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Potato Productivity (*Solanum tuberosum* L.) of G_0 Granola L. Varieties at Different Planting Distance and Temperature Grown in Aeroponics

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ABSTRACT

Purpose : *Both quantity and quality potato seed production in Indonesia is relatively low, because it is still cultivated conventionally. Aeroponic cultivation can produce seeds in large quantities and quality with environmental control through setting the spacing and temperature regulation of the rooting area (room box). This research was to study the increase in productivity of G0 type potatoes at planting distance and the room temperature of the box.*

Research Method : *The research to study the productivity of G0 type potatoes at different planting distance (j0: 20 cm x 20 cm, j1: 20 cm x 25 cm, and j3: 20 cm x 30 cm), and the room temperature of the box (t0: room temperature (control) and t1: 150C. The experiment was set up as randomized block design and repeated 4 times. Data were analyzed for variance and Duncans' further test.*

Findings : *The results showed no interaction between planting distance and temperature. The planting space of 20 cm x 20 cm gave a significant effect on plant height at the age of 45 DAP. The temperature treatment of 150C has a significant effect on plant height at 15, 30, 45 and 60 days after planting (DAP), a number of leaves at 15 and 45 DAP, and the number of potential tubers.*

Limitations : *Limititations in this research was that harvest time was not optimal because due to the plants inability to continue their lives due to wilting disease and high air temperatures.*

Value : *Information from this research is very important for potato seed farmers in increasing crop productivity by managing temperatures to cool down at night in the rooting area.*

Keywords: *G_0 type potato seeds, aeroponic, planting distance, root area, temperature*

INTRODUCTION

Potato production in Indonesia is still low, partly because of the lack of high quality and superior potato seeds. This also happened in Buthan, where the annual seed potato requirement for Bhutan is approximately 10,000 ton and almost 99% of the requirement is covered through seed sources from informal system (Chettri *et al.,* 2006) in Ngawang and Thubten Sonam (2018).

Aeroponic potato seed cultivation is one of the efforts to produce potato seeds in large quantities, relatively uniform in size and quality. Research on spacing and concentration of chitosan in the seeds of aeronautically cultivated G_0 potato type plants has been carried out and the result is a spacing of 20 cm x 20 cm with a chitosan concentration of 40mg.L^{-1} increases the number of tubers about 5 times more than the conventional cultivation method. Now the research will be tried by widening the planting distance by engineering temperature in the rooting area.

Plant spacing is an effort to regulate space and will affect temperature, humidity, light and space in aeroponic cultivation. According to Singh and Singh (2002) in Adrienn Szarvas *et al.,* (2019), it is explained that the establishment of an optimum population per unit area of

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the field is essential to get maximum yield. Therefore, the optimum plant population of individual crops should be worked out under suitable environmental conditions. Meanwhile, according to Norman (1963) in Adrienn Szarvas (2019), it is described that both too narrow and too wide spacing do affect yields through competition (for nutrients, moisture, air, radiation, etc) due to the inefficient utilization of the growth factors. A number of factors also influence spacing: fertility status of the soil, moisture availability, growth pattern of the crop and cultural practices.

Potato (*Solanum tuberosum* L.) is characterized by specific temperature requirements and develops best at about 20^0C. High temperatures during the growing season cause an array of changes in potato plants, which affect its development and may lead to a drastic reduction in economic yield (Krystyna Rykaczewska, 2015). From conducted experiments in growth, it is known that haulm growth is the fastest in the temperature range of 20 – 25^0C whereas the optimal range for tuberization and tuber growth is 15 – 20^0C. Under high-temperature conditions, tuberization is significantly inhibited and photo assimilate partitioning to tubers is greatly reduced (Ewing 1981; Haynes *et al.,* 1989; Krauss and Marschner1984; Lafta and Lorenzen1995 in Krystyna Rykaczewska 2015). The stepwise linear regression showed that the potato productivitywas mainly regulated by the surface (10 cm) soil temperature and soil water moisture at 20 and 30 cm depths (Xiaolin Liao, 2016)

Based on the Yogyakarta Agricultural Technology Assessment Center, to obtain maximum production, during the growth of the potato plants, it requires an average temperature of 15.5^0C – 18.3^0C and it is assumed that cold night temperatures are more important than low temperatures during the day. This has something to do with tuberization (tuber formation) which is driven by a short day. The purpose of this study is to further examine the spacing and room temperature of the box in the production of aeroponic G_0 potato seeds and hopefully more complete information can be obtained in an effort to increase the productivity of G_0 potatoes type.

