

**INFLUENCE OF PHOTOPERIOD AND
EXOGENOUS HORMONE ON GROWTH AND
DEVELOPMENT OF STRAWBERRY
(*Fragaria x ananassa* DUCH.)**

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**Thesis Submitted in Fulfillment of the Requirement for
the Degree of Doctor of Philosophy in the Faculty of
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DEDICATION

To whom Allah honors and gives charity to them who spend much more in my upbringing and my teaching, my father and mother.

To whom eager to know about my success, my brothers and sisters

To my beloved wife, she spent most of her time with me in the field and laboratory

To my beloved children Islam and Azam who did not have much right of fatherhood during my study. To dear, Mr. Shif Al-hosainy for his kind support.

ABSTRACT

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfillment of the requirement for the Degree of Doctor of Philosophy of Science

INFLUENCE OF PHOTOPERIOD AND EXOGENOUS HORMONE ON GROWTH AND DEVELOPMENT OF STRAWBERRY (*Fragaria x ananassa* DUCH.)

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The interaction effect of the photoperiod \times exogenous hormone \times cultivars (genetic) on the vegetative growth and development of strawberry (*Fragaria x ananassa* DUCH.) was investigated in this study. Two cultivars of strawberry 'Camarosa' and 'Camaroga' cvs., with a total of 2592 plantlets were involved in this study. Each plantlet was grown in pot and kept under the 12h, 15h and 17h photoperiod conditions. They were sprayed with 50mg/l of GA₃, 6-BA and IBA either singly or in combination. The pots were arranged in split plot randomized completely block design (RCBD) with hormone and cultivars factors as a sub-plot in the main plot of photoperiod.

The result of the study showed that under the 15h photoperiod treatment, strawberry 'Camarosa' cv. sprayed with 50 mg/l of GA₃ capable of inducing the number of plantlets per stolon (runner) up to 53.2% higher than the control plant. An application of

a combination of hormones 6-BA or IBA with GA3 had an antagonising effect on the role of GA3. The application of 6-BA had increased the percentage of plant produces flower, however, the flower decreased with the increasing photoperiod.

The application of GA3 resulted in a great increase in peduncle length of 'Camarosa' and 'Camaroga' cvs., with about 622.1% and 252.3 % respectively compared with the control plant. The same treatment had also increased in the number of flowers per plant, where about 91.6% and 186.3% had increased in 'Camarosa' and 'Camaroga,' respectively. The percentage of fruit set had also increased with about 68.6% in Camarosa cv. when IBA was applied to the plant and for about 294.1%, in 'Camaroga' plants when GA3 was applied to plant. However, the combination of the two hormones displayed a mutual antagonising effect on the vegetative growth and on the production of the endogenous (internal) hormone. Nevertheless, such combination could enhance the fruiting and fruit quality of strawberry. Application of 6-BA+IBA was found to give the highest harvest index in 'Camarosa' with about 110.3% more than the control plants. Application of 6-BA helped 'Camaroga' produce the highest percentage of flower and the highest harvesting index with about 611.3% higher than the control. A combination of GA3 with the other hormone caused the greatest percentage of increased in number of plant flowering in 'Camarosa'. The combined application of GA3 + 6-BA significantly increased the fruit weight, fruit organic matter, fruit TSS% and fruit dry matter (DM) contents in 'Camaroga' to about 56%, 1.6%, 62.9% and 54.35%, respectively than the control plant. The IBA + 6-BA treatment increased the fruit ash and anthocyanin contents in 'Camaroga' to about 72.9% and 21.9% respectively, compared to the control

plant. The percentage of TA and the vitamin C contents of the fruit had increased by approximately 7.7% and 21% respectively in ‘Camaroga’ when GA3 was applied to the plants. Meanwhile, in ‘Camarosa’, the application of GA3 caused an increase of TA by about 30.9% than the control plant. Meanwhile, the application of GA3+IBA increased the vitamin C content to about 39.9% higher than the control plant and the application of GA3+6-BA+IBA significantly increased the anthocyanin content to about 47.3% higher than the control plant.

Additionally, the percentage of DM, starch, glucose, fructose and sucrose content of the plant varied depending upon the organ parts, growth stages and cultivars. In general, the changing rate of the starch, the DM% and soluble carbohydrate content were lowered during the stage of flower bud formation and then increased during the flower opening stage. Meanwhile, the application of the exogenous hormone improved the conversion of starch to other forms of soluble carbohydrate in the plant. The relative growth rate (RGR) based on the dry matter content in the different organs was found to be significantly reduced during the stages of bud formation and flower opening, and this significantly positively correlated with the RGR of petiole length and negatively correlated with the RGR of the crown diameter. This result indicated that the application of the exogenous hormone enhanced the flowering and fruiting of strawberry via improving the carbohydrate content level in plant. The result also showed that there were a significant correlation between the output (flowering, fruiting, harvest index and fruit quality) and the glucose, fructose and sucrose levels of strawberry plant.

