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Effect of biochar composition and paclobutrazol concentration on growth and yield of G1 medians cultivar potato seeds in Jatinangor medium plain

Abstract. Potato seed production in the medium plain is necessary to avoid environmental damage and the limited area of potato seed production in the high plain. The effort to increase the production of G1 potato seeds on the medium plain is the evaluation of the biochar composition and concentration of paclobutrazol that can increase the production G1 potato seeds cv Medians in the medium plain of Jatinangor. The research was conducted from August to December 2022 at the Ciparanje Experimental Field. Jatinangor. Faculty of Agriculture. Universitas Padjadjaran. The experiment used a Factorial Randomized Block Design (RBD). The first factor was the biochar composition: m_1 (100% compost), m_2 (80% compost + 20% rice husk biochar), m_3 (80% compost + 20% coconut shell biochar), and m_4 (80% compost + 10% biochar husk rice + 10% coconut shell biochar). The second factor was the paclobutrazol concentration: p_1 (without paclobutrazol), p_2 (100 ppm paclobutrazol), and p_3 (150 ppm paclobutrazol). The experimental results showed that there was no reaction effect of biochar compositions and paclobutrazol concentrations on the growth and yield of G1 potato seeds. The application of 80% compost + 20 % rice husk biochar gave significantly higher yields than treatment without biochar. The number of tubers was 6.29 knol per plant and the tuber weight was 66.80 g per plant. Application of 100 ppm paclobutrazol resulted in lower plant height, gave the number of tubers was 6.39 knol per plant, tuber weight per plant was 63.34 g higher than without paclobutrazol and produced more seed tubers with S class.

Keywords: Biochar · Medium plain · Paclobutrazol · Potato · Seed

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Introduction

Potato (*Solanum tuberosum* L.) is one of the horticultural plants with the sweet potato target organ. Potato tubers are highly nutritious, with essential amino acids like lysine and metabolites enhancing their biological value and overall utilization (Górska-Warsewicz, 2021). They are rich in vitamins B6 and C, along with small amounts of folate, thiamin, niacin, and riboflavin; potatoes also provide 0.5–2% dietary fiber and contain minerals like magnesium, iron, potassium, and phosphorus (Beals, 2019; Górska-Warsewicz, 2021). Potatoes are a type of vegetable that has high economic value, both processed as fresh and processed products. In addition, potatoes are an alternative food source to rice, wheat, and corn.

One of the problems in potato cultivation is the low availability of quality seed potatoes at the farm level. According to Hamdani (2020), the low availability of quality potato seeds causes some farmers to use seeds produced from previous plantings. The use of seeds from the previous harvest cannot be done continuously because the quality of potatoes produced will decrease.

In 2013, Balitsa successfully developed superior seed potatoes. One of them was the Medians cultivar. The Medians cultivar is the result of selection from the progeny of a cross that uses the Atlantic as one of its parents so that its characters are similar to the Atlantic but have higher production. According to (Balitsa, 2013). the advantages of the Medians cultivar include the potential for potato production to reach 31.9 tons/ha and resistance to late blight.

Highland with suitable air temperatures for potato cultivation in Indonesia is still limited. Continued cultivation of upland potatoes can harm the environment and diminish soil productivity by depleting nutrients and exhausting the soil. (Gunadi & Pronk, 2023). One alternative that can be pursued is the expansion of potato planting areas in the medium lands (Dewi et al. 2024). The main problem in the development of potato cultivation in the medium plains is high temperature, reaching more than 20°C. Potato growth stages, including sprouting, emergence, and leaf area development, are sensitive to temperature (Adekanmbi et al.2023). Ohtaka et al. (2020) mentioned that high temperatures can increase genes and concentrations of gibberellin, causing translocation of photosynthetic products to the top of the plant and reducing the translocation of photosynthetic products to the sweet potato.