MATERIAL AND METHODS

Material and Tools

The research materials needed were rooted G_0 type bud potato cutting (3 weeks old), root stimulator, AB Mix aeroponic nutrition specifically for potatoes, clean water, clorox, chitosan, fungicide, sphagnum moss, and rope. The used instrument is a set of aeroponic installations with various plant spacing (according to research treatment), Sitomas Machine (temperature reducing machine), measuring devices (ruler), EC Meters, and stationery.

The study was conducted in the green house of the experimental garden Faculty of Agriculture, Winaya Mukti University, West Java-Indonesia with a height of 870 m above sea level.

Methods

Experiment treatments consist of 2 factors, namely the distance of planting with 3 levels (j_0: 20 cm x 20 x cm, j_1: 20 cm x 25 cm, and j_3: 20 cm x 30 cm) and temperature with 2 levels (t_0: without refrigeration (control) and t_1: temperature 15^0C). Observation data were obtained through sample measurements of each treatment which was repeated 4 times, including plant height, number of leaves, number of buds, and number of potential tubers. Primary data were analyzed using variance analysis and further tested by Duncan.

Seed Cuttings Preparation

Planlets from in vitro seeds were acclimatized on the husk charcoal media until they have thick stem and perfect leaves. Then the shoot the of plants are cut (10 cm), give root stimulants and replanted in the husk charcoal media to take root (3 weeks). After taking root, the plants were pulled out slowly and the roots are cleaned from the husk charcoal media.

Aeroponic Installation Preparation and Nutrition

The aeroponic box was cleaned of dirt and dust, washed thoroughly. The planting hole was made in accordance with each treatment, then coated with mulch plastic. Nutrients were made by mixing macro and micro nutriens as recommended plus chitosan, while stirring until it dissolves completely. All nutriens were put into a 500 liter water container and then distributed to the pipes in the box. Some boxes use a temperature-reducing device (Sitomas) with a setting of 15^0C, and some other boxes do not (control).

Planting and Roping

The base of potato shoots cutting stem wrapped with moist sphagnum moss, then the roots are inserted into the planting hole until the bottom surface of box cover penetrates. Before the plant grows, give it a rope so that the plant can grow well and straight.

Maintenance, Observation and Harvesting

Nutrients solution flows for 3 minutes in the form of fine grains and stops for 12 minutes, arranged using a timer machine. To keep the nozzle running smoothly, it is necessary to clean the pipe filter regularly. The root area must be in a dark condition to stimulate tuber growth. If exposed to light, the stolon will not become a bulb but become a spreading plant. In this study the harvest was done less than the specified time because the plants could not stand the extreme heat conditions in the greenhouse, causing the plants to wither.

