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Effect of Nitrogen and Potassium Concentrations on the Development and Productivity of Linseed (Linum Usitatissimum L.)

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ABSTRACT:

The research was carried out at SAU, Tando Jam. Our findings revealed notable differences in flaxseed growth and yield. We evaluated the impact of different N levels and potassium levels of 55 kg/ha and 55 kg/ha on the growth and yield of line seed. The study employed nine distinct potassium and nitrogen concentrations, and applied the subsequent treatments to the variety PR-75. T1 is the control group that doesn't use fertilizers. T2 is equal to 30 kg/ha (N) plus 20 kg/ha (K), T3 is equal to 35 kg/ha (N) plus 25 kg/ha (K), T4 is equal to 40 kg/ha (N) plus 30 kg/ha (K), T5 is equal to 45 kg/ha (N) plus 35 kg/ha (K), T6 is equal to 50 kg/ha (N) + 40 kg/ha (K), T7 is equal to 55 kg/ha (N) + 45 kg/ha (K), T8 is equal to 60 kg/ha (N) + 50 kg/ha (K), T9 is equal to 65 kg/ha (N) + 55 kg/ha (K). The present study's results indicate that T9, which is equivalent to 65 kg/ha (N) + 55 kg/ha (K), yielded the best results, exhibiting a maximum plant height of 95.00, the highest number of branches (5.70), a dry weight (g/plant) of 12.53, and the highest crop growth rate (g/m2/day). The results indicate a relative growth rate of the plant (g/g/day) of 0.018. The test weight (g) was 8.76, the seeds/capsule ratio was 9.40, the number of capsules per plant was 45.00, the seed yield (t/ha) was 1.19, and the stove yield (t/ha) was 0.5. It is concluded that administering 65 kg/ha of nitrogen and 55 kg/ha of potassium exhibited advantageous effects on both the growth and yield of flaxseed, surpassing the untreated control group, which received no fertilization.

Keywords: nitrogen, potassium, concentration, productivity, linseed.

1. Introduction

Linseed (*Linum usitatissimum*) is an annual herb belonging to the *Linaceae* family. The Mediterranean region extensively cultivates it for its edible oil, durable fiber, food, and medicinal benefits [1]. Farmers primarily grow linseed for its seeds and oil, which makes it significant in oil production and the food industry. It contains essential polyunsaturated fatty acids, such as linoleic acid, and high levels of soluble dietary fiber, both of which offer additional health benefits [2]. As a multipurpose oilseed plant, linseed is also a valuable source of feed and seeds [3]. Flax's high content of protein, lignans, fiber, and linolenic acid-rich oil contributes to its rising demand [4]. Researchers have reported that consuming flax seeds or flaxseed oil enhances cardiovascular health and offers benefits for cancer, inflammatory diseases, and neurological and hormonal disorders [5]. Pakistan primarily cultivates flax for its seeds, from which it extracts oil. After extracting the fiber, you can pulp the residual material to manufacture paper and strawboard. Paints, varnishes, cloth, and linoleum production use linseed oil. The by-product, oil cake or meal, serves as cattle feed and manure, enhancing soil fertility over time. Linseed seeds contain 32%–34% oil, and the straw yields high-quality fiber. Linseed holds significant economic value due to the commercial utility of its oil and fibers. Medical practitioners use linseed oil as a demulcent, emollient, and laxative, administering it orally for bronchial infections and diarrhea. It also finds commercial use in soap manufacturing [6]. Nitrogen is an important fundamental component of chlorophyll and proteins. Its importance extends to ensuring the proper functioning of carbohydrate and protein metabolism, as highlighted in research by [7]. A high amount of nitrogen increases the vegetative mass of flax and the thickness of the stems, but increasing the amount of woody core reduces the yield and quality of fibers. This diminishes the suitability of flax fibers as a raw material for yarn and fabric manufacturing, complicating further fiber processing. Phosphorus has a positive influence on root development and fiber strength, as well as seed formation. Meanwhile, potassium promotes fiber and seed formation, strengthens the bonds among fiber bundles, and makes the stems easier to process technically [8]. This study investigated various growth parameters, such as plant height (measured in centimeters), number of branches per plant, dry weight per plant (measured in grams), crop growth rate (CGR) (measured in grams per square meter per day), and relative growth rate (RGR) (measured in grams per gram per day). Rising concentrations of nitrogen and phosphorus significantly influenced the growth of linseed. The aim of this study was to examine the combined effect of nitrogen and potassium on linseed when applied in appropriate quantities, as recommended for normal soils.

