The Effectiveness Of Paclobutrazol And Organic Fertilizer For The Growth And Yield Of Potatoes (Solanumtuberosuml.) In Medium Plain

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Abstract: This research was aimed to study the effect of paclobutrazol concentration and hyacinth liquid organic fertilizer application frequency on growth and yield of Kalosi potato in medium plain. This research was conducted in Gowa regency during August to December 2012 in medium plain at altitude of 490 m above sea level. This research used two-factor factorial experiments repeated twice and continued with Duncan test at significance level of 5%. The first factor was the application of growth regulator containing paclobutrazol at concentration of 0, 1, and 3 ml l^{-1} . The second factor is hyacinth liquid organic fertilizer with several application frequencies: control, two applications, three applications, and four application. Study findings indicate that the application of paclobutrazol at the concentration of 3 mll^{-1} with four applications ofhyacinth liquid organic fertilizer produced the best effect on tuber amount (64.0 tubers) compared to the application of paclobutrazol 1 mll^{-1} water with four applications of fertilizer (54.2 tubers) and 1 ml l^{-1} paclobutrazol application with three applications of hyacinth fertilizer (53.1 tubers). In regards to potatoes tuber weight per plot, the application of 3 ml l^{-1} palcobutrazol with three applications of liquid organic fertilizer produce higher tuber weight (1.99 kg $plot^{-1}$) compared to the application of paclobutrazol 1 ml l^{-1} water with three applications of fertilizer and without paclobutrazol application with three applications of fertilizer, weighting 1.87 kg $plot^{-1}$ and 1.49 kg $plot^{-1}$, respectively.

Keywords: Paclobutrazol, liquid organic fertilizer, hyacinth, Kalosi

INTRODUCTION

Potato is among the five world food commodity groups beside corn, wheat, rice, and sorghum. Potato can be utilized as a carbohydrate source because it can produce much more calories compared to rice, corn, and wheat. The prospect in developing potato plant as carbohydrate source in Indonesia is potential. According to central statistical agency (BPS) in 2012 [1], the area of harvested potatoes in Indonesia was about 65,989 ha, with national potatoes production of about 1,094,232 tons and productivity of 16.58 ton ha^{-1}. The availability of land to develop potatoes in Indonesia is very high, where there are more than 11,331,700 ha of available land at altitude of 700 m above sea level with used land just 65,420 ha [2]. These areas are generally found in outside Java island, such as in Aceh, North Sumatera, West Sumatera, Jambi, Bengkulu, South Sulawesi, North Sulawesi, and Papua [3]. Potato plants generally reproduce optimally in high plain. In medium plain, their production is not optimal, but researches have been intensified to increase potatoes production in medium plain [4,5]. The main problem faced in potatoes planting in medium plain is the high temperature [6]. At high temperature, the change of the stolon into tuber is limited [7], and there is an increase in biosynthesis of gibberelic acid (GA) in leave buds [8], whereas GA has been confirmed to limit tuber production [9]. However, the negative effects of GA can be minimized by the application of anti-GA, such as paclobutrazol [10], CCC [11,12], Ancymidol [13], or Coumarine [14]. In addition to the increase of respiration rate, high temperature also decreases the photosynthesis rate, translocation of assimilates to root and tuber, and conversion rate of sucrose into starch, resulting the limitation of tuber formation and its growth [15,16]. One of the attempts to increase potatoes production in medium plain is the application of paclobutrazol. Lever, et al [17] suggested that paclobutrazol is a growth stimulator with wide-spectrum activities and various functions. The most prominent activity of paclobutrazol is the inhibition of gibberellin synthesis in plants [18]. The inhibition of biosynthesis by paclobutrazol is due to the slow cells division and elongation without resulting in toxicity to cells. Direct effects on plant morphology include inhibited plant vegetative growth. The utilization of organic fertilizer is one of the alternatives in achieving agricultural efficiency by utilizing local resources. Hyacinth organic fertilizer is processed by fermentative technology to produce a finer and completely decomposed organic product. The application of liquid organic fertilizer through leaves provide better plant growth and yield compared to application through soil [19]. The higher the dosage and application frequency of leaves fertilizer, the higher the nutrient obtained by the plant. Excessive dosage will result in wither in plan [20]. This research was aimed to study the effect of paclobutrazol and hyacinth liquid organic fertilizer use on the improvement of potatoes production in medium plain.