Soils in the Jatinangor medium plains belong to the Inceptisol soil order. Inceptisols generally contain a high proportion of clay and silt fractions (Schadosin et al., 2023). Jatinangor Inceptisols soil has relatively low soil fertility but can be improved with proper handling and technology. The growing medium can be improved by applying organic materials such as compost, rice husk charcoal, and coconut shell charcoal.

Another effort that can be made to increase the growth of yield and quality of G1 potato seeds in the hope of regulating the balance of growth is by giving a growth regulator substance. Growth regulators can be used to affect the intensity and direction of physiological processes (Rohach et al., 2023). One of the inhibitory growth regulators is paclobutrazol. Paclobutrazol, a triazolic fungicide with plant growth-regulating properties, inhibits cytochrome P450-mediated ent-kaurene oxidase activity in the gibberellic acid biosynthesis pathway, leading to reduced gibberellic acid levels (Pant et al., 2019), when the plant cells are prompted to elongate and divide (Oliveira et al. 2022). The beneficial effects of paclobutrazol treatment on improving various root crops, such as carrots and potatoes, have been documented, showing increases in both yield and overall plant quality (Wang et al., 2015; Mabvongwe et al., 2016).

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 photosynthate-producing sites for vegetative growth and tuber formation can be suppressed.

With the combination treatment between biochar composition and paclobutrazol application on potato plants, it is expected that the availability of nutrients is higher and suited for the needs of plants. The addition of biochar is expected to create an ideal planting media structure for the root system and tuber development. An improvement in the plant growth and yield, particularly tuber, is also expected by adding paclobutrazol. Therefore, the purpose of this study was to determine the effect of interaction between biochar composition and paclobutrazol concentration on the growth and yield of G1 potato seed cultivar Median in Jatinangor medium plains.

Materials and Methods

The experiment was conducted from August to December 2022 at the Plastic House. Ciparanje Experimental Farm Jatinangor. Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency, West Java at an altitude of ± 658 m above sea level (above sea level) with Inceptisols soil order.

Materials used during the experiment were G0 seed potatoes of Medians cultivar, inceptisol soil from Ciparanje experimental garden, compost, rice husk biochar, coconut shell biochar, paclobutrazol Goldstar 250 SC (active ingredient Paclobutrazol 250 g/L), stakes. 30 x 30 cm polybags, urea fertilizer (46% N), SP-36 fertilizer (36% P_2O_5), KCl fertilizer (48% K_2O), Basamid 98 G (Dazomet 98%), Curracron 500 EC insecticide (Profenofos 500 g/L), Plantomycin bactericide (Streptomycin sulfate 6.87%), Curzate 8/64 WP fungicide (Mankozeb 64%) and Furadan 3G nematicidal (Carbofuran 3%).

The experimental design used was a Factorial Randomized Group Design (RDG) pattern consisting of two factors. The first factor is biochar composition (M) which consists of four levels, including: m_1 (100% compost), m_2 (80% compost + 20% rice husk biochar), m_3 (80% compost + 20% coconut shell biochar), and m_4 (80% compost + 10% rice husk biochar + 10% coconut shell biochar). The second factor is paclobutrazol concentration (P) which consists of 3 levels, including: p_1 (without paclobutrazol). p_2 (100 ppm paclobutrazol), and p_3 (150 ppm paclobutrazol). From these two factors, 12 treatment combinations were repeated 3 times so that there were 36 experimental units. Each experimental unit consisted of 5 plants. resulting in 180 experimental plants.

The experiment began with the preparation of planting media consisting of soil, compost, and biochar composition according to the treatment mixed and put into polybags. Paclobutrazol application was carried out by foliar spray technique or spraying on plant leaves and applied 2 (two) times when the plants were 30 days after planting (DAP) and 40 DAP.

Observations consisted of measurements of plant height. leaf area. index. chlorophyll content. stomatal conductance. plant dry weight. root pupil count. number of tubers and tuber weight per plant. percentage of seed tubers per quality class. The effect of treatment was tested with the F test with a significant level of 5% while testing the difference in the mean value of treatment was done with the Duncan test at a significant level of 5%.