2. Material and Methods

The research was carried out at the student-operated farm within the Agronomy Department at SAU in Tando Jam. Its objective was to evaluate the impact of various fertilizers on the growth and yield of linseed crops. The trial employed a RCBD design, with each plot measuring 4x5 meters (20 m2). The sowing date of the current study was 15 October. 2022. The land preparation adhered to the recommended practices for linseed cultivation. The seed had been sown using a drilling method. The growth period of a linseed (flaxseed) crop generally spans 90 to 120 days, influenced by factors like weather conditions, soil quality, and the specific linseed variety. As a cool-season crop, linseed thrives best in temperate climates with moderate temperatures and sufficient moisture. The study focused on the PR-75 variety and was replicated three times to ensure precision. Throughout this study, during seeding, nitrogen and potassium were applied to different stages of linseed. The fertilizer was used one month after the sowing of the plant and during the 1st flowering stage, after the seedlings had emerged. The fertilizer should provide nitrogen and potassium, with the broadcasting method in the form of urea and muriate of potash. The current study was harvested in March 2023. The progress of plant growth and development was vigilantly tracked by selecting five plants from each plot every five days during the initial 10 days following crop emergence.T1 control group without any fertilizers.

1. T2 = 30 (N) kg/ha + 20 (K) kg/ha
2. T3 = 35 (N) kg/ha + 25 (K) kg/ha
3. T4 = 40 (N) kg/ha + 30 (K) kg/ha
4. T5 = 45 (N) kg/ha + 35 (K) kg/ha
5. T6 = 50 (N) kg/ha + 40 (K) kg/ha
6. T7 = 55 (N) kg/ha + 45 (K) kg/ha
7. T8 = 60 (N) kg/ha + 50 (K) kg/ha
8. T9 = 65 (N) kg/ha + 55 (K) kg/ha

The parameters were recorded one month before harvesting of the plant, including plant height, dry weight, crop growth rate, and relative growth rate, whereas following all The parameters were calculated after harvesting of the plant, including the average number of **seeds/capsules, capsule/plant, test weight (g), seed yield (t/ha), and stover yield (t/ha).**

Collect a random sample of mature capsules from the linseed plant.

1. Count the total number of seeds in each capsule.
2. Calculate the average number of seeds per capsule by dividing the total number of seeds by the number of capsules in the sample.

Formula: Seeds/Capsule=Total number of seeds Number of capsules Seeds/Capsule = Number of capsules Total number of seeds

Example: If you count 750 seeds in 100 capsules, the average seeds per capsule would be 750100=7.5100750=7.5 seeds/capsule.

Capsule/Plant:

1. Select a random sample of mature linseed plants.
2. Count the total number of capsules on each plant.
3. Calculate the average number of capsules per plant by dividing the total number of capsules by the number of plants in the sample.

Formula: Capsule/Plant = Total number of capsules Number of plants Capsule/Plant = Number of plants Total number of capsules

Example: If you count 500 capsules on 20 plants, the average capsules per plant would be 50020 = 2520500 = 25 capsules/plant.

Test Weight (g):

1. Collect a random sample of linseed seeds.
2. Weigh the sample using a precision scale.
3. Calculate the test weight (also known as the thousand-seed weight) by dividing the weight of the sample by the number of seeds in the sample, multiplied by 1,000.

Formula: Test Weight (g) = (Weight of sample) Number of seeds in sample: 1,000 Test Weight (g) = (Number of seeds in sample) Weight of sample: 1,000

Example: If the weight of the sample is 25 grams and it contains 250 seeds, the test weight would be (25 g 250 seeds)<0xCB><0xA3>1,000=100(250 seeds)<0xCB><0xA3>1,000=100 grams per 1,000 seeds.

