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Growth and Yield of Rice (*Oryza sativa* L.) as Influenced by Different Crop Establishment Methods and Nitrogen Levels

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A B S T R A C T

A field experiment was conducted during *Kharif* season of 2016 at Crop Research Farm (CRF), SHUATS, Allahabad. The experiment consisted of three planting methods, (P_1: Conventional transplanting; P_2: System of Rice Intensification; P_3: Machine transplanting) and three different levels of Nitrogen (N_1: 60 kg Nitrogen ha^{-1}; N_2: 90 kg Nitrogen ha^{-1}; N_3: 120 kg Nitrogen ha^{-1}) replicated thrice in a randomized block design. The results revealed that there was significant and higher number of effective tillers hill^{-1} (18.59) observed in treatment T_9 (SRI + 120 kg Nitrogen ha^{-1}) and same treatment recorded significantly higher grain yield (5.34 t ha^{-1}) which was 39.42% higher than the lowest grain yield (3.83 t ha^{-1}), however treatment T_8 (SRI + 90 kg Nitrogen ha^{-1}), T_7 (SRI + 60 kg Nitrogen ha^{-1}) and T_6 (MTR + 120 kg Nitrogen ha^{-1}) were statistically at par with treatment T_9.

Introduction

Rice is India's pre-eminent crop, covering about one-fourth of the total cropped area and providing food to about half of the Indian population. In Asia alone, more than 2,000 million people obtain 60 to 70 per cent of their calories from rice and its products. Rice is mostly grown under submerged soil conditions and requires much more water compared with other crops. India has 44.14 million hectare area under rice and production of 106.65 million tonnes with an average yield of 2416 kg ha^{-1} during 2013-14 (GOI, 2016). Uttar Pradesh has an area of 5.98 m ha, production of 14.64 million tonnes and productivity of 2.447 t ha^{-1} of rice (GOI, 2016). It is estimated that 5000 liters of water is needed to produce 1 kg of Rice (Bouman, 2009). Manual transplanting is the most common practice of rice cultivation in south and south-east Asia. In recent years, water table is running down at a very rapid rate throughout the globe, thus sending an alarming threat and limiting the scope for cultivation of high water requiring crops very seriously. Rice being a crop having high water requirement, there is a need to search for alternative methods to reduce water requirement of rice without reduction in yield. Changes in crop establishment have important implications for farm operations, including primary tillage, seedbed preparation, planting, weeding, and water management that have a considerable impact on rice growth, especially seedling development and rice canopy structure establishment (Saha and Bharti, 2010). Tiwari and Rai (2003) reported that by using eight row self-propelled rice transplanter save 68 per cent of labour compared to manual transplanting. Recently a water-saving rice cultivation method known as the system of rice intensification (SRI) developed in Madagascar during the early 1980s (Laulanié, 1993; Stoop *et al.*, 2002) has generated considerable debate globally The components of SRI include the use of young seedlings, single seedlings per hill, wider spacing of transplanted seedlings plants leading to greater root growth and better tillering potential and limited irrigation. Though the individual agronomic factors of SRI may have their own effects, the synergistic effects of the components of SRI have a major role in the gains of SRI cultivation (Uphoff, 2002). Nitrogen is a key component of many organic compounds. Without applied nitrogen, the crop yield should be limited by the available nitrogen within the soil. Yoshida (1972) reported that nitrogen plays an important role in developing yield capacity and maintaining the photosynthetic activity during grain filling stage of the crop. Nitrogen application can improve the root system, so that water and nutrient absorption are facilitated.

Materials and Methods

A field experiment was conducted during summer season 2015 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Allahabad. The experiment site lies between 25- 27° N latitude, 8.5°E Longitude and 98 meters altitude. The climate is characterized by the alternate hot rainy season from late June to early September with mean temperature of 38°C. The soil was sandy loam in texture having a pH (7.3), EC (0.26 dSm^{-1}), organic carbon (0.40%), available N (250 kg ha-1), P (13.50 kg ha^{-1}), K (313 kg ha^{-1}) during the experimental year. The experiment was laid down in randomized block design (RBD) with three planting methods viz., conventional transplanting, machine transplanting and System of Rice Intensification (SRI) planting and three different levels of nitrogen (60, 90 and 120 kg ha^{-1}) with 9 treatments and 3 replications. Twenty one days old seedlings were transplanted conventionally at a spacing of 20 x 15 cm; while twelve days old seedlings of mat nursery were transplanted with a spacing of 25 x 25 cm in SRI. With respect to machine planting, seedlings of 18 days raised under tray nursery were used for transplanting and a self propelled paddy transplanter was used for the purpose. Transplanting was taken up on 18 July 2016 for all the methods. The crop was fertilized with full dose of phosphorus and potassium at the time of planting and the remaining N in two equal split doses at active tillering and planting stage. Irrigation was scheduled at 5-6 days interval during vegetative growth; in conventional and machine transplanting 5 cm standing water was maintained from tillering upto dough stage while in the case of SRI, intermittent wetting and drying was followed for the same period. For controlling of weeds in SRI, cono weeder was passed between lines at 10 and 20 days after transplanting (DAT) followed by two hand weedings at 30 and 40 DAT.

