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Research Article
Growth and Yield of Cultivar Atlantic Potato in Medium Altitude with Paclobutrazol Application and Different Amount of Watering

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Abstract

Objective: The objective of this research was to study the growth and yield of Atlantic Potato cultivar grown in medium altitude areas with different amount of watering. **Methodology:** This study was conducted in search station of Agriculture Faculty of Padjadjaran University located in Jatinangor at the altitude of 685 m.a.s.l., at D3 rainfall rate in Inseptisol soil. A split plot design was used during the experiment. The main plot factor was using paclobutrazol at 3 different levels of concentrations (0, 50 and 100 ppm) and the second factor was watered at 4 different levels (100, 85, 70 and 55% water of field capacity). **Results:** The experiment result showed that applying 100 ppm of paclobutrazol could increase the tubers weight per plant, the starch content (12.50%) and reduce the sugar content (0.45%) for growing atlantic cultivar potato in medium altitude, however, it showed low height of the plants. The potato plants which were watered by 85% of field capacity showed the same height as ones watered by 100% while in other parameters low percentage of watering inhibited potato growth and its yield. **Conclusion:** Applying 100 ppm of paclobutrazol could increase the tubers weight per plant, starch content (12.50%) and reduced its sugar content (0.45%) other than that low percentage of watering inhibited potato yield for growing atlantic cultivar potato in medium altitude.

Key words: Medium altitude, paclobutrazol, potatoes, waterin

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Potato is a type of vegetables which plays more important role either as fresh products or as processed products; an alternative commodity within food diversification. Wider range of potato lands in high altitude areas has caused negative effect to the environment, such as environment damage, due to erosion. For this reason, some alternative ways need to be implemented in order to develop the possibility of growing potato in medium altitude areas at 300-700 m a.s.l., found in many areas of Indonesia, which could produce relatively same yield and quality. The experiment showed that cultivar Atlantic potato could grow and produced well when planted in medium altitude[1,2].

In medium altitude of Indonesia and at low rainfall rate, water is not always obtainable. Thus, it will aggravate the growth of plants, especially during the phases when amount of water needs to be sufficient. In the field, young plants will be often dead if the environment gets very dry. This basically happens because evapotranspiration is bigger than the water absorbed by the plants through their root systems.

Based on the previous fact, if the roots ability to absorb water is improved, plants will be able to survive the drought. This is very vital as in certain areas rain may start very late while plants need sufficient water. Paclobutrazol application is one of the innovations in plants modification which needs further experiment for growing Atlantic potato cultivar in medium altitude with different amountof watering. It is expected that the application of hormonal growth of paclobutrazol can overcome those problems. This is possible because paclobutrazol role in improving the process of assimilation fotosintat from the leaves to the potato so sweet potatoes have high starch content[3]. Furthermore, a plant that applied paclobutrazol needed less water and fertilizer compared to one without paclobutrazol[4].

Applications paklobutrazol influential in increasing crop yields for potatoes grown in plain medium[5], having an effect in improving the quality of the roses[6] and influential in improving the quality of begonia[7].

One of paclobutrazol growth retardant factors is the decline in leaf area on traspirational surface, which in turn reduces transpiration[3,5,6]. It could also induce the stomatal closure which reduced transpiration. A plant which was given paclobutrazol is able to adapt with low light condition, survive the drought, increase the plants caroten substances and improve photosyntesis efficiency[4]. Furthermore, a plant that applied paclobutrazol needed less water and fertilizer compared to one without paclobutrazol[4,8,9].

According to the facts, if the ability of the roots to absorb water can be improved, transpiration and evapotransipartion can be reduced, so a plant can survive the drought. This becomes important where in certain areas rain can start late while the plants needs sufficient amount of water. Growing factor like paclobutrazol, considered as an innovation in cultivation technique, should be tried on growing potatoes in medium altitude which are watered differently.

