Effect of Various Crop Establishment Method and Integrated Nutrient Management on Growth, Yield and Economics of Rice (*Oryza sativa* L.)

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A field experiment was carried out during rainy (*Kharif*) season in 2012-2013 at Agricultural Research Farm, IAS, BHU-Varanasi, to evaluate the various crop establishment method and Integrated Nutrient Management on growth, yield and economics of rice (*Oryza sativa* L.).The treatments were comprised three crop establishment methods *viz.* SRI (T_1), Wetland transplanting (T_2) and farmer's practice (T_3) and five nutrient management sources *viz.*100% RDF (N_1), 100 % RDF + Zinc (5 kg Zn ha^{-1} from ZnSO4.7H2O) (N_2), 100 % RDF + 2.5 t ha^{-1} Vermicompost (N_3), 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} Vermicompost (N_4), and 100 % RDF + 5 t ha^{-1} FYM (N_5) in split plot design with three replications and fifteen treatment. Significant effects of various crop establishment and integrated nutrient management were observed on rice during experiment in comparision with 100% RDF. With crop establishment methods, grain and straw yields of rice were 4.28 t ha^{-1} and 7.23 t ha^{-1} under SRI, which were 13.24 and 4.53% higher as compared to farmer's practice. The effect of application of nutrient management sources (100 % RDF +5 kg Zinc + 2.5 t ha^{-1} Vermicompost) resulted in the highest rice grain (4.37) and 7.32 (t ha^{-1}) with respect to 100% RDF. Highest gross returns (62599.56 [1] ha^{-1}) were examined with 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} Vermicompost as compared to rest of the treatments but in case of net returns and output/input ratio, the net returns (23503.40 [1] ha^{-1}) and output/input ratio (1.69) were found higher with 100% RDF+5 kg Zn ha^{-1} as compared to rest of the treatments.

Key words: Crop establishment method, nutrient management, growth, yield, net return and output/input ratio.

Rice (*Oryza sativa* L.) is one of the most important cereal crop of the world as its forms the staple diet of 70 percent of the world's population (Sahu *et al.*,2014). Rice (*Oryza sativa* L.) is the premier food crop of India and therefore, national food security system largely relies on the productivity of rice in different agro-ecosystems. Among the rice growing countries, India stands first in area (36.95 m ha) and second in production (120.6 m t) next only to china. However, the average productivity of rice in India is only 3.26 t ha^{-1} against the global average of 4.37 t ha^{-1} (FAO, 2010). Rice is the staple food for more than half of the world's population. In Asia, more than 80% of the people derive their food requirements from the amount of rice produced (Kabir, 2006). System of Rice Intensification (SRI) is another alternative practice to solve the water crisis and as a methodology for increasing the productivity of irrigated rice by changing the management of plant,

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soil, water and nutrients (Natarajan, *et. al.*, 2008). Farmer's practice is a traditional rice cultivation system, common throughout the rainfed regions of eastern India. This method facilitates stable rice yields under low levels of inputs and uncertain climatic conditions through effective weed control, stimulated root growth and optimum plant stand with enhanced tillering.

Integrated nutrient management is an age old practice but its importance was not very much realized in pre-green revolution era due to low nutrient demands of the contemporary subsistence agriculture. Integrated Nutrient Management seems to be a suitable approach to achieve these goal. 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 and Wijewardena, 2003). The major components of integrated nutrient supply system are fertilizer, FYM, vermicompost, green manure, crop residue/recyclable wastes and biofertilizers. These components possess great diversity in terms of chemical and physical properties, nutrient release efficiencies, positional availability, crop specificity and farmer acceptability. Farmyard manure is the proven source of nutrition to agricultural crops but its availability is quite inadequate (Mishra and Prasad, 2000). The use of organic manure (FYM) or other farm waste is the tool to improve the physical, chemical and biological properties of the soil. Organic manure also plays vital role inhabitating beneficial bacteria thus making the nutrients available to crops. Keeping above facts in view, the present investigation was taken to study the effect of "Various Crop Establishment Method and Integrated Nutrient Management on Dynamics of Nutrient uptake, Yield and Quality of Rice (*Oryza sativa* L.)

