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PENGARUH JENIS MEDIA DAN ZAT PENGATUR TUMBUH TUMBUHAN PADA PRODUKSI UMBI MINI KENTANG KULTIVAR GRANOLA SECARA AEROPONIK

Abstrak

Kentang merupakan salah satu tanaman sayuran yang paling berkembang karena memiliki daya saing yang tinggi dibanding sayuran lainnya. Kentang merupakan salah satu komoditas yang mendapat prioritas dalam program penelitian dan pengembangan. Penelitian ini bertujuan untuk mempelajari pengaruh nutrient dan zat pengatur tumbuh terhadap produksi umbi mini kentang kultivar Granola. Penelitian ini merupakan penelitian eksperimenal dengan Rancangan Petak-petak Terpisah dengan tiga ulangan. Petak utama adalah jenis nutrient yang terdiri dari nutrient Grow More-dimodifikasi dan AB-Mix. Anak petak adalah jenis ZPT yang terdiri dari BAP dan GA_3, sedangkan anak petak adalah konsentrasi ZPT yang terdiri dari 0 µM; 5 µM; 10 µM; 15 µM; 20 µM dan 25 µM. Produksi umbi mini kentang granola pada sistem aeroponik dipengaruhi oleh jenis hara, dan jenis serta konsentrasi ZPT yang digunakan. Knol yang ditumbuhkan pada media AB-Mix dengan penamabahan 20 µM GA_3 menghasilkan umbi mini kentang granola terbaik. Hasil penelitian ini dapat digunakan oleh Kebun Bibit Hortikultura untuk memproduksi umbi mini bibit kentang kultivar Granola secara aeroponik. Dalam jangka panjang diharapkan akan meningkatkan ketersediaan bibit bermutu tinggi dan berkontribusi pada peningkatan produksi kentang nasional.

Kata Kunci : AB-mix, BAP, GA_3, Grow More.

THE EEFECTS OF MEDIA AND PLANT GROWTH REGULATORS ON MINITUBER PRODUCTION OF GRANOLA CULTIVAR OF POTATO IN AEROPONICS SYSTEM

Abstract

Potato is one of the most developed vegetable crops which has higher competitiveness compared to vegetables. Indonesian potato production has not been able to meet the increasing demand, which led to a very intensive research and development programs. The objective of this research was to study the effect of nutrients and growth regulators on mini tuber production in the aeroponic system and to determine the best type of nutrient as well as the type and concentration of growth regulators to increase mini tuber production in aeroponics system. The research has been carried out experimentally using a split-split plot design. The main plots wes the types of nutrient media consisting of Grow More-modified nutrient and AB-Mix nutrient medium. The sub-plot was the types of PGR which consisted of BAP and GA*3*, whereas the sub-sub-plot was the concentration of PGR, which consisted of 0 µM; 5 µM; 10 µM; 15 µM; 20 µM and 25 µM. Each treatment combination was repeated three times. The type of nutrient and the type and concentration of PGR affected the development of granola potato mini tubers in an aeroponic system. Knols grown in AB-Mix medium supplemented with 20 uM GA3 resulted in the best minituber formation. This finding can be applied by Kledung Horticultural Seed Garden, Temanggung, to produce high quality tuber seed in the form of minituber using the available aeroponics system. For longer term the availability of high-quality tuber seed may increase national potato production.

***Keywords* :** AB-mix, BAP, GA_3, Grow More

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one the most developed vegetable crops because due to its high competitiveness compared to other vegetables (Hidayat, 2016). Potato is an essential food commodity in Indonesia which is needed throughout the year. The high demand for potatoes results in the need to produce a larger quantity of high-quality potato. Potato production in Indonesia has increased from 1,219,270 tons in 2015 to 1,314,657 tons in 2019 (Statistics Indonesia, 2020). However, this production has not been able to meet the ever-increasing market demand of potato. Granola cultivar of potato is one of the most cultivated cultivars in Indonesia which has a high productivity and long harvest life. Research and development programs have been prioritised to increase potato production in Indonesia (Karjadi, 2014).

Potato production in developing countries is hampered by constraints such as low soil fertility, pest and diseases as well as inadequate supply of good quality seed tubers. Majority of farmers recycle their own seeds or get them from informal sources. This leads to seed degeneration and buildup of tuber-borne diseases and hence low yields (Muthoni et al., 2013). Good tuber is one of the most important factors in increasing potato productivity (Nuraini et al., 2016; Wulandari et al., 2014). In mitigating the problem of shortage of good quality seeds, strategies to rapidly multiply the seed tubers such as tissue culture in conjunction with hydroponics and aeroponics have been tried (Muthoni et al., 2013). Sumarni et al. (2013) stated that the use of aeroponic techniques on potato tuber seed production could improve the quality of tuber seed produced.

