Effect of Different Concentration of BAP on Growth Performance and Yield in *Musa acuminata* cv. Berangan after Six Months Post Planting Stage.

Ahmad Lukman Bin Supian

F15A0003

A report submitted in fulfilment of the requirement for the degree of Bachelor Applied Science (Agrotechnology) with Honours

Faculty of Agro-Based Industry

University Malaysia Kelantan

2019

DECLARATION

I hereby declare that the work embodied in this Report is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

_____

Student

Name:

Date:

I certify that the Report of this final year project entitled "The Effect of Different Concentration of BAP on Growth Performance and Yield in *Musa acuminata* cv. Berangan after Six Months Post Planting Stage." by Ahmad Lukman Bin Supian, matric number F15A0003 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Agrotechnology) with Honours, Faculty od Agro-Based Industry, Universiti Malaysia Kelantan.

Approved by:

_____

Supervisor

Name:

Date:

ACKNOWLEDGEMENT

In the name of ALLAH, the Most Gracious and the Most Merciful.

Alhamdulillah, all praises to ALLAH for the strengths and His blessing that given to me in completing this thesis. Firstly, I very thankful my previous supervisor, Prof Madya Dr Fatimah Bt Kayat for her supervision and continuous support, motivation and guidance to me in completing my final year project. Not forgotten, my special appreciation goes to my latest supervisor Dr Raimi Bt Mohamed Redwan for willing to accept me and helping me to settle my final year project.

I would like to thank everyone who supported me throughout the course of this final year project. To all my course mate and senior, I am thankful for their guidance and advice during the project work. Thank you for all moral the support that has been given to me.

A special thanks goes to my senior Hafiz Yani, master student that help, assistant and guidance me a lot throughout this experiment. Also thanks to lab assistant and agropark staff for their help to make the experiment become easy by provided me with facilities required and conducive condition for my final year project.

Last but not least, my deepest gratitude goes to my beloved parents, Supian Bin Sulaiman and Hanifah Binti Ibrahim and all my brother and sister for their support, prayer and encouragement. For those who indirectly contributed in this research, your kindness means a lot to me. Thank you very much.

Kesan Kepekatan BAP yang Berbeza Terhadap Prestasi dan Hasil Pertumbuhan di Musa acuminata cv. Berangan Selepas Peringkat Penanaman Selepas Enam Bulan.

ABSTRAK

Musa acuminata cv Berangan adalah sejenis pisang Cavendish yang banyak ditanam di Malaysia tetapi masih tidak dapat memenuhi permintaan pasaran dan pelanggan. Eksperimen ini dijalankan untuk menilai pertumbuhan dan prestasi hasil *Musa acuminata* cv Berangan pada penanaman pasca selepas 6 bulan dirawat dengan kepekatan benzylaminopurine (BAP) 0 mg/L, 5 mg/L, 10 mg/L dan 15 mg/L semasa fasa in vitro. Tujuan kajian ini adalah untuk mengenal pasti kepekatan BAP yang mana membawa kepada prestasi tertinggi dalam bidang ini. Parameter yang telah diukur untuk menilai prestasi pertumbuhan adalah panjang daun, lebar daun, bilangan daun berfungsi, ketinggian tumbuhan dan saiz lilit manakala parameter untuk menilai prestasi hasil adalah berat tandan, berat tanpa tandan, panjang tandan, bilangan sikat, bilangan jari per sikat, panjang jari dan lilitan jari. Keputusan menunjukkan bahawa tumbuhan yang dirawat dengan 5 mg/L BAP menunjukkan prestasi yang lebih tinggi dalam pertumbuhan dan hasil berbanding dengan rawatan lain. Perubahan somaklonal telah direkodkan dalam rawatan 5 mg/L BAP yang menunjukkan ciri-ciri agronomi yang baik di tumbuhan dan hasil yang sesuai untuk digunakan dalam industri pertanian.

Kata Kunci: *Musa acuminata* cv. Berangan, prestasi pertumbuhan, prestasi hasil, selepas 6 bulan dalam tapak penanaman, kepekatan BAP yang berbeza.

The Effect of Different Concentration of BAP on Growth Performance and Yield in *Musa acuminata* cv. Berangan after Six Months Post Planting Stage.

ABSTRACT

Musa acuminata cv Berangan is a Cavendish type of banana that is popularly grown in Malaysia but still cannot fulfil the market and customer demand. This experiment was carried out to evaluate the growth and yield performance of *Musa acuminata* cv Berangan at post planting after 6 months being treated with different concentration of BAP 0 mg/L, 5 mg/L, 10 mg/L and 15 mg/L during *in vitro* stage. The aim of this study is to identify which concentration of BAP lead to the highest performance in the field. Parameters that have been measured to evaluate growth performance were leaf length, leaf width, number of functional leaves, plant height and the girth size while the parameter to evaluate the yield performance were bunch weight, weight without bunch, bunch length, number of hand, number of finger per hand, finger length and finger girth. The results showed that the plants treated with 5 mg/L BAP showed highest performance in growth and yield as compared to other treatments. Somaclonal variation had been recorded in treatment 5 mg/L BAP that showed good agronomical characteristics at the plant and yield which suitable for mass propagation in commercial planting.

Keywords: *Musa acuminata* cv. Berangan, growth performance, yield performance, after 6 months in field, different concentration of BAP.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATION AND SYMBOLS

ANOVA	Analysis of variance
BAP	6- Benzylaminopurine
Mg/L	Milligram per litter
SPSS	Social Package for the Social Science
CV	Cultivar

CHAPTER 1

INTRODUCTION

1.1 Background of study

Banana or *Musa* acuminata is one of the most important commercial tropical fruits traded. The genus of *Musa* is a member of the family Musaceae (Constantine & Rossel, 2001). *Musa acuminata* is the most cultivated species worldwide in *Musa* family (Daniells *et a*l., 2001). This species grow in various type of environment and give many benefits to human starting from banana fruits, plantain of the banana to cold-hardy fibre and ornamental fruits. The ripe fruits contain 22 percent of carbohydrate, high quantities of dietary fibre, potassium, manganese and vitamin B6 and C. There are various types of banana variety being cultivated with different colour when ripe like yellow, purple and red.

The fruit is usually eaten raw or cooked further, this fruits also can be processed into flour and also can be fermented for the production of beverages such as banana juice, beer, wine and vinegar (Morton 1987; Pillay *et al.,* 2002; Nelson *et al.,* 2006; Edmeades *et al.,* 2006; Pillay & Tripathi 2007). This genus is special because not just their fruits but the other parts also can be eaten (Espino *et al.,* 1992). The flower can be

eaten raw or cooked, the trunk can be used for cooking and the leaf buds are eaten as vegetables (Nelson *et al.,* 2006).