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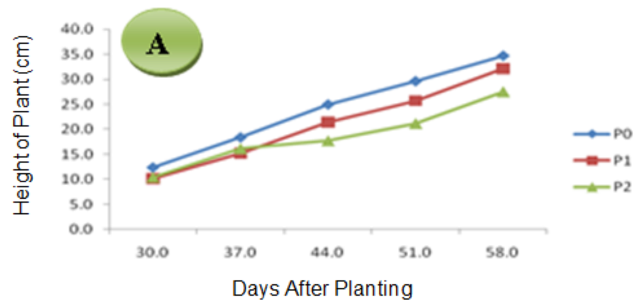
MATERIAL AND METHOD

Materials used in this study were potato seeds of Kalosi variety (G1) (local variety of South Sulawesi), commercial paclobutrazol (Golstar), 1 ton of rice hays, 500 kg of banana stems, 25 kg of hyacinth waste, bioactivator MO-Plus, water, organic fertilizer of poultry wastes 10 ton ha^{-1}, and inorganic fertilizer Urea 150 kg ha^{-1}, TSP 100 kg ha^{-1} and KCl 100 kg ha^{-1}. This study was conducted in Bikokoro, Lonjo'boko village, Parangloesubdistrict, Gowa regency, South Sulawesi at the altitude of 490 m above sea level, from August to December 2012. This study utilized two-factor factorial experiment, repeated three times. Paclobutrazol levels were divided into three levels: Po = without paclobutrazol (control), P1 = paclobutrazol at 1 ml l^{-1}, and P2 = paclobutrazol 3 mll^{-1}. The frequency of hyacinth liquid organic fertilizer application was divided into four levels: E0 = without hyacinth liquid organic fertilizer (control), E1 = two applications during planting period, applied at day 35 after plating and day 49 after planting (14 days interval), E2 = three applications during planting period, applied at day 30, 40, and 50 after planting (10 days interval), E3 = Four applications during planting period, applied at day 35, 42, 49 and 56 after planting (7 days interval). Each lot was applied with 44 kg bokashi. Experimental lots sized 350 cm x 225 cm with total 36 lots. Space between each sub plot was 100 cm and between repetitions was 150 cm. Potatoes were planted at space of 80 cm between row (4 rows) x 25 cm in column (6 columns) resulting in 24 plants in each lot. From each of the experimental plot 8 random plant samples were obtained. Observed variables are: plant height, leavenumber, flowering time, tuber amount er plot and tuber weight per plot.

RESULT AND DISCUSSION

Plant Height

The effect of growth regulator Paclobutrazol and hyacinth liquid organic fertilizer applications on potato plant height was observed in day 30, 37, 44, 51, and 58 after planting. In general, study results indicate that application of paclobutrazol at concentration of 1 mll^{-1} (P1) and 3 mll^{-1} (P2) in potato plants inhibited the height growth of the plant as can be seen from plant response in where control treatment showed better result compared to plants treated with paclobutrazol. The application of 3 mll^{-1} (P2) more suppressed the plant height at day 58 after planting compared to the concentration of 1 mll^{-1} (P1) (Figure 1.a). The opposite situation was observed with hyacinth liquid organic fertilizer, where the rate of height growth was in parallel to plant age and organic fertilizer application frequency. The more frequent the liquid organic fertilizer application, the higher the height growth rate starting from day 30 to 58 after planting (Figure 1.b). This finding is in accordance to Davys, et al [21] requirement that triazole working mechanism is by reducing the crown elongation based on GA biosynthesis inhibition. The inhibition of GA biosynthesis results in disturbed stem elongation due to inhibited cell division in bud sub-apical meristem part that in turn causes dwarf. Gianfragna [22], reported that the application of paclobutrazol in potato from seed tuber will inhibit the stem elongation. Mamarimbing [23,24] indicated that paclobutrazol application by direct spraying through leaves and poured through soil can depress the height growth of rice plant.



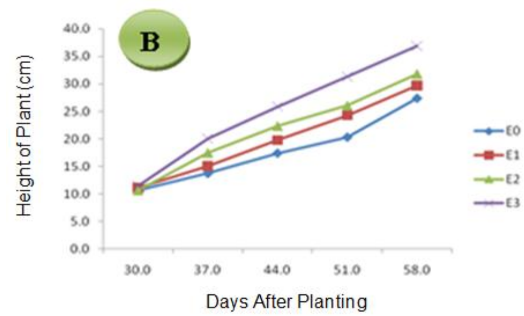


Figure 1. Potato plant height growth at day 30, 37, 44, 51 and 58 after planting. (A) The effect of growth regulator Paclobutrazol application (B).The effect of hyacinth liquid organic fertilizer application.

The use of paclobutrazol at the tested concentrations could inhibit the height growth rate of the plants, whereas the application of hyacinth liquid organic fertilizer increase the height growth rate of the plant. The application of hyacinth liquid fertilizer three times during planting period (E2) and four times (E3) had a more significant influence compared to without application (E0), whereas the group with two applications (E1) had no significant effect compared to E0, the same was true for E1 treatment with no significant difference from E2 treatment. The application of liquid organic fertilizer at the frequency of 4 times was associated to average height of plant 36.9 cm, whereas without application it was only 27.4 cm (Table 1). The more frequent the application of hyacinth liquid organic fertilizer during this growth period, the higher the height growth rate of the plants (Figure 2.1). The application of paclobutrazol at the concentrations of 3 mll^{-1} (P2) and 1 mll^{-1} (P1) at day 58 after planting had significant effect that lower compared to control (P0). At the concentration of 3 mll^{-1}, paclobutrazol provided lower effect compared to at 1 mll^{-1} (P1) (Table 1). This indicated that the higher the paclobutrazol concentration applied the higher the inhibition of plant height growth (Figure 2b).

