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Effect of enriched compost and crop establishment methods on productivity and profitability of rice (*Oryza sativa*)

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ABSRACT

A field experiment was conducted during *kharif* 2018–19 at ICAR-IARI, New Delhi to study the effect of rice (*Oryza sativa* L.) establishment methods and enriched organic nutrient sources on growth and productivity of rice. The experiment was laid out in split plot design with three replications having two main plot treatments, viz. aerobic rice (AR) and conventional transplanted (CT) rice and five sub plot treatments, viz. Control (No fertilizer), 100% RDF (100% mineral fertilization), 50% P through P enriched compost + 50% P through DAP, 50% N through N enriched compost + 50% N through urea and DAP and 100% organic (through N enriched compost and P enriched compost). Results showed that plant growth, productivity and profitability were significantly superior in CT rice than AR. Among the nutrient management options, 50% N through N enriched compost + 50% N through urea and DAP resulted in significantly higher grain yield (4.85 and 5.13 t/ha), gross (₹ 1.35 lakh and 1.43 lakh) and net return (₹ 85 lakh and 0.85 lakh) and yield attributes than other treatments and it was at par with 50% P through P enriched compost + 50% P through DAP in both the years. Hence, the conventional transplanting of rice along with integrated application of enriched compost and inorganic fertilizer may be recommended to farmers for getting higher productivity and profitability in rice.

Keywords: Aerobic rice, Enriched compost, Nitrogen, Phosphorus, Yield

Rice (*Oryza sativa* L.) is the most important staple food crop which plays a key role in maintaining the food security of the country. Transplanting has been reported to be the best rice establishment method to attain the maximum rice productivity but it transforms the soil's environment completely due to sudden change of aerobic environment into anaerobic environment, leading to several physical and electro-chemical and biological transformations. But in the current scenario, due to the rising water crisis, depletion of ground water table, rising labour costs with limited resource availability, there is urgency in switching to alternative establishment methods water saving technologies developed such as alternate wetting and drying, system of rice intensification, continuous soil saturation and direct seeding may reduce the water requirement of rice to some extent. (Choudhary *et al.* 2010 and Shah *et al*. 2014). Aerobic rice (AR) culture is one of the promising options which not only reduce the water requirement but may sustain the rice productivity.

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The sustainability in crop production cannot be achieved without a proper balanced nutrient sheet in a long run. This issue has generated special attention of researchers worldwide due to its ever increasing imbalance. Enriched compost may be one of the game changer which will address the above issue. So we need to enrich these organic manures with suitable amendment which not only narrow down the C:N or C:P ratio but also increase the percentage of major nutrients in these organic manures. This will decrease the need for huge quantity of organics needed per unit area and also reduce the competition of these organics from another enterprise. But the information regarding its effect on growth and productivity of rice is very less and the research work done on this aspect is very minuscule.

MATERIALS AND METHODS

The field experiment was conducted at research farm of ICAR-Indian Agricultural Research Institute, New Delhi during *kharif* 2018–19. Delhi is located under sub-tropical and semi-arid type with hot and dry summer and cold winter and falls under the 'Trans-Gangatic plains'. During the experimental period, there was variation in rainfall received during the first (899.2 mm) and second (1338.5 mm) season of cropping. During the experimental period, there was variation in rainfall received during the first (915.6 mm) and second (512.7 mm) season of cropping. The soil was alluvial, sandy clay loam in texture with moderate water holding capacity and level topography. The initial *p*H of the soil was 7.98 and electrical conductivity 0.23 dS/m. The soil was low in organic carbon (0.43%) and available nitrogen (185 kg/ha), medium in available phosphorous (16.39 kg/ha) and available potassium (264 kg/ha). The experiment was laid out in split-plot design with three replications. The treatments comprised two main plot treatments, viz. aerobic rice (AR) and conventional transplanted (CT) rice and five sub plot treatments, viz. control (No fertilizer), 100% RDF (100% mineral fertilization), 50% P through P enriched compost + 50% P through DAP, 50% N through N enriched compost + 50% N through urea and DAP and 100% organic (through N enriched compost and P enriched compost). The recommended dose of NPK was 120 kg N, 26.2 kg P and 50 kg kg/ha.

