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Development of potato plants as the results of Aeroponic Technology by treating of methanol in Plain Medium at Ulu Ere Sub district, Bantaeng Regency, South Sulawesi, Indonesia

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KEYWORDS

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A B S T R A C T

The aim of the study is bring down sealevel requirement from 900 metres above sea level of 500 above sea level by applying aero phonic seed with the treatment of methanol in three levels concentrate and one control.This research was carried out in October – June 2015, in Seed potato Center, Bantaeng District, South Sulawesi. Indonesia. Other purposes of this study was obtain the potato from Aeroponic technology by using methanol in the medium to acquire land plateau production rate and high productivity, as well as free from pest attack. The experiment used a split plot design . In the main plot, consist of two different varieties; Atlantic variety and Granola variety. The second plot is the concentration of methanol which is made up control: 0 % (without methanol); 5 % of Methanol , 10 % methanol and 15 % methanol. The results showed that methanol application on plain medium multiplication results Aeroponic technology, giving a better results than without methanol. 15 % Methanol gives the best effect, if it's compared with 5 % and 10 %. Interm of yield. Granola variety gives more respon than the Atlantic variety.

Introduction

The Productivity of potatoes in Indonesia is still very low, it is 13 t ha^{-1}, the potential production may reach 40 t ha^{-1} (DJBPH, 2014). Weak seed systems, is one of causes due to low production , the high risk of failure due to the Plant Pest Organisms (OPT) and low mastery of production technology is a major problem of the low potato production nationally. This causes the need for a national seed potatoes are still heavily dependent on imports, the availability of only around 5.97% of the needs of 121,753.5 tons $year^{-1}$, with a value of Rp 1.25 trillion ± (Baharuddin, 2014; DPSP 2014).

One of the seed production technology which is being developed is an aeroponic technology. The solution is the provision of nutrients to plant roots by means of nebulization (Jensen and Collins, 2005; Howard, 2006), plant roots are left hanging, then on down through the sprinklers sprayed nutrient solution and the roots will capture and absorb the nutrients (Resh, 2004; Park, 2005).

Development of potato plant in South Sulawesi has been directed at the plateau region (800-1500) m above sea level with a potential of 11,405 ha (BPS, 2014). The region is increasingly narrow due to conversion and other uses, so it is necessary to find alternatives that can be developed in plain medium (500-700) m asl. Nevertheless, the plain medium, temperature and high light intensity, especially in tropical regions such as Indonesia caused high photorespiration, resulting in waste/release of CO_2 from the plant (Barnes and Houghton, 1994; McGiffen and Manthey, 1996). This situation reduces the diffusion of CO_2 into the leaf and subsequently decrease the rate of fotosintesis. It is addressedto the problem of methanol that can be used to supply CO_2 to the cells of the leaves, so as to compensate for the loss of CO_2 in the process of photorespiration (McGiffen and Manthey, 1996; Zakaria, 2010) . The results of a preliminary study performed on plain medium in the greenhouse by spraying methanol, Muhibuddin showed that 10% spraying every week on potato plant have increasedproduction 35%, compared with no methanol (Muhibuddin *et al.,* 2015). By aeroponic technology systems through the application of methanol, which is using tissue culture cutting are expected to contribute in solving most of the problems to accelerate the improvement of the national potato production, while reducing the import of seeds gradually. However, the ability of methanol increases the production of potato in plain medium still needs to be tested further at various locations/regions plain medium with a different geographical location. The purpose of this study was to obtain potatoes from the Aeroponic technology by the using of methanol in the medium to acquire land plateau production rate and high productivity, and free from pathogens.

Materials and Methods

The first year of research activities carried out in two parts in parallel experiments lasted from June to October 2015 at the site of horticultural seed center Bantaeng South Sulawesi at medium altitude plains land (500-700) m above sea level, which is one of the development centers of the potato crop in Sulawesi South. The stages of the experiment are: The materials used include: Seed potato varieties Atlantic and Granola conventional cropping results and aeroponic technology, fertilizer (ZA, SP-36 and KCl). The tools used include: a hoe, scales, meters, oven, manure, tarpaulins, drill, stakes, ropes and Basamid Rapiah. Experiment was conducted to test the results of aeroponics potato varieties Atlantic and Granola in field plots using design models Separated (Split Plot Design). As the main plot (main plot) is: Granola potato varieties (V_1) and Atlantic varieties (V_2). The second factor is the concentration of methanol comprising: M_0 = 0% (without methanol); M_1 = 5% methanol; M_2 = 10% methanol; and M_3 = 15% methanol. Both of the two factors obtained 8 combination treatment. Each treatment combination was repeated three times, so there are 24 units of study.

