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Impact of various Transplanting Dates, Seedling Spacing and Seedling Numbers on Growth, Yield Attributes and Yield of Hybrid Rice (*Oryza sativa*)

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ABSTRACT: A field study was conducted in Selaqui, Dehradun (Uttarakhand), at the Crop Research Farm, Department of Agronomy, Maya College of Agriculture and Technology, during the 2016 *kharif* season. The experiment included 18 treatments, including 3 transplanting dates (15 July, 27 July, and 09 August), 2 seedling rates (1 seedling hill^{-1} and 2 seedling hill^{-1}) and 3 spacings (20 × 10 cm, 20 × 15 cm and 20 × 20 cm). The experiment was replicated three times and set up using a randomized block design. The test crop was rice of the "Arize 6444 variety". Treatment T6-15 July + 20 × 20 cm + 2 seedling hill^{-1} obtained significantly higher growth (plant height and dry matter at harvest, yield attributes (number of effective tillers hill^{-1}, panicle length, grains panicle^{-1} and test weight), grain yield (63.33 q ha^{-1}) and straw yield (80.67 q ha^{-1}) of rice.

Keywords: Date of transplanting, Growth, Hybrid rice, Spacing, Yield attributes and Yield.

INTRODUCTION

Rice is a member of the genus *Oryza*, the family Poaceae (Gramineae) and the tribe Oryzeae. It has 25 species, 23 of which are wild and only two are cultivated, namely *Oryza sativa* and *Oryza glaberrima*. *Oryza sativa* is primarily grown in Asia, whereas *O. glaberrima* is grown in Africa. According to archaeological and historical evidence, cultivated rice originated in South-East Asia for *Oryza sativa* and Africa for *Oryza glaberrima*. Rice is grown in a wide range of agro-climatic conditions, from hilly (Jammu) lands to low-land delta regions (Sundarban), ranging in area from 53° latitude North to 35° South of the equator, but Asia accounts for approximately 90% of the crop's production and consumption. The rice crop covers the most land in India, followed by China and Indonesia, with China has the highest production. In terms of area, production and consumer preference, it is one of India's most staple food crops. It is grown on approximately 164.19 million hectares globally, with annual productivity and production of 3105 kg ha^{-1} and 509.87 million tonnes, respectively. Rice is grown on approximately 45 million ha in India, with an annual production and productivity of 118.87 million tonnes and 2641.5 kg ha^{-1}, respectively. West Bengal, Bihar, Maharashtra, Uttar Pradesh, Punjab and Haryana are the major rice producing states in India (FAO STAT 2020).

Rice is an excellent food that is high in carbohydrates and energy. According to Lu and Chang (1980) rice crops produce more food energy and protein per hectare of land than wheat and maize, based on mean grain yield. As a result, rice can feed more people per unit of land. Among the cereals, rice unquestionably provides the most energy. Rice flour is the main ingredient in face powders and infant formulas because it is nearly pure starch and free of allergens. Because of its low fibre content, rice powder is increasingly being used to polish camera lenses and expensive jewellery. Rice starch can also be used to replace glucose in oral rehydration solutions for diarrheal infants. Rice's protein quality (66%) is only slightly lower than that of oats (68%) but higher than that of whole wheat (53%) and corn (49%). Rice, which is low in sodium and fat and free of cholesterol, can help prevent hypertension. It is also allergen-free and is now widely used in baby foods (James and McCaskill 1983). The coarse and silica-rich rice hull is finding new applications in building materials. Rice straw is used less in the rope and paper industries than it once was, but with the exception of modern varieties, it is still an important cattle feed throughout Asia. Rice is also used in the production of infant foods, snack foods, breakfast cereals, beer, fermented products, and rice bran oil, and rice wine is still a popular alcoholic beverage in East Asia (Juliano, 1985).

Rice is typically sown in the first week of July after being planted at the end of May. Transplanting is a traditional method that produces a high and consistent yield, but it is also a time-consuming and costly task. Farmers are now shifting to other methods, such as direct seeding rice, to reduce costs and difficulties (Mehmood *et al*., 2002). The precise sowing date for direct seeding of rice is also important in improving growth and yield. The timing of rice crop sowing is critical for three reasons. Firstly, it ensures that vegetative growth takes place during a period of favourable temperatures and high levels of solar radiation. Second, the best time to sow each cultivar ensures that the cold-sensitive stage occurs when the minimum night temperatures are historically the warmest. Third, sowing on time ensures that grain filling occurs when milder autumn temperatures are more likely, resulting in good grain quality (Farrell *et al*., 2003). The rate of establishment of rice seedlings is also affected by the date of sowing (Tashiro *et al*., 1999).