Results and Discussion

Plant Height. The results of the analysis of variance showed that there was no interaction effect between biochar composition and paclobutrazol concentration on plant height. The independent effect of biochar composition and paclobutrazol concentration on plant height can be seen in Table 1.

The results of plant data at the age of 20 DAP to 50 DAP. The m_2 and m_4 treatments can produce plants that are significantly higher than m_1 and m_3 treatments. The m_4 treatment has a higher percentage of air space so that the mixed biochar composition treatment can absorb and store water for plant growth. Plants at the age of 60 DAP. treatment m_4 produced significantly higher plant height than m_3 but both treatments were not significantly different compared to treatments m_1 and m_2. Based on the results of the physical analysis of the planting media. it shows that the planting media in the m_3 treatment has a high percentage of water-holding capacity but the percentage of porosity is also higher. so it will be able to evaporate faster than the m_2 and m_4 treatments which have a lower percentage of water holding capacity and porosity percentage.

Table 2 shows that the treatment of paclobutrazol concentration has a significant effect on plant height from 40 DAP to 60 DAP. This is because paclobutrazol began to be applied at 30 DAP so that its effect on plant height can be seen starting at 40 DAP observation. Based on the results of the data in Table 6, at 50 and 60 DAP, the treatment of 100 ppm paclobutrazol and 150 ppm paclobutrazol can suppress the growth of plant height compared to the treatment without paclobutrazol. This is because paclobutrazol has the property of inhibiting vegetative growth and inhibiting the biosynthesis of gibberellin (Pant et al., 2016). Paclobutrazol application causes stunted plant growth by inhibiting cell elongation and internode extension, resulting in shorter shoots with the same number of leaves and internodes condensed into a smaller length (Desta & Amare, 2021). According to Tesfahun (2018), paclobutrazol is commonly used to reduce plant height, and increasing its concentration can lead to dwarfism.

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Table 1. Effect of biochar composition and paclobutrazol concentration on plant height.

Treatment	Plant Height (cm)				
	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP
m_1 (100% compost)	16.90 a	21.66 a	23.84 a	25.60 a	34.67 ab
m_2 (80% compost + 20% rice husk biochar)	20.42 b	25.76 b	28.30 b	30.25 b	35.93 ab
m_3 (80% compost + 20% coconut shell biochar)	17.13 a	22.09 a	23.87 a	25.45 a	33.71 a
m_4 (80% compost + 10% rice husk biochar + 10% coconut shell biochar)	21.10 b	26.63 b	30.03 b	32.17 b	36.95 b
p_1 (without paclobutrazol)	18.60 a	24.07 a	29.18 b	33.35 b	39.58 b
p_2 (100 ppm paclobutrazol)	18.97 a	23.72 a	25.08 a	25.85 a	34.00 a
p_3 (150 ppm paclobutrazol)	19.09 a	24.32 a	25.27 b	25.89 a	32.36 a

Notes: The numbers in the same column followed by the same letter are not significantly different based on Duncan multiple range test at the 5% level.

Table 2. Effect of biochar composition and paclobutrazol concentration on leaf area index, chlorophyll content index, and stomatal conductance.

Treatment	Leaf Area Index	Chlorophyll Content Index (CCI)	Stomatal Conductance (mmol H_2O m^{-2} s^{-1})
m_1 (100% compost)	4.38 a	37.96 b	198.18 a
m_2 (80% compost + 20% biochar rice husks)	4.58 a	32.45 a	181.34 a
m_3 (80% compost + 20% biochar coconut shell)	4.27 a	34.41 ab	205.25 a
m_4 (80% compost + 10% biochar rice husks + 10% biochar coconut shell)	4.72 a	33.56 ab	199.84 a
p_1 (0 ppm paclobutrazol)	4.78 a	34.49 a	155.94 a
p_2 (100 ppm paclobutrazol)	3.98 a	33.01 a	206.85 b
p_3 (150 ppm paclobutrazol)	4.71 a	36.28 a	225.67 b

Notes: The numbers in the same column followed by the same letter are not significantly different based on Duncan multiple range test at the 5% level.

