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Response of growth, yield, and seeds quality of G_0 potato on different potassium fertilizer doses and retardant concentrations in Jatinangor medium land

Abstract. This study aims to determine the best interaction of potassium (K) fertilizer dose and retardant concentration on the growth, yield, and seed quality of G_0 potato grown in the medium land of Jantinangor. The experiment was conducted at Screen House Station Ciparanje, Jatinangor, Faculty of Agriculture Universitas Padjadjaran from November 2022 until January 2023 at an elevation of ± 685 meters above sea level. The experimental design used was the Factorial Randomized Block Design (RBD). The first factor was the K fertilizer dose including 50%, 100%, and 150%. The second was the retardant concentration including without retardant, 100 ppm paclobutrazol, 100 ppm prohexadione-Ca, and 150 ppm prohexadione-Ca. The experimental results showed that there was an interaction effect between the K dose and retardant concentration. The interaction effect of 150% K and 100 ppm prohexadione-Ca showed the highest percentage of L class seed tuber and the lowest tuber weight loss. Independently, 150% K improved growth rate, number of tubers (6.67 knol/plant), and weight of tubers (73.33 g/plant). Independently, 100 ppm paclobutrazol concentration increased the chlorophyll content index. 150 ppm prohexadione-Ca concentration suppressed leaf area and plant height but increased stomatal conductance, fast emergence shoot time, and shoot length. 100 ppm prohexadione-Ca concentration produced the highest number of tubers and the weight of tubers, i.e., 6.78 knol/plant and 74.33 g/plant, respectively.

Keywords: Paclobutrazol · Potassium · Potato Seed · Prohexadione-Ca

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Introduction

Potato (*Solanum tuberosum* L.) is one of the horticultural crops with tuber as its commercial part. Indonesia is one of the countries that has developed potato commodities, both for direct consumption as a vegetable and for industry. The need for potatoes is increasing year by year, along with the increasing population of Indonesia. Based on the Statistics Indonesia (2020) potato production in Indonesia in 2020 reached 1.28 million tonnes which shows a decrease of 2.42% from 2019.

Efforts to increase the production of potatoes are intensification of cultivation techniques. Improving the cultivation technique can be in the use of high-quality seeds which include genetic quality, physical quality, and physiological quality, because seed is the key factor in determining the final yield obtained (Hamdani et al., 2021). However, the availability of high quality potato seeds in Indonesia is still limited. The availability of high quality potato seeds in 2015 only met 31% of the national need for potato seeds or 125,000 tons (Ranti et al., 2017). According to Hamdani et al. (2020), the low availability of quality potato seeds forces some farmers to re-use seeds produced from previous plantings.

The potato cultivar (cv.) Medians can adapt well in medium plains (Supriatna et al., 2018). This potato cultivar has high productivity, reaching 31.9 tonnes ha^{-1} (Vegetable Crops Research Institute, 2018). The Medians cultivar is the result of selection from the progeny of a cross between Atlantic as one of its parents, so the characteristics of the Medians cultivar are similar to Atlantic but its production is higher. Median potatoes are a type of processed potato with a high yield, making it suitable for the needs of the potato chip manufacturing industry. It is hoped that the development of the potato cv. Median can fulfil some of the needs of the increasingly increasing yield processing industry. The need for potatoes for large industries can reach 30 tonnes/day.

The main problem in G_0 seed production from cuttings is the low formation of tubers from stolon, so the number of tubers produced per plant is small. One effort to solve the problem of increasing the number of potato produced is by applying potassium fertilizer. Potassium (K) fertilization is expected to increase the growth and production of both the quantity and quality of the potato tubers produced. Zelelew et al. (2016) reported that potassium fertilization greatly affected the growth and production of potatoes. The results of Gunadi's research (2007) showed that the application of 50 kg ha^{-1} of potassium fertilizer could produce a marketable percentage of potato tubers of 81.8%. The results of the research by Sitepu et al. (2011) stated that the application of KCl fertilizer 20 g m^{-2} resulted in the largest tuber diameter, fresh tuber weight per plant and dry yam weight per plant which were 3.72 cm, 186.9 g and 56.1 g sequentially.

