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Investigation of Nitrogen Levels and Row Spacing on Growth and Yield of Mustard Crop Variety VNR 509: A Case Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Objective: To investigate the effect of varying nitrogen levels and row spacings on the growth and yield of the mustard crop (variety VNR 509).
Methods: The experimental trial was conducted during the rabi season at ASPEE Agricultural Research and Development Foundation (ARDF) in the north Konkan region of Maharashtra, India. A factorial randomized block design (FRBD) with three replications was employed to test different combinations of treatments.

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Results: The study found a significant influence of nitrogen levels and row spacings on mustard growth and yield. Specifically, applying 90 kg N per hectare at a row spacing of 45 cm x 10 cm resulted in optimal plant growth and yield. Higher nitrogen doses and wider row spacings increased plant height, branch development, and the number of seeds per siliquae. Conversely, reducing row spacing increased the number of pods per plant

Conclusion: The findings suggest that a balanced approach in nitrogen application and row spacing can significantly enhance mustard crop yield and quality. These insights can aid in developing cultivation strategies for similar crops to achieve higher yields and maintain crop quality.

Keywords: Mustard crop; nitrogen levels; row spacing; growth; yield; factorial randomized block design; rabi season; VNR 509 variety.

1. INTRODUCTION

The consistently rising demand for edible oil may significantly impact the economics of trade policies related to the export and import sectors of a country. In India, the current consumption of edible oil stands at approximately 23.46 million metric tons (MMT), with an estimated average per capita consumption of 16 kg. It is projected that this consumption will escalate to 30 million tons by 2025. During the first 11 months of the 2022-23 oil year, India's import of edible oils surged to 15.469 million tonnes.

India has significant potential to enhance the cultivation of oilseed crops, which can help meet the growing demand for edible oils domestically and reduce dependency on imports. Among various sources of edible oils, mustard (Brassica juncea) ranks as the second-largest oilseed crop cultivated in India, following soybean. In the 2022-23 period, mustard production reached 12.82 million tonnes out of a total of 40 million tonnes of oilseeds, accounting for 32.2% of the total oilseed production. The primary mustard-producing states include Rajasthan, Haryana, Uttar Pradesh, Punjab, and West Bengal [1].

Mustard is a popular and economically valuable crop, primarily cultivated for its seeds, which are a rich source of cooking oil. These seeds contain significant amounts of nutritive ingredients, including 38-57% erucic acid, 5-13% linoleic acid, and approximately 27% oleic acid. Additionally, they are excellent carriers of antioxidant vitamins A, D, E, and K [2]. The oil content of mustard seeds generally ranges from 37 to 49% [3].

Given its economic importance and nutritional value, optimizing mustard cultivation is crucial. The present study focuses on two key factors that significantly influence the growth and yield of mustard: nitrogen levels and row spacing. Nitrogen is an essential nutrient that plays a vital role in plant development, affecting various physiological processes. Row spacing, on the other hand, influences plant density and crop architecture, which can impact light penetration, nutrient availability, and overall plant growth.

This paper is structured to provide a comprehensive analysis of the materials and methods used in the study, followed by a statistical analysis of the data collected. The subsequent sections discuss the results obtained and their implications, culminating in a conclusion that highlights the key findings and recommendations for optimal mustard cultivation practices.

2. MATERIALS AND METHODOLOGY

The experiments were conducted during the rabi season on farming land at the ASPEE Agricultural Research and Development Foundation (ARDF), which is located in the northern Konkan region of Maharashtra, India. This region is known for its diverse agro-climatic conditions, making it an ideal location for agricultural research. The experimental setup was meticulously planned to ensure accurate and reliable results. It involved cultivating the mustard variety VNR 509, which is recognized for its high yield potential and adaptability to various climatic conditions.

To systematically examine the effects of different agricultural practices, a factorial randomized block design (FRBD) was employed. This sophisticated experimental design is particularly useful when studying the interaction effects of multiple independent variables. In this setup, three replications of each treatment were conducted, as detailed in Table 1, to ensure the results were statistically significant and reproducible. The FRBD layout is designed to explore the combined effects of various factors, allowing researchers to understand not only the individual impact of each variable but also how different variables interact with each other. Each level of one independent variable is combined with each level of the other variables, providing a comprehensive understanding of their interplay. This approach enhances the robustness of the experimental findings, offering valuable insights into the optimal agricultural practices for maximizing crop yield and quality.

In this study, a systematic approach was adopted to investigate the impact of varying nitrogen levels and row spacing on the growth and yield of mustard crops. Four distinct levels of nitrogen application were meticulously tested: N1 (30 kg/ha), N2 (60 kg/ha), N3 (90 kg/ha), and N4 (120 kg/ha). These levels were chosen to cover a broad spectrum of nitrogen availability, from low to high, providing insights into how different quantities of this essential nutrient influence crop performance.

Additionally, two row spacing configurations were examined to understand their role in optimizing plant growth. The configurations tested were D1 (30 cm × 10 cm) and D2 (45 cm × 10 cm). Row spacing is a crucial factor in agriculture as it affects plant density, light interception, air circulation, and ultimately, crop yield. By varying the spacing between rows and plants, the study aimed to determine the most effective arrangement for maximizing growth and productivity.

