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The Effect of Potassium Fertilizer and Paclobutrazol Application Time on the Growth and Yield of Sweet Corn in Peat Soil

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ABSTRACT: For optimal effects on sweet corn growth and yield, it is critical to determine when to apply Paclobutrazol and how much potassium fertilizer to apply. The goal of the study is to determine the optimal K fertilizer dosage and Paclobutrazol application timing for sweet corn plant growth and yield in peat soil in West Kalimantan, Indonesia. A split-plot design with two factors was used for the study. The time of application of Paclobutrazol 1500 ppm (W) as the main plot and dosage of potassium fertilizer (K) as the subplot. Paclobutrazol's application period only suppressed plant height and leaf number, whereas potassium application markedly enhanced sweet corn yield. Paclobutrazol's application period only reduced plant height by 13.06-28.42 cm. The 5-week (WAP) Paclobutrazol spraying period had the most significant impact on reducing sweet corn plant height. Potassium fertilization significantly improved sweet corn yield components. Doses of 200–300 kg·ha^{-1} increased cob weight, husk-free cob weight, and cob length relative to lower doses, while cob diameter responded effectively from 100 kg·ha^{-1} onward. The highest overall performance was achieved at 300 kg·ha^{-1}, indicating that this dose was the most effective for maximizing sweet corn yield under the study conditions.

Keywords: Paclobutrazol, Peat Soil, Potassium, Sweet Corn

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INTRODUCTION

Of the province's 14,880,700 ha, 1,543,752 ha are peatlands (Widiawati et al., 2024). Peatland development faces several challenges, including low soil fertility (Lestari et al., 2021), low pH, low availability of macro (N, P, K, Ca, Mg, P) and micro (Cu, Zn, Mn, Bo) nutrients, the presence of toxic organic acids, and a high Cation Exchange Capacity (CEC) but low Base Saturation (Armanto et al., 2025). Increasing potassium levels in the soil through fertilization can increase sweet corn yields and improve the chemical properties of peat soil, thereby making it more suitable for corn growth.

Strong gusts frequently topple sweet corn plants in Rasau Jaya II Village at both the vegetative and generative stages. The land's position on the riverbank is the cause of this. The use of a retardant is necessary to prevent the fall of sweet corn stalks. According to Mubarok et al. (2022), a retardant is a plant growth regulator that also acts as a growth inhibitor. Paclobutrazol is a commonly used retardant that inhibits plant growth (Tesfahun, 2018). To create plant stems that are more resilient to lodging or falling, Paclobutrazol reduces plant height and increases stem diameter (Tesfahun & Menzir, 2018). It is also necessary to determine the appropriate potassium fertilizer rate for sweet corn to support yield and quality. Additionally, Paclobutrazol can promote sweet corn development and yield when applied at the appropriate time. This study aimed to determine the optimal potassium fertilizer dosage and Paclobutrazol application timing for sweet corn development and production in peat soil in Rasau Jaya II.

MATERIALS AND METHODS

Study Area

The research was conducted on farmers' land in Rasau Jaya II Village, Rasau Jaya Sub-district, Kubu Raya Regency, West Kalimantan, Indonesia. The initial soil analysis was performed at the Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Tanjungpura University, Indonesia.

Methods Research

Peat soil was used as a planting medium. Land preparation began with clearing the land from weeds and crop residues, which were then processed with a hand tractor at a depth of 20 cm. Twenty-five experimental plots were made. Each experimental plot measured 2 m x 2.3 m.

Fertilizer was applied 2 times: ½ dose at planting and the remaining ½ dose 25 days after planting. The dose of Urea fertilizer was 350 kg.ha^{-1}, and SP-36 fertilizer was 100 kg.ha^{-1}. Potassium fertilizer was applied at 0 and 100 kilograms. ha-1, 200 kg. ha-1, and 300 kg. ha-1 according to the treatment.

Paclobutrazol at 1500 ppm was applied at 3, 4, and 5 weeks after planting (WAP). Paclobutrazol at 1500 ppm was applied by evenly spraying the entire upper and lower leaf surfaces with a sprayer; each plant was sprayed with 110 ml in the morning from 07.00 a.m. to 09.00 a.m. Western Indonesian Time.