Potassium fertilizer application is expected to affect increasing yield growth and optimal quality of G_0 potato seed yields. Potato plants can grow optimally if the necessary nutrients can be fulfilled. K fertilizer contains the element K which is one of the macronutrients needed by potato plants in the process of forming and filling potato because K functions to stimulate assimilate translocation from the leaves to the potato parts. In addition, potassium in potato plants will be needed for the accumulation and translocation of the carbonate formed by plants from the results of photosynthesis and plant physiological responses. Potassium also functions as a catalyst for protein formation, sugar translocation, increasing water use efficiency, expanding root growth, strengthening plant tissues and organs so they don't fall off easily, increasing plant resistance to pest attacks, and increasing the quality and quantity of tuber (Martias, 2011).

In addition, using K fertilizer can overcome potato cultivation in medium plains which have high temperatures reaching more than 20°C. High temperatures in potato plants increase the synthesis of gibberellins, causing the translocation of photosynthetic products to the top of the plant and reducing the translocation of photosynthetic products to tuber. High temperatures cause the synthesis of gibberellin to take place more quickly at the tips of stems, young leaves and roots. If gibberellin synthesis is not inhibited, it can result in plant growth being focused on the top of the plant continuously and inhibiting the formation of tuber. Therefore, it is necessary to apply plant growth inhibitors to balance the growth of potato plants. Giving growth inhibitors can be done as an effort to increase the yield and quality of G_0 potato seeds from cuttings in the hope that they can regulate the balance of growth and yield. One of the growth regulators that act as inhibitors are retardants, namely paclobutrazol and prohexadione-Ca.

Paclobutrazol is a growth regulator that inhibits vegetative growth and inhibits gibberellin biosynthesis which functions in the process of elongating plant cells and tissues (Masniawati, 2016). According to Hamdani et al. 2016) potato plants treated with inhibitory hormones are intended to speed up the filling phase of potato tubers and can focus energy on the formation of tuber. The use of paclobutrazol can regulate plant growth patterns by maintaining a balance between generative and vegetative growth, so that competition in the utilization of photosynthates-producing locations or sources for vegetative growth and tuber formation can be suppressed. Giving paclobutrazol will affect the decrease in plant height, increase in chlorophyll content, fresh weight of tuber, yield per hectare, and percentage of the quality class of tuber (Hamdani et al., 2021).

Apart from paclobutrazol, another inhibitor for the body is prohexadione-Ca. Prohexadione-Ca is a growth inhibitor that has the same physiological properties as paclobutrazol but does not leave a long-term residue. According to Adiel et al. (2011), Prohexadione-Ca is a growth inhibitor with a short residual effect lasting only a few weeks. Thus, the use of Prohexadion-ca can inhibit vegetative plant growth and induce the growth of potato stolons and tubers without causing any risk to the soil. The prohexadione-Ca chemical substance is a type of retardant substance whose way of action is similar to other anti-gibberellin retardants such as paclobutrazol, coumarin, chlormequat chloride (CCC) which inhibits gibberellin biosynthetic activity in plants (Kofidis et al., 2008).

The effectiveness of using paclobutrazol and prohexadione-Ca is influenced by the concentration and time of application, the time of application is related to the conditions of the plant growth stage. The concentration of retardant substances needs to be given precisely to each plant because each plant will show a different response depending on the genotype and physiological conditions of the plant (Lestari, 2011). Giving growth regulators with excessive concentrations will disrupt cell functions as well as if the use of concentrations that are less than the optimal concentration then the use of these substances becomes invisible (Kamillia et al., 2019). Another thing to note is the growing stage of the plant. The use of growth regulators will not respond if they are not given during the sensitive period of the plant. The sensitive period is the time of application according to the plant growth stage (Hamdani et al., 2019). Prohexadione-Ca and paclobutrazol are inhibitors of gibberellin synthesis, so to increase potato yields both must be applied at the beginning of the tuber formation phase, which is between 30-50 DAP.

