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EFFECT OF HILLING ABOVE MULCH AND TYPES OF RETARDANT ON GROWTH AND PRODUCTION OF POTATO (*Solanum tuberosum* L.) MEDIANS CULTIVAR IN MEDIUM ALTITUDE

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ABSTRACT

Potato (*Solanum tuberosum* L.) cultivation in medium-altitude regions faces the primary challenge of high temperatures that inhibit stolon initiation and tuber formation. This study aimed to determine the effect of hilling above mulch and the application of growth retardants prohexadione-Ca and paclobutrazol on the growth and production of Medians potato cultivar at medium altitude. The experiment was conducted from October 2025 to February 2026 at PT. Central Horti Agro Makro, Cisurupan District, Garut, West Java (±800 m asl) using a Split Plot Design. The main plot consisted of hilling treatments (b_1: no mulch, no hilling; b_2: hilling without mulch; b_3: mulch without hilling; b_4: mulch with hilling) and the subplot consisted of retardant types (r_o: no retardant; r_1: prohexadione-Ca 100 ppm; r_2: paclobutrazol 100 ppm), replicated three times. Results showed that paclobutrazol 100 ppm significantly suppressed plant height at 60 DAP (33.20 cm) compared to prohexadione-Ca (37.80 cm) and the control (42.21 cm). No significant differences were observed among treatments for leaf area index (1.23 – 2.00). The b_4 treatment produced the highest total stolon count (15.33) and tuber number (12.89 knols plant^{-1}). Prohexadione-Ca 100 ppm yielded the highest tuber number per plant (11.83 knols), while paclobutrazol 100 ppm produced the highest tuber weight per plant (178.11 g). The b_4 treatment also yielded the highest tuber weight (260.11 g plant^{-1}), demonstrating a synergistic effect between mulching, hilling, and retardant application in improving potato production at medium altitude.

Key words: Hilling, Medium altitude, Paclobutrazol, Prohexadione-Ca, Tuberization

INTRODUCTION

Potatoes (*Solanum tuberosum* L.) are one of Indonesia's key horticultural commodities, holding strategic importance as the world's fourth-most important staple food after rice, wheat, and maize (FAO, 2023). Consequently, potatoes play a key role in supporting food diversification programs to meet public nutritional needs (Hernawati *et al*., 2022).

According to data from the Central Statistics Agency (2025), national potato production in 2023 was 1.24 million tons, and it is projected to reach 1.27 million tons in 2024. Although there has been a slight increase, this figure remains far below the industry's annual demand of 1.8 – 2.0 million tons, leading to a continued rise in imports of frozen potatoes and processed products (US$265 million in 2024, a 20% increase from the previous year) (Ministry of Agriculture, 2025).

Hilling and mulching are key cultivation techniques to maximize production. Hilling, which involves piling soil around plants during early vegetative growth, creates favorable conditions for tuber formation and development (Gutema, 2016). Mulching covers the soil surface with organic or synthetic materials to enhance plant growth (Kader *et al*., 2017), retain nutrients in the root zone, and improve water availability (Qiu *et al*., 2020).

Potato plants require temperatures of 15 – 22 °C, limiting cultivation to highlands at 800 – 1,500 meters above sea level (m asl) (Enoch *et al*., 2018; Tjahjoleksono *et al*., 2024). However, land constraints and increasing market demand necessitate expansion into medium-altitude regions (Amelia *et al*., 2023), where high-temperature stress poses the primary challenge to optimal growth and yield (Prabaningrum *et al*., 2014).

To overcome this, gibberellin biosynthesis inhibitors known as retardants are applied to suppress vegetative growth and direct photosynthates toward tuber formation (Hamdani, 2024). Paclobutrazol inhibits cell elongation and internode extension in the apical meristem without causing cellular toxicity (Chairunnisa *et al*., 2024). Prohexadione-Ca works similarly but leaves no long-term soil residues, and is known to induce stolons to cease elongation and enlarge into tubers (Hamdani *et al*., 2024).