Banana can be planted in single rows or double rows (Daniells & O'Farrell, 2004). Single rows planting practice usually using one sucker for each hole in the same row while double rows using two suckers for each hole in the same row. The spacing between plants in each row is 1.8 m while distance between rows are also 1.8 m. Wider planting distance give a lot of benefits to the plant as it would allow better water intake between rows to reduce chances of disease occurrence while for the non-irrigated farm would reduce the competition for water (Broadley *et al.*, 2004). Banana or *Musa* is a fast growing plant which required continuous supply of nutrients and water for high yield. Banana can get the nutrients from the soil and also from the previous ratoon.

Tissue culture or *in-vitro* technique produces selected plant that are suitable to the agricultural standard, in large numbers banana seedlings within a short period of time. This method apply cytokinin such as benzylamionopurine (BAP) to reduce the apical meristem dominance thus induce both axillary and adventitious shoot formation from the meristematic tissue (Madulanta, Anbalagan, Jayachandaran, & Sakthivel, 2004). The original tissue can be taken from shoot tip, leaf, lateral bud, stem or root tissue of mother plant depends on the species. Plantlets produced will undergo initiation, multiplication and rooting stages for producing the cell into fully-fledged plants. Developed plantlets need to acclimatize at nursery environment through pre-hardening and hardening process to enhance the plant growth.

1.2 Problem statement

Banana is one of the most important commercial fruits in Malaysia. However, the production of banana in Malaysia is still inadequate to meet the current market demands. Micropropagation supplemented with plant growth regulator using Benzylaminopurine (BAP) is commonly used to increase the number of plantlet for the production of quality planting material. Application of high concentration of plant growth regulator for *in vitro* propagation could induce somaclonal variation or off-types plants. Some of these off-types plant display good agronomic characteristic such as shorten flowering time and high quality of yield. However, some of the off-types showed the characteristics that agronomically inferior to the parental clone such as low yield or higher rate of growth.

1.3 Objective of study

The objectives of this research are;

a) To measure the growth performances of plants produce from different concentration of BAP (during their *in vitro* stage) after 6 months during field.
b) To evaluate the yield produce from banana seedlings at tissue culture with different concentration of BAP after 6 months during field.

1.4 Scope of study

In this research, the study focused on the growth performance of banana plant from different concentration of BAP after 6 months in the field. The growth performance of banana was observed until harvesting. During the harvesting stage, the data of the banana fruit also was measured to identify their differences. This study aimed to identify which concentrations of BAP give the optimum for the growth and yield of banana.

1.5 Hypothesis

The hypothesis for this experiment is that different concentration of BAP could give significant different on the morphological structure of banana plant produce. So, there will be differences in their growth in the farm which could also affect the banana yield. Therefore, BAP concentration that producing superior plants with higher yield could be selected for mass propagation. Alternatively, those concentration that producing inferior plants could be avoided for micropropagation.

CHAPTER 2

LITERATURE REVIEW

2.1 Banana Origin & Distribution

Banana and plantains (*Musa* spp.) placed fourth as the most important food commodity in the world after wheat, rice and milk products (Chadha & Sahijram, 2000). There are almost 97.5 million tonnes per year covering 10 million hectares that the estimation in the current world of banana's production (Kallo, 2002; Singh, 2002). India shows the largest country that produce banana with the total annual production of 16.91 million tonnes from 0.49 million ha land cultivated with bananas. It contributes to 26% of the world production while 37% of national food production (Samuel & Singh, 2002). The precise origin of the banana is unknown but the theory that is accepted is that Malesia, a biogeographical region including Malay Peninsula, the Philippines and New Guinea was the primary centre while India was the secondary centre (Simmonds & Shepherd 1955). Asia shows the most banana production and then spreaded to the other region.

2.2 Taxonomy of Banana

The genus of *Musa* is derived from the Arabic name for plant (*mouz*) which mean in turn that show the honour to Antonius Musa, first emperor of Rome (Hyam & Pankhurst, 1995) while banana is derived from Arabic word *banan* = finger (Boning, 2006). Banana varieties or hybrids belong to genus *Musa*, order Zingiberales, family Musaceae. There are almost 30-40 species of *Musa* with all wild species being diploids (2n=2x= 14, 18, 20, 22) and native to South East Asia (Stover & Simmonds, 1987). Most of cultivated banana and plantains are triploid varieties that evolved from two wild species *M. acuminata* with the genome of 'AA' and *M. balbisiana* with the genome of 'BB' (Simmonds & Shepherd, 1955).

2.3 Banana Propagation

Bananas are propagated vegetatively because nearly all cultivated varieties are seedless and fruits develop parthenocarpically (in the absence of seed development). The most common propagation material in banana is sucker which is sword sucker with well developing base and leaf blades narrow with pointed tip and another sucker is water sucker which is smaller in size, with broad leaved and emerged in clumps (Singh, Uma, Selvarajan & Karihaloo, 2011).

2.3.1 Macropropagation

Macropropagation is the method with low cost production of producing quality banana planting material. This method is simple for ease multiplication, save the cost and it can produce 50-60 shoots per sucker in 4-5 months. There were two methods being practised in macropropagation which are macro-proliferation and rhizome cuttings that could be adopted either in the field conditions (*in situ*) or in the nursery (*ex situ*). The steps that involved in this method were decapitation, decortication and hardening (Singh *et al.*, 2011).

2.3.2 Micropropagation

Micropropagation is the method that implying rapid multiplication of planting material for producing large number of progeny plants using modern plant tissue culture methods under aseptic condition (Singh *et al.*, 2011). Micropropagation allows plant cells to multiply and regenerate in a large scale while retaining their constituent genes. This method had been used worldwide with banana is the highest micropropagated crop compare to other fruits (Smith, Hamill, Becker, & Dale, 2005). Micropropagated plants could cause limitation to grow for the country that still in developing progress because higher cost is needed in this technology (Escalant & Jain, 2004). Application of micropropagated improved germplasm handling of *Musa* is great for the purpose of uniform production, clonal propagation, and breeding.

2.4 Somaclonal Variation

Somaclonal variation is a term being used for variation appear among plants from tissue culture. This tissue cultured plants displayed variation in their phenotypic caused either by genetic variability or changes in epigenetic marks of the cell of origin. Somaclonal variation that permissible in any micropropagation program is only 3-5 % (Hwang & Tang, 1996) but up to 10 % the variation is permitted for banana because of the flexible genetic make-up of the crop. There are a few factors that contribute to somaclonal variation including effect of the explant use or explant source, effect of culture age, effect of hormonal factors, genotypic fidelity, flexibility of genotype, effect of ploidy level, karyotype change and role of transposable elements. Israeli et al., (1991) reported various somaclonal variants had been observed in Cavendish subgroup of seven different cultivars with agronomically inferior characteristics compared to the normal plants. Plant stature, foliage, pseudostem pigmentation, variation in inflorescence and fruit characteristic have been evaluated.

Although somaclonal variation is undesirable in micropropagation procedures, it could be a useful source for new variability in fruit crops where long generation time hinders conventional breeding (Hammerschlag, 1992). Tissue culture could provide great potential in crop improvement and also can be exploited to generate resistant clones to diseases. Somatic heterogeneity as well as the probable existence of chimeras among clones provides a source of variation for clonal selection (Monette, 1988). Somaclonal variation can be considered for improvement to increase the breeder stock for selection of improved cultivar (Hwang & Tang, 2000).