This experimental design, combining different levels of nitrogen with varying row spacings, allowed for a comprehensive assessment of their effects on the mustard crop. The factorial nature of the design enabled the researchers to analyze not only the individual impact of each factor but also their interaction effects. This holistic approach provided a deeper understanding of how these variables work together to influence crop outcomes.

The results of these treatments, summarized in Tables 2 and 3, offer detailed insights into the optimal conditions for mustard cultivation. Table 2 presents the growth parameters, such as plant height and number of branches per plant, while Table 3 focuses on yield parameters, including the number of pods per plant and overall seed yield. These tables serve as a critical resource for farmers and researchers, guiding them in making informed decisions about nitrogen application and row spacing to achieve the best possible results in mustard farming.

Throughout the experiment, a meticulous and systematic approach was taken to record data on various growth and yield parameters. This comprehensive data collection was crucial for accurately assessing the impact of different nitrogen levels and row spacings on the mustard crop. The parameters measured included: plant height, number of branches per plant, number of pods per plant, length of pods, number of seeds per pod, test weight (1000-seed weight), and overall seed yield.

The collected data were then thoroughly analyzed to understand the influence of the different nitrogen levels and row spacings on these growth and yield parameters. This analysis was detailed in Table 4, which presented a comprehensive overview of the findings.

By examining the data, researchers could identify trends and patterns that highlighted the optimal nitrogen levels and row spacings for maximizing mustard crop performance. For instance, they could determine which combination of nitrogen application and row spacing resulted in the tallest plants, the highest number of pods, or the greatest overall seed yield. This information is invaluable for farmers aiming to enhance their crop productivity, as it provides evidence-based recommendations for optimizing fertilizer use and planting arrangements.

The systematic data collection and rigorous analysis ensured that the conclusions drawn from the experiment were robust and reliable. This approach not only validated the experimental results but also provided actionable insights for improving mustard cultivation practices.

Table 1. Experimental details

Particular	Details
Crop:	Mustard
Variety:	VNR 509
Sowing date:	30/01/2023
Experimental Layout:	Factorial Randomized Block Design (FRBD)
Plot Size:	5.0 X 2.4 m
No. of Replication:	3

Table 2. Treatment Details

Nitrogen levels		Row Spacing	
N1	30 kg N per ha	D1	30 x 10 cm
N2	60 kg N per ha	D2	45 x 10 cm
N3	90 kg N per ha		
N4	120 kg N per ha		

Table 3. Treatment Combination

Treatment	Action
T1	30 kg N per ha + 30cm x 10 cm
T2	30 kg N per ha + 45cm x 10 cm
T3	60 kg N per ha + 30cm x 10 cm
T4	60 kg N per ha + 45cm x 10 cm
T5	90 kg N per ha + 30 cmx 10 cm
T6	90 kg N per ha + 45cm x 10 cm
T7	120 kg N per ha + 30m x 10 cm
T8	120 kg N per ha + 45cm x 10 cm

3. RESULTS AND DISCUSSION

The results of the study are presented in Table 4, which provides a detailed overview of the effects of different nitrogen levels and row spacing configurations on various growth and yield parameters of the mustard crop. This table encapsulates the comprehensive data collected during the experiment, illustrating how each treatment influenced plant height, number of branches, number of pods, pod length, number of seeds per pod, test weight, and overall seed yield.

To ensure the reliability and validity of these findings, the recorded data were subjected to a rigorous statistical analysis of variance (ANOVA). This statistical technique was employed to determine the significance of the differences observed between the various treatments. By partitioning the total variability into components associated with different sources of variation, ANOVA helped in understanding whether the observed differences in growth and yield parameters were statistically significant or merely due to random chance.

In addition to ANOVA, different regression models were developed to depict the pattern of seed yield in response to the varying levels of nitrogen and row spacing. These models, illustrated in Fig. 1, provided a visual representation of the relationships between the independent variables (nitrogen levels and row spacing) and the dependent variable (seed yield). By fitting regression lines to the data points, these models helped in predicting the seed yield under different treatment combinations and identifying the optimal conditions for maximizing crop performance.

Critical difference (CD) values and standard errors (S.Em. ±) were also calculated to provide further insights into the data. The critical difference is a statistical measure used to determine the smallest difference between treatment means that is considered significant at a given confidence level. This helps in comparing the treatment effects more accurately. For example, if the difference between two treatment means is greater than the CD value, it can be concluded that the difference is statistically significant.

The standard error of the mean (S.Em. ±) was calculated to estimate the precision of the sample mean. A larger standard error indicates greater variability in the sample mean, suggesting that the sample means are spread out over a wider range of values. This measure is crucial for understanding the reliability of the data; smaller standard errors indicate more precise estimates of the population mean.