In this research, the application of K fertilizer combined with retardants, namely paclobutrazol, and prohexadione-Ca, is expected to have a better impact on increasing the number and weight of potato seeds planted in medium plains. This refers to the results of Yuniarti's research (2017), which showed that 150 kg/ha K fertilizer treatment with a 100 ppm paclobutrazol concentration could increase the weight of the potato plants, the chlorophyll content and the starch content of the potato. The research results of Wijana et al. (2015) showed that there was an interaction between the concentration of paclobutrazol and the dose of K fertilizer which had a significant effect on the number of leaves and the yield of shallots. Furthermore, according to Conover (1994), plants given retardants such as paclobutrazol usually require less water and fertilizer than those without paclobutrazol treatment. however, there is still limited studies on K fertilizer and retardant application for seed potato production. Therefore, this study aims to determine the best interaction of potassium (K) fertilizer dose and retardant concentration on the growth, yield, and seed quality of G_0 potato grown in the medium land of Jantinangor.

Materials and Methods

The tools used in this experiment were hoes, calipers, hammers, digital scales, cutters, documentation equipment, and stationery. The materials used in this experiment were seed cuttings of the Medians potato aged 14 days after acclimatization from PT. Horti Agro Macro. The planting medium uses the soil of the order Inceptisol originating from the Ciparanje experimental, polybag, mica plastic, stakes, silver-black plastic mulch, rope plastic, snack box, compost, husk charcoal, cocopeat, retardant substance Prodex® containing the active

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ingredient Prohexadione-Calcium 15% WP and Golstar containing the active ingredient Paclobutrazol 250 SC, Fungicide Plantomycin (Streptomycin Sulfate 6.87%), Antracol fungicide (Propineb 70%), Basamid 98 GR (Dazomet 98%) for media sterilization, Curacron insecticide (Profenofos 500 g/L), urea fertilizer (46% N), SP-36 (36% P_2O_5) and KCl (60% K_2O).

Results and Discussion

Chlorophyll Content Index (CCI) and Stomatal Conductance. The results of the statistical analysis showed that there was no interaction between the doses of K fertilizer and the retardant concentration on the index of chlorophyll content and stomatal conductance. The independent effect of the treatment of K fertilizer dose and retardant concentration on the index of chlorophyll content and stomatal conductance is presented in Table 1.

The treatment of retardant concentrations had a significantly different effect on the index of chlorophyll content. The concentration of 100 ppm paclobutrazol showed the highest chlorophyll content index, namely 52.90 but not significantly different from 150 ppm prohexadione-Ca. In line with research conducted by Nuraini et al. (2021); Hernawati et al. (2022) that the treatment of paclobutrazol increased chlorophyll content. This is presumably because paclobutrazol can increase the synthesis of chlorophyll in the leaves (Tekalign et al., 2005). Giving paclobutrazol could affect the increase in chlorophyll content, decrease in plant height, fresh weight of tuber, yield per hectare, and percentage of the quality class of tuber (Hamdani et al., 2021).

The physiological role of the retardant paclobutrazol is to suppress stem elongation, thicken the stem, and encourage the formation of pigments (chlorophyll, xanthophyll, anthocyanin) which can produce a darker green leaf color with high chlorophyll content. The chlorophyll content is one of the factors that affect plant metabolism through the process of photosynthesis. According to Wieland and Wampe (1985) in Sambeka et al. (2012), the application of paclobutrazol increases the chlorophyll content of leaves so that photosynthetic activity can run well and inhibition of shoots stimulates photosynthetic results to be used for the formation of carbohydrates. The higher the rate of photosynthesis in plants, the higher the growth and productivity of plants. The leaf chlorophyll content is one of the main factors affecting the photosynthetic capacity of potato plants (Kantikowati et al., 2019).

Dosing of K fertilizer also did not have a significantly different effect on stomatal conductance, but retardant had a significant effect on stomatal conductance. Treatment with a concentration of 150 ppm prohexadione-Ca showed higher stomatal conductance, but was not significantly different from the treatment with a concentration of 100 ppm paclobutrazol and 100 ppm prohexadione-Ca. The concentration of 150 ppm prohexadione-Ca gives a high stomatal conductance response, high stomatal conductance indicates the plant is in good condition for photosynthesis or metabolism. Stomata are a tool for the passage of CO_2 and H_2O gases from outside the plant into the plant so that metabolic processes go hand in hand with the opening and closing of stomata, if metabolism is hampered then the conductance of the stomata could decrease and even stop (Soleh et al., 2017). Several factors affect stomatal conductance including phytohormones, light, drought stress, carbon dioxide, and signals originating from microbes (Ye et al., 2020).

