

Application of Cytokinin and Mycorrhiza to Increase Production and Quality of Pineapple Seedlings from Crown Leaf Bud Cuttings

Dirgahani Putri^A, M. Rahmad Suhartanto^{*B,C}, Eny Widajati^B

^A Seed Science and Technology, Faculty of Agriculture, IPB University,
Jalan Meranti, Bogor 16680, Indonesia

^B Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University,
Jalan Meranti Road, Bogor 16680, Indonesia

^C Center for Tropical Horticultural Studies, IPB University
Jalan Pajajaran, Bogor 16144, Indonesia

*Corresponding author; e-mail : tantosuhartanto63@gmail.com

Abstract

The pineapple vegetative propagation method using crown leaf bud cuttings has potential to produce seedlings of greater uniformity and in larger quantities than other methods. This study, aimed to explore the potential effects of concentration and frequency of Benzylaminopurine (BAP) application for increasing the production and quality of pineapple seedlings from crown leaf bud cutting propagation. The experiment used a randomized complete block design (RCBD) with two factors. The first factor was the concentration of BAP (0, 200, 400, 600, 800 ppm) and the second factor was the frequency of BAP application (1, 2, 3 times). Furthermore, this study investigated the effects of applying mycorrhizae to accelerate seedling growth and improve seedling quality during production from crown leaf bud cutting propagation. The experiment used a RCBD with one factor (dose of mycorrhiza: 0, 50, 100, 150, 200 spores). The results indicated that the effects of concentration and frequency of BAP application and their interaction increased seed production as determined by sprout cuttings at 5 weeks after planting by applying 600 ppm 2 times. Generally, with increasing concentration and frequency of BAP application, leaf chlorophyll content was reduced. However, the application mycorrhiza positively influenced the production of seedlings from pineapple crown bud cuttings and improved seedling quality as measured by root dry weight, chlorophyll content, root infection, and phosphatase enzyme activity.

Keywords : fast propagation, split crown, tropical fruit

Introduction

Pineapple seedlings (*Ananas comosus* L.) are important for the expansion of cultivated areas and for the development of new varieties. The availability of seedlings is currently limited, yet pineapple production, on a commercial scale, requires planting material of $\geq 40,000$ seedlings per hectare (Naibaho, 2012).

Vegetative propagation of pineapple can be done using crowns, slips, suckers, and ratoons (Hadiati and Indriyani, 2008). However, seedling production is limited and hence, cannot provide enough material for the expansion of planting areas.

The vegetative propagation method using crown leaf bud cuttings has the potential to produce seedlings uniformly and in great quantity. This method utilizes the bud meristem tissue on each leaf of the crown. Each crown leaf has dormant axillary buds and attached to each axillary of the crown. These dormant shoots have the potential to produce buds and become potential seedlings (Py et al., 1984; Hepton, 2003). Tassew (2014) reported that one pineapple crown can produce 23-32 seedlings depending on crown leaf bud size.

The propagation of pineapple using crown leaf bud cuttings is disadvantageous because it negatively affects the growth of roots and shoots (Chairunnisak et al., 2015). This problem can be solved by applying growth regulators (GR) to the cuttings. Eprilian (2019) stated that the application of 250 ppm IBA via soaking treatment can increase the cutting and root growth percentage as well as root dry weight.

Cytokinin functions in the process of division and increasing the number of cells in plant organs forming new shoots and breaking dormancy (Gardner et al., 1991). Exogenous cytokinin applications have been reported to stimulate shoot growth (Yaish et al., 2010). One type of exogenous cytokinin that is widely used is Benzylaminopurine (BAP). Several studies related to the effect of BAP on the success of sprout cuttings already done. Hadiati (2011) reported that BAP application at concentrations of 200-600 ppm increase plant height and shoot numbers in a hybrid variety of pineapple stem cuttings and accelerated the time of bud rupture by 6 days compared to the control treatment. When applying growth regulators to plants both the concentration and the application time must be carefully considered. The response to growth regulators can be optimized by administering ideal concentrations during a favorable plant growth phase (Wicaksono et al., 2017).