Aside from nutrition, the transplanting date has a significant impact on the grain yield of transplanted rice. Late planting subjects the crop's reproductive phase as well as phenological events to an unfavourable temperature regime, resulting in high spikelet sterility and poor plant growth. However, optimal rice planting dates vary depending on location and genotype (Bruns and Abbas 2006). Adjustment at the time of transplanting allows the plants to take advantage of naturally favourable growing conditions. The time of transplanting was found to have a significant impact on rice growth, yield, and yield-contributing characteristics (Islam *et al*., 1999).

Spacing is another important parameter that influences nutrient uptake, plant growth, and yield. With increased spacing, the total population decreases, but with increased nutrition, the individual plant grows better and produces more, and vice versa. The yield is influenced by the increase or decrease in row spacing and plant population. There should be a point where maximum yield is expected in these simultaneous opposing effects of the two components, and that should be at the optimum spacing (Tan *et al*., 2000). Another important factor that might help increase rice output is plant spacing and the number of seedlings hills^{-1}. Numerous studies have shown that because of increased intra-specific competition, closer spacing may result in mutual shading, lodging, and insect pest infestation. By utilising more sunlight and soil nutrients, optimal plant density ensures healthy plant growth (Mondal *et al.,* 2013). Additionally, Number of Seedling Hill^{-1} regulates other physiological processes that ultimately affect the growth and development of rice plants, such as tiller formation, solar radiation interception, nutrient uptake, rate of photosynthesis, and others (Khan *et al*., 2013).

MATERIAL AND METHODS

An experiment was carried out at plot no. 16 B of the Crop Research Farm, Department of Agronomy, Maya College of Agriculture and Technology, Selaqui, Dehradun (Uttrakhand) during the *kharif* of 2016. Selaqui is situated at 25.28° N Latitude, 81.54° E Longitude and 410 m above mean sea level, receives 1040.0 mm on an average rainfall during experimentation period. Temperatures at the maximum and minimum on average are 35.34°C and 12.94°C, respectively. The soil of the experimental site was sandy-loam with good drainage capabilities and slightly alkaline (pH 7.93) in reaction. The soil was found low in available nitrogen (278.09 kg ha^{-1}), medium in available phosphorus (18.25 kg ha^{-1}) and available potassium (150.34 kg ha^{-1}) and low in organic carbon (0.336%). The trial consisted of eighteen treatments combinations *i.e.* three factor combinations: three date of transplanting (15 July, 27 July and 09 August), two seedlings rate (1 seedling hill^{-1} and 2 seedling hill^{-1}) with three spacing (20 × 10 cm, 20 × 15 cm and 20 × 20 cm) and were replicated three times.

Rice 'Arize 6444 variety' was transplanting in three date of transplanting (15 July, 27 July and 09 August), two seedlings rate (1 seedling hill^{-1} and 2 seedling hill^{-1}) with three spacing (20 × 10 cm, 20 × 15 cm and 20 × 20 cm) with seed rate of 8 kg ha^{-1}. Transplanting was done with puddling. The recommended dose of fertilizer given to the crop was N, P, K and Zn through urea, SSP, MOP and zinc sulphate, respectively. The field was maintained in a moist condition and provides eight irrigations as per recommendation during the crop growing period. Weed management was done by manually and weeding was done three times @ 20, 30 and 47 DAT. The crop was harvested separately from each plot according to transplanting date. The produce from net plot was tied in bundles separately and then tagged.

The tagged bundles were allowed to dry out in the sun in the field and then placed on the threshing floor. Rice was threshed manually by beating panicles on the sheaf with a wooden baton, and seeds were separated by winnowing. Grain yield was calculated for each treatment and expressed as q ha^{-1}.

At 60 DAS and harvest, plant height was determined from the ground level to the tip of the growing point in tagged plants, and the mean was expressed in cm.For dry matter analysis, randomly five plants were selected from border rows in each plot. The plants were cut, air dried initially and then oven dried at 65 $\pm$ 5°C for till constant weight was obtained and then their weights were recorded. Dry mater accumulation was recorded at 60 DAS and at harvest and expressed as g plant^{-1}. Number of effective tillers hill^{-1} was counted from five tagged plants in each plot at harvest.

The grains from each of the ten panicles, which were collected at random from tagged hills, were counted individually and their averages were noted. From panicles taken from each plot, one thousand grains were randomly counted, weighed, and documented as test weight at 14% moisture. Rice was manually threshed by beating panicles with a wooden baton on the sheaf, and the seeds were then separated by winnowing. The cereal yield was documented treatment-by-treatment and expressed as q ha^{-1}. Straw yield was calculated by subtracting grain yield from respective biological yield of each plot and expressed as q ha^{-1}.

