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Different transplanting dates, spacing and number of seedlings have an impact on the productivity and profitability of hybrid rice

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Abstract
Field experiment was conducted to evaluate the effect of different transplanting dates, seedling rates and spacings on yield and economics of hybrid in Selaqui, Dehradun (Uttarakhand), at the Crop Research Farm, Department of Agronomy, Maya College of Agriculture and Technology, during the 2016 kharif season. Experiment comprised 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 X 10 cm, 20 X 15 cm and 20 X 20 cm). The experiment was replicated three times and using a randomized block design. The test crop was rice of the "Arize 6444 variety". Results revealed that hybrid rice transplanted at 15 July with 20 x 20 cm spacing and 2 seedlings hill^{-1} proved to be the best for obtaining maximum grain (64.33 q ha^{-1}), straw (80.67 q ha^{-1}) and biological yield [145.00 q ha^{-1}) and returns (gross (□ 93330 ha^{-1}), net returns (□ 42514 ha^{-1}) and B:C ratio (1.83)].

Keywords: Date of transplanting, Hybrid rice, Number of seedlings hill^{-1}, Productivity, Profitability and Spacing

Introduction
The tribe Oryzeae, the family Poaceae (Gramineae), and the genus *Oryza* all have rice as a member. Only two of its 25 species, *Oryza sativa* and *Oryza glaberrima*, are grown; the other 23 are wild. While *O. Glaberrima* is primarily grown in Africa, *Oryza sativa* is primarily grown in Asia. Rice cultivation is thought to have started in South-East Asia for *Oryza sativa* and Africa for *Oryza glaberrima*, based on historical and archaeological data. A wide variety of agro-climatic conditions, from hilly (Jammu) fields to low land delta areas (Sundarban), are suitable for growing rice; nonetheless, the majority of the crop-about 90%-is cultivated and consumed in Asia (Alston *et al*., 2000) [1]. India is the country that grows rice on the most acreage, followed by China and Indonesia, with China producing the most. It is one of the most significant staple food crops in India in terms of production, acreage, and consumer choice. Around 164.19 million hectares of land are used to grow rice, with yearly productivity and production totalling 3105 kg ha^{-1} and 509.87 million tonnes, respectively. With an annual yield and productivity of 118.87 million tonnes and 2641.5 kg ha^{-1}, respectively, rice is produced on over 45 million ha in India. The largest rice-producing states in India include West Bengal, Bihar, Maharashtra, Uttar Pradesh, Panjab and Haryana (FAO STAT 2020) [5].
Rice is a fantastic dish that is abundant in energy and calories. Based on mean grain yield, rice crops produce more food energy and protein per hectare than wheat and maize. Therefore, rice can feed more people on a given amount of land (Lu and Chang, 1980) [17]. Rice is without a doubt the grain that gives you the greatest energy. Due to its near-pure starch content and lack of allergies, rice flour serves as the major component in face powders and newborn formulae. For newborns with diarrhoea, rice starch can also be used in oral rehydration solutions in place of glucose. Only marginally inferior to oats (68%) but superior to whole wheat (53%) and corn (49%), rice has a protein quality of 66%. Rice, which has no cholesterol and is low in sodium and fat, can help reduce hypertension. It is also devoid of allergens and is increasingly a common ingredient in infant foods (James and McCaskill, 1983) [13]. Although it is no longer as widely utilised in the rope and paper sectors, rice straw is still a significant cattle feed throughout Asia, with the exception of newer kinds. Additionally, rice is used to make baby food, snacks, morning cereals, beer, fermented goods, rice bran oil, and rice wine, which is still a widely consumed alcoholic beverage in East Asia (Juliano, 1985) [14].

Rice is normally planted at the end of May and sowed in the first week of July. The conventional method of transplanting yields a high and steady production, but it is also a time-consuming and expensive task. Farmers are now switching to alternative techniques, such direct sowing rice, to cut expenses and challenges (Mehmood *et al*., 2002) [21]. For direct seeding of rice, the exact sowing date is crucial for enhancing growth and output. Three factors make the timing of rice crop sowing crucial. First of all, it makes sure that vegetative development occurs during a time when the temperature is favourable and there is a lot of solar radiation. Furthermore, the ideal time to plant each cultivar is when the minimum night time temperatures are typically the warmest. This guarantees that the cold-sensitive stage develops. Third, timely sowing increases the likelihood that grain filling will take place during warmer autumn temperatures, leading to high grain quality (Farrell *et al*., 2003) [6]. The date of sowing has an impact on rice seedling establishment rates as well (Tashiro *et al*., 1999) [31].