Table 1. Potato plant height (cm) in medium plain with growth regulator paclobutrazol and hyacinth liquid organic fertilizer at day 58 after planting

Paclobutrazol	Hyacinth Application Frequency					Duncan α=0.05
	E0	E1	E2	E3	Mean	
P0	30.3	35.3	39.0	41.2	36.4^c	2.64
P1	28.4	27.6	34.9	37.8	32.2^b	2.77
P2	23.5	29.5	25.4	31.5	27.5^a	
Mean	27.4^a	30.8^{ab}	33.1^b	36.9^c		
Duncan α=0.05	3.05	3.20	3.30			

Note: Values followed by different symbols in same column and row indicates significant difference at Duncan Multiple Range test α=0.05

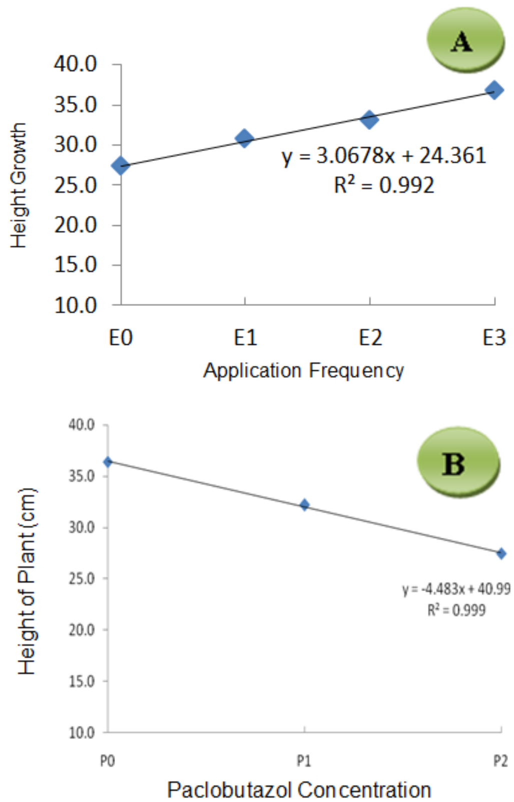


Figure 2. Potatoes plant height growth at day 58 after planting. (A) The effect of hyacinth liquid organic fertilizer application frequency. E0= control, E1= 2 applications, E2= 3 applications, E3: 4 applications (B) The effect of paclobutrazol concentration: P0= control, P1=1 ml l^{-1}, P2=3 ml l^{-1}

A study on combined application of paclobutrazol and liquid organic fertilizer in carrot found similar findings, where the interaction did not significantly influence the plant height. This was suggested attributable to the medium N level in soil, resulting in invisible response against N addition through fertilization. In addition, Prasetya, Kurniawan and Febrianingsih [25] suggested that nitrogen elements are useful for vegetative growth of plant, particularly in new cell formations such as leaves, branch, and replacing the damaged cells. The application of liquid organic fertilizer can also propagate the cells in stem bud to immediately perform division and scaling particularly in meristem area. According to Bonner &Galston [26], anticlinal and periclinal divisions and meristematic cell scaling occur in stem tip, despite different rate. The application liquid organic fertilizer in potato plants was suggested to accelerate the amino acid and protein synthesis that accelerate the plant growth. This is in accordance to Rao [27] and Poerwowidodo [28] suggesting that liquid organic fertilizer contain potassium that plays important role in plant metabolism, particularly in the synthesis of amino acid and proteins from ammonium ions and takes part in maintaining the turgor pressure well, enabling the smoothness of metabolism processes and secure the cell elongation sustainability.

Leaf Amount

The growth rate of leaf amount was parallel to plant age and paclobutrazol (P) concentration effect and the single factor of hyacinth liquid organic fertilizer application frequency (E) partially (Figure 3). The observation of leaf amountat day 30 after planting without treatment (P0) and with treatment of 1 mll^{-1} (P1) and 3 mll^{-1} (P2) showed similar results for each treatment, but in observation at day 44 to 72 after planting, the application of paclobutrazol 3 mll^{-1} provided poor response on leaf amount compared to control (P0) (Table 3.a). In contrast, the application of hyacinth liquid organic fertilizer provided better effect on leaf amount starting from day 30 after planting to day 72 after planting. The more frequent the hyacinth liquid organic fertilizer application the higher the leaf amount Figure 3.b).

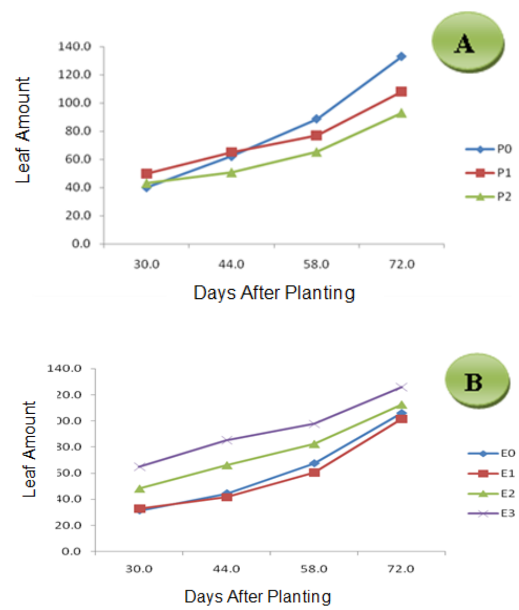


Figure 3. Leaf amount growth rate in potato plants at day 30, 44, 58and 72 after planting. (A) The effect of growth regulatorpaclobutrazol application (B) The effect of hyacinth liquid organic fertilizer application