Table 1. Effect of different K fertilizer doses and retardant concentrations on chlorophyll content index and stomatal conductance of G_0 potato

Treatment	Chlorophyll Content Index (CCI)	Stomatal conductance (µmol H_2O/m^2s)
d_1: 50% dose of K (50 kg KCl/ha)	29.26 a	47.84 a
d_2: 100% dose of K (100 kg KCl/ha)	32.89 a	41.39 a
d_3: 150% dose of K (150 kg KCl/ha)	32.10 a	46.25 a
r_1: without retardan	46.61 a	49.64 a
r_2: 100 ppm paclobutrazol	52.90 b	53.93 ab
r_3: 100 ppm prohexadione-Ca	32.49 a	65.71 ab
r_4: 150 ppm prohexadione-Ca	35.56 ab	71.59 b

Note : Means followed by the same letter in the same column and factor is not significantly different based on Duncan's Multiple Range Test at 5% significance level.

Table 2. Effect of different K fertilizer doses and retardant concentrations on relative growth rate and potato growth rate of G_0 potato

Treatment	Relative Growth Rate ($g\ g^{-1}\ day^{-1}$)	Tuber Growth Rate ($g\ plant^{-1} day^{-1}$)
d_1: 50% dose of K (50 kg KCl/ha)	0.0260 a	0.0924 a
d_2: 100% dose of K (100 kg KCl/ha)	0.0150 a	0.127 ab
d_3: 150% dose of K (150 kg KCl/ha)	0.0156 a	0.232 b
r_1: without retardant	0.0379 a	0.187 a
r_2: 100 ppm paclobutrazol	0.0129 a	0.162 a
r_3: 100 ppm prohexadione-Ca	0.0287 a	0.272 b
r_4: 150 ppm prohexadione-Ca	0.0212 a	0.181 a

Note : Means followed by the same letter in the same column and factor is not significantly different based on Duncan's Multiple Range Test at 5% significance level.

Relative Growth Rate and Tuber Growth Rate. The results of the analysis can be seen in Table 2. That the application of K fertilizer doses and retardant concentrations did not have a significantly different effect on the relative growth rate (RGR). RGR illustrates an increase in plant dry weight at certain time intervals (Nurmuliana & Akib, 2019). The growth rate is relatively closely related to plant dry weight, which is then divided per unit of time to see the increase in plant dry weight. There was no significant difference in the treatment of the relative growth rate of plants, meaning that the growth rate of all plants was almost uniform at the age of 50-60 DAP. That time the plants entered the advanced vegetative growth phase which caused all treatments to have the same rate so that the growth rate was relatively not different.

Furthermore, from Table 2. Data can be seen that the dose of K fertilizer and the concentration of the retardant had a significantly different effects on the rate of growth of tuber. The rate of growth of tuber is a parameter that describes the speed of assimilate accumulation in the tuber. The highest growth rate of potato was in the treatment of 150% dose of K (is 0.232 $g\ plant^{-1} day^{-1}$). The element K is directly involved in plant physiological processes, namely it plays a role in enzyme activation, stimulates assimilation and assimilates transport. Potassium triggers the translocation of carbohydrates from leaves to carbohydrate-storing plant organs. According to Pahlevi et al. (2016), potassium plays a role in the assimilate translocation process from the source (source) to the storage (yam), Helal & AbdElhady (2015) added that potassium can increase tuber yield a plant.

The 100 ppm prohexadione-Ca treatment gave a significantly different effect on the growth rate of tuber, namely 0.272 $g\ plant^{-1} day^{-1}$. TGR is greatly affected by environmental factors such as temperature. High temperatures can cause low levels of photosynthesis in providing assimilation for all plant growth and can reduce the distribution of carbohydrates to tuber. According to Azima et al. (2017), the formation of potato is also strongly influenced by the photosynthetic capacity of plants, one of the results of plant photosynthesis could be translocated to the stolon section for initiation of potato. Giving prohexadione-Ca could focus the results of photosynthesis on the tuber. The larger the photosynthate partition results, the greater the assimilation that can be transferred to the tuber. High temperatures can also shorten the filling time of tuber, because high temperatures stimulate the synthesis of gibberellin which inhibits the initiation of tuber. Prohexadion-Ca is a compound that can cause decreased growth by blocking gibberellin biosynthesis, thereby inhibiting vegetative growth (Adiel et al., 2011).