Another crucial factor that affects nutrient intake, plant growth, and productivity is spacing. The overall population declines with increasing space, but each individual plant grows better and yields more with increased nutrition, and vice versa. The number of plants and the distance between rows both affect the yield. In these concurrently conflicting impacts of the two components, there should be a point when maximum yield is anticipated, and that point should be at the optimal spacing (Tan *et al*., 2000) [30]. Plant spacing and the quantity of seedling hills^{-1} are two significant factors that could aid in boosting rice production. Numerous studies have demonstrated that closer spacing may promote mutual shading, lodging, and insect pest infestation due to greater intra-specific competition. A plant's healthiest growth is ensured by proper plant density, which makes better use of sunshine and soil nutrients (Mondal *et al*., 2013) [23]. In addition, Number of seedling hill^{-1} controls other physiological processes, including tiller development, solar radiation absorption, nutrition uptake, photosynthesis rate, and others, that eventually influence the growth and development of rice plants (Khan *et al*., 2013) [16].

Material and Methods

A study was conducted at plot number 16 B of the crop research farm at the Maya College of Agriculture and Technology in Selaqui, Dehradun (Uttarakhand), during the 2016 *kharif* season. Selaqui receives 1040.0 mm of rainfall on average throughout the course of the experimental period. Selaqui is located at 25.28° N Latitude, 81.54° E Longitude, and 410 m above mean sea level. The average temperature for the maximum and minimum is 35.34°C and 12.94°C, respectively. The experimental site's soil had a sandy-loam with adequate drainage qualities and a reaction pH of 7.93. The soil was found to have low organic carbon (0.336%) and low levels of available nitrogen (278.09 kg ha^{-1}) and medium inavailable phosphorus (18.25 kg ha^{-1}) and potassium (150.34 kg ha^{-1}). Eighteen treatments were included in the trial. These included three transplantation dates (15 July, 27 July, and 09 August), two seedling rates (1 seedling hill^{-1} and 2 seedling hill^{-1}), and three spacings (20 X 10 cm, 20 X 15 cm, and 20 X 20 cm). 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 X 10 cm, 20 X 15 cm and 20 X 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.

S. No.	Parameter	Value (unit)	Method (reference)
1.	Available nitrogen	278.09 kg ha^{-1}	Alkaline permanganate method (Subbiah and Asija, 1956)
2.	Available phosphorus	18.25 kg ha^{-1}	Olsen's method (Olsen *et al.*, 1954)
3.	Available potassium	150.34 kg ha^{-1}	Flame photometer method (Metson, 1956)
4.	Organic carbon	0.336%	Walkely and Black rapid titration method (Jackson, 1973)
5.	pH	7.93	Backman and Glass electrode (Jackson, 1973)
6.	EC	0.266 dS m^{-1}	Measured on soluble bridge in soil: water solution (1:2) (Jackson, 1967)

The tagged bundles were allowed for sun drying in field and after drying on the threshing floor, the weight of bundles was recorded for obtaining biological yield. Threshing of rice was done manually by beating panicles on the sheaf with wooden baton and then seeds were separated by winnowing and recorded grain yield as treatments wise 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 ratio of economic yield (grain yield) to the biological yield (grain + straw yield) was worked out and expressed in percentage as advocated by Donald and Hamblin (1976) [4].

$$\text{HI (\%)} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

The gross returns (□ha^{-1}) occurred due to different treatments in the present study were worked out by considering market prices of economic product and by product during the experimental year. Net returns were calculated by subtracting the total cost of cultivation from gross returns and expressed as □ha^{-1}. In order to evaluate the benefit accrued from the treatments applied, the economics of different treatments were worked out as follows in terms of net return (□ ha^{-1}) and Benefit: Cost (B:C ratio), so that most remunerative treatment could be recommended. This was calculated on treatment yield basis and prevailing market rates of inputs and outputs.

$$\text{B:C ratio} = \frac{\text{Net Returns}}{\text{Cost of cultivation}}$$

Data was statistically analyzed by following the method of analysis of variance as suggested by Gomez and Gomez (1984). Critical difference was calculated wherever "F test" was found significant at 5 percent probability level and the values were furnished.

