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

Divya Pyngrope*, Gautam Ghosh, Teruo Miura and Amit Masih

Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, (U.P.) 211 007, India

*Corresponding author

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<sub>1</sub>: Conventional transplanting; P<sub>2</sub>: System of Rice Intensification; P<sub>3</sub>: Machine transplanting) and three different levels of Nitrogen (N<sub>1</sub>: 60 kg Nitrogen ha<sup>-1</sup>; N<sub>2</sub>: 90 kg Nitrogen ha<sup>-1</sup>; N<sub>3</sub>: 120 kg Nitrogen ha<sup>-1</sup>) replicated thrice in a randomized block design. The results revealed that there was significant and higher number of effective tillers hill<sup>-1</sup> (18.59) observed in treatment T<sub>9</sub> (SRI + 120 kg Nitrogen ha<sup>-1</sup>) and same treatment recorded significantly higher grain yield (5.34 t ha<sup>-1</sup>) which was 39.42% higher than the lowest grain yield (3.83 t ha<sup>-1</sup>), however treatment T<sub>8</sub> (SRI + 90 kg Nitrogen ha<sup>-1</sup>), T<sub>7</sub> (SRI + 60 kg Nitrogen ha<sup>-1</sup>) and T<sub>6</sub> (MTR + 120 kg Nitrogen ha<sup>-1</sup>) were statistically at par with treatment T<sub>9</sub>.

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<sup>-1</sup> 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<sup>-1</sup> 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 transplanters 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 quadrat (1 m²) 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 T9 (SRI +120 kg Nitrogen ha⁻¹), however treatment T8 (SRI +90 kg Nitrogen ha⁻¹) showed statistical parity with treatment T9. 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 T9 (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 T9 (SRI +120 kg Nitrogen ha⁻¹); however treatment T8 (SRI + 90 kg Nitrogen ha⁻¹) was at par with treatment T9. 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 T9 (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 T8 (SRI + 90 kg Nitrogen ha⁻¹) was found to be statistically at par with treatment T9 (SRI +120 kg Nitrogen ha⁻¹). The increased yield attributes in SRI may be accounted due to concept of phylochronic 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

**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

SEd (±):
- T\(_1\): 1.39
- T\(_2\): 0.33
- T\(_3\): 0.10
- T\(_4\): 0.24

CD (P= 0.05):
- T\(_1\): 2.94
- T\(_2\): 0.71
- T\(_3\): 0.22
- T\(_4\): 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.

References

Awan, T. H., Ali, R.I., Manzoor, Z., Ahmad, M. and Akhtar, M. 2011. Effect of different nitrogen levels and row spacing on the performance of newly evolved medium grain rice variety, KSK-133. J. Anim. Plant Sci., 21(2): 231-234

Bouman, B.A.M. 2009. How much water does rice use? Rice Today, 8(1): 28-29.

Debbarma, V. and Abraham, T. 2017. Agronomic performance of certified organic rice [Oryza sativa (L.) sub sp. japonica] as influenced by cultural practices. Res. Environ. Life Sci., 10(3): 216-220

GOI. 2016. Agricultural statistics at a glance: Ministry of Agriculture, Govt. of India. http://agricoop.nic.in

Haefele, S.M., Jabbar, S.M.A., Siopongco, J.D.L.C., Tirol-Padre, A., Amarante, S.T., Cruz, P.C. and Cosici, W.C. 2008. Nitrogen use efficiency in selected rice genotypes under different water regimes and nitrogen levels. Field Crops Res., 107: 137-46.

Laulanié, H. 1993. Le système de riziculture intensive malgache. Tropicultura (Brussels). 11: 110-114.

Mobasser, H.R., Tari, D.B., Vojdani, M., Abadi, R.S. and Eftekhar, A. 2007. Effect of seedling age and planting space on yield and yield components of rice (Neda variety). Asian J. Plant Sci., 6(2): 438–40.

Padmavati, P., Singh, S. and Prasad, R. 1998. Effect of planting patterns and levels of nitrogen on performance of conventional
and hybrid rice variety. In: Extended Summary of First International Agronomy Congress, held during 23-27 November at New Delhi, pp: 105.

Rahman, M.H., Khatun, M.M., Mamun, M.A.A., Islam, M.Z. and Islam, M.R. 2007. Effect of Number of Seedling Hill and Nitrogen Level on Growth and Yield of BRRI dhan32. J. Soil and Nature, 1: 1-7.

Rao, V.P., Subbaiah, G. and Sekhar, K.C. 2013. Response of rice varieties to high level nitrogen on dry matter production, yield and nitrogen uptake of rice. Int. J. Appl. Biol. Pharm., 4(4): 216-218.

Saha, A. and Bharti, V. 2010. Pollution free environment- an approach. Environ. Ecol., 28: 23-29.

Shukla, U.N., Srivastava, V.K., Singh, S., Sen, A. and Kumar, V. 2014. Growth, yield and economic potential of rice (Oryza sativa) as influenced by different age of seedlings, cultivars and weed management under system of rice intensification. Indian J. Agri. Sci., 84(5): 628–36.

Sowmya, C.H., Ramana, M., Venkata and Kumar, M. 2011. Effect of system of rice cultivation, cultivars and nutrient management options on growth, yield attributes and yield of rice. Crop Res., 42(1, 2 & 3): 1-5.

Stoop, W.A., Uphoff, N. and Kassam, A. 2002. A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. Agril. Sys., 71(3): 249-274.

Thiyagarajan, T.M., Senthilkumar, K., Bindraban, P.S., Hengsdijk, H and Ramaswamy, S. 2002. Crop management options for increasing water productivity in rice. J. Agric. Res. Manage., 1: 169-181.

Tiwari, R.C. and Rai, M. 2003. Field evaluation of puddling and transplanting equipment for rice crop under rainfed agro eco system. In: Paper presented in 37th annual convention of ISAE held at Udiapur (Rajasthan) from 29-31Jan, 2003.

Uphoff, N. 2002. System of Rice Intensification (SRI) for enhancing the productivity of land, labour and water. J. Agric. Res. Manage., 1: 43-49.

Vijayakumar, M., Ramesh, S., Chandrasekaran, B. and Thiyagarajan, T.M. 2006. Effect of System of Rice Intensification (SRI) Practices on Yield Attributes Yield and Water Productivity of Rice (Oryza Sativa L.) Res. J. Agri. Biol. Sci., 2(6): 236-242.

Wani, S.A., Qayoom, S., Bhat, M.A., Lone, B.A. and Nazir, A. 2016. Influence of sowing dates and nitrogen levels on growth, yield and quality of scented rice cv. Pusa Sugandh-3 in Kashmir valley. J. Appl. Natural Sci., 8(3): 1704 – 1709.

Yoshida, S. 1972. Physiological aspects of grain yield. Annual Rev. Plant Physiol., 23: 437–533.

---

How to cite this article:

Divya Pyngrope, Gautam Ghosh, Teruo Miura and Amit Masih. 2017. Growth and Yield of Rice (Oryza sativa L.) as Influenced by Different Crop Establishment Methods and Nitrogen Levels. Int.J.Curr.Microbiol.App.Sci. 6(7): 3968-3974. doi: https://doi.org/10.20546/ijcmas.2017.607.410