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Research Paper

Performance of mechanically transplanted *Basmati* rice (*Oryza sativa*) under different age of seedlings and planting densities

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ABSTRACT

A field experiment was conducted during the rainy (*kharif)* seasons of 2013, 2014, 2015 and 2016 at Ludhiana, Punjab, to study the effect of age of seedlings and planting density on growth and yield of mechanically transplanted *Basmati* rice (*Oryza sativa* L.). Mechanical transplanting of 3-weeks–old seedlings at 30 cm × 12 cm spacing showed significantly higher plant height, dry-matter accumulation, leaf-area index and number of effective tillers/unit area than 3, 4 and 5-weeks–old seedlings at 30 cm × 16 cm. The grain yield of mechanically transplanted 3-weeks–old seedlings at 30 cm × 12 cm spacing was 4.1 and 12.1% higher than 30 cm × 14 cm and 30 cm × 16 cm spacing respectively. Although the grain yield under mechanical transplanting of 3-weeks–old seedlings at 30 cm × 12 cm spacing was statistically similar with manual transplanting at 20 cm × 15 cm and 30 cm × 12 cm, but the net returns and benefit: cost ratio of mechanically transplanted 3-weeks–old seedlings at 30 cm × 12 cm spacing (₹77.58 × 10^3/ha and 3.61) were significantly higher than manual transplanting at 20 cm × 15 cm (₹71.50 × 10^3/ha and 2.87) and 30 cm × 12 cm (₹72.27 × 10^3/ha and 2.90) spacing, respectively.

Key words: *Basmati* rice, Mechanical transplanting, Net returns, Planting density, Seedling age

Basmati rice is a high-quality crop grown over an area of 2.1 million ha, with production of 8.77 million tonnes in India; and in Punjab, 3.50 million tones basmati is produced from 0.62 million ha. In India, it is grown mainly by manual transplanting method. The cost of cultivation of manual transplanted *Basmati* rice increased due to increasing wages of labour for transplanting as well as for uprooting of nursery (Kumar *et al.,* 2012). Manual transplanting is a time-consuming method, and in addition, this method also creates the problem of suboptimal planting density as compared to optimum planting density and delay in transplanting which leads to low crop productivity (Singh *et al.,* 2006). These problems can be solved by shifting transplanting method from manual to mechanized planting technique (Kamboj *et al.,* 2013). Paddy transplanters have a different row spacing (30 cm) than the currently recommended (20 cm) which cannot be altered. Plant-to-plant spacing can be adjusted in paddy transplanter. Height of seedlings (affected by age of seedlings) is an important parameter which can interfere with proper working of the paddy transplanter. So, in this study, we tried to investigate the optimum seedling age and planting density to obtain maximum productivity of mechanically transplanted basmati rice.

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MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) season of 2013, 2014, 2015 and 2016 at the Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana. The treatments comprised 3 ages of seedlings, viz. 3, 4 and 5-weeks-old seedlings and 3 planting densities, viz. 30 cm × 12 cm, 30 cm × 14 cm and 30 cm × 16 cm; and 2 treatments as control, i.e. manual transplanting of 4-weeks-old seedlings at 20 cm × 15 cm and 30 cm × 12 cm spacing. The experiment was laid out in a randomized block design with 4 replications. The soil was loamy sand, low in available N and medium in P and K with normal soil reaction. The sowing of mat-type nursery of *Basmati* rice cv 'Pusa *Basmati* 1121' was done on 16, 23 and 30 June in 2013; 9, 16 and 23 June in 2014; on 7, 14 and 22 June in 2015; and 8, 15 and 22 June in 2016 to have 5, 4 and 3-weeks-old seedlings, respectively, at the time of transplanting. The mats were fertilized with urea @ 300 g/200 mats (required for transplanting of 0.4 ha

area) at 10-day intervals after sowing. The nursery for manual transplanting was sown with traditional method and 4-weeks-old seedlings were used for transplanting. The mechanical transplanting of seedlings of *Basmati* rice was done on 23, 15, 14 and 13 July in 2013, 2014, 2015 and 2016, respectively, with Japanese transplanter (Model: NSPU- 68 C). A dose of 30 kg P_2O_5/ha was applied before the last puddling, whereas 40 kg N/ha was applied in 2 equal splits – 3 and 6 weeks after transplanting. Nitrogen and phosphorus were supplied from urea and single superphosphate respectively. Plant protection measures were adopted as per the recommendations of Punjab Agricultural University, Ludhiana. The crop was harvested manually during first week of November.