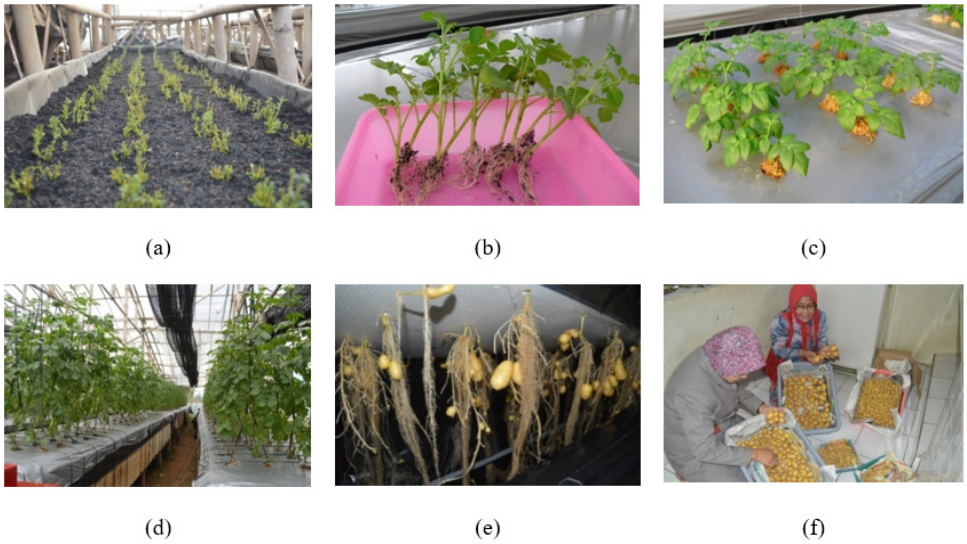

Figure 01: **Research Flow : (a) Acclimation of Potato planlet, (b) Rooted seed cuttings, (c) Aeroponic planting, (d) Plant 50 days after planting, (e) Tuber formation process, (f) Tuber observation process**

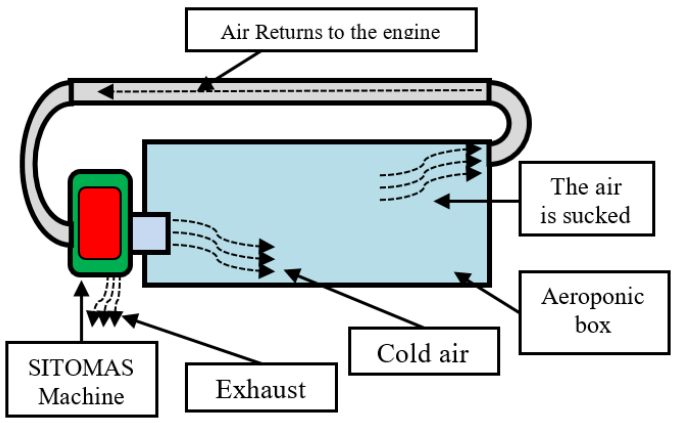

Figure 02: **Illustration of Temperature Control Machine (Sitomas) Seen from the Top Side**

RESULTS AND DISCUSSIONS

Plant Height (cm)

The plant spacing affected the plant height after 45 days of planting (DAP). While the temperature affected the plant height of 15 DAP, 30 DAP, and 45 DAP, respectively based on Table 01. The spacing of 20 cm x 20 cm (control) is still the best one among other spacing, because with a wider spacing it does not have a real effect. According to Hasan *et al.,* (2017), wider spacing ensures the basic nutritional requirements but decreases the total number of plants as well as total yield.

Mean while the temperature of 15^{0}C was the best temperature compared to the control, because it gives a real influence on plant height. Increase in soil temperature (root area) improves root growth because of the increase in metabolic activity of root cells and the development of lateral roots (Repo *et al.,* 2004 in Brownmang Onwuka, 2018). It is suspected that this can cause stunted growth of leaves, stems and tubers. In Tables 1, 2, 3, 4, and Table 05 the average number in each column followed by the same letter shows no significant difference according to Duncan's Multiple Range Test at a 5% significance level.

Number of Leaves

The interaction effect between plant spacing and temperature on the variable number of tested leaves was not significant, but the independent temperature significantly affected the number of leaves 15 DAP and 45 DAP. Although plant spacing affects plant height, it does not affect the number of leaves (only affect the length of the plant segment). This is thought to have been etiolated at narrow plant spacing (20 cm x 20 cm), where plant spacing causes light competition. According to Antonio Anderson de Jesus Rodrigues *et al.,* (2017), the length of stem segment was greater in the absence of light.

