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 15 x 15 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_3 (Spacing 15 x 15 cm + Nitrogen 120 kg/ha) of kalanamak rice. The highest economics was computed under treatment T_3 (spacing 15 x 15 cm 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_0 (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_0 (B:C ratio) (1.93) Therefore, T_3 (spacing 15 x 15 cm with 120 kg N/ha) obtaining the highest gain 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 Welfare). There are many scented rice cultivars, among them Kalanamak is one of the finest quality scented rice of India (Chaudhary et al., 2008) [13]. 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) [14] It has a low glycaemic index, thus better for diabetic people and also has higher protein content when compared to other paddy varieties. 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, Mahrangunj, Siddharth Nagar districts), Basti (Basti, Sant Kabir Nagar, Siddharth Nagar districts), and Devipatan (Bahraich, Balmampur, Gonda, Shrivasti 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 KN1 x Swarna Sub1 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) [7] 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) [8].

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 P₂O₅ 16.7%, Available K₂O 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 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 m² area of each plot was harvested for the determination of crop yield. Observations were recorded for yield attributes viz., Number of panicle/hills, Plant height (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

| Plant height: | Spacing and different nitrogen levels significantly affected plant height. The highest Plant height was observed 102.43 cm with treatment combination T₃ (Spacing 25 X 25 cm + 120 kg N/ha). The lowest height observed 83.06 cm with treatment T₁₀ (Control). |
| Number of tillers/hills: | At harvest, T₁ (25.47) produced significantly more tillers than T₂. 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 T₇. |
| Plant dry weight: | Significantly highest plant dry weight (76.83) was recorded in the treatment with T₃ (Spacing 25 X 25 cm + Nitrogen 120 kg/ha) over all the other treatments. Among all treatment T₁₀ (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 T₃ (Spacing 25 X 25 cm + Nitrogen 120 kg/ha). The smaller number of panicles was recorded in T₁₀ (100% RDF control) (15.11). |
| Plant dry weight: | Significantly highest plant dry weight (76.83) was recorded in the treatment with T₃ (Spacing 25 X 25 cm + Nitrogen 120 kg/ha) over all the other treatments. Among all treatment T₁₀ (control) recorded lowest plant dry weight (56.83). |
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| Number of productive tillers/hills: | There was a significant improvement in the productive tillers/hill with T₃ (Spacing 25 X 25 cm + Nitrogen 120 kg/ha), which produced significantly higher productive tillers/hill (377.53). The lower number of productive tillers/hills was recorded in T₁₀ (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 T₃ (Spacing 25 X 25 cm + Nitrogen 120 kg/ha) (377.53) of the investigation. The lower number of grains/panicles was recorded in T₁₀ (100% RDF control) (330.73). |
| Seed yield (t/ha): | The highest seed yield (t/ha), (4.49 t/ha) was recorded significantly in spacing and different nitrogen levels treatment T₉ (Spacing 15 X 15 cm + Nitrogen 120 kg/ha) which was superior. T₁₀ 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 T₉ (Spacing 15 X 15 cm + Nitrogen 120 kg/ha) which was superior. T₁₀ 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 T₉ (Spacing 15 X 15 cm + Nitrogen 120 kg/ha). Least biological yield at all treatment combination was recorded by T₁₀ Control (12.74 t/ha). |
| Harvest Index (%): | Higher and lower harvest index was found non-significantly with T₁ (Spacing 25 X 25 cm + Nitrogen 80 kg/ha) (24.38%), T₁₀ Control (21.71%) respectively. |
Cost of cultivation (₹/ha): Maximum cost of cultivation of (3561.40 ₹/ha) was recorded T_10 (Spacing 15 X 15 cm + Nitrogen 120 kg/ha) and being lowest (33345.00 ₹/ha) with T_1 (Control).

Gross returns (₹/ha): Maximum gross income of (157755.00 ₹/ha) was recorded under T_5 (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_6 (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.

<table>
<thead>
<tr>
<th>Tr. No.</th>
<th>Treatment combination</th>
<th>Growth parameters</th>
<th>Yield parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Plant height (cm)</td>
<td>Plant dry weight (g/plant)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No. of tillers/hill</td>
</tr>
<tr>
<td>T_1</td>
<td>Spacing 25 X 25cm + Nitrogen 80 kg/ha</td>
<td>97.83</td>
<td>72.97</td>
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<tr>
<td>T_2</td>
<td>Spacing 25 X 25cm + Nitrogen 100 kg/ha</td>
<td>98.73</td>
<td>74.87</td>
</tr>
<tr>
<td>T_3</td>
<td>Spacing 25 X 25cm + Nitrogen 120 kg/ha</td>
<td>102.43</td>
<td>76.83</td>
</tr>
<tr>
<td>T_4</td>
<td>Spacing 20 X 20cm + Nitrogen 80 kg/ha</td>
<td>91.00</td>
<td>65.73</td>
</tr>
<tr>
<td>T_5</td>
<td>Spacing 20 X 20cm + Nitrogen 100 kg/ha</td>
<td>91.87</td>
<td>67.70</td>
</tr>
<tr>
<td>T_6</td>
<td>Spacing 20 X 20cm + Nitrogen 120 kg/ha</td>
<td>92.77</td>
<td>68.53</td>
</tr>
<tr>
<td>T_7</td>
<td>Spacing 15 X 15cm + Nitrogen 80 kg/ha</td>
<td>87.78</td>
<td>61.93</td>
</tr>
<tr>
<td>T_8</td>
<td>Spacing 15 X 15cm + Nitrogen 100 kg/ha</td>
<td>88.73</td>
<td>64.17</td>
</tr>
<tr>
<td>T_9</td>
<td>Spacing 15 X 15cm + Nitrogen 120 kg/ha</td>
<td>90.27</td>
<td>65.27</td>
</tr>
<tr>
<td>T_10</td>
<td>100% RDF (Control)</td>
<td>83.06</td>
<td>56.83</td>
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</table>

