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Influence of spacing and nitrogen levels on growth and yield of rice (*Oryza sativa* L.) Kalanamak variety

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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 nitrogen level on the growth and yield of Kalanamak rice. The experiment consisted of three spacing treatments *viz.* 25 x 25 cm, 20 x 20 cm and 15 x 15 cm and three nitrogen levels *viz.* 80 kg/ha, 100 kg/ha and 120 kg/ha. The experiment was laid out in randomized block design with three replications. The highest plant height (102.43 cm), Number of tiller/hill (25.47), Plant dry weight (76.83 g/plant), Yield attributes, No. of panicle/hill (21.27), panicle length (24.01 cm), No. of grain/panicle (377.53), No. of productive tillers/hill (22.83) and Test weight (16.40 g) was recorded in treatment T_3 (Spacing 25 x 25 cm + Nitrogen 120 kg/ha) while highest Seed yield (4.49 t/ha), Straw yield (15.44 t/ha), Biological yield (19.92 t/ha) was recorded in treatment T_9 (Spacing 15 x 15 cm + Nitrogen 120 kg/ha) of kalanamak rice. The highest economics was computed under treatment T_9 (spacing 15 x 15cm with 120 kg N/ha) i.e. net return (122141.00 Rs/ha), gross return (157755.00 Rs/ha), highest cost of cultivation (35614.00 Rs/ha) and (B:C ratio) (3.43). The lowest plant height (83.06 cm), Number of tiller/hill (17.17), Plant dry weight (56.83 g/plant), Yield attributes, No. of panicle/hill (15.11), panicle length (17.99 cm), No. of grain/panicle (330.73), No. of productive tillers/hill (15.37), Test weight (13.20 g), Seed yield (2.76 t/ha), Straw yield (9.97 t/ha), Biological yield (12.74 t/ha), of kalanamak rice. The lowest net return was computed under T_{10} (Control) and net return (64515.00 Rs/ha), gross return (97860.00 Rs/ha), lowest cost of cultivation (33345.00 Rs/ha) recorded in T_{10} (B:C ratio) (1.93) Therefore, T_9 (spacing 15 x 15 cm with 120 kg N/ha) obtaining the highest grain and straw yields of Kalanamak rice.

Keywords: Spacing, nitrogen level, Kalanamak, rice

Introduction
Rice (*Oryza sativa* L.) belongs to poaceae family and genus *Oryza* with chromosome number i.e. 2n = 24. It is one of the important cereals crop mainly grown in *kharif* season and play very significant role in Indian food security. Rice is a staple food crop of India, providing 43% of calorie requirement for more than 70% of Indian population. Rice provides 21% of global human per capita energy and 15% of per capita protein. Calories from rice are particularly important in the Asian countries, especially among the poor, accounting for 50- 80% of daily caloric intake. (Singh *et al.*, 2013) [14]. 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. (Agricultural Statistics at a Glance 2022, Department of Agriculture & Farmer Welfares).
There are many scented rice cultivars, among them Kalanamak is one of the finest quality scented rice of India (Chaudhary *et al.*, 2008) [7]. Kalanamak rice having glycaemic index 49% – 52% but other rice contains 85%. The kalanamak rice is rich in micronutrients like Iron and Zinc i.e. 3 mg and 0.4 mg respectively. Chaudhary *et al.*, (2020) [4] It has a low glycaemic index, thus better for diabetic people and also has higher protein content when compared to other paddy verities It derives its name from black husk (kala = black) and suffix `namak' means salt. Kalanamak has also received geographical Indication (GI) mark for 11 districts of U.P., which

will benefit farmers further. (Chaudhary *et al.*, 2010) [5]. Kalanamak rice was granted the Geographical Indication (GI) Tag in 2012 by the government of India. Kalanamak Rice is approved for 11 districts of Zone 7 of UP. These 11 districts are located in the divisions Gorakhpur (Deoria, Gorakhpur, Mahrajganj, Siddharth Nagar districts), Basti (Basti, Sant Kabir Nagar, Siddharth Nagar districts), and Devipatan (Bahraich, Balrampur, Gonda, Shravasti districts). (Chaudhary *et al.*, 2010) [5]. Kalanamak rice, popularly known as "scented black pearl" of eastern Uttar Pradesh.

