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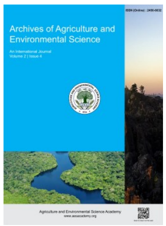

ORIGINAL RESEARCH ARTICLE

CrossMark

Effects of nitrogen levels on growth and yield of mustard greens (*Brassica juncea var. rugosa*) in Gauradaha-2, Jhapa, Nepal

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ABSTRACT

This experimental study was carried out at the research field of Gauradaha Agriculture Campus, Tribhuvan University, Jhapa, during the year 2024 to 2025. The aim of this study was to find the optimum level of nitrogen (Urea) fertilizer that provides maximum yield of mustard (Marpha broad leaf) greens under the local climatic conditions. The experiment was laid out in a Randomised Complete Block Design (RCBD) with five treatments and four replications. Urea was used to provide the nitrogen to the mustard greens plants. Five nitrogen doses (T_0 =0 kg per ha, T_1= 75 kg per ha, T_2= 100 kg per ha, T_3 = 125 kg per ha, and T_4= 150 kg per ha) were used as treatment variables for the fertilization of mustard greens in the experiment. Plant height, leaf number, leaf length, leaf width, and yield of mustard greens were the parameters taken into consideration, with three harvests carried out at an interval of 20 days. The results showed that different doses on nitrogen diversely affected the different parameters of mustard greens. The plant height (36.75) and leaf number (8.5) were highest at T_3, and leaf length (25.48), leaf width (21.2) and yield (3.03) of mustard greens were recorded highest at T_2. Therefore, a dose of 100 kg per ha of Urea can be recommended as an optimum dose of nitrogen for the commercial production of mustard greens in Gauradaha-2, Jhapa, Nepal.

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INTRODUCTION

Leafy mustard (*Brassica juncea var. rugosa*), locally known as *lai patta*, is a tall, slow-growing crop with beautiful green leaves that range in hue from light green to dark purple. It is a widely consumed vegetable crop across Asia and beyond (Meena *et al.*, 2022). In terms of nutrition, 100g fresh weight serving of mustard serves 2.4g protein,0.4g g fat, 4.3 g carbohydrates, 160 mg Ca, 48 mg P, 2.7 mg Fe, 24 mg Na, 297 mg K, 1825 µg ß-carotene equivalent, 0.06 mg thiamine, 0.14 mg riboflavin, 0.8 mg niacin and 73 mg ascorbic acid (Maereka *et al.*, 2007; Kumar & Chopra, 2014). It also contains a large number of phytocompounds such as sinigrin, allyl isothiocyanate, kaempferol glycosides, catechin, and others, that have health-promotional and disease prevention properties (Pant *et al.*, 2020; Tian & Deng, 2020; Yokozawa *et al.*, 2002; Yoon *et al.*, 2007). While nitrogen is essential for the development of the canopy and rich green colour of the crop (Ali *et al.*, 2023; Ali *et al.*, 2022a, b; Mozaffari *et al.*, 2012; Cheema *et al.*, 2001). It is also an important constituent of nucleic acid, chlorophyll and other plant components (Maereka *et al.*, 2007). The requirement of nitrogen varies as per soil type, climate, and management practice (Keivanrad & Zandi, 2012). Although mustard has high levels of nitrogen in its leaves and stem, and its exigency for nitrogen is also high (Rathke *et al.*, 2005; Svečnjak & Rengel, 2006), the overuse of nitrogen causes problems, such as lodging and also increases the bitterness of leaves (Maereka *et al.*, 2007; Hashan *et al.*, 2023). Urea and DAP are the important fertilizers that are mainly using to provide the nitrogen and phosphorous during the cultivation of crops (Chopra *et al.*, 2011; Srivastava *et al.*, 2015). In recent years, the agricultural trends have shown excessive fertilizer use, leading to nutrient leaching, greenhouse gas emissions, heavy metal contamination, and the formation of carcinogenic nitrosoamines in leafy vegetables (Savci, 2012). Another serious impact includes acid rain that damages vegetation, buildings, harming organisms that live in both lakes and reservoirs. Thus, the application of the optimum dose of nitrogen fertilizer, critical for balancing both productivity and sustainability, remains a pressing issue. Additionally, previous studies have highlighted the role of nitrogen in mustard growth, but the focus was mostly on oilseed mustard. Limited research has been done on Marpha broad leaf mustard, a locally important variety in Nepal, under specific agro-climatic conditions of Jhapa, leaving a gap in providing locally validated nitrogen dose recommendations. The study aimed to determine the optimal dose of nitrogen fertiliser for Marpha Broad leaf mustard for commercial production at Gauradaha, Jhapa.

