

The Effect of KNO_3 Fertilizer Dosage and Paclobutrazol Concentration on The Growth and Yield of Long Bean (*Vigna sinensis* L.)

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ABSTRACT

Long bean production has decreased in Indonesia due to uncertain seasonal factors, such as long dry seasons and short rainy seasons. Long bean production has decreased due to inappropriate and optimal cultivation techniques. Several efforts can be made to overcome the problem of decreasing long bean productivity by fertilizing and applying growth regulators. The aim of this research is to understand the combined effect of KNO_3 fertilizer doses and paclobutrazol concentrations on the growth and yield of long bean plants. This research was conducted in Ketawang Village, Nganjuk, East Java. The research was a factorial experiment with Split Plot Design consisted of two treatment levels, namely KNO_3 fertilizer dose (0 g/plant, 8 g/plant, 10 g/plant and 12 g/plant) and paclobutrazol concentration (0 ppm, 150 ppm, 175 ppm and 200 ppm). The combination of 10 g/plant KNO_3 + 150 ppm paclobutrazol influences the growth and yield of long bean plants, however the application of KNO_3 fertilizer alone has no effect on the growth and yield of long bean plants.

1. INTRODUCTION

There are various types of garden plants in Indonesia, one of which is long beans. Long Beans (*Vigna sinensis* L.) are vegetables that are commonly cultivated and consumed in Indonesia. The land area for planting long beans in Indonesia in 2023 is 43,998 ha, with a total harvest of 309,427 ton. In 2022, long beans will have a productivity value of around 360,871 ton/ha. Long bean production has decreased in Indonesia due to uncertain seasonal factors, such as long dry seasons and short rainy seasons (Suhaeni, 2007). The productivity level of long bean plants in Indonesia is only 6.79 ton/ha. The level of long bean productivity in Indonesia can be increased to reach 15-20 ton/ha, so that it can have an impact on increasing the income of Indonesian farmers (Hutapea et al., 2021). Various problems faced by long bean farmers have caused a decline in long bean production. Causes of decreased long bean production include climate, soil, fertilization, disease and insect pests. One way to increase long bean production is to improve fertilization techniques (Pertiwi et al., 2021).

Efforts that can be made to overcome the problem of decreasing long bean productivity are by fertilizing and applying growth regulators (ZPT). Growth Regulators (ZPT) are included in active organic compounds that play a role in stimulating, inhibiting and changing plant growth and development. ZPT is divided into two groups of properties, namely encouraging growth and inhibiting growth (Ramadhan, 2022). ZPT which has the property of inhibiting plant growth is paclobutrazol with gibberellin biosynthesis. Paclobutrazol applied to plants can suppress the growth of the vegetative phase, thereby speeding up the generative phase of the plant. The mechanism of action of paclobutrazol is to suppress the oxidation of kaurene to convert it into amino acids so that gibberellin production is inhibited

(Yutamimah, 2023). Inhibition of gibberellin production results in the rate of cell breakdown being reduced, growth in the vegetative phase being reduced, and through other means the translocation of assimilate will refer to the generative phase, namely flower formation and fruit development (Zulfita & Hariyanti, 2020).

An important role in cultivation activities is fertilization. Fertilizer is responsible for meeting the nutritional needs of plants so that they grow optimally. KNO_3 fertilizer or potassium nitrate fertilizer is a type of inorganic fertilizer that contains nutrients, namely potassium (44%) and nitrogen (13%) (Pitaloka *et al.*, 2023). The potassium element contained in KNO_3 fertilizer plays a role in accelerating the rate of synthesis and translocation of starch (carbohydrates) to storage organs so that cell wall thickness can increase and stem strength (Syahrullah, 2015). The role of nitrate (NO_3^-) in KNO_3 fertilizer is to help absorb potassium nutrients and other elements in the soil, so that it can speed up the fertilization process. It is hoped that administering doses of KNO_3 fertilizer and Paclobutrazol ZPT with different concentrations can be a solution in overcoming the problem of decreasing long bean crop yields. The aim of this research is to understand the combined effect of KNO_3 fertilizer doses and paclobutrazol concentrations on the growth and yield of long bean plants.