Characteristics of enriched compost: Enriched compost was prepared by blending the traditional composting technique with inorganic N (urea), rock phosphate and biologically active substance for improving its nutritional and quality status. For characterization of matured compost, representative fresh samples (500 g) were drawn were lab analysis was done for *p*H, EC, total N, total P, total K, micronutrient, organic carbon %, biochemical parameters like dehydrogenase and alkaline phosphatase activity. The total C content in compost was determined by the ignition method. Total N content was determined by the micro-Kjeldahl method (Bremner and Mulvaney 1982). For determination of total P and K, the di-acid digestion nitric acid: perchloric acid (HNO_3:$HClO_4$: :9:4) method was followed (Jackson 1973). Total N, P and K content found in N-enriched compost was 3.44, 1.20 and 0.86% and P-enriched compost had 2.16, 4.01 and 1.1%, respectively. Dehydrogenase activity and alkaline phosphatase activity in N-enriched compost was 92 and 1437 μg TPF/g compost/hr while P-enriched compost had 98, 1204 μg TPF/g compost/hr respectively.

To grow aerobic rice (AR), pre-soaked and incubated seeds (for 24 hr) of cv. Pusa Basmati 1509 in moist gunny cloth was taken. After one hour it was used for sowing (25^{th} June 2018 and 23^{rd} June 2019). Seeds were drilled at the depth of 4 cm with the row spacing of 22.5 cm by using seed drill and light irrigation was applied to facilitate germination. Thinning and gap filling was done at 15 days after sowing (DAS). For weed management pre emergence herbicide (Pretilachlor @ 450 *a.i.* g/ha) was sprayed and subsequently manual weeding done twice. In conventional transplanted (CT) rice the field preparation consisted of harrowing followed by puddling in standing water. Transplanting was done on 10^{th} July, 2018 and 8^{th} July, 2019 by planting 2 seedlings per hill. The field was maintained with standing water until 10 days prior to physiological maturity of crop. Entire dose of phosphorus, potassium and enriched compost were applied at basal as per treatments. The mineral phosphorus and potassium was applied through di ammonium phosphate (DAP) and muriate of potash, respectively. Mineral source of nitrogen was supplied through the mineral fertilizer DAP and the remaining dose was compensated with urea. Nitrogen was supplied to the plant in 3 splits, i.e. at 50% at basal, 25% at active tillering and 25% at panicle initiation stage except 100% organic treatment where all enriched compost applied at basal. Observations on growth, yield attributes, grain and straw yield were recorded at harvest stages of the crop. The economics of cultivation of rice, viz. cost of cultivation, gross return, net return and net B : C ratios were recorded on the basis of prevailing market prices of inputs and outputs.

RESULTS AND DISCUSSION

Yield attributes: The yield attributes, i.e. no. of grains/panicle, no. of filled grains/panicle, no. of unfilled panicle, spikelet fertility (%) and 1000–grain weight were also significantly affected by the establishment methods except the no. of unfertile tillers/m^2 in both the years (Table 1). The yield attributes in conventional transplanted rice recorded significantly better result than the DSR except the no. of unfertilized tiller/m^2. This might be due to the favourable environment for growth and development like less physical, chemical and biological stress in conventional transplanted rice compared to aerobic rice. Similar results were observed by other researchers earlier (Pooniya and Shivay 2012, Suryavanshi *et al.* 2012, Saha *et al.* 2014).The no. of unfertilized tillers/m^2 was higher in DSR than conventional transplanted rice. All yield attributes recorded better in 2019 than 2018 except the no. of unfertile tillers/m^2. Among the nutrient management practices, all the treatments performed significantly better than control except the no. of unfertile tillers/m^2. Number of unfertile tillers/m^2 was significantly higher in control than other treatments. 50% N through N enriched compost + 50% N through urea and DAP recorded significantly higher effective tillers/m^2, fertile tillers (%), panicle length and panicle weight than other treatments and those were at par with the 50% P through P enriched compost + 50% P through DAP. The 100% RDF recorded higher yield attributes than 100% organic in terms of the above yield attributes. This might be attributed to the better synchrony in availability of major and micro nutrients.

Yield

Significantly higher grain (4.30 and 4.49 t/ha) and straw yields (6.65 and 6.77 t/ha) were recorded in CT rice than AR (Table 1). Among the nutrient management practices, 50% N through N enriched compost + 50% N through urea and DAP gave significantly higher grain yield (4.85 and 5.13 t/ha) and straw yield than other treatments and statistically at par with 50% P through P enriched compost + 50% P through DAP. Combined use of enriched composts and inorganic sources of nutrient could be attributed to better synchrony of nutrient availability to crop, which was reflected in higher grain yield and biomass production. Along with supply of major nutrients and organic matter, it also supplied with secondary and micronutrients which were absent in inorganic fertilizer alone; improvement in

Table 1 Effect of planting methods and nutrient management practices on yield attributes, grain yield, straw yield, and harvest index of rice