Applying an optimal fertiliser dose can maximise agricultural output and improve leaf quality in mustard greens while reducing input costs and improving farm profitability. Consumers can enjoy safe and nutrient-rich vegetables. Environmental pollution associated with excessive fertilizer application will be solved, ensuring sustainability. The blanket dose of fertilizer has been suggested., but location-specific doses of fertilizer for application are currently uncommon. This research focused on determining the optimum dose of nitrogen fertilizer for Marpha broad leaf mustard in Gauradaha, Nepal.

MATERIALS AND METHODS

About the study area

The study was conducted at the research area of Gauradaha Agricultural Campus, located in Ward Number 2 of Gauradaha Municipality (26.56407° N 87.71503° E), during December to February, 2024/25. Geographically, Gauradaha is at an elevation of 98 masl. The seed was collected from Agrovet, and the variety used was Marpha broad leaf mustard.

Experimental design and treatment factors

The experiment was a single-factor (fertilizer) randomised complete block design with four replications. Five levels of nitrogen (Urea) were used as a treatment in this experiment.

T_0: 0 kg ha^{-1}
T_1: 75 kg ha-^{1}
T_2: 100 kg ha^{-1}
T_3: 125 kg ha^{-1}
T_4: 150 kg ha^{-1}

Each plot was 2m × 2m in dimension. A buffer zone of 1m between plots was made to prevent the nitrogen spill over, thus an area of 180m^2 was under study.

Cultivation practices

The soil was ploughed and levelled using a power tiller to ensure uniformity across all plots. Then, the plot was prepared manually with available implements and levelled properly. Well-decomposed FYM was applied @ 10 t/ha as an organic fertiliser. The following doses of NPK were used: 0:83:48 kg/ha, 75:83:48 kg/ha, 100:83:48 kg/ha, 125:83:48 kg/ha and 150:83:48 kg/ha. Urea was used as the source of nitrogen. Single Super Phosphate (SSP), Muriate of Potash (MoP) were used as the source of phosphorus and potassium, respectively. Total amount of SSP and MoP, and half the amount of urea were applied as a basal dose. The remaining urea was top-dressed 20 DAT. A bed of 1 m width, 10 cm height and of suitable length was prepared in greenhouse. The seeds were sown during November 23, 2024, with 5cm in between rows at a depth of 2-3cm and irrigated immediately. The seedling was transplanted to the field on December 20, 2024, at a depth of 4-5 cm into the soil at a spacing of 45cm row to row and 30cm plant to plant. The seedlings were irrigated lightly using a watering can. During the later stages, as the crop water requirements increased, the field was irrigated using water pipes. Insect pests were controlled using Cypermethrin 10% EC and cow urine solution. Manual weeding was carried out regularly. In total, three harvests from the net plot area were taken for the study. Harvesting was done manually by plucking the leaves near the ground level.

Observations

Five plants were randomly selected and tagged in each plot, excluding the border plants. The data for these selected plants were recorded 20 days after transplanting, and the measurement process was repeated two more times at regular 20-day intervals. The total number of leaves and plant height were measured before harvesting. The freshly harvested leaves were weighed and noted.

Statistical analysis

R-Studio, version 4.4.0. And Microsoft Excel were used for data analysis. The data were recorded on a note copy and entered and organized in Microsoft Excel. Analysis of variance was done by using R-Studio.

RESULTS AND DISCUSSION

Effects on plant height

Effects of nitrogen on plant height at different stages of plant growth of mustard greens are shown in Table 1. T_3 showed the tallest plants at 20 DAT (22.45 cm) and 60 DAT (36.75), whereas T_1 resulted in the tallest plant height at 40 DAT (28.3), which was at par with T_3 (24.57). These results highlight the superiority of T_3 in promoting plant height. The exception might be because of a temporary imbalance between nitrogen supply and the plant's physiological demand at that stage. A similar result was obtained from Shorna *et al.* (2020), who noticed the highest plant height with the application of 150 kg N ha^{-1} and 100 kg N ha^{-1} treatments.