The use of crown leaf bud cuttings as a planting material has limitations because seedling growth requires a long period of approximately 22-24 months after planting (Elfiani and Aryati, 2012). It is possible to enhance the vegetative growth rate of seedlings by manipulating the root zone (*rhizosphere*) and by applying beneficial microbes to the growth media i.e. inoculation (Lakitan, 2008). Mycorrhiza display a mutualistic symbiotic relationship between fungi and plant root systems, which plays a role in the absorption of plant nutrients, especially phosphate, increases growth rate, and positively affects yield potential (Suharno and Sancayaningsih, 2013).

This study aimed to investigate the effects of concentration and frequency of cytokinin application, as well as explore appropriate mycorrhiza applications to increase growth rate, production and quality of seedlings from pineapple crown bud cuttings. Therefore, this research is an important step towards developing pineapple propagation technology with crown leaf bud cuttings to obtain seedlings of good quality.

Materials and Methods

The study was conducted in November 2018 to June 2019. The study was conducted at the Cikabayan experimental green house, Bogor Agricultural University. The leaf content analysis of nitrogen, phosphate, and potassium was done in the Department of Agronomy and Horticulture laboratory, Bogor Agricultural University. The analysis of root infections was undertaken at the Research Center for Bioresources and Biotechnology, Bogor Agricultural University. The phosphatase analysis was performed

at the Indonesian Research Institute for Biotechnology and Bioindustry, Bogor.

Evaluation of Cytokinin Application to Increase the Production and Quality of Pineapple Seedlings

The first experiment used a factorial randomized complete block design with two factors. The first factor was cytokinin and had five levels (concentrations), specifically: 0, 200, 400, 600, and 800 ppm. The second factor was the frequency of Benzylaminopurine (BAP) application and consisted of three levels, namely 1 times, 2 times, and 3 times. The treatments were grouped based on planting time (7, 8, and 9 days after crown wilting). Each treatment was repeated three times, so there were 45 experimental units. Each experimental unit was a seedling box of 40 cm x 30 cm and consisted of 30 pineapple crown leaf bud cuttings with a total of 1350 cuttings.

The experimental procedure was performed by spraying BAP 1 times at 2 weeks after planting (WAP), 2 times at 2 and 3 WAP, and 3 times at 2, 3, and 4 WAP using a hand sprayer according to the level of treatment on the buds. Each cutting received a BAP dose of 1 ml. Maintenance of the seedlings was done intensively during the experiment.

The measurements were taken from all seedling in each experimental unit from 5 WAP onwards. The observed variables were growth percentage, sprout percentage, seedling height, chlorophyll content, rooting percentage, root number, root length, shoot dry weight, and root dry weight. The data were analyzed using analysis of variance (ANOVA) at the level of 5%. If significant differences were detected, a Duncan's Multiple Range Test (DMRT) was performed at the 5% level of significance (Gomez and Gomez, 1984) using SAS 9.0 software.

The Potential Uses of Mycorrhiza to Increase the Production and Quality of Pineapple Seedlings

The second experiment used a RCBD with mycorrhizal doses as the treatment. The doses of *Glomus* sp. consisted of five levels: 0 spores, 50 spores, 100 spores, 150 spores, and 200 spores. The seeds were grouped according to their size, i.e. small (0.5-3 cm), medium (> 3-5.5 cm), and large (> 5.5 cm). Each treatment was replicated three times, resulting in fifteen experimental units. Each experimental unit consisted of 25 seedlings derived from pineapple crown bud cuttings; hence, 375 seedlings were used in total.

The procedure for the second experiment was similar to the first experiment. The main difference was the use of growth regulator. In the second experiment only IBA was used as a growth regulator with a concentration of 250 ppm (Eprilian, 2019). Pineapple seedlings 10 WAP were transferred to nurseries based on budding size (small, medium and large). The planting media was a mixture of rice husk, compost, cocopeat, and soil with a ratio of 1 : 3 : 3 : 3 with the weight of 500 g per polybag (Kurniawan, 2014). Mycorrhiza application was performed when the seedlings were transplanted by applying mycorrhiza around the roots according to the treatment categories.

Measurements were taken from all seedlings in each experimental unit from 1 week after transplanted (WAT) onwards. The observed variables were growing percentage, seedling height, leaf number, root length, shoot dry weight, root dry weight, chlorophyll content, root infection percentage, growth of seedlings, and phosphatase enzyme activity. The data were analyzed using analysis of variance (ANOVA) at the level of 5%. If significant differences were detected, a Duncan's Multiple Range Test (DMRT) was performed at the 5% level of significance (Gomez and Gomez, 1984) using SAS 9.0 software.

