaluation. Elongation ratio was ratio of ten average length of cooked rice to the average length of raw rice (Prakash *et al*. 2002).

Kernel length after cooking (KLAC)

Ten average length of cooked rice in each treatment were taken where length of uncooked rice was calculated primarily.

Analysis of harvest index

The harvest index was calculated by the formula below and expressed in percentage.

$$HI = \frac{\text{Economic yield } (kg/ha)}{\text{Biological yield } (kg/ha)} x100$$

Analysis of Economics

Cost of production for all treatments were worked out on the basis of the prevailing market price of the input and the produce. The net return per hectare was calculated by deducting the cost of production from the gross return. The benefit-cost ratio was calculated treatment wise as per following formula to assess the economic impact of the treatments.

$$\text{Benift-cost ratio } (\text{B:C ratio}) = \frac{\text{Gross return } (\text{Rs.})}{\text{Cost of cultivation } (\text{Rs.})}$$

RESULTS AND DISCUSSION

Basmati rice grain yield obtained with 75% N (75% FYM + 25% vermicompost)+ Azospirillum (10 kg/ha)+ PSM (10 kg/ha) + EM spray (two times) + Neem cake (250 kg/ha) was maximum (3.57 t/ha) which was at par with 100% N (75% FYM + 25% vermicompost) *i.e.*, T_1 (3.32 t/ha), 75% N (75% FYM + 25% vermicompost)+ Azospirillum + PSM + EM spray *i.e.*, T_6 (3.31 t/ha), 75% N (75% FYM + 25% vermicompost) + Azospirillum + PSM *i.e.*, T_5 (3.24 t/ha), 50% N (75% FYM + 25% vermicompost) + Azospirillum+ PSM+ EM spray + Neem cake *i.e.*, T_{11} (3.12 t/ha) and 75% N (75% FYM + 25% vermicompost) + Azospirillum *i.e.*, T_4 (3.11 t/ha).

There was significant reduction in grain yield due to decline in organic nitrogen nutrition from 100% N to 50% N through 75% N from 75% FYM + 25% N from vermicompost (Table 1). Application of biofertilizers in the form of either Azospirillum, Azospirillum + PSM or Azospirillum + PSM + EM spray increased the grain yield in all the treatments. The increases in grain yield were in the respective order of 1, 5 and 7 per cent at 75% N (75% FYM + 25% vermicompost) level and 0.4, 4 and 8 per cent at 50% N (75% FYM + 25% vermicompost) level. The increase in yield due to 75% N (75% FYM + 25% vermicompost) + Azospirillum + PSM + EM spray + Neem cake, 100% N (75% FYM + 25% vermicompost) and 75% N (75% FYM + 25% vermicompost) + Azospirillum + PSM + EM spray were 43.9, 33.8 and 33.5 per cent, respectively, over the control. These results are in close conformity with the findings of Singh *et al*. (2006), Davari and Sharma (2010), Singh *et al*. (2007), Yadav *et al*. (2009), Singh *et al*. (2011) and Moola Ram *et al*. (2011) where in they recorded significantly higher yield of rice under combined application of various organic source of nutrients.

In the present study with Basmati rice,

Table 1. Yield and economics of organic basmati rice as influenced by nutrient management.

Treat-ment	Grain (kg/ha)	Straw (kg/ha)	Har-vest index (%)	Cost of culti-vation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C
T_1	3320	5850	36.20	38100	71080	32980	1.86
T_2	3080	5730	34.96	34950	66184	31234	1.89
T_3	2800	5720	32.86	31800	60576	28776	1.90
T_4	3110	5330	36.84	35450	66464	31014	1.87
T_5	3240	5840	35.68	35950	69472	33522	1.93
T_6	3310	6330	34.33	36250	71264	35014	1.96
T_7	3570	6380	35.87	36850	76504	39654	2.07
T_8	2810	5750	32.83	32300	60800	28500	1.88
T_9	2920	5930	32.99	32700	63144	30444	1.93
T_{10}	3030	5830	34.19	33200	65264	32064	1.96
T_{11}	3120	5290	37.09	33650	66632	32982	1.98
T_{12}	2480	4920	33.51	25550	53536	27986	2.09
SEm(±)	0.16	0.13	0.01	-	626	326	0.03
$CD_{(0.05)}$	0.48	0.39	0.03	-	1976	1976	0.08

significant response to biofertilizer application was noted. The result revealed that application of Azospirillum, Azospirillum + PSM, Azospirillum + PSM + EM spray with 75%N (75% N from FYM + 25% N from vermicompost) was at par with 100% N (75% FYM + 25% vermicompost) nutrition. Thus, addition of Azospirillum, Azospirillum + PSM, Azospirillum + PSM + EM spray could save 25% organic N source and combined application of Azospirillum + PSM + EM spray + Neem cake could save 50% organic N source without any considerable yield reduction in Basmati rice. Similar results were also reported by several researchers (Singh *et al*. 2011; Davari and Sharma, 2010 and Moola Ram *et al*. 2011) that combined application of two, three or four sources of organic nutrients with biofertilizers resulted in higher grain yield of Basmati rice.