Seed Yield (t/ha):

1. Measure the area of the linseed plot (in square meters).
2. Collect the entire seed harvest from the plot.
3. Weigh the seed harvest using a precision scale.
4. Calculate the seed yield in tons per hectare (t/ha) by dividing the weight of the seed harvest by the area of the plot, multiplied by 10 (to convert from square meters to hectares).

Formula: Seed Yield (t/ha) = (Weight of seed harvest Area of plot) * 10 Seed Yield (t/ha) = (Area of plot) Weight of seed harvest (10

Example: If the weight of the seed harvest is 2,500 kilograms and the plot area is 1,000 square meters, the seed yield would be (2,500 kg, 1,000 m2)/10=2.5(1,000 m, 22,500 kg)/10=2.5 t/ha.

Stover Yield (t/ha):

1. Measure the area of the linseed plot (in square meters).
2. Collect the entire stover (plant residue) from the plot.
3. Weigh the stover using a precision scale.
4. Calculate the stover yield in tons per hectare (t/ha) by dividing the weight of the stover by the area of the plot, multiplied by 10 (to convert from square meters to hectares).

Formula: Stover Yield (t/ha) = (Weight of stoverArea of plot) / 10 Stover Yield (t/ha) = (Area of plot) Weight of stover: 10

Note: These calculations assume a random and representative sample of the linseed crop. Actual values may vary depending on factors such as crop variety, growing conditions, and environmental factors.

Chemical Characters of Soil

Organic Manure	0.79%
Nitrogen	0.38%
Potassium	70.00 mg/kg
PH	7.40

4. Results

The information presented in Table 1 suggests that there are no notable distinctions between the plant populations at the beginning and end stages. This indicates that the treatments did not exert a significant influence on seed emergence or seedling survival rates. This observation aligns with the findings of [10], which demonstrated that different levels of nitrogen and potassium did not alter the number of plants per square meter in linseed crops.

Plant height (cm)

The utilization of applied fertilizers in linseed cultivation proved highly effective, particularly in enhancing physiological characteristics and yield. The utilization of nitrogen (N) and potassium (K) in Treatment 09 led to a notable rise in the maximum plant height when compared to alternative treatments (Control). The application of nitrogen and potassium to the foliage of linseed plants significantly and favorably impacted various physiological yields and characteristics of yield constituents. (Table 1). The growth of linseed, measured in centimeters, varies according to different nitrogen and potassium levels. Among the treatments, T9 with nitrogen at 65 kg/ha and potassium at 55 kg/ha resulted in the highest plant height, reaching

95.00 cm. Conversely, the T1 control group, lacking any fertilizers, recorded the lowest plant height of 80.50 cm.

Number of branches

Different levels of nitrogen and potassium affect the number of branches of linseed. We observed that the treatment T9, which consists of 65 kg/ha of nitrogen and 55 kg/ha of potassium, resulted in a maximum of 5.70 branches and a minimum of 4.11 branches of linseed, compared to T1, the control group that did not receive any fertilizers.

Dry weight (g/plant)

Different levels of nitrogen and potassium affect the dry weight (g/plant) of linseed. We noted the maximum number of branches at 12.53, the minimum dry weight (g/plant) of linseed at 8.12, and the treatments T9, which include 65 kg/ha of nitrogen and 55 kg/ha of potassium.

Crop Development Rate (g/m2/day)

Variations in nitrogen and potassium levels have an impact on the linseed crop growth rate, which is expressed in Crop Development Rate (g/m2/day). T9, which had 65 kg/ha of nitrogen and 55 kg/ha of potassium, had the most branches (5.36) of all the treatments. The T1 control group, without any fertilizers, recorded the minimum crop development rate (g/m2/day) of linseed at 3.19.

Relative Growth Rate (g/g/day)

Applications of nitrogen and potassium influence the relative growth rate of flaxseed, measured in grams per gram per day. In Treatment T9, which applied nitrogen at a rate of 65 kg/ha and potassium at a rate of 55 kg/ha, the maximum number of branches observed was 0.18. Meanwhile, T1, the control group without any fertilizers, recorded the lowest relative growth rate of flaxseed at 0.222 grams per gram per day.