Results and Discussion

Yield

The grain yield was significantly influenced by the different transplanting date, spacing and number of seedlings hill^{-1} (Table 1). The maximum grain yield (64.33 q ha^{-1}) was recorded with 15 July transplanted with wider spacing 20 cm x 20 cm and 2 seedling hill^{-1} sown rice crop. This might be due to early transplanting which helped to absorb nutrients and translocate the photosynthates from source to sink. Similar findings were also corroborated by Mukesh *et al*. (2013) [24], Manoj *et al*. (2013) [19] and Islam *et al*. (2014) [10]. Wider spacing and more seedlings hill^{-1} help increased the nutrient uptake efficiently which results in better translocation of photosynthates to the reproductive part and improved the yield and yield attributing characters. This result is supported with the findings given by Patra and Nayak (2001) [27], Chopra *et al*. (2006) [3] and Mahato *et al*. (2007) [18].

The maximum straw yield (80.67 q ha^{-1})of rice was recorded in treatment T_6 - 15 July + 20 x 20 cm + 2 seedling hill^{-1}, increased significantly higher as compared to rest of the treatments. This might be due to the cumulative effect of early transplanting on all the growth components like plant height, fresh and dry weight of plant as discussed earlier. Manoj *et al*. (2013) [19] concluded that early transplanted rice performed better in terms of yield, yield attributing character. Similar findings were also corroborated by Khalifa *et al*. (2014) [15]. The increased in straw yield might be due to increased in wider spacing, resulting in increased level of yield components like effective tiller, filled grain, and panicle length and the accumulation of carbohydrates in plants ultimately increased the yield attributes and increased the straw yield. Patra and Nayak (2001) [27] reported wider spacing gave significant straw yield. Similar findings were also corroborated by Gunri *et al*. (2004) [9] and Pal *et al*. (2008) [26].

Among treatments (Table 1), treatment T_6 - 15 July + 20 x 20 cm + 2 seedling hill^{-1} recorded significantly highest biological yield (145.00 q ha^{-1}) over rest of the treatments during experimentation. The biological yield is a function of grain and straw yield. These results are consistent with those mentioned by Chopra *et al*. (2006) [3].

The maximum harvest index (44.37) of rice was recorded in treatment T_6 - 15 July + 20 x 20 cm + 2 seedling hill^{-1}. Harvest index is dependent on the ability of variety or a treatment to produce more grain yield than the straw accumulation. As such, higher grain yields than the straw would account for higher harvest index. The variation in harvest index due to date of transplanting, spacing and number of seedlings hill^{-1} but, could not be increased significantly.

Economics

A brief overview of the Table 2 indicated that maximum gross returns (□ 93330 ha^{-1}), net returns (□ 42514 ha^{-1}) and B:C ratio (1.83) was recorded when crop was transplanting at 15 July and 20 x 20 cm spacing with 2 seedlings hill^{-1}. This might be due to higher yield attributes and yield. Mahato *et al*. (2007) [18] reported higher economic return due to wider spacing. These findings are in accordance with the results reported by Chaudhary *et al.* (2011) [2] and Gohil *et al.* (2016) [7]. These findings are substantiated with those reported by Singh *et al*. (1997) [28] and Maurya *et al*. (2017) [20].

Table 1: Effect of sowing date, spacing and number of seedlings on yield of hybrid rice