Treatment	No. of grains/ panicle		No. of filled grains/panicle		No. of unfilled/ panicle		Spikelet fertility (%)		1000–grain weight (g)		Plant height at harvest (cm)		Grain yield (t/ha)		Straw yield (t/ha)		Harvest index (%)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Establishment methods (EM)																		
AR	84.93	102.00	72.42	91.32	12.51	10.68	85.14	88.73	24.27	24.37	91.82	93.57	3.52	3.69	5.87	5.77	37.93	38.89
CT	91.40	109.87	80.19	101.06	11.21	8.80	87.64	91.33	24.42	24.58	99.58	100.80	4.30	4.49	6.65	6.77	38.67	39.53
SEm±	0.77	0.40	0.95	0.76	0.27	0.36	0.42	0.43	0.01	0.02	0.53	0.82	0.09	0.09	0.12	0.16	0.45	0.44
LSD (P= 0.05)	4.70	2.45	5.75	4.63	1.64	2.21	2.57	2.63	0.06	0.12	3.20	5.00	0.57	0.55	0.76	0.98	2.73	2.70
Nutrient management practices (NMP)																		
Control	77.33	73.50	65.77	59.93	11.56	13.57	85.00	81.43	24.09	23.93	87.75	85.25	4.60	4.03	4.60	4.03	36.65	37.33
100% RDF	89.00	111.33	76.91	101.65	12.09	9.68	86.30	91.22	24.27	24.44	96.68	98.67	6.64	6.75	6.64	6.75	37.83	38.67
Enriched-P	92.50	115.50	81.12	107.66	11.38	7.84	87.68	93.20	24.55	24.72	98.42	101.33	6.71	6.80	6.71	6.80	39.50	40.55
Enriched-N	97.83	121.67	86.76	114.83	11.07	6.84	88.65	94.35	24.72	24.93	101.99	104.50	7.22	7.45	7.22	7.45	40.33	40.83
100% Organic	84.17	107.67	70.97	96.89	13.20	10.78	84.32	89.95	24.10	24.35	93.67	96.17	6.12	6.30	6.12	6.30	37.17	38.67
SEm±	1.48	1.63	1.26	1.52	0.43	0.69	0.62	0.59	0.05	0.06	1.71	1.73	0.22	0.25	0.19	0.25	1.04	1.22
LSD (P= 0.05)	4.44	4.90	3.77	4.54	1.30	2.07	1.87	1.78	0.15	0.17	5.12	5.20	0.67	0.76	0.57	0.76	3.11	3.66
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

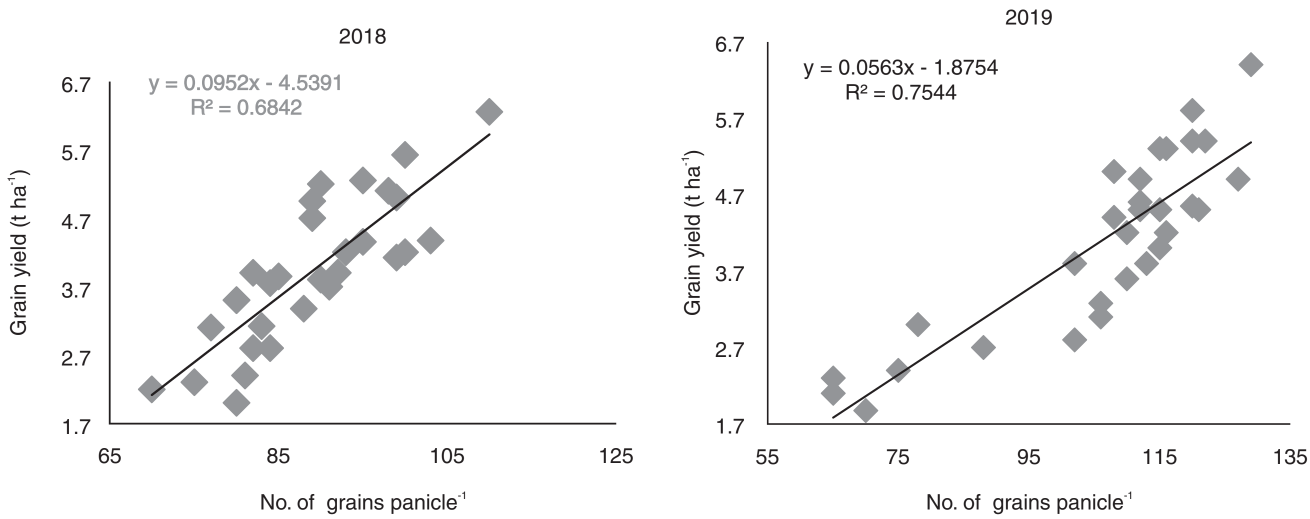

Fig 1 Relation between yield attributes and grain yield in 2018 and 2019.