Analysis of variance for leaf amount at day 72 after planting indicated that there was no significant interaction between paclobutrazol concentration and hyacinth liquid organic fertilizer application. Paclobutrazol application at the tested concentrations could reduce the foliage growth, whereas the application of hyacinth liquid organic fertilizer improve the foliage growth rate of plants. Study on combined use of paclobutrazol and liquid organic fertilizer in *Dendrobiumsp*found similar finding, the interaction did not significantly influence the plant height and foliage [29]. Application of paclobutrazol at concentration of 3 mll^{-1} (P2) and 1mll^{-1} (P1) at day 72 after planting provided lower foliage abundance compared to control (P0) and at concentration of 1 mll^{-1} (P1). This indicated that the higher the concentration of paclobutrazol the more inhibited the leave formation (Table 2). Relationship between paclobutrazol and leaf amount was a linear relationship with equation: y = 20.04x + 1512.05,R^2=0.909.This indicated that the higher the concentration of applied paclobutrazol the lower the formed leaves (Figure 3.a). Krishnamoorthy [30], suggested that retardant contained in paclobutrazol is a chemical compound that has physiological that inhibit the apical meristem cell division that inhibit the leaves formation. Application of hyacinth liquid organic fertilizer four times (E3) provide higher leaf amount compared to control, 3 applications (E2), and 2 applications. Treatment E2 had leaf amount that was not different from treatment E1 and E0 (Table 2). Relationship between hyacinth liquid organic fertilizer application frequency and leaf amount was a linear relationship with equation Y = 7.106x + 93.67,R^2=0.741, indicating that the more frequent the hyacinth liquid organic fertilizer application the more the leaf amount formed (Figure 3.b). The application of liquid organic fertilizer in potato plants is suggested to accelerate the amino acid and protein synthesis which in turn accelerate the plant growth. According to Rao [27] and Poerwowidodo [28], liquid organic fertilizer contain potassium that plays important role in plant metabolism, particularly in the synthesis of amino acid and proteins from ammonium ions and takes part in maintaining the turgor pressure well, enabling the smoothness of metabolism processes and secure the cell elongation sustainability. The same is true for phosphors that play important role in storing and transferring energyfor synthesis of carbohydrate, protein, and photosynthesis process. Liquid organic fertilizer contains micro elements, including Boron (B) which is highly needed in the differentiation of growing cells, helping in carbohydrate metabolism and regulate the water need in [31].

Table2. Leaves amount of potato plant (sheet) in medium plain under paclobutrazol and hyacinth liquid organic fertilizer treatment

Paclo-butrazol	Hyacinth Application Frequency					Duncan α=0.05
	E0	E1	E2	E3	Mean	
P0	129.0	118.8	133.1	151.8	133.2 c	10.5
P1	101.0	96.2	108.2	127.0	108.1 b	11.0
P2	87.7	89.7	95.7	99.2	93.1a	
Mean	105.9 a	101.6 a	112.3 a	126.0 b		
Duncan α=0.05	12.10	12.72	13.10			

Note: Values followed by different symbols in same column and row indicates significant difference at Duncan Multiple Range test α=0.05

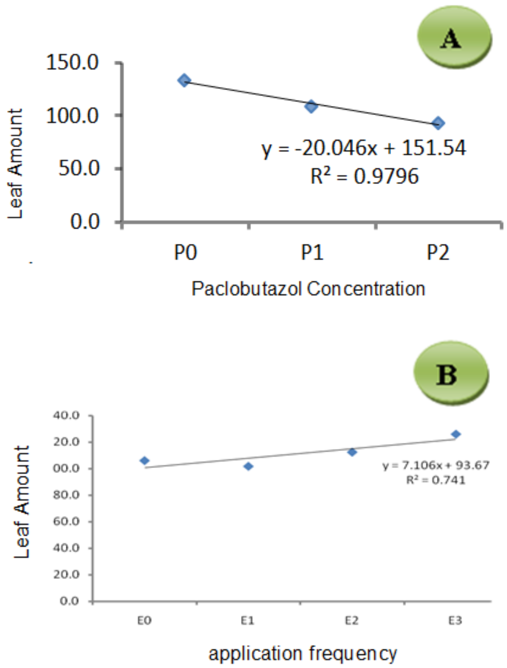


Figure 4. Leaves abundance growth of potato plants at day 72 after planting. (A) The effect of paclobutrazol concentration: P0 = control, P1 = 1ml l^{-1}, P2 = 3 ml l^{-1}. (B) The effect of hyacinth liquid organic fertilizer E0= control, E1= 2 applications, E2= 3 applications, E3: 4 applications.