Aeroponics is a cultivation system which able to increase the product quality and yield, and is very efficient in soil, water, and nutrients use. Compared to conventional techniques, the aeroponic systems can initiate potato tubers more quickly (Dianawati et al., 2013). Potato production in an aeroponic system is influenced by several factors, including potato genotype, Plant Growth Regulator (PGR), light, temperature, humidity, media, and planting techniques (Fadhil et al., 2015; Sonnewald & Sonnewald, 2014).

The types of PGR that can be used to stimulate plant growth and productivity including 6-Benzylaminopurine (BAP) which stimulates shoot growth (Feng et al., 2012; Munarti & Kurniasih, 2014), and Gibberellic acid (GA_3) which stimulates stems and leaf area growth (Karjadi, 2014). The growth of axillary shoots is the beginning of micro tuber formation. These shoots can develop into stolons and micro tubers if the conditions are suitable for tuber formation (Chiipanthenga et al., 2012; Pratama et al., 2014). GA_3 can induce micro tuber formation because it stimulates the differentiation and morphogenesis, especially the formation of shoots, which is very important in mini tuber formation (Karjadi & Waluyo, 2017). The objective of this research was to study the effect of nutrients and growth regulators on mini tuber production in the aeroponic system and to determine the best type of nutrient as well as the type and concentration of growth regulators to increase mini tuber production in aeroponics system.

MATERIALS AND METHODS

The research has been conducted in Kledung Horticultural Seed Garden, Temanggung, Central Java, Indonesia. The research has been carried out experimentally using a split-split plot design. The main plots wes the types of nutrient media consisting of Grow More-modified nutrient and AB-Mix nutrient medium. The sub-plot was the types of PGR which consisted of BAP and GA*3*, whereas the sub-sub-plot was the concentration of PGR, which consisted of 0 µM; 5 µM; 10 µM; 15 µM; 20 µM and 25 µM. Each treatment combination was repeated three times.

Aeroponics system

The aeroponics system, which includes cubical size, plant material (A certified-G1-tuber-seed-derived plantlets (knol) of Granola cultivar), planting techniques, planting density (75 plants/m^2), and plant maintenance were carried out according to procedures described in Sugiyono et al., 2021). The knol and planting density of 75 plants/m^2 were used in this study because they showed the best results in the previous study (Sugiyono et al., 2021).

Data collection and analysis

The variable observed was the production of granola cultivar potato mini tuber. The parameters measured included the total number of mini tubers, mini tuber total weight, average weight per mini tuber, and mini tuber average diameter. Data were collected and subsequently analysed using an analysis of variance (ANOVA), followed by Honestly Significance Difference (HSD) Test, with a confidence level of 95% when a significant difference between treatments was observed.

RESULTS AND DISCUSSION

The development of potato tuber consists of two aspects: morphological development and biochemical changes that lead to carbohydrate formation and storage. During the morphological development, tuber formation consists of two sequential processes i.e., stolon formation and tuber formation on its tip. Lateral shoot can give rise to a stolon due to the changes in cell division and cell elongation. It is generally agreed that longitudinal growth of the stolon ceased just before the swelling of stolon tip, is started. The cells inside the pit and the cortex enlarge and begin to divide lengthwise, resulting in the swelling of the stolon tip. Afterwards, random cell division and enlargement occur mainly in the perimedular zone until the specified tuber size is reached (Momena et al., 2014; Rykaczewska, 2016; Tierno et al., 2014).

The HSD test results on the effect of nutrients on mini tuber formation showed that only the total mini tuber weight was controlled by the nutrients used. Tabel 1 shows that AB-mix resulted in a significantly heavier average minituber total weight. AB-Mix is a commercially available hydroponics solution which rich in both macronutrients (especially potassium (40%), phosphorus (23%) and nitrogen (14%) and micronutrients. Plant growth on AB-mix medium can be seen on Figure 1. On the other hand, Grow More is a commercially available leaf-manure that contains slightly lower macro and

micronutrient content. It seems that the AB-Mix nutrient is sufficient to support the growth and minituber formation of granola cultivar of potato, due to its higher nutrients content compare to that of Grow More medium. This finding was consistent with the finding previously reported by Sugiyono et al. (2021).

Figure 1. The appearance of potato cultivar Granola in an aeroponics system, a) the condition of the potato vultivar Granola crop in an aerohonic system, b) mini tubers generated in an aeroponic system.

Table 1. The effect of different nutrients on total minituber weight of granola cultivar of potato in aeroponics system

Nutrient	Total minituber weight
Grow More-modified Nutrient	5,56[b]
AB-mix	8,41[a]

Note: Numbers followed by different letters show significant difference in HSD (≤0.05)

Further HSD analysis (Table 2) showed that the interaction between nutrients and PGRs controlled the average minituber weight of Granola cultivar of potato in the aeroponics system. It was found that knol planted on AB-Mix nutrient treated with GA_3 produced a significantly heavier average of minituber weight. GA_3 application has been aimed to improve internode elongation and stimulate tuber enlargement due to longitudinal growth of the stolon. GA_3 can accelerate the formation of stolons which later develop into shoots or tubers (Salem & Hassanein, 2017).