Potato cultivar selection is a critical factor for specific processing purposes, as potato processing requires specific physicochemical and sensory properties (Vaitkevičienė *et al*., 2022). One of the superior varieties for producing french fries and potato chips is the Medians potato cultivar (Asgar *et al*., 2023). The Medians potato cultivar is known to be resistant to bacterial wilt and leaf blight (Dianawati *et al*., 2019). According to the Directorate of Horticultural Seed Production (2014), the Medians potato cultivar has a production potential of up to 31.9 tons ha^{-1}.

Based on this background, this study aims to determine the effect of hilling over mulch and the application of a growth retardant on the growth and production of Medians potato plants in medium-altitude areas. The combination of hilling techniques and the use of growth regulators is expected to yield good results in increasing industrial potato production in terms of both quantity and quality.

MATERIALS AND METHODS

This research was conducted at PT. Central Horti Agro Makro, Cisurupan District, Garut Regency, West Java (±800 m asl) from October 2025 to February 2026, using Andisol soil with a pH of 5 – 6.5. Main materials included G2 Medians cultivar potato seeds (>15 g), chicken manure, NPK 16:16:16, ZA, SP-36 fertilizers, and two retardants prohexadione-Ca and

paclobutrazol each at 100 ppm. Supporting tools included hoes, black-silver plastic mulch, mulch perforators, dibbles, knapsack sprayers, rulers, scales, and documentation equipment.

The experiment used a Split Plot Design with hilling as the main plot (b_1: no mulch, no hilling; b_2: hilling without mulch; b_3: mulch without hilling; b_4: mulch with hilling) and retardant type as the subplot (r_0: no retardant; r_1: prohexadione-Ca 100 ppm; r_2: paclobutrazol 100 ppm), replicated three times.

Land preparation involved herbicide application, soil cultivation, and ridge formation (0.5 × 3 m, 20 cm height) incorporating chicken manure and basal fertilizers (NPK, SP-36, ZA). Black-silver plastic mulch was installed silver-side up and perforated with a 10 cm diameter perforator. Seeds were planted 5 – 7 cm deep at 80 × 30 cm spacing, with 10 plants per ridge. Follow-up fertilization was applied at 30 DAP, and routine maintenance included watering, manual and chemical weeding, staking, and pest control as needed.

Observations included growth parameters such as plant height at 40, 50, and 60 days after planting, leaf area index, and the number and weight of tubers per plant. Data analysis was performed using the Shapiro-Wilks normality test and a variance test in accordance with a split-plot experimental design, using SmarstatXL software. Data analysis used analysis of variance (ANOVA) at the 5% level, followed by further testing using the Duncan Multiple Range Test at the 5% level.

RESULTS AND DISCUSSION

1. Plant Height (cm)

Plant height is one indicator of plant growth. This parameter evaluates the plant's morphological response. Plant height is measured using a ruler from the base of the stem to the highest growing point.

Table 1. Effect of hilling up and retardant type on potato plant height at 40, 50 and 60 days after planting (DAP)

Treatment	Plant Height (cm)		
	40 DAP	50 DAP	60 DAP
Main Plot (b)			
b_1	26,97 a	29,81 a	37,26 a
b_2	24,82 a	27,65 a	37,21 a
b_3	26,70 a	29,87 a	37,10 a
b_4	28,54 a	30,19 a	39,38 a
Sub Plot (r)			
r_0	27,08 a	30,08 a	42,21 c
r_1	26,91 a	29,86 a	37,80 b
r_2	25,28 a	28,94 a	33,20 a

Note: Values followed by different letters within a column indicate significant differences according to Duncan Multiple Range Test at $p \leq 0.05$.

Paclobutrazol application can suppress plant height growth better than prohexadione-Ca at 60 days after planting. This is consistent with research by Darmawan *et al*. (2014), which

reported that shoot length in tangerine plants resulting from paclobutrazol application was shorter than that of prohexadione-Ca. Another study by Oliveira *et al*. (2021) also stated that plant height resulting from prohexadione-Ca application was shorter than that of the control, but still higher than that of paclobutrazol.

