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# Effect of Different Levels of Nitrogen on Growth and Yield of Flax under Kabul Agro-Ecological Conditions

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**ABSTRACT:** Flax is among the most significant industrial oilseed crops in the world, as well as in Afghanistan. It is high in health-promoting fatty acids. However, its yield and quality are low owing to poor nitrogen fertilizer use and lack of improved cultivars in Afghanistan. Hence, a field trial was conducted at the Research Farm of the Agriculture Faculty of Kabul University during the main cropping season of 2025 to evaluate four nitrogen rates (0, 50, 100, and 150 kg/ha). The study was conducted using a randomized complete block design (RCBD) arrangement with four replications. The size of each experimental unit was 2 m × 2 m (4 $m^2$), with six rows. Distances of 30 cm and 40 cm were left between plots and blocks, respectively. The spacing between rows was 30 cm, and the spacing between plants was 15 cm. Significant differences were observed in the different levels of nitrogen on plant height, number of capsules per plant, number of branches per plant, number of seeds per capsule, 1000-seed weight, length of roots, biological yield, grain yield, and straw yield. However, the results showed that the 100 kg N/ha fertilization level significantly outperformed in number of seeds per capsule, number of capsules per plant, 1000-seed weight, and seed yield. Meanwhile, the 150 kg N/ ha fertilization level excelled in plant height and number of branches per plant, biological yield, and straw yield.

**KEYWORDS:** flax, nitrogen rates, flax yield, biological yield, harvest index.

## INTRODUCTION

Flax is one of the oldest plant crops known to humans and has been cultivated since ancient times to take advantage of oil, fiber, or both(Goyal et al., 2014). Flaxseed is one of the most important oilseed crops for industrial as well as food, feed, and fiber purposes. Almost every part of the flax plant is utilized commercially, either directly or after processing. The stem yields good quality fiber having high strength and durability. The seed provides oil rich in omega-3, digestible proteins, and lignin's. In addition to being one of the richest sources of α-linolenic acid oil and lignin's, flaxseed is an essential source of high-quality protein and soluble fiber and has considerable potential as a source of phenolic compounds. Flaxseed is emerging as an important functional food ingredient because of its rich contents of α-linolenic acid (ALA), lignin's, and fiber. Lignin's appear to be anti-carcinogenic compounds. The omega-3 and lignin phytoestrogens of flaxseed are in focus for their benefits for a wide range of health conditions and may possess chemoprotective properties in animals and humans (Singh et al., 2011). Flax is a dual-purpose crop cultivated for both fiber and oil production. Flax seeds are important raw material for both industrial and nutritional purposes (Hassen & Shaker, 2013). Flax oilseed plays a significant role in the global oil market due to its short growth period and broad adaptability(Xie et al., 2015). It is mostly an industrial crop grown for its seeds as well as its fiber, which is used to make linen. About 30-45% of seeds are oil, which is utilized in the production of paint, varnish, printing ink, soap, and patent leather(Mhiret & Heslop-Harrison, 2018).

The fertilizer requirement of crops, including flax, depends on several factors such as climate conditions, plant species, cultivars, and soil fertility status(Casa et al., 1999). Nitrogen plays a vital role in promoting vegetative growth, protein synthesis, cell enlargement, photosynthesis efficiency, and the development of flowers and buds (Al-Juheishy et al., 2024). Appropriate nitrogen application enhances photosynthesis by promoting chlorophyll and protein synthesis, thus improving the quantity and quality of flax yield (Dordas, 2010).

Several researchers have investigated the response of flax to different nitrogen levels under diverse environmental conditions. Krusk et al. (2025) conducted a field experiment in Iraq during the 2022–2023 growing season to evaluate the effects of humic acid and nitrogen fertilizer on flax. The study found that increasing rates of humic acid and nitrogen significantly improved plant growth, yield components, seed yield, nutrient uptake, and seed oil content, highlighting their important role in flax production. Dökülen. (2024) evaluated the effect of different nitrogen fertilizer rates on oil flax under dry conditions in Turkey during 2020–

2021. The results showed that nitrogen application significantly improved growth, seed yield, and oil yield, with 100–130 kg N/ha being the most effective rates. For better fertilizer efficiency, 100 kg N/ha was recommended. Sayram et al. (2024) reported significant improvements in growth and yield attributes of flax with appropriate nitrogen fertilization. Similarly, Osmari et al. (2019) found that increasing nitrogen levels enhanced seed yield, oil yield, and biomass accumulation in flax. Nevertheless, excessive nitrogen application may increase vegetative growth at the expense of reproductive performance and may reduce nitrogen use efficiency (Zhang et al., 2024). Despite the known importance of nitrogen, there remains a need to determine the optimal levels of nitrogen application specific to flax under varying conditions to maximize both growth and yield while minimizing negative environmental impacts. This study aims to determine how different levels of nitrogen fertilization affect the growth characteristics and yield performance of flax and to find the optimum amount of Nitrogen for satisfactory flax yield.

