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EFFECT OF CROP ESTABLISHMENT METHODS AND INTEGRATED NUTRIENT MANAGEMENT PRACTICES ON NUTRIENT UPTAKE AND QUALITY ATTRIBUTES OF RICE (*Oryza Sativa* L.)

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ABSTRACT
A field experiment was carried out during the rainy (*Kharif*) season in 2012-2013 at Agricultural Research Farm, Institute of Agricultural Sciences- BHU, Varanasi, to evaluate the various crop establishment methods and Integrated Nutrient Management practices on nutrient uptake and quality attributes of rice (*Oryza sativa* L.). The treatments comparised, Crop Establishment Methods in main plots *viz.* Farmer's practice (T_1), Wetland transplanting (T_2) and System of Rice Intensification (T_3) and Integrated Nutrient Management practices in sub plots *viz.*100% RDF (120, 60 and 40 kg ha^{-1} of N, P and K) (N_1), 100 % RDF + Zinc (5 kg Zn / ha from ZnSO4.7H_2O) (N_2), 100 % RDF + 2.5 t / ha Vermicompost (N_3), 100 % RDF +5 kg Zinc + 2.5 t / ha Vermicompost (N_4), and 100 % RDF + 5 t / ha FYM (N_5), were laid out in split- plot design with three replications. Results of the experiment revealed that the maximum nutrient uptake and quality parameters: *viz.* protein content (%) in grain , protein yield (q ha^{-1}), carbohydrate yield (q ha^{-1}), hulling, milling and head rice recovery (%) was found under SRI method of transplanting as compared to other methods of transplanting and also nutrient uptake and quality parameters: *viz.* protein content (%) in grain , protein yield (q ha^{-1}), carbohydrate yield (q ha^{-1}), hulling, milling and head rice recovery (%) was found maximum under the application of 100 % RDF +5 kg Zinc + 2.5 t / ha Vermicompost as compared to rest of the treatments. Integrated Nutrient Management (100 % RDF +5 kg Zinc + 2.5 t / ha Vermicompost) cropped under SRI methods of transplanting was found effective for better nutrient enhancement and improving quality of rice.

KEY WORDS: Nutrient uptake, System of Rice Intensification, Quality parameter.

INTRODUCTION
Rice (*Oryza sativa* L.) is the major staple food for more than 3 billion people in the worldwide. The present and future of global rice production largely depends on irrigated rice production systems in Asia, which provide about 75% of the world's rice supply (Qin *et al*., 2006). However, growing larger amounts of rice with less water is one of the major challenges for food security faced by humanity in the 21st century. India has the largest area under rice cultivation *i.e.* 42.56 (m ha) and occupies second position in production (106 mt) next to China among the rice growing countries of the world with average productivity of 2.24 (t ha^{-1}) (www.agricop.nic.in, 2014). Rice cultivation requires large quantity of water and for producing one kg rice, about 3000-5000 litres of water depending on the different rice cultivation methods such as transplanted rice, direct sown rice (wet seeded), alternate wetting and drying method (AWD), system of rice intensification (SRI) and aerobic rice. Traditionally, irrigated rice grows under continuous flooding or submerged soil conditions, thus requiring much more water than other cereals. It was recently estimated that rice production consumes more than 45% of total freshwater resources in Asia and approximately 30% of the worlds freshwater used for irrigation (Bouman *et al*., 2007). It has been estimated that about 15–20 million hectares of Asia's irrigated rice will suffer from water scarcity by the year 2025 (Tuong and Bouman, 2003).

