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Effect of age of seedlings and planting geometry on growth of rice (*Oryza sativa* L.)

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Abstract
The present investigation entitled was conducted at Agronomy Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during *Kharif* season of 2019. The experiment was laid out in split plot design with three replications keeping three age of seedlings *viz*., three weeks old seedlings, four weeks old seedlings and five weeks old seedlings in main plots and four planting geometries 20 cm x 10 cm, 25 cm x 10 cm, 20 cm x 15 cm and 25 cm x 15 cm in sub plots. Result revealed that there was significant variation among different time of transplanting in respect of growth. Growth parameters as plant height (cm), number of tiller (m^{-2}), dry matter accumulation (g) and leaf area index were higher in paddy transplanted in three weeks old seedlings as compared to rest of the age of seedlings. Planting geometry of 20 cm x 10 cm was recorded superior in respect of growth over rest of the planting geometry.

Keywords: Genetic combining ability, specific combining ability, okra, variance, growth, yield and quality

Introduction
Rice (*Oryza sativa* L.) is one of the most important food grain crops of more than 60 % of the world's population. About 90 % of all rice grown in the world is produced and consumed in the Asian region. It is the world's leading food crop in terms of area and production. The maximum area under rice is in Asia. India ranks first in area and second in production of rice after China. In India, it is grown over an area of 43.79 million hectares having production of 112.91 million tonnes and average productivity of 2578 kg ha-1. Rice contributes 43% of total food grain production and 46 % of the total cereal production of the country. In India, Uttar Pradesh is an important rice growing state. The area and production of rice in the state is about 5.95 million hectares and 13.27 million tonnes respectively with productivity of 2230 kg ha-1 (Anonymous, 2018) [1].

Age of seedlings at transplanting is an important factor for uniform stand of rice (Paddalia, 1980) [8] and regulating its growth (Bassi *et al.*, 1994) [2]. When seedlings stay for a longer period of time in the nursery beds, the primary tiller buds on the lower nodes of the main culm become degenerated leading to reduced tiller production (Mobasser *et al.*, 2007) [5]. Also, early transplantation allows better plant growth with short phyllochrons interval due to less transplanting shock. This short phyllochrons interval facilitates more number of tillers produced per hill as two phyllochrons produces another tiller later under favorable growing conditions (Singh *et al.*, 2009) [12]. When rice seedlings are transplanted at the right time in terms of age, tillering and growth precede normally but late transplanting results in lower tiller number during vegetative growth (Mobasser *et al.*, 2007) [5].

Crop geometry plays a significant role for optimization of rice yield due to efficient utilization of solar radiation as well as nutrients in rice (Siddiqui *et al.*, 1999) [10]. Closer spacing hampers intercultural operations and as such more competition arises among the plants for nutrients, air and light as a result, plant becomes weaker and thinner producing lower yield. The plant geometry and spatial configuration exploit the initial vigor of the genotypes with enhanced soil aeration creating congenial condition for better establishment (Shukla *et al.*, 1996) [13]. In view of the above observations a field experiment was conducted to find out the effect of age of seedlings and planting geometry on growth of rice (*Oryza sativa* L.)

Materials and Methods
The experiment was conducted at Agronomy Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during *Kharif* season

of 2019. It was laid out in split plot design with three replications keeping three age of seedlings *viz*., three weeks old seedlings, four weeks old seedlings and five weeks old seedlings in main plots and four planting geometries 20 cm x 10 cm, 25 cm x 10 cm, 20 cm x 15 cm and 20 cm x 15 cm in sub plots. Land preparation was started after commencement of monsoon or in case of late monsoon pre-sowing irrigation was applied in the experimental field. One deep ploughing was done by disc plough followed by two ploughing by tractor drawn cultivator and planking was done after each ploughing and then layout was done. A common procedure was followed in raising seedlings in the seedbed. Area of 1/10th required for paddy nursery to transplant one hectare land. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when necessary. Nursery bed was fertilized with recommended dose of fertilizer (120:60:40). Half N, full P and K applied as basal at last harrowing before puddling and half N was top dressed at 15 day after sowing the nursery. Healthy and bold seeds of rice variety NDR-2064 was sown for nursery and transplanted as per treatment. The moisture was maintained in the seedbed properly two to three day interval, which ensured proper growth of all the seedlings in the seedbed. Half dose of nitrogen, total phosphorus and potash were applied as basal application before puddling and incorporated in the top 15 cm soil. Remaining dose of nitrogen was applied as top dressing in two equal splits each at tillering and panicle initiation stages, respectively. The crop was harvested manually by serrated edged sickles at physiological maturity when panicles had about 85% ripened and upper portion of panicles look straw colored. At the time of harvesting the grains were subjected to hard enough, having less than 16% moisture in the grains. The harvesting of net plot area was done separately and the harvested material from each plot was carefully bundled and tagged after drying for three days in the field and then brought to the threshing floor. Threshing of each bundle of individual plot was done manually by wooden sticks.

