GSJ: Volume 11, Issue 2, February 2023, Online: ISSN 2320-9186
www.globalscientificjournal.com

Impact of plant density on growth and yield performance of mechanically transplanted rice

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KeyWords
Mechanically transplanted rice; Plant spacing; Planting density; Farmer practice; Grain yield

Abstract
The mechanically transplanted rice (MTR) is well known agriculture implement for the precise transplantation of rice crop in the world. Proper inter and intra row plant spacing to acquire optimum planting density is crucial for higher yield in MTR. Present study was planned to evaluate the impact of different planting densities by adjusting inter and intra plant spacing of mechanical transplanter (MT) i.e. T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})], T-2 [PP × RR = 20 cm × 25 cm (200,000 hills ha^{-1})], T-3 [PP × RR = 22.5 cm × 22.5 cm (200,000 hills ha^{-1})], compared to T-4 [farmers practice (125,000 hills ha^{-1})]. The results showed that highest number of fertile tillers (442 m^{-2}) was recorded in T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})]. However, highest number of tillers per hill was produced by T-3 [(PP × RR = 22.5 cm × 22.5 cm (200,000 hills ha^{-1})]. Maximum number of trays (315) was consumed in T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})] followed by T-2 [PP × RR = 20 cm × 25 cm (200,000 hills ha^{-1})] (300) and T-3 [(PP × RR = 22.5 cm × 22.5 cm (200,000 hills ha^{-1})] (285). The effect of planting density on 1000-grain weight was non-significant. The grain yield was significantly affected by different planting densities and the order was T-1 (4.403 t ha^{-1}) > T-2 (4.257 t ha^{-1}) > T-3 (4.17 t ha^{-1}) > T-4 (4.064 t ha^{-1}). In conclusion, highest and lowest grain yield was recorded in T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})] and T-4 [farmers practice (125,000 hills ha^{-1})], respectively, exhibiting that T-1 could be exploited for obtaining maximum grain yield in MTR.

Introduction
Basmati rice is cultivated mostly in irrigated areas of rice in Punjab, Pakistan. Basmati rice attained agreeable and sweet-scented variety, that is the specialty of Pakistani Punjab, having the grain quality in term of elongation after cooking and the fluffiness that makes it unique in the world (Sheikh and Abbas, 2007). In the rice cultivation, nursery raising and its transplantation are laborious and costly which are performed in the hot months of June-July. During these days, better available employment opportunities and the laborers already engaged in non farming jobs are generally reluctant to perform rice transplantation, resulting in the shortage of labor. Moreover, low plant population of rice transplanted by hired labor, improper fixation of nursery plants in the soil, a higher percentage of gaps and un-even transplantation in paddy fields causes reduction in rice yield (Farooq et al., 2001).

The mechanical transplanting method of rice was initially developed in Japan, Korea and other countries due to its ease of cultivation, considerable economic benefits like labor cost savings, optimum plant population and ultimately higher yield (Park et al., 2002; Hemmat and Taki, 2003; Choi et al., 2006; Kobayashi et al., 2009). In Pakistan, mechanical transplanting technique for rice has been explored from last five years and this technology is spreading in rice growing areas of Punjab. Agricultural mechanization plays a significant role to impel the energy between objects and mankind (Khalequzzaman and Karim, 2007) in the production of farm's commanded area by engine and motorized agriculture means (Negrete, 2019). Farm mechanization overcome heavy work, pay back labor shortage resulting in enhanced productivity and reduced climatic threats (Negrete, 2018).

The plant spacing and planting density are crucial in enhancing the productivity and economic benefits of MTR (Liu et al., 2017). Planting density has established role in influencing population attributes (Li et al., 2016), regulation of the production of tillers (Huang et al., 2013), radiation use efficiency (Chen et al., 2019), regulation of photo-assimilation and grain yield formation (Nakano et al., 2012). It has been observed that lower plant population results in decreased grain yield due to less number of tillers per unit area; while, higher plant population than optimum causes a reduction in grain yield by decreasing the number of grains per panicle and/or grain weight of rice (Yu et al., 2006; Hossen et al., 2018). Therefore, it is essential to optimize the plant density of MTR by modulating inter and intra row plant spacing.