2.5 BAP Application in Banana Tissue Culture

In commercial banana production, the consistency in supplying the good quality of planting material is very important. About 39% higher yield had been produced from tissue cultured plants compared to sword sucker plants (Pradeep, Zachariah, Estelitta & Suma, 1992; Faisal, Haque, & Quasem, 1998). The clonal planting materials could be achieved through tissue culture propagation technique that provide high rates multiplying of genetically uniform, pest and disease-free planting materials. Tissue culture also produce the material that is free from disease during the time of planting and can be maintained as anti-disease plant by implementation of good agricultural practise and proper crop management (Njukwe, 2013). Most of the journal said that the plant form tissue culture performed better growth in the field thus resulting less harvesting time and better yield performance compared to the conventional sucker.

Although it is widely known that tissue culture technology can produce more plantlets than the conventional method over time but it involves high cost for the planting material since the protocol requires aseptic condition with designated facility. Other than that, the breeding that involve in tissue culture require highly skilled since the complex procedure and the produce always differ according to the variety of the plants. For the small-holder in rural areas the technique may not be feasible to apply since it require skilled personnel during the process (Singh, 2011). Very high attention is needed for this technology at the early stage of plant establishment in the field.

In tissue culture, plant growth regulators (PGR) are the important components that determine the developmental pathway of plant cells. PGR like auxin, cytokinin, gibberellin and absidic acid like kinetin, indole-3-acetic acid, and benzylaminopurine

were used for *in vitro* regeneration of various plants (Ali *et al.*, 2014 and 2015; Momena *et al.*, 2014). The function of cytokinin such as benzylaminopurine (BAP) is known to reduce apical meristem dominance and induce both axillary and adventitious shoot formation from meristematic explants in banana (Madhulatha *et al.*, 2004). Although BAP stimulates shoot proliferation in banana, it also known to have mutagenic effect at high concentration that may produce off type plantlets (Bairu, Strik, Dolezal & Staden, 2008). Due to these reasons, the application of BAP in media need to be monitored carefully because use of higher level of cytokinin produces abnormality and affects the genetic variability (Martin, Pachathundikandi, Zhang, Slater & Madassery, 2006; Shirani, Mahdavi & Maziah, 2009). It is widely known that somaclonal variation will result when there is usage of Plant Growth Regulator (PGR).

2.6 Nutrient management

Banana plant require high amount of nutrient for their better growth and yield performance which supplied only by the soil. This presence of nutrient can affect the banana whether it can grow better or it can be stunted because of the limitation of nutrient in the plant. Soil may be not enough to supply complete nutrient because the nutrient from soil had been absorbed into banana plant to ensure their growth. For improved yield performance, additional nutrient is needed for production of high yield and thus can be achieved through application of organic manure or mineral fertilizer (Gowen, 1995).

Potassium is the main element that needed in banana nutrition to increase both the yield and quality of the fruits. High dry matter and glucose content in the peel and pulp of banana fruit when there is high content of potassium and calcium given to the plant

(Caussiol, 2001). The plants with deficient potassium will cause lower rate of respiration that occur in the plant and indirectly would affect the reduction of photosynthesis due to the low potassium supply on dry matter production. The low level phosphorus, nitrogen and magnesium cause high dry matter in the pulp and produces thin fruits and fragile branches but excessive amount of potassium compared to the nitrogen causes a premature ripening of fruits. On the other hand, nitrogen is the second nutrition that needed in growth and production of banana. Besides the effect towards growth and production, nitrogen also affect the bunch maturation period and fruit quality. In addition, there also showed the effect towards number of hand and finger, fruit circumferences and weight that indirectly cause effect in bunch weight. By reducing the total sugars and total soluble solids, it will affect the fruit quality and increase the acidity of the fruits (Gowen, 1995).

2.7 Banana Maturity Indices

Banana can be harvested about three month after their flowering stage. It will produce large bunch that contain multiple number of fruits and can achieve the weight between 50 – 200 kg for one bunch. Within the bunch are clusters of double rows of fruit called “hands” and individual fruit called “fingers” (Ogazi, 1996). Maturity standard for banana is more precise compared to the plantain. In determining the maturity of plantain, seven different internal and external characteristic can be measured such as fruit diameter, age of the bunch, angularity of fruit, length of the fruit and peel colour (Johnson, Brennan & Addo-Yobo, 1998).

Harvest maturity is the stage of development when a plant or part of the plant possesses the prerequisites for utilization by consumers for particular purpose (Kader,

1999). It refers to the time when the inflorescence emerges from the stem to the time of harvesting. The maturity period depends on the environmental conditions that includes temperature, rainfall, soil moisture, latitude, altitude and nutrients. The temperature has a huge influence on the physiological maturity period (Karugaba & Kimaru, 1999). During the maturity stage, the size of fruit is fully developed, green in peel colour and has higher level of starch. Starch is converted into sugar progressively as ripening progresses. The stage of maturity for harvesting is depending on the target market.

2.8 Fruit Ripening

Banana ripening is the process that involves physiological, biochemical and physical changes to fruit (Wills, 1990). Banana is typical fruits that having climacteric rise which is the physiological phenomenon that caused by ethylene. Ethylene is the plant hormone that initiates the ripening process of banana (Sjaifullah & Daisuki, 1992; Taiz & Zeiger, 1998). The controlled of ethylene treatment in commercial practice will show the quality of ripening the banana fruits. The peel colour changed, the flavour developed and the pulp soften during banana ripening process.