Leaf Area Index. The independent effects of biochar composition and paclobutrazol concentration on leaf area index can be seen in Table 2. The treatment of biochar composition and paclobutrazol concentration did not significantly affect the leaf area index. The addition of compost and biochar can create a good planting media structure for the root system of potato plants so that the process of absorption of nutrient and water by the roots can be more optimal to meet the needs of potato plants. In line with the results of research by Hamdani et al. (2019) stated that the application of the type of growth regulator paclobutrazol. did not significantly affect the leaf area index. This is because canopy growth in general with the application of paclobutrazol does not have a significantly different effect.

Chlorophyll Content Index. The independent effects of biochar composition and paclobutrazol concentration on chlorophyll content index can be seen in Table 2. The treatment of biochar composition m_2 has a lower chlorophyll content index than the treatment m_1 but is not significantly different from the other treatments. The low chlorophyll content index in the m_2 treatment is related to the leaf area index. which has a greater value than the m_1 treatment. This is because the structure of the growing media produced with the addition of rice husk biochar spurs the process of cell division and elongation in plants. namely the growth of the plant canopy which is the result of the photosynthesis process. Paclobutrazol concentration did not significantly affect the chlorophyll content index. T

Stomatal Conductance. The independent effects of biochar composition and paclobutrazol concentration on stomatal conductance can be seen in Table 2. Biochar composition has no significant effect on stomatal conductance. This is because the composition of biochar can produce a good planting media structure for potato plants by providing sufficient water for plants and increasing water uptake by roots. The treatment of paclobutrazol concentration has a significant effect on stomatal conductance. Retardant treatment can increase stomatal

conductance. Larger stomatal opening and increased stomatal density thus increasing the concentration of CO_2 in the chloroplast which is a factor in increasing stomatal conductance (Xia et al., 2018).

Plant Dry Weight and Shoot Root Ratio. The independent effects of biochar composition and paclobutrazol concentration on plant dry weight and root shoot ratio can be seen in Table 3. The treatment of biochar composition did not have a significant effect on plant dry weight and root shoot ratio. This is because the addition of compost and biochar can improve the physical properties of planting media, namely the availability of water for plants, improve drainage and aeration, and can bind nutrients well for plants to carry out the photosynthesis process. If the rate of photosynthesis can take place well, the photosynthate produced in the form of plant biomass such as roots stems and leaves will increase.

The treatment of paclobutrazol concentration has a significant effect on plant dry weight. Plants without paclobutrazol produced the highest plant dry weight compared to 100 ppm and 150 ppm paclobutrazol. According to Ajmi et al. (2020), paclobutrazol decrease plant dry weight by 59%. Therefore, plants that are not inhibited by paclobutrazol could produce higher dry weight.

Number of Stolons and Percentage of Stolons Forming Tubers. The independent effects of biochar composition and paclobutrazol concentration on the number of stolons and the percentage of stolons forming tuber can be seen in Table 3. Biochar composition has no significant effect on the number of stolons and the percentage of stolons forming tuber. This is because the treatment of biochar composition can improve the structure of the planting media so that stolons can grow well.

Table 3. Effect of biochar composition and paclobutrazol concentration on dry weight, root shoot ratio, number of stolons, and percentage of stolons forming sweet potato.