In summary, the results detailed in Table 4 and the accompanying statistical analyses provided a robust framework for understanding the effects of nitrogen levels and row spacing on mustard crop performance. The use of ANOVA and regression models, along with the calculation of CD values and standard errors, ensured that the findings were both statistically sound and practically relevant for optimizing mustard cultivation practices.

3.1 Plant Height

The obtained results show that the highest plant height was recorded with treatment of 90 kg N per ha with row spacing 45 cm x 10 cm (T6). The increased spacing probably helped to obtain more sunlight, nutrients, and water while reducing competition between inter- and intra-plants. Similar observations have also been reported by Dabi et al. [4], Rameti et al., [5] and Sai et al. [2].

Table 4. Data showing the effects of nitrogen levels and row spacing on mustard growth and yield

Treatment	Plant height (cm)	No. of branches per plant	No. of siliquae per plant	Length of siliquae	No. of seeds per siliquae	Test weight (g)	Seed Yield (kg/ha)
T 1	94.28	7	10.3	2.84	9	4.07	1361.2
T 2	97.25	7.5	12.1	3.2	10.1	4.97	1686.2
T 3	99.88	8	13.3	3.4	10.7	5.61	1967.7
T 4	100.94	8.7	14.3	3.68	11.4	5.86	2108
T 5	103.71	9.5	17.6	4.06	12.4	6.18	2260.6
T 6	108.11	10.5	21.7	4.5	14	6.78	2532.5
T 7	101.79	9.1	16	3.91	11.8	6.06	2200.5
T 8	104.59	10	20.1	4.21	13.3	6.35	2388.6
S.Em.±	0.27	0.07	0.18	0.02	0.11	0.02	19.1
CD	0.81	0.22	0.55	0.08	0.34	0.05	57.66

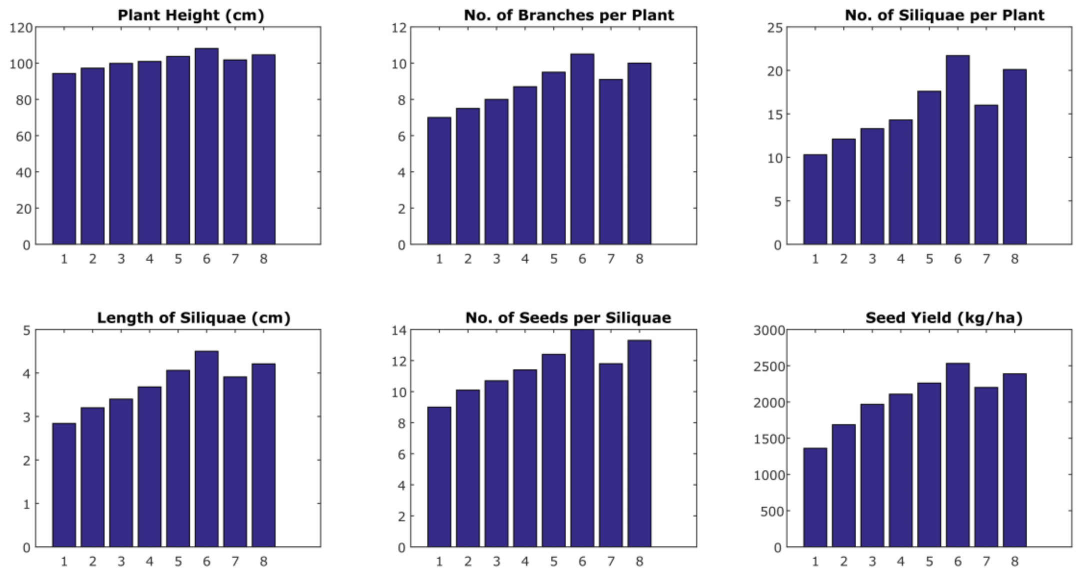

Fig. 1. Illustrative effect of treatments on variable parameters of plant

3.2 Branches/Plant

The larger plant spacing of 45 cm × 10 cm between plants provides more sunlight, soil moisture, and nutrients, leading to increased photosynthesis, metabolic activities, and overall growth and development, which results in a higher number of branches. A similar finding was also found by Raghuvanshi et.al. [6] for mustard and Gadade et al. [7] for groundnut.

3.3 Yield: Siliquae/Plant and Yield

T6 exhibited a significant number of siliquae per plant (21.7), which may be due to better photosynthetic activities by sufficient light and balanced nutrient supply during the growth stages. This resulted in a significant and appreciable yield of 2532.5 Kg/ha. Keivanrad and Zandi [8], Duval et al. [9] and Anjana et al. [10] found similar outcomes [11,12].

The above discussion reveals that selecting appropriate treatments with increased nitrogen levels and wide row spacing plays a significant role in mustard growth and yield.

4. CONCLUSION

The results of experiments carried out at the ASPEE foundation highlighted that nitrogen levels and row spacing have significant roles in influencing the growth and yield of the mustard variety VNR 509. These results also emphasize the need to establish a balance between the use of fertilizers to achieve the desired yield of mustard oil seeds and oil quality in terms of nutritional value. As mustard farming continues to evolve, these findings offer valuable insights into optimizing crop production.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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