Effects of nitrogen on leaf number

Effects of nitrogen on the number of leaves at different stages of plant growth of mustard greens are shown in Table 2. The highest number of leaves, 6.5 and 8.5, were obtained at T_3 at 20

Table 1. Effect of nitrogen levels on plant height of mustard greens at 20, 40 and 60 DAT, Gauradaha, Jhapa.

Treatment	Plant height (cm) at 20 DAT	Plant height (cm) at 40 DAT	Plant height (cm) at 60 DAT
T0	11.08^{c}±0.822	12.55^{c}±1.508	14.05^{b}±1.369
T1	21.4^{a}±0.583	27.35^{a}±1.224	33.3^{a}±5.662
T2	20.53^{a}±2.381	28.3^{a}±2.628	36.15^{a}±2.614
T3	22.45^{a}±3.651	28.625^{a}±0.873	36.75^{a}±0.929
T4	16.68^{b}±1.815	24.575^{b}±2.286	32.4^{a}±3.536
Grand mean	18.42	24.28	30.53
CV%	11.49	7.35	10.96
F-value	19.3***	57.160***	31.544***
LSD	3.26	2.75	5.15

Where ns =non-significant, (*) = significant at 5%, (**) = significant at 1%, (***) = significant at 0.1%, same letter signifies no significant differences between treatments (homogeneity effect of treatments).

Table 2. Effect of nitrogen levels on leaf number of mustard greens at 20, 40 and 60 DAT, Gauradaha, Jhapa.

Treatment	Leaf number at 20 DAT	Leaf number at 40 DAT	Leaf number at 60 DAT
T0	4.25^{c}±0.500	4.5^{c}±0.577	4^{b}±0.816
T1	6^{ab}±0.000	6.75^{ab}±0.500	7.5^{a}±1.000
T2	6.5^{a}±1.290	7.25^{a}±1.258	8.5^{a}±1.290
T3	6.5^{a}±0.577	7.5^{a}±0.577	8.5^{a}±1.290
T4	5^{bc}±0.816	6.25^{b}±0.500	7.75^{a}±0.957
Grand mean	5.65	6.45	7.25
CV%	13.52	9.06	9.42
F-value	6.771**	16.610***	30.000***
LSD	1.18	0.90	1.05

Where ns =non-significant, (*) = significant at 5%, (**) = significant at 1%, (***) = significant at 0.1%, same letter signifies no significant differences between treatments (homogeneity effect of treatments).

Table 3. Effect of nitrogen levels on leaf length of mustard greens at 20, 40 and 60 DAT, Gauradaha, Jhapa.

Treatment	Leaf length (cm) at 20 DAT	Leaf length (cm) at 40 DAT	Leaf length (cm) at 60 DAT
T0	9.3^{c}±0.743	10.925^{c}±0.987	12.60b±1.705
T1	19.56^{a}±0.719	24.887^{ab}±2.455	30.25a±5.082
T2	18.23^{a}±2.206	25.475^{a}±0.788	32.75a±2.055
T3	19.56^{a}±3.273	25.3^{a}±2.130	32.35a±2.048
T4	15^{b}±1.134	22.437^{b}±1.870	29.90a±4.126
Grand mean	16.32	21.81	27.57
CV%	10.77	8.31	12.38
F-value	24.349***	46.836***	24.585***
LSD	2.71	2.79	5.26

Where ns =non-significant, (*) = significant at 5%, (**) = significant at 1%, (***) = significant at 0.1%, same letter signifies no significant differences between treatments (homogeneity effect of treatments).

and 60 DAT, respectively. At 40 DAT, the highest leaf number was seen in T_1 (7.5), which was at par with T_4 (6.25). The number of leaves per plant increased with the increasing amount of nitrogenous fertiliser, because increased nitrogen eventually leads to mitotic division. Except at 40 DAT, which could be because of an imbalance between nitrogen supply and the plant's physiological demand. The findings justified the results of Mir *et al.* (2010) and Shorna *et al.* (2020).

Effects of nitrogen on leaf length

Effects of nitrogen on leaf length at different stages of plant growth of mustard greens are shown in Table 3. T_3 exhibited significantly longer leaves, averaging 19.56 by 20 DAT. However, by 40 DAT the leaf length appeared longer at T_2. This trend persisted at 60 DAT, with T_2 maintaining its superiority, yielding an average of 25.48 cm. These findings were in alignment with prior studies by Kumar *et al.* (2017), who found that the leaf length increased significantly with increasing levels of nitrogen up to 120 kg N per hectare.