MATERIALS AND METHODS

The experiment took place in a research station located at the Agriculture Faculty of Padjadjaran University from March-September 2015. The altitude of 685 m.a.s.l., with D3 rainfall in inseptisol soil. Split-plot design was being used during the experiment. The main-plot factor applying paclobutrazol consisted of three different levels of applications (0, 50 and 100 ppm). The split-plot was the experiment design with the amount of water given in four different levels (100, 85, 70 and 55% of water field capacity). From those two treatments, 12 treatment per unit were obtained with three replications, so in total there were 36 plots treated. Each treatment was provided with 10 polybags of 15 kg and each polybag consisted of 1 plant, thus, 360 pots were obtained.

Growing media, which had been prepared in polybag, was given 20 t ha^{-1} of fertilizer on the left and the right side of the plant. About 300 kg ha^{-1} of N fertilizer was given twice on the 1st day planting and on the 30th day after planting. While 100 kg ha^{-1} of K and 150 kg ha^{-1} of P fertilizer were given at one time on the 1st day planting. After being fertilized, a diemeter of 10 cm hole was initially made to grow potato seed. The second generation of the seed of Atlantic cultivar of 30-45 g per piece was planted in 7.5 cm depth. To avoid soil insects and other pests, 3 g of furadan was spread around the seeds with a dose of 37.5 kg ha^{-1}. About 30% paranet shield was put up before growing the potatoes[5]. Paclobutrazol application was given on the 30th day after planting by spraying 15 mL per plant. Based on 100% water capacity for inseptisol soil, 1,950 L of water was needed. Plants were watered everyday with the appropriate amount of water accordingly. To mantain the amount of water on treatment, the provision of water was given as much water loss through evapotranspiration added with fresh weight of the plant as a correction factor that is maintained by weighing.

Weeds were removed and then soil was loosen and tiled and added with N fertilizer. Spraying dithane M-45 fungicide and decis 2,5 EC insecticide were aimed to control insects and pests based on the frequency of their attack. Harvesting could

be started when the top of potato plants, the stems and the leaves, became yellow and began to fall and the skin of tubers were not peeled off.

Observation was done on the changing factors; leaves Relative Water Content (LRWC) calculated based on calculation:

$$LRWC = \frac{BS\text{-}Bko}{BT\text{-}Bko} \times 100\%$$

Where:

BS = Fresh weights of leave which is opened perfectly

BT = Turgor weights was obtained by saturating the leaves for about 2 clock

Chlorophyl content was counted by using chlorophyl meter. The parameters of growth consisted of plants height, leaf area and dry weight, while the parameter of yield consisted of numbers of tubers per plant, the weight of tubers per plant and per hectare as well as the yield quality which consisted of starch and sugar content. The F test was performed to determine the differences in each treatment. If there's significant effect of treatment, Duncan's multiple range test at the 5% significance level will be applied.

RESULTS AND DISCUSSION

Content of leaves relative water: From Table 1, it was found that leaves relative water content with 100 ppm paclobutrazol concentration were much higher than with 50 and 0 ppm concentration. Reducing water had caused decline of the content of leaves relative water.

Plants growth-plant height, leaf area and chlorophyll content: Variance analysis results showed no interaction between the effects of packlobutrazol and the amount of the provision of water in the height of potato plant but the effect independently showed that paclobutrazol and the amount of water administration show the effect on plant height, leaf area and chlorophyll content. Treatment of 50 and 100 ppm paclobutrazol shown lower plants height and leaves area than 0 ppm paclobutrazol, which however, showed higher chlorophyll content. Plant height, leaves area and chlorophyll content became lower as a greater amount of water given (Table 2).

Number of tubers and its total weight per plant: Variance analysis result showed that there's no interaction between paclobutrazol application and the water procentage of field capacity on the number of tubers per plant but it had independently showed influence. Application of 50 and 100 ppm of paclobutrazol could increase the number of tubers and its total weight per plant. The amount of water given had also affected them.The number of tubers watered by 85% of field capacity showed most tubers and differed from other treatments. However, they indicated different result when watered by 100% of field capacity. Then, the number and the weight of potatoes decreased as less water given (Table 3).