Result and Discussion

Evaluation of Cytokinin Application to Increase the Production and Quality of Pineapple Seedlings

Through the use of ANOVA, significant positive effects of the concentration and frequency of cytokinin application and their interaction were shown on the production of pineapple crown bud cuttings as measured by the cutting bud variables at 5 WAP. Improvement of the quality of crown bud cuttings significantly affected leaf chlorophyll content which was only influenced by BAP concentration at 20 WAP (Table 1).

Seedling production

Towards the beginning of the experiment (5 WAP), an interaction of concentration and frequency of BAP application was detected. Table 2 shows that the cuttings sprouted at a concentration of 0 ppm BAP showed no significant effect. When the BAP concentration was increased to 200 ppm, the sprouting of cuttings was also increased after 3 times BAP application. The sprouting of cuttings at concentrations of 400-800 ppm was significantly increased after only 2 times BAP application. It was suspected that the cuttings were still active in terms of cell division, so the concentration and BAP applications were able to effectively increase sprouting of cuttings. According to Nuraini et al. (2016), the application of cytokinin affected the early growth of buds. Furthermore, it was observed that the single BAP application did not

Table 1. The effects of concentration and frequency of cytokinin application on the production and quality of pineapple seedling from crown leaf bud cutting propagation at 5-20 WAP

No	Variables	Age (WAP)	F-values			
			Concentration BAP	Frequency BAP	Block	Interactions
Cuttings production						
1	Growth percentage (%)	5-20	ns	ns	ns	ns
2	Sprout percentage (%)	5	**	**	**	**
		10-20	ns	ns	ns	ns
Cuttings quality						
1	Seedling height (cm)	20	ns	ns	ns	ns
2	Chlorophyll content (CCI)	20	**	ns	*	ns
3	Rooted cuttings (%)	20	ns	ns	ns	ns
4	Root number	20	ns	ns	ns	ns
5	Root length (cm)	20	ns	ns	ns	ns
6	Shoot dry weight (mg)	20	ns	ns	ns	ns
7	Root dry weight (mg)	20	ns	ns	ns	ns

Note: ** P < 0.01 (ANOVA); * P < 0.05; ns = not significant at $\alpha = 0.05$

increase sprouting of cuttings. Eprilian (2019) reported that 1 BAP application by spraying did not have a significant effect on sprouting of pineapple cuttings. After 10 WAP, the concentration and frequency of BAP application did not display any effect, because the cuttings already developed roots and leaves. According to Octaviani (2009) the presence of roots caused the nutrient absorption to become optimal so shoots development can be maximized.

Seedling quality

BAP concentration and application did not show a significant effect on seedling height, rooted cuttings, root number, root length, shoot dry weight, root dry weight except chlorophyll content (Table 3).

The highest chlorophyll content was detected at 0 ppm BAP and was significantly higher than at BAP concentrations of 200-800 ppm. The seedlings with 0 ppm BAP had a greener color compared with 200-800 ppm BAP. This was caused by high BAP

concentrations disrupting the synthesis of chlorophyll. According to Kocot et al. (2011), the application of cytokinin can affect the formation of chlorophyll, specifically via supporting the transport of Mg^{2+} ions into leaf mesophyll cells. However, the application of cytokinins at high concentration results in reduced accumulation of Mg^{2+} , thereby disrupting chlorophyll synthesis.

The Potential Uses of Mycorrhiza to Increase the Production and Quality of Pineapple Seedlings

The application of mycorrhizal fungi showed no significant effect on production and quality of seedlings except for the root dry weight. Furthermore, there was no significant effect on production. This shows that mycorrhiza can be applied safely to pineapple bud cutting seedlings, which can be seen from the percentage of growing cuttings (100%) (Table 4). Further, mycorrhiza function as a biological barrier against root pathogen infections (Prihastuti, 2007).

Table 2. Interaction of concentration and frequency of BAP application on sprout percentage (%) at 5 WAP.

BAP concentration (ppm)	Frequency of BAP application (times)		
	1	2	3
0	56.70 bcd	42.20 d	42.20 d
200	50.00 dc	38.90 d	63.30 abc
400	45.60 dc	72.20 ab	68.90 ab
600	43.30 d	81.10 a	81.10 a
800	45.60 dc	74.40 ab	78.90 a

Note: Values followed by the same letters in the same column are not significantly different according to DMRT at $\alpha = 0.05$

Table 3. Effect of BAP concentration and application on seedling height, chlorophyll content analysis, rooted cuttings, root number, root length, shoot dry weight, root dry weight at 20 WAP.