The Gomez and Gomez technique of analysis of variance was used to statistically analysis the data (1976). When the F test was significant at a 5 percent probability level and the values were provided, the critical difference was calculated.

RESULTS AND DISCUSSION

Plant height and dry matter. The results showed that the growth attributes (height of plant and plant dry matter) were significantly affected by different planting date and spacing of rice. However, the plant height and dry matter at 60 DAT was found to be significantly not affected by different transplanting date, spacing and number of seedlings. Among treatments, treatment T6 - 15 July + 20 × 20 cm + 2 seedling $hill^{-1}$ significantly highest plant height and dry matter at harvest over rest of the treatments (Table 1). This might be due to more duration and higher heat accumulation, have favoured most of the growth parameters *viz*., plant height and dry matter in July 15 planting as compared to 27 July and 09 August planting. This is most likely due to timely sowing, which may have benefited from favourable climatic conditions in terms of temperature and other factors during crop growth, as well as better mineral nitrogen availability to the plants due to favourable soil temperature, which has led to better utilisation of carbohydrates to form more protoplasm, resulting in increased cell division and enlargement. The increased plant height could be attributed to the fact that the higher number of plants per unit area stimulated competition among plants, particularly for light, which influenced plant height. Similarly, results were also reported by Kumari *et al*. (2000), Nayak *et al*. (2003); Yadav and Tripathi (2006); Muhammad *et al*. (2008); Ganvit *et al*. (2019).

The maximum plant height of rice was recorded at all growth stages at a spacing of 20 × 20 cm over 20 × 15 cm and 20 × 10 cm spacing (Table 1). Tallest plants of rice were found in 2 seedlings $hill^{-1}$ as compared to 1 seedlings $hill^{-1}$ during investigation. This might be due to exposure of larger number of plant and leaf area to sunlight during the growth period resulting higher photosynthesis and consequently higher plant height. According to Kumari *et al.* (2000), the increased vigour caused by the plant's wider spacing, which helps in the effective absorption of nutrients at critical stages, increased physiological activity and increased dry matter production. The results of investigation are in line with those of Shrivastava *et al.* (1997).

Yield attributes. Yield attributing characters were significantly affected by different transplanting date, spacing and number of seedlings. The maximum number of effective tillers $hill^{-1}$, grains $panicle^{-1}$, panicle length and test weight were recorded with treatment T6 - 15 July + 20 × 20 cm + 2 seedling $hill^{-1}$, increased significantly higher as compared to rest of the treatments (Table 1). Early transplanting accelerated the buildup of carbohydrates in plants, which in turn enhanced yield characteristics like the number of effective tillers $hill^{-1}$, panicle length, grains $panicle^{-1}$ and test weight. According to Muhammad *et al.* (2008), early transplanting produced the greatest amount of effective tillers $hill^{-1}$. These conclusions agree with those made about rice by Nayak *et al*. (2003). According to Devi and Singh (2000), there was a noticeable increase in productivity at $hill^{-1}$ with broader spacing. Since plants are spaced farther apart, nutrients are absorbed more quickly, increasing the quantity of tillers and grain $panicles^{-1}$.

Yield. The grain yield was significantly influenced by the different planting date and spacing (Table 1). The maximum grain yield was recorded with 15 July transplanted rice with wider spacing 20 cm × 25 cm sown rice crop. This might be the result of early transplanting, which aided in nutritional absorption and the movement of photosynthates from source to sink. Mukesh *et al.* (2013); Manoj *et al.* (2013); Islam *et al.* (2014) all came to similar conclusions. More seedlings per hill and wider spacing improve nutrient uptake, which enhances photosynthetic translocation to the reproductive portion and boosts production and yield attributing traits. The results from Patra and Nayak (2001); Chopra *et al.* (2006); Mahato *et al.* (2006) are used to support this conclusion.

The maximum straw yield was recorded in treatment T6 - 15 July + 20 × 20 cm + 2 seedling $hill^{-1}$, increased significantly higher as compared to rest of the treatments. This might be because early transplanting has an overall impact on all aspects of growth, including plant height as well as fresh and dry weight, as was previously mentioned. According to Manoj *et al.* (2013), rice that was transplanted early had higher yield and yield-attributing character. Khalifa *et al.* (2014) also came to similar conclusions. The increased yield of straw might be the result of wider spacing, which in turn led to an increase in the level of yield components like effective tiller, filled grain and panicle length. The accumulation of carbohydrates in plants also increased the yield attributes, which in turn increased the yield of straw. Wider spacing, according to Patra and Nayak (2001), increased straw yield. Similar findings were also corroborated by Gunri *et al*. (2004); Pal *et al*. (2008).