## MATERIALS AND METHODS

A field experiment was conducted at the Research Farm of the Faculty of Agriculture, Kabul University during the 2025 growing season from 24 April to 30 July 2025 to evaluate the effect of different nitrogen levels on the growth and yield of Badakhshi flax. The experimental site is located at 34°31′1″ N latitude and 69°8′21″ E longitude at an altitude of approximately 1782 m above sea level. The climate of the study area is semi-arid, characterized by low precipitation and relatively high summer temperatures. During the cropping season, total rainfall was 166.3 mm, while precipitation from May to August was only 13.3 mm. The average minimum and maximum temperatures during the growing period ranged from 26.25 to 36.25°C, with an average relative humidity of 51.75%. Before sowing, soil samples were collected from the experimental field to determine the physical and chemical properties of the soil. Ten soil samples were collected randomly from a depth of 0–25 cm using a soil auger and mixed thoroughly to form a composite sample. The composite sample was analyzed in the soil laboratory of Badambagh, Kabul. The soil of the experimental site was classified as sandy loam with a pH of 8.3, electrical conductivity (EC) of 0.259 ds/m, organic matter content of 2.7%, total nitrogen of 0.02%, calcium carbonate of 12%, cation exchange capacity (CEC) of 16.4 meq/100 g soil, and available phosphorus of 1.83 pp. The Badakhshi variety of flax was used in this study. Seeds were obtained from the Badambagh Research Farm and sown at a seed rate of 7 kg/ha. Diammonium phosphate (DAP) fertilizer was applied uniformly at the rate of 100 kg/ha before sowing to improve soil fertility. Four nitrogen fertilizer levels (0 kg N/ha, 50 Kg/ha, 100 kg N/ha, and 150 kg N/ha) were used as treatments. Nitrogen fertilizer was applied in two equal splits, with 50% applied at sowing and the remaining 50% applied at the budding stage. The experiment was arranged in a randomized complete block design (RCBD) with four replications. Each experimental plot measured 2 m × 2 m (4 m²). The spacing between blocks and ridges was 40 cm and 30 cm, respectively. Each plot consisted of six rows with 30 cm row-to-row spacing and 15 cm plant spacing. Land preparation was carried out using disk plowing followed by leveling to obtain a fine seedbed. Sowing was performed manually on 24 April 2025 by placing healthy seeds uniformly on ridges. Light irrigation was applied before sowing to ensure adequate soil moisture for seed germination. Irrigation was applied at intervals of 10–15 days depending on crop water requirements and climatic conditions. Weeding and thinning operations were carried out manually whenever necessary to maintain proper plant population and reduce weed competition. Flax seeds started germination five days after sowing, and germination was nearly completed within ten days. Flowering started approximately 54 days after sowing and continued for about 30 days. Physiological maturity was reached 97 days after sowing, and harvesting was performed manually during the morning hours to minimize seed loss.

### Data Collection

Data were recorded from randomly selected plants in each experimental unit for the following growth and yield parameters. Plant height was measured at physiological maturity from the base of the plant to the tip of the main stem using a measuring tape, and the average value was recorded. The number of days from sowing to the stage when 50% of the plants in each plot had flowered was recorded. Days to maturity were determined by counting the number of days from sowing until physiological maturity of the plants. The number of branches arising from the main stem of randomly selected plants was counted and averaged. The total number of capsules was counted from ten randomly selected plants per plot, and the mean value was calculated. Ten capsules from randomly selected plants in each plot were used to determine the average number of seeds per capsule. The 1000 seeds weight one thousand seeds were randomly sampled from each treatment and weighed using a sensitive digital balance. Seed yield was determined by harvesting plants from a 1 m² area in each plot at maturity. Seed weight was recorded and converted to kilograms per hectare (kg/ha). Biological yield was measured by harvesting all aboveground biomass from a 1 m² area of each plot at maturity. The harvested

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materials were dried and weighed, and the values were converted to kilograms per hectare (kg/ha). Harvest index was calculated using the following formula:
Harvest index = seed yield/ Biological yields*100

**Data Analysis**

The data were analyzed statistically using Statistical Tools for Agricultural Research (STAR).