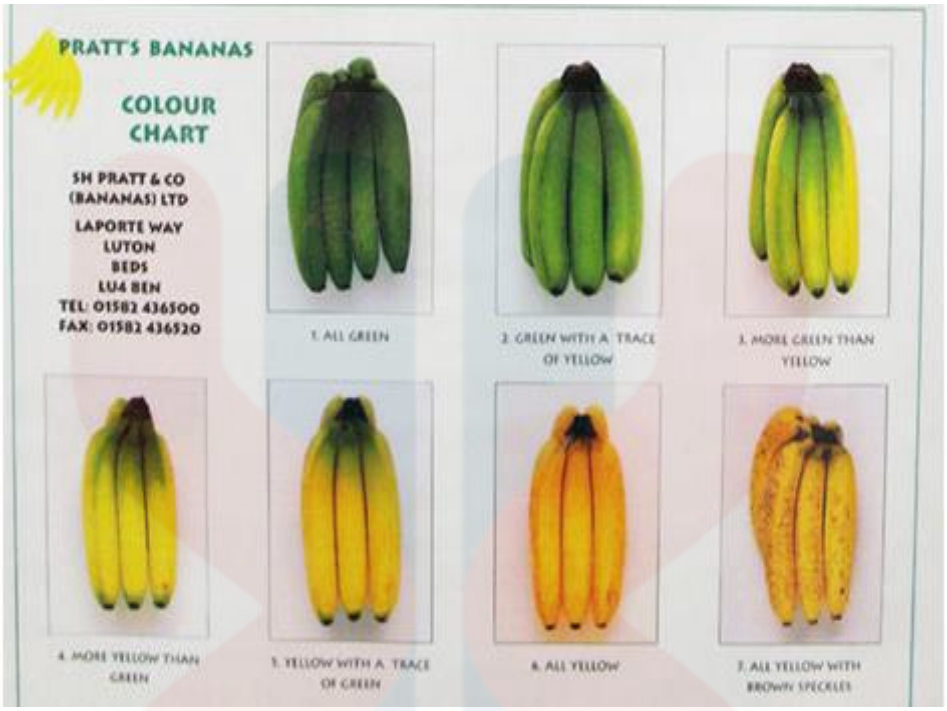


Figure 2.1: The ripening of banana according to their grade and colour

The sign of ripening shows when the colour changes from green to yellow. The peel's colour change during ripening due to the degradation of chlorophyll even it is constant at carotenoid level throughout the banana ripening stages (Thompson, 1996). The pigments or the failure of the yellow pigments to not appear at specific stage of development may occur if adequate ripening conditions are not provided. The other problem can caused that is associated with inadequate ripening include delay time of ripening, lack of taste and flavour on ripening, and peel colour changes such ad red-brown that is affected by low temperature stress or the failure of the fruit peel to ripen due to high temperature stress. At various stage of ripening, the aroma constituents are different because it depends on ripening temperature (Marriott, 1980). The analysis of volatile constituents will be useful in determining the undesirable aroma differences between bananas grown at various times of the year and ripened using different ripening

procedures. There are three factors that regulated the ripening process of bananas which is temperature, ethylene and humidity levels. These factors have an effect that determine the final product quality and storage life while knowing this optimal levels are also beneficial for increasing product quality.

CHAPTER 3

METHODOLOGY

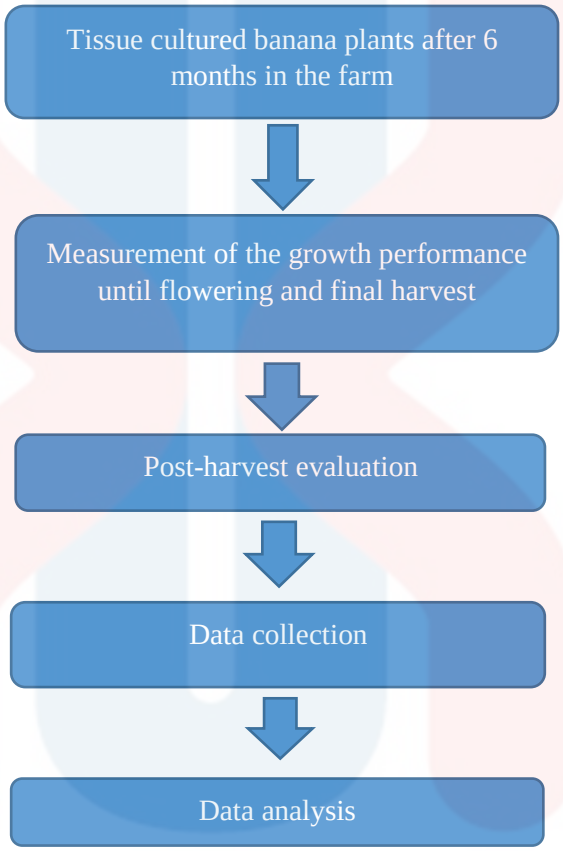
3.1 Experimental site

The field experiment was conducted at the Agricultural Techno Park in Universiti Malaysia Kelantan, Jeli Campus. The experimental plot covers around 1 hectare that equipped with electric fences to protect the banana plants from being damage by wild boar intrusions. The type of soil on this area is loamy clay soil which is rich in nutrient and humus that suitable for banana cultivation. For the irrigation system, this experiment applied conventional method that utilizes the nearby water resources for watering the plant.

3.2 Planting material

Banana plant of about 6 months in the farm at the Agricultural Techno Park obtained from previous study at UMK tissue culture laboratory were used as planting material in this research. Plants had been developed using different BAP concentration (5mg/L, 10mg/L, 15mg/L) during *in vitro* stage in the previous study as well as the positive control. The plant growth after 6 months planting in the farm was observed and measured until the yield is produce including the flowering to fruiting stage until harvesting of the yield.

3.3 Experimental flow



For the first experiment, study had been focused on the effect of different concentration of BAP (during their *in vitro* stage) on the growth performance and yield of Pisang Berangan after 6 months in the farm. Four treatments involved in this experiment were the negative control (plant produce from 0 mg/L BAP) and BAP treated plants at 5 mg/L, 10 mg/L and 15 mg/L concentrations. The growth performance was measured until fruiting stage and harvesting of the yield. The parameters measured were length and width of leaf, girth size, pseudostem height, number of leaves and length of peduncle.

3.4 Experimental design, treatment and management

Experimental Design

The experiment was conducted using completely randomized block design (CRBD) with 4 treatments and 30 samples of replicate for each treatment which make the total number of plant involve are 120.

Table 3.1: Number of sample in Experiment

No.	Treatment	Number of sample
1.	T0	30
2.	T1	30
3.	T2	30
4.	T3	30

T0 = negative control

T1 = 5ml/L concentration of BAP

T2 = 10ml/L concentration of BAP

T3 = 15ml/L concentration of BAP

3.5 Data Collection on Growth Performance in Experiment

For the data collection, measurement was taken in three weeks interval. The period for the growth performance collection was taken for 3 months until the flowering and harvesting stage. For leaf development, it may take about 7-14 days for new leaf to emerge (Turner *at el.,* 2007). The parameters measured for the growth performance is length and width of leaves, plant height, girth size, number of functional leaves and the length of petiole (Buah, Kawamitsu, Yonemori & Murayama, 2000). Data was measured and recorded in tables (Table 3.2).

Table 3.2: Data collection for growth of banana.

Parameter	Treatment			
	T0	T1	T2	T3
Length & width of leaf				
Number of leaves				
Leaves height				
Girth size				

3.5.1 The length and width of leaves

The measurement for the length of leaf, starts from the petiole until the tip while the width of leaf is measure from end to end of the widest lobes of the lamina. Ruler with the unit of centimetre was used for the measurement this leaf (Figure 3.1).

3.5.2 The height of stem

The height of the stem was measured starting from bottom at the base to the higher level of the stem (Figure 3.1). A ruler was used to measure this stem. Measuring tape was used when the pseudostem getting taller.

3.5.3 Size of girth

The girth size was measure at the middle of the stem to get the optimum circumference. The measuring tape used in this activity (Figure 3.1).