The number of plants per unit of study 100 plants, thus totaling 2400 plants. Each unit of study observed/ measuring 10 plants as samples, bringing the total of 240 plant samples Land in the screen house processed

until crumbly depth (25-30) cm, then leveled, cleaned and made water channel with a width of 30 cm. After processing, sterilization Basamid done by sprinkling on the ground dose of 40 g m^{-2}, stirred with a hoe until evenly distributed. Making research plots were 24 plots. Each plot size (1.6 x 5) m which is repeated three times, beds 30 cm high and 40 cm distance per plot. Then the closed ground tarp for two weeks. While waiting for the soil is ready for planting, manure strelisasi done with Basamid-G. Ahead of planting, tarp opened and sprinkled plots sterile manure dose of2 kg m^{-2}. After one week left fertilization ie, 40 g m^{-2} ZA, SP-36 60 g m^{-2}, and KCl 20 g m^{-2}. Planting bulbs is done by using a rope marked with appropriate spacing (25 x 20) cm. Fertilization II performed at the age of three weeks at 40 g m^{-2} ZA, SP-36 60 g m^{-2}, and 20 g of KCl m^{-2}.

Maintenance of the plant include: watering, weeding, and tilling the soil, as well as pembubunan. Harvesting is done after the ± 90-day-old plants with stems trimmed means as high as 5 cm of soil and left for 10 days to tuber skin strong and not easily scratched at harvest. observations: Aspects of Production: Number of tubers per plant, tuber diameter (cm), weight of tubers per plant (g), Water Content (KA) tubers (%), production of tubers ha^{-1}. Aspects of Quality Bulbs: The content of carbohydrates, vitamin C content, water content, hardness bulbs, tubers and thickness.

Results and Discussion

Number of Bulbs

Based on Duncan's test showed that the number of tubers varieties plant produce $granola^{-1}$ were not significantly different compared with the Atlantic varieties (Table 1). Based on Duncan's test showed that treatment M_3 produces the highest number of tubers (29,76 fruits) and significantly different from treatment M_0 and M_1 but not significantly different from M_2 treatment.

Weight of Bulbs

Based on Duncan's test showed that granola varieties produce tuber weight $plant^{-1}$ were higher and significantly different compared with the Atlantic variety (Table 2). The treatment resulted in weight of tuber crops M_3^{-1} the highest (327,97 g) and significantly different from M_0 and M_1 treatment but not singnicantly different from M_2 treatment

Table.1 Number of tubers per plant (fruit) with treatment of potato varieties and concentration of methanol

Variety	Concentration of metanol			
	M_0	M_1	M_2	M_3
V_1	26,24	27,72	29,04	29,76
V_2	24,02	25,50	26,82	29,76
Average	$25,42^{c}$	$27,20^{bc}$	$28,12^{ab}$	$29,76^{a}$

Remarks: Figures followed by the same letter in the row (a, b, c) and are not significantly different at level α = 0.05 Duncan test

Table.2 Weight of tubers per plant (g) the treatment of potato varieties and concentration of methanol

Varietas	Concentration of methanol				Rataan
	M_0	M_1	M_2	M_3	
v_1	291,30	335,05	351,73	340,99	329,77^{x}
v_2	267,50	290,65	299,19	314,95	293,07^{y}
Average	279,40^{c}	312,85^{b}	325,46^{ab}	327,97^{a}	

Remarks : Figures followed by the same letter in the row (a, b, c) and Column (x, y) are not significantly different at level α = 0.05 Duncan test

Table.4 Production of tubers per hectare by treatment of potato varieties and concentration of methanol

Varieties	Methanol concentration				Average
	M_0	M_1	M_2	M_3	
	……ton ……				
v_1	32,50	32,78	35,99	36,75	34,25 ^{x}
v_2	24,61	27,65	28,90	27,48	27,91 ^{y}
Average	26,77^{b}	30,22^{ab}	31,45^{a}	32,12^{a}	

Remarks : Figures followed by the same letter in the row (a, b, c) and Column (a, b) are not significantly different at level α = 0.05 Duncan test.

Diameter Bulbs

Based on Duncan's test showed that the Atlantic varieties produce tubers diameter was not significantly different compared with granola varieties (Table 3). Treatment M_3 produces the highest tuber diameter (3,67 cm) and significantly different from M_0treatment but not significantly different from the treatment of M_1 and M_2.

Production Bulbs

Based on Duncan's test showed that granola varieties produce higher tuber production and significantly different compared with the Atlantic varieties (Table 4). Treatment M_3 produces the highest number of tubers (32,12 ton) but not significantly different from treatment M_0 and M_1 and M_2.

Carbohydrate Content of Bulbs

Based on Duncan's test showed that the Atlantic varieties produce higher carbohydrate content and significantly different compared with granola varieties (Table 5). Treatment M_3 produces the highest carbohydrate content (19.54 g/100 g) and significantly different from m0 treatment but was not significantly different treatment effects of M_1 and M_2.

