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Effect of crop geometry (Spacing) and varieties on growth and yield of rice (*Oryza sativa*) Prayagraj region

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Abstract
The research work was conducted at the Agronomy Research Field, United University, Prayagraj (U.P.) during *Kharif* season from June to December, 2023 to study the effect of spacing and varieties on the growth and yield of Rice (*Oryza sativa*). The experiment consisted of three spacing treatments *viz.* 15 x 15 cm, 20 x 20 cm and 25 x 25 cm and for varieties *viz.* Sonam, Vishnu-Bhog, Kalanamak and Basmati-1718. The experiment was laid out in randomized block design with three replications. The highest plant height (94.01 cm) was recorded T_3 (spacing 15 x 15 cm with Basmati-1718). While Number of tiller/hill (19.27), Plant dry weight (89.26 g/plant), Yield attributes, No. of panicle/hill (274.59), panicle length (32.45 cm), No. of grain/panicle (220.68), and Test weight (24.23 g) was recorded in treatment T_{12} (Spacing 25 x 25 cm + Basmati-1718) while highest Seed yield (4.20 t/ha), Straw yield (15.19 t/ha) was recorded in treatment T_{12} (Spacing 25 x 25 cm + Basmati-1718) of rice. The highest economics was computed under treatment T_{12} (Spacing 25 x 25 cm + Basmati-1718) i.e. cost of cultivation (39598.36 Rs/ha), gross return (133521.63 Rs/ha), net return (93923.27 Rs/ha), highest and B:C ratio (2.32). The lowest plant height (94.01 cm), Number of tiller/hill (13.43), Plant dry weight (74.86 g/plant), Yield attributes, No. of panicle/hill (15.11), panicle length (25.55 cm), No. of grain/panicle (199.23), Test weight (23.27 g), Seed yield (3.85 t/ha), Straw yield (10.81t/ha) rice. The lowest net return was computed under T_1 (Control) and net return (70306.16 Rs/ha), gross return (110704.52 Rs/ha), lowest cost of cultivation (39598.36 Rs/ha) recorded in T_{10} (B:C ratio) (1.82) Therefore, T_1 (spacing 15 x 15 cm with Sonam Rice) obtaining the highest grain and straw yields of rice.

Keywords: Rice, spacing, varieties, growth and yield

Introduction
Rice (*Oryza sativa* L.) is one of the important staple foods for more than 50% of the world's population providing major source of the food energy. Rice is the crop of Poaceae family. Chromosome number of rice is 2n=24. It is grown in 114 countries across the world on an area of 161 million hectares with annual production of 678.7 million tons.

The option of intensifying the area under rice in the near future is limited. It is one of the most important cereal crops of Nepalese agriculture and economy. (Mahato and Adhikari 2017) [7]. According to USDA (United State Department of Agriculture). Nutritional value of rice in per hundred gram. Calories- 242 g, Fat- 0.4 g, Carbohydrate- 53.4 g, Fiber- 0.6 g, Protein- 4.4 g, Manganese- 0.7g, Iron- 2.7 mg, Thiamin-
0.3 mg.In India, West Bengal is top producing state followed by Uttar Pradesh, Punjab and Orissa. In India, it is grown over an area of 43.90 million hectares having production of 114.45 million tones with average yield of 2607 kg/ha. In Uttar Pradesh, it is grown on 5.70 million hectares area with production of 11.72 million tones and yield of 2679 kg/ha. Department of Planting geometry of a crop affects the interception of solar radiation, crop canopy coverage, dry matter accumulation and crop growth rate. The closer planting geometry causes competition among plants for light, water, and nutrients which consequently slow down growth as well as the grain yield. Optimum planting geometry ensures the proper growth of aerial as well as underground plant parts by efficient utilization of solar radiation, nutrients and water.

Similarly, the tillering habit and formation of spikelet per panicle also influenced by the planting geometry, which is responsible for the yield of rice per unit area. So the planting geometry and plant spacing should be optimized by keeping in mind different aspects of cropping management techniques. Hence, this study aim was carried out to investigate the influence of different planting geometry on growth of drought tolerant rice varieties. (Mahato and Adhikari 2017) [7].