The data on plant height at harvesting was recorded from the 5 hills tagged randomly in each plot and then average was calculated. Dry-matter accumulation at harvesting was recorded by taking the plants from 50-cm-row length, dried in the oven at 65°C till constant weight and then expressed as g/m^2. Leaf-area index (LAI) was measured 90 days after transplanting (DAT) with the help of Plant Canopy Analyzer (LI-COR) Model LAI-2000. The yield attributes, viz. effective tillers/m^2, panicle length, grains/panicle, weight of grains/panicle, 1,000-grain weight, and biological, grain and straw yields were recorded at harvesting. The gross returns were calculated by multiplying the prevalent market price of grain and straw with their respective yields, and net returns were calculated by subtracting cost of cultivation from the gross returns. Benefit: cost ratio was calculated by dividing the net returns with cost of cultivation under the respective treatment. Statistical analysis was done as per randomized block design (Gomez and Gomez, 1984) and treatment means were compared at 5% level of significance.

RESULTS AND DISCUSSION

Growth and yield attributes

The data on the plant height at harvesting of the crop (Table 1) revealed that the maximum plant height was recorded in mechanically transplanted 3-weeks–old seedlings at 30 cm × 12 cm spacing (3w-30 × 12) and it was statistically at par with 3w-30 × 14, 4w-30 × 12, 5w-30 × 12, manual- 20 × 15 (conventional) and manual- 30 × 12 but significantly higher from 3w-30 × 16, 4w-30 × 14, 4w-30 × 16, 5w-30 × 14 and 5w-30 × 16. The increase in plant height in 30 cm × 12 cm spacing might be owing to more competition among plants for light as compared to wider plant spacing. Gautum *et al.* (2008) and Bozorgi *et al.* (2011) also reported significantly higher plant height with closer spacing as compared to wider spacing. The maximum dry-matter accumulation at harvesting (Table 1) and leaf-area index (LAI) at 90 DAT (Fig. 1) were recorded in manual transplanting at 20 cm × 15 cm spacing and it was found statistically at par with 3w-30 × 12, 3w-30 × 14, 4w-30 × 12, 5w-30 × 12 and manual- 30 × 12, but it differed significantly from 3w-30 × 16, 4w-30 × 14, 4w-30 × 16, 5w-30 × 14 and 5w-30 × 16. The higher dry-matter accumulation under closer spacing might be due to higher plant population/unit area and more plant height. Fayaz *et al.* (2015) also reported significantly higher dry-matter production under higher plant density in scented rice. Rao *et al.* (2010) also did not observe any significant difference in LAI between planting of 30-and-45-days-old seedlings. The higher LAI under closer spacing might be owing to higher tiller count/unit area and more plant height. Gautum *et al.* (2008) and Asmamaw (2017) also reported higher leaf-area index under higher plant densities as compared to low plant densities.

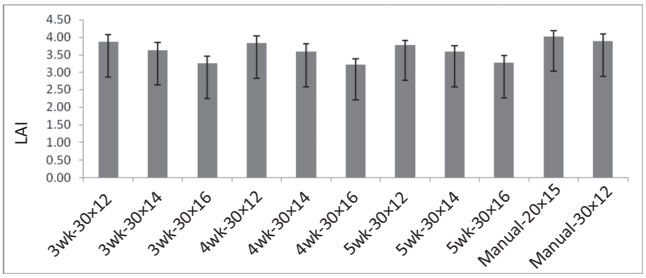

Fig. 1. Effect of age of seedlings and planting density on leaf-area index (LAI) 90 days after transplanting of basmati rice. 3w-30 × 12 denotes 3-weeks-old seedlings at 30 cm × 12 cm spacing