Tuber Number and Tuber Weight per Plant. The results of the analysis of variance showed that there was no interaction effect of K fertilizer dosing and concentration inhibition on the number of tuber and the weight of the tuber. Independently application of K fertilizer dose and retardant concentration showed a significant effect on the number of tuber and the weight of G_0 potato tubers from cuttings. The independent effect on the number of tuber and the weight of tuber is presented in Table 3

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Table 3. Effect of different K fertilizer doses and retardant concentrations on number of tuber and weight of tuber of G_0 potato

Treatment	Number of Tuber Per Plant (knol)	Weight of Tuber Per Plant (g)
d_1: 50% dose of K (50 kg KCl/ha)	5.42 a	58.83 a
d_2: 100% dose of K (100 kg KCl/ha)	5.17 a	55.42 a
d_3: 150% dose of K (150 kg KCl/ha)	6.67 b	73.33 b
r_1: without retardant	4.44 a	49.78 a
r_2: 100 ppm paclobutrazol	6.56 bc	69.67 bc
r_3: 100 ppm prohexadione-Ca	6.78 c	74.33 c
r_4: 150 ppm prohexadione-Ca	5.22 ab	56.33 ab

Note : Means followed by the same letter in the same column and factor is not significantly different based on Duncan's Multiple Range Test at 5% significance level.

The dose of K fertilizer and the concentration of the retardant had a significantly different effects on the number of potato tubers. The treatment of 150% dose K showed the number of tubers per plant was more when compared to the 50% dose K and 100% dose K treatments. This was due to an increase in the dose of K fertilizer which could stimulate the formation of tuber, so that the number of tuber produced was optimal (Osman, 1996). K plays a role in the process of photosynthesis because K is an activator of various essential enzymes. The formation of tuber is strongly influenced by the accumulation of photosynthate from the process of photosynthesis. Some of the results of photosynthesis could be translocated to the roots to initiate the formation of tuber (Gutomo et al., 2015). So that in the process of forming potato tubers, K is needed which is quite high. This is in accordance with the results of the experiments carried out, namely the 150% dose of K (d_3) treatment was able to produce more potato tubers compared to other K fertilizer dose treatments.

The treatment of retardant concentrations had a significantly different effect on the number of tuber per plant. The 100 ppm prohexadione-Ca treatment showed a high amount of tuber, but it was not different from the 100 ppm paclobutrazol treatment. Giving prohexadione-Ca could inhibit the endogenous gibberellin content so that the stolons stop elongating and begin to enlarge at the ends of the stolons to form and produce tuber in large quantities. An increase in gibberellins in potato plants grown in unsuitable conditions, namely high temperatures such as in medium plains could certainly lead to an increase in gibberellin synthesis in stolons so that a large number of stolons grow. The temperature in the field is quite high, which causes an increase in gibberellin synthesis in stolons so that the number of stolons increases (Struik, 2007).

A large number of stolons have the opportunity to become tuber if there is a stimulus for potato initiation. Paclobutrazol and prohexadion-Ca are thought to play a major role in the differentiation of stolons into tuber, so that more tuber are formed. The use of retardants accelerates the occurrence of tuberization. According to Sakia et al. (2013), giving retardants can reduce gibberellin activity so that it can inhibit the vegetative phase such as stolon elongation so that it can focus the flow of photosynthate for the formation and enlargement of tuber.

The dose of K fertilizer had a significantly different effect on the weight of potato tubers per plant. 150% of the given K dose resulted in the highest G_0 potato weight of 73.33 g per plant. It is suspected that in the treatment of 150% dose of K, the nutrient K available and absorbed by plants was more than in the other treatments. This is in accordance with the results of the analysis of K content that the treatment of 150% dose of K showed the highest K nutrient content, namely 0.09%. The availability of high K nutrients can help enlarge potato tubers and be able to translocate the assimilated results from photosynthesis to maximize tuber formation because K fertilizer is needed by plants in the formation of carbohydrates in tuber, increases leaf resistance and water absorption so as to prevent wilting and can enlarge potato size. According to Hanafiah (2010), K can make the photosynthesis process and photosynthate distribution running smoothly. Sutrisna et al. (2003) stated that the balance of K nutrients in the soil plays an important role in the synthesis of carbohydrates and proteins so it greatly helps grow tuber.