Table 2. Effect of interaction between nutrients and PGRs on average minituber weight of granola cultivar of potato in aeroponics system

Type of Nutrient	PGR type	Average minituber weight
Grow More-modified Nutrient	**BAP**	1,67[ab]
	GA_3	1,32[b]
AB-mix Nutrient	**BAP**	1,39[b]
	GA_3	2,29[a]

Note: Numbers followed by different letters show significant difference in HSD (≤0.05)

Furthermore, results of the HSD test on the effect of PGR concentration on mini tuber formation of Granola cultivar of potato in aeroponics system (Table 3) showed that PGR at a concentration of 0 µM produced the highest average number of tuber (8.58 tubers/plant) and the heaviest average tuber weight (9.85 gr/plant) or 514.8 tubers/m^2. These results also indicated that knols planted on the media without growth regulator produced the highest number of tubers, which led to the heaviest total tuber weight. It also indicated that Grow More-modified nutrient and AB-Mix medium capable of inducing stolon formation and growth, thus accelerating mini tuber induction.

Table 3. The effect of different concentrations of PGR on total number and total weight of minitubers of granola cultivar of potato in aeroponics system

Consentration of PGR (µM)	Number of mini tuber	Total minituber weight
0	8.58 [a]	9.85 [a]
5	3.42 [b]	6.54 [bc]
10	5.17 [b]	5.90 [bc]
15	4.75 [b]	5.88 [bc]
20	4.67 [b]	8.85 [ab]
25	3.50 [b]	4.90 [c]

Note: Numbers followed by different letters show significant difference in HSD (≤0.05)

Looking at the influence of the interaction between nutrient type and PGR concentration mini tuber average diameter, HSD test results (Table 4) showed that AB mix nutrient without any PGR addition resulted in the largest average tuber diameter (12.19 mm). AB mix media is a hydroponic solution with high macronutrients, especially potassium, phosphorus, nitrogen, and micronutrients. This high nutrient content may have been sufficient to stimulate minituber production. Sugiyono et al. (2021) reported that the use of AB-Mix medium was very effective for the formation minituber as indicated in the number, average weight and diameter.

Moreover, the HSD test results on the effect of the interaction between PGR type and concentration on total minituber weight (Table 5) shows that the use of GA_3 at a concentration of 20 µM resulted in the heaviest minituber (12.91 g / plant). This finding indicates that GA_3 at a concentration of 20 µM can increase both the source strength and sink capacity in potato minituber formation. Gibberellin enhance cellular proliferation leading to the enhancement of lateral organs development and minituber growth (Kumlay, 2014; Sonnewald & Sonnewald, 2014; Wang et al., 2018).

In addition, results of the HSD test on the effect of the interaction among the type of nutrients, type of PGRs and PGR concentration on minituber formation of granola cultivar of potato in aeroponics system (Table 6) showed that knols grown in Grow More-modified nutrient medium at 0 µM GA_3 resulted in the highest total number of minitubers (Figure 2), although was not significantly different with that of knol grown in AB-Mix medium supplemented with 20 µM GA_3. Gibberellin was found to be more effective in inducing the growth of potato shoots than its ability to induce tuber formation.

Other PGRs, such as auxin, are thought to be more effective in inducing potato tuber formation (Faramarzi et al., 2012; Roumeliotis et al., 2012). Table 6 also showed that knols grown in AB-Mix nutrient medium supplemented with GA3 20 µM resulted in the highest total minituber weight (21.38 g/plant). These results indicated that AB-Mix and GA3 nutrients at a concentration of 20 µM were able to produce the highest source strength and sink capacity to form potato mini tubers in aeroponic systems.

Table 4. Effect of interaction between nutrients and concentrations of PGR on average minituber diameter of granola cultivar of potato in aeroponics system.

Type of Nutrient	Consentration of PGR (µM)	Average Minituber Diameter
Grow More-modified Nutrient	**0 µM**	8,76^{e}
	5 µM	10,98^{abcd}
	10 µM	9,42^{de}
	15 µM	9,71^{cde}
	20 µM	10,85^{abcde}
	25 µM	11,70^{abc}
AB-mix Nutrient	**0 µM**	12,19^{a}
	5 µM	11,90^{ab}
	10 µM	11,07^{abcd}
	15 µM	10,25^{abcde}
	20 µM	11,36^{abcd}
	25 µM	9,97^{bcde}

Note: Numbers followed by different letters show significant difference in HSD (≤0.05)

Table 5. The effect of interaction between PGRs and concentrations on total minituber weight of granola cultivar of potato in aeroponics system.