Sugar and starch content: The result of statistic analysis showed that the sugar content of a plant with 100 ppm paclobutrazol application was 0.45 as the lowest value, while the starch content showed the highest value, 12.50%. Less water of field capacity percentage had caused higher sugar content, yet lower starch content (Table 4).

Table 1: Effect of paclobutrazol and the amount of water on the Leaves Relative Water Content (LRWC)

Treatments	LRWC
Paclobutrazol concentration (ppm)	
0	0.66
50	0.69
100	0.72
Amount of water (Percentage of field capacity)	
100	0.84
85	0.77
70	0.67
55	0.62

Table 2: Effect of paclobutrazol and the amount of water on plants height, leaf area and the chlorophyll content of 56 days old potato

Treatments	Plant height (cm)	Leaf area (cm^2)	Chlorophyll content (CCI)
Paclobutrazol concentration (ppm)			
0	53.54^b	1101.24^b	34.9^a
50	39.65^a	920.37^a	38.2^b
100	37.96^a	887.91^a	38.9^b
Amount of water (Percentage of field capacity)			
100	38.36^a	1130.81^c	40.6^b
85	37.19^a	921.77^b	40.4^b
70	36.99^a	868.58^b	35.0^a
55	35.74^a	717.14^a	33.7^a

Average numbers followed by same letters are the same based on Duncan's multiple range test on 5% level

Table 3: Effect of paclobutrazol and percentage of water content of field capacity on the numbers of tubers

Treatments	No. of tubers per plant (piece)	Tubers weight per plant (g)
Paclobutrazol concentration (ppm)		
0 ppm	6.15[a]	356.22[a]
50 ppm	8.42[b]	398.43[ab]
100 ppm	8.59[b]	442.32[b]
Amount of water (Percentage of field capacity)		
100	8.46[b]	441.67[b]
85	9.01[b]	364.64[b]
70	6.57[a]	252.81[a]
55	5.95[a]	234.22[a]

Average numbers followed by same letters are the same based on Duncan's multiple range test on 5% level

Table 4: Effect of paclobutrazol and the amount of water on starch and sugar content

	Content (%)	
Treatments	Sugar	Starch
Paclobutrazol concentration (ppm)		
0	0.56	10.72
50	0.49	10.98
100	0.45	12.50
Amount of water (Percentage of field capacity)		
100	0.50	10.72
85	0.56	9.97
70	0.58	9.64
55	0.57	9.49

Average numbers followed by same letters are the same based on Duncan's multiple range test on 5% level

As water of field capacity was less given, content of leaf relative water was smaller. This was consistent with the research[10] which had found that leaf area, dry weight of leaf, its relative water content and its index were decreasing when less water was given. It happened because the cell had became smaller and the leaf hadn't developed well during the water stress. It also decreased the ability for photosynthesis due to smaller leaf area[11]. The relative water content of leaves of the plants which had been given paclobutrazol were higher than one without paclobutrazol. One of the retardant substances of paclobutrazol was reducing leaf area on transpirational surface, which in turn reduced transpiration ability[3]. It could also induce stomatal closure, which then reduced transpiration as well. Therefore, the relative water content of the leaves could be maintained.

About 50 and 100 ppm paclobutrazol tretments showed that the plant was shorter and the leaves were smaller compare to 0 ppm paclobutrazol. Paclobutrazol application on plants would cause inhibition of the synthesis of gibberellins which implicated on shorter stems of the plants. The plants response on paclobutrazol application was there would be a reduction in the growth of the shoots[6,7,8,11]. Plants applying paclobutrazol would be shorter and compact, that was related to shortened stems. It happened because applying paclobutrazol could reduce plants height through inhibition of gibberellins biosynthesis, an important hormone for cell elongation and enlargment[6,12]. The content of photoshyntesis of potato plants which had been given paclobutrazol were higher than ones without paclobutrazol. Paclobutrazol application could cause the content of leaf photosynthesis went through the pathway of certain substances formation on gibberellin synthetic pathway, such as pytol which was chlorophyll formation precursor[4,13].