## RESULTS AND DISCUSSION

The experiment was conducted in the Agriculture Faculty Research Farm at Kabul University. The results show that plant height, number of branches per plant, number of capsules per plant, number of seeds per plant, test weight, seed yield, biological yield, stover yield, and harvest index were significantly influenced by different concentrations of nitrogen. also observed the similar status seeing the increasing levels of nitrogen on various yield attributes.

**Plant height (cm)**

Findings in Table 1 show that plant height was significantly influenced by different levels of nitrogen ($P \leq 0.05$). The highest value for this trait (57.625cm) was observed at the fourth fertilization level (150 kg N/ha) compared to the first level (control), which resulted in the lowest average plant height (37.55cm). This may be attributed to the role of N in cell division and expansion in the meristematic tissues at the growing tips of the stem, leading to increased plant height. These findings are consistent with a major previous studied Sayram et al. (2024), who revealed that higher nitrogen rates resulted in greater plant height. Similarly, Homayoun et al. (2013) reported that plant height increased with rising nitrogen level.

**Number of Branches per Plant**

The results of the number of branches per plant at both locations in Table 1 show that different nitrogen levels had a significant effect ($P \leq 0.05$) on this trait. The highest average number of branches per plant (13.375 branches/plant) was observed at the fourth application rate (150 kg N/ha). In comparison, the lowest average (7.475 branches/plant) was noted in the control treatment. An increase in the number of branches per plant can be attributed to the role of nitrogen in enhancing vegetative growth, promoting meristematic cell division and elongation, and activating biological processes in the plant, including photosynthesis. Results are consistent with those stated by Krusk et al. (2025), who observed significant increases in the number of branches per plant with increasing nitrogen rates. The results also align with Al-Juheishy et al. (2024), who found that higher nitrogen levels increased vegetative growth, particularly the number of branches per plant.

**Length of Roots (cm)**

The results in Table 1 show significant differences among nitrogen fertilization levels in root length ($P \leq 0.05$). The maximum root length (29.325 cm) was noted at the third fertilizer rate. The lowest root length (17.90 cm) was observed at control. These findings are consistent with Xie et al. (2015), who reported that nitrogen application significantly influenced nitrogen accumulation and translocation within the plant, affecting growth dynamics including root development. Similarly, Hassen & SHAKER (2013) found that nitrogen fertilization significantly enhanced overall plant growth, including root-related traits due to improved nutrient availability.

**Number Capsule per plants**

In Table 1, the results show A significant difference among nitrogen fertilization levels in terms of the number of capsules per plant. The third fertilization level (100 kg N /ha) recorded the largest average number of capsules per plant, 342.75 capsules/plant. Compared to the control treatment (0 kg N/ha), which showed the lowest average (209.575) capsules per plant. These results are in agreement with several previous studies. For example, Dökülen (2024) reported that optimum level of nitrogen significantly improved yield components, including number of capsules per plant under dry conditions. Similarly, Xie et al. (2015) found that moderate nitrogen levels (around 90 kg /ha) maximized yield and reproductive efficiency.

**Number of Seeds per Capsule**

The results in Table 1 show significant differences among nitrogen fertilization levels in terms of the number of seeds per capsule. maximum number of seeds per capsule (11.625) was observed at the third fertilization level. In comparison, the lowest number of seeds per capsule (7.755) was recorded in the Control. The increase can be attributed to improved plant growth due to enhanced photosynthetic efficiency, resulting in a higher number of seeds for each capsule. These findings are in agreement with Al-Juheishy et al. (2024), who observed that a moderate nitrogen level (75 kg N/ha) significantly increased the number of seeds per capsule.

**Table 1: Effect of different nitrogen levels on growth attributes of flax.**

| Treatment | Plant height (cm) | Number of branches per plant | Length of roots (cm) | Number of capsules per plant | Number of seeds per plant |
|---|---|---|---|---|---|
| T1 | 37.55 d | 7.47 c | 17.90 d | 209.575 d | 7.7557 c |
| T2 | 43.15 c | 10.13 bc | 22.98 c | 272.85 c | 9.441 b |
| T3 | 49.48 b | 12.49 ab | 29.32 a | 342.75 b | 11.625 a |
| T4 | 57.62 a | 13.38 a | 24.75 b | 310.5 a | 10.35 b |
| LSD | 4.3415 | 2.7029 | 0.6382 | 57.5672 | 1.2343 |
| CV (%) | 5.78 | 15.55 | 1.68 | 1.34 | 7.88 |

**1000 Seed weight (g)**

The results of 100 weights in Table 2 showed significant differences among nitrogen fertilization levels in 1000-seed weight ($P \leq 0.05$). The highest average weight (5.865 gr) was recorded at the third fertilization level. Whilst the lowest average weight (5.61g) was observed in the no-fertilization treatment. These findings are consistent with Al-Juheishy et al. (2024), who reported that moderate nitrogen levels significantly enhanced 1000-seed weight along with other yield components. Similarly, Sayram et al. (2024) observed that increasing nitrogen levels improved 1000-seed weight, with the highest values recorded at optimal nitrogen application.