2. RESEARCH MATERIALS AND METHODS

The research was conducted in December 2023 – March 2024 in Ketawang Village Land, Nganjuk, East Java, which is located at an altitude of ± 85 meters above sea level. The materials used during the research were long bean seeds of the Parade Tavi variety, KNO_3 fertilizer, and paclobutrazol GoBest 250 sc. A factorial experiment was performed using the Split Plot Design with 2 treatment factors, namely the dose of KNO_3 (K) fertilizer consisting of 4 levels and the concentration of Paclobutrazol (P) consisting of 4 levels. The detail is presented in Table 1. Each treatment combination was carried out in triplicates, so that 48 experimental units were prepared.

Table 1. Dosage of KNO_3 fertilizer and concentration of paclobutrazol applied in the experiment

Dose of KNO_3 (K) fertilizer	Concentration of paclobutrazol (P)
K0 = 0 kg/ha + NPK 300 kg/ha, equivalent to 12 g/plant	P0 = 0 ppm
K1 = 200 kg/ha, equivalent to 8 g/plant	P1 = 150 ppm
K2 = 250 kg/ha, equivalent to 10 g/plant	P2 = 175 ppm
K3 = 300 kg/ha, equivalent to 12 g/plant	P3 = 200 ppm

2.1. Application of KNO_3 Fertilizer

KNO_3 fertilizer was applied when long bean plants enter the generative phase, namely 14 day after planting (DAP), 28 DAP, and 42 DAP. The KNO_3 fertilizer was applied at three different doses, namely 200 kg/ha, 250 kg/ha and 300 kg/ha. KNO_3 fertilizer was sowed around the long bean plants according to planned doses. For control treatment (K_0) only NPK Phonska fertilizer at a dose of 300 kg/ha was given weekly to the plants 6 times, at 14 DAP to 42 DAP.

2.2. Application of Paclobutrazol

Paclobutrazol was applied 3 times at 20 DAP, 30 DAP and 40 DAP. The application of paclobutrazol was carried out by spraying evenly over all parts of the long bean plant. Paclobutrazol was applied according to the treatment levels, namely 0 ppm, 150 ppm, 175 ppm and 200 ppm. The application of paclobutrazol was carried out in the morning, namely at 07.00–10.00.

2.3. Observation Parameters

- Plant length: measure the length of the long bean plant starting at 14 to 49 DAP at 7 day intervals.
- Number of leaves: count the number of leaves of the long bean starting at 14 to 49 DAP at 7 day intervals.
- Age of flower appearance: counting the DAP of the first flower to bloom on each plant.
- Number of flowers: count the number of flowers formed on each plant starting at age 35 DAP.

- e. Number of pods for each long bean plant: count all the long bean fruit harvested twice a week.
- f. Pod weight of each long bean plant: weigh all the harvested long bean pods.
- g. Weight of long bean pods for each plot: calculate weigh the harvested long bean pods for each plot.
- h. Total weight of long bean pods: adding up the total weight of all harvests and converted into ton/ha.
- i. Pod length: measure the length of the pod using a tape measure.
- j. Fruit set: the percentage of blooming flowers that successfully become long bean fruit in each plant.

$$\text{Fruit Set (\%)} = \frac{\text{Number of harvested pods}}{\text{Number of white flowers}} \times 100\% \quad (1)$$

The collected data was analyzed using linear model analysis of variance (ANOVA). If there is a significant difference, a 5% Honestly Significant Difference (HSD) test was then carried out.