Treatment	Plant Dry Weight(g)	Shoot Root Ratio	Number of Stolons	Percentage of Stolons Forming Tubers (%)
m_1 (100% compost)	9.55 a	8.30 a	5.88 a	59.96 a
m_2 (80% compost + 20% biochar rice husks)	9.04 a	8.23 a	5.11 a	53.72 a
m_3 (80%compost + 20% biochar coconut shell)	8.53 a	7.01 a	4.22 a	65.60 a
m_4 (80% compost + 10% biochar rice husks + 10% biochar coconut shell)	9.15 a	7.88 a	5.22 a	64.15 a
p_1 (0 ppm paclobutrazol)	12.05 b	9.76 a	4.83 ab	48.66 a
p_2 (100 ppm paclobutrazol)	7.34 a	6.72 a	6.41 b	64.15 b
p_3 (150 ppm paclobutrazol)	7.82 a	7.08 a	4.08 a	69.77 b

Notes: The numbers in the same column followed by the same letter are not significantly different based on Duncan multiple range test at the 5% level.

Table 4. Effect of biochar composition and paclobutrazol concentration on the number of tubers and tubers weight.

Treatment	Number of tubers	Tubers weight (g)
m_1 (100% compost)	5.55 a	53.95 a
m_2 (80% compost + 20% biochar rice husks)	6.29 b	66.80 b
m_3 (80%compost + 20% biochar coconut shell)	6.14 ab	59.16 ab
m_4 (80% compost + 10% biochar rice husks + 10% biochar coconut shell)	6.07 ab	57.67 ab
p_1 (0 ppm paclobutrazol)	5.22 a	49.65 a
p_2 (100 ppm paclobutrazol)	6.39 b	63.34 b
p_3 (150 ppm paclobutrazol)	6.44 b	65.54 b

Notes: The numbers in the same column followed by the same letter are not significantly different based on Duncan multiple range test at the 5% level.

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Paclobutrazol concentration had a significant effect on the number of stolons and the percentage of stolons forming sweet potatoes. Treatment p_2 produced a significantly higher number of stolons compared to p_3 but was not significantly different from treatment p_1. Treatment p_3 produced a higher percentage of stolons forming sweet potatoes than treatment p_1 but significantly different from treatment p_2.

Number of tubers and Tuber Weight. The independent effects of biochar composition and paclobutrazol concentration on the number of sweet potatoes and sweet potato weight per plant can be seen in Table 4. Biochar composition had a significant effect on the number of sweet potatoes and sweet potato weight per plant. The m_2 treatment produced a higher number of sweet potatoes and sweet potato weight per plant than the m_1 treatment but was not significantly different from the other treatments. This is because. with the addition of rice husk biochar. the planting media has a low density so the condition of the planting media becomes quite fine structure. good drainage. and availability of nutrient and water sufficient for plant growth. The m_2 treatment which was higher than the m_1 treatment was also influenced by the low percentage of stolons forming sweet potatoes so that the photosynthate flowed was concentrated and stored as food reserves. A positive correlation existed between the number of stolons and the tuber yield (Milagres et al., 2019).

The concentration of paclobutrazol significantly influenced the number of sweet potatoes and the weight of sweet potatoes per plant. Treatments p_2 and p_3 significantly produced a higher number and weight of sweet potatoes compared to treatment p_1 (without paclobutrazol). This is related to the low plant height but produced a high index of chlorophyll content. stomatal conductance, and percentage of stolons forming sweet potatoes. This shows that the paclobutrazol concentration treatment given can inhibit the growth of several parts of the plant by suppressing gibberellin synthesis. According to the results of research by Dalimunthe et al. (2021), the application of paclobutrazol can increase the fresh weight of tubers per plant compared to without paclobutrazol application.

G1 Potato Seed Grade. The results of the analysis of variance showed that there was no interaction effect between biochar composition and paclobutrazol concentration on the percentage of seed tubers per quality class. The independent effects of biochar composition and paclobutrazol concentration on the percentage of seed tubers per quality class can be seen in Table 5. Biochar composition and paclobutrazol concentration did not significantly affect the percentage of tubers per class S (<40 g), class M (40-90 g), and class L (91-120 g). This is due to the influence of high temperatures in the medium plains which can affect the formation of sweet potatoes related to the value of the root shoot ratio which is quite high and the photosynthate produced can be spread evenly to each organ of the potato plant so that the sweet potatoes formed are small and tend to be small. The provision of biochar can support the improvement of soil structure with a crumbly structure, loose, contains organic matter, and has good drainage so that it is a good planting medium for the growth and development of potatoes.