The values of plants height, leaf area and chlorophyll contents were lower as less water was given (Table 2). Plants growth are very much influenced by water provision, because water is one of the most improtant components needed for photosynthesis process besides CO_2 and sunlight. The height of stems, numbers of green leaves and the length of leaf were sensitive parameters for drought[14]. While, on less water or dry condition chlorophyll formation could be inhibited[15]. Drought is an inhibitory factor on growth and leaf development of potato. Early drought caused leaf limitation and branch development[16]. It happened because the cells had became smaller and under developed during the water stress, which resulted in reducing leaf area for photoshynthesis[15]. The numbers of tuber per plant with 85% water of field capacity showed higher number of tubers, different from other treatment. However, it didnt showed any difference when watered with 100%. Then, the number of tubers were decreasing as less water was given (Tabel 3). There was a significant difference between the high amount of water with the low amount of water given, yet giving 85-100% of water could still support plants growth and produce more tubers due to higher numbers of stolon forming the tubers. Number of tubers per plant tends to decrease as the response of water insufficiency[17].

Packlobutrazol of 50 and 100 ppm application showed the numbers of tubers and its weight were much higher than without paclobutrazol. Paclobutrazol application could increase clear assimilation phase[18]. It's related to the high content of chlorophyll and the postponment of senescence on potato leaf and it's also related to the effect caused by paclobutrazol stimulating cytokinins hormone. The increased cytokinins hormone would trigger chlorophlast diffrentiation and biosynthesis, it would prevent chlorophyll degradation as well. Finally, those conditions affected tuberization on potatoes because the phase of photosynthate translocation into the tubers were increased due to paclobutrazol application[11,18].

The sugar and starch content of potato with paclobutrazol application were close to its standard value accepted in potato processing industry. Based on industrial standard, to make potato chips the value of starch content should be above 11.90% and sugar content[2,19] is below 0.5%. One of photosynthesis product is starch. Starch is a polysaccharide that is the end product of carbon fixation during photosynthesis. In addition to starch, sucrose is another product of photosynthesis[20,21].

Paclobutrazol application had lessened gibberellins accumulation in the tuber tissue, therefore, it increased the strength of sink storage to accommodate more assimilates and starch synthesis[18]. Furthermore, photoshyntate translocation occurs because the plants avoided high accumulation of sugar in order to maintain osmotic gradient. One of organ sink mechanisms in reducing the accumulation of sugar was to synthesize starch or other macromolecules substance which have a lower osmotic activity[22].

CONCLUSION

- About 100 ppm paclobutrazol application increased the tuber weight per plant, its starch content (12.50%) and reduced its sugar content (0.45%) for growing atlantic cultivar potato in medium altitude, yet, it showed low height
- Potato plants watered by 85% of field capacity showed the same height as watered by 100% of field capacity while other parameters less water inhibited its growth and yields for growing Atlantic potato cultivar in medium altitude