Treatment	Seedling height (cm)	Chlorophyll content analysis (CCI)	Rooted cuttings (%)	Root number	Root length (cm)	Shoot dry weight (mg)	Root dry weight (mg)
BAP concentration (ppm)							
0	8.26	39.40 a	85.60	5.30	11.90	438	43
200	8.51	34.60 b	88.10	5.20	13.90	462	43
400	8.57	34.70 b	92.20	5.20	16.70	488	49
600	8.26	33.70 b	90.00	4.90	15.60	464	43
800	8.14	33.90 b	88.50	5.10	15.60	439	45
BAP application (times)							
1	8.39	35.70	90.20	5.20	14.60	473	50
2	8.53	34.80	87.80	5.10	14.80	471	44
3	8.11	35.30	88.70	5.10	14.80	434	41
BAP concentration X application time	ns	ns	ns	ns	ns	ns	ns

Note: ns = not significant according to DMRT at $\alpha = 0.05$

The mycorrhizal application tended to increase the root dry weight and maximum root dry weight was obtained with the application of 200 spores (91 mg) and this was significantly higher than the control (0 spores) 79 mg (Table 4). The infected plants were of larger volume and length; hence, increasing mycorrhizal dose resulted in corresponding increases in dry weight. These results were similar to Djazuli (2011) which stated that mycorrhizal application at a dose of 30 g per pot significantly increased the root dry weight of *Pimpinella pruatjan*. According to Prasasti et al. (2013), mycorrhizal application increased the absorption of water and plant nutrients and increased the dry weight of plants.

The highest chlorophyll content was found in the mycorrhizal application of 200 spores but this did not differ significantly from the application of 100 spores (Table 5). Based on root infection, almost all mycorrhizae were infected in their roots, and therefore affected the dry weight of the roots and leaf chlorophyll. This was caused by the ability of mycorrhiza to increase the levels of nitrogen and phosphate of plant tissue which affect chlorophyll levels. Basela and Mahadeen (2008) stated that nitrogen was a key element in the formation of amino acids for protein synthesis which has a structural role in chlorophyll. According to Naisumu et al.

(2017), phosphate also plays an important role in the formation of chlorophyll especially regarding the stability of chlorophyll molecules. Roots, which were infected with mycorrhiza, impacted the growth speed of pineapple seedlings. This can be seen from the increase in growth speed of seedlings which were treated with mycorrhiza (5 mm per week) compared to those which were not treated with mycorrhiza (4 mm per week). However, this effect was not statistically significant.

Based on Table 5, seedlings that were not treated with mycorrhiza did not have phosphatase enzyme activity, but the seedlings that were amended with mycorrhiza showed an increase in phosphatase activity. The highest phosphatase activity was seen in mycorrhiza applications of 100 spores. The activity of the phosphatase enzyme in the application of 100 spores was correlated with the phosphate content available in the leaves (Table 6). Margalef et al. (2017) stated that the higher the activity of the enzyme phosphatase, the more phosphate would be produced.

The effects of mycorrhizal dose on the N, P and K content of pineapple crown leaf bud cuttings showed that the application to the pineapple crown did not differ significantly in terms of nutrient uptake (N,

Table 4. The effect of mycorrhizal application on the percentage displaying growth, seedling height, leaf number, root number, root length, shoot dry weight and root dry weight at 10 WAT.

Mycorrhiza doses (spores)	Growing percentage (%)	Seedling height (cm)	Leaf number (sheet)	Root number (sheet)	Root length (cm)	Shoot dry weight (mg)	Root dry weight (mg)
0	100	9.70	10.20	5.80	16.50	399	79 b
50	100	10.10	10.50	6.27	16.64	476	84 ab
100	100	10.20	10.40	6.21	16.28	493	84 ab
150	100	10.20	10.50	5.76	15.61	454	83 ab
200	100	10.40	10.70	5.73	17.10	469	91 a

Note: Values followed by the same letters in the same column are not significantly different according to DMRT at $\alpha = 0.05$

Table 5. The effect of mycorrhizal application on chlorophyll content analysis, root infection, growth speed of seedlings, and phosphatase activity at 10 WAT.