Table 01: Plant height of at 15, 30 and 45 DAP

Treatment	Plant Height (cm)			
	15 DAP	30 DAP	45 DAP	60 DAP
Spacing				
j_0(20x20cm)	25.75 a	56.56 a	105.92 c	135.34 a
j_1(20x25cm)	26.20 a	56.53 a	92.68 b	94.09 a
j_2(20x30cm)	25.00 a	54.11 a	85.51 a	89.96 a
Temperature				
t_0 (control)	21.43 a	50.07 a	81.73 a	85.58 a
t_1 (15^{0}C)	29.87 b	61.39 b	107.68 b	127.35 b

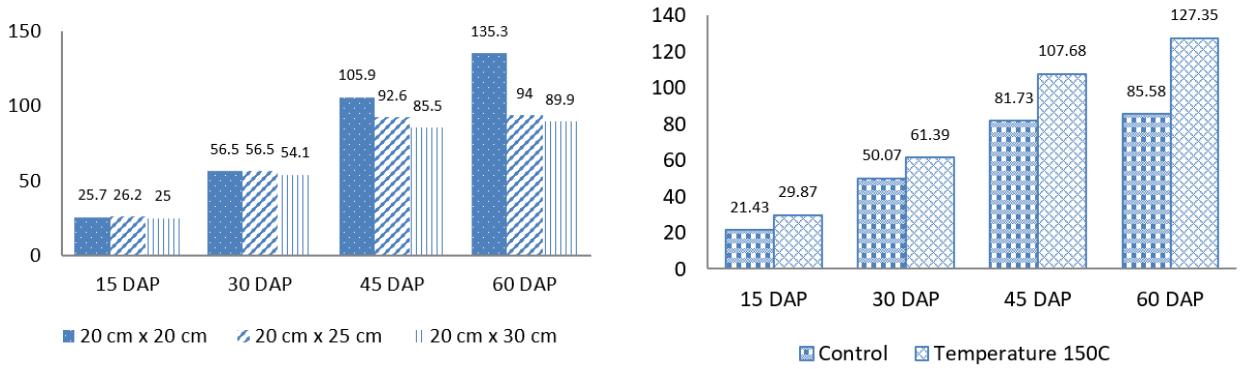

Figure 03: Plant height of 15 DAP, 30 DAP, and 45 DAP (a) effect of planting space (b) temperature

Table 02: Number of Leaves at 15, 30, 45 and 60 DAP

Treatment	Plant Height (cm)							
	15 DAP		30 DAP		45 DAP		60 DAP	
Spacing								
j_0(20x20cm)	7,98	a	12,33	a	15,73	a	14,21	a
j_1(20x25cm)	8,20	a	12,20	a	15,38	a	14,59	a
j_2(20x30cm)	7,35	a	11,58	a	14,42	a	14,39	a
Temperature								
t_0 (control)	6,98	a	11,93	a	14,28	a	14,18	a
t_1 (15^0C)	8,70	b	12,13	a	16,07	b	14,61	a

Table 03: Number of Buds

Treatment	Number of Buds	
j_0t_0	8.86	a
j_0t_1	8.35	a
j_1t_0	9.16	a
j_1t_1	8.28	a
j_2t_0	8.70	a
j_2t_1	8.55	a

Table 04: Number of Formed Tubers

Treatment	Number of Tubers Formed	
j_0t_0	5.37	a
j_0t_1	6.70	a
j_1t_0	5.74	a
j_1t_1	7.18	a
j_2t_0	5.89	a
j_2t_1	6.00	a

The temperature of 15^0C was the best temperature compared to the control, because it gives a real influence on the number of leaves. Gutschick (2010) in Anju Giri *et al.,* (2017) states that in many cases, it is expected that increases in extreme high-temperature events (e.g., heat waves) will affect plants more negatively than increases in average temperatures. High-temperature stress reduces root growth, number, and mass (Huang *et al.,* 2012 in Anju Giri 2017), which affects the growth of aboveground tissue by restricting the supply of water and mineral nutrients, affecting production of hormones synthesized in roots and transported to shoots, and altering sink-source relationships between shoots and roots (Huang *et al.,* 2012, Renneberg *et al.,* 2006, Wahid *et al.,* 2007 in Anju Giri 2017).