Treatments	Yield (q ha^{-1})			Harvest index (%)
	Grain	Straw	Biological	
T1 - 15 July + 20 x 10 cm + 1 seedling hill^{-1}	35.33	48.00	83.33	42.40
T2- 15 July + 20 x 10 cm + 2 seedling hill^{-1}	37.00	50.27	87.27	42.40
T3- 15 July + 20 x 15 cm + 1 seedling hill^{-1}	48.33	65.67	114.00	42.39
T4- 15 July + 20 x 15 cm + 2 seedling hill^{-1}	50.67	68.55	119.22	42.50
T5- 15 July + 20 x 20 cm + 1 seedling hill^{-1}	60.27	79.27	139.54	43.19
T6- 15 July + 20 x 20 cm + 2 seedling hill^{-1}	64.33	80.67	145.00	44.37
T7- 27 July + 20 x 10 cm + 1 seedling hill^{-1}	32.67	44.33	77.00	42.43
T8- 27 July + 20 x 10 cm + 2 seedling hill^{-1}	34.00	46.27	80.27	42.36
T9- 27 July + 20 x 15 cm + 1 seedling hill^{-1}	43.67	59.33	103.00	42.40
T10- 27 July + 20 x 15 cm + 2 seedling hill^{-1}	46.17	62.77	108.94	42.38
T11- 27 July + 20 x 20 cm + 1 seedling hill^{-1}	56.17	75.44	131.61	42.68
T12- 15 July + 20 x 20 cm + 2 seedling hill^{-1}	58.33	76.27	134.60	43.34
T13- 09August + 20 x 10 cm + 1 seedling hill^{-1}	28.55	41.67	70.22	40.66
T14- 09 August + 20 x 10 cm + 2 seedling hill^{-1}	30.27	42.27	72.54	41.73
T15- 09 August + 20 x 15 cm + 1 seedling hill^{-1}	38.67	52.55	91.22	42.39
T16- 09 August + 20 x 15 cm + 2 seedling hill^{-1}	41.77	56.77	98.54	42.39
T17- 09 August + 20 x 20 cm + 1 seedling hill^{-1}	52.27	71.67	123.94	42.17
T18- 09 August + 20 x 20 cm + 2 seedling hill^{-1}	54.67	74.33	129.00	42.38
S.Ed.	0.32	0.20	0.52	0.35
CD (P=0.05)	0.64	0.40	1.04	-

Table 2: Effect of sowing date, spacing and number of seedlings on economics of hybrid rice

Treatments	Gross returns (□ ha^{-1})	Cost of cultivation (□ ha^{-1})	Net returns (□ ha^{-1})	B:C ratio
T1 - 15 July + 20 x 10 cm + 1 seedling hill^{-1}	63996	50754	13245	1.26
T2 - 15 July + 20 x 10 cm + 2 seedling hill^{-1}	66454	54022	12431	1.23
T3 - 15 July + 20 x 15 cm + 1 seedling hill^{-1}	71130	49618	21512	1.43
T4 - 15 July + 20 x 15 cm + 2 seedling hill^{-1}	74514	52248	22266	1.42
T5 - 15 July + 20 x 20 cm + 1 seedling hill^{-1}	88178	48637	39540	1.81

T6 - 15 July + 20 x 20 cm + 2 seedling hill^{-1}	93330	50816	42514	1.83
T7 - 27 July + 20 x 10 cm + 1 seedling hill^{-1}	60070	50754	9316	1.18
T8 - 27 July + 20 x 10 cm + 2 seedling hill^{-1}	62054	54022	8031	1.14
T9 - 27 July + 20 x 15 cm + 1 seedling hill^{-1}	64270	49618	14652	1.29
T10 - 27 July + 20 x 15 cm + 2 seedling hill^{-1}	67958	52248	15710	1.30
T11 - 27 July + 20 x 20 cm + 1 seedling hill^{-1}	82492	48637	33854	1.69
T12 - 15 July + 20 x 20 cm + 2 seedling hill^{-1}	85250	50816	34434	1.67
T13 - 09 August + 20 x 10 cm + 1 seedling hill^{-1}	54594	50754	3840	1.07
T14 - 09 August + 20 x 10 cm + 2 seedling hill^{-1}	56778	54022	2755	1.05
T15 - 09 August + 20 x 15 cm + 1 seedling hill^{-1}	68914	49618	19296	1.38
T16 - 09 August + 20 x 15 cm + 2 seedling hill^{-1}	61478	52248	9230	1.17
T17 - 09 August + 20 x 20 cm + 1 seedling hill^{-1}	82058	48637	33420	1.68
T18 - 09 August + 20 x 20 cm + 2 seedling hill^{-1}	80470	50816	29653	1.58

Conclusion

From the experiment, it is concluded that the optimum sowing date for transplanting of hybrid rice variety Arize-6444 is 15 July and 20 x 20 cm spacing with 2 seedlings hill^{-1} for getting maximum yield and returns (gross, net income and B:C ratio**)**, while delay in transplanting after 15 July reduce the yield gradually.

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