Sonam-It is a kind of hybrid variety. Hybrid varieties are normally high tillering, nitrogen responsive and high yielding varieties. The Indian council of Agricultural Research (ICAR), New Delhi initiated the hybrid rice research in India during the year 1989. Sonam is a fine-grained rice variety developed by Ankur seeds limited, Nagpur. Plants are dwarf, strong with good tillering ability. The yield parameters are the corresponding water supplied at 60

% water stressing and 40% water stressing in ADT-36and Sonam were recorded both short term and medium duration varieties that were has responded in same way to water stressing in respect of grain yield. (Tiwari *et al.*, 2017) [14]. Vishnu-Bhog- Most of the landraces or varieties grown by the farmers are maintained by the ministry, simply by keeping the seed of previous year crop. These land races are very famous in the state and outside among the consumers since having specific aroma and cooking quality. (Patel *et al.*, 2015) [9]. Kalanamak- There are almost hundreds of varieties of rice in India alone and one of them is Kala Namak rice. Kala namak is one of the naturally scented Rice of India. (Singh *et al.*, 2020) [12]. Basmati- 1718- Pusa Basmati 1718 (PB 1718) has been released for the Basmati growing states of Punjab, Haryana and Delhi of the vide Gazette notification no. S.O.2805 (E) dated 25.08.2017. PB 1718 has extra-long slender grains (8.10 mm) with very occasional grain chalkiness, very good kernel length after cooking (17.00 mm), intermediate amylose (22.2%) and strong aroma. In the panel tests. (Singh, 2018) [11].

Materials and Methods

During the 2023 *Kharif* season, a field experiment involving rice was carried out at United University's Agriculture Research Farm in Prayagraj (U.P.). The soil composition was silty loam, with 27.5% sand, 54.0% silt, 18.5% clay, pH 8.1, 0.42% organic carbon, EC 0.28 dSm-1, 16.7% available P2O5, and 257.00 kg/ha of available K2O. Uttar Pradesh, India is 113 meters above mean sea level and is situated at located at 24.390 N latitude, 82.750 E longitude. Three different spacing *viz.*, 15 x 15 cm, 20 x 20 cm and 25 x 25 cm was kept and for varieties *viz.* Sonam, Vishnu-Bhog, Kalanamak and Basmati-1718 was kept in different plot. The experiment in Randomize Block Design (RBD) with three replications of 20 m2 plots. N, P and K were applied at the rate of 120, 60 and 40 kg/ha, through Urea, di ammonium phosphate DAP and muriate of potash (MOP). Full P and K applied as basal dose. N was applied treatment wise in three splits i.e. 50 % at basal dose, 25 % at maximum tillering and 25 % at panicle initiation. FYM was applied basally fifteen days before transplanting in rice plots. One m2 area of each plot was harvested for the determination of crop yield. Observations were recorded for yield attributes *viz.*, Number of panicle/hills, Panicle length (cm), Number of grains per panicle, Number of productive tillers/hills, Test weight, Seed yield (t/ha), Straw yield (t/ha) Biological yield (t/ha) and Harvest index (%) for each replication. Grain yield was reported at 14% moisture content. Plant N was determined by Kjeld Hal method, while P and K contents were estimated in di-acid digests using vanado molybdo phosphoric yellow colour method and flame photometer, respectively (Jackson, 1973) [5].

Results and Discussions

Growth parameters

Plant height: Spacing and different nitrogen levels significantly affected plant height. The highest Plant height was observed 115.24 cm with treatment combination T_4 (Spacing 15 x 15 cm + Basmati-1718). The lowest height observed 94.01 cm with treatment T_9 (25 x 25 cm + Sonam Rice).

Number of tillers/hills: At harvest, T_{12} (19.27) produced significantly more tillers than T_{11}. It is also clear from the data that the number of tillers/hills increased with the increase in the spacing and varieties for rice. Rice at a wider spacing of Spacing 25 x 25 cm and highest dose of Basmati-1718 produced a significantly higher number of tillers/hills. Less tillers/hill produced by T_1.