Result and Discussion

The data pertaining to growth characters namely plant height (cm), number of tiller (m^{-2}), dry matter accumulation (g) and leaf area index has been presented in Table-1, Table-2, Table-3 and Table-4 respectively.

Effect of age of seedlings at transplanting

Table 1: Plant height (cm) of rice as influenced by different treatments

Treatments	Plant height (cm)			
	30 DAT	**60 DAT**	**90 DAT**	**At harvest**
Age of seedlings				
Three weeks old seedlings	41.50	77.35	92.80	92.48
Four weeks old seedlings	42.78	74.00	88.80	89.70
Five weeks old seedlings	43.63	70.30	84.35	85.20
S.Em±	1.184	1.317	1.442	1.432
C.D. at 5%	NS	3.336	3.653	3.628
Planting geometry				
20 cm x 10 cm	46.23	79.87	95.83	96.83
25 cm x 10 cm	41.07	71.87	86.23	87.10
20 cm x 15 cm	44.17	75.90	91.07	91.97
25 cm x 15 cm	39.07	67.90	81.47	80.60
S.Em ±	0.886	1.275	1.420	1.432
C.D. at 5%	NS	2.774	3.089	3.626

Table 2: Number of tillers (m^{-2}) of rice as influenced by different treatments

Treatments		Number of tillers (m^{-2})		
	30 DAT	**60 DAT**	**90 DAT**	**At harvest**
Age of seedlings				
Three weeks old seedlings	147.40	266.62	286.44	290.89
Four weeks old seedlings	153.99	261.81	284.99	288.32
Five weeks old seedlings	149.19	255.59	273.94	281.90
S.Em ±	1.640	2.390	2.673	2.744
C.D. at 5%	NS	6.046	6.762	5.954
Planting geometry				
20 cm x 10 cm	166.44	256.40	298.14	283.94
25 cm x 10 cm	147.84	253.18	294.95	279.76
20 cm x 15 cm	159.18	251.85	276.84	276.90
25 cm x 15 cm	140.67	252.93	259.22	246.88
S.Em ±	1.211	2.359	2.876	2.674
C.D. at 5%	NS	5.119	6.240	5.802

Table 3: Dry matter accumulation (gm^{-2}) of rice as influenced by different treatments

Treatments	Dry matter accumulation (gm^{-2})			
	30 DAT	**60 DAT**	**90 DAT**	**At harvest**
Age of seedlings				
Three weeks old seedlings	261.00	961.82	1118.39	1096.46
Four weeks old seedlings	256.65	940.33	1093.40	1071.96
Five weeks old seedlings	249.75	870.31	1012.94	992.15
S.Em ±	3.107	16.736	25.148	15.702
C.D. at 5%	6.742	42.397	63.705	39.77
Planting geometry				
20 cm x 10 cm	277.40	1036.41	1206.40	1181.50
25 cm x 10 cm	265.40	951.12	1105.37	1084.17
20 cm x 15 cm	246.00	886.14	1030.98	1010.29
25 cm x 15 cm	232.40	822.93	956.90	938.14
S.Em ±	5.318	15.825	19.971	15.702
C.D. at 5%	11.567	34.421	43.438	33.55

Table 4: Leaf area index of rice as influenced by different treatments

Treatments	Leaf area index		
	30 DAT	**60 DAT**	**90 DAT**
Age of seedlings			
Three weeks old seedlings	2.42	5.40	5.51
Four weeks old seedlings	2.37	5.13	5.24
Five weeks old seedlings	2.32	4.68	4.77
S.Em ±	0.063	0.134	0.117
C.D. at 5%	NS	0.339	0.255
Planting geometry			
20 cm x 10 cm	2.52	5.53	5.64
25 cm x 10 cm	2.40	5.26	5.36
20 cm x 15 cm	2.31	4.88	4.98
25 cm x 15 cm	2.25	4.60	4.69
S.Em ±	0.050	0.113	0.117
C.D. at 5%	0.109	0.245	0.255

All the growth observations were significantly influenced by the treatments of age of seedlings at transplanting. Regarding plant height, three weeks old seedlings recorded significantly more plant height than four weeks old seedlings and five weeks old seedlings during the entire life span of the crop (Table 1). In this case the three weeks old seedlings days might have established themselves earlier as they have received comparatively less damage to the root system of the seedlings. However, with increase in the age of seedlings the root system gets expanded and that causes more damage to the root system due to uprooting and therefore it takes longer time for establishment. This findings are in line with those reported by Singh *et al.* (2012) [11].