MATERIALS AND METHODS

Site Description

A field experiment was conducted during rainy season of 2012-13 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The geographical situation of the farm is $25^0 18'$ N latitude, $88^0 03'$ E longitude and at an altitude of 128.93 meters from the mean sea level in the Northern Gangetic Alluvial plains. The soil of the experimental site was sandy clay loam in texture having pH 7.2, organic carbon 0.45% available N- 198.05 kg ha^{-1}, P_2O_5- 23.64 kg ha^{-1}, and K_2O- 207.5 kg ha^{-1}.In order to evaluate the initial fertility status of the soil and to know about physical and chemical properties of the experimental plot, soil samples (0-15 cm depth) were randomly taken with the help of soil auger to make a composite sample. The soil samples were analyzed for mechanical composition and chemical properties and the results of the experimental field was sandy clay loam in texture, neutral in reaction, low in nitrogen and medium in available phosphorus and potassium.

Experimentation

The experiment 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 SRI (T_3) and 5 integrated nutrient management sources *viz.*100% RDF (120, 60 and 40 kg ha^{-1} of N, P and K) N_1, 100 % RDF + Zinc (5 kg Zn ha^{-1} from ZnSO4.7H_2O) N_2, 100 % RDF + 2.5 t ha^{-1} Vermicompost (N_3), 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} Vermicompost (N_4), and 100 % RDF + 5 t ha^{-1} FYM (N_5) in sub-plots. In addition to this a uniform dose of 120 kg N, 60 kg P_2O_5, and 40 kg K_2O ha^{-1} was applied in all the plots through urea, DAP and MOP respectively. 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.

Statistical analysis

The observations recorded during the course of investigation were tabulated and analyzed statistically to draw a valid conclusion. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by Gomez and Gomez (1984). The significance of treatment was tested by 'F' test (variance ratio). Standard error of mean was computed in all cases. The difference in the treatment mean were tested by using Least Significant Difference (LSD) at 5% level of probability where 'F' test showed significant differences among means by the following formula:

$$\mathrm{LSD} = \sqrt{\frac{2 \times \text{error sum of square}}{N}} \times t\ (\text{error d.f. } 5\%)$$

RESULTS AND DISCUSSION

Growth parameters

Establishment methods

Different crop establishment method and integrated nutrient management significantly influenced growth parameters (Table-2). The careful screening of the data revealed that the plant height at harvest was examined significant superior under SRI method of transplanting as compared to other method of transplanting. The maximum leaf area index at 60 days was recorded under SRI method of transplanting followed by the other method of transplanting. No. of tillers m^{-2} was found significantly superior in case of SRI technique as compared to rest of the treatment. The lowest effective tillers were recorded under farmer's practice. Dry matter accumulation was also found significantly superior in SRI method as compared to rest of the treatments. The effect of various crop establishment method implied in rice on the growth and yield attributes characters have been studied in the present investigation. The effect of weather conditions during the crop season is one of the most important factors which determine the extent of crop growth, development and its overall performance. The weather conditions have greater significance for a crop like rice which requires high temperature, humidity and precipitation during the vegetative phase and more sun-shine duration during the reproductive phase for higher yield. A slight deviation from the normal range in weather condition may adversely affect the crop growth and ultimately the yield. The growth parameters *viz.* plant height, number of tillers, leaf area index and plant dry matter were markedly influence by various planting method applied in rice. These results are in accordance with the findings of Verma *et al*. (2015). Dry matter accumulation hill^{-1} in plants was the higher at all the stages of growth due to combined application of vermicompost and NPK effect of all the growth parameters. Improvement in dry matter accumulation by plant at higher level of nitrogen supplied through bio-organic sources was also reported (Meena, *et al.*, 2010).