An analysis of cytokinin showed that the concentration of zeatin (Z), benzyladenine (BA) and isopentenyladenine (ip) in the plant increased during the bud formation stage, in which the zeatin level was significantly greater. The effect of the exogenous hormone on the level of the endogenous hormone has been detected in plants grown in the growth chamber. The result showed that the crown portion of the strawberry was the pool centre for the accumulation of the endogenous hormone in the plant. The application of the exogenous hormone led to an increase in the level of the active and bound endogenous hormones of the same hormone in the crown portion of the plant. However, the level of endogenous hormones reduced in the other parts of plant. The application of either IBA or 6-BA led to the increase of the other endogenous hormones in the strawberry plant. The result also showed that the concentration of the endogenous gibberellin positively correlated with the endogenous cytokinin and auxin. Besides, active and bound cytokinin displayed mutual correlation with the activity of the endogenous auxin.

This study concluded that the cultivars (genetic), photoperiod and exogenous hormone are the major factors, which play a crucial role in strawberry production cultivated under the tropical climatic conditions like in Malaysia.

ABSTRAK

**Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu
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PENGARUH FOTOPERIOD DAN HORMON EKSOGENOS KE ATAS TUMBESARAN DAN PERKEMBANGAN STRAWBERI (*Fragaria x ananassa* *DUCH.*)

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Kesan interaksi daripada fotoperiod x hormon eksogenos x kultivar (genetik) ke atas tumbesaran dan perkembangan vegetative strawberi (*Fragaria x ananassa DUCH.*) telah dikaji dalam penyelidikan ini. Dua kultivar strawberi iaitu ‘Camarosa’ dan ‘Camaroga’ kultivar dengan sejumlah 2,592 plantlets (anak pokok) telah digunakan dalam kajian ini. Setiap plantlet telah ditanam di dalam pasu dan diletakkan di bawah keadaan fotoperiod 12 jam, 15 jam dan 17 jam. Pokok-pokok tersebut disemur dengan 50 mg/l GA₃, 6-BA dan IBA samada secara tunggal atau dalam bentuk gabungan. Pasu-pasu tersebut disusun secara rawak dalam plot berasingan mengikut rekabentuk blok rawak lengkap (RCBD) dimana faktor hormon dan kultivar adalah sub-faktor dalam plot utama fotoperiod.

Hasil kajian menunjukkan bahawa di bawah perlakuan 15 jam fotoperiod, strawberi kultivar ‘camarosa’ yang disemur dengan 50 mg/l GA₃ mampu menggalakkan

peningkatan pengeluaran bilangan plantlet setiap stolon (runner) kepada 53.2% berbanding dengan pokok kawalan. Penggunaan gabungan hormone 6-BA atau IBA dengan GA3 memberi kesan gangguan kepada peranan GA3 dalam strawberi. Penggunaan 6-BA telah meningkatkan peratusan pokok yang berbunga dalam semua paras fotoperiod, dan peratusan tersebut meningkat dengan penurunan paras fotoperiod. Penggunaan GA3 telah memberikan peningkatan yang besar kepada kepanjangan peduncle (tangkai jambak bunga) dengan kira-kira 622% dan 252% masing-masingnya dalam kultivar 'Camarosa' dan 'Camaroga' berbanding dengan pokok kawalan. Perlakuan yang sama juga telah menyebabkan bilangan bunga setiap pokok meningkat dengan kira-kira 91.6 % dan 186.3% masing-masingnya telah meningkat dalam 'Camarosa' dan 'Camaroga' berbanding dengan kawalan. Peratus pembentukan buah juga telah bertambah apabila IBA digunakan ke atas tumbuhan 'Camarosa' dan GA3 digunakan ke atas tumbuhan 'Camaroga' dengan pertambahan masing-masingnya sebanyak 68.6 % dan 294.1% berbanding dengan kawalan. Walau bagaimanapun, penggunaan gabungan dua hormon menunjukkan mereka saling memberi kesan gangguan ke atas tumbesaran tampang dan juga ke atas pengeluaran hormon dalaman pokok. Namun, penggunaan gabungan hormon boleh meningkatkan kualiti dan penghasilan buah strawberi. Penggunaan IBA+6-BA telah memberikan indeks hasil tertinggi dalam kultivar 'Camarosa' kira-kira 110.3% berbanding pokok kawalan. Penggunaan 6-BA membantu kultivar 'Camaroga' menghasilkan peratusan bunga dan indeks hasil tertinggi dengan kira-kira 611.3% lebih tinggi daripada kawalan. Penggunaan gabungan GA3 dengan hormon lain menyebabkan peningkatan peratusan tertinggi ke atas bilangan pokok berbunga dalam 'Camarosa'. Penggunaan gabungan