Effect on quality parameters

Basmati rice variety "Geetanjali" with 75% N (75% FYM + 25% vermicompost) + Azospirillum + PSM + EM spray recorded the highest hulling per cent (84.2), milling per cent (76.1) and head rice recovery percent (60.2) which was at par with 100% N (75% FYM + 25% vermicompost) and 75% N (75% FYM + 25% vermicompost) + Azospirillum + PSM + EM spray + Neem cake with respective values of 83.1, 75.2, 59.2 per cent and 79.8, 72.6 and 58.3 per cent. There was no significant difference due to various treatments for kernel length, kernel breadth, kernel length-breadth ratio and elongation ratio (Table 2). However, application of 75% N (75% FYM + 25% vermicompost) + Azospirillum + PSM + EM spray + Neem cake recorded the highest value in each of the above characters and also it resulted in significantly higher values of kernel length after cooking, amylose content and protein content. This result is in conformity with the findings of Lognadhan and Rajeswari (2005), Davari and Sharma (2010), Singh *et al.* (2007) and Moola Ram *et al.* (2011) who observed that marketing oriented parameters like hulling, milling and head rice recovery were higher in organic manured plots compared to inorganic fertilizers applied plots. Higher contents of amylose and protein in organic Basmati rice was also reported by Murali and Setty (2001) and Hemalatha *et al.* (2000). Prakash *et al.* (2002) also reported that

Table 2. Quality of grains of organic Basmati rice as influenced by nutrient management practices.

Treatment	Hulling (%)	Milling (%)	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)	Length breadth ratio	Kernel length after cooking (mm)	Elongation ratio	Volume expansion ratio	Protein content (%)	Amylose content (%)
T_1	83.1	75.2	59.2	7.6	1.66	4.57	13.1	1.72	3.58	7.25	23.48
T_2	71.3	64.3	52.8	7.4	1.63	4.54	12.6	1.70	3.54	6.62	22.95
T_3	75.6	67.5	55.3	7.6	1.64	4.63	12.8	1.68	3.56	6.01	22.74
T_4	77.1	69.0	53.5	7.3	1.63	4.47	12.6	1.72	3.52	6.69	23.26
T_5	76.8	68.5	54.2	7.5	1.61	4.65	12.7	1.69	3.60	6.75	23.39
T_6	84.2	76.1	60.2	7.7	1.64	4.69	13.1	1.70	3.75	7.00	23.51
T_7	79.8	72.6	58.3	7.9	1.65	4.79	13.7	1.73	3.50	7.37	23.58
T_8	77.6	70.3	58.1	7.6	1.62	4.69	12.7	1.67	3.52	6.06	22.47
T_9	79.4	75.0	56.4	7.8	1.61	4.84	12.9	1.65	3.64	6.12	22.84
T_{10}	78.6	71.5	58.4	7.7	1.64	4.69	12.8	1.66	3.58	6.44	22.16
T_{11}	71.2	67.5	54.6	7.8	1.63	4.78	12.9	1.65	3.60	6.75	22.96
T_{12}	73.2	65.0	53.2	7.6	1.61	4.72	12.5	1.72	3.33	5.75	22.42
SEm (±)	1.55	1.18	0.75	0.20	0.03	0.15	0.10	0.04	0.02	0.15	0.11
$CD_{(0.05)}$	4.55	3.45	2.19	NS	NS	NS	0.28	NS	0.07	0.43	0.32

elongation ratio and breadth expansion ratio after cooking remained unattached by FYM and vermicompost application. Quality of the crop, being the varietal character (genetic), is also affected by crop and environment management including fertilizers and manures. The result of present findings with regard to quality of grains might be due to better soil environment including increased level of available nutrients (Table 3) which released nutrients for longer time resulting in enhanced level of N, P and K uptake (Table 4), thereby better growth and development with supply of two or more sources of organic nutrients.