Figure 3.1: The parameter measured for growth performance

A = Plant height

B = Length of leaf

C = Width of leaf

D = Girth size

3.6 Data Collection on Harvesting Stage

In this stage, the data of the harvesting banana was collected and recorded in Table 3.3. The parameter measured are the bunch weight, weight without bunch, bunch length, number of hand, number of finger, finger length (cm) and finger girth (cm) for each bunch (Buah, Kawamitsu, Yonemori & Murayama, 2000). Weighing tool of 1kg to 10kg was used to measure the fruit weight during harvesting.

Table 3.3: Data Collection in Harvesting Stage of *Musa 21 acuminate*

Parameter	Treatment			
	T0	T1	T2	T3
Bunch Weight (kg)				
W/o Bunch (kg)				
Bunch Length (cm)				
Number Hand				
Number Finger				
Finger Length (cm)				
Finger Girth (cm)				

3.7 Farm management

Banana requires good water management. Excess of water or water logging may trigger oxygen starvation of the roots and can cause plant death (Daniells & Evans, 2005). Besides that, the plant growth will be stunted, or plant will be fallen down because of weak pseudostem, reducing of yield and discoloration of fruits and leaves that may cause unfavourable to the market (OGTR, 2016). Pruning of leaves is also required to allow better photosynthesis in order to let the plant grow in optimum rate. It is very important to prune the dead or infected leaves once in two weeks because it can avoid the fungal spores to spread to the other plants (UNCST, 2007).

3.8 Weeding control

Establishing of good weed control from the outset is very important to ensure good banana growth. Weed is harmful as it gives competition for nutrient and water and should be remove immediately (Henriques, Jeffer, Lacher & Kendall, 1996). Weeds typically grow at banana cultivation are 'kapal terbang' grass (*Chromolaena odorale*), '*lalang*' (*Imperata cylindrica*) and white blossom grass (*Asystasia intursa*). In this experiment, weed control was done manually by using hoe to clear about 2/3 m around the plant beside the herbicide application. Herbicides were sprayed during hot weather condition to ensure that it will dry quickly and not affecting the growth of banana plants.

3.9 Fruiting management

During the fruiting stage, the banana bunch was covered using plastic or cloth bags to prevent damage from birds, flying foxes or sugar gliders. This technique is also suitable to enhance the effectiveness of insecticides application for better fruits development (Broadley *et al.,* 2004; Daniells & Lindsay 2005). Covering of the fruit was done at about 21 days after shooting to ensure that the finger is strong enough to resist friction damage (Morton, 1987). Different colour of plastics does not affect the bunch ripening (Daniells & Lindsay, 2005). Besides that, bunch trimming, insecticide treatment and removal the 'male bud' at the end of the inflorescence was also carried out to ensure that the sugar produced from the photosynthesis is redirected to the fruits development (Morton 1987; Broadley *et al.,* 2004; Daniells & Lindsay, 2005).

3.10 Data Analysis

Data collected in this experiment was recorded in the logbook before transfer it into the table. Data was analysed using Statistical Package for Social Science (SPSS) software. The different of growth and development between treatments was calculated by the Analysis of Variance (one-way ANOVA). The test of significant differences was conducted based on Tukey's Test at $p<0.05$.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Growth performance and yield of *Musa Acuminata* with different concentrations of BAP in field.

Four different treatments being applied in this research which were negative control, 5mg/L, 10mg/L, and 15mg/L concentration of BAP. The growth performance being evaluated which included their leaf area, height and girth of pseudostems of each planting material after post-planting stage (after 6 months in the field). Meanwhile, the bunch length, number of hand, number of finger/hand, total number of finger, length of finger, girth of finger and bunch weight were observed and measured for the yield performance. Evaluation of growth and yield performance were studied in order to determine the effect of different concentration of BAP on the growth. This data would help in selecting the best line with better growth performance and yield productions that can be mass propagated for the production of commercial planting material to the farmers.

4.1.1 Leaf Area

The length and width of leaf was measured to obtain the leaf area of the planting material from all the treatments. Each plants have different measurement of their leaf area

which had been observed and studied. The table 4.1 and figure 4.1 below showed the leaf area for those planting material.

Based on the Table 4.1, the leaf area of planting material from treatment 1 (5 mg/L BAP) showed the highest reading starting from initial data at week 27. In this week, the mean leaf area of plants in treatment 1 (5mg/L BAP) was 4200.5±716.84. The leaf area of the plants in this treatment continuously increased until week 48 that the reading was 7779.6±9.79. Until the end of the experiment, the plants in treatment 1 (5 mg/L BAP) showed significant different of the leaf area as compared to other treatments.

A one-way ANOVA test was conducted to compare the leaf area of banana from tissue culture. In initial week (week 27), there were significance difference between treatment 5 mg/L concentration of BAP (4200.5±716.84) with treatment 0 mg/L BAP (1010.4±42.12), treatment 10 mg/L BAP (1219.6±130.2) and treatment 15 mg/L BAP (738.5±29.89) while there was no significance difference between treatment 0 mg/L BAP, 10 mg/L BAP and 15 mg/L BAP. At the end of the week (week 48), there were significance difference between treatment 5 mg/L BAP (7769.6 ± 760.36) with treatment 0 mg/L BAP (2849 ± 136.02), 10 mg/L BAP (3757.2 ± 452.97) and 15 mg/L BAP (1438.6 ± 52.37). Treatment 0 mg/L BAP also had a significance difference with treatment 15 mg/L BAP but there was no significance difference with treatment 10 mg/L BAP. The means and standard deviation between experiment and one-way ANOVA test was enclosed in Appendix A.

This Figure 4.1 showed that the growth performance of leaves area for all four treatment were increased when time increase (from week 27 to week 48). The increment of the leaf area happened due to the effect of photosynthesis that occur in the leaf even though there was different treatment with different concentration of BAP that had been

used. The leaf length and width could be the areas that influence the plant growth because the length and width of leaf will determine the surface area of the leaf. Larger surface area allows higher intake of sunlight and thus photosynthesis can occur productively. Photosynthesis is vital in plant growth as it is the source of food and nutrient for the plant and major growth of the plant is contributed by this process.

Table 4.1: Mean of leaf area (cm^2) for four different treatment of planting material sources from 6 months post planting, week 27 to week 48.