Integrated nutrient management (INM) and organic farming practices are being increasingly advocated as environmental friendly alternatives for nutrient management. Imbalance fertilization may deteriorate soil quality to a greater extent than the use of balanced fertilization on long term basis. Therefore there is a need to develop quantitative parameters to determine soil quality under different fertilizer management practices. Nutrient management aimed to use a combination of nutrients by taking measures to ensure that production increased in order to achieve or maintain a target, while coordinating the efficient use and environment friendly nutrient resources, and steadily improve soil productivity (Walia *et al*., 2010). The drawbacks associated with inorganic sources of plant nutrient are often overcome when they are used in judicious combinations with organic manures. When used in combination interactions occur and the yield increase is always more than that from the use of equivalent quantities of these nutrient sources alone (Wickramasinghe *et al*., 2003). Such scientific efforts may also help to determine suitable combination of organic and inorganic fertilizers in right proportion for maintaining soil quality to ensure crop production on sustainable basis. Keeping above facts in view, the present investigation was taken to study the effect of "Various Crop Establishment Method and Integrated Nutrient Management on Nutrient uptake and Quality of Rice (*Oryza sativa* L.)"

MATERIALS & METHODS

The proposed study was conducted at Agricultural Research Farm, Institute of Agricultural Sciences- BHU, Varanasi. The experimental farm falls under the Indo-Gangetic Alluvial track in eastern Uttar Pradesh, located at an altitude of 128.93 meters from the mean sea level in class IV of land capability with a moisture deficit index of -02—40. The geographical situation of the farm is $25^0$18' N latitude, 88^0 03' E longitudes. The physico-chemical properties of soil of experimental field are presented in table- 1.

TABLE 1. Physico-chemical properties of soil of the experimental field

Properties	Measured value	Method employed for analysis	Properties	Measured value	Method employed for analysis
Textural class	Sandy clay loam	Hydrometer method (Bouyoucos, 1962)	pH	7.3	Glass electrode digital pH meter (Jackson, 1973)
Coarse sand (%)	10.84		EC (dS/m) at 25^0C	0.258	Systronic electrical conductivity method (Rechards, 1954)
Fine sand (%)	50.51		CEC mole/kg)	12.50	Ammonium Saturation (distillation) Method (Baruah and Bharthakur, 1997)
Silt (%)	19.83		Organic carbon (%)	0.41	Walkley and Black's method (Jackson, 1973)
Clay (%)	20.64		Available N (kg ha^{-1})	212.05	Alkaline permanganate (Subbiah and Asija, 1956)
Bulk density (g/cm^3)	1.47	Core sampler (Piper, 1950)	Available P_2O_5 (kg ha^{-1})	20.64	0.5*N* NaHCO3 extractable P (Olsen *et al.*, 1954)
Particle density (g/cm^3)	2.61	Hydrometer method (Bouyoucos, 1962)	Available K_2O (kg ha^{-1})	197.50	Ammonium acetate extractable flame photometer (Jackson, 1973)

The experiment conducted in rainy season *(kharif*) 2012-2013, was laid out in Split Plot Design with 15 treatment combination. The main plot treatments consisted of 3 crop establishment methods *viz.* Farmer's practice (T_1), Wetland transplanting (T_2) and System of Rice Intensification (T_3) and 5 integrated nutrient management practices *viz.*100% RDF (120, 60 and 40 kg ha^{-1} of N, P and K) (N_1), 100 % RDF + Zinc (5 kg Zn / ha from ZnSO4.7H_2O) (N_2), 100 % RDF + 2.5 t / ha Vermicompost (N_3), 100 % RDF +5 kg Zinc + 2.5 t / ha Vermicompost (N_4), and 100 % RDF + 5 t / ha FYM (N_5) in sub-plots. Half of total N and full dose of P_2O_5, zinc and K_2O were applied as basal while the remaining half dose of N was top dressed in two equal splits at active tillering (30 DAT) and panicle initiation (55 DAT) stages, respectively. 'HUBR 2-1' non aromatic rice seedlings of 12 days in SRI method, 25 days in Wetland method and 35 days in Farmer's practice were transplanted, keeping 1 seedling $hill^{-1}$ at 25x25 cm spacing in SRI method of transplanting and 2-3 seedling $hill^{-1}$ at 20x15 cm under wetland methods of transplanting under puddle conditions. The crop was harvested in the first fortnight of November. The other agronomic practices were followed as per standard recommendations. The data obtained from the different treatments were computed to determine the mean values. The mean values after suitable transformation were subjected to statistical analysis to test significance as per as Gomez and Gomez (1984) for the interpretation of the results.