Cultivation of Kalanamak rice is recorded since the Buddhist period (600 BC). Kalanamak Kiran was developed from the cross KN_3 x Swarna Sub_1 and notified in 2029 as Kalanamak Kiran by the central Variety Release and Notification Committee of Government of India. (Chaudhary *et al*., 2009) [6].

Nitrogen is a constituent of protoplasm and is associated with the activity of every living cell; plants continue absorb nitrogen till maturity. Nitrogen helps in building vegetative growth and regulates the utilization of other nutrients like phosphorus and potassium. (Dubey *et al.*, 2016) [9] Spacing plays a critical role in optimizing rice cultivation practices, ensuring efficient resource utilization, minimizing risks, and maximizing yields. Farmers carefully consider spacing as part of their crop management strategies to achieve optimal results in rice production. (Avasthe *et al.*, 2012) [1].

Materials and Methods

A field experiment was conducted with rice at the Agriculture Research Farm, United University, Prayagraj (U.P.) during (*Kharif*) season of 2023. The soil type was silty loam, sand 27.5%, silt 54.0%, clay 18.5%, pH 8.1, organic carbon 0.42%, and EC 0.28 dSm^{-1}, Available P_2O_5 16.7%, Available K_2O 257.00 kg/ha. Three different spacing *viz*. 25x25cm, 20x20cm and 15x15cm was kept and three Nitrogen levels *viz*. 80 kg, 100 kg, 120 kg was kept in different plot. The experiment in Randomize Block Design (RBD) with three replications of 20 m^2 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 three days before transplanting in rice plots.

One m^2 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) [16].

Results and Discussions

Growth parameters

Plant height: Spacing and different nitrogen levels significantly affected plant height. The highest Plant height was observed 102.43 cm with treatment combination T_3 (Spacing 25 x 25 cm + 120 kg N/ha). The lowest height observed 83.06 cm with treatment T_{10} (Control).

Number of tillers/hills: At harvest, T_3 (25.47) produced significantly more tillers than T_2. It is also clear from the data that the number of tillers/hills increased with the increase in the spacing and nitrogen levels for kalanamak rice. Kalanamak rice at a wider spacing of Spacing 25 x 25 cm and highest dose of nitrogen 120 kg N/ha produced a significantly higher number of tillers/hills. Less tillers/hill produced by T_{10}.

Plant dry weight: significantly highest plant dry weight (76.83) was recorded in the treatment with T_3 (Spacing 25 X 25cm + Nitrogen 120 kg/ha) over all the other treatments. Among all treatment T_{10} (control) recorded lowest plant dry weight (56.83).

Yield parameters

Number of panicle/hills: A perusal of the data clearly indicates that the number of panicle/hills was significantly affected due to spacing and different levels of nitrogen. Higher number of panicles with the value (21.27) were recorded in T_3 (Spacing 25 X 25cm + Nitrogen 120 kg/ha). The smaller number of panicles was recorded in T_{10} (100% RDF control) (15.11).

Panicle length: A critical examination over the data revealed that spacing and different nitrogen levels significantly influenced the length of panicle. The maximum in number of length (cm), (24.01 cm), recorded significantly higher in T_3 (Spacing 25 X 25cm + Nitrogen 120 kg/ha). The lower panicle length was recorded in T_{10} (100% RDF control) (17.99 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_3 (Spacing 25 X 25cm + Nitrogen 120 kg/ha) (377.53) of the investigation. The lower number of grains/panicles was recorded in T_{10} (100% RDF control) (330.73).

Number of productive tillers/hills: There was a significant improvement in the productive tillers/hill with T_3 (Spacing 25 X 25cm + Nitrogen 120 kg/ha), which produced significantly higher productive tillers/hill (377.53). The lower number of productive tillers/hills was recorded in T_{10} (100% RDF control) (330.73).

Test weight (g): The highest test weight (g), (16.40 g) was recorded significantly in Spacing and different level of nitrogen treatment T_3 (Spacing 25 X 25cm + Nitrogen 120 kg/ha). The lowest test weight was recorded in T_{10} (100% RDF control) (13.20 g).