Table. 1 Nitrogen and potassium concentrations on the development and productivity of Linseed

Treatments	**Plant heig (cm)**	**No. of brar**	**Dry Weigh (g/plant)**	**Crop Grow Rate (g/m2/c**	**Relative Growth (g/g/day)**
T1 control grou without any Fertilizers.	80.50	4.16	8.12	3.19	0.222
T2 = 30 (N) kg/h + 20 kg/h (K)	81.90	4.66	9.23	4.25	0.020
T3 = 35 (N) kg/h + 25 kg/h (K)	83.22	4.88	9.38	4.59	0.021
T4 = 40 kg/h (N) + 30 kg/h 1 (K)	85.11	5.00	9.55	4.66	0.013
T5 = 45 kg/h (N) + 35 kg/h (K)	87.98	5.11	10.11	4.77	0.011

T6 = 50 kg/h (N) + 40 kg/h (K)	90.10	5.20	11.79	4.88	0.020
T7 = 55 kg/h (N) + 45 kg/h (K)	92.76	5.30	11.17	5.00	0.014
T8 = 60 k kg/h (N) + 50 kg/h (K)	93.09	5.50	12.14	5.10	0.016
T9 = 65 kg/h (N) + 55 kg/h (K)	95.00	5.70	12.53	5.36	0.018
Sem (+)	0.67	0.03	0.164	0.50	0.00
C.D(P=0.05%)	2.055	0.10	0.44	1.49	0.01

Table 2 shows that the **seeds and capsules** of linseed are affected by different levels of nitrogen and potassium. The treatments T_9 = Nitrogen 65 kg/ha + 55 kg/ha potassium, the maximum number of branches 9.40, and the minimum seeds or capsules of linseed 7.18 were noted with the T1 control group without any fertilizers.

Capsule/Plant

The **capsule or plant** of linseed is affected by different levels of nitrogen and potassium affect the linseed capsule or plant. The treatments T_9 = Nitrogen 65 kg/ha + 55 kg/ha potassium, the maximum number of branches 45.00, and the minimum capsule/plant of linseed 30.33 were noted with the T1 control group without any fertilizers.

Test Weight (g)

The test weight (g) of linseed is affected by different levels of nitrogen and potassium. The T9 treatments (65 kg/ha of nitrogen and 55 kg/ha of potassium) had the most branches (8.76), and the linseed test weight (5.11) was the lowest. The T1 control group did not use any fertilizers.

Seed Yield (t/ha)

The tons per hectare of linseed that are produced depend on the different amounts of potassium and nitrogen. The highest number of branches seen in Treatment T9, 65 kg/ha of nitrogen and 55 kg/ha of potassium, was 1.19, and the lowest recorded linseed seed production was 0.75 tons per hectare with the T_1 control group without any fertilizers.

Stover Yield (t/ha)

Stover yield, measured in tons per hectare, is influenced by varying levels of nitrogen and potassium in the soil for linseed cultivation. In Treatment T9, where nitrogen was applied at a rate of 65 kg/ha along with 55 kg/ha of potassium, the maximum number of branches observed was 2.80, while the minimum stover yield of linseed was recorded at 1.80 tons per hectare. Conversely, the Treatment T_1 control group without any fertilizers

Table. 2 Nitrogen and potassium concentrations on the development and productivity of Linseed

Treatments	Seeds/Capsule	Capsules/ plant	Test Weight (g)	Seed Yield (t/ha)	Stover yield (t/ha)
T1 control group wit any Fertilizers.	7.18	30.33	5.11	0.75	1.80
T2 = 30 kg/h(N) + 20 kg/h (K)	7.21	35.11	6.50	0.78	2..00
T3 = 35 kg/h (N) + 25 kg/h (K)	7.25	36.60	6.90	0.80	2.15
T4 = 40 kg/h (N) + 30 kg/h (K)	7.45	38.64	7.11	0.85	2.21
T5 = 45 kg/h(N) + 35 kg/h (K)	7.66	40.22	7.45	0.90	2.34
T6 = 50 kg/h (N) + 40 kg/h (K)	7.90	41.95	7.77	1.01	2.41
T7 = 55 kg/h (N) + 45 kg/h (K)	8.22	42.88	7.90	1.09	2.45
T8 = 60 kg/ ha-1 (N) + 50 kg/ ha-1 (K)	9.00	43.55	8.10	1.12	2.55
T9 = 65 kg/h (N) + 55 kg/h (K)	9.40	45.00	8.76	1.19	2.80
Sem (+)	00.19	0.118	0.49	0.35	0.03
C.D(P=0.05%)	0.55	0.550	1.50	1.11	0.10