RESULTS & DISCUSSION

Nutrient uptake (kg ha^{-1})

The careful screening of the data examined that the maximum N uptake in grain and straw of rice was recorded with SRI method of transplanting, whereas the lowest N uptake in grain and straw of rice was recorded with farmer's practice followed by the other method of transplanting. Among various nutrient management practices, application of 100%RDF+5kg Zn/ ha+2.5 t/ha vermicompost recorded significantly higher N uptake in grain and straw of rice over rest of the treatments (Table 2). There is evidence that BNF is increased by the mixing of aerobic and anaerobic soil horizons (Magdoff & Bouldin, 1970). The improvement in soil environment with organic manure addition probably encouraged root proliferation to draw more nitrogen uptake in rice.

Data pertaining to P uptake in grain and straw of rice shows that the maximum P uptake in grain and straw was found with the SRI method of transplanting, however, it was at par with the wetland method of transplanting followed by the farmer's practice. Under nutrient management practices, significantly higher P uptake in grain and straw of rice was quantified with application of 100%RDF + 5kg Zn/ ha+ 2.5 t/ ha vermicompost as compared to rest of the treatments (Table 2). There is also evidence that P solubilization and availability are increased by alternate wetting and drying of soil (Turner & Haygarth, 2001). The organic acids produced from the degradation of organic materials might have resulted in the solubility and release of native and applied P to result in higher P uptake. Improvement in the uptake of nutrients was also mainly associated with the increase in dry matter production with organic sources of nutrients.

The careful screening of the data revealed that the maximum K uptake in grain and straw of rice was observed with SRI method of transplanting as compared to other method of transplanting. Among various nutrient management practices in case of K uptake in grain and straw, the maximum K uptake in grain and straw of rice was examined significantly higher with application of 100% RDF+ 5kg Zn/ ha+2.5t/ ha vermicompost as compared to rest of the treatments (Table 2). Increased uptake of K with higher doses of organic manure has been reported by (Sharma et al. 2002) and that of N by (Mishra, *et al*. 2006). Vermicompost is rich in most of the major nutrients, which are readily available to the crops, and therefore the effect of 2.5t/ ha vermicompost is comparable to the effect of 5 tonnes FYM/ ha.

Integrated nutrient management system has been found promising in arresting the decline in productivity through the correction of marginal efficiencies of some secondary and micronutrients and their beneficial influence on the physical and biological properties of soil. This can bring about equilibrium between degenerative and restorative activities in the soil environment. Hence, it may be concluded that growing of the rice crop with incorporation of 100% RDF+5 kg Zn/ ha+2.5 t/ ha vermicompost in conjunction with SRI method of transplanting holds great promise for increasing production and productivity of rice crop.

TABLE 2: Effect of various crop establishment method and Integrated Nutrient Management practice's on nutrient uptake (kg ha^{-1}).

Treatments	Nutrient uptake (kg ha^{-1})								
	N uptake (kg ha^{-1})			P uptake (kg ha-^{1})			K uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
(A) Main Plot : Crop Establishment Method									
Farmer's practice	49.96	30.68	80.65	4.42	7.69	12.11	7.61	96.53	104.14
Wetland transplanting	52.06	31.61	83.67	6.04	8.21	14.25	8.03	95.77	103.80
SRI	62.15	35.41	97.56	6.35	9.23	15.58	9.38	103.86	113.24
SEm±	1.9	0.63	2.5	0.32	0.20	0.42	0.25	1.49	1.67
CD (P=0.05)	7.7	2.45	9.7	1.27	0.80	1.66	0.97	5.85	6.57
(B)Sub plot : Integrated Nutrient Management									
100 % RDF	49.10	29.39	78.49	5.00	7.15	12.15	6.74	93.06	99.80
100 % RDF + Zinc	52.74	31.42	84.16	5.13	7.66	12.79	7.46	95.89	103.34
100 % RDF + Vermicompost	53.24	31.79	85.02	5.35	8.36	13.71	8.36	96.09	104.44
100 % RDF + Zinc + Vermicompost	63.89	36.96	100.85	7.33	10.00	17.34	10.33	108.16	118.49
100 % RDF + FYM	54.64	33.29	87.93	5.20	8.72	13.92	8.81	100.41	109.22
SEm±	1.5	0.79	1.6	0.43	0.26	0.52	0.32	1.69	1.77
CD (P=0.05)	4.3	2.29	4.8	1.25	0.77	1.52	0.94	4.95	5.18