GA3+6-BA telah meningkatkan secara signifikan berat buah, kandungan bahan organik buah, TSS% buah dan bahan kering (DM) buah 'Camaroga' masing-masingnya kepada 56%, 1.6%, 62.9% dan 54.35% berbanding dengan kawalan. Perlakuan IBA+6-BA telah meningkatkan kandungan abu buah dan anthosianin dalam 'Camaroga' masing-masingnya kepada 72.9% dan 21.9% berbanding dengan kawalan. Peratus kandungan TA dan vitamin C buah pula meningkat masing-masingnya 7.7% dan 21% dalam 'Camaroga' apabila GA3 diberi kepada pokok. Manakala dalam kultivar 'Camarosa', penggunaan GA3 menyebabkan peningkatan TA dengan kira-kira 30.9 % berbanding dengan kawalan. Manakala penggunaan GA3+IBA telah meningkatkan kandungan vitamin C kepada kira-kira 39.9% berbanding pokok kawalan dan penggunaan GA3+6BA+1BA telah meningkatkan kandungan anthosianin secara signifikan kepada kira-kira 47.3% berbanding dengan pokok kawalan.

Seterusnya, kandungan peratusan DM, kanji, glukosa, fruktosa dan sukrosa pokok adalah berbagai-bagai bergantung kepada bahagian organ, peringkat tumbesaran dan kultivar. Secara umumnya, kadar perubahan kanji, peratusan DM dan kandungan karbohidrat adalah menurun ketika peringkat pembentukan tunas bunga, dan kemudiannya meningkat ketika peringkat bunga berkembang. Manakala, penggunaan hormon eksogenos telah memperelokkan pertukaran kanji kepada lain-lain jenis karbohidrat terlarut dalam strawberi. Kadar tumbesaran perbandingan (RGR) berdasarkan kepada kandungan bahan kering di dalam organ berbeza didapati secara signifikan berkurangan ketika peringkat pembentukan tunas dan bunga berkembang, dan ini secara signifikan berkait secara positif dengan RGR panjang petiol dan berkait secara

negatif dengan RGR diameter jambak. Keputusan ini menunjukkan bahawa penggunaan hormon eksogenos telah memperkuat pembentukan bunga dan buah strawberi melalui pembaikan paras kandungan karbohidrat dalam tumbuhan. Keputusan juga menunjukkan bahawa terdapat satu pertalian yang signifikan diantara output (pembentukan bunga, buah, indeks hasil dan kualiti buah) dengan paras glukosa, fruktosa dan sukrosa pada tumbuhan strawberi.

Analisis sitokinin menunjukkan bahawa kepekatan zeatin (Z), benzyladenine (BA), dan isopenteniladenin (IP) dalam tumbuhan meningkat ketika peringkat pembentukan tunas, dalam mana paras zeatin secara signifikannya adalah lebih tinggi. Kesan hormon eksogenos ke atas paras hormone endogenos telah dikesan di dalam tumbuhan yang ditanam di dalam bilik tumbesaran. Hasil kajian menunjukkan bahawa bahagian jambak strawberi merupakan pusat takungan untuk pengumpulan hormon endogenos di dalam tumbuhan tersebut. Penggunaan hormon eksogenos menyebabkan peningkatan paras hormon endogenos aktif dan hormon eksogenos pengikat daripada hormon sama dalam bahagian jambak pokok. Walau bagaimanapun paras hormon endogenos di bahagian-bahagian lain tumbuhan adalah menurun. Penggunaan samada IBA atau 6BA menyebabkan peningkatan kepada lain-lain hormon endogenos dalam strawberi. Hasil juga menunjukkan bahawa kepekatan GA3 endogenos adalah berkait rapat secara positif dengan auksin dan sitokinin endogenos. Disamping itu sitokinin aktif dan sitokinin pengikat telah menunjukkan saling berkait rapat dengan aktiviti auksin endogenos.

Kajian ini memberi kesimpulan bahawa kultivar (genetik), fotoperiod dan hormone eksogenos (luaran) adalah faktor utama yang memainkan peranan penting dalam penghasilan strawberi yang ditanam di bawah keadaan iklim tropika seperti di Malaysia.