Week	Treatment 0 (negative control)	Treatment 1 (5 mg/L of BAP)	Treatment 2 (10 mg/L of BAP)	Treatment 3 (15 mg/L of BAP)
Week 27	1010.4 ± 42.12^{a}	4200.5 ± 716.84^{b}	1219.6 ± 130.20^{a}	738.5 ± 29.89^{a}
Week 30	1209.9 ± 65.43^{a}	4725.8 ± 804.81^{b}	1410.3 ± 164.10^{a}	821.4 ± 31.24^{a}
Week 33	1453.2 ± 72.90^{a}	5384.4 ± 833.26^{b}	1748.6 ± 207.70^{a}	929.2 ± 34.40^{a}
Week 36	1707.6 ± 84.18^{a}	6063.1 ± 869.30^{b}	2089.9 ± 236.44^{a}	1028.6 ± 37.88^{a}
Week 39	2006.5 ± 97.78^{a}	6637.1 ± 870.65^{b}	2461.4 ± 280.14^{a}	1130.6 ± 43.19^{a}
Week 42	2303.8 ± 114.17^{a}	7051.7 ± 839.61^{b}	2906.0 ± 354.11^{a}	1235.1 ± 46.46^{a}
Week 45	2570.7 ± 126.05^{ab}	7417.7 ± 798.33^{c}	3359.4 ± 416.01^{b}	1340.8 ± 48.58^{a}
Week 48	2849.0 ± 136.02^{ab}	7769.6 ± 760.36^{c}	3757.2 ± 452.97^{b}	1438.6 ± 52.37^{a}

Different letters indicate values are significantly different ($P \leq 0.05$) by Tukey's Multiple Range test. Values are mean ± standard deviations based on at least thirty replicates

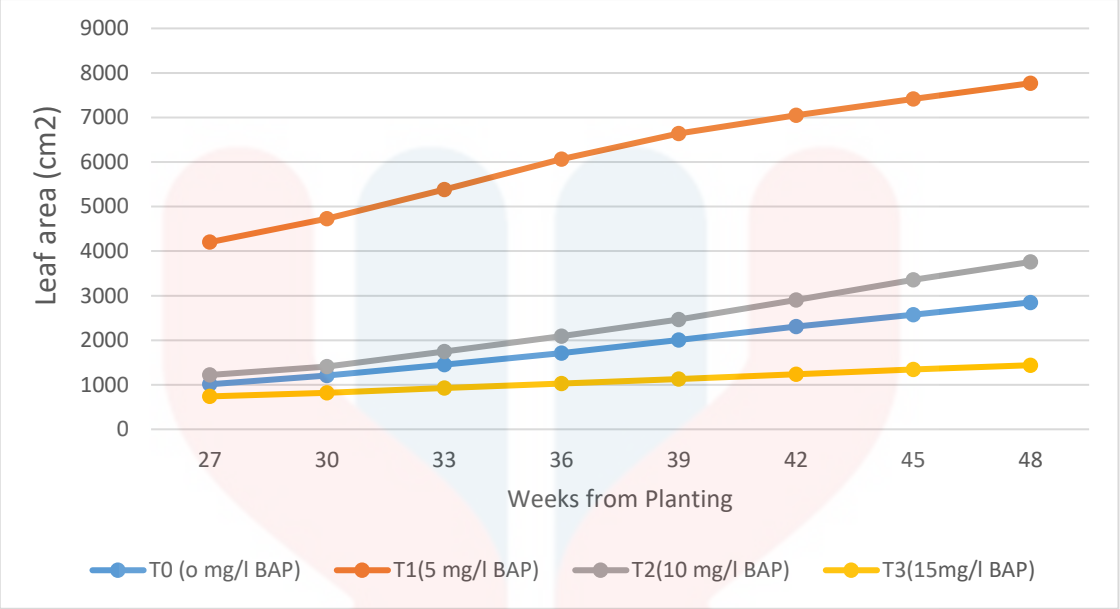


Figure 4.1: Mean on growth performance of leaf area (cm²) for four different treatment of planting material sources after 6 months post planting, week 27 to week 48.

4.1.2 Pseudostem Height

The mean of pseudostem height of all plants in the four treatments were evaluated as shown in Table 4.2. In week 48, the highest pseudostem height (196.60±14.62) was recorded in treatment 1 that apply 5 mg/L concentration of BAP while the lowest severity of pseudostem height (73.68±1.71) was recorded in treatment 3 (15 mg/L concentration of BAP). The treatment 0 (control) and treatment 2 (10 mg/L BAP) showed moderate performance of their growth and their severity was (94.88±1.98) and (118.22±8.60).

A one-way ANOVA test was conducted to compare the leaf area of banana from tissue culture. In initial week (week 27), there were significance difference between treatment 5 mg/L concentration of BAP (117.59 ± 12.31) with treatment 0 mg/L BAP (48.87 ± 1.18), treatment 10 mg/L BAP (48.09 ± 3.71) and treatment 15 mg/L BAP (41.82 ± 1.05) while there was no significance difference between treatment 0 mg/L BAP, 10

mg/L BAP and 15 mg/L BAP. At the end of the week (week 48), there were significance difference between treatment 5 mg/L BAP (196.60 ± 14.62) with treatment 0 mg/L BAP (94.88 ± 1.98), 10 mg/L BAP (118.22 ± 8.60) and 15 mg/L BAP (73.68 ± 1.71). Treatment 0 mg/L BAP also had a significance difference with treatment 15 mg/L BAP but there was no significance difference with treatment 10 mg/L BAP. The means and standard deviation between experiment and one-way ANOVA test was enclosed in Appendix A.

Based on the Figure 4.2, treatment 0 and treatment 2 showed the same rate of growth in the early week (week 27) until week 30 but the highest rate was in treatment 1 that grow continuously when the weeks were increase. In week 39, the growth rate of pseudostem height of banana in treatment 1 slowly decreased because most of the plant had started their flowering stage. During flowering stage, the stem of the inflorescences reaches the top when all the leaves have unravelled and make the pseudostem stop growing.

Table 4.2: Mean of pseudostem height (cm) for four different treatment of planting material sources from 6 months post-planting, week 27 until week 48.

Week	Treatment 0 (negative control)	Treatment 1 (5 mg/L BAP)	Treatment 2 (10 mg/L BAP)	Treatment 3 (15 mg/L BAP)
Week 27	48.87±1.18[a]	117.59±12.31[b]	48.09±3.71[a]	41.82±1.05[a]
Week 30	52.49±1.31[a]	133.97±14.54[b]	52.37±4.35[a]	43.89±1.08[a]
Week 33	59.54±1.57[a]	151.57±15.69[b]	66.83±6.71[a]	49.76±1.30[a]
Week 36	67.18±1.66[a]	167.59±16.86[b]	78.20±7.01[a]	55.84±1.45[a]
Week 39	75.14±1.74[a]	179.55±16.57[b]	88.71±7.18[a]	61.81±1.56[a]
Week 42	81.90±1.74[a]	185.87±15.97[b]	98.80±7.55[a]	66.80±1.76[a]
Week 45	88.05±1.84[ab]	191.58±15.25[c]	108.39±7.99[b]	70.13±1.74[a]
Week 48	94.88±1.98[ab]	196.60±14.62[c]	118.22±8.60[b]	73.68±1.71[a]

Different letters indicate values are significantly different (P≤0.05) by Tukey's Multiple Range test. Values are mean ± standard deviations based on at least thirty replicates