Number of Buds

The interaction effect between planting distance and temperature on the variable number of buds tested was not significant, as well as the independent effect showed no significant effect. Spacing and temperature were unable to increase the number of buds on potato tubers. This is presumably because the tuber size at harvest has almost the same size in the range of 16 g. According Naik and Karihaloo (2015), the number of sprouts growing on a tuber is determined by the size of the tuber. Generally, more sprouts develop on large tubers stored for longer periods.

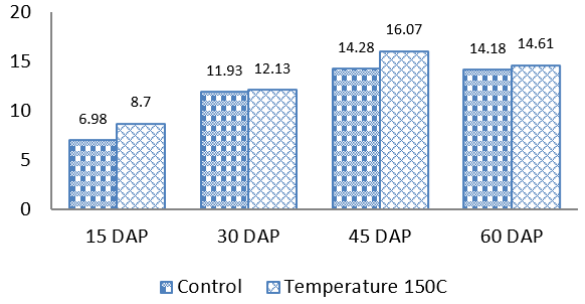

Figure 04: Number of Leaves at 15, 30, 45 and 60 DAP

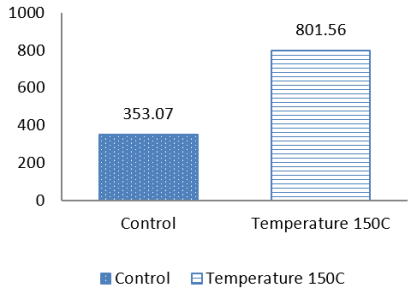

Figure 05: Number of Formed Tubers

Number of Tubers Formed

The interaction effect between plant spacing and temperature on the variable number of tubers formed was not significant, as well as the independent effect showed no significant effect. Spacing and temperature are unable to increase the number of tubers formed by potato plants. This is presumably due to the age of harvest that is not optimal, where when entering the age of 60 days after the plant is attacked by wilting disease. This is supported by the opinion of Li (1983), that high temperatures can stimulate wilting disease which causes inhibition of tuber initiation, reduced amount of tuber consumption and ultimately crop failure. Not all spacing settings affect the results as in the study of Fisseha Negash and Tewodros Mulualem (2015), different row spacing or their interaction with planting methods had not caused significant differences in seed productivity and yield components of cotton.

In previous studies when the optimal harvest, potato cultivation increased aeroponic increase five times compared to conventional cultivation. According to Rykaczewska (2016), the most important parameter of minituber production, their number, was on average 32.5–36.0 per plant and 1268–1396 per m^2 depending on cultivar. Number of minitubers was two to three times greater in the case of aeroponic production than by traditional method.

Number of Potential Tubers

The results of the analysis showed that the treatment distance of planting with a tested temperature is not significant, but independently the treatment temperature of 15^0C gives a significant effect while the treatment of plant spacing shows no significant effect. According to Muthoni & Kabira (2015), potato is a cool season crop and grows best between 15^0C and 18^0C and soil pH of 5.5 to 6.0. Temperatures above 21^0C have adverse effects on growth. According to Struik (2007) in Yean Uk Kim and Byun Woo Lee (2019), tuber development has lower optimum temperature; tuber induction is optimal at 15^0C, initiation at 22^0C, and setting at 15^0C. Based on Table 05. the temperature treatment of 15^0C was able to increase the number of potential tubers by two times (801.56) compared to controls (353.07).

Table 05: Number of Potential Tubers

Treatment	Number of Potential Tubers	
Spacing		
j_0(20x20cm)	438,96	a
j_1(20x25cm)	516,08	a
j_2(20x30cm)	776,90	a
Temperature		
t_0 (control)	353,07	a
t_1 (15^0C)	801,56	b

CONCLUSION

The results showed no interaction between planting distance and temperature. In the independent effect, handling spacing of 20 cm x 20 cm gives a significant effect on plant height at the age of 45 DAP. The temperature treatment of 15^0C has a significant effect on plant height at 15, 30, 45 and 60 days after planting (DAP), number of leaves at 15 and 45 DAP, and the number of potential tubers.

Data Availability Statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on a reasonable request.

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