Optimum planting density is essential for obtaining higher grain yield in mechanical transplanter (MT) and thus needs the determination of optimum plant spacing and planting density. It was hypothesized that low plant population decreases the yield of rice by decreasing the number of tillers per unit area. The present study was planned to evaluate the effect of different plant populations by manipulation of plant spacing on grain yield and related attributes of mechanical transplanter.

Materials and Methods

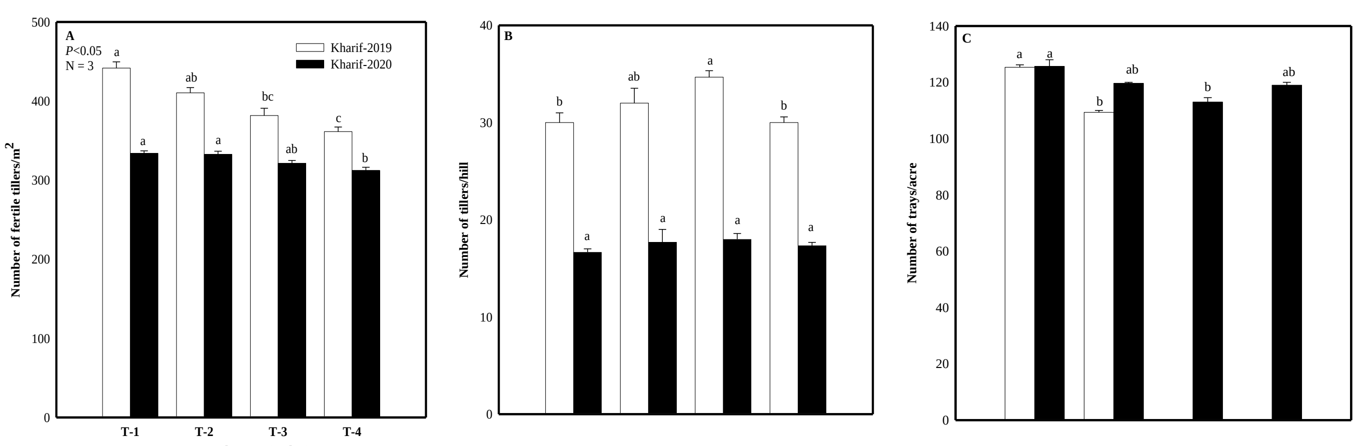
The present study was conducted to evaluate the impact of different plant population levels for mechanically transplanted rice (MTR) compared with farmers practice (FP). The studied treatments were comprised of different planting densities i.e. T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})], T-2 [PP × RR = 20 cm × 25 cm (200,000 hills ha^{-1})], T-3 [PP × RR = 22.5 cm × 22.5 cm (200,000 hills ha^{-1})] compared to T-4 [farmers practice (125,000 hills ha^{-1})]. The field trials were conducted with randomized complete block design (RCBD) using three replications at Adaptive Research Farm, Gujranwala, Punjab-Pakistan during Kharif 2019 and Kharif 2020.

The soil was prepared well with cultivator initially in dry land and puddling was done with water tight rotavator followed by planking. The nursery grown in trays having 25 days age was transplanted by using the walk after type rice transplanter. The fertilizers were applied at the rate of 120-88-62 kgha^{-1} NPK to crop. Whole of the P and K, and 1/3rd N was applied as basal dose, while remaining N was applied in two equal splits at 30 and 45 days after transplanting (DAT). Zinc sulfate (33%) was applied at the rate of 15 kg ha^{-1} 20 days after transplantation. Water was kept standing upto a depth of 5 cm in the field for 25 days. Afterwards, irrigation was applied to keep the soil in moist condition and stopped fifteen days before harvesting. Acetachlor applied @ 250 ml ha^{-1} in the rice field with shaker bottle, keeping in view the level of water upto 7.62 centimeter (Iqbal et al., 2021a). The granular insecticide Cartap hydrochloride @ 22 kg ha^{-1} was applied in the first week of September both years for the control of borers and sucking insect-pests, keeping in view the economic threshold level.