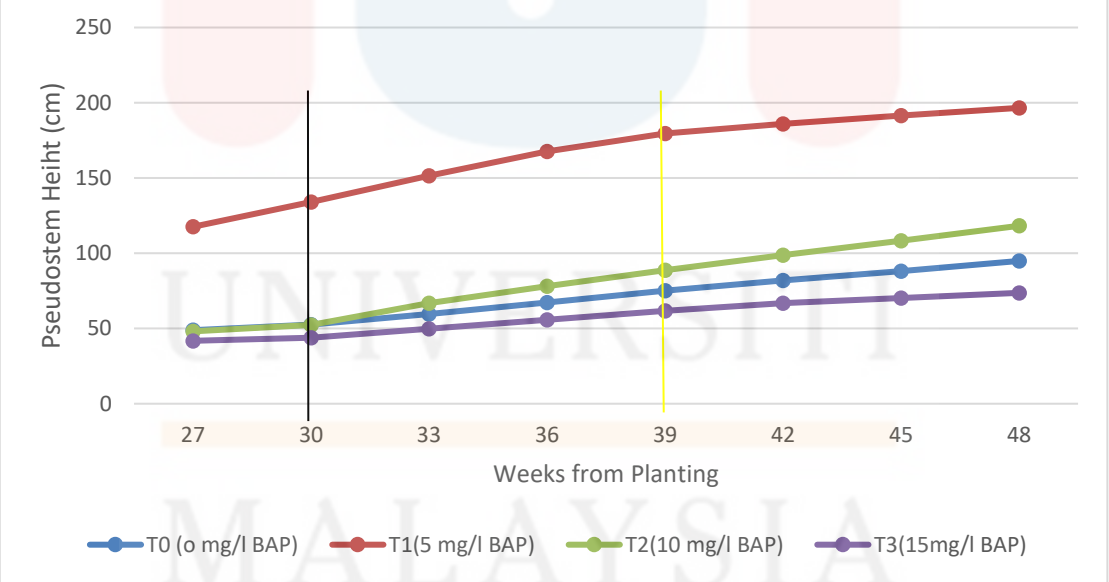


Figure 4.2: The growth rate of (pseudostem height) in (cm) for four different treatment of planting material sources from 6 months post-planting.

4.1.3 Girth size

The mean of girth size of all plants in the four treatments was evaluated as shown in Table 4.3. In week 48, the highest girth size (57.26 ± 1.97) was recorded in treatment 1 that apply 5 mg/L concentration of BAP while the lowest severity of girth size (37.39 ±1.35) was recorded in treatment 2 (10 mg/L concentration of BAP). The treatment 0 (control) and treatment 3 (15 mg/L BAP) showed moderate performance of their growth and their severity was (42.49 ± 0.87) and (44.27 ± 0.73).

A one-way ANOVA test was conducted to compare the girth size of banana from tissue culture. In initial week (week 27), there were significance difference between treatment 5 mg/L concentration of BAP (36.06 ± 2.41) with treatment 0 mg/L BAP (18.42 ± 0.51), treatment 10 mg/L BAP (21.03 ± 1.19) and treatment 15 mg/L BAP (19.13 ± 0.55) while there was no significance difference between treatment 0 mg/L BAP, 10 mg/L BAP and 15 mg/L BAP. At the end of the week (week 48), there were significance difference between treatment 5 mg/L BAP (57.26 ± 1.97) with treatment 0 mg/L BAP (42.49 ± 0.87), 10 mg/L BAP (37.39 ±1.35) and 15 mg/L BAP (44.27 ± 0.73). Treatment 0 mg/L BAP also had a significance difference with treatment 10 mg/L BAP but there was no significance difference with treatment 15 mg/L BAP. The means and standard deviation between experiment and one-way ANOVA test was enclosed in Appendix A.

Based on the Figure 4.3, the growth rate of girth size remains constantly increased in week 27 until week 30 for all four treatments. Starting week 30, treatment 0 mg/L BAP and treatment 15 mg/L BAP showed sudden increase in their growth rate but treatment 10 mg/L BAP remained the same. After week 36, the rate of treatment 10 mg/L BAP gained the last rate since their rate of girth size had been suddenly decrease.

Table 4.3: Mean of girth size (cm) for four different treatment of planting material sources from 6 months post-planting, week 27 until week 48.

Week	Treatment 0 (negative control)	Treatment 1 (5 mg/L BAP)	Treatment 2 (10 mg/L BAP)	Treatment 3 (15 mg/L BAP)
Week 27	18.42 ± 0.51[a]	36.06 ± 2.41[b]	21.03 ± 1.19[a]	19.13 ± 0.55[a]
Week 30	20.00±0.53[a]	40.55±2.91[b]	22.83±1.28[a]	20.35±0.63[a]
Week 33	23.60±0.61[a]	44.26±2.88[b]	25.41±1.30[a]	24.94±0.60[a]
Week 36	28.07±0.77[a]	47.96±2.91[b]	27.88±1.33[a]	29.48±0.72[a]
Week 39	32.31±0.81[a]	50.85±2.72[b]	30.59±1.39[a]	33.12±0.79[a]
Week 42	35.79±0.93[a]	53.02±2.49[b]	32.92±1.43[a]	36.76±0.73[a]
Week 45	39.22±0.91[a]	55.06±2.24[b]	35.18±1.38[a]	40.16±0.70[a]
Week 48	42.49±0.87[b]	57.26±1.97[c]	37.39±1.35[a]	44.27±0.73[b]

Different letters indicate values are significantly different (P≤0.05) by Tukey's Multiple Range test. Values are mean ± standard deviations based on at least thirty replicates

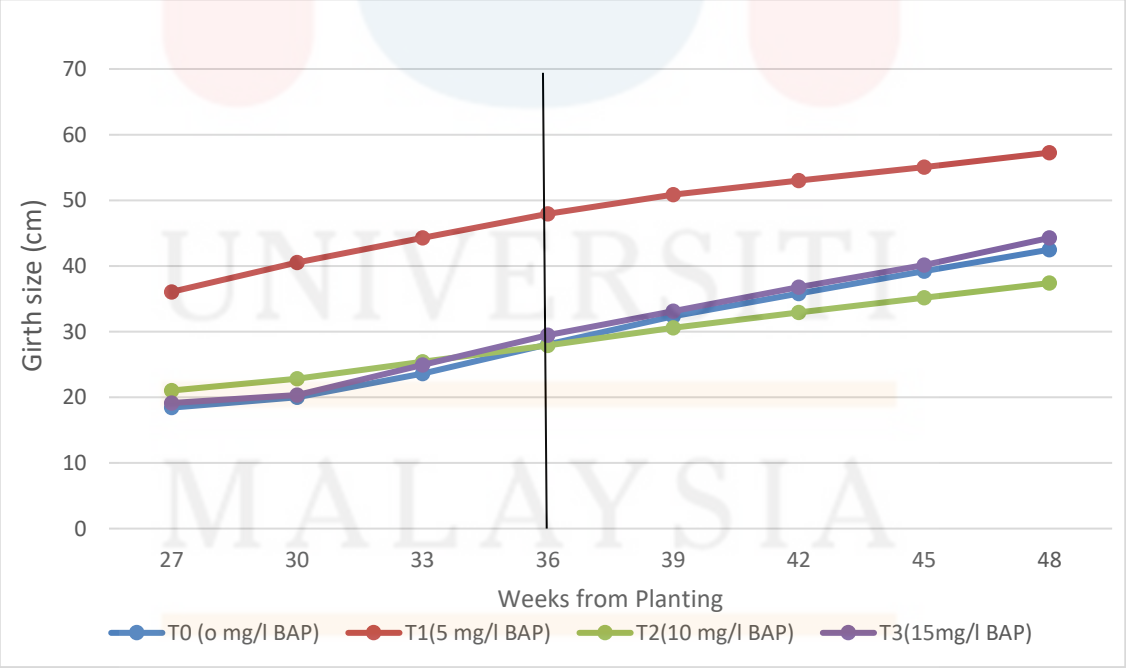


Figure 4.3: The growth rate of (girth size) in (cm) for four different treatment of planting material sources from 6 months post-planting