Giving retardant concentrations in the 100 ppm prohexadione-Ca treatment had a significant effect on producing a higher tuber weight of 74.33 g per plant compared to other treatments. Prohexadione-Ca with a concentration of 100 ppm was able to suppress the synthesis of gibberellins so that the growing stolons stopped elongating and then formed tubers. The high or low weight of the tuber formed depends on the amount of assimilates that can be produced by the plant. The more assimilates produced by a plant, the higher the weight of the tuber and vice versa. This is consistent with the observation of the rate of growth of potato that the 100 ppm prohexadion-Ca treatment showed the highest growth rate of potato, namely 0.272 g $plant^{-1} day^{-1}$.

Under these conditions, according to (Sutater et al., 1993) the number of photosynthates that flowed and stored as food reserves determine the weight of tuber because tuber are a food reserve resulting from photosynthesis. Increasing the formation and filling of tuber resulted in a large number of tuber with large sizes (Sutater et al., 1993). Apart from how much photosynthates flow, the weight of the potatoes is also related to the number of potatoes that are formed. The more tuber of the same size, the higher the weight of the tuber produced. On the other hand, if a few potato seeds are formed, the photosynthetic flow received by each tile becomes more, causing optimal enlargement of the tubers.

Percentage of Class L Potato Seeds G_0. Classification of G_0 potato seeds is based on seed weight. Class L weight > 20 g, class M seeds weight 5-20 g and class S weight < 5 g (Directorate of Horticulture Seeds, 2014). Table 4 shows that there is an interaction between the K dose and the retardant treatment. Class L seeds with a dose of 150% K (d_3) at 100 ppm prohexadione-Ca (r_3) were higher when compared to 50% dose K and 100% dose K, but significantly different when compared to other retardant treatments.

This shows that the interaction between the treatment of K fertilizer doses and the concentration of the retardant was able to increase the size of the potato to larger, in this treatment class L potato reached 63.3%. Treatment of 150% dose K plus 100 ppm prohexadione-Ca gave a higher 63.3% percentage of L seed class tuber when compared to other treatments. Element K helps to facilitate the translocation of photosynthetic into the tuber, the more photosynthetic that is produced and absorbed, the larger the potato tuber size could be. Gutomo et al. (2015) suggested that the process of filling potato tubers is related to the photosynthetic ability of plants.

The available K nutrients could increase the rate of photosynthesis as a result of the additional K dose. The photosynthetic results could be stored in food reserves, the photosynthate translocation could be faster when stimulated by giving prohexadione-Ca. This is due to the function of prohexadione-Ca which can increase the rate of photosynthate storagein tuber . This situation can support the growth of tuber so that there are more large tuber due to the more photosynthetic content in these tuber. Most of the results of photosynthesis from plants could flow to plant roots for tuberization such as in potato plants.

Table 4. Interaction effect of different K fertilizer doses and retardant concentrations on the yield of G_0 potato in the L class seeds

Dose of K (D)	The L Class Seeds (%)			
	Retardant (R)			
	r_1	r_2	r_3	r_4
d_1	25.2 a A	44 a B	37.0 a AB	35.5 b AB
d_2	23.1 a A	31.7 a A	23.5 a A	23.3 a A
d_3	23.3 a A	32.6 a A	63.3 b B	17.8 a A

Note : d_1 =50% dose of K (50 kg KCl/ha), d_2=100% dose of K (100 kg KCl/ha), d_3=150% dose of K (150 kg KCl/ha); r_1 = without retardant, r_2 =100 ppm paclobutrazol, r_3 =100 ppm prohexadione-Ca, r_4= 150 ppm prohexadione-Ca. Means followed by the same letter is not significantly different based on Duncan's Multiple Range Test at 5% significance level. Lowercase letters are read vertically and capital letters are read horizontally

Table 5. Effect of different K fertilizer doses and retardant concentrations on time of shoots appear, shoot length, percentage of seeds shoot of G_0 potato

Treatment	Time Shoots appear (Day)	Shoot Length (mm)	Seed Sprout (%)
d_1: 50% dose of K (50 kg KCl/ha)	60 a	3.3 a	50.50 a
d_2: 100% dose of K (100 kg KCl/ha)	60 a	3.6 a	52.00 a
d_3: 150% dose of K (150 kg KCl/ha)	61 a	2.6 a	53.00 a
r_1: without retardant	60 b	3.1 a	51.22 a
r_2: 100 ppm paclobutrazol	61 b	3.5 ab	41.66 a
r_3: 100 ppm prohexadione-Ca	63 b	2.2 a	56.66 a
r_4: 150 ppm prohexadione-Ca	54 a	4.0 b	57.77 a

Note : Means followed by the same letter in the same column and factor is not significantly different based on Duncan's Multiple Range Test at 5% significance level.