In case of traditional and machine transplanting, two normal hand weeding was done with the help of "Khurpi" after 30 days after transplanting and 50 days after transplanting. One quadrate (1 m^2) was harvested in every plot for the determination of results and data was subjected to statistical analysis separately by using analysis of variance technique. The difference among treatment means was compared by using least significant difference test at 5% probability levels.

Results and Discussion

Growth attributes

Plant height (cm)

Plant height is not a yield component especially in grain crops but it indicates the influence of various nutrients on plant metabolism. It was found that with increase in nitrogen level, the plant height was also increased. Significantly higher plant height (110.95 cm) was observed in treatment T_9 (SRI +120 kg Nitrogen ha^{-1}), however treatment T_8 (SRI + 90 kg Nitrogen ha^{-1}) showed statistical parity with treatment T_9. Plant height increased generally in treatments with SRI method of transplanting component, which may have allowed greater potential for increase rooting (Debbarma and Abraham, 2017).

Number of tillers $hill^{-1}$

Treatment T_9 (SRI +120 kg Nitrogen ha^{-1}) showed significant and highest number of tillers $hill^{-1}$ (19.33). It is apparent from the data that tiller production $hill^{-1}$ was significantly affected by the influence of levels of nitrogen. The higher number of tillers $hill^{-1}$ in SRI may be due to the fact that when seedlings stay for a longer period of time in the nursery beds, primary tiller buds on the lower nodes of the main culm become degenerated leading to reduced growth parameters and tiller production (Mobasser *et al.*, 2007). Enhanced tillering by increased nitrogen application might be attributed to more nitrogen supply to plant at active tillering stage (Wani *et al.*, 2016). These results were also in accordance with the findings of Haefele *et al.*, (2008).

Dry weight (g)

Significantly higher dry weight (66.58 g $hill^{-1}$) was registered by treatment T_9 (SRI +120 kg Nitrogen ha^{-1}); however treatment T_8 (SRI + 90 kg Nitrogen ha^{-1}) was at par with treatment T_9. The accelerated growth and development of the crop under SRI at successive stages particularly at advanced phases resulted in higher dry matter accumulation (Sowmya *et al.*, 2011). The increase in dry matter with successive nitrogen levels might be due to the fact that increased nitrogen levels cause an increase in plant height, tiller m^{-2} which subsequently increase dry matter production (Wani *et al.*, 2016) (Table 1).

Yield attributes

The yield attributes of rice, viz., number of effective tillers $hill^{-1}$, number of grains $panicle^{-1}$, test weight, length of panicle were significantly influenced by the different planting systems in conjunction with nitrogen levels, with treatment T_9 (SRI +120 kg Nitrogen ha^{-1}) registering the significant and highest number of effective tillers $hill^{-1}$ (18.59), number of filled grains $panicle^{-1}$ (108.88), test weight (24.82 g) and length of panicle (27.90 cm).

However, treatment T_8 (SRI + 90 kg Nitrogen ha^{-1}) was found to be statistically at par with treatment T_9 (SRI +120 kg Nitrogen ha^{-1}). The increased yield attributes in SRI may be accounted due to concept of phyllochronic utilization that follows by young age seedling (Shukla *et al.*, 2014). All the yield attributes were favourably influenced by wider spacing of 25 x 25 cm.