Flowering Time

The observation of average flowering time indicated that the application of paclobutrazolaccererelated the flowering time. This can be seen from the application at the concentration of 1 mll^{-1} (P1) and 3 mll^{-1} (P2) which resulted in earlier flowering time compared to control (P0). Average time neede to flower for treatment P1 and P2 was at day 51.0 and 47.1, respestively, whereas without paclobutrazol application (P0) it needed ageragely 58 days to start to flower (Tabel 3). Flowering in potato plants are influenced by genetic, physiological, and environmental factors. Genetic factor will influence the basic shape of plant, flowering color, adaptation level, growth rate, and disease vulnerability, whereas the physiological factor includes all the activities related to functions and activities that support plant flowering, and environmental factor plays important role in plant flowering process that include light intensity, temperature, and humidity [32].

Table 3. The flowering time (day) of potato plants in medium plain under growth regulator paclobutrazol and hyacinth liquid organic fertilizer applications

Paclobutrazol	Hyacinth Application Frequency						Duncan α=0.05
	E0	E1	E2	E3	Mean		
P0	59.6	61.0	60.0	51.5	58.0	b	7.0 (2)
P1	47.9	57.3	45.7	53.0	51.0	a	7.4 (3)
P2	55.8	54.8	38.6	39.1	47.1	a	

Note: Values followed by different symbols in same column and row indicates significant difference at Duncan Multiple Range test α=0.05

Tuber Amount per Plot

Application of paclobutrazol and hyacinth liquid organic fertilizer application frequency indicated significant interaction to tuber amount per plot. The increase in paclobutrazol concentration from 1 mll^{-1} to 3 mll^{-1} followed by hyacinth liquid organic fertilizer application further increased the tuber amount per plot. Interaction between paclobutrazol at concentration of 3 mll^{-1} and four applications of hyacinth liquid organic fertilizer application (P2E3) provided higher tuber ampunt per plot compared to the interaction between paclobutrazol3 ml l^{-1} and 2 applications hyacinth liquid organic fertilizer (P2E1) and interaction between paclobutrazol3 mll^{-1} without application of hyacinth liquid organic fertilizer (P2E0). Interaction between P2E3 was associated to higher tuber amount per plot compared to interactionbetween paclobutrazol3 ml l^{-1} and 4 applicationsof hyacinth liquid organic fertilizer (P2E3) and between paclobutrazol 0 mll^{-1} and 4 applications of hyacinth liquid organic fertilizer (P0E3) (Table 3). Two factors have been found to influence the tuber formation, namely internal and environmental factors. Internal factor consists of body hormones and carbohydrate metabolism, whereas the environmental factor includes rooting medium environment and the availability of nutrients to plant. According to Fisher [33], tuber surface and buds number will influences the stem tipgrowth which in turn influence the most tuber. In addition, Lakitan [34] suggested that internal factors that affect tuber growth were photosynthesis rate and quantity that are supplied from plant crown.

Table 4. Tuber amount per plot of planted potatoes in medium plain under growth regulator paclobutrazol and hyacinth liquid organic fertilizer applications

Paclobutrazol	Hyacinth Application Frequency E0		E1		E2		E3		Duncan α=0.05
P0	32.3^a	y	33.3^a	x	37.3^b	x	47.7^c	x	8.0 (2)
P1	29.3^a	xy	32.0^a	x	46.3^b	y	54.2^c	y	8.4 (3)
P2	26.2^a	x	30.0^a	x	53.1^c	z	64.0^d	z	
Duncan α=0.05	4.6 (2)		4.8 (3)		5.0 (4)				

Note : Values followed by different symbols in same row (a, b, c) and columns (x, y, z) indicates significant difference at Duncan Multiple Range test α=0.05

Figure 5.a indicates a correlation between paclobutrazol concentration and tuber amount per plot in each application frequency of hyacinth liquid organic fertilizer. Four applications of hyacinth liquid organic fertilizer (E3) and 3 applications (E2) were found to increase the tuber amount per plot which was in parallel to increase paclobutrazolcocentration, with regressionequation E3:Y=8.16x+38.96 , R^2=0.98 and E2:Y=7.83 X+29.81, R^2=0.93. In contrast, two applications of hyacinth liquid organic fertilizer (E1) and without application (E0) tended to decrease tuber amount per plot in parallel to increased paclobutrazol concentration with regression equation E1:: Y=-1.66 x+35.11, R^2=0.98 and E0: Y=-3.88 X + 35.44, R^2=0.91.

Figure 5.b indicates a relationship between hyacinth liquid organic fertilizer application frequency (E) and tuber amount per plot at each concentration of paclbutrazol. Application of paclobutrazol 3mll^{-1} (P2) and 1 mll^{-1}(P1) increased the weight of potato tuber per plot in parallel with the increase in hyacinth liquid organic fertilizer application frequency, with regression equation P2: Y=13.66 x + 9.16, R^2=0.94 and P1 : Y=8.9 X + 18.21, R^2=0.94.