Time Shoots Appear, Shoot Length and Seeds Sprout. Based on the analysis of variance, it was shown that there was no interaction effect between the dose of K fertilizer and the retardant concentration applied to G_0 seeds at the time of shoot emergence, shoot length and percentage of seeds sprouting. However, independently the retardant concentration treatment showed its effect on the time of shoot emergence and shoot length on G_0 seeds during seed storage. The results of Duncan's multiple range test for the time of shoot emergence due to the application of K fertilizer doses and retardant concentrations are presented in Table 5.

The dose of K fertilizer did not have a significant effect on the time of shoot emergence, shoot length and the percentage of seeds sprouting as can be seen in Table 5. The results of data analysis showed that increasing the number of doses of K fertilizer had no effect on the time of shoot emergence, shoot length, and the percentage of seeds that sprouted during storage.

Giving retardant concentrations to G_0 seeds from cuttings showed a significantly different effect on the time of emergence of shoots. The retardant concentration of 100 ppm prohexadione-Ca (r_3) required a longer time to produce shoots, namely 63 days after storage, while the concentration of retardant in the treatment of 150 ppm prohexadione-Ca (r_4) broke dormancy faster, namely 54 days when compared to treatment without retardant, 100 ppm paclobutrazol and 100 ppm prohexadione-Ca. Potatoes could start to sprout after the dormancy period ends. Giving prohexadione-Ca affects the physiological properties of plants which can accelerate the breaking of potato seed dormancy as seen by the emergence of shoots. In line with research conducted by Darmawan et al. (2014) the treatment of prohexadione-Ca can accelerate flowering by 21 days compared to control and paclobutrazol.

In addition to being influenced by internal factors, the chemical processes that occur during storage are also influenced by environmental factors, namely the temperature of the storage room. Nuraini et al. (2019) stated that one of the factors that caused the length of dormancy was the temperature conditions of storage of potato tubers. Storage of seeds in the medium plains can affect the time of emergence of shoots due to higher temperatures compared to storage in the highlands. High temperatures during the storage of tuber could affect the dormancy of tuber , shorten the resting period, and even accelerate the emergence of shoots (Levy & Veilleux, 2007). Potato seeds could experience a longer dormancy period if stored at 4°C compared to potato seeds stored at 25°C. The average temperature of the storage room in this study was 25°C. The average temperature of the storage room is in accordance with the temperature required for the germination of potato seeds during storage.

Giving the retardant concentration has a significant effect on the length of shoots. The 150 ppm prohexadione-Ca treatment had the highest effect on shoot length and was not significantly different from 100 ppm paclobutrazol while the 100 ppm prohexadione-Ca treatment had the lowest effect. This proves that the treatment of 150 ppm prohexadione-Ca resulted in good potato seed production, which was characterized by higher shoot length growth. The length of the potato shoots is related to the seed dormancy period. Shoots could appear when the seeds have broken their dormancy period. The faster the breakdown of dormancy, the longer the shoots could be, according to the experiment that the 150 ppm prohexadione-Ca treatment gave rise to shoots the fastest, namely 54 days.

Apart from being related to the long dormancy period of the shoots, it is also related to the flow of photosynthetic which is translocated to the tuber. Treatment of 150 ppm prohexadione-Ca can increase photosynthate storage in tuber so they have good vigor. It is this diversion of the flow of photosynthates that can increase food reserves in tuber (Warnita et al., 2019). The higher the content of food reserves contained in tuber , the more shoots that grow could be bigger.

Tuber Weight Loss. The results of the statistical analysis showed that there was an interaction between the doses of K fertilizer and the retardant concentration on the percentage of tuber weight loss. The results of Duncan's Multiple Range Test are presented in Table 6.