Effective tillers/m^2 recorded at harvesting (Table 1) were maximum in manual- 20 × 15 treatment and it was statistically at par with 3w-30 × 12, 3w-30 × 14, 4w-30 × 12, 4w-30 × 14, 5w-30 × 12, 5w-30 × 14 and manual- 30 × 12, but significantly higher than rest of the treatments. The effective tillers produced were not significantly affected by age of seedlings, i.e. 3, 4 and 5-weeks old seedlings. Singh *et al.* (2018) also showed that 40 and 50 days old seedlings of rice did not affect effective tillers significantly; however, produced significantly more than 60, 70 and 80-days-old seedlings. Asmamaw (2017) also obtained higher panicle number in 50 hills/m^2 followed by 33.3 hills/m^2 over the standard density (22.2 hills/m^2). However, other yield-attributing characters, viz. panicle length, grains/panicle, grain weight/panicle and 1,000-grain weight, were not significantly affected by age of seedlings and spacing (Table 1). Faghani *et al.* (2011) also revealed that seedling age had no significant effect on total spikelets/panicle, sterile spikelet/panicle and 1,000-grain weight. Further, the perusal of data showed that numerically there was an increase in yield-attributing characters under wider spacing as compared with closer spacing.

Uddin *et al.* (2011) also observed decreased spikelet number/panicle with an increase in planting density.

Yield

The data on biological yield (Table 2) showed that the maximum biological yield (11.30 t/ha) was obtained in manual transplanting at 20 cm × 15 cm spacing, being statistically at par with 3w-30 × 12, 3w-30 × 14, 4w-30 × 12, 4w-30 × 14, 5w-30 × 12 and manual- 30 × 12, but significantly more than rest of the treatments. The maximum grain yield was obtained in mechanical transplanting of 3-weeks-old seedling at 30 cm × 12 cm spacing and it was statistically at par with mechanical transplanting of 4-and 5-weeks-old seedlings at 30 × 12 cm and 30 × 14 cm and manual transplanting at 20 × 15 cm and 30 cm × 12 cm spacing, but significantly more than rest of the treatments (Table 2). Grain yield under mechanical transplanting of 3 weeks–old seedlings at 30 cm × 12 cm spacing was 12.1, 14.8 and 17.7% higher than mechanical transplanting of 3, 4 and 5 weeks–old seedlings at 30 cm × 16 cm spacing. The maximum straw yield was obtained in manual- 20 × 15 and it was statistically at par with 3w-30 × 12, 3w-30 × 14, 4w-30 × 12, 4w-30 × 14, 5w-30 × 12, and manual-30 × 12 but it differed significantly from rest of the treat-

Table 1. Effect of age of seedlings and planting density on growth and yield-attributing characters of mechanically transplanted *Basmati* rice (pooled data of 4 years)

Treatment (cm × cm)	Plant height at harvesting (cm)	Dry-matter accumulation at harvesting (g/m^2)	Effective tillers/m^2	Panicle length (cm)	Grains/ panicle	Grain weight/ panicle (g)	1,000-grain weight (g)
3w-30 × 12	110.2	1018.6	215.0	27.2	68.6	2.42	27.59
3w-30 × 14	108.8	988.9	209.2	27.5	70.7	2.56	27.91
3w-30 × 16	106.8	967.1	198.5	28.1	71.7	2.59	27.95
4w-30 × 12	109.2	994.0	212.8	27.3	67.6	2.24	27.12
4w-30 × 14	107.6	975.4	207.0	27.3	69.4	2.45	27.27
4w-30 × 16	105.5	953.9	195.3	27.9	70.8	2.50	27.90
5w-30 × 12	109.3	991.7	211.8	27.3	67.0	2.18	27.00
5w-30 × 14	106.9	968.5	204.3	27.2	68.9	2.33	27.21
5w-30 × 16	105.1	946.0	194.0	28.0	67.2	2.47	27.82
Manual-20 × 15	109.4	1033.0	216.6	27.3	67.2	2.39	27.01
Manual-30 × 12	110.1	1012.1	213.1	27.2	69.1	2.37	27.59
SEm±	0.85	17.1	4.4	0.70	3.70	0.18	1.06
CD (P=0.05)	2.48	49.7	12.7	NS	NS	NS	NS