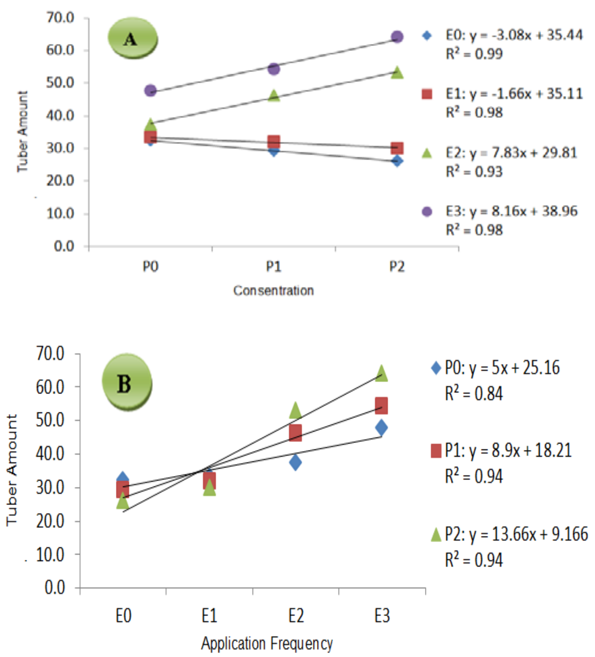


Figure 5. Interaction between paclobutrazol application and hyacinth liquid organic fertilizer application frequency (A) Relationship between paclobutrazol concentration and tuber amount per plot for each application frequency of hyacinth liquid organic fertilizer, (B) Relationship between application.frequency of hyacinth liquid organic fertilizer (E) and tuber amount per plot for each paclobutrazol concentration between E0= control, E1= 2 applications, E2= 3 applications, E3: 4 applications, P0= control, P1=1 ml l^{-1}, P2=3 ml l^{-1}

Tuber Weight per Plot

Study findings indicate that application of paclobutrazol and application frequency of hyacinth liquid organic fertilizer were significantly associated to tuber weight per plot. The increase in paclobutrazol concentration from 1 mll^{-1} to 3 mll^{-1} followed by increased aplication frequency of hyacinth liquid organic fertilizer was associated to increased tuber weight per plot. Table 5 indicates that paclobutrazol at the concentration of 3 mll^{-1} water with four applications of hyacinth liquid organic fertilizer (P2E3) was associated to higher significant effect on tuber weight per plot compared to interaction between paclobutrazol 3ml l^{-1}and 3 applications of hyacinth liquid organic fertilizer (P2E2), between paclobutrazol3 mll^{-1}and 2 applications of hyacinth liquid organic fertilizer (P2E1), between paclobutrazol3 mll^{-}

1 and without application of hyacinth liquid organic fertilizer (P2E0). P2E3 interaction provided higher tuber weight compared to P1E3 itneraction and P0E3 interaction. Paclobutrazol and hyacinth liquid organic fertilizer treatment were complementary in affecting the growth and production of potato plant production at the same time. Application of hyacinth liquid organic fertilizer accelrated the plant growth by increasing cell growth, whereas paclobutrazol inhibited the cell growth in potato plants. The tuber formation process was influenced by photosyntesis smoothness of the plant. According to Hartmann and Kester [35], tuber developmental process is associated to growing activity visible above soil, the enlargement oftuber constantly depend on adequate photosyntesis supply.

Table 5. Tuber weight per plot potatoes (kg plot^{-1}) planted in medium plain under the treatment of growth regulator paclobutrazol and hyacinth liquid organic fertilizer

Paclobutrazol	Hyacinth Application Frequency E0	E1	E2	E3	Duncan α=0.05
P0	0.99 A y	1.09 A x	1.24 B X	1.49 C x	0.09 (2)
P1	0.93 A y	1.16 B x	1.31 C xy	1.87 D y	0.10 (3)
P2	0.82 A x	1.13 B x	1.39 C Y	1.99 D z	
Duncan α=0.05	0.11 (2)	0.12 (3)	0.13 (4)		

Note : Values followed by different symbols in same row (a, b, c) and columns (x, y, z) indicates significant difference at Duncan Multiple Range test α=0.05

Figure 6.a indicates a relationship between paclobutrazol concentration and tuber amount per plot in each application frequency of hyacinth liquid organic fertilizer. Four applications of hyacinth liquid organic fertilizer (E3), 3 applications (E2), and 1 application (E1) increased the potate tuber weight per plot in parallel to paclobutrazol concentration increase, with regression equation E: Y=0.25 x+1.29, R^2=0.92, E2:Y= 0.08 X+1.16, R^2=0.93 and E1=0.02 x+ 1.09, R=0.92. In contrast, no application (E0) tended to decrease tuber amount per plot in parallel with increased concentration of applied paclobutrazol with regression equation E0: Y=- 0.088 X + 1.09, R^2=0.39.

Figure 6.b indicates a relationship between application frequency of hyacinth liquid organic fertilizer (E) and tuber ampunt per plot in each level of paclobutrazol. Application of paclobutrazol3 mll^{-1} (P2) and 1 mll^{-1} (P1) increased the potata tuber weight per plot in parallel to increased application frequency of hyacinth liquid organic fertilizer, with regression equation P2: Y=13.66 x + 9.16 , R^2=0.94 and P1 : Y=8.9 X + 18.21, R^2=0.94.