Based on Table 6, the treatment of 50% dose K (d_1) in the treatment of 100 ppm prohexadione-Ca (r_3) resulted in 0.42% higher potato weight loss compared to the treatment without retardants, 100 ppm paclobutrazol and 150 ppm prohexadione-Ca and different when compared to the treatment of 100% dose K and 150% dose K. Loss of weight of tuber during storage determines the quality and duration of seeds when stored (Pande et al., 2007). The high temperature and low humidity in the storage room are one of the factors that can increase the transpiration process. Transpiration is the evaporation of water inside the seed to the surface of the seed and from the surface of the seed to the surrounding environment. The loss of water from inside the seed to the surface of the seed results in loss of water from inside the seed which has an impact on decreasing the fresh weight of the seed (Sukarman & Seswita, 2012). Low seed weight loss causes low transpiration and respiration.

Treatment of a 150% dose of K (d_3) in the treatment of 100 ppm prohexadione-Ca (r_3) resulted in lower tuber weight loss of 0.11%. This is because the treatment of a 150% dose of K plus a retardant concentration of 150 ppm prohexadione-Ca can suppress the transpiration and respiration processes in G_0 potato seeds from cuttings during storage. Based on research conducted by Oliveira et al. (2021) that prohexadione-Ca can increase the starch and protein content of potato tubers compared to controls. Decreased starch content, increased reducing sugar content, and increased water content in the potato during storage is a form of damage that greatly affects the seeds.

During storage, potato tubers could undergo a metabolic process, namely a process of breaking down starch into sugars, and this process is influenced by the level of respiration rate. The higher the rate of respiration, the faster conversion of starch into sugars. Sugars could be used as energy in the process of respiration (Tronggono, 1990). The water content in potato tubers is also a catalyst in metabolic reactions, therefore fresh potatoes could easily experience quality changes (Winarno, 1980). This is due to the reduced sugar levels that accumulated during storage at cold temperatures being broken down into starch and there is an increase in the respiration and transpiration processes so that the tuber releases water and carbon dioxide into the indoor air. This also causes the weight of the potato tuber to decrease. The low weight loss of tuber in the 150 ppm prohexadione-Ca treatment coupled with a high K dose indicates that the role of K together with prohexadione-Ca is synergistic in facilitating the process of photosynthesis, improving yield quality, reducing the speed of yield decay during transportation and storage (Darmawan et al., 2014).

Table 6. Effect of interaction between K fertilizer dose and retardant concentration on G_0 seeds from cuttings on tuber weight loss

Dose of K (d)	Tuber Weight Loss (%)			
	Retardant (r)			
	r_1	**r_2**	**r_3**	**r_4**
d_1	0.14 a A	0.09 a A	0.42 b B	0.22 a AB
d_2	0.36 b B	0.17 a A	0.38 b B	0.13 a A
d_3	0.17 a A	0.12 a A	0.11 a A	0.12 a A

Note : d_1 =50% dose of K (50 kg KCl/ha), d_2=100% dose of K (100 kg KCl/ha), d_3=150% dose of K (150 kg KCl/ha); r_1 = without retardant, r_2 =100 ppm paclobutrazol, r_3 =100 ppm prohexadione-Ca, r_4= 150 ppm prohexadione-Ca. Means followed by the same letter is not significantly different based on Duncan's Multiple Range Test at 5% significance level. Lowercase letters are read vertically and capital letters are read horizontally

Conclusion

From the experimental results and discussion, it can be concluded that:

1. There is an interaction between K fertilizer dose and retardant concentration on the L seed class and potato weight loss. Treatment with 150% dose K and 100 ppm prohexadione-Ca concentration showed the highest percentage of L seed class and lowest G_0 seed weight loss.
2. The application of K fertilizer independently affects the growth rate of tuber, the number of tuber and the weight of G_0 seed potato. 150% dose of K showed the highest growth rate of tubers and gave the highest number of tubers (6.67 knol/plant) and the highest tuber weight (73.33 g/plant). A concentration of 150 ppm prohexadione-Ca, increased stomatal conductance, and accelerated shoot emergence time and shoot length. The concentration of 100 ppm prohexadione-Ca produced the highest amount of tuber (6.78 knol/plant) and the highest weight of tuber (74.33 g/plant).

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