The crop was harvested manually in first week of November and threshed by mini thresher during both years. The number of fertile tillers m^{-2}, number of tillers hill^{-1}, number of trays ha^{-1}, number of hills m^{-2}, 1000-grain weight (g) and paddy yield (t ha^{-1}) was recorded according to protocol. The data was analyzed statistically by using Fisher's Analysis of Variance Technique (Steel et al., 1997) and treatments means were compared using the Tukey's HSD test. The graphical representation was designed by sigma 10.0 software (Iqbal et al., 2021b; Iqbal and Feng, 2020; Iqbal et al., 2020).

Results and Discussion

Significantly (P<0.05) higher fertile tillers (442 m^{-2}) were found in T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})], as compared to low performance in the farmers practice (125,000 hills ha^{-1}) during 2019 (Fig. 1A). The graphical representation showed non-significant (P>0.05) fertile tillers found in T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})] and T-2 [PP × RR = 20 cm × 25 cm (200,000 hills ha^{-1})] but found statistically significant (P<0.05) result compared to T-4 [farmers practice] during 2020. The number of tillers per hill was found maximum in T-3 [(PP × RR = 22.5 cm × 22.5 cm (200,000 hills ha^{-1})] compared to other treatments during 2019 (Fig. 1B). The result regarding number of tillers per hill were non-significant (P>0.05) during 2020.



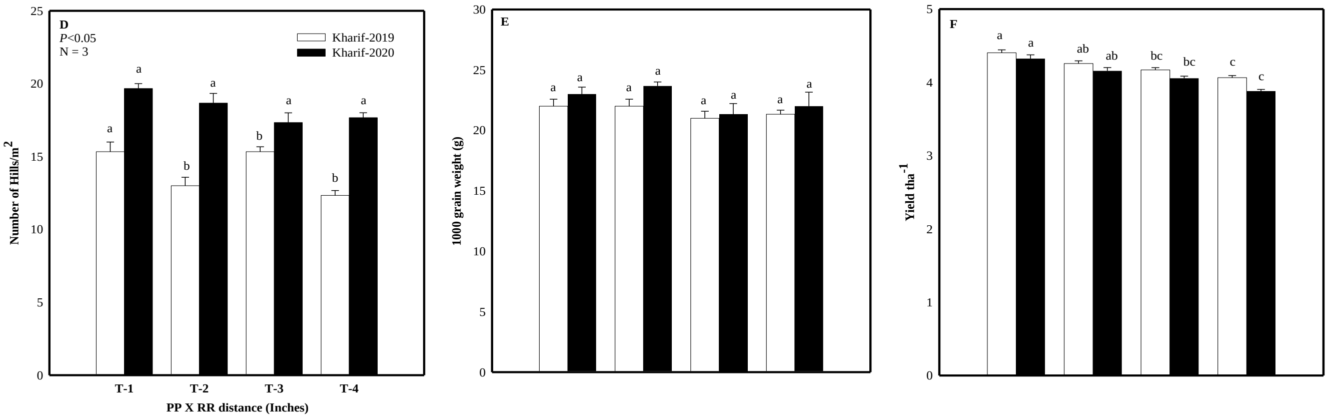


Figure 1 showing the impact of plant density on growth and yield performance of mechanically transplanted rice. Different letters indicates significant difference (*P* < 0.05; one way analysis of variance).