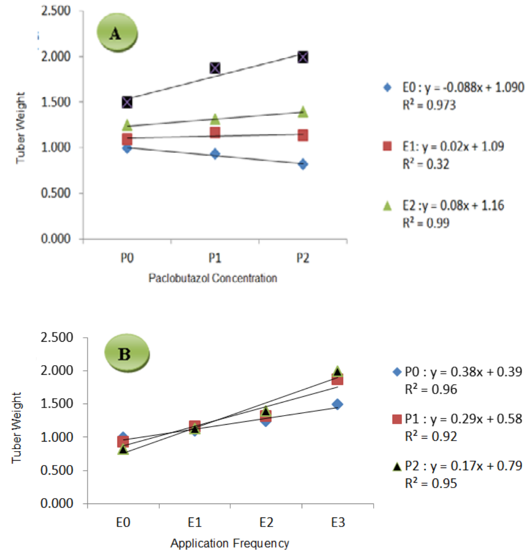


Figure 6. Interaction between paclobutrazol application and application frequency of hyacinth liquid organic fertilizer. (A) Relationship between paclobutrazol concentration and potatoes tuber weight per plot for each application frequency of hyacinth liquid organic fertilizer, (B) Relationship between application frequency of hyacinth liquid organic fertilizer (E) and tuber weight per plot for each paclobutrazol concentration between E0= control, E1= 2 applications, E2= 3 applications, E3: 4 applications, P0= control, P1=1 ml l^{-1}, P2=3 ml l^{-1}

CONCLUSIONS

1. Application of palcobutrazol at concentration of 1 ml l^{-1}and 3 ml l^{-1}water inhibited the potato plant height growth and leaf amount but accelerated the flowering time, increased tuber amount, and tuber weight of potato plants.
2. Application of hyacinth liquid organic fertilizer at the frequency of four times increased the height growth and leaf amount. The more frequent the application of hyacinth liquid organic fertilizer, the higher the plant height growth, leaf amount, tuber amount, and tuber weight.
3. Interactionbetweenconcentration of 3 ml l^{-1} and four applications of hyacinth liquid organic fertilizer increased significantly the weight of potato tubers per plot.

REFERENCES

[1]. BadanPusatStatistik (BPS) Republik Indonesia, 2012.LuasPanen, ProduksidanProduktivitasKentang.Jakarta.http://www.bps.go.idaccessed 2 May 2013

[2]. Laksana, N. 2006. KebijakanPerbenihanKentang Indonesia.DirekturPerbenihandanSaranaProduksiHortikultura.DirektoratJendralHortikutura.Paper presented in *PertemuanKoordinasiNasionalMenujuSwasembadaBenihKentang*. Bandung 19 – 21 April 2006.

[3]. Wattimena, G.A. 2006. Prospek Plasma

NutfaKentangdalamMendukungSwasembadaBenih Kentang di Indonesia.PusatPenelitianSumberdayaHayatidanBioteknologi (PPSHB) IPB danJurusanAgrohorti, Agricultural Faculty. IPB.

[4]. Sutater, T., Wiroatmodjo, S. Solahuddin, I.I. Nasoetion, A. Bey, dan M.A. Nur. 1987. PertumbuhanDuaVarietasKentang (*SolanumtuberosumL.*) di LingkunganDataranRendah. Forum PascaSarjana 10 (1) : 1- 13.

[5]. Syarif, Z. 2004. KarakteristikaPertumbuhanTanamanKentang yang DitopangdenganTurusdalamSistemTumpangsariKentang/JagungdenganBerbagaiWaktuTanamJagung di Dataran Medium.Stigma 12 (4): 431 -436.

[6]. Ewing, E.E and P.C. Struik 1992. Tuber Formation in Potato : Induction, Initiation, and Growth. Hort. Rev. 14:89–197.

[7]. Stark, J.C. and S.L. Love 2003.Potato Production Systems : a Comprehenshive Guide for Potato Production. University of Idaho Extension. Idaho. U.S.A 426 pages.

[8]. Menzel, C.M. 1983. Tuberization in Potato at High Temperatures : Gibberellins Content and Transport from Buds. Ann. Bot. 52 : 697 – 702.

[9]. Vreugdenhil, D., Y. Boogard, R.G.F. Visser, and S.M. de Brujin. 1998. Comparison of Tuber and Shoot Formation from in-vitro Cultured Potato Explants. Plant Cell, Tissue and Organ Culture 53:197 – 204.

[10]. Wang, B. And A.R. Langille. 2005. Response of a GA-deficient Potato Mutant to Induction and Growth Regulators asa a Working Model for Tuber Initiation. Amer. J. Potato Res. 82 (1): 95 (Abstract).

[11]. Menzel, C.M. 1980. Tuberization in Potato at High Temperatures : Response to Gibberellins and Growth Inhibitors. Ann. Bot. 46; 259 – 265.

[12]. Mardalena, Z. 2006. PembentukanUmbiMikroSecara in-vitro padaDuaSuhuInkubasi(18dan 25 ^{0}C) denganperlakuan CCC danCoumarine . Undergraduate Thesis of Agricultural Cultivation, Agricultural Faculty of UNIB (*unpublished*).