Plant dry weight: Significantly highest plant dry weight (89.26 g) was recorded in the treatment with T_{12} (Spacing 25 X 25cm + Basmati-1718) over all the other treatments. Among all treatment T_1 (15 x15 cm + Sonam Rice) recorded lowest plant dry weight (74.86 g).

Yield parameters

Number of panicle/row m2: A perusal of the data clearly indicates that the number of panicle/hills was significantly affected due to spacing and different varieties. Higher number of panicles with the value (274.59) were recorded in T_4 (Spacing 25 X 25cm + Basmati-1718). The smaller number of panicles was recorded in T_1 (15 x15 cm + Sonam Rice) (259.09).

Panicle length: A critical examination over the data revealed that spacing and different varieties significantly influenced the length of panicle. The maximum in number of length (cm), (32.45 cm), recorded significantly higher in T_{12} (Spacing 25 X 25cm + Basmati-1718). The lower panicle length was recorded in T_1 (15 x15 cm + Sonam Rice) (25.55 cm).

Number of grains per panicle: A perusal of the data indicates that number of grains/panicles was found significantly higher with treatment combination T_{12} (Spacing 25 X 25cm + Basmati-1718) (220.68) of the investigation. The lower number of grains/panicles was recorded in T_{10} (15 x15 cm + Sonam Rice) (199.23).

Test weight (g): The highest test weight (g), (24.23 g) was recorded significantly in Spacing and different level of nitrogen treatment T_{12} (Spacing 25 X 25cm + Basmati-1718). The lowest test weight was recorded in T_1 (15 x15 cm + Sonam Rice) (23.27 g).

Seed yield (t/ha): The highest seed yield (t/ha), (4.20 t/ha) was recorded significantly in spacing and different nitrogen levels treatment T_{12} (Spacing 25 X 25cm + Basmati-1718) was significantly more. T_1 plot produced lowest seed yield (3.85 t/ha).

Straw yield (t/ha): The highest straw yield of (15.19 t/ha) was recorded with treatment T_{12} (Spacing 25 X 25cm + Basmati-1718) which was superior. T_1 (15 x15 cm + Sonam Rice) plot produced lowest straw yield (10.81 t/ha).

Harvest Index (%): Higher and lower harvest index was found significantly with T_1 (Spacing 15 X 15 cm + Sonam Rice) (27.74 %), T_{12} (Spacing 25 X 25cm + Basmati-1718) (22.32 %) respectively.

Cost of cultivation (₹/ha): Maximum cost of cultivation of (40398.36 ₹/ha) was recorded T_1 (Spacing 15 X 15 cm + Sonam Rice) and being lowest (39598.36 ₹/ha) with T_{12} (Spacing 25 X 25cm + Basmati-1718).

Gross returns ((₹/ha): Maximum gross income of (133521.63 ₹/ha) was recorded under T_{12} (Spacing 25 X 25cm + Basmati-1718) followed by and minimum under T_1 (Spacing 15 X 15 cm + Sonam Rice) (110704.52 ₹/ha).

Net returns (₹/ha): Maximum net return (93923.27 ₹/ha) was noted with T_{12} (Spacing 25 X 25cm + Basmati-1718) and being lowest net return (70306.16 ₹/ha) under T_1 (Spacing 15 X 15 cm + Sonam Rice).

Benefit cost ratio: Highest benefit: cost ratio of 2.32 was noted under treatment T_{12} (Spacing 25 X 25cm + Basmati-1718) and being lowest benefit: cost ratio under the T_1 (Spacing 15 X 15 cm + Sonam Rice) 1.82.