Maximum number of trays (315) was consumed in T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})] followed by T-2 [PP × RR = 20 cm × 25 cm (200,000 hills ha^{-1})] and T-3 [(PP × RR = 22.5 cm × 22.5 cm (200,000 hills ha^{-1})] compared to T-4 [farmers practice (125,000 hills ha^{-1})]. Due to high rainfall during the year 2019, T-3 treatment was not applied according to protocol (Fig. 1C). The effect of plant spacing on number of hills found statistically non-significant ($P > 0.05$) although highest number of hills was found in T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})], compared to other treatments (Fig. 1D). The effect of planting density/spacing on 1000-grain weight (g) was non-significant ($P>0.05$) during both the years compared to all other treatments (Fig. 1E). Our results showed better performance by the use of mechanically transplanted rice over conventional method of transplantation.

Significantly ($P < 0.05$) high yield (4.403 t ha^{-1}) was recorded by T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})], compared to T-2 (4.257), T-3 (4.17) and the low yield was recorded in T-4 (4.064) (Fig. 1F). The overall yield difference was found maximum in T-1 (339 kg ha^{-1}) with mechanically transplanted rice (MTR) compared to conventional method of transplantation i.e. farmer practice (FP). Our results are in line with the researchers who reported that the adaptation of mechanical transplanted rice helps to increase the productivity of rice crop and farm income, by overcoming labor scarcity, less plant population, delay in transplanting, improper fixation of nursery plants in the soil (Latif et al., 2022). Our results are in accordance with the researchers who reported that mechanically transplanted rice (MTR) technique is an efficient practice that save labor, cost, water, time and increase the impact of uniform spacing and enhanced productivity level compared to FP (Kumar et al., 2012). Our results are contradictory to the researchers who reported that the paddy yield was recorded maximum in conventional methods of transplantation (FP) followed by MTR (Gautam et al., 2021).

Conclusion

In conclusion, T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})] recorded maximum yield compared to T4 [farmers practice (125,000 hills ha^{-1})]. The difference in yield was recorded 339-443 kg hectare^{-1} with mechanically transplanted rice (MTR) compared to farmer's practice (FP). It is recommended that mechanical transplanting of rice must be preferred over conventional method and T-1 [PP × RR = 15 cm × 25 cm (270,000 hills ha^{-1})] must be used to obtain maximum yield in MT.

References

Chen, S., Yin, M., Zheng, X., Liu, S., Chu, G., Xu, C., Wang, D., Zhang, X. (2019): Effect of dense planting of hybrid rice on grain yield and solar radiation use in southeastern China. – Agronomy Journal 111: 1229-1238.

Choi, W.-Y., Moon, S.-H., Park, H.-K., Choi, M.-G., Kim, S.-S., Kim, C.-K. (2006): Optimum planting density in low fertilizing culture of machine transplanting in rice. – Korean Journal of crop science 51: 379-385.

Farooq, U., Sheikh, A. D., Iqbal, M., Bashir, A., Anwar, Z. (2001): Diffusion possibilities of mechanical rice transplanters. – International Journal of Agriculture & Biology 3: 17-20.

Gautam, A., Singh, V., Aulakh, G. S. (2021): Performance of paddy cultivation under different methods in South-Western part of Punjab, India. – Indian Journal of Extension Education 57: 131-134.

Hemmat, A., Taki, O. (2003): Comparison of compaction and puddling as pre-planting soil preparation for mechanized rice transplanting in very gravelly Calcisols in central Iran. – Soil and Tillage Research 70: 65-72.

Hossen, M. A., Hossain, M. M., Haque, M. E., Bell, R. W. (2018): Transplanting into non-puddled soils with a small-scale mechanical transplanter reduced fuel, labour and irrigation water requirements for rice (Oryza sativa L.) establishment and increased yield. – Field Crops Research 225: 141-151.

Huang, M., Yang, C., Ji, Q., Jiang, L., Tan, J., Li, Y. (2013): Tillering responses of rice to plant density and nitrogen rate in a subtropical environment of southern China. – Field Crops Research 149: 187-192.