Effect of nitrogen on leaf width

The impact of nitrogen on leaf width of mustard greens is shown in Table 4. In terms of leaf width, T_2 consistently outperformed other treatments, resulting in the highest leaf width of 11.03 cm, 16.075 cm and 21.2 cm at 20, 40, and 60 DAT, respectively. This could be because the nitrogen induces cell division and multiplication, and enhances cell elongation. Similar findings were found in the study of Kumar *et al.* (2017) and Shorna *et al.* (2020), that the availability of other nutrients and favourable conditions for the growth of the mustard plant might be because nitrogen increases the size of the cell, which is expressed morphologically as increased leaf area.

Table 4. Effect of nitrogen levels on leaf width of mustard greens at 20, 40 and 60 DAT, Gauradaha, Jhapa.

Treatment	Leaf width (cm) at 20 DAT	Leaf width (cm) at 40 DAT	Leaf width (cm) at 60 DAT
T0	4.65^c±0.500	5.875^c±0.525	7.1^b±0.959
T1	11.63^a±1.001	15.725^{ab}±1.699	19.85^a±3.371
T2	11.03^a±1.170	16.075^a±0.298	21.2^a±0.748
T3	8.8^a±2.711	16.112^a±2.119	20.8^a±2.039
T4	4.65^b±0.771	13.975^b±1.021	19.2^a±2.315
Grand mean	9.61	13.53	17.63
CV%	14.95	9.81	12.70
F-value	17.835***	43.447***	28.131***
LSD	2.21	2.05	3.45

Where ns =non-significant, (*) = significant at 5%, (**) = significant at 1%, (***) = significant at 0.1%, same letter signifies no significant differences between treatments (homogeneity effect of treatments).

Table 5. Effect of nitrogen levels on yield of mustard greens at 20, 40 and 60 DAT, Gauradaha, Jhapa.

Treatment	Yield (gm) at 20 DAT	Yield (gm) at 40 DAT	Yield (gm) at 60 DAT
T0	(1.561^c±0.221)	(1.549^c±0.188)	(1.409^c±0.141)
T1	(2.488^b±0.087)	(2.705^{ab}±0.066)	(2.853^{ab}±0.126)
T2	($2.610a^b$±0.088)	(2.904^a±0.122)	(3.030^a±0.159)
T3	(2.797^a±0.206)	(2.910^a±0.119)	(2.988^{ab}±0.082)
T4	(2.460^b±0.093)	(2.653^b±0.125)	(2.790^b±0.144)
Grand mean	2.38	2.54	2.61
CV%	5.72	5.25	5.68
F-value	49.23***	72.25***	83.80***
LSD	0.21	0.20	0.22

Where values observed are transformed values, ns =non-significant, (*) = significant at 5%, (**) = significant at 1%, (***) = significant at 0.1%, same letter signifies no significant differences between treatments (homogeneity effect of treatments).

Effects of on yield

The impacts of nitrogen on the yield of mustard greens are highlighted in Table 5. T_3 produced the highest yield of 2.910 g till 40 DAT, which was then substituted by T_2 by 60 DAT with an average yield of 3.03 g. The yield improvement by T_2 could be because the amount of nitrogen supplied addressed the plant's demand, resulting in cell division and elongation, strengthening the sink capacity, which favours acquiring more photosynthesis (Gao *et al.*, 2012). These findings corroborate those of Shorna *et al.* (2020).

Conclusion

The comprehensive analysis of different levels of nitrogen on Marpha broad leaf at Gauradaha, Jhapa, provided valuable insights into its growth and yield dynamics. The single-factor randomised complete block design with five doses of nitrogen assisted in a better understanding of mustard greens development. T_2 (100 kg urea per ha) and T_3 (125 kg urea per ha), displayed superior traits such as increased plant height, higher leaf number and higher yields of mustard greens in later stages. Excess nitrogen may volatilize and/or leach out, which leads to environmental damage. The application of 100 kg of urea per ha is suitable for the commercial production of mustard green in Gauradaha. This research enriches mustard green cultivation strategies, emphasising the necessity for a tailored approach to optimize crop productivity.

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DECLARATIONS

Authors' contribution statement: Conception and Methodology: S.L.; Software and Validation: S.L.; Investigation: S.L.; Data Curation: S.L. and H.K.K.; Writing original draft: S.L.; Writing-review and editing: H.K.K. and S.L.; Supervision: S.L. and H.K.K. All authors have reviewed and approved the final version of the manuscript before submission.

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