Increase in plant height may be due to synchronized availability of essential plants nutrients to the crop especially spacing for a longer period during its growth stages. The result conformed with Deshpande and Devasenpathy, 2011 [3]. Also, reason for maximum plant height might be due to more favorable weather condition associated and was criticized by the higher growing degree days and hydrothermal units gained in these hybrids was found by Bahure *et al.* (2019) [1]. The probable reason for maximum dry matter accumulation depends upon the photosynthesis and respiration rate, which finally increases the plant growth with respect to increased plant height, leaf area and tillers/hill etc. Thus, the treatment which attained maximum growth, also accumulated higher dry matter similar result have also been reported by Kumar (2016) [6]. The other reason of high dry matter accumulation in might be due to the significant increase in morphological parameters which responsible for the photosynthetic capacity of the plant thereby increasing the straw yield. The result conformed with Bozorgi *et al.* (2011) [2]. The probable reason for high yielding varieties have high tillering capacity. Similar findings are also reported by Yadav *et al.* (2004) [16]. Wang *et al.* (2016) [15] reported that the unequal distribution of photo- synthetically active radiation (PAR) was the source of heterogeneity in individual tiller yields, in that early emerging superior tillers pre-empted the uppermost light source, and shaded the late emerging tillers under limited light conditions. The results show that the adoption of 20 x 10 cm2 spacing for rice transplanting resulted in heavier filled and healthy grain higher test weight in hybrid. Similar results have been also reported by Haque *et al.* (2015) [4]. The higher grain yield/hill under variety might be due to the optimum utilization of nutrient. The hybrids of short duration high yielding have the potential to give the maximum grain yield then rest of the varieties .The other reason of the high yield of variety is due to the better growth attribute resulting to produce higher grain yield. Similar findings were reported by Ranjitha *et al.* (2013) [10]. The increase in harvest index might be due to higher rate of translocation of photosynthates to grains at grain filling stage. Harvest index reflects the physiological capacity of a crop variety to mobilize and translocate the photosynthates to the sink. Marri *et al.*, 2005 [8] found that harvest index negatively correlated with plant height, but positively correlated with grain number/pancle, grain number/plant, percentage spikelet fertility and yield/plant in rice.

Table 1: Effect of spacing and varieties on growth and yield of rice.

Treatment No.	Treatment Combination	Growth attributes		
		Plant Height (cm)	Dry Weight (g)	No. of tillers/plant
T_1	15 x15 cm + Sonam Rice	105.40	74.86	13.43
T_2	15 x15 cm + Vishnubhog	107.01	77.29	14.42
T_3	15 x15 cm + Kalanamak	111.82	79.35	15.26
T_4	15 x 15 cm + Basmati-1718	115.24	79.62	15.36
T_5	20 x 20 cm + Sonam Rice	99.47	81.44	16.10
T_6	20 x 20 cm + Vishnu Bhog	102.80	81.87	16.28
T_7	20 x 20 cm + Kalanamak	103.63	82.47	16.52
T_8	20 x 20 cm + Basmati-1718	104.79	84.06	17.16
T_9	25 x 25 cm + Sonam Rice	94.01	84.22	17.23
T_{10}	25 x 25 cm + Vishnu Bhog	97.91	85.74	17.93
T_{11}	25 x 25 cm + Kalanamak	98.05	85.96	18.51
T_{12}	25 x 25 cm + Basmati-1718	99.40	89.26	19.27

F Test	S	S	S
CD (p=0.5)	1.88	1.46	0.83
S.Em±	0.94	0.73	0.42

Table 2: Effect of spacing and varieties on yield of rice.