Table 1: Effect of sowing date, spacing and number of seedlings on plant height, dry matter of hybrid rice at different stages.

Treatments	Plant height		Dry matter		No. of effective tillers hill^{-1}	Panicle length	No. of grains panicle^{-1}	Test weight	Grain yield	Straw yield
	60 DAT	At harvest	60 DAT	At harvest						
T1 - 15 July + 20 × 10 cm + 1 seedling hill^{-1}	66.85	80.27	3.70	23.27	18.77	23.17	160.44	19.17	35.33	48.00
T2 - 15 July + 20 × 10 cm + 2 seedling hill^{-1}	77.41	80.55	2.86	23.44	19.17	23.33	162.67	19.33	37.00	50.27
T3 - 15 July + 20 × 15 cm + 1 seedling hill^{-1}	75.07	86.07	3.17	25.27	21.55	24.17	176.17	22.33	48.33	65.67
T4 - 15 July + 20 × 15 cm + 2 seedling hill^{-1}	76.22	89.33	3.42	25.67	21.88	24.33	179.00	23.67	50.67	68.55
T5 - 15 July + 20 × 20 cm + 1 seedling hill^{-1}	71.88	100.88	3.44	27.93	29.55	25.67	193.55	29.67	60.27	79.27
T6 - 15 July + 20 × 20 cm + 2 seedling hill^{-1}	74.42	103.67	3.12	29.27	33.27	27.33	202.33	32.55	64.33	80.67
T7 - 27 July + 20 × 10 cm + 1 seedling hill^{-1}	72.15	78.88	2.67	22.55	18.00	22.27	155.67	18.44	32.67	44.33
T8 - 27 July + 20 × 10 cm + 2 seedling hill^{-1}	69.13	79.33	3.47	22.93	18.33	23.07	158.00	18.88	34.00	46.27
T9 - 27 July + 20 × 15 cm + 1 seedling hill^{-1}	68.87	82.17	3.35	24.67	20.17	23.88	170.33	20.44	43.67	59.33
T10 - 27 July + 20 × 15 cm + 2 seedling hill^{-1}	72.12	83.67	3.19	24.93	21.27	24.00	173.27	20.77	46.17	62.77
T11 - 27 July + 20 × 20 cm + 1 seedling hill^{-1}	66.60	97.44	3.23	27.17	25.33	24.88	187.33	27.55	56.17	75.44
T12 - 15 July + 20 × 20 cm + 2 seedling hill^{-1}	62.99	99.27	3.13	27.55	27.07	25.17	190.44	29.33	58.33	76.27
T13 - 09 August + 20 × 10 cm + 1 seedling hill^{-1}	60.41	76.55	3.33	19.93	17.07	20.27	150.67	14.67	28.55	41.67
T14 - 09 August + 20 × 10 cm + 2 seedling hill^{-1}	58.22	77.44	3.03	21.27	17.67	22.17	153.55	16.27	30.27	42.27
T15 - 09 August + 20 × 15 cm + 1 seedling hill^{-1}	65.49	80.77	3.06	23.77	19.55	23.55	165.00	19.67	38.67	52.55
T16 - 09 August + 20 × 15 cm + 2 seedling hill^{-1}	57.84	81.44	3.41	24.07	19.88	23.67	167.27	20.00	41.77	56.77
T17 - 09 August + 20 × 20 cm + 1 seedling hill^{-1}	63.40	93.67	3.24	26.07	22.60	24.55	182.17	25.17	52.27	71.67
T18 - 09 August + 20 × 20 cm + 2 seedling hill^{-1}	60.89	95.77	3.26	26.44	23.67	24.67	185.27	25.88	54.67	74.33
S.Ed.	6.30	0.27	0.48	0.08	0.12	0.13	0.93	0.11	0.32	0.20
CD (P=0.05)	-	0.56	-	0.16	0.24	0.26	1.89	0.22	0.64	0.40

CONCLUSIONS

Rice transplanted at 15 July + 20 × 20 cm + 2 seedling hill^{-1} obtained significantly higher growth (plant height and dry matter at harvest, yield attributes (number of effective tillers hill^{-1}, panicle length, grains panicle^{-1} and test weight) and yield (grain and straw).

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Conflict of Interest. None.

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