The application of prohexadione-Ca and paclobutrazol did not show any significant differences, but after three applications of prohexadione-Ca, a significant difference was observed between the control and prohexadione-Ca treatments. According to Ozbay and Ergun (2015), because the growth-inhibitory effect of prohexadione-Ca is temporary, more frequent applications are required throughout the plant cycle. Darmawan *et al*. (2014) also explained that the use of prohexadione-Ca in plants can reduce gibberellin biosynthesis, which results in reduced vegetative growth. Plant height growth at 60 days after planting begins to slow, even stopping, because the plants are no longer in the vegetative phase.

2. Leaf Area Index

The leaf area index is a parameter used to measure a plant's ability to photosynthesize. A leaf area index that is too high can reduce photosynthesis because the plant's leaves shade each other, resulting in the shaded lower leaves being unable to photosynthesize optimally. Therefore, these leaves use the photosynthesis produced by the leaves above them for respiration.

Table 2. Effect of hilling up and retardant type on leaf area index

Treatment	Leaf Area Index
Main Plot (b)	
b_1	1,44 a
b_2	1,23 a
b_3	2,00 a
b_4	1,67 a
Sub Plot (r)	
r_0	1,50 a
r_1	1,82 a
r_2	1,44 a

Note: Values followed by different letters within a column indicate significant differences according to Duncan Multiple Range Test at p ≤ 0.05.

Table 2. shows that the leaf area index did not show significant differences in each factor. All treatments produced leaf area indices that were not significantly different. The 100 ppm paclobutrazol treatment produced a lower leaf area index compared to the treatment without retardant and 100 ppm prohexadione-Ca. The earlier the paclobutrazol application, the lower the leaf area index value (Azima *et al*., 2017).

3. Stolon Numbers

Stolons are a plant part that plays an important role in determining the number of tubers produced, and are generally formed when the plant is in the vegetative growth phase (Hamdani *et al*., 2020). The hilling and mulching treatment (b_4) produced the highest total

number of stolons, at 17.33, significantly different from the treatments without hilling and without mulching (b_1), and mulching without hilling (b_3). This is because hilling creates a dark and humid environment around the base of the stem, which stimulates the growth of additional stolons above the mulch. Hilling stimulates the rate of stolon formation during the active growth phase, so the number of stolons influences the number of tubers formed (Kugedera *et al*., 2022). Upper stolons form due to the presence of mounded soil above the mulch, so the treatments without hilling (b_1 and b_3) produced 0.00 upper stolons.

Table 3. Effect of hilling up and retardant type on stolon numbers

Treatment	Stolon Numbers		
	Upper Stolons	Lower Stolons	Total Stolons
Main Plot (b)			
b_1	0,00 a	11,11 a	11,11 a
b_2	2,78 b	11,11 a	13,89 a
b_3	0,00 a	11,22 a	11,22 a
b_4	2,89 b	12,44 a	15,33 a
Sub Plot (r)			
r_0	1,71 a	11,33 a	12,50 a
r_1	1,75 b	12,25 a	14,00 a
r_2	1,33 a	10,83 a	12,17 a

Note: Values followed by different letters within a column indicate significant differences according to Duncan Multiple Range Test at p ≤ 0.05.

The prohexadione-Ca 100 ppm treatment produced the highest number of upper stolons (2.25 stolons), significantly different from the treatment without retardant and paclobutrazol 100 ppm. Prohexadione-Ca induces stolon elongation and tuber formation by inhibiting gibberellin biosynthesis at the final stage (Hamdani *et al*., 2024). According to Nuraini (2016), increased cytokinin levels due to gibberellin inhibition lead to an increase in the number of stolons in potato plants.

4. Tuber Number per Plant

The number of tubers is an important parameter in evaluating yield. This parameter reflects the success of the initiation and development of stolons into tubers.

Table 4. Effect of hilling up and retardant type on tuber number per plant.