Economics

Gross returns from Basmati rice as influenced by organic source of nutrients were in the order of $T_7 > T_6 > T_1 > T_5 > T_{11} > T_4 > T_2 > T_{10} > T_9 > T_8 > T_3 > T_{12}$ (Table 1), the highest being Rs. 76,504/ha. The net returns obtained were in order of $T_7 > T_6 > T_5 > T_{11} > T_1 > T_{10} > T_2 > T_4 > T_9 > T_3 > T_8 > T_{12}$, the highest being Rs. 39,654/ha and lowest being Rs. 27,986/ha. The highest gross returns and net returns in T_7 were due to more grain yield and less cost of cultivation in comparison to T_1. Similar trend was also observed for other organic source of nutrients. Benefit-cost ratio was maximum (2.09) in T_{12} followed by T_7 (2.07). This might be due to the lower cost of cultivation in T_{12} and more grain production in T_7. There were marginal reduction of benefit-cost ratios due to various organic nutrient management practices. The lowest benefit-cost ratio of 1.86 was estimated with T_1 which might be due to higher cost of production towards FYM and vermicompost. Similar results were also reported by Davari and Sharma (2010) who observed that application of FYM increased cost of cultivation by 34-38%, vermicompost by 61-71%, FYM + wheat residues (WR) by 50-60% and Vermicompost + WR + biofertilizer by 83-94%. But all the above organic manure treatments recorded higher net return over control. Singh *et al*. (2009) also reported that green manuring along with biofertilizers (Azospirillum + PSB + BGA) coupled with FYM (5 t/ha) or vermicompost (2.5 t/ha) recorded higher average net return and benefit-cost ratio followed by application of biofertilizers (Azospirillum + PSB + BGA) along with green manuring. Niru kumari *et al*. (2010) also observed that scented rice receiving dhaincha green manure @ 5 t/ha + FYM @ 10 t/ha was found to be the most appropriate organic nutrient management system for higher productivity and profitability. Similar results were also reported by Barik *et al*. (2011).

Table 3. Soil fertility status after harvesting of organic Basmati rice as influenced by nutrient management

Treat-ment	Soil pH	Soil EC (dS/m)	OC (%)	Available nutrients (kg/ha) N	P_2O_5	K_2O
T_1	6.26	0.045	0.61	253.48	45.46	181.62
T_2	6.13	0.042	0.57	250.88	44.38	175.29
T_3	6.01	0.041	0.55	248.25	43.98	169.28
T_4	6.16	0.042	0.57	250.97	44.39	176.28
T_5	6.18	0.043	0.58	251.06	44.50	179.74
T_6	6.20	0.044	0.59	252.16	43.78	180.68
T_7	6.27	0.045	0.63	252.51	44.72	181.40
T_8	6.09	0.042	0.56	248.97	43.73	170.88
T_9	6.12	0.043	0.57	249.88	43.98	171.89
T_{10}	6.18	0.044	0.58	250.06	44.15	173.37
T_{11}	6.21	0.044	0.59	250.60	44.81	175.54
T_{12}	6.06	0.041	0.51	225.79	42.94	156.62
SEm (±)	0.04	0.00	0.02	2.55	0.98	1.33
$CD_{(0.05)}$	0.12	0.01	0.06	7.47	2.88	3.90
Initial	5.70	0.040	0.51	246.21	43.38	167.84

Table 4. Nutrient uptake at harvest of organic Basmati rice as influenced by nutrient management

Treat-ment	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1	38.51	26.91	8.39	3.45	12.52	76.11
T_2	32.65	24.07	7.64	3.04	11.21	76.90
T_3	26.88	23.45	6.83	2.80	10.02	76.30
T_4	33.28	22.39	7.81	2.72	10.95	70.41
T_5	34.99	25.11	8.06	3.09	11.53	78.02
T_6	37.07	27.85	8.57	3.61	11.95	85.58
T_7	42.13	30.62	9.38	3.25	13.53	85.87
T_8	27.26	23.00	7.19	2.99	10.26	76.59
T_9	28.62	24.31	7.38	3.32	10.92	80.29
T_{10}	31.21	24.49	7.51	2.86	10.97	78.47
T_{11}	33.69	22.75	7.86	2.85	11.76	72.37
T_{12}	22.82	18.70	5.65	2.11	8.56	65.14
SEm(±)	1.56	1.63	0.33	0.12	0.97	3.52
$CD_{(0.05)}$	4.57	4.77	0.97	0.35	2.85	10.32

Increasing cost of fertilizers, growing ecological concern and conservation of energy have created considerable interest for the use of organics as a source of plant nutrients. A combination of organic nutrients can be used for maintaining productivity and profitability of Basmati rice thus benefiting a larger section of farming community.

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