3w-30 × 12 denotes 3 weeks old seedlings at 30 cm × 12 cm spacing

Table 2. Effect of age of seedlings and planting density on yield and economics of mechanically transplanted *Basmati* rice (pooled data of 4 years)

Treatment (cm × cm)	Biological yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Cost of cultivation (× 10^3₹/ha)	Gross returns (× 10^3₹/ha)	Net returns (× 10^3₹/ha)	Benefit: cost ratio
3w-30 × 12	11.19	3.33	7.86	29.8	21.47	99.05	77.58	3.61
3w-30 × 14	10.78	3.20	7.58	29.7	21.28	95.82	74.54	3.50
3w-30 × 16	10.31	2.97	7.34	29.3	21.13	89.00	67.86	3.21
4w-30 × 12	11.11	3.25	7.84	29.4	22.02	97.47	75.45	3.43
4w-30 × 14	10.77	3.17	7.60	29.4	21.83	94.87	73.04	3.35
4w-30 × 16	10.28	2.90	7.38	28.6	21.68	87.66	65.98	3.04
5w-30 × 12	11.05	3.23	7.82	29.3	22.57	96.50	73.93	3.27
5w-30 × 14	10.69	3.14	7.55	28.5	22.38	91.14	68.76	3.07
5w-30 × 16	10.20	2.83	7.37	28.7	22.23	84.96	62.73	2.82
Manual-20 × 15	11.30	3.24	8.06	28.6	24.94	96.44	71.50	2.87
Manual-30 × 12	11.15	3.27	7.88	29.3	24.94	97.21	72.27	2.90
SEm±	0.18	0.09	0.17	0.10	–	2.55	2.55	0.13
CD (P=0.05)	0.53	0.27	0.49	NS	–	7.40	7.40	0.35

3w-30 × 12 denotes 3 weeks old seedlings at 30 cm × 12 cm spacing

ments. This might be owing to more number of effective tillers/m^2 under closer spacing. Similar results were reported by Aggarwal and Singh (2015) and Liu *et al.* (2017) in mechanically transplanted rice. Islam *et al.* (2013) also showed significantly enhanced grain yield under higher plant density due to more panicles/m^2. Although, harvest index was not significantly affected by age of seedlings and planting densities, but, numerically it was highest in treatment where 3 weeks–old seedlings were mechanically transplanted at 30 cm × 12 cm.

Economics

The cost of cultivation was the highest in manual transplanting at 20 cm × 15 cm and 30 cm × 12 cm due to more labour requirement for transplanting (Table 2). The highest gross and net returns were obtained in mechanical transplanting of 3 weeks–old seedlings at 30 cm × 12 cm spacing which were statistically similar with 3w-30 × 14, 4w-30 × 12, 4w-30 × 14, 5w-30 × 12, manual- 20 × 15 and manual- 30 × 12, but were significantly higher than rest of the treatments. Similarly, benefit: cost ratio was maximum in 3w-30 × 12 treatment and was statistically at par with 3w-30 × 14, 4w-30 × 12, 4w-30 × 14 and 5w-30 × 12, but significantly higher than that recorded with manual- 20 × 15, manual-30 × 12 and 3, 4 and 5 weeks–old seedlings at 30 cm × 16 and 5w- 30 × 14. The higher net returns in mechanical transplanting of 3w-30 × 12 as compared to manual transplanting might be owing to reduced cost of cultivation and statistically similar grain and straw yields among these treatments. Fayaz *et al.* (2015) also reported maximum net returns and B:C ratio with 20 cm × 15 cm spacing as compared with 20 cm × 20 cm due to higher grain and straw yields.

