Oryza Vol. 49. No. 2, 2012 (102-107)

Yield sustainability and quality of basmati rice as influenced by conventional, organic and integrated modes of cultivation

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ABSTRACT

The impact of conventional, organic and integrated mode of cultivation on yield sustainability, soil fertility and quality of Pusa basmati-1 rice was studied. Among the different modes of cultivation studied, organic mode of cultivation sustained the productivity of basmati rice after five year of conversion period which was increased by 52.96 % over first year rice grain yield (2.26 t ha^{-1}). However, inorganic and integrated mode of cultivation maintained more or less same yields. Bulk density of soil improved to a great extent after five years under organic mode (1.26 g cc^{-1}) over initial (1.37 g cc^{-1}) followed by inorganic (1.28 g cc^{-1}) and integrated mode (1.30 g cc^{-1}). In organic mode it decreased by 8.03 per cent over initial value. Organic mode of cultivation was found superior in improving the organic carbon (0.79 %) status of soil followed by integrated mode (0.71 %). The per cent increases in organic carbon were 21.54 and 9.23 under organic and integrated modes.

Key words: *basmati rice, organic, chemical, integrated mode, soil fertility, basmati rice grain quality*

Basmati rice is a globally reputed aromatic group of rice, having pleasant aroma, superfine grain along with extensive kernel elongation and soft texture of cooked rice. Production of high quality basmati rice is therefore, a major concern of future agricultural strategy. The implementation of organic farming in the cultivation of the Pusa basmati-1 makes it much more improved in quality it is best suited to this farming system due to its lower nutritional requirement. Through organic farming, incidences of occurrence of diseases and insect may be reduced in addition to improvement in soil and grain quality (Stockdale et al. 2001). The quality of rice, such as physical appearance, cooking characters and nutritional qualities are the important factors which determine its acceptability by the consumers. Keeping this in view, the present study was undertaken to study the influence of organic and integrated nodes of cultivation on the productivity, quality and changes in status of soil fertility under *tarai* conditions of Uttarakhand.

MATERIALS AND METHODS

A field experiment was carried out at Seed Production Centre of G.B. Pant University of Agriculture and Technology, Uttarakhand, during wet seasons of 2004 to 2008 in the mollisols of tarai region of Uttarakhand. The soil of the experimental site was silty- loam with neutral pH; medium in organic carbon, available N, available P and low in available K and available S . The available micronutrients *viz.* Zn, Fe, Cu and Mn level in the soil were in adequate amount (*viz*. 0.84, 30.24, 3.0 and 31.25 mg kg^{-1} soil, respectively). The initial bulk density and water holding capacity of soil was 1.37 g cc^{-1} and 17.30%, respectively. The experiment was set up in strip plot design with three management practices *viz.* organic, inorganic and integrated in horizontal strips and four cropping systems *viz*. basmati rice(Pusa Basmati-1)-wheat, basmati rice-lentil, basmati rice-vegetable pea and basmati rice- *Brassica napus* in vertical strips which were replicated thrice. Green manuring with Pant Ses-1 was done prior to basmati rice cultivation. Twenty to twenty-five days old seedlings were transplanted in a puddled field at 20 x 10 cm spacing with 2 seedlings per hill in the experimental plot of 14 m x 7 m in size. Recommended dose of nutrients for basmati rice were considered as 120:60:40 kg N, P_2O_5 and K_2O ha^{-1} in inorganic mode and 20 t FYM ha^{-1} (dry weight basis) in organic mode

of cultivation. Under integrated mode after green manuring, half of the recommended dose (*i.e.* 60:30:20 kg N, P_2O_5 and K_2O ha^{-1}) were applied. Half of the fertilizer N and full dose of P and K was applied as basal at the time of final puddling and remaining half of N was applied in two equal splits at the stage of tillering and panicle initiations, respectively. After four year of experimentation a uniform dose of rock phosphate were applied @ 2.0 t ha^{-1} in organic mode of cultivation. Organic manure was applied at final land preparation as per the treatment schedule. To control weeds, two hand weedings were done at 20 DAT and 40 DAT. To control the insects mainly stem borer under organic mode of cultivation, trichocards (1 card $acre^{-1}$ area; 5 releases), pheromone traps (20 traps ha^{-1} at 20 x 25m distance) and cow urine (10%) were used after within 15 days of transplanting and to control the diseases seed treatment, soil and foliar application of *Tricoderma* and *Pseudomonas* were done. Grain yield was recorded at each schedule of harvesting. Post harvest soil was analyzed for water holding capacity, organic carbon, available macro and micro nutrients after every crop cycle using standard procedures. Quality tests *viz*. hulling, milling, length-breadth ratio, thousand kernel weight, grain hardness, crude fat, protein and fiber per cent, mineral composition, amylose content, gelatinization temperature etc. were done by using a composite sample of three replicates. Standard methods were followed to determine protein content (Sadasivam and Manickam, 1996). Total ash and crude fiber in rice samples were estimated using A.A.C.C method. The carbohydrates were expressed as per cent and calculated by substracting the sum of moisture, protein, fat, ash and crude fiber from 100. Amylose content in rice samples was determined by the simplified method of Sowbhagya and Bhattacharya (1971).The rice samples cooked for their optimum cooking time were evaluated by a panel of 10 members for appearance, taste, texture, aroma and overall acceptability on 9 point hedonic scale (Saikia and Bains, 1993)