Treatment No.	Treatment Combination	Yield attribute			Yield				
		No. of panical	Panical length (cm)	No. of grain per panical	Seed yield	Straw yield (t/ha)	Harvest index %	Test weight (g)	Day of maturity
T_1	15 x15 cm + Sonam Rice	259.09	25.55	199.23	3.85	10.81	27.74	23.27	122.44
T_2	15 x15 cm + Vishnubhog	261.71	26.41	202.84	3.91	11.26	26.05	23.74	120.75
T_3	15 x15 cm + Kalanamak	263.93	27.15	205.92	3.96	12.47	24.31	23.77	114.36
T_4	15 x 15 cm + Basmati-1718	264.21	27.24	206.31	3.97	12.53	24.11	23.80	110.05
T_5	20 x 20 cm + Sonam Rice	266.18	27.89	209.03	4.01	12.54	24.35	23.85	124.69
T_6	20 x 20 cm + Vishnu Bhog	266.63	28.04	209.66	4.02	12.57	24.32	23.90	123.83
T_7	20 x 20 cm + Kalanamak	267.28	28.25	210.56	4.03	12.98	23.79	23.92	116.18
T_8	20 x 20 cm + Basmati-1718	268.99	29.41	212.93	4.07	13.22	23.66	23.95	114.43
T_9	25 x 25 cm + Sonam Rice	269.17	29.49	213.17	4.07	13.56	23.32	23.96	121.27
T_{10}	25 x 25 cm + Vishnu Bhog	270.80	30.54	215.43	4.11	13.90	23.15	24.02	122.08
T_{11}	25 x 25 cm + Kalanamak	271.03	31.34	215.75	4.12	14.04	22.96	24.17	112.45
T_{12}	25 x 25 cm + Basmati-1718	274.59	32.45	220.68	4.20	15.19	22.32	24.23	114.09
	F Test	S	S	S	S	S	S	S	S
	CD (p=0.5)	2.19	0.72	2.65	0.04	1.00	1.39	0.17	1.40
	SED(+_)	1.10	0.36	1.33	0.02	0.50	0.77	0.08	2.78

Table 3: Effect of spacing and varieties on economics of rice.

Treatment No.	Treatment Combination	Economics			
		Cost of cultivation (Rs/ha)	Gross return(Rs/ha)	Net return (Rs/ha)	B:C ratio
T_1	15 x15 cm + Sonam Rice	40398.36	110704.52	70306.16	1.82
T_2	15 x15 cm + Vishnubhog	40398.36	115575.29	75176.93	1.90
T_3	15 x15 cm + Kalanamak	40398.36	123138.60	82740.24	1.99
T_4	15 x 15 cm + Basmati-1718	40398.36	123277.89	82879.53	2.00
T_5	20 x 20 cm + Sonam Rice	39998.36	121826.61	81828.25	2.05
T_6	20 x 20 cm + Vishnu Bhog	39998.36	119960.64	79962.28	2.06
T_7	20 x 20 cm + Kalanamak	39998.36	120371.60	80373.24	2.09
T_8	20 x 20 cm + Basmati-1718	39998.36	125525.65	85527.29	2.12
T_9	25 x 25 cm + Sonam Rice	39598.36	133145.70	93547.34	2.17
T_{10}	25 x 25 cm + Vishnu Bhog	39598.36	121305.09	81706.73	2.21
T_{11}	25 x 25 cm + Kalanamak	39598.36	127724.73	88126.37	2.22
T_{12}	25 x 25 cm + Basmati-1718	39598.36	133521.63	93923.27	2.32

Summary and Conclusion

The observations of crop growth parameters like plant height (115.24 cm), number of tiller hill-1 (19.27), plant dry weight (89.26 g/plant) were recorded at harvest.

Yield attributing parameters number of panicle/m2 (274.59), panicle length (32.45 cm), number of grains per panicle (220.68), and test weight (24.23 g), yield grain yield (4.20 t/ha), straw yield (15.19 t/ha) and harvest index (22.32 %) of crop were recorded after harvest.

The economics analysis of test crop as influenced due to different treatments like- cost of cultivation (40398.36 Rs/ha), gross returns (133521.63 Rs/ha), net returns (93923.27 Rs/ha) and benefit: cost ratio (2.32) were calculated on the basis of current market prices of inputs and outputs during the year.

The maximum spacing and highest nitrogen level was found in treatment T_{12} (Spacing 25 X 25cm + Basmati-1718) produced significantly highest plant height (cm), No. of tiller/hill, Plant dry weight (g/plant), and in yield No. of panicle/hill, Panicle length (cm), No. of productive tiller/hill, and Test weight (g). Highest Seed yield (t/ha), Straw yield (t/ha) and biological yield (t/ha), Harvest index (%) found in treatment T_{12} (Spacing 25 X 25cm + Basmati-1718) and treatment T_1 (15 x15 cm + Sonam Rice) produces lowest among all.

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