Sample Collection

The study used a split-plot design with two components. With 12 treatments, the first factor was the application time of Paclobutrazol (W), with three treatment levels as the main plot, and the second factor was potassium fertilizer (K), with four treatment levels as the subplot. Five plant samples were used per treatment unit, and each combined treatment was performed three times. Plant height, stem diameter, number of leaves, cob weight with and without husks, cob length, cob diameter, and cob weight per plot were the variables that were measured.

Data Analysis

The data obtained in this study were primary field data from direct observation. The observational data for each variable were analyzed statistically using analysis of variance (ANOVA). If the treatment had a significant effect, the Duncan Multiple Range Test (DMRT) was used to compare means. The DMRT test indicated that, when Sig < 0.05, the treatments differed significantly at the 5% level.

RESULTS AND DISCUSSION

Differences in the treatment of variables that gave a real effect on both the combination treatment between the dose of potassium fertilizer and Paclobutrazol application time, and the single treatment of potassium fertilizer dose and Paclobutrazol application time treatment were carried out through the Duncan Multiple Range Test (DMRT) at the 5% level. The results of the DMRT test at 5% level can be seen in Table 1, Table 2, Table 3, and Table 4.

Stem Diameter

Based on the results of the DMRT test at the 5% level in Table 1, it shows that the stem diameter of sweet corn plants at the time of Paclobutrazol application 3, 4 and 5 weeks after planting at various doses of potassium fertilizer starting from 0 kg.ha^{-1}, 100 kg.ha^{-1} and 200 kg.ha^{-1}showed plant diameters that were not significantly different between treatments. The diameter of sweet corn stems at the time of Paclobutrazol application, 4 weeks after planting. A dose of potassium fertilizer of 300 kg.ha^{-1} is significantly different from the diameter of the stems at the time of Paclobutrazol application, 5 weeks after planting and a dose of 300 kg.ha^{-1}, but not substantially different from the diameter of the stems at the time of Paclobutrazol application, 3 weeks after planting, and a dose of 300 kg.ha^{-1}. Paclobutrazol inhibits the oxidation of kaurene to kaurenic acid in gibberellin biosynthesis, thus inhibiting cell elongation growth (Lienargo et al. 2014). Although growth in leaf length and plant height was reduced, leaf width could be increased, so that total leaf area remained relatively unchanged, which might explain why paclobutrazol had no noticeable effect on some aspects of growth.

A prior study reported that increasing PACLOBUTRAZOL concentration to 1500 ppm in maize plants could increase stem diameter by 8.9% (Maulidi et al. 2024). This is due to the action of PACLOBUTRAZOL, which inhibits gibberellin biosynthesis by blocking the oxidation of kaurene to kaurenic acid. Subsequently, this leads to stunted plant growth and accelerates lateral enlargement, resulting in a larger stem diameter (Salisbury and Ross 1995). Another study demonstrated that PACLOBUTRAZOL application resulted in shorter plant height and thicker stems due to the reduction in gibberellin levels (Kumar et al. 2023)

The research found that the best Paclobutrazol application time was at 4 WAP, with the most significant potassium fertilizer dose of 300 kg. ha^{-1}. According to Biswas (2023), higher potassium doses promoted plant growth by increasing the number and length of internodes through greater cell division and elongation, resulting in higher plant height. However, the findings of Swetha et al. (2017) suggest that potassium fertilization can benefit delayed leaf senescence, sustained photosynthesis, and vegetative growth, thereby improving crop performance.

