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Growth and yield response of rice (*Oryza sativa* L.) to different seedling ages and planting geometry

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Abstract

A field experiment was conducted on Growth and yield response of Rice (*Oryza sativa* L.) to different seedling ages and planting geometry during *kharif* season, 2025 at the Crop Research Farm, Department of Agronomy with 25.40° N latitude, 81.85° E longitude, and 112.05 m above mean sea level at SHUATS, Prayagraj, U.P. The soil of the experimental plot was sandy loam in texture, had a pH of 7.8, contained 0.72 percent organic carbon, and had 178.48 kg of nitrogen, 27 kg of phosphorus, and 233 kg of potassium available per hectare. The experiment was laid out in Randomized Block Design with nine treatments which are replicated thrice. The results revealed that significantly higher growth attributes of Rice at 100 DAS viz., plant height (115.5 cm), number of tillers/plant (26.13), dry weight (73.89 g) and yield attributes i.e., number of effective tillers/plant (19.67), number of grain/panicles (42.09), test weight (21.11 g) higher grain yield (7.29 t/ha) and stover yield (13.57 t/ha) were recorded in treatment-9 (24 Days of seedling along with 30 cm x 10 cm) compared to other treatments. And maximum gross return (INR 1,71,660.08/ha), net return (INR 1,20,314.08/ha) and B:C ratio (2.34) were also recorded in the same treatment.

Keywords: Growth, economics, spacing, seedlings, rice and yield

Introduction

Rice (*Oryza sativa* L.) is the most crucial cereal food crop of India, which occupies about 24% of gross cropped area of the country. It contributes 42% of total food grain production and 45% of total cereal production of the country. India has a long history of Rice cultivation and stands first in Rice area and second in Rice production, after China (Yadav *et al.* 2010) [22]. Rice plants have been traced back to 5000 BC, but the practice of Rice growing is believed to have originated in areas of China, and southern & eastern Asia, in about 2000 BC. Rice cultivation is considered to have begun simultaneously in many countries over 6500 years ago. Most believe the roots of Rice come from 3000 BC India, where natives discovered the plant growing in the wild began to experiment with it. The UN/FAO forecasts that global food production will need to increase by over 40% by 2030 and 70% by 2050 (FAO, 2009) [5]. Thus, Rice production in India as well as in several other Asian countries must be doubled by the year 2025 to meet the requirement of the increasing population.

India is major Rice growing country in world with an area of 407.34 lakh hectares, having production 1132.59.79 lakh tones and productivity of 2780 kg/ha (DES 2023-24) [2]. In Uttar Pradesh 57.32 lakh ha and production 158.65 lakh tones with an average productivity of 2768 kg/ha (DES 2023-24) [2]. Rice is the most crucial cereal food crop of India, which occupies about 24% of gross cropped area of the country. It contributes 42% of total food grain production and 45% of total cereal production of the country. India (2010) yield of Rice was 120.62 MT 44 M ha followed by China (197.21 MT) and in year 2025-25 the Area, Production, Productivity in Uttar Pradesh and India was 5.73 million ha., 15.86 million tones, 2768 kg/ha and 40.73 million Hectares, 11.32 million tones, 2780 kg/ha respectively (DES 2023-24) [2].

Age of seedlings at transplanting is an important factor for uniform stand of Rice (Paddalia 1980) [13] and regulating its growth and yield (Bassi *et al.* 1994) [3]. Tillering is an important agronomic trait which finally determines the number of panicles, grains and grain yield per unit land area (Li *et al.* 2003) [9]. Tillering dynamics of the Rice plant greatly depends on the age of seedlings at transplanting (Pasuquin *et al.* 2008) [14].

For optimum yield, age of seedlings at transplanting of a suitable variety at a particular season may not be suitable for other varieties at another season. The use of over aged seedling ultimately affects the general performance of crop and the yield of the crop reduces drastically. So, it is very important to find out the optimum age of seedlings of a variety for a particular season. 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) ^[10]. Also, early transplantation allows better plant growth with short phyllochrons interval due to less transplanting shock. This short phyllochrons interval facilitates a greater number of tillers produced per hill as two phyllochrons produces another tiller later under favorable growing conditions (Singh *et al.* 2012) ^[20]. 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) ^[10].