Table 5. Effect of biochar composition and paclobutrazol concentration on the percentage of seed tubers per class quality.

Treatment	Percentage of Seed Tuber per Class Quality		
	S (%)	M (%)	L (%)
m_1 (100% compost)	95.00 a	5.00 a	0.00 a
m_2 (80% compost + 20% biochar rice husks)	94.05 a	5.95 a	0.00 a
m_3 (80%compost + 20% biochar coconut shell)	96.97 a	3.03 a	0.00 a
m_4 (80% compost + 10% biochar rice husks + 10% biochar coconut shell)	91.97 a	6.79 a	0.00 a
p_1 (0 ppm paclobutrazol)	98.33 a	1.67 a	0.00 a
p_2 (100 ppm paclobutrazol)	91.79 a	8.20 a	0.00 a
p_3 (150 ppm paclobutrazol)	93.35 a	5.71 a	0.00 a

Notes: The numbers in the same column followed by the same letter are not significantly different based on Duncan multiple range test at the 5% level.

The provision of paclobutrazol did not have a significant effect on the number of potato seeds per class S, M, and L due to the equilibrium of endogenous growth regulators contained in plants followed by the time of administration and the combination of less appropriate treatments because the administration of plant growth regulator depends on various factors such as plant parts, developmental phases. The concentration of ZPT given and various environmental factors. The results of this experiment, the percentage of G1 seed tuber class S has a higher percentage value than class M and L. A high percentage of G1 seed tuber class S in potato planting with the aim of seed production will be by market demand. In line with the results of research by Adiyoga et al. (2014), it is stated that potato farmers in Indonesia prefer the use of potato tubers measuring 30-40 g compared to seed potatoes with a size of more than 40 g which included the G1 class S seed tuber because it has a smaller weight and size so it is easy to store and distribute.

Conclusion

From the results and discussion, it can be concluded that there is no interaction effect between biochar composition and paclobutrazol concentration on the growth and yield of G1 seed potato cultivar Medians in the Jatinangor medium plain. The application of 80% compost + 20 % rice husk biochar gave significantly higher yields, the number of potatoes is 6.29 knol per plant, and tuber weight is 66.80 g per plant than without biochar. Application of 100 ppm paclobutrazol resulted in lower plant height, gave the number of tubers was 6.39 knol per plant, tuber weight per plant is 63.34 g higher than without paclobutrazol and produced higher S class of seeds potatoes.

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References

Adekanmbi T, Wang X, Basheer S, Nawaz RA, Pang T, Hu Y, Liu S. 2023. Assessing future climate change impacts on potato yields—A case study for Prince Edward Island, Canada. Foods, 12(6): 1176.

Ajmi A, Larbi A, Morales M, Fenollosa E, Chaari A, Munné-Bosch S. 2020. Foliar paclobutrazol application suppresses olive tree growth while promoting fruit set. Journal of Plant Growth Regulation, 39: 1638-1646.

Balitsa. 2013. Deskripsi Kentang Varietas Medians. Tersedia di http://balitsa.litbang.pertanian.go.id (Diakses pada 24 September 2022)

Beals KA. 2019. Potatoes, nutrition and health. American Journal of Potato Research, 96(2): 102-110.

Dalimunthe RH, Setiado H, Lubis K, Damanik RI. 2021. Effect of Paclobutrazol in micro tuberization of Potato (*Solanum tuberosum* L.) cultivar Granola Kembang and Repita. In IOP Conference Series: Earth and Environmental Science, 782(4): 042058.

Desta B, Amare G. 2021. Paclobutrazol as a plant growth regulator. Chemical and Biological Technologies in Agriculture, 8: 1-15.