3. RESULTS AND DISCUSSION

3.1. Long Bean Plant Length

The combination treatment of KNO₃ fertilizer dose with paclobutrazol concentration had a significant difference in plant length (cm) of long beans aged 35 DAP. Table 2 shows that the combination treatment of KNO₃ fertilizer dose and paclobutrazol concentration had a significant difference in plant length (cm) of long beans aged 35 DAP. The largest mean length of long bean plants at 35 DAP was 177.94 cm in the treatment combination of 10 g/plant KNO₃ + 150 ppm paclobutrazol, while the lowest plant length was in the combination of 12 g/plant KNO₃ + 175 ppm paclobutrazol. Providing KNO₃ with essential nutritional content, namely potassium and nitrogen, can be used to induce fruit plants because it can break the dormancy of flower buds. It was further stated that KNO₃ is a dormancy-breaking substance that is effective in overcoming the dormancy of generative buds which is shown by the induced buds that can develop to produce flowers (Hendrajaya *et al.*, 2019). Treatment without paclobutrazol or 0 ppm paclobutrazol had a significant effect on long bean plant length, which had the highest average plant length compared to paclobutrazol concentrations of 150, 175 and 200 ppm. Giving paclobutrazol at different concentrations produces different responses, the higher the concentration given, the lower the height of the plants (Marshel *et al.*, 2015).

Table 2. Interaction impact of KNO₃ fertilizer dosage and Paclobutrazol concentration on long bean height (cm)

Age	KNO ₃ Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
		0	150	175	200
35 DAP	0	174.43 cdef	153.06 ab	144.10 a	172.89 bcdef
	8	174.03 cdef	176.67 cdef	165.03 bcde	159.97 abcd
	10	187.66 f	177.94 def	176.47 cdef	163.24 abcde
	12	191.09 f	166.67 bcde	156.78 abc	181.75 ef
LSD 5%		19.94			

Note: The 5% LSD test shows no significant differences between the means equivalent to age and treatment conditions.

Table 3 shows that the dose of KNO₃ fertilizer has a significant effect on plant length (cm) of long beans aged 14 DAP. The average result of the longest plant length (cm) was the treatment of 8 g/plant KNO₃, namely 36.04 cm. Application of a single concentration of paclobutrazol had a significant effect on plant length (cm) of long beans aged 28, 42 and 49 DAP. The results of the longest average plant length (cm) in sequence in the 0 ppm paclobutrazol treatment were 150.66 cm, 207.17 cm and 215.83 cm. In accordance with research by Safitri (2023), the length of long bean plants aged 28, 35, 42 and 49 DAP in the 0 ppm paclobutrazol treatment showed the largest average plant length compared to 150, 175 and 200 ppm. The plant length in sequence was 92.67; 121.72; 162.11; and 192.06 cm.

Treatment without paclobutrazol or 0 ppm paclobutrazol had a significant effect on long bean plant length. Plant growth and development is the role of ZPT or growth regulators. Paclobutrazol is a type of phytohormone that has inhibitory (retardant) properties to restrain vegetative growth in plants so that photosynthesis is used for fruit and flower formation (Ardigusa & Dewi Sukma, 2015).

Table 3. Effect of KNO₃ fertilizer dosage and Paclobutrazol concentration on long bean height (cm)

Treatment	Plant Length (cm)				
	14 DAP	21 DAP	28 DAP	42 DAP	49 DAP
KNO ₃ Fertilizer Dosage (g/plant)					
0	34.33 c	79.18 a	128.39 a	198.14 a	208.06 a
8	36.04 d	88.28 a	126.05 a	191.98 a	201.24 a
10	34.04 b	84.83 a	129.18 a	204.03 a	204.00 a
12	30.50 a	77.79 a	123.69 a	200.87 a	208.31 a
LSD 5%	2.06	ns	ns	ns	ns
Paclobutrazol concentration (ppm)					
0	34.19 a	86.14 a	150.66 b	207.17 b	215.83 b
150	34.13 a	86.42 a	115.84 a	188.64 a	199.92 a
175	33.29 a	75.35 a	115.85 a	204.82 b	200.67 a
200	33.31 a	82.18 a	124.96 a	194.39 a	205.18 a
LSD 5%	ns	ns	17.37	8.92	5.99

Note: Different letters following mean values at the same column mean significantly different based on HSD test at $\alpha = 5\%$ (ns = not significant).