RESULTS AND DISCUSSION

Basmati rice grain yield and straw yield along with the yield components differed significantly under organic, inorganic and integrated mode of cultivation both in first and after five year (Table 1). Basmati rice grain yield in the first year was found to be significantly higher (2.73 t ha^{-1}) in inorganic mode which after five years shifted to organic mode of cultivation *i.e.* significantly higher grain yield (3.44 t ha^{-1}) in the organic mode as compared to inorganic (2.86 t ha^{-1}) and integrated modes (3.15 t ha^{-1}).This might be due to the favourable soil condition and synchronized and balanced release of nutrients throughout the crop growth period (Murali and Setty, 2004). Reductions in grain yield under inorganic and integrated modes were due to attack of bacterial blight (BB) disease. The attack of BB was very negligible in organic mode of production. Similar trend was observed in case of straw yield and yield attributes with organic, inorganic and integrated mode of treatments. The yield attributes like effective tillers m^{-2}, filled grain $panicle^{-1}$ and 1000 grain weight was significantly higher in inorganic mode in the first year. However, after five year significantly higher value of yield attributes except 1000 grain weight was observed with organic mode of cultivation followed by integrated mode of cultivation (Table 1). Significantly higher tiller production of (202 m^{-2}) was observed after five years was obtained with organic mode of cultivation as compared to inorganic and integrated modes.

Table 1. Grain yield and yield attributes of influenced by different modes of cultivation

Treatments	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Effective tillers m^{-2}		Filled grains $panicle^{-1}$ (g)		1000 grain weight (g)	
	First year	After five year	First year	After five year	First year	After five year	First year	After five year	First year	After five year
Organic	2.26	3.44	5.30	5.46	180	202	78	97	22.07	19.64
Inorganic	2.73	2.86	6.40	5.46	195	186	90	85	22.57	19.67
Integrated	2.52	3.15	5.91	5.60	186	199	83	88	22.50	20.10
CD(P=0.05)	0.09	0.79	0.38	0.19	9.6	4.4	10.6	3.6	1.5	0.2

In regard to soil fertility status, except available N, K and Fe, the bulk density, organic carbon, available P, S, Zn, Cu, and Mn were affected significantly by different mode of cultivation (Table 2 and 3). Bulk density of soil decreased to a great extent after five year of experiment under organic modes (1.26 g cc^{-1}) from the initial level followed by inorganic (1.28 g cc^{-1}) and integrated mode (1.30 g cc^{-1}) which was of 8.03 % lower over initial value. Organic mode of cultivation was found superior in improving the organic carbon status of soil after five years followed by integrated mode and there was 21.54 and 9.23 per cent increase over initial, respectively, under organic and integrated mode. These result are in conformity with the result obtained by (Swarup and Yaduvanshi ,2000) with FYM application only. After five years, availability of nitrogen was highest in inorganic mode (220.89 kg ha^{-1}) followed by integrated (218.11 kg ha^{-1}) and organic modes (213.94 kg ha^{-1}). Similar trend was also observed in available S under all the modes of cultivation. The available P was recorded highest in integrated mode followed by inorganic mode with no significant difference. The per cent change in availability of P was of the order of 151.49, 142.75 and 131.08 under integrated, inorganic and organic modes, respectively. The available K was found to be maximum under inorganic mode followed by integrated and organic modes with no significant difference among them.

Micronutrient status of soil after harvest of rice after five year was improved under organic mode of cultivation. Significantly increase in available Zn was recorded with organic (1.11) followed by integrated mode with no significant difference between them. Available Zn was increased to the extent of 32.14 and 28.57 per cent under organic and integrated modes, respectively; however it was decreased to the extent of 30.95 per cent with inorganic mode of cultivation over initial levels. Available Fe, Cu and Mn was recorded highest in organic mode followed by integrated mode of cultivation.