5. Discussion

The utilization of applied fertilizers in linseed cultivation proved highly effective, particularly in enhancing physiological characteristics and yield. The utilization of nitrogen (N) and potassium (K) in Treatment 09 led to a notable rise in the maximum plant height when compared to the alternative treatment control group without any fertilizers. This emphasizes the positive impact of the integrated fertilization method on the overall growth of plants. Notably, the combined application of nitrogen and potassium in Treatment 09 exhibited greater effectiveness. The findings showed that the combination application of fertilizer T9 (65 kg/ha nitrogen and 55 kg/ha potassium) produced the greatest benefits in plant height at maximum: 95.00 cm; 5.70 branches; 12.53 grams of dry weight per plant The following information is included: test weight (g); capsules/plant (45.00); relative growth rate (g/g/day): 0.018; crop growth rate (g/m2/day): 5.36; seed yield (t/ha); stover yield (t/ha); and test weight (g). The results are consistent with the deductions made by [9], who similarly observed that the use of fertilizer on saline, sodic soil resulted in enhancements in linseed's agronomic traits. These findings imply that Linseed plants readily absorb certain nutrients, particularly nitrogen and potassium, immediately after their application, as demonstrated in this study. Similarly, [10] reported that the plant density per square meter remained consistent regardless of the nitrogen application rates and their combinations in linseed cultivation. In a 2015 study on linseed, [11] and colleagues observed a significant decrease in growth parameters due to the absence of nitrogen (N0). Nitrogen plays a critical role in flax development by promoting the formation of protoplasm and protein structures. Consequently, this promotes cell division and meristematic activity, resulting in increased cell number and size. These mechanisms contribute to the overall growth of flax plants, ultimately resulting in increased fiber and seed production. Increased availability of nitrogen and nutrients leads to enhanced production of photosynthetic assimilates through enhanced photosynthesis rates, thereby improving growth factors. Additionally, studies conducted by [14] have shown that linseed crops with higher nitrogen levels exhibit a significant increase in the number of branches per plant. The study found that plant height and the number of branches per plant both increased [9]. These findings aligned with earlier studies conducted by [13] and [14]. Furthermore, the study emphasized the substantial influence of nitrogen (N) on the interaction effects within plant growth parameters. Potassium levels significantly influenced the plant's absorption of nitrogen and potassium. The plant's overall absorption of nitrogen and potassium increased steadily with each subsequent increase in potash levels. The augmented nutrient uptake at higher potash levels is likely due to the increased availability of potassium. [15] All studies [15] and [16] reported consistent results, demonstrating that increased levels of potassium, particularly potassium sulfate, exhibited enhancement in capsules per plant. These findings are in line with our own research. The elevation in growth indicators could stem from heightened nitrogen and other nutrient availability, resulting in enhanced production of photosynthetic assimilates due to increased photosynthetic rates. [17] Corroborated the correlation between increased plant height and higher nitrogen levels and improved vegetative growth. Additionally, potassium fertilizer plays a pivotal role not only in boosting yield but also in improving quality. The findings of [18] substantiate these assertions.

6. Conclusion

The results show that using 65 kg/ha of nitrogen and 55 kg/ha of potassium together greatly improves crop growth and development. This results in better plant height, branch number, capsule count, seed yield, and other growth-related traits compared to other treatment combinations. We observed that the increased amounts of nitrogen and potassium significantly impacted most growth- and yield-related characteristics, thereby contributing to the overall improvement and increased crop yield.

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