3.2. Number of Long Bean Leaves

The combination treatment of KNO₃ fertilizer dose with paclobutrazol concentration had a significant difference in the number of long bean leaves (strands) at the ages of 28, 35, 42 and 49 DAP. The largest number of leaves (strands) of long bean plants aged 28 DAP was 16.72 pieces in the treatment combination of 10 g/plant KNO₃ + 0 ppm paclobutrazol and 12 g/plant KNO₃ + 200 ppm paclobutrazol. The number of leaves on a plant and the rate of photosynthesis are interconnected. The more leaves you have, the higher the photosynthesis rate. The addition of N elements in the soil is related to the formation of chlorophyll in the leaves, which then increases the photosynthesis process and encourages the growth of the number of plant leaves (Dendi & Putra, 2019). The N element contains ATP and ADP which have an important role in photosynthesis, ion absorption and leaf development (Kusuma, 2017).

Table 4. Interaction effect of KNO₃ fertilizer dose and Paclobutrazol concentrations on the number of leaves

Age	KNO ₃ Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
		0	150	175	200
28 DAP	0	14.11 abcd	13.11 ab	14.28 abcd	16.00 ef
	8	15.39 de	14.78 cde	13.83 abc	14.28 abcd
	10	16.72 f	15.33 de	14.22 abcd	14.56 cd
	12	13.00 a	13.11 ab	14.33 bcd	16.72 f
	LSD 5%	1.30			
35 DAP	0	25.44 fg	20.11 a	23.61 cde	24.78 efg
	8	23.06 bcd	23.67 cde	21.72 ab	26.33 g
	10	25.44 fg	20.83 a	24.39 def	23.61 cde
	12	22.61 bc	20.83 a	22.72 bcd	25.00 efg
	LSD 5%	1.71			
42 DAP	0	28.78 abcdef	29.50 bcdef	31.72 f	31.39 ef
	8	27.66 ab	27.89 abc	26.44 a	30.78 cdef
	10	30.94 def	28.67 abcde	26.78 ab	26.78 ab
	12	27.17 ab	28.78 abcdef	31.17 def	28.17 abcd
	LSD 5%	3.00			
49 DAP	0	31.89 ab	33.00 abcd	36.11 e	35.06 de
	8	31.67 a	31.89 ab	31.50 a	34.33 bcde
	10	34.50 cde	31.33 a	31.17 a	31.67 a
	12	32.78 abcd	31.28 a	32.22 abc	31.11 a
	LSD 5%	2.57			

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

3.3. Flower Appearance Age (days)

The treatment of KNO₃ fertilizer dose and paclobutrazol concentration each also had a significant difference in the flower emergence age (days) of long bean plants (Table 5). The fastest average age for flower emergence (days) for long bean plants was 30.67 DAP in the combination of 8 g/plant KNO₃ + 175 ppm paclobutrazol. Providing paclobutrazol with a concentration of 175 ppm can stimulate flower formation more quickly and also increase the number of flowers on long bean plants. Application of the growth regulator paclobutrazol to plants can speed up the flowering process and produce more fruit and flowers (Hidayat, 2022). This occurs because paclobutrazol stops gibberellin synthesis. According to Koryati & Tistama (2020), the mechanism of action of paclobutrazol is to inhibit gibberellin biosynthesis. Inhibition occurs in the caurenate formation pathway, so that this pathway switches its role to carrying out the biosynthesis of abscisic acid.

Table 5. Interaction effect of KNO₃ fertilizer dose and Paclobutrazol concentrations on the flowers appearance (day)

KNO ₃ Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
	0	150	175	200
0	35.33 h	34.00 efg	33.33 def	33.00 cde
8	34.33 fgh	35.33 h	30.67 a	34.33 fgh
10	35.33 h	31.67 ab	32.00 bc	34.67 gh
12	32.33 bcd	34.67 gh	31.67 ab	31.67 ab
LSD 5%	1.05			

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

Table 6. Interaction effect of KNO₃ fertilizer dose and Paclobutrazol concentrations on the number of flowers