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

<table>
<thead>
<tr>
<th>Tr. No.</th>
<th>Treatment combination</th>
<th>Yield parameters</th>
<th>Test weight (g)</th>
<th>Seed yield (t/ha)</th>
<th>Straw yield (t/ha)</th>
<th>Days of maturity</th>
<th>Biological yield (t/ha)</th>
<th>Harvest Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_1</td>
<td>Spacing 25 X 25cm + Nitrogen 80 kg/ha</td>
<td>15.77</td>
<td>10.49</td>
<td>130.67</td>
<td>13.86</td>
<td>24.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T_2</td>
<td>Spacing 25 X 25cm + Nitrogen 100 kg/ha</td>
<td>16.03</td>
<td>11.83</td>
<td>128.33</td>
<td>15.22</td>
<td>22.29</td>
<td></td>
<td></td>
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<tr>
<td>T_3</td>
<td>Spacing 25 X 25cm + Nitrogen 120 kg/ha</td>
<td>16.40</td>
<td>11.94</td>
<td>118.67</td>
<td>15.60</td>
<td>23.42</td>
<td></td>
<td></td>
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<tr>
<td>T_4</td>
<td>Spacing 20 X 20cm + Nitrogen 80 kg/ha</td>
<td>14.07</td>
<td>12.57</td>
<td>133.00</td>
<td>16.28</td>
<td>22.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T_5</td>
<td>Spacing 20 X 20cm + Nitrogen 100 kg/ha</td>
<td>14.43</td>
<td>13.11</td>
<td>132.33</td>
<td>17.26</td>
<td>24.12</td>
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<tr>
<td>T_6</td>
<td>Spacing 20 X 20cm + Nitrogen 120 kg/ha</td>
<td>13.37</td>
<td>13.18</td>
<td>145.33</td>
<td>17.39</td>
<td>24.23</td>
<td></td>
<td></td>
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<tr>
<td>T_7</td>
<td>Spacing 15 X 15cm + Nitrogen 80 kg/ha</td>
<td>13.80</td>
<td>13.94</td>
<td>136.67</td>
<td>18.22</td>
<td>23.72</td>
<td></td>
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<tr>
<td>T_8</td>
<td>Spacing 15 X 15cm + Nitrogen 100 kg/ha</td>
<td>14.00</td>
<td>15.44</td>
<td>134.00</td>
<td>19.92</td>
<td>22.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T_9</td>
<td>Spacing 15 X 15cm + Nitrogen 120 kg/ha</td>
<td>13.20</td>
<td>2.76</td>
<td>9.97</td>
<td>150.33</td>
<td>12.74</td>
<td>21.71</td>
<td></td>
</tr>
<tr>
<td>T_10</td>
<td>100% RDF (Control)</td>
<td>13.20</td>
<td>2.76</td>
<td>9.97</td>
<td>150.33</td>
<td>12.74</td>
<td>21.71</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Tr. No.</th>
<th>Treatment combination</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost of cultivation (₹/ha)</td>
<td>Gross return (₹/ha)</td>
</tr>
<tr>
<td>T_1</td>
<td>Spacing 25 X 25cm + Nitrogen 80 kg/ha</td>
<td>33726.00</td>
</tr>
<tr>
<td>T_2</td>
<td>Spacing 25 X 25cm + Nitrogen 100 kg/ha</td>
<td>34160.00</td>
</tr>
<tr>
<td>T_3</td>
<td>Spacing 25 X 25cm + Nitrogen 120 kg/ha</td>
<td>34594.00</td>
</tr>
<tr>
<td>T_4</td>
<td>Spacing 20 X 20cm + Nitrogen 80 kg/ha</td>
<td>33996.00</td>
</tr>
<tr>
<td>T_5</td>
<td>Spacing 20 X 20cm + Nitrogen 100 kg/ha</td>
<td>34430.00</td>
</tr>
<tr>
<td>T_6</td>
<td>Spacing 20 X 20cm + Nitrogen 120 kg/ha</td>
<td>34864.00</td>
</tr>
<tr>
<td>T_7</td>
<td>Spacing 15 X 15cm + Nitrogen 80 kg/ha</td>
<td>34746.00</td>
</tr>
<tr>
<td>T_8</td>
<td>Spacing 15 X 15cm + Nitrogen 100 kg/ha</td>
<td>35180.00</td>
</tr>
<tr>
<td>T_9</td>
<td>Spacing 15 X 15cm + Nitrogen 120 kg/ha</td>
<td>35614.00</td>
</tr>
<tr>
<td>T_10</td>
<td>100% RDF (Control)</td>
<td>33345.00</td>
</tr>
</tbody>
</table>
Some picture of the research field of Vivek Singh

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

Making Nursery field

Check germination percentage of seeds

Making Layout of the field
Making Sub-plots in main field

Puddling in Main field

Transplanting of plant in main field

Application of Nitrogen by Urea 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 (137755 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\(_1\) 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.

References
15. Vijaya Aparna B, Anny Mrudhula K, Prasad PVN, Ravi Babu M. Effect of planting geometry and nitrogen levels on growth parameters, yield attributes and yield of black rice. To be continued.