Regarding number of tillers (m^{-2}), the three weeks old seedlings was recorded significantly highest number of tillers (m^{-2}) which was at par with the four weeks old seedlings while significantly superior over the five weeks old seedlings (Table 2). This can be attributed to the fact that the trauma of root damage received during uprooting and transplanting of the seedlings was comparatively less under young seedlings (three weeks old seedlings) than rest of age of seedlings. Similar observations were reported by Chaudhari *et al.* (2015) [3].

Dry matter accumulation is an important growth observation which indicates general performance of the crop. In the present investigation on the basis of dry matter production (Table 3) the age of seedlings treatments can be arranged in the following descending order of significance i.e. Three weeks old seedlings > four weeks old seedlings > five weeks old seedlings. Here the young seedlings established earlier, could have developed good root system earlier which have resulted in more leaf area under three weeks old seedlings followed by four weeks old seedlings and five weeks old seedlings in the order of significance. The higher leaf are available under three weeks old seedlings made it possible for the crop to trap more sunlight and assimilate more CO_2 to produce higher photosynthesis than four weeks old seedlings and five weeks old seedlings. Therefore, the dry matter production was significantly higher under three weeks old seedlings followed by four weeks old seedlings and five weeks old seedlings in the order of significance. Kumar *et al.* (2002) [4] reported the similar results.

Further the leaf area index (Table 4 were significantly higher under three weeks old seedlings which was at par with four weeks old seedlings while significantly superior over five weeks old seedlings. This may be due to the early establishment of the seedlings when they are transplanted at early age i.e. three weeks old seedlings. Because of that the seedling transplanted at early age i.e. three weeks old seedlings might have developed better root growth. These results are in line with those reported by Upadhyay *et al.* (2008) [14].

Effect of planting geometry

In the present investigation, plant population per unit area was significantly higher under A_1 (20 cm x 10 cm) than rest of the planting geometry. This itself indicated that the inter plant competition was more under 20 cm x 10 cm than 25 cm x 10 cm, 20 cm x 15 cm and 25 cm x 15 cm which is evident from the production of significantly taller plants under 20 cm x 10 cm due to more competition than the broader spacing (Table 1). Similar findings were reported by Om *et al.* (1993) [7].

Further, in respect of other growth attributes such as number of tillers (m^{-2}), dry matter production (gm^{-2}) and leaf area index, was recorded significantly higher with 20 cm x 10 cm over rest of planting geometry. This might be due to the availability of more plant for utilize resources such as solar energy, air movement and availability of more nutrients from the larger area. Similar findings related to dry matter were reported by Nayak *et al.* (2003) [6].

The number of tillers was significantly higher in planting geometry of 20 cm x 10 cm than rest of the planting geometry (Table 2). This might be due to the plant population of rice under 20 cm x 10 cm was more than rest of the planting geometry. These findings are in confirmation with those reported by Pol *et al.* (2005), Rasool *et al.* (2013) [9].

The higher dry matter accumulation under 20 cm x 10 cm than rest of the planting geometry clearly indicated that the growth of rice under 20 cm x 10 cm was better than 25 cm x 10 cm, 20 cm x 15 cm and 25 cm x 15 cm (Table 3). This is clear from production of significantly higher number of functional leaves (m^{-2}) and number of tillers (m^{-2}) under 20 cm x 10 cm than rest of the planting geometry. Similar results were reported by Verma *et al.* (2002) [15] and Nayak *et al.* (2003) [6].

Further, in respect of leaf area index (20 cm x 10 cm) was recorded significantly higher over rest of planting geometry a(Table 3). This might be due to the availability of more plant for utilize resources such as solar energy, air movement and availability of more nutrients from the larger area. Similar findings related to dry matter were reported by Nayak *et al.* (2003) [6] and Pol (2003).

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