Table 1. Response of Sweet Corn Growth and Yield to Potassium Fertilizer and Paclobutrazol Application Time in Peat Soil on Stem Diameter

Paclobutrazol Application Time (Weeks After Planting)	dose of potassium (kg.ha^{-1})			
	0	100	200	300
3 WAP	2,22bc	2,38bc	2,35bc	2,54ab
4 WAP	2,05c	2,07c	2,05c	2,84a
5 WAP	2,24bc	2,28bc	2,19bc	2,18bc

Description: Numbers followed by the same letter indicate that they are not significantly different between treatments

An adequate supply of potassium will help corn plants form sturdy and large stems (Mutaqin et al., 2019). According to Utomo et al. (2015), potassium can enhance carbohydrate synthesis and translocation, thereby increasing cell wall thickness and stem strength. However, in the table above, the stem diameter at 3, 4, and 5 weeks after planting does not differ significantly across treatments. Generally, peat soils also require input such as fertilizers and ameliorants to improve and maintain soil fertility. The longer the Paclobutrazol application time and the higher the potassium fertilizer dose did not result in a larger stem diameter. According to Tajuddin et al. (2018), when solid fertilizer is applied to the soil surface, the water and fertilizer mix, and the water may leach. Besides, solid fertilizer takes longer to fully dissolve than liquid fertilizer, which can act together with water and flow into the groundwater.

Number of Leaves

Leaf was an important variable as an appropriate proxy for plant growth, morphological, and physiological characteristics. The number of leaves, including Leaf size, in terms of leaf length and width, of sweet corn at present, proved to be significantly affected by the application of PGR. In theory, GA3 application increased leaf length by promoting plant cell division and elongation, but higher doses of gibberellic acid inhibited leaf growth, yielding shorter leaves (Utami et al. 2018). Paclobutrazol is also reported to inhibit canopy leaf development and could divert plant photosynthates to the roots.

Based on the results of the DMRT test at the 5% level in Table 2, it shows that the number of leaves of sweet corn plants at the time of Paclobutrazol application, 3, 4, and 5 weeks after planting, in the treatment of potassium fertilizer doses starting from 0 kg. ha$^{-1,}$ showed that the number of leaves was not significantly different. The number of leaves of potato plants was not affected by the interaction of Paclobutrazol concentration and time of application of Paclobutrazol. This is because the number of plant leaves is strongly influenced by genotype and environmental factors. Giving paclobutrazol reduces leaf number by suppressing increases in plant height, so that shorter plants form fewer new branches and leaves (Kristina et al. 2024). This is in line with the findings of Genaly et al.

(2022), who reported that Paclobutrazol concentration did not affect the number of potato leaves. Gianfagna (1987) stated that growth retardants (retardants) are chemical compounds that have little effect on leaf and root production.

Table 2. Response of Sweet Corn Growth and Yield to Potassium Fertilizer and Paclobutrazol Application Time in Peaty Soil on the Number of Leaves

Paclobutrazol Application Time (Weeks After Planting)	dose of potassium (kg.ha^{-1})			
	0	100	200	300
3 WAP	9,08abc	9,67ab	9,83a	9,67ab
4 WAP	9,33abc	9,58ab	9,00bc	9,42abc
5 WAP	9,50abc	8,75c	9,58ab	9,75ab

Description: Numbers followed by the same letter indicate that they are not significantly different between treatments

Plant Height

Based on the results of the DMRT test at the 5% level in Table 3, the plant height of sweet corn plants at the time of Paclobutrazol application at 5 WAP is significantly different from the height of sweet corn plants at the time of application at 3 WAP, but not substantially different from 4 WAP. It was found that the longer the application duration of Paclobutrazol, the lower the height of sweet corn plants. This finding is consistent with the notion that reduced plant height was a consequence of paclobutrazol-induced gibberellin inhibition, resulting in decreased internode elongation (Ichsan et al., 2024). The optimal application time for Paclobutrazol is 4-5 weeks after planting, as it inhibits sweet corn plant height. Inhibition of plant height has a positive effect on plants by reducing the likelihood of falling. Kamran et al. (2020) also reported that paclobutrazol can improve leaf longevity by delaying leaf senescence, which is associated with oxidative stress and lipid peroxidation, by upregulating the activities of enzymatic antioxidants and enhancing the antioxidant defense system, thereby helping sustain plant growth.

Table 3. Plant Height Response to Paclobutrazol Application Time in Peat Soil

Paclobutrazol Application Time (Weeks After Planting)	Height of plant (cm)
3 WAP	186,49b
4 WAP	181,06ab
5 WAP	171,58a

Description: Numbers followed by the same letter in the same column are not significantly different in the DMRT test at the 5% level.