Mycorrhiza doses (spores)	Chlorophyll content analysis (CCI)	Root infection (%)	Growth speed of seedlings (mm/week)	Phosphatase enzyme ¹⁾ ($\mu\text{M/g}$)
0	40.20 c	0 b	4	0.0
50	44.70 b	35.50 a	5	0.18
100	45.30 ab	62.50 a	5	2.78
150	44.20 b	37.90 a	5	0.64
200	47.20 a	47.30 a	5	1.34

Note: Values followed by the same letters in the same column are not significantly different according to DMRT at $\alpha = 0.05$.

¹⁾each value represents one sample

Table 6. The effect of mycorrhizal application on the leaf N, P and K content at 10 WAT

Mycorrhizal doses (spores)	Leaf nutrient content (%)		
	N	P	K
0	1.30	0.41	5.97
50	1.35	0.41	6.03
100	1.38	0.49	6.77
150	1.36	0.44	6.43
200	1.38	0.47	6.51
	ns	ns	ns

Note: ns = not significant according to DMRT at $\alpha = 0.05$

P and K; Table 6). The results of this leaf analysis showed that mycorrhizal application can not improve the quality of seedlings from pineapple crown bud cuttings.

Conclusion

The effects of concentration and frequency of BAP application and their interaction increased seed production sprout cuttings at 5 weeks after planting by applying 600 ppm 2 times. Generally, with increasing concentration and frequency of BAP application, leaf chlorophyll content was reduced. However, the application mycorrhiza positively influenced the production of seedlings from pineapple crown bud cuttings and improved seedling quality as measured by root dry weight, chlorophyll content, root infection, and phosphatase enzyme activity.

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References

Basela, O., and Mahadeen, A. (2008). Effect of fertilizers on growth, yield, yield components, quality and certain nutrient contents in broccoli (*Brassica oleracea*). *International Journal of Agriculture and Biology* **10**, 627-632.

Chairunnisak, Hasanuddin, and Halimursyadah. (2015). Pengaruh media tanam dan lama perendaman dengan auksin terhadap pertumbuhan setek basal daun nanas (*Ananas Comosus* L. Merr.). In "Prosiding Restorasi Sumber Daya Alam Hayati melalui Ekoedukasi

Berbasis Local Widsom sebagai Inovasi Pendidikan" (M.E.S. Sri, Y.V. Karnan, A. J. S Debby, Y. Fakhri, S.B. Mursito, K. Roni, R. Chumidach, and Mudatsir, eds). pp 284-291. Aceh, Indonesia.

Djazuli, and Muhamad. (2011). Pengaruh Pupuk P dan Mikoriza Terhadap Produksi dan Mutu Simplisia Purwoceng (*Pimpinella pruatjan*). *Buletin Penelitian Tanaman Obat dan Rempah* **22**, 147-156.

Elfiani, and Aryati, V. (2012). Prospek pengembangan dan penyediaan bibit tanaman nanas In "Prosiding Seminar dan Kongres Nasional Sumber Daya Genetik". pp 7-12. Medan. Indonesia.

Eprilian, H.F. (2019). Pengaruh tingkat kemasakan buah serta optimasi auksin dan sitokinin pada setek basal daun mahkota nanas (*Ananas comosus* (L.) Merr) cv. smooth cayenne. [Thesis]. Bogor Agricultural Institute. Bogor. Indonesia.

Gardner, G.P., Pearce, R.B., Mitchell, R.L. (1991). Fisiologi Tanaman Budidaya. In "Physiology of Crop Plants" (Susilo and Subiyanto, eds). 428 pp. UI Press.

Gomez, K. A., and Gomez A. A. (1984). Prosedur Statistik untuk Penelitian Pertanian. In "Statistical Procedures for Agricultural Research" (Sjamsuddin, E., and Baharsyah, J.S, eds). 698 pp. UI Press.

Hadiati, S., and Indriyani, N. L. P. (2008). Petunjuk Teknis Budidaya Nanas. 24 pp. Balai Penelitian Tanaman Buah Tropika.

Hadiati, S. (2011). Pengaruh konsentrasi BAP terhadap pertumbuhan stek batang nanas (*Ananas comosus* L.). *Jurnal Agrin* **15**, 127-132.