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REFERENCES

1. Hamdani, J.S. and Y.R. Suradinata, 2015. Effects of row intercropping system of corn and potato and row spacing of corn on the growth and yields of Atlantic potato cultivar planted in medium altitude. Asian J. Agric. Res., 9: 104-112.
2. Kusandriani, Y., 2014. [Tuber yield trial and quality of eight potato genotypes for national potato chipping industry use local raw material]. Jurnal Hortikultura, 24: 283-288, (In Indonesian).
3. Davis, T.D., E.A. Curry and G.L. Steffens, 1991. Chemical regulation of vegetative growth. Crit. Rev. Plant Sci., 10: 151-188.
4. Chaney, W.R., 2004. Growth retardants: A promising tool for managing urban trees. FNR-252-W, Purdue Extension, Purdue University, West Lafayette, IN., USA. https://www. extension. purdue.edu/extmedia/fnr/fnr-252-w.pdf
5. Mariana, M. and J.S. Hamdani, 2016. Growth and yield of *Solanum tuberosum* at medium plain with application of paclobutrazol and paranet shade. Agric. Agric. Sci. Procedia, 9: 26-30.
6. Suradinata, Y.R. and J.S. Hamdani, 2015. Effect of paclobutrazol and 1-methylcyclopropene (1-MCP) application on rose (*Rosa hybrida* L.). Asian J. Agric. Res., 9: 69-76.
7. Suradinata, Y.R., R. Rahman and J.S. Hamdan, 2013. Paclobutrazol application and shading levels effect to the growth and quality of Begonia (*Begonia rex-cultorum*) cultivar Marmaduke. Asian J. Agric. Rural Dev., 3: 566-575.
8. Hamdani, J.S., Sumadi, Y.R. Suradinata and L. Martin, 2016. [Effects of shading and plant growth regulator on growth and yield of potato Atlantik cultivar planted in medium altitude]. Jurnal Agronomi Indonesia, 44: 33-39, (In Indonesian).
9. Lengkong, E.F.D. Tiwow and J. Najoan, 2015. Study paclobutrazol applications and several types of foliar fertilizer on the growth and yield of potatoes middle plains. Agricultural Science Lecturer Departement of Agriculture Faculty, Universitas of Sam Ratulangi.
10. Parvin, S., T. Javadi and N. Ghaderi, 2015. Proline, protein, Rwc and Msi contents affected by paclobutrazol and water deficit treatments in strawberry Cv. Paros. Cercetari Agronomice Moldova, 48: 107-114.
11. Tekalign, T. and P.S. Hammes, 2005. Growth responses of potato (*Solanum tuberosum*) grown in a hot tropical lowland to applied paclobutrazol: 2. Tuber attributes. N.Z. J. Crop. Hortic. Sci., 33: 43-51.
12. Latimer, J.G., 2009. Selecting and using plant growth regulators on floricultural crops. College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University.
13. Banon, S., A. Gonzalez, E.A. Cano, J.A. Franco and J.A. Fernandez, 2002. Growth, development and colour response of potted *Dianthus caryophyllus* cv. Mondriaan to paclobutrazol treatment. Scientia Horticulturae, 94: 371-377.
14. Deblonde, P.M.K. and J.F. Ledent, 2001. Effects of moderate drought conditions on green leaf number, stem height, leaf length and tuber yield of potato cultivars. Eur. J. Agron., 14: 31-41.
15. Salisbury, F.B. and C.W. Ross, 1995. Plant Physiology (Translated by Diah R. Lukman and Sumaryo). 1st Edn., ITB., Bandung, Indonesia.
16. Ingram, K.T., 1980. Mathematical modeling of the growth and development of potatoes (*Solanum tuberosum* L.). Ph.D. Thesis, The University of Florida.

17. Levy, D., 1983. Varietal differences in the response of potatoes to repeated short periods of water stress in hot climates. 2. Tuber yield and dry matter accumulation and other tuber properties. Potato Res., 26: 315-321.
18. Tekalign, T. and P.S. Hammes, 2005. Growth and biomass production in potato grown in the hot tropics as influenced by paclobutrazol. Plant Growth Regulat., 45: 37-46.
19. Basuki, R.S., Kusmana and A. Dimyati, 2005. [Analysis of yield potency, quality and user acceptance of potato clones 380584.3, TS-2, FBA-4, I-1085 and MF-II as raw material for chips]. Jurnal Hortikultura, 15: 160-170, (In Indonesian).
20. Vreugdenhil, D., J. Bradshaw, C. Gebhardt, F. Govers, D.K.L. Mackerron, M.A. Taylor and H.A. Ross, 2007. Potato Biology and Biotechnology Advances and Perspectives. Elsevier Ltd., Amesterdam, The Netherlands, Pages: 856.
21. Lambers, H., F.S. Chapin III and J.L. Pons, 2008. Plant Physiological Ecology. 2nd Edn., Springer-Verlag, New York, USA., ISBN-13: 9780387783413, Pages: 605.
22. Singh, J. And L. Kaur, 2009. Advances in Potato Chemistry and Technology. Elsevier Inc., Amesterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Deigo, San Francisco, Singapore, Sydney, Tokyo, Pages: 528.