TABLE 3: Effect of various crop establishment method and Integrated Nutrient Management practice's on quality parameters of rice

Treatments	Protein content (%)	Protein yield (q/ha)	$(CH_2O)_n$ (q/ha)	Hulling (%)	Milling (%)	Head rice recovery (%)
(A) Main Plot : Crop Establishment Method						
Farmer's practice	8.04	3.12	47.95	67.65	57.20	47.63
Wetland transplanting	8.27	3.25	51.08	68.77	58.83	49.03
SRI	9.04	3.88	54.31	70.08	59.16	51.81
SEm±	0.14	0.12	1.10	0.41	0.39	0.55
CD (P=0.05)	0.57	0.48	4.34	1.63	1.54	2.16
(B)Sub plot : Integrated Nutrient Management						
100 % RDF	8.24	3.06	47.09	67.32	56.51	48.44
100 % RDF + Zinc	8.22	3.30	50.59	68.69	57.64	48.74
100 % RDF + Vermicompost	8.35	3.33	50.62	67.11	57.36	49.27
100 % RDF + Zinc + Vermicompost	9.13	3.99	55.38	71.97	61.71	51.09
100 % RDF + FYM	8.35	3.42	51.88	69.09	58.76	49.92
SEm±	0.15	0.09	1.16	0.31	0.46	0.42
CD (P=0.05)	0.44	0.27	3.39	0.91	1.36	1.22

Quality Parameters

The careful screening of the data revealed that the maximum protein content and protein yield in rice was recorded in SRI which was found significantly higher over the wetland transplanting and farmer's practice. Carbohydrate content, hulling and milling (%) of rice was examined maximum with SRI method of transplanting, however, it was at par with wetland method of transplanting. The maximum head rice recovery (%) was quantified in SRI which was found significantly higher over the wetland and farmer's practice methods of transplanting (Table 3). Increased supply of NPK through organic and inorganic sources brought about significant improvement in growth and development due to adequate availability of nutrient. Availability of nutrients particularly nitrogen from organic sources might have favoured greater assimilation of protein and carbohydrate. These two compounds, when present in meristematic region of the plant, induce rapid cell division and greater enlargement of the cells, which ultimately result in better growth performance. In rice, the sink lies in panicle and grains. The improvement in quality of rice grain with the application of 100 % RDF + Zinc + Vermicompost might be due to favorable soil condition and synchronized release of nutrients (macro and micro) throughout the crop growth period, facilitated by addition of organic manure over the chemical fertilizers only. Improvement in quality parameters of rice due to combined application of organic sources of nutrient along with inorganic fertilizer was also reported by Dixit *et al.* (2000).

Data pertaining to various nutrient management practices show that, the maximum protein content, protein yield and carbohydrate content in rice was pronounced with application of 100% RDF +5 kg Zn/ ha+2.5 t/ha vermicompost which was recorded significantly higher over rest of the other treatments (Table 3). The hulling, milling and head rice recovery (%) was also examined significantly higher with application of 100% RDF +5 kg Zn/ ha+2.5 t/ ha vermicompost as compared to rest of the treatments. Application of 100% RDF+5 t/ ha FYM was recorded second best treatments in this regard. Therefore, under adequate N supply there would have been greater translocation of photosynthetic from source to sink site. This resulted in production of longer and heavier panicle with more grains panicle^{-1} results was also supported by Murali *et al*. (2004).

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