Iqbal, M. F., Ahmed, I., Hussain, M., Asghar, M. (2021a): Impact of copper sulphate for the management of bacterial leaf blight in transplanted rice. – Int. J. Adv. Res. Biol. Sci 8: 10-15.

Iqbal, M. F., Feng, Y.-L. (2020): Species diversity of different insect families trapped under beer-based volatile fermentation. – BMC chemistry 14: 1-12.

Iqbal, M. F., Feng, Y.-L., Feng, W.-W., Liu, M.-C., Lu, X.-R. (2021b): Ecological impacts of the invasive plant Xanthium strumarium and the impacts of three aboveground herbivores on the invader. – Ecological Indicators 131: 108140.

Iqbal, M. F., Liu, M.-C., Iram, A., Feng, Y.-L. (2020): Effects of the invasive plant Xanthium strumarium on diversity of native plant species: A competitive analysis approach in North and Northeast China. – Plos One 15: e0228476.

Khalequzzaman, K. M., Karim, M. A. (2007): Study of agricultural mechanization and its impact on rural environment. – J Innov Dev Strategy 1: 37-40.

Kobayashi, K., Takahashi, Y., Fukuyama, T. (2009): Studies on the seedling raising method in giant-embryo rice cultivar'Koshiguruma'and its adaptability to machine transplanting. – Japanese Journal of Crop Science 78: 17-26.

Kumar, S., Singh, S. S., Sundram, P. K., Bhatt, B. P. (2012): Agronomic management and production technology of unpuddled mechanical transplanted rice. –

Latif, M. T., Hussain, M., Latif, A., Bajwa, M. H., Ahmad, I., Zohaib, A., Faisal, N., Hamza, M. (2022): Economic Viability and Profitability Analysis of Mechanical Transplanting of Rice in Rice-Wheat Cropping System of Pakistan. – Sarhad Journal of Agriculture 38:

Li, G., Zhang, J., Yang, C., Liu, Z., Wang, S., Ding, Y. (2016): Population Characteristics of High-Yielding Rice under Different Densities. – Agronomy Journal 108: 1415-1423.

Liu, Q., Zhou, X., Li, J., Xin, C. (2017): Effects of seedling age and cultivation density on agronomic characteristics and grain yield of mechanically transplanted rice. – Scientific reports 7: 1-10.

Nakano, H., Morita, S., Kitagawa, H., Wada, H., Takahashi, M. (2012): Grain yield response to planting density in forage rice with a large number of spikelets. – Crop science 52: 345-350.

Negrete, J. (2019): The role of agricultural mechanization in food security. – Journal of Agricultural Research Adcances 1: 12-15.

Negrete, J. C. (2018): Trends and perspectives of mechanization and agricultural machinery in Mexico for the 21st century. – Journal of Agricultural & Crop Sciences: Open Access 1: 29-38.

Park, H.-K., Kim, S.-S., Choi, W.-Y., Lee, K.-S., Lee, J.-K. (2002): Effect of continuous cultivation years on soil properties, weed occurrence, and rice yield in no-tillage machine transplanting and direct dry-seeding culture of rice. – Korean Journal of Crop Science 47: 167-173.

Sheikh, A. D., Abbas, A. (2007): Barriers in efficient crop management in rice-wheat cropping system of Punjab. – Pak. J. Agri. Sci 44: 341-349.

Steel, R. G. D., Torrie, J. H., Dickey, D. (1997): Principles and procedure of statistics. A biometrical approach 3rd Ed. McGraw HillBookCo. – Inc., New York 352-358.

Yu, L. H., Ding, Y. F., Xue, Y. F., Ling, Q. H., Yuan, Z. H. (2006): Factors affecting rice seedling quality of mechanical transplanting rice. – Transactions of the Chinese Socity of Agriculture Engineering 22: 73-78.