Treatment	Tuber Number per Plant		
	Upper Tuber	Lower Tuber	Total Tuber
Main Plot (b)			
b_1	0,00 a	5,78 a	6,78 a
b_2	2,44 b	7,33 ab	11,44 b
b_3	0,00 a	7,22 ab	8,22 a
b_4	2,56 b	8,56 a	12,89 b
Sub Plot (r)			
r_0	1,08 a	6,58 a	9,17 a

r_1	1,50 b	8,92 b	11,83 b
r_2	1,17 a	6,17 a	8,50 a

Note: Values followed by different letters within a column indicate significant differences according to Duncan Multiple Range Test at p ≤ 0.05.

Hilling and mulching (b_4) produced the highest total number of tubers (12.88 knol plant^{-1}). Treatments involving hilling (b_2 and b_4) consistently produced higher tuber yields. This is in line with Gebremedhin *et al*. (2008), who stated that hilling at least twice can increase tuber yields by 10–20% compared to the control. According to Kugedera *et al*. (2022), the difference in tuber yield was greater in the hilling treatment.

The 100 ppm prohexadione-Ca treatment produced the highest number of tubers per plant (11.83 knol), significantly different from the treatment without retardant and 100 ppm paclobutrazol. Ramadhani *et al*. (2024) stated that prohexadione-Ca at a concentration of 100 ppm can inhibit gibberellin synthesis, preventing stolon elongation and initiating tuber production in large numbers. Hamdani *et al*. (2024) confirmed that prohexadione-Ca produced more stolons that enlarged to form tubers compared to paclobutrazol, especially in the tuber initiation phase.

5. Tuber Weight per Plant

The weight of the sweet potato was also evaluated as a response to production results.

Table 5. Effect of hilling up and retardant type on tuber weight per plant

Treatment	Tuber Weight per Plant
Main Plot (b)	
b_1	110,22 a
b_2	153,75 b
b_3	112,44 a
b_4	260,11 c
Sub Plot (r)	
r_0	144,54 a
r_1	154,75 b
r_2	178,11 c

Note: Values followed by different letters within a column indicate significant differences according to Duncan Multiple Range Test at p ≤ 0.05.

Hilling significantly affects the average weight of tubers potentially produced during mound formation, which is influenced by the number of tubers per plant, tuber yield, number of stems per mound, and environmental conditions during the early growth phase (Tafirt *et al*., 2010; Kugedera *et al*., 2022). Therefore, hilling provides sufficient space for stolons to develop into tubers, resulting in higher tuber weights than unhilled plants.

Hamdani *et al*. (2024) stated that prohexadione-Ca treatment resulted in a larger number of stolons and tuber formation compared to paclobutrazol, especially during the initiation or tuber formation phase. According to Hamdani *et al*. (2018), paclobutrazol can increase tuber weight per plant due to increased chlorophyll content, which allows photosynthates to accumulate in the tubers. In potato plants, paclobutrazol has also been shown to increase tuber weight compared to without paclobutrazol application (Mubarok *et al*., 2024).

CONCLUSION

1.The combined application of hilling-up on mulch and growth retardants, namely prohexadione-Ca and paclobutrazol, effectively enhances growth and production of Medians potato cultivar at medium altitude regions.

2. Hilling-up with mulch independently increased both stolon number and tuber count, providing a favorable environment for tuber initiation and development.

3. Prohexadione-Ca at 100 ppm notably promoted the highest number of tubers per plant. Meanwhile, paclobutrazol 100 ppm significantly suppressed plant height and increased tuber weight per plant by redirecting assimilates towards tuber bulking.

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Treatment	Plant Height (cm)		
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Treatment	Leaf Area Index
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r_2	1,44 a

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Table 3. Effect of hilling up and retardant type on stolon numbers

Treatment	Stolon Numbers		
	Upper Stolons	Lower Stolons	Total Stolons
Main Plot (b)			
b_1	0,00 a	11,11 a	11,11 a
b_2	2,78 b	11,11 a	13,89 a
b_3	0,00 a	11,22 a	11,22 a
b_4	2,89 b	12,44 a	15,33 a
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