Table 2. Available macro-nutrients status in soil after five years of conversion period

Treatments	Bulk Density (g cc^{-1})		Organic carbon (%)		Available N(kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
	After five year	% change over initial	After five year	% change over initial	After Five year	% Change over initial	After five year	% Change over initial	After five year	% Change over initial
Organic	1.26	-8.03	0.79	21.54	213.94	-10.11	38.59	131.08	167.1	7.14
Inorganic	1.28	-6.57	0.63	-3.08	220.89	-7.19	40.54	142.75	172.5	10.55
Integrated	1.30	-7.00	0.71	9.23	218.11	-8.36	42.00	151.49	170.4	9.25
CD(P=0.05)	0.03	-	0.08	-	NS	-	3.16	-	NS	-

*Initial soil fertility status: Bulk density (g cc^{-1}); Organic carbon (%); Available N (kg ha^{-1}); Available P(kg ha^{-1})and Available K (kg ha^{-1}) were 1.37, 0.65, 238.0, 16.7 and 156.0, respectively

Table 3. Available nutrients and micro-nutrients status in soil during five years of experimentation

Treatments	Available S (kg ha^{-1})		Available Zn (kg ha^{-1})		Available Cu (kg ha^{-1})		Available Fe (kg ha^{-1})		Available Mn (kg ha^{-1})	
	After five year	% change over initial	After five year	% change over initial	After Five year	% Change over initial	After five year	% Change over initial	After five year	% Change over initial
Organic	12.59	-57.03	1.11	32.14	3.08	2.67	27.44	9.26	21.19	59.92
Inorganic	11.86	-59.52	0.58	30.95	2.78	-7.23	27.15	10.22	18.70	41.13
Integrated	14.85	-49.32	1.08	28.57	2.93	-2.33	27.32	9.66	20.08	51.55
CD(P=0.05)	1.39	-	0.06	-	0.40	-	NS	-	0.56	-

*Initial soil fertility status: Available S (kg ha^{-1}); Available Zn (ppm); Available Cu (ppm); Available Fe (ppm) and Available Mn(ppm) were 29.3, 0.84, 3.00, 30.24 and 13.25, respectively

Quality of grains produced under different modes of farming were found to differ significantly and ranged from 12.77 to 13.31 mm in length (Table 4). Grains produced under organic mode of cultivation had the maximum length, whereas those produced inorganically had the minimum grain length. No significant differences were seen in L/B ratio among paddy grains produced by different modes of farming. The average value for L/B ratio of paddy grains ranged from 6.57 to 6.67 whereas the average 1000 grain weight was found in the range of 18.7-21.0 g. The highest weight was for the paddy produced organically and the lowest for the paddy produced by inorganic mode of farming. These observed values were within the range of 15.1-23.1 g reported by Kumar *et al.* (2003).

Table 4. Grain quality characteristics of Pusa basmati-1 as influenced by different mode of cultivation after five years of conversion period

Treatments	Length (mm)	Breadth (mm)	Length breadth ratio	Hulling (%)	Milling (%)	Amylose content (%)	Alkali score	Protein (%)	Fiber (%)	Ash (%)	Carbohydrate (%)	Energy (KCal $100g^{-1}$)
Organic	13.31	2.01	6.61	79.07	69.0	38.3	4	7.29	0.37	0.59	89.6	352
Inorganic	12.77	1.91	6.67	81.07	69.9	33.4	3	10.12	0.26	0.54	86.6	357
Integrated	12.93	1.97	6.57	79.96	70.2	36.5	3	9.38	0.24	0.98	86.4	355
CD(P=0.05)	0.41	0.03	NS	NS	NS	0.64	0.11	0.39	0.03	0.06	0.56	1.02

Hulling percentage obtained by the three methods of cultivation were found to be statistically at par. Yield of brown rice obtained from different modes of farming varied from 79.07 to 81.07 per cent. Organic paddy gave lowest yield of brown rice on account of its highest hull content, followed by integrated mode and inorganic mode. The yield of brown rice obtained from organic mode fell within the range while the values obtained from inorganic and integrated methods of cultivation were slightly higher than the range (75.1 to 79.60 per cent) reported by Pandey and Gupta (2000).