Spacing in Rice cultivation is crucial for optimizing yield and resource utilization. Proper spacing ensures adequate access to sunlight, nutrients, and water, promoting vigorous growth and tillering. It also facilitates efficient weed control and allows for better air circulation, reducing the risk of diseases. Additionally, optimal spacing enables easy management practices such as irrigation and fertilization, leading to uniform crop development and higher yields. Hence, the effect of seedling ages and plant geometry along with recommended doses of fertilizers significantly improves the growth parameters (plant height, tillers, Dry weight) and yield attributes (No of seed/panicles, grain yield) of Rice, resulting in higher tillers/plant which is affected by plant geometry and fertilizers nutrients increases in grain and Stover yield. Keeping all these facts in view, the present investigation entitled "Growth and yield response of Rice (*Oryza sativa* L.) to different seedling ages and planting geometry" was conducted.

Materials and Methods

An experiment was conducted during the *Kharif* season of 2025. It was conducted in alluvial soil at the Department of Agronomy. The experiments were carried out at Crop Research Farm, Department of Agronomy, NAI, SHUATS, Prayagraj, U.P. At a depth of 0-30 cm, a composite soil sample was taken. It underwent crushing, air drying, and physical and chemical testing. The soil of the experimental plot was sandy loam in texture, had a pH of 7.8, contained 0.72 percent organic carbon, and had 178.48 kg of nitrogen, 27 kg of phosphorus, and 233 kg of potassium available per hectare. The experiment was laid out in Randomized Block Design with nine treatments which are replicated thrice. *Viz.*, T₁: 12 Days of Seedling + 20 cm x 10 cm, T₂: 12 Days of Seedling + 25 cm x 10 cm, T₃: 12 Days of Seedling + 30 cm x 10 cm, T₄: 18 Days of Seedling + 20 cm x 10 cm, T₅: 18 Days of Seedling + 25 cm x 10 cm, T₆: 18 Days of Seedling + 30 cm x 10 cm, T₇: 24 Days of Seedling + 20 cm x 10 cm, T₈: 24 Days of Seedling + 25 cm x 10 cm, T₉: 24 Days of seedling + 30 cm x 10 cm. To apply nutrients as a spreading method, 4-5 cm deep furrows were dug along the seed rows using a hand hoeing. Ten days after sowing, the gaps were filled by transplanting nursery. In order to reduce crop density, weed competition, intercultural operations were carried out between 25-and 45-days intervals. At regular intervals from germination to harvest, plant growth parameters such as plant height (cm), number of tillers/hill,

dry weight (g/plant), CGR and RGR were assessed. Whereas, at harvest, yield metrics such as effective tillers/hills, number of grains/Panicles, test weight (g), grain yield (t/ha), straw yield (t/ha), and harvest index (%) were measured after harvesting. Whereas, Economics analysis *i.e.*, cost of cultivation, gross return, net return and benefit cost ratio was observed. Analysis of variance (ANOVA), as it relates to randomized block design, was used to statistically examine the observed data of ten treatments (Gomez and Gomez, 1984 and Mohan *et al.* 2024) ^[7, 11].

Results and Discussions

Growth parameter

The data of growth parameter are presented in Table 1. Significantly highest plant height (115.39 cm) was recorded in treatment-9 (24 Days of seedling + 30 cm x 10 cm). However, treatment-8 (24 Days of seedling + 25 cm x 10 cm) were shown statistically at par with treatment-9 (24 Days of seedling + 30 cm x 10 cm). This might be due to seedling effect which might increase the early growth and development of seedlings. The results obtained that among Rice in respect of other growth attributes such as plant height was recorded significantly higher with (30 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 plant dry weight were reported Pol (2003) ^[16] and Rasool *et al.* (2013) ^[18]. Hence, in this treatment significant higher number of tillers/hill was recorded (26.13) was recorded with treatment-9 (24 Days of seedling + 25 cm x 10 cm). However, treatment-7 (24 Days of seedling + 20 cm x 10 cm) which was statistically at par with highest. The probable reason for this result was attributed to higher plant tillers/hill recorded in this treatment. Age of seedling encourage the growth and development of roots, which improve nutrient uptake and shoot development. The results obtained that among Rice number of tillers to the fact that the trauma of root damage received during uprooting and transplanting of the seedlings was comparatively less under young seedlings than rest of age of seedlings. The results obtained that among Rice in respect of other growth attributes such as tillers was recorded significantly higher with (30 cm x 10 cm) over rest of planting geometry. Similar observations were reported by Aggarwal and Singh (2015) ^[1]. Further growth attributes such as number of tillers/m², was recorded significantly higher with (30 cm x 10 cm) over rest of planting geometry were reported by Nayak *et al.*, (2003) ^[12]. Whereas, significant higher plant dry weight was recorded (73.89 g/hill) was recorded in treatment-9 (24 Days of Seedling + 30 cm x 10 cm). The results obtained that among Rice in respect of the dry matter production was significantly higher under in the order of significance. Kumar *et al.*, (2002) ^[8] and Aggarwal and Singh (2015) ^[1] reported the similar results. Further results revealed that among Rice in respect of other growth attributes such as dry matter was recorded significantly higher with (30 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 Pawar (2017) ^[15]. Significantly showed effect on maximum diameter might be due to rapid photosynthetic rate by more leaf area exposed to sunlight that helped accumulation of dry matter in plant crop geometry. Similar results were reported by Ghuraiya *et al.* (2021) ^[6].