Table 1. Cropping history of the experimental field

Year	Kharif	Rabi
2008-09	Rice	Wheat
2009-10	Rice	Wheat
2010-11	Rice	Wheat
2011-12	Rice	Wheat
2012-13	Rice (Experimental crop)	_

Plant height at harvest was found significantly higher with 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} Vermicompost as compared to rest of treatments (Table-2). Leaf area index at 60 days was examined significantly superior with 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} vermicompost remaining of the treatments. In case of effective tillers m^{-2} was observed with 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} Vermicompost over the other treatments. The lowest effective tillers were recorded with 100% RDF as compared to rest of the treatments. Dry matter accumulation was found significantly higher with 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} vermicompost remaining of the treatments. The second best treatment was recorded with 100% RDF+FYM ha^{-1}, where, it was found at par with 100% RDF+Vermicompost and 100% RDF+5 kg Zn ha^{-1} with each other during over the growth period of the crop. But in case of dry matter accumulation, the second best treatment was examined with 100% RDF+Vermicompost, where, it was found at par with 100%RDF+FYM and 100% RDF+5 kg Zn ha^{-1} with each other. Maximum values of these parameters were recorded with system of rice intensification of rice closely followed by wetland transplanting than farmer's practices. This is particularly planting has significant effect in rice cultivation. It facilitates good transplanting, availability of nutrient, ensure better seedling establishment, kills weed and helps plant to grow vigorously. Early establishment and subsequent growth of transplanted seedling in were faster as reflected in taller plants, more number of tillers per hill and plant dry matter production per plant. These results are in conformity with finding of Similar results were reported by Gangwar *et al*., (2009) and Singh *et al.*, (2005).

Yield attributes and Yield

Establishment methods

Panicle length was found higher with SRI method of transplanting of rice than remaining of the treatments but it was observed at par with wetland method of transplanting (Table-3). Panicle weight was recorded significantly higher with SRI method of transplanting as compared to rest of the treatments. 1000 grain weight and grain yield was also quantified higher similar with panicle length under SRI technique of rice than remaining of the treatments but it was also found at par with wetland method of transplanting of rice. Straw yield and harvest index was found significantly higher with SRI method of transplanting as compared to rest of the treatments. The panicle length and number

Table 2. Effect of various crop establishment method and integrated nutrient management on growth attributes of rice

Treatments	Plant height at harvest (cm)	Leaf-area index at 60 DAT	Effective tillers m^{-2}	Dry matter production (g) at harvest
(A) Main Plot : Crop Establishment Method				
Farmer’s practice	90.7	3.4	214.5	32.44
Wetland transplanting	91.9	3.5	215.1	33.41
SRI	94.5	4.4	219.8	35.41
SEm±	0.71	0.11	0.70	0.50
CD (P=0.05)	2.78	0.42	2.74	1.96
(B)Sub plot : Integrated Nutrient Management				
100% RDF	91.3	3.7	214.4	32.03
100% RDF + Zinc	91.8	3.6	215.8	33.43
100% RDF + Vermicompost	91.8	3.6	216.0	33.83
100% RDF + Zinc + Vermicompost	94.2	4.1	219.2	35.51
100% RDF + FYM	92.9	3.8	216.7	33.52
SEm±	0.42	0.11	0.63	0.45
CD (P=0.05)	1.22	0.33	1.83	1.30

Table 3. Effect of various crop establishment method and integrated nutrient management on yield attributes and yield of rice

Treatments	Panicle length (cm)	Panicle weight (g)	1,000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
(A) Main Plot : Crop Establishment Method						
Farmer’s practice	22.94	2.96	18.02	37.76	69.13	34.21
Wetland transplanting	23.88	3.15	20.76	40.22	70.30	35.67
SRI	24.22	3.46	22.19	42.76	72.26	37.76
SEm±	0.23	0.07	0.64	0.87	0.58	0.51
CD (P=0.05)	0.92	0.29	2.50	3.41	1.97	2.00
(B)Sub plot : Integrated Nutrient Management						
100% RDF	22.81	3.11	18.74	37.08	69.12	35.10
100% RDF + Zinc	23.29	3.12	19.63	39.83	70.12	35.28
NPK + Vermicompost	23.70	3.12	19.54	39.86	70.50	35.14
100% RDF + Zinc + Vermicompost	24.67	3.48	22.27	43.61	73.15	37.60
100% RDF + FYM	23.93	3.14	21.42	40.85	71.08	36.29
SEm±	0.30	0.90	0.57	0.91	0.71	0.50
CD (P=0.05)	0.87	0.25	1.66	2.67	2.15	1.45

Table 4. Effect of various crop establishment method and integrated nutrient management on economics of rice