[13]. Escalante, B.Z and A.R. Langille. 1998. Photoperiod, Temperature, Gibberelin, and An Anti-gibberelin Affect Tuberization of Potato Stem Segments in-vitro. HortSci. 33(4) 701 – 703.

[14]. Andrianie, T. 2006. PertumbuhandanPembentukanUmbiMikroKentang padaBeberapaTarafCoumarinedanDuaSuhuInkubasi (18 dan 25 ^{o}C).Skripsi S-1 JurusanBudidayaPertanian, FakultasPertanian UNIB (*tidakdipublikasikan*).

[15]. Reynolds, M.P., E.E. Ewing, and T.G. Owens. 1990. Photosynthesis at High Temperature in Tuber- bearing Solanum Species. Plant Physiol. 93 : 791 – 797.

[16]. Sarquis, J.I., H. Gonzales, I. Bernal-Lugo. 1996. Response of Two Potato Clones (*Solanumtuberosum*) to Contrasting Temperature Regimes in the Field. Amer. Potato J. 73 : 285 – 300

[17]. Lever BG, SJ Shearing, JJ Batch (1982) PP 333 – a new broadspectura growth retardan, ProcBr Crop Protect Conf Weeds, pp 3 – 10.

[18]. Graebe J.E. (1982) Gibberellin biosyntesis in cell – free, system from higher plants, In PF Wareing, ed, Plant Growth Substances, Academic Press, London, PP 71 – 80.

[19]. Hanolo, W. 1997.TanggapantanamanseladadanSawiterhadap dosisdancarapemberianpupukcairstimulan.Agrotropika Journal 1 (1): 25 – 29.

[20]. Suwandidan N, Nurtika, 1987.PengaruhPupukBiokimia "Sari Humus" padaTanamanKubis.BuletinPenelitianHortikultura 15 (20) : 213 – 218.

[21]. Davis, T.D, G.L. Steffens and Sankla, 1988. Triazol Plant Growth Regulators. In. J. Janick (Ed). Hort. Rev. 10 : 105. Timber Press. Portland Oregon.

[22]. Gianfragna, T.J. 1987. Natural and Synthetic Growth Regulators and Their use in Horticultura Agronomic Crops.In Davies.P.J (ed) Plant Hormones and Their Role in Growth and Development.MartinusNijhof Publisher. Dodrecht. Pp : 614 -632.

[23]. Mamarimbing, R. 2002 a. Responpertumbuhandanhasilpadigogo (*Oryza sativa* L.) TerhadapPemberianPaclobutrazoldanPupuk Nitrogen. Eugenia 9 (3) : 169 – 173.

[24]. Mamarimbing, R. 2002 b. HasilPadiGogo (*Oryza sativa* L.) Var. KalimutupadabeberapakonsentrasiPaclobutrazol Eugenia 9 (4) : 265 – 268.

[25]. Prasetya, B., S, Kurniawan, danFebrianingsih. 2009. PengaruhDosisdanfrekuensiPupukCairTerhadapSerapanPertumbuhanSawi (*Brassica junsea*L.) PadaEntisol. Univ. Brawijaya. Malang.

[26]. Bonner, J. And W. Galston, 1951.Principle of Plant

Physiologi.Wh Freeman and Company, San Fransisko.

[27]. Rao, S. 1994. MikroorganismedanPertumbuhanTanaman.Univ. Indonesia Jakarta.

[28]. Poerwowidodo, 1992.TelaahKesuburan Tanah. PenerbitAngkasa. Bandung.

[29]. Rachmi H.H, Sarawa, I GustiR.Sadimantara2012 .ResponTanamanAnggrekDendrobium Sp. TerhadapPemberianPaclobutrazoldanPupukOrganikCair.BerkalaPenelitianAgronomi Vol. 1 No. 1 hal 71 – 78 ISSN: 2089 – 9858. PS. Agronomi, PPs UNHALU.

[30]. Krishnaamoorthy, 1981.Plant growth substances including application in agriculture.Tata MC Grow-Hill pub, Co, ltd, New Delhi. 241p.

[31]. Novizan, 2002.PetunjukPemupukanSecaraEfektif. AgroMedia. Jakarta.

[32]. Gardner, F.P., R.B. Pearredan R.I. Michell. 1992. ThePhysiology of Crop Plants. TerjemahanHerawatiSusilo. FisiologiTanamanBudidayaTropik. Gajah Mada University Press, Yogyakarta. 734 pages

[33]. Fisher, N. M. dan P. R. Goldsworthy. 1992. FisiologiTanamanBudidaya. Penerbit UI – Press. Jakarta.

[34]. Lakitan, B. 1996.FisiologiTumbuhandanPerkembanganTanaman. PT. Raja GrafindoPersada. Jakarta. 218 pages.

[35]. Hartmann, H.T. and D.E. Kester , 1983. Plant Propagation Principles and Practices. Prentice – Hall, Inc. Englewood Cliffs, New Jersey.pp. 507 – 509.