- Hepton, A. (2003). Cultural System. In "The Pineapple : Botany, Production, and Uses"(D.P. Bartholomew, R.E. Paull, and K.G. Rohrbach, eds). pp 109-140. CABI Publishing.
- Kocot, K.P., Andrzej, K, and Aleksandra, H. (2011). The effect of kinetin on the chlorophyll pigments content in leaves of *zea mays* L. seedlings and accumulation of some metal ions. *Inzynieria i Ochrona Środowiska* **14**, 397-409.
- Kurniawan, A. (2014). Keberhasilan aplikasi pangkas akar dan inokulasi ektomikoriza pada bibit melinjo (*Gnetum gnemon*). [Thesis]. Bogor Agricultural Institute. Bogor. Indonesia.
- Lakitan, B. (2008). "Dasar-Dasar Fisiologi Tumbuhan". 222 pp. Raja Grafindo Persada.
- Margalef, O., Sardans, J., Fernández, M., Molowny, H. R., Janssens, I. A., Ciais, P., Goll, D., Richter, A., Obersteiner, M., Asensio, D., *et al.* (2017). Global patterns of phosphatase activity in natural soils. *Scientific Reports* **7**, 1-13.
- Naibaho, N. (2012). Pengembangan teknologi perbanyakkan bibit nanas *Smooth cayenne* secara in vivo melalui aplikasi auksin dan sitokinin. [Thesis]. Bogor Agricultural Institute. Bogor. Indonesia.
- Naisumu, Y.G., and Trimurti, H.W. (2017). Pengaruh MVA *Glomus mosseae* terhadap pertumbuhan dan kualitas rumput gajah pada cekaman kekeringan. In "Prosiding Optimalisasi Sumberdaya Lokal Peternakan Rakyat dalam Mendukung Pengembangan Program Peternakan Berkelanjutan" (M. Ratmawati, N. Asmuddin, P. Wempie, P. Sri, S.I. Veronica, S. Nurani, M. Nahariah, A.D. Ihsan, M. Rachman H., eds), pp 125-141. Makasar. Indonesia.
- Nuraini, A., Sumadi, and Pratama, R. (2016). Aplikasi sitokinin untuk pematangan dormansi benih kentang G1 (*Solanum tuberosum* L.). *Journal Kultivasi* **15**, 202-207.
- Octaviani, D. (2009). Pengaruh media tanam dan asal bahan setek terhadap keberhasilan setek basal daun mahkota nanas (*Ananas comosus* (L.) Merr). [Thesis]. Bogor Agricultural Institute. Bogor. Indonesia.
- Prasasti, O.H., Kristanti, I.P., and Sri, N. (2013). pengaruh perlakuan dosis mikoriza *Glomus fasciculatum* terhadap pertumbuhan vegetatif tanaman kacang tanah varietas Domba yang diinfeksi patogen *Sclerotium rolfsii*. *Journal Sains dan Seni Pomits* **2**, 75-78.
- Prihastuti. (2007). Isolasi dan karakterisasi mikoriza vesikular-arbuskular di lahan kering masam, Lampung Tengah. *Berkala Penelitian Hayati* **12**, 99-106.
- Py, C., Lacoueilhe, J.J., and Teisson, C. (1984). "The Pineapple: Cultivation and Uses". 568 pp. G. P. Maisonneuve and Larose.
- Suharno, and Sancayaningsih, R.P. (2013). Fungi mikoriza arbuskula: potensi teknologi mikorizoremediasi logam berat dalam rehabilitasi lahan tambang. *Bioteknologi* **10**, 23-34.
- Tassew, A. A. (2014). Evaluation of leaf bud cuttings from different sized crowns for rapid propagation of pineapple (*Ananas comosus* L. [Merr.]). *Journal of Biology, Agriculture and Healthcare* **4**, 1-7.
- Wicaksono, F. Y., Putri A. F., Yuwariah Y., Maxiselly Y., and Nurmala, T. (2017). Respons tanaman gandum akibat pemberian sitokinin berbagai konsentrasi dan waktu aplikasi di dataran medium Jatinangor. *Journal Kultivasi* **16**, 349-354.
- Yaish, M. W. F., Guevara, D. R., El-Kereamy, A., and Rothstein, S. J. (2010). Axillary shoot branching in plants (Chapter 3). In "Plant Developmental Biology" (E.C. Paul and M.R. Davey, eds), pp 37-52. Springer.