microbial activity and reducing nutrient loss from the soil (Yadav *et al*. 2000 and Singh *et al*. 2005). Improved soil physical properties in the enriched compost treated plots might have also contributed to the improvement in crop yields. Similar results in improving soil physical properties due to addition of organic amendments were reported by others (Gopinath *et al.* 2008). The 100% RDF produced higher grain yield and straw yield than 100% organic but values of both were statistically at par. The higher grain yield recorded under the application of inorganic sources of nutrient may have been due to the immediate release and availability of nutrients as compared to sole organic sources of nutrient, which release nutrient comparative slowly. All the treatments showed significantly better results than control in terms of grain yield and straw yield. Harvest index was not significantly affected by planting methods but significantly affected by nutrient management practices. The 50% N through N enriched compost + 50% N through urea and DAP resulted higher HI than other treatments. All treatments produced significantly higher HI than control which means nutrient management practice plays a great role in partitioning of photosynthates from vegetative portion to the reproductive portion.

Correlation between yield attributes and yield: Yield attributes had strong positive correlation with grain yield which shows that yield attributes are highly correlated with grain yield. The R^2 value of No. of grains/panicle and grain yield is 0.68 and 0.74 in 2018 and 2019 respectively which mean that 68% and 74% variability in the grain yield of rice as explained by the fitted regression equation or line (Fig 1).

Table 2 Effect of planting methods and nutrient management practices on economics of rice cultivation

Treatment	Cost of cultivation (₹ ×10^3/ ha)		Gross returns (₹×10^3/ha)		Net returns (₹×10^3/ha)		B:C ratio	
	2018	2019	2018	2019	2018	2019	2018	2019
Establishment methods (EM)								
AR	41.80	47.68	99.47	103.70	57.67	56.02	1.42	1.19
CT	52.06	61.43	121.11	125.71	69.05	64.27	1.35	1.04
SEm±			2.65	2.54	2.65	2.54	0.07	0.06
LSD (P=0.05)			16.11	15.44	16.11	15.44	0.42	0.35
Nutrient management practices (NMP)								
Control	37.55	45.12	75.45	67.97	37.90	22.85	1.00	0.51
100% RDF	44.17	51.73	114.64	120.49	70.48	68.75	1.61	1.35
Enriched-P	43.18	51.05	123.11	129.43	79.93	78.38	1.87	1.56
Enriched-N	50.04	57.60	135.79	143.03	85.75	85.43	1.72	1.49
100% Organic	59.71	67.28	102.45	112.60	42.74	45.32	0.70	0.66
SEm±			6.62	5.76	6.62	5.76	0.14	0.11
LSD (P=0.05)			19.83	17.27	19.83	17.27	0.42	0.33
Interaction			NS	NS	NS	NS	NS	NS

Economics: The cost of cultivation and gross return were significantly affected by establishment method (Table 2). The cost of cultivation and gross return in CT of rice were significantly higher than aerobic rice in both the years. Among the nutrient management practices, control resulted in lowest cost of cultivation and 100% organic nutrient resulted in highest cost of cultivation. Gross return in 50% N through N enriched compost + 50% N through urea and DAP was significantly higher than other treatments except enriched-P which was at par with it. The 100% RDF generated more gross return than 100% organic though both of these were at par. Control gave lowest gross return. Among the nutrient management treatments, 50% N through N enriched compost + 50% N through urea and DAP resulted higher net return than other treatments. The 100% RDF generated significantly more net return than 100% organic in both the years because of the higher cost associated with the enriched compost and comparatively lesser grain and straw yield which resulted in lesser gross outcome. Net B: C ratio was not significantly affected by establishment method although it was more in aerobic rice than transplanted rice. It showed that net profit generated from a rupee investment was higher in aerobic rice than transplanted rice. Among the nutrient management practices, 50% P through P enriched compost + 50% P through DAP resulted highest net B:C in both the years which was due to lower cost of cultivation.

It may be concluded that the performance of rice was superior under conventional transplanted condition than aerobic rice in respect of plant growth, yield attributes, yield and profitability. Integrated application of enriched compost and inorganic fertilizer performed superior than the others in terms of productivity and profitability. Hence, the conventional transplanting of rice along with integrated application of enriched compost and inorganic fertilizer can be recommended to farmers for getting higher productivity and profitability from rice.

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