KNO ₃ Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
	0	150	175	200
0	46.11 ab	42.22 a	42.89 ab	42.78 a
8	43.89 ab	40.78 a	55.45 b	44.78 ab
10	45.55 ab	41.22 a	45.11 ab	44.11 ab
12	44.11 ab	43.78 a	47.89 ab	40.33 a
LSD 5%	8.20			

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

3.4. Number of Long Bean Flowers

The combination of KNO₃ fertilizer dose with paclobutrazol concentration had a significant difference in the number of flowers on long bean plants (Table 5). The largest value for the number of flowers on long bean plants was 55.45 flowers in the treatment combination of 8 g/plant KNO₃ + 175 ppm paclobutrazol. The availability of nitrogen from KNO₃ can accelerate flower formation and increase the number and size of flowers. Plants need nitrogen for the formation of basic structures such as leaves and stems, which can then help produce more and bigger flowers. Supporting plant growth apart from applying fertilizer is the application of phytohormones. Paclobutrazol is a type of phytohormone that has the role of inhibiting gibberellin biosynthesis, thereby preventing stem elongation and being allocated to trigger flower formation (Aritonang, 2018). The treatment dose of KNO₃ fertilizer of 200 kg/ha had the highest value at cob length of 20.11 cm, cob diameter of 47.9 cm, cob weight of 204.60 grams, and production per hectare of 13.63 tons/ha (Irawan *et al.*, 2023).

3.5. Pods of each Long Bean Plant

The combination treatment of KNO₃ fertilizer dose with paclobutrazol concentration had a significant difference in the number of pods per long bean plant (Table 7). The largest pod value per long bean plant was 33.06 pods in the treatment combination of 8 g/plant KNO₃ + 175 ppm paclobutrazol. In this combination, there is a balance in the availability of the nutrients nitrogen and potassium with the phytohormone paclobutrazol which can trigger the generative growth of long bean plants. Paclobutrazol works optimally in increasing plant yields at a concentration of

Table 7. Interaction effect of KNO₃ fertilizer dose and Paclobutrazol concentrations on the number of pods per plant

KNO ₃ Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
	0	150	175	200
0	32.11 cde	33.06 e	29.78 abc	31.22 abcde
8	30.72 abcde	29.44 a	32.44 de	30.89 abcde
10	30.27 abcd	30.00 abc	30.77 abcde	31.88 bcde
12	30.11 abcd	30.55 abcd	30.67 abcde	29.55 ab
LSD 5%	2.41			

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

150 ppm, however increasing higher concentrations can cause delays in fruit formation and reduced yields (Sugiharto *et al.*, 2022).

Addition of paclobutrazol affects growth in line with increasing concentration and is allocated to increasing yield up to a certain level. A paclobutrazol concentration of 100 ppm showed the largest pod yield of 31.06 pods, followed by a concentration of 200 ppm 28.25 pods, 0 ppm 27.25 pods and the one with the lowest value of 300 ppm 25.99 pods (Zulfaniah *et al.*, 2020). Thus, it shows that the optimum concentration of paclobutrazol for increasing the number of edamame soybean pods is a concentration of 100 - 200 ppm. Paclobutrazol had a positive effect on yield parameters but an opposite effect on vegetative growth. So it can be stated that the application of paclobutrazol is beneficial in the generative phase, especially in terms of the number of plant pods (Harpitaningrum *et al.*, 2017).

3.6. Pod Weight per Long Bean Plant

The combination treatment of KNO₃ fertilizer dose with paclobutrazol concentration had a significant difference in the pod weight of each plant (grams) of long beans. Table 8 shows that the combination treatment of KNO₃ fertilizer dose and paclobutrazol concentration had a significant effect on the pod weight of each plant (grams) of long beans. The largest value of pod weight per plant (grams) for long beans was 820.67 grams in the treatment combination of 10 g/plant KNO₃ + 150 ppm paclobutrazol. The smallest value of pod weight per plant (grams) for long beans was 571.33 grams in the treatment combination of 12 g/plant KNO₃ + 200 ppm paclobutrazol.