Seed yield (t/ha): The highest seed yield (t/ha), (4.49 t/ha) was recorded significantly in spacing and different nitrogen levels treatment T_9 (Spacing 15 X 15cm + Nitrogen 120 kg/ha) was significantly more. T_{10} Control plot produced lowest seed yield (2.76 t/ha).

Straw yield (t/ha): The highest straw yield of (15.44 t/ha) was recorded with treatment T_9 (Spacing 15 X 15cm + Nitrogen 120 kg/ha) which was superior. T_{10} Control plot produced lowest straw yield (9.97 t/ha).

Biological Yield (t/ha): Highest biological yield (19.92 t/ha) was recorded by treatment combination of T_9 (Spacing 15 X 15cm + Nitrogen 120 kg/ha). Least biological yield at all treatment combination was recorded by T_{10} Control (12.74 t/ha).

Harvest Index (%): Higher and lower harvest index was found non-significantly with T_1 (Spacing 25 X 25 cm + Nitrogen 80 kg/ha) (24.38%), T_{10} Control (21.71%) respectively.

Cost of cultivation (₹/ha): Maximum cost of cultivation of (35614.00 ₹/ha) was recorded T_9 (Spacing 15 X 15 cm + Nitrogen 120 kg/ha) and being lowest (33345.00 ₹/ha) with T_{10} (Control).

Gross returns ((₹/ha): Maximum gross income of (157755.00 ₹/ha) was recorded under T_9 (Spacing 15 X 15 cm + Nitrogen 120 kg/ha) followed by and minimum under T_{10} (Control) (97860.00 ₹/ha).

Net returns (₹/ha): Maximum net return (122141.00 ₹/ha) was noted with T_9 (Spacing 15 X 15 cm + Nitrogen 120 kg/ha) and being lowest net return (64515.00 ₹/ha) under T_{10} (Control).

Benefit cost ratio: Highest benefit:cost ratio of 3.43 was noted under treatment T_9 (Spacing 15 X 15 cm + Nitrogen 120 kg/ha) and being lowest benefit: cost ratio under the T_{10} (Control) 1.93.

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

Tr. No.	Treatment combination	Growth parameters			Yield parameters			
		Plant height (cm)	No. of tillers/hill	Plant dry weight (g/plant)	No. of panicle/hill	Panicle length (cm)	No. of grain /panicle	No. productive tillers /hill
T_1	Spacing 25 X 25cm + Nitrogen 80 kg/ha	97.83	22.63	72.97	19.93	22.04	348.60	20.13
T_2	Spacing 25 X 25cm + Nitrogen 100 kg/ha	98.73	24.67	74.87	20.85	22.68	372.47	21.17
T_3	Spacing 25 X 25cm + Nitrogen 120 kg/ha	102.43	25.47	76.83	21.27	24.01	377.53	22.83
T_4	Spacing 20 X 20cm + Nitrogen 80 kg/ha	91.00	20.57	65.73	16.87	19.47	337.60	18.67
T_5	Spacing 20 X 20cm + Nitrogen 100 kg/ha	91.87	20.67	67.70	17.51	19.70	342.47	19.00
T_6	Spacing 20 X 20cm + Nitrogen 120 kg/ha	92.77	21.13	68.53	17.93	20.31	344.50	19.17
T_7	Spacing 15 X 15cm + Nitrogen 80 kg/ha	87.78	17.80	61.93	16.45	18.84	332.53	15.40
T_8	Spacing 15 X 15cm + Nitrogen 100 kg/ha	88.73	18.07	64.17	16.80	19.39	333.23	16.57
T_9	Spacing 15 X 15cm + Nitrogen 120 kg/ha	90.27	18.73	65.27	17.13	19.41	335.27	17.13
T_{10}	100% RDF (Control)	83.06	17.17	56.83	15.11	17.99	330.73	15.37
	F-test	S	S	S	S	S	S	S
	Sem±	3.15	0.97	2.71	0.82	1.00	10.53	1.06
	CD (P=0.05)	9.38	2.88	8.06	2.45	2.98	31.31	3.15