Treatments	Cost of cultivation (^{1} ha^{-1})	Gross returns	Net returns	Output /Input ratio
(A) Main Plot : Crop Establishment Method				
Farmer's practice	40083.69	55359.60	15275.60	1.37
Wetland transplanting	39458.69	58298.27	18839.39	1.50
SRI	38433.69	61498.33	23064.30	1.63
SEm±	-	-	-	0.71
CD (P=0.05)	-	-	-	2.78
(B)Sub plot : Integrated Nutrient Management				
100% RDF	33025.35	54570.56	21544.9	1.61
100% RDF + Zinc	34275.35	57779.11	23503.4	1.69
100% RDF + Vermicompost	45525.35	57823.33	12297.7	1.27
100% RDF + Zinc + Vermicompost	46775.35	62599.56	15823.9	1.34
100% RDF + FYM	37025.35	59154.44	22128.8	1.60
SEm±	-	-	-	0.04
CD (P=0.05)	-	-	-	1.09

of grain/panicle in SRI transplanted rice were significantly higher than other planting method. It may be attributed due to higher availability of nutrients in submerged field as compared to upland conditions. Low availability of nutrient due to application of poor supply of NPK resulted in poor performance of the growth parameters increased. However, increased supply of NPK through organic and inorganic sources brought about significant improvement in growth and development due to adequate availability of nutrient. This might be due to transplanting of young, single and widely spaced seedling which might have resulted in better availability of nutrients, light and space during growth stages. Similar results have been reported by Sharma *et al.* (2008) and Gupta *et al.* (2006).

Panicle length, 1000 grain weight , straw yield and harvest index was examined higher with 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} vermicompost than remaining of the treatments, where, it was found at par with 100% RDF+ 5 t ha^{-1} FYM applied in experimental field of rice. The lowest values were observed with 100% RDF as compared to rest of the treatments (Table-3). Panicle weight and grain yield was quantified significantly higher with 100 % RDF +5 kg Zinc + 2.5 t ha^{-1} vermicompost as compared to rest of the treatments. The second best treatment was found with 100% RDF+5 t ha^{-1} FYM followed by other treatments which were applied in experimental field of rice. Availability of nutrients particularly nitrogen from organic sources might have favoured greater assimilation of protein and carbohydrate. These two compounds, when present in merismatic region of the plant, induce rapid cell division and greater enlargement of the cells, which ultimately result in better growth performance. Consequently, the growth of crops is a function of availability of nitrogen in the soil. The maximum grain and straw yield was due to marked improvement in dry matter accumulation, yield attributes and greater nutrient content and their uptake by rice crop. These findings are in direct conformity with that of Meena *et al.* (2011) and Barik *et al.* (2008). Nitrogen is an important constituent of chlorophyll and so, if supplied adequately stimulates photosynthesis in plants. Thus at higher N levels, there would have been more photosynthetic activity in plant. In rice, the sink lies in panicle and grains. Therefore, under adequate N supply (125% RDF) there would have been greater translocation of photosynthates from source to sink site. This resulted in production of longer and heavier panicle with more grains panicle^{-1}. The results of the present experiment confirmed the findings of Ramamoorthy *et al*. (1997) and Maqsood *et al*. (2005).

Economics

Acceptation of any advanced agro-technique by the farmers directly depends on economic status of the farmer and economic feasibility of the technique. Therefore, it is essential to analyze the results from the economic point of view. The cost of cultivation, grass returns, net returns and output/input ratio were worked out and the data are presented in (Table-4). Data pertaining to revealed that the gross returns (61498.33^{1} ha^{-1}), net returns (23064.30 ^{1} ha^{-1}) and output/input ratio (1.63) was observed higher with SRI method of transplanting followed by other method of transplanting of rice. The careful screening of the data revealed that the under sub-plot treatments, the maximum gross returns (62599.56 ^{1} ha^{-1}) was quantified with 100% RDF+5 kg Zn ha^{-1} + 2.5 t ha^{-1} vermicompost as compared to other treatments but net returns (23503.40 ^{1} ha^{-1}) and output/input ratio (1.69) was examined higher with 100% RDF+ 5 kg Zn ha^{-1}) than remaining of the other treatments.

CONCLUSIONS

It was concluded that under prevailing agro-climatic conditions, SRI method of transplanting of rice with 100% RDF+5 kg Zn ha^{-1} +2.5 t ha^{-1} vermicompost proved most remunerative, economic feasible and practicable.

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