Table 8. Interaction effect of KNO₃ fertilizer dose and Paclobutrazol concentrations on the pod weight (g/plant)

KNO ₃ Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
	0	150	175	200
0	843.00 abc	853.67 abc	771.67 ab	962.67 c
8	817.67 abc	728.33 ab	747.00 ab	780.00 ab
10	799.00 b	820.67 abc	735.67 ab	715.00 ab
12	765.00 ab	764.33 ab	724.33 ab	571.33 a
LSD 5%	157.15			

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

The largest pod weight value per plant was in the combination of 10 g/plant KNO₃ + 150 ppm paclobutrazol. The increase in the number of pods indicates that vegetative growth is inhibited because paclobutrazol does not reduce the yield of long bean plants. This is thought to be due to photosynthetic assimilation allocated to the generative sink organs of the plant for fruit formation. Therefore, a paclobutrazol concentration of 150 ppm can accelerate the development of generative organs in long bean plants. A paclobutrazol concentration of 150 ppm is the best concentration because it can increase the number of flowers, number of pods planted, weight of pods planted, and weight of fruit per plot (Safitri, 2023).

3.7. Weight of Pods per Plot

The combination treatment of KNO₃ fertilizer dose with paclobutrazol concentration had a significant difference in the pod weight of each plot (kg) of long bean plants (Table 9). The pod weight value per plot (kg) of long bean plants was

the largest due to the combination of KNO₃ fertilizer dose and paclobutrazol concentration, namely 6.64 kg in the treatment combination of 10 g/plant KNO₃ + 200 ppm paclobutrazol. The smallest total pod weight value per plot (kg) for long bean plants was 4.57 kg in the treatment combination of 12 g/plant KNO₃ + 200 ppm paclobutrazol. Plants that receive adequate nutrition have the potential to produce higher yields. When plants have an adequate supply of nutrients from soil or fertilizer, plants can use energy and resources to produce maximum yields. Potassium is very important for fruit formation or the generative phase (Issukindarsyah *et al.*, 2022). This is because potassium plays a crucial role in carbohydrate transport, thus, the use of KNO₃ fertilizer can increase this flow resulting in an increase in fruit weight (Pitaloka *et al.*, 2023).

Table 9. Interaction effect of KNO₃ fertilizer dose and Paclobutrazol concentrations on the pod weight (kg/plot)

KNO ₃ Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
	0	150	175	200
0	6.71 abcd	7.01 cd	6.17 abc	7.72 d
8	6.54 abcd	5.83 abc	5.96 abc	6.42 abc
10	6.24 abc	6.64 abcd	5.91 abc	5.64 ab
12	6.51 abc	6.11 abc	6.55 abcd	4.57 a
LSD 5%	1.19			

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

3.8. Long Bean Pod Weight

The combination treatment of KNO₃ fertilizer dose with paclobutrazol concentration had a significant difference in the weight of pods in hectares (tons) of long bean plants (Table 10). The largest pod weight value for hectares (tons) of long bean plants was 20.52 ton/ha in the treatment combination of 10 g/plant KNO₃ + 150 ppm paclobutrazol. This is believed to be because paclobutrazol inhibits plant growth mechanisms, allowing plants to accumulate more carbohydrates and speeding up the flowering and fruiting process (Dini *et al.*, 2022). The highest productivity of long beans in Nganjuk City in 2021 was around 13.0 to 18.5 ton/ha (BPS, 2022). Compared with the research results, it appears that the combination of treatments is able to increase the productivity of long bean plants, because it is supported by the use of KNO₃ and Paclobutrazol fertilizers. Giving paclobutrazol also accelerates flowering, increases the number of flowers and the number of fruit. Paclobutrazol, a growth regulator, is absorbed through the roots, stems, and leaves, and spreads to the shoot meristem tissue. Paclobutrazol induces flowering by suppressing vegetative growth. If this happens, the plant enters the generative phase, namely flowering (Gultom, 2016). Increased plant production is supported by several factors, namely genes, environment, flowering, stressors and so on which are interconnected. Paclobutrazol is a retardant, if used in too high a concentration it can result in less than perfect pods appearing and not being able to grow into perfect pods.