Table 2: Effect of spacing and nitrogen level on yield of rice

Tr. No.	Treatment combination	Yield parameters					
		Test weight (g)	Seed yield (t/ha)	Straw yield (t/ha)	Days of maturity	Biological yield (t/ha)	Harvest Index (%)
T_1	Spacing 25 X 25cm + Nitrogen 80 kg/ha	15.77	3.37	10.49	130.67	13.86	24.38
T_2	Spacing 25 X 25cm + Nitrogen 100 kg/ha	16.03	3.39	11.83	128.33	15.22	22.29
T_3	Spacing 25 X 25cm + Nitrogen 120 kg/ha	16.40	3.66	11.94	118.67	15.60	23.42
T_4	Spacing 20 X 20cm + Nitrogen 80 kg/ha	14.07	3.72	12.57	133.00	16.28	22.85
T_5	Spacing 20 X 20cm + Nitrogen 100 kg/ha	14.17	3.96	12.83	133.00	16.79	23.69
T_6	Spacing 20 X 20cm + Nitrogen 120 kg/ha	14.43	4.15	13.11	132.33	17.26	24.12
T_7	Spacing 15 X 15cm + Nitrogen 80 kg/ha	13.37	4.21	13.18	145.33	17.39	24.23
T_8	Spacing 15 X 15cm + Nitrogen 100 kg/ha	13.80	4.28	13.94	136.67	18.22	23.72
T_9	Spacing 15 X 15cm + Nitrogen 120 kg/ha	14.00	4.49	15.44	134.00	19.92	22.92
T_{10}	100% RDF (Control)	13.20	2.76	9.97	150.33	12.74	21.71
	F-test	S	S	S	NS	S	NS
	Sem±	0.66	0.21	0.85	2.91	0.83	1.59
	CD (P=0.05)	1.96	0.63	2.53	8.64	2.47	4.72

Table 3: Effect of spacing and nitrogen level on economics of rice.

Tr. No.	Treatment combination	Economics			
		Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_1	Spacing 25 X 25cm + Nitrogen 80 kg/ha	33726.00	116830.00	83104.00	2.46
T_2	Spacing 25 X 25cm + Nitrogen 100 kg/ha	34160.00	119450.00	85290.00	2.50
T_3	Spacing 25 X 25cm + Nitrogen 120 kg/ha	34594.00	127715.00	93121.00	2.69
T_4	Spacing 20 X 20cm + Nitrogen 80 kg/ha	33996.00	130370.00	96374.00	2.83
T_5	Spacing 20 X 20cm + Nitrogen 100 kg/ha	34430.00	138120.00	103690.00	3.01
T_6	Spacing 20 X 20cm + Nitrogen 120 kg/ha	34864.00	144170.00	109306.00	3.14
T_7	Spacing 15 X 15cm + Nitrogen 80 kg/ha	34746.00	146170.00	111424.00	3.21
T_8	Spacing 15 X 15cm + Nitrogen 100 kg/ha	35180.00	149215.00	114035.00	3.24
T_9	Spacing 15 X 15cm + Nitrogen 120 kg/ha	35614.00	157755.00	122141.00	3.43
T_{10}	100% RDF (Control)	33345.00	97860.00	64515.00	1.93

Some picture of the research field of Vivek Singh

Making Nursery field

Check germination percentage of seeds

Taking Seed by breeder Dr. R.C. Chaudhary Sir

Making Layout of the field

Making Sub-plots in main field

Application of Nitrogen by Urea in main field

Puddling in Main field

Transplanting of plant in main field

Summary and Conclusion

The observations of crop growth parameters like plant height (102.43 cm), number of tiller hill^{-1} (25.47), plant dry weight (76.83 g/plant) were recorded at harvest.

Yield attributing parameters number of panicle/hill (21.27), panicle length (24.01 cm), number of grains per panicle (377.53), number of productive tillers/hill (22.83) and test weight (16.40 g), yield grain yield (4.49 t/ha), straw yield (15.44 t/ha) and biological (19.92 t/ha) and harvest index (24.59%) of crop were recorded after harvest.

The economics analysis of test crop as influenced due to different treatments like- cost of cultivation (35614 Rs/ha), gross returns (157755 Rs/ha), net returns (123161 Rs/ha) and benefit: cost ratio (3.56) 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_3 Spacing 25 X 25 cm + Nitrogen 120 kg/ha 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_9 Spacing 15 x 15 cm + Nitrogen 120 kg/ha and treatment T_{10} (Control) produces lowest among all.

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