Water Levels Bulbs

Based on Duncan's test showed that granola varieties produce moisture content were not significantly different compared Atlantic varieties (Table 6). Treatment M_3produces the lowest water content(74,25%) and signicantly different from the treatment of M_0, M_1, and M_2.

Moisture contain of Bulbs

Based on Duncan's test showed that granola varieties produce moisture content were not significantly different compared Atlantic varieties (Table 7). Treatment M_3bulbs produce the highest hardness (3.53 Psi) and significantly different with M_0 treatment, but not significantly different from the M_2 and M_1.

Table.5 Treated carbohydrate content of potato varieties and concentration of methanol

Varietas	Concentration of methanol				Rataan
	M_0	M_1	M_2	M_3	
	..... g 100 g^{-1}				
v_1	18,52	18,99	19,81	19,90	$19,31^{x}$
v_2	17,30	18,07	18,76	18,77	$18,53^{y}$
Variety	$17,91^{b}$	$18,53^{ab}$	$19,29^{a}$	$19,54^{a}$	

Remarks: Figures followed by the same letter in the row (a, b, c) and column (x, y) are not significantly different at level α = 0.05 Duncan test

Table.6 Water content of potato tubers with a variety of treatment and concentration methanol

Varieties	**Methanol Concentration**			
	M_0	M_1	M_2	M_3
	..... %			
v_1	75,44	75,25	74,17	73,33
v_2	77,69	76,24	75,42	75,17
Average	$76,37^{a}$	$75,75^{b}$	$74,80^{c}$	$74,25^{d}$

Remark : Figures followed by the same letter in the row (a,b,c) not significantly Different at level α = 0.05 Duncan test.

Table.7 Mouister Cantain varieties of potato tubers with treatment and concentration Methanol

Varietas	Konsentrasi Metanol			
	M_0	M_1	M_2	M_3
	..... Psi			
v_1	3,40	3,52	3,53	3,54
v_2	3,47	3,50	3,51	3,53
Average	$3,49^{b}$	$3,51^{a}$	$3,52^{a}$	$3,53^{a}$

Remarks: Figures followed by the same letter in the row (a, b, c, d) are not significantly different at level α = 0.05 Duncan test

Table.8 Treated tuber skin thickness potato varieties and concentration of methanol

Varieties	Methanol Concentration			
	M_0	M_1	M_2	M_3
	……... mm ……..			
v_1	$0,27^{b}_{x}$	$0,28^{b}_{x}$	$0,30^{a}_{x}$	$0,31^{a}_{x}$
v_2	$0,27^{b}_{y}$	$0,27^{b}_{x}$	$0,28^{a}_{y}$	$0,28^{a}_{y}$

Remarks: Figures followed by the same letter in the row (a, b) and column (x, y) are not significantly different at level α = 0.05 Duncan test.

Skin Thickness Bulbs

Based on Duncan's test showed that the interaction of varieties of granola with methanol concentration resulted in higher skin thickness and significantly different compared with granola varieties interaction with methanol concentration (Table 8). Interaction and the concentration of methanol Atlantic varieties produce the highest tuber skin thickness (0.31 mm) in the treatment and significantly different from V_1M_3, V_1M_0 interaction significantly different from V_1M_1 but not with the interaction V_1M_2.

The effect of various methanol concentrations on production and the quality of potato is inseparable from the physiological activity of the potato crop, especially photosynthesis. Photosynthetic activity determines the growth and production of potato crop. The treatment of granola varieties produce tuber weight umbi and amount higher than the Atlantic variety (Table 1 and 2). This relates to both the growth of types of varieties, which is due to differences in genotype that causes differences in the ability of each variety in the absorption of nutrients, especially CO_2. The results of Mueller *et al.,* (2004) showed that the effect of nutrients on plant growth depends, among others, by the concentration of CO_2 and plant species. Methanol concentration of 15% (M_3) increases the number of tubers, tuber weight and tuber diameter compared the effect of treatment M_0, M_1, and M_2. The influence of the concentration levels of $CO_2$is to produce methanol production components, especially the number of tubers, tuber weight and tuber diameter was also associated with the vegetative growth of potato plants (Table 1, 2, 3 and 4)

The weight of tubers produced by plants is the result of the process of photosynthesis, respiration, and translocation. Glucose is formed from the photosynthesis immediately converted to fructose or combine to form sucrose, and then translocated to other cells or be polymerized carbohydrate as food reserves whilst within the chloroplast. Sucrose into the cell wall was enlarged and in the cells transformed into structural components such as cellulose. Sucrose is also transferred to the parts of the plant such as to place the active growth (meristems) or the change into polysaccharide as a food reserve or structural compounds (Gardner *et al,* 1985).