**Grain yields (kg/ha)**

The third nitrogen fertilization rate greatly outperformed the others, according to the data in Table 2, showing third fertilization rate produced the highest seed yield of 1341.75 kg/ha. On the other hand, the lowest seed yield was recorded at 1038.5 kg/ha with no nitrogen addition. The increase in seed yield can be attributed to higher number of capsules/plant, number of seeds/capsule, and 1000-seed weight, which positively impacted seed yield. These findings are in agreement with Dökülen (2024), who reported that moderate nitrogen levels (100–130 kg N/ha) were most effective in improving seed and oil yield of flax under dry conditions.

**Biological yields (kg/ha)**

The results of biological yields in Table 2 show significant differences among nitrogen fertilization levels in terms of biological yield. The highest biological yield (5269.25kg/ha) was recorded at the fourth fertilization level (150 kg/ha). Whilst the lowest average biological yield (4033.25 kg/ha) was observed in the no-fertilization treatment. These findings are in agreement with those of Demirbaş et al. (2023), who reported that biological yield significantly increased with increasing nitrogen levels. Similarly, Zemolin et al. (2023) observed a linear increase in plant dry mass with higher nitrogen doses in flax across different environments.

**Straw yield (kg/ha)**

The results of straw yields in Table 2 show significant differences among nitrogen fertilization levels in straw yield. The highest straw yield (3815 kg/ha) was recorded at the fourth fertilization level (150 kg/ha). While the lowest straw yield (3225 kg/ha) was observed under control. The present results are also consistent with Osmari et al. (2019), who found that nitrogen fertilization increased biomass production and yield components, including straw yield. Likewise, Zemolin et al. (2023) reported a linear increase in plant dry mass with increasing nitrogen doses, supporting the observed increase in straw yield in the current study.

**Harvest Index (%)**

The results in Table 2 show significant differences among nitrogen fertilization levels in harvest index; the highest harvest index (24.64166232) was recorded at the third fertilization level (100 kg/ha). Whilst the lowest average harvest index (23.63067304) was observed in the no-fertilization.

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**Table 2. Effect of different levels of nitrogen on yield attributes of flax.**

| Treatment | 1000 seeds weight | Grain yield (kg/ha) | Biological yield (kg/ha) | Straw yield (kg/ha) | Harvest index (%) |
|---|---|---|---|---|---|
| T1 | 5.61 b | 1038.5 c | 4033.25 d | 3225 d | 23.63 d |
| T2 | 5.71 b | 1185.25 bc | 4455.5 c | 3465 c | 23.57 c |
| T3 | 5.865 a | 1425 a | 4941.75 b | 3705 b | 24.64 a |
| T4 | 5.685 b | 1341.75 ab | 5269.25 a | 3815 a | 23.85 b |
| LSD | 0.1221 | 168.9311 | 320.4106 | 12.5045 | 0.4959 |
| CV (%) | 1.34 | 8.46 | 4.28 | 0.2201 | 1.31 |

## CONCLUSION

From this result, it can be concluded that the results of the present study show that the application of 150 kg N/ha nitrogen significantly increased plant number, number of branches per plant, biological yields, and straw yields. Application of 100 kg N/ha significantly increased yield parameters and yield components such as number of capsules per plant, number of seeds per capsule, 1000 seed weight, grain yields, and length of roots. In general, all growth and yield attributes improved with increasing nitrogen levels up to 100 kg N/ha. However, further increase to 150 kg N/ha did not consistently improve yield components and in some cases led to a reduction in seed-related traits. The application of 100 kg N/ha consistently produced the highest values for most yield components, including number of capsules per plant, number of seeds per capsule, 1000-seed weight, and grain yield, indicating that it is the optimum nitrogen level under the conditions of this study. Although 150 kg N/ha produced the highest vegetative growth (plant height, biomass, and straw yield), it did not result in the highest grain yield, suggesting that excessive nitrogen may promote vegetative growth at the expense of reproductive performance. Overall, it can be concluded that balanced nitrogen application is essential for achieving optimum growth and maximum economic yield of flax, and 100 kg N/ha is the most effective rate under Kabul conditions.

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