Type of PGR	Consentration of PGR (µM)	Total Minituber Weight
BAP	**0 µM**	9,25^{abc}
	5 µM	5,52^{c}
	10 µM	6,02^{bc}
	15 µM	6,94^{bc}
	20 µM	4,80^{c}
	25 µM	5,18^{c}
GA_3	**0 µM**	10,46^{ab}
	5 µM	7,57^{bc}
	10 µM	5,77^{bc}
	15 µM	4,81^{c}
	20 µM	12,91^{a}
	25 µM	4,61^{c}

Note: Numbers followed by different letters show significant difference in HSD (≤0.05)

Table 6. Effect of interactions among nutrients, PGRs, and concentrations on minituber formation of granola cultivar of potato in aeroponics system.

The type of Nutrient	Type of PGR	Consentration of PGR (µM)	Total Number of Minituber	Total Minituber Weight	Average Minituber Diameter
Grow More-modified Nutrient	BAP	0	5.67 bcd	6.00 bcd	9.56 cdef
		5	4.67 bcd	5.94 bcd	10.38 bcdef
		10	9.33 ab	4.76 d	7.51 f
		15	5.00 bcd	7.88 bcd	10.42 bcdef
		20	3.33 cd	5.71 bcd	10.97 abcde
		25	2.67 d	7.16 bcd	13.83 a
	GA_3	0	12.67 a	8.31 bcd	7.96 ef
		5	2.67 d	5.37 cd	11.58 abcd
		10	2.33 d	4.00 d	11.33 abcd
		15	4.33 bcd	3.62 d	9.00 def
		20	3.00 d	4.44 d	10.72 bcde
		25	4.67 bcd	3.55 d	9.57 cdef
AB-mix Nutrient	BAP	0	9.33 ab	12.50 bc	12.26 abc
		5	3.33 cd	5.10 d	11.80 abcd
		10	4.33 bcd	7.28 bcd	11.27 abcd
		15	6.00 bcd	6.00 bcd	9.94 bcdef
		20	4.00 cd	3.89 d	9.68 cdef
		25	2.67 d	3.20 d	9.22 cdef
	GA_3	0	6.67 bcd	12.61 b	12.11 abcd
		5	3.00 d	9.76 bcd	12.00 abcd
		10	4.67 bcd	7.55 bcd	10.88 abcde
		15	3.67 cd	6.00 bcd	10.56 bcdef
		20	8.33 abc	21.38 a	13.05 ab
		25	4.00 cd	5.67 bcd	10.73 bcde

Note: Numbers followed by different letters show significant difference in HSD (≤0.05)

Figure 2. The appearance of granola cultivar potato tubers in an aeroponic system: a) Treatment of Grow More media with GA_3 0 µM, b) treatment of Grow More media with GA_3 10 µM.

Table 6 also showed that knols grown in Grow More-modified nutrient medium supplemented with 25 µM BAP resulted in the largest average minituber diameter (13,83 mm/minituber), and was not significantly different with that of knol grown in AB-Mix medium supplemented with 20 µM GA_3. These results indicated that the Grow More-modified nutrient supplemented with 25 µM BAP was able to produce the highest source strength resulted in sufficient photosynthate to be translocated into minitubers, thus having the largest diameter of the mini tubers. Aksenova et al. (2012) showed that cytokinin inflows from roots situated close to the stolons regulate the tubes' sinking ability. Looking at the number of mini tubers formed, total minituber weight, and minituber diameter, it can be seen that knols grown in AB-Mix medium supplemented with 20 uM GA3 resulted in the best minituber formation. This treatment resulted in as many as 8.33 tubers/plant with total minituber weight of 21.38 g /plant, and average minituber diameter of 13.05 mm/minituber.

Due to cell division and extension modifications, lateral buds grow to form stolons. Cells of the pit and cortex expand and split the stolon lengthwise towards tuber development, producing an end swelling of the stolon. The tuber morphology obtained in this study appeared to be oval, not round. It indicates a longer longitudinal growth, even though the tubers have formed. However, the addition of BAP or GA3 treatment seems to cause this longitudinal growth to continue at a faster rate than the growth rate of tuber enlargement, resulting in an oblong tuber morphology (Aksenova et al., 2012; Kianmehr et al., 2012; Roumeliotis et al., 2012).

CONCLUSION

The type of nutrient and the type and concentration of PGR affected the development of granola potato mini tubers in an aeroponic system. Knols grown in AB-Mix medium supplemented with 20 uM GA3 resulted in the best minituber formation. This finding can be applied by Kledung Horticultural Seed Garden, Temanggung, to produce high quality tuber seed in the form of minituber using the available aeroponics system. For longer term the availability of high-quality tuber seed may increase national potato production.

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