This was consistent with the findings of Syafrizal et al. (2024), which showed a significant effect of paclobutrazol on agronomic variables and corn productivity, including stem diameter, leaf area, leaf area index, plant dry weight, cob weight, and cob length. Desta and Amare (2021) stated that paclobutrazol's physiological role in suppressing stem elongation is to inhibit gibberellin biosynthesis. Plant height during vegetative growth will be inhibited by paclobutrazol, resulting from reduced stem internode length, increased stem diameter, and increased photosynthetic yield.

Table 4. Response of Weight of Cob, Weight of Cob without Husks, Length of Cob, Diameter of Cob, and Weight of Cob per Plot to Potassium Fertilizer Treatment in Peat Soil

Dose of Potassium (kg. ha^{-1})	Weight of cob (g)	Weight of Cob without Husks (g)	Length of Cob (cm)	Diameter of Cob (cm)	Weight of Cob per Plot (kg)
0	221,83c	178,52c	16,96c	4,92b	11,67d
100	256,99b	203,32b	17,81b	5,13a	13,79c
200	295,50a	235,24a	18,62a	5,27a	15,80b
300	322,25a	243,45a	18,81a	5,30a	17,64a

Description: Numbers followed by the same letter in the same column are not significantly different in the DMRT test at the 5% level.

Crop Yield

The DMRT test at the 5% level in Table 4 shows that the cob weight, husk-free cob weight, and cob length of sweet corn at potassium fertilizer doses of 200 kg·ha^{-1} and 300 kg·ha^{-1} were significantly higher than those obtained at 0 kg·ha^{-1} and 100 kg·ha^{-1}. The doses of 0 kg·ha^{-1} and 100 kg·ha^{-1} were insufficient to achieve optimal cob characteristics. Increasing the potassium fertilizer dose tended to enhance cob weight, husk-free cob weight, and cob length, with 200 kg·ha^{-1} identified as the effective dose. The lowest values (221.83 g, 178.52 g, and 16.96 cm) were recorded at 0 kg·ha^{-1}, whereas the highest (322.25 g, 243.45 g, and 18.81 cm) occurred at 300 kg·ha^{-1}.

The cob diameter also increased with potassium fertilization. Treatments of 100 kg·ha^{-1}, 200 kg·ha^{-1}, and 300 kg·ha^{-1} produced significantly larger diameters than the unfertilized control. This indicates that even a relatively low dose, beginning at 100 kg·ha^{-1}, is sufficient to improve cob diameter, although further increases beyond this dose did not result in substantial differences. Thus, 100 kg·ha^{-1} is considered the effective dose for this variable. Cob diameter reflects overall cob size, meaning plants receiving potassium produced larger cobs than those without fertilization. The lowest diameter (4.92 cm) occurred at 0 kg·ha^{-1}, while the highest (5.30 cm) was obtained with 300 kg·ha^{-1}.

The weight of cobs per plot at 300 kg·ha^{-1} differed significantly from all lower doses (0, 100, and 200 kilograms ·ha^{-1}), showing that higher potassium inputs increased total cob yield. This variable is strongly influenced by cob weight with husks, husk-free cob weight, cob length, and cob diameter. Based on Table 4, the 300 kg·ha^{-1} dose consistently produced the highest averages for all measured parameters, making it the most effective treatment for maximizing cob yield per plot.

Potassium application promotes assimilation and the translocation of assimilates from source to sink (Khumar et al., 2016). Potassium (K) uptake by plants influences metabolic and enzyme activity. A previous study found greater cob production, with increases in length and girth, at 60 kg.ha^{-1} and 90 kg. ha^{-1} (Brar et al. 2012) were used in corn production, and similar findings were recorded from this study.

CONCLUSION

A 5-week application of paclobutrazol after planting yielded the most significant suppression of sweet corn plant height. Potassium fertilizer doses of 200–300 kg·ha^{-1} resulted in greater cob weight, husk-free cob weight, and cob length compared with lower application rates. In contrast, cob diameter showed notable improvement starting at 100 kg·ha^{-1}. Overall, the 300 kilograms ·ha^{-1} dose produced the highest yield, indicating it is the optimal rate for maximizing sweet corn production.

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