Varieties of the Atlantic who have tuber number and tuber weight were much higher due to the distribution of assimilates which spread to any cause tuber competition in obtaining assimilates from source to sink (tuber) is higher due to the weight of tubers affected by the number and diameter of the tuber crop potato during generative growth (Okazawa, 1983; Muhibuddin *et al.,* 2013). Tuber formation process can be defined as

the activity of the establishment of a network storage at the bottom of the plant the stolon, while tuber development process is a continuation process of stolon formation, tuber formation started and followed with a tuber food storage until it reaches a certain number and size (Muhibuddin *et al.,* 2015). The process of tuber formation is closely related to plant growth (Swiezynki *et al.,* 1998) and the second process is still associated with the process of tuber development (Wheeler *et al.,* 2008).

Methanol concentration of 15% (M_3) is able to increase the carbohydrate content, both varieties of granola and the Atlantic compared with the effect of treatment but not significantly different from M_0 to M_1 and M_3 treatment effect (Table 5). Increased carbohydrate content with 15% methanol concentration (M_3), because methanol breaks down into CO_2 as a raw material in the process of photosynthesis (Gardner et al., 1985). In addition, CO_2 is an essential ingredient for the carbohydrate, protein and fat (Salisbury and Ross, 1995).

The application of methanol 15% (M_3) is able to increase CO_2 in the mesophyll of leaves which increase theorganic compounds in the plant, including protein content compared with the effect of treatment but not Significantly different from M_0 to M_1 and M_3 treatment effect. This Occurs due to the increase of CO_2which will happen in interactions with other elements that affect the metabolic processes of plants (Gardner *et al*., 1985; Salisbury and Ross, 1995).

The treatment of 15% methanol (M3) produces the lowest tuber wáter content (74.25%) and significantly different from the treatment of M_0 and M_1 but not significantly different with thetreatment of M_2 (Table 6). Concentration of methanol 15% resulted in the lowest wáter content tan other treatments. The percentage of wáter content of tubers determine the content of dry material. This relates to the accumulation of moisture content percentage tuber determine the content of dry material. This is related to the accumulation of assimilates or dry matter in tubers were determined by the total drymatter accumulation assimilate in to tubers. According Tan and Lee (2003) in addition to the light intensity factor and nutrient availability, the crucial factor istheprocess of plantphysiology photosynthesis, respiration, and other metabolism, whichwillaffectthe balance of source and sink on plants that will affect the content of the water.

The treatment of 15% methanol (M_3) produces the highest tuber hardness (03,53 Psi) and significantly different from the treatment M_0, but not significantly different from treatment of M1 and M_2 (Table 7). 15% metanol application is able to produce the highest tuber violence tan other treatments. The high hardness bulbs at 15% metanol concentration associated with increased carbohydrate content of potato tubers. This is because carbohydrates are the main constituent of the cellwall composed of cellulose, pectin, hemicellulose and other polysaccharides as reinforcement between the cells in potato tubers (Wattimena, 2005).

The treatment of 15% methanol (M3) produces the highest tuber skin thickness (0, 31 mm) and significantly different from the treatment M0, but not significantly different from treatment of $M_1$and M_2. It is associated with an increased carbohydrate content of tubers (Table 8), which is a cell wall constituent carbohydrates are composed of hemicellulose and cellulose that accumulates in the cell walls of thetubers skin. According to Permadi *et al*., (1989) tuber skin

(periderm) of potato composed by 6-10 layers of cells in the absence of a rectangular cavity inter celland undergo cell wall suberisasi. Periderm layer began to form since swelling stolon end which is the initial formation of the bulb (Wattimena, 2005). The cells in the outer layers of the bulb (epidermis) splitting towards the tubers, whereas the cells in a layer beneath the epidermis (hypodermic) divide outwards with increasing carbohydrate content of tubers (Muhibuddin *et al*, 2015), a layer of cells that divide is called phellogen. The cells of the newly formed (phellem) will be a constituent component periderm (bark) and also experienced suberisasi). This happens because of the addition of CO_2 from methanol cause an increase in photosynthesis that add the carbohydrate content of tubers (Table 5).

Conclusion

Methanol concentration of 15% (M_3) gives the best effect in increasing the production of potato namely: an increase in the number of tubers plant^{-1} from 25.42 into 29.76 fruit, tuber weight plant^{-1} from 279.40 into 327.97 g, and bulb diameter of 3.54 to 3.67 cm, and tuber production of 26.77 tons ha^{-1} to 32.12 tons ha^{-1}. Methanol concentration of 15% (M_3) gives the best effect in improving the quality of the bulbs, the carbohydrate content of 17.1 into 19.54 g 100^{-1} g, 3.49 tubers violence Psi be 3.53, and the lower the water content of 76,37 % to 74,25 %.

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