Dewi TP, Hamdani JS, Mubarok S. 2024. Response of growth and tuber seed production of G0 potato (*Solanum tuberosum* L.) cv Medians in medium lands of Jatinangor to biochar composition and retardant type. Jurnal Kultivasi, 23(1): 14-22.

Górska-Warsewicz H, Rejman K, Kaczorowska J, Laskowski W. 2021. Vegetables, potatoes and their products as sources of energy and nutrients to the average diet in Poland. International Journal of Environmental Research and Public Health, 18(6): 3217.

Gunadi N, Pronk A. 2023. Identifying key factors to improve productivity and reduce environmental impact of potato farms in West Java, Indonesia. E3S Web of Conferences, 373: 04019.

Hamdani JS, Dewi TP, Sutari W. 2019. Pengaruh Compostisi Media Tanam dan Waktu Aplikasi Zat Pengatur Tumbuh terhadap Pertumbuhan dan Hasil Benih Kentang (*Solanum tuberosum* L.) G2 Kultivar Medians di Dataran Medium Jatinangor. Jurnal Kultivasi. 18(2): 875-881.

Hamdani JS. 2020. Pertumbuhan dan Hasil Benih Kentang G0 pada Komposisi Media Tanam dan Interval Pemberian Air yang Berbeda di Dataran Medium. Jurnal Kultivasi. 19(3): 1237-1246.

Mabvongwe O, Manenji BT, Gwazane M, Chandiposha M. 2016. The effect of paclobutrazol application time and variety on growth, yield, and quality of potato (Solanum tuberosum L.). Advances in Agriculture, 2016(1): 1585463.

Milagres CDC, Fontes PCR, Silva JMD. 2019. Potato tuber yield and plant morphological descriptors as affected by nitrogen application. Communications in Soil Science and Plant Analysis, 50(15): 1897-1906.

Ohtaka K, Yoshida A, Kakei Y, Fukui K, Kojima M, Takebayashi Y, Yano K, Imanishi S, Sakakibara H. 2020. Difference between day and night temperatures affects stem elongation in tomato (*Solanum lycopersicum*) seedlings via regulation of gibberellin and auxin synthesis. Frontiers in Plant Science, 11: 577235.

Oliveira KÂS, Lopes PRV, Cavalcante Í, Filho JC, Silva LS, Pereira ECV, Silva JTL. 2022. Impact of paclobutrazol on gibberellin-like substances and soluble carbohydrates in pear trees grown in tropical semiarid. Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo, 54(1): 46-56.

Pant R, Dimri DC, Rai R, Rao VK, Kumar A. 2019. Impact of Soil Applied Paclobutrazol on Vegetative Growth of Litchi (*Litchi chinensis* Sonn.) cv. Rose Scented. Journal of Pharmacognosy and Phytochemistry, 8(2): 332-337.

Rohach VV, Kuryata VG, Kiriziy DA, Sytnyk SK, Grabyk IH, Kaitanyuk OV, Tarasyuk MV, Rohach TI. 2023. Effect of antigibberellins on morphogenesis, photosynthetic apparatus, productivity and their residual content in tomato fruits. Biosystems Diversity, 31(2): 191-201.

Schadosin J, Saab SC, Brinatti AM, Pires LF. 2023. Quantitative and qualitative characterization of the granulometry of an Inceptisol. Química Nova, 46(4): 329-335.

Tesfahun W. 2018. A review on: Response of crops to paclobutrazol application. Cogent Food & Agriculture, 4(1): 1–9.

Wang GL, Xiong F, Que F, Xu ZS, Wang F, Xiong AS. 2015. Morphological characteristics, anatomical structure, and gene expression: novel insights into gibberellin biosynthesis and perception during carrot growth and development. Horticulture research, 2 : 15028.

Xia X, Tang Y, Wei M, Zhao D. 2018. Effect of Paclobutrazol Application on Plant Photosynthetic Performance and Leaf Greenness of Herbaceous Peony. Horticulturae, 4(1): 2-14.