Based on the present study, it can be concluded that in order to obtain maximum profit (B:C ratio), 3-weeks-old basmati rice seedlings should be transplanted mechanically at 30 cm × 12 cm spacing.

REFERENCES

Aggarwal, N. and Singh, A. 2015. Crop performance, nutrient uptake vis-a-via weed suppressive ability of mechanically transplanted rice (*Oryza sativa*) as influenced by age of seedlings and planting density. *Indian Journal of Agronomy* **60**(2): 255–260.

Asmamaw, B.A. 2017. Effect of planting density on growth, yield and yield attributes of rice (*Oryza sativa* L.). *African Journal of Agricultural Research* **12**(35): 2,713–2,721.

Bozorgi, H.R., Faraji, A., Danesh, R.K., Keshavarz, A., Azarpour, E. and Tarighi, F. 2011. Effect of plant density on yield and yield components of rice. *World Applied Sciences Journal* **12**(11): 2,053–2,057.

Faghani, R., Mobasser, H.R., Dehpor, A.A. and Kochaksarai, S.T. 2011. The effect of planting date and seedling age on yield and yield components of rice (*Oryza sativa* L.) varieties in North of Iran. *African Journal of Agricultural Research* **6**(11): 2,571–2,575.

Fayaz, A., Singh, P., Qayoom, S., Ahmad, L., Lone, B., Singh, L. and Singh, K.N. 2015. Influence of different dates of sowing and spacings on growth and yield of scented rice cv. Pusa Sugandh 3 under temperate conditions of Kashmir. *Journal of Cereals and Oilseeds* **6**(4): 20–23.

Gautam, A.K., Kumar, D., Shivay, Y.S. and Mishra, B.N. 2008. Influence of nitrogen levels and plant spacing on growth, productivity and quality of two inbred varieties and a hybrid of aromatic rice. *Archives of Agronomy and Soil Science* **54**(5): 515–532.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. Edn. 2. John Wiley & Sons, New York.

Islam, M.S., Rashid, M.M., Mondal, M.K., Nath, S.C. and Karim, M.R. 2013. Effect of planting density on the performance of hybrid rice (*Oryza sativa* L.) under waterlogged condition. *Agriculturists* **11**(2): 109–111.

Kamboj, B.R., Yadav, D.B., Yadav, A., Goel, N.K., Gill, G., Malik, R.K. and Chauhan, B.S. 2013. Mechanized transplanting of rice (*Oryza sativa* L.) in non-puddled and no-till conditions in the rice-wheat cropping system in Haryana, India. *American Journal of Plant Sciences* **4**: 2,409–2,413.

Kumar, R., Bansal, N.K., Yadav, A., Ram, M. and Sharma, V. 2012. Evaluation of alternative crop establishment method in rice at Haryana. *Environment and Ecology* **30**(3A): 722–725.

Liu, Q., Zhou, X., Li, J. and Xin, C. 2017. Effects of seedling age and cultivation density on agronomic characteristics and grain yield of mechanically transplanted rice. *Scientific Reports* **7**: 14,672–14,677.

Singh, K.K., Lohan, S.K., Jat, A.S. and Rani, T. 2006. New technologies of planting rice for higher production. *Research on Crops* **7**(2): 369–371.

Singh, T., Satapathy, B.S., Lal, B. and Pun, K.B. 2018. Productivity and profitability of rice (*Oryza sativa*) varieties as influenced by age of seedlings in north-eastern Himalayan region. *Indian Journal of Agronomy* **63**(3): 307–311.

Rao, A.U., Murthy, K.M.D. and Sridhar, T.V. 2010. Growth and yield of rice as influenced by age of seedlings and integrated N management for late planted situation. *International Journal of Agricultural Sciences* **6**(2): 481–484.

Uddin, J., Ahmed, S., Harun, O.R., Hasan, M. and Asaduzzaman. 2011. Effect of spacing on the yield and yield attributes of transplanted aman rice cultivars in medium lowland ecosystem of Bangladesh. *Journal of Agricultural Research* **49**(4): 465–476.