Yield attributes

The data pertaining to yield-attributing characters are presented in Table 2. The maximum number of effective tiller/hill at the time of harvest (19.67) was recorded in treatment-9 (24 Days of seedling + 30 cm x 10 cm) which was superior over all other treatments. The significant and higher number of effective tillers/hill attributed to the fact that the trauma of root damage received during uprooting and transplanting of the seedlings was comparatively less under young seedlings (24 days old) than the older seedlings. Pramanik and Bera (2013) ^[17]. 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 Pol (2003) ^[16] and Rasool *et al.* (2013) ^[18]. Significantly higher number of grains/panicles (42.09) was recorded in treatment-9 (24 Days of seedling + 30 cm x 10 cm) which was superior over all other treatments. Whereas, highest test weight (21.11 g) was recorded in treatment-9 (24 Days of seedling + 30 cm x 10 cm). The significant and higher number of grains/panicle attributed to the fact that the trauma of root damage received during uprooting and transplanting of the seedlings was comparatively less under young seedlings (24 days old) than the older seedlings. Vishwakarma *et al.*, (2015) ^[21] reported similar results. Further the results revealed that among Rice in respect of other Seed/Panicle such as plant height was recorded significantly higher with (30 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 grain/panicles were reported Pol (2003) ^[16] and Rasool *et al.*, (2013) ^[18].

Grain yield (t/ha)

The statistical data in Table 2 showed that significantly highest grain yield was recorded significantly maximum grain yield (7.29 t/ha) which was superior over all other treatments. The significant and higher grain yield attributed to the fact that the trauma of root damage received during uprooting and transplanting of the seedlings was comparatively less under young seedlings (24 days old) than the older seedlings was similar to Vishwakarma *et al.* (2015) ^[21] reported similar results. Further the results revealed that among Rice in respect of other seed yield such as plant height was recorded significantly higher with (30 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 Chaudhari *et al.* (2015) ^[4].

Straw Yields (t/ha)

The data in Table 2 showed that a significantly maximum stover yield (significantly maximum Straw yield (13.57 t/ha) which was superior over all other treatments. significant and higher straw yield attributed to the fact that the trauma of root damage received during uprooting and transplanting of the seedlings was comparatively less under young seedlings (24 days old) than the older seedlings. Chaudhari *et al.*, (2015) ^[4] and Vishwakarma *et al.*, (2015) ^[21] reported similar results. Further the results revealed that among Rice in respect of other straw yield such as plant height was recorded significantly higher with (30 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 Pol (2003) ^[16] and Rasool *et al.*, (2013) ^[18].

Harvest index (%)

Data presented in table 2. showed at the time of harvest, highest harvest index (39.77%) was recorded in treatment (18 Days of Seedling + 25 cm x 10 cm), though there was no significant difference among the treatments.

Economics

In Table 3. Data pertaining to economics of growing as effect of different age of seedlings and planting geometry on Rice has been exhibited. The common and variable cost of production has been given in table 3.

The economics of growing as effect of different age of seedlings and planting geometry on Rice which shows the highest Gross return (INR 171660.08/ha) was found in the treatment-9 with (24 Days of Seedling + 30 cm x 10 cm) as compared to other treatments. And Maximum net return (INR 120314.08/ha) was found in the treatment-9 with (24 Days of Seedling + 30 cm x 10 cm) as compared to other treatments. Whereas, Benefit cost ratio (2.34) was shown highest in treatment-9 (24 Days of Seedling + 30 cm x 10 cm) and minimum benefit cost ratio (1.63) was shown in treatment-1 (12 Days of Seedling + 20 cm x 10 cm) as compared to other treatments. Higher benefit cost ratio was recorded with the application of different age of seedlings and planting geometry might be due to higher grain and stover yield which resulted in increases the gross return, ultimately increases the benefit ratio. Similar result was recorded by Rasool *et al.*, (2013) ^[18].