Table.1 Effect of crop establishment methods and nitrogen levels on plant height, number of tillers hill^{-1}, dry weight, number of effective tillers hill^{-1} and test weight of rice

	Treatment	Plant height (cm)	No. of tillers hill^{-1}	Dry weight (g)	Number of effective tillers hill^{-1}	Test weight (g)
T_1	CTR + 60 kg Nitrogen ha^{-1}	101.03	10.49	27.17	9.90	21.85
T_2	CTR + 90 kg Nitrogen ha^{-1}	102.30	12.95	29.38	11.73	22.97
T_3	CTR + 120 kg Nitrogen ha^{-1}	102.60	12.70	31.45	12.13	23.48
T_4	MTR + 60 kg Nitrogen ha^{-1}	103.97	14.47	52.48	13.99	23.56
T_5	MTR + 90 kg Nitrogen ha^{-1}	103.99	15.83	58.52	14.99	23.64
T_6	MTR + 120 kg Nitrogen ha^{-1}	105.98	17.57	60.37	16.80	24.11
T_7	SRI + 60 kg Nitrogen ha^{-1}	107.31	17.45	59.46	16.73	23.99
T_8	SRI + 90 kg Nitrogen ha^{-1}	108.31	18.07	64.63	17.97	24.17
T_9	SRI + 120 kg Nitrogen ha^{-1}	110.95	19.33	66.58	18.59	24.82
	F test	S	S	S	S	S
	SEd (±)	1.27	0.50	1.93	0.54	0.55
	CD (P= 0.05)	2.70	1.05	4.09	1.15	1.17

Table.2 Effect of crop establishment methods and nitrogen levels on no. of grains panicle^{-1}, length of panicle, grain yield and straw yield of rice

	Treatment	No. of filled grains panicle^{-1}	Length of panicle (cm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	CTR + 60 kg Nitrogen ha^{-1}	93.74	26.27	3.83	8.95
T_2	CTR + 90 kg Nitrogen ha^{-1}	94.96	26.47	3.98	8.98
T_3	CTR + 120 kg Nitrogen ha^{-1}	96.07	26.54	4.13	9.23
T_4	MTR + 60 kg Nitrogen ha^{-1}	99.58	26.59	4.24	9.46
T_5	MTR + 90 kg Nitrogen ha^{-1}	101.89	27.07	4.43	9.76
T_6	MTR + 120 kg Nitrogen ha^{-1}	105.98	27.43	5.20	10.06
T_7	SRI + 60 kg Nitrogen ha^{-1}	105.75	26.50	4.84	9.66
T_8	SRI + 90 kg Nitrogen ha^{-1}	107.00	27.46	5.25	10.13
T_9	SRI + 120 kg Nitrogen ha^{-1}	108.88	27.90	5.34	10.26
	F test	S	S	S	S
	SEd (±)	1.39	0.33	0.10	0.24
	CD (P= 0.05)	2.94	0.71	0.22	0.71

This might be due to efficient utilization of resources and less inter and intra space competition among widely spaced plants which may be assigned as the reason for superiority in these yield attributes of rice and consequently increased yield (Vijayakumar *et al.,* 2006). These results are in accordance with the findings of Padmavati *et al.*, 1998.

Increase in level of nitrogen fertilizer increased the number of grains in rice. Higher number of grains per panicle at higher nitrogen rate might be due to higher nitrogen absorption which favored formation of higher number of branches per panicle (Rahman *et al.,* 2007).

Yield

Significant and highest grain yield (5.34 t ha^{-1}) was reported in treatment T_9 (SRI +120 kg Nitrogen ha^{-1}), however treatments T_6 (MTR +120 kg Nitrogen ha^{-1}) and T_8 (SRI + 90 kg Nitrogen ha^{-1}) showed statistical parity with treatment T_9. Further, highest straw yield (10.26 t ha^{-1}) was reported in treatment T_9 (SRI +120 kg Nitrogen ha^{-1}), while treatments T_5 (MTR + 90 kg Nitrogen ha^{-1}), T_6 (MTR + 120 kg Nitrogen ha^{-1}), T_7 (SRI + 60 kg Nitrogen ha^{-1}) and T_8 (SRI + 90 kg Nitrogen ha^{-1}) were at par with treatment T_9.

The increased grain yield under SRI could be attributed to the higher root growth which enabled them to access to nutrients from much greater volume of soils. It helped to capture all the essential nutrient elements important for plant growth and thereby leading to higher tillering and grain filling (Thiyagarajan *et al.,* 2002). The same was also opined by Vijayakumar *et al.,* 2006. With regard to nitrogen, Awan *et al.,* (2011) and Rao *et al.,* (2013) also reported higher yield with successive increase in nitrogen levels (Table 2).

In conclusion, from the data pertaining to the different treatments, it may be indicated that by suitably modifying crop establishment methods, higher grain yield and monetary benefits can be realized over traditional transplanting. Similarly, the yield potential of a cultivar could be exploited to a maximum extent by judicious management of applied nitrogen. The actual yield advantage depends on the agronomic management including that of nitrogen management. As nitrogen deficiency is universal, significant yield increase due to nitrogen use is common.

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