Table 10. Interaction effect of KNO₃ fertilizer dose and Paclobutrazol concentrations on the pod weight (ton/ha)

KNO ₃ Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
	0	150	175	200
0	21.08 abc	21.34 abc	19.29 ab	24.07 c
8	20.44 abc	18.21 ab	18.68 ab	19.50 ab
10	19.98 ab	20.52 abc	18.39 ab	17.88 ab
12	19.13 ab	19.11 ab	18.11 ab	14.28 a
LSD 5%	3.93			

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

3.9. Long Bean Pod Length

The combination treatment of KNO₃ fertilizer dose with paclobutrazol concentration had a significant difference in pod length (cm) of long bean plants (Table 11). The largest value of pod length (cm) for long bean plants treated with 8 g/plant KNO₃ was 68.97 cm. Providing the right dose of KNO₃ fertilizer can increase fruit and flower production in

fruiting and flowering plants. Providing appropriate levels of KNO_3 fertilizer can increase pod production in long bean plants. Because the potassium element in KNO_3 fertilizer helps in the formation of healthy flowers and fruit, while the nitrogen element supports flower formation by accelerating plant vegetative growth (Hendrajaya *et al.*, 2019). Providing KNO_3 fertilizer can improve plant quality, including color, leaves, taste, and fruit texture.

Table 11. Effect of KNO_3 fertilizer dose and Paclobutrazol concentrations on the pod length (cm)

KNO_3 Fertilizer Dosage (g/plant)	Pod Length (cm)	Paclobutrazol concentration (ppm)	Pod Length (cm)
0	71.92 b	0	70.63 a
8	68.97 a	150	69.72 a
10	67.78 a	175	68.13 a
12	66.85 a	200	67.03 a
LSD 5%	1.80	LSD 5%	tn

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

Table 12. Interaction effect of KNO_3 fertilizer dose and Paclobutrazol concentrations on the fruit set (%)

KNO_3 Fertilizer Dosage (g/plant)	Paclobutrazol concentration (ppm)			
	0	150	175	200
0	69.78 abcd	59.68 a	69.83 abcd	73.32 cd
8	70.32 abcd	72.48 abcd	76.96 d	69.45 abcd
10	66.71 abc	72.79 abcd	68.74 abcd	72.74 abcd
12	68.41 abcd	69.90 abcd	64.04 ab	73.85 cd
LSD 5%	9.04			

Note: Different lowercases following mean values mean significantly different according to HSD test at $\alpha = 5\%$.

3.10. Fruit Set Long Beans

The combination treatment of KNO_3 fertilizer dose with paclobutrazol concentration had a significant difference in the percentage of flowers turning into pods (fruit set) in long bean plants (Table 12). The largest average fruit set percentage for long bean plants was 76.96% for the treatment combination of 8 g/plant KNO_3 + 175 ppm paclobutrazol. The process by which paclobutrazol inhibits gibberellins in the subapical meristem causes a reduction in the rate of cell division, which stops vegetative growth which is essential for the formation of flowers, fruit and fruit development (Wattimena, 2018). The interaction between 8 g/plant KNO_3 and 0 ppm paclobutrazol on sweet corn plants showed the highest production on acidic sulfate soil (Pratama *et al.*, 2024).

4. CONCLUSIONS

Providing a paclobutrazol at a concentration of 150 ppm had a significant effect on the pod weight per plot. The paclobutrazol concentration of 175 ppm had a significant effect on the age of flower emergence. The paclobutrazol concentration of 200 ppm had a significant effect on the number of leaves (ages 28 and 35 DAP). KNO_3 fertilizer at a dose of 8 g/plant or 200 kg/ha has a significant effect on plant height at 14 DAP and number of leaves at 49 DAP, age of flower emergence, number of pods per plant, pod weight, and pod length. Combination of 10 g/plant KNO_3 + 150 ppm paclobutrazol was able to increase the growth and yield of long bean. This combination had a significant effect on plant height at 35 DAP (177.94 cm), total pod weight per plant (820.67 g), total pod weight per plot (6.64 kg) and pod weight per hectare (20.52 ton).

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