Table 1: Effect of Seedling ages and Plant geometry on growth attributes of Rice.

S. No.	Treatments	Plant height (cm)	Number of tillers/hills	Dry weight (g/hill)
		100 DAS	100 DAS	100 DAS
1	12 Days of Seedling + 20 cm x 10 cm	102.30	18.60	62.01
2	12 Days of Seedling + 25 cm x 10 cm	101.35	20.06	56.75
3	12 Days of Seedling + 30 cm x 10 cm	104.89	20.13	59.91
4	18 Days of seedling + 20 cm x 10 cm	108.83	21.06	60.11
5	18 Days of seedling + 25 cm x 10 cm	112.93	20.40	64.81
6	18 Days of seedling + 30 cm x 10 cm	105.47	20.00	60.26
7	24 Days of seedling + 20 cm x 10 cm	114.96	24.93	56.89
8	24 Days of seedling + 25 cm x 10 cm	111.55	25.33	64.55
9	24 Days of seedling + 30 cm x 10 cm	115.39	26.13	73.89
F-test		S	S	S
SEm(+)		2.50	1.52	4.26
CD (P = 0.05)		7.51	4.57	12.78

Table 2: Effect of Seedling ages and Plant geometry on yield attribute and yield of Rice.

S. No.	Treatment combinations	Yield attribute and yield					
		No. of effective tillers/plant	No. of Grains/Panicle	Test weight (g)	Seed yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
1.	12 Days of Seedling + 20 cm x 10 cm	15.00	32.14	18.57	5.81	9.73	37.47
2.	12 Days of Seedling + 25 cm x 10 cm	15.47	32.92	19.72	6.04	8.87	39.77
3.	12 Days of Seedling + 30 cm x 10 cm	16.47	33.40	17.67	6.82	10.79	38.80
4.	18 Days of seedling + 20 cm x 10 cm	16.93	33.89	18.29	6.61	11.75	35.98
5.	18 Days of seedling + 25 cm x 10 cm	17.40	35.49	20.46	6.30	10.69	37.40
6.	18 Days of seedling + 30 cm x 10 cm	17.20	37.02	19.22	6.87	12.90	35.26
7.	24 Days of seedling + 20 cm x 10 cm	18.67	37.79	20.50	6.83	12.60	35.37
8.	24 Days of seedling + 25 cm x 10 cm	18.40	39.79	18.96	7.09	13.19	35.00
9.	24 Days of seedling + 30 cm x 10 cm	19.67	42.09	21.11	7.29	13.57	34.95
	F-test	S	S	NS	S	S	NS
	SEm ($\pm$)	0.68	1.14	0.73	0.28	0.66	1.99
	CD (p = 0.05)	2.05	3.44	-	0.85	1.98	-

Table 3: Effect of Seedling ages and Planting geometry on economics of Rice.

S. No.	Treatment combination	Economics			
		Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	12 Days of Seedling + 20 cm x 10 cm	51,346.00	135158.50	83812.50	1.63
2.	12 Days of Seedling + 25 cm x 10 cm	51,346.00	138632.00	87286.00	1.70
3.	12 Days of Seedling + 30 cm x 10 cm	51,346.00	157629.83	106283.83	2.07
4.	18 Days of seedling + 20 cm x 10 cm	51,346.00	152681.50	101335.50	1.97
5.	18 Days of seedling + 25 cm x 10 cm	51,346.00	145794.83	94448.83	1.84
6.	18 Days of seedling + 30 cm x 10 cm	51,346.00	161828.33	110482.33	2.15
7.	24 Days of seedling + 20 cm x 10 cm	51,346.00	160685.67	109339.67	2.13
8.	24 Days of seedling + 25 cm x 10 cm	51,346.00	166830.33	115484.33	2.25
9.	24 Days of seedling + 30 cm x 10 cm	51,346.00	171660.08	120314.08	2.34

Conclusion

From the results, it is concluded that application of 24 Days age of seedling along with 30 cm x 10 cm in treatment-9 in Rice has recorded highest grain yield, net return and benefit cost ratio.

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