The per cent milling yield on the basis of paddy ranged from 68.98 to 70.23 per cent, the highest being for integrated mode and the lowest for organic mode of farming. The values observed were in accordance with the data reported by Pandey and Gupta (2000)

All the modes of farming exhibited significantly different amylose content. It was observed to be minimum in rice produced by inorganic mode (33.4 per cent) and maximum in the rice produced by organic mode (38.3 per cent). Higher amylose content was reported by Subbiah and Kumaraswamy (2000) in rice that received an integrated treatment which received organic manures than in the treatment that received NPK only.

The average alkali scores of rice produced by different modes of farming ranged from 3.0 to 4.0, the highest being for rice produced by organic mode (4.0) followed by both inorganic and integrated mode (3.0). The experimental values obtained were in agreement with that reported by Pandey *et al.* (1999) who found that the alkali value was higher with the application of organic or inorganic mode of farming individually than a combination of both.

The protein content in milled rice varied from 7.29 to 10.12 per cent (Table 4). White rice produced by inorganic mode contained the highest protein content followed by integrated and organic mode of farming. The protein content of organic rice was reduced as reported by Okuda *et al.* (2005)

The crude fiber in white rice ranged from 0.24 to 0.37 per cent. Rice produced by organic farming contained the highest value of crude fiber, whereas that produced by integrated mode had the lowest amounts. The values observed were in accordance with the range reported by Manay and Shadaksharaswamy (2008).

The amount of ash content in milled rice produced by different modes of cultivation was found

to vary from 0.54 (inorganic) to 0.98 per cent (integrated). Since minerals are largely concentrated in bran layers of brown rice, the amount of bran removed during milling determines the amount of ash left in the milled rice. Differences in ash content of polished rice may be attributed to these variations also.

The carbohydrate content in milled rice produced by different methods of cultivation ranged from 76.11 to 77.98 per cent, the lowest being with integrated mode and the highest with organic mode of farming. The results observed were in agreement with the report of Manay and Shadaksharaswamy (2008).

The calculated values of energy content in milled rice ranged from 352.16 to 356.61 Kcal $100g^{-1}$. The highest value was seen in rice obtained by inorganic mode, followed by integrated mode and the lowest by organic mode. The values were in agreement with the range reported by Deka *et al.* (2000).

The panelists evaluated the cooked rice obtained from different modes of farming for their aroma, appearance, texture, taste and overall acceptability on 9–point hedonic scale (Fig. 1). The mean score for aroma varied from 6.78 to 7.62, with the highest scores received by rice produced by organic mode of farming. Rice produced by inorganic mode received the lowest score. The average score for appearance of cooked rice ranged from 7.18 to 7.65. Rice produced by organic mode of farming received the highest score, followed by that produced by inorganic mode and the lowest by integrated mode of farming. Texture scores of cooked rice of different methods varied from 7.00 to 7.50, the lowest and highest being for rice produced by inorganic and organic mode, respectively. Statistical analysis of data showed significantly different texture scores of rice on cooking. Rice produced by organic farming was found to exhibit best texture score.

The taste scores of cooked rice ranged from 6.87 to 7.53, with highest score being for rice produced organically and the lowest for the rice produced by inorganic mode, respectively. Overall acceptability score of cooked rice of various methods of cultivation ranged from 6.94 to 7.53. Rice produced by organic mode received highest scores for all the organoleptic characteristics and was therefore considered as the best among the three modes of cultivation studied. This was followed by the rice grown under integrated mode of farming. Rice grown using inorganic mode received the lowest sensory scores and was thus considered typically poor organoleptically.

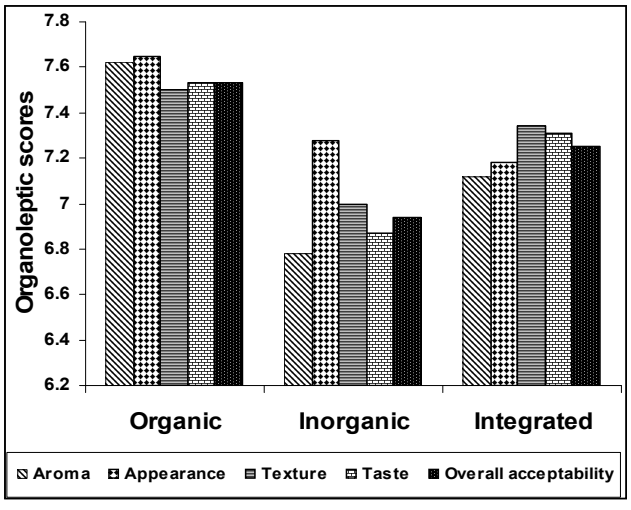

Fig. 1. Average organoleptic scores of cooked Pusa basmati-1 rice as influenced by different mode of cultivation after five years of conversion period

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