4.1.4 Leaf number

The mean of leaf number for all plants in the four treatments were evaluated as shown in Table 4.4. In week 48, the highest leaf number (6.23±0.13) was recorded in treatment 1 that apply 5 mg/L concentration of BAP while the lowest severity of girth size (5.7±0.15) was recorded in treatment 0 (control). The treatment 2 (10 mg/L BAP) and treatment 3 (15 mg/L BAP) showed moderate performance of their growth and their severity was (5.73±0.02) and (5.77±0).

A one-way ANOVA test was conducted to compare the girth size of banana from tissue culture. In initial week (week 27), there were significance difference between treatment 10 mg/L concentration of BAP (5.73±0.03) with treatment 15 mg/L BAP (4.8±0.01) while there were no significance difference between treatment 0mg/L BAP (5.03±0.23) with treatment 5 mg/L BAP(5.53±0.19). At the end of the week (week 48), there were no significance difference between all four treatment. The means and standard deviation between experiment and one-way ANOVA test was enclosed in Appendix A.

Based on the Figure 4.4, the graph showed fluctuation in their number of leaves for all four treatments starting from week 27 until week 48. The functional leaves for each treatment had an unsteady growth performance. There are some reasons that contribute to the high variance in the plants. The nutrient content is unstable in the soil could contribute to the high nutrient variability in the plant. Other contributing factors that affect the leaf number could be mutation caused by long exposure of PGR during tissue culture stage. Plant growth regulator may induce the changes in cell cycle and thus producing somaclonal variation of the plant.

Table 4.4: Mean of the leaf number for four different treatment of planting material sources from 6 months post-planting, week 27 until week 48.

Week	Treatment 0 (negative control)	Treatment 1 (5 mg/L BAP)	Treatment 2 (10 mg/L BAP)	Treatment 3 (15 mg/L BAP)
Week 27	5.03±0.23^{ab}	5.53±0.19^{ab}	5.73±0.03^{b}	4.80±0.01^{a}
Week 30	5.90±0.23^{b}	5.73±0.20^{ab}	6.10±0.04^{b}	5.07±0.01^{a}
Week 33	5.93±0.14^{b}	5.70±0.18^{ab}	5.03±0.03^{a}	5.17±0.01^{a}
Week 36	5.50±0.14^{a}	6.27±0.13^{b}	5.10±0.02^{a}	5.63±0^{ab}
Week 39	5.67±0.15^{a}	5.80±0.15^{a}	5.73±0.03^{a}	5.53±0^{a}
Week 42	5.70±0.15^{a}	6.33±0.14^{b}	6.10±0.03^{ab}	5.77±0^{ab}
Week 45	5.67±0.15^{ab}	6.3±0.12^{b}	5.10±0.02^{a}	5.53±0^{a}
Week 48	5.70±0.15^{a}	6.23±0.13^{a}	5.73±0.02^{a}	5.77±0^{a}

Different letters indicate values are significantly different (P≤0.05) by Tukey's Multiple Range test. Values are mean ± standard deviations based on at least thirty replicates

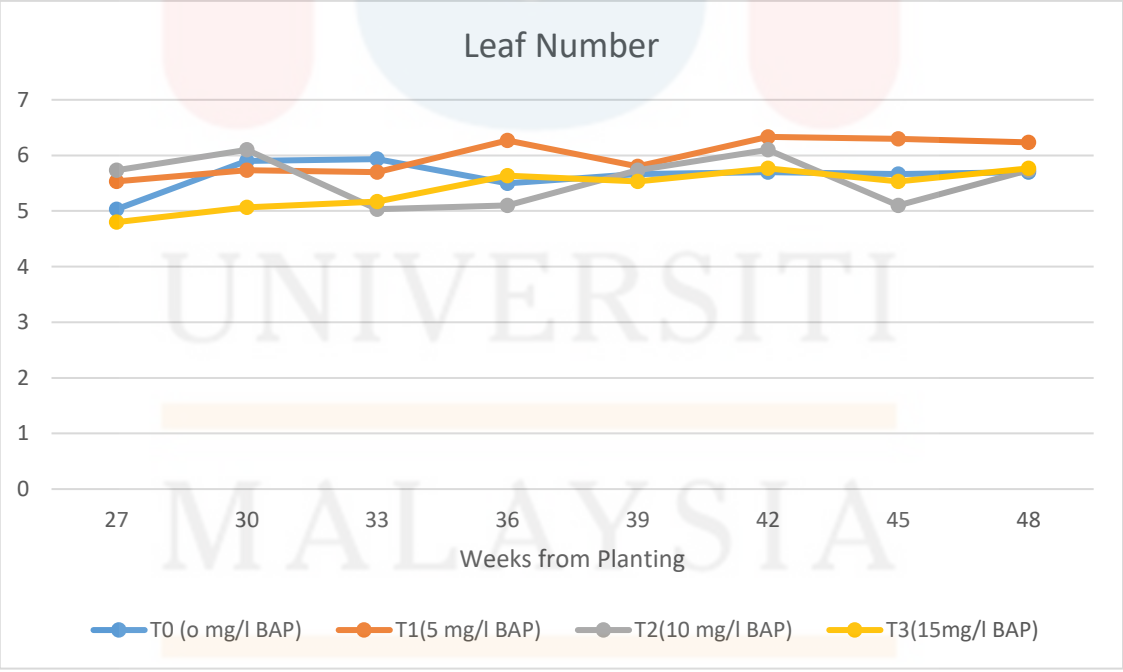


Figure 4.4: Mean of the leaf number of banana tissue culture plant in four different treatment from 6 months post planting

4.1.5 Flowering days

Figure 4.5 showed the mean of flowering days in treatment 1 and treatment 2. Mean of flowering days for treatment 1 are 279.89 while treatment 2 are 402.33. The lower of flowering days, the faster the plants start to produce inflorescences. Based on Figure 4.6, there were two treatments that showed positive reaction when using different concentration of BAP by producing the inflorescences to the banana plants. In treatment 1, replicate 26 showed the shortest days (213) to start flowering and produce inflorescences while the highest days (414) to start flowering was plant in treatment 2 replicate 16. Other replicate showed the range between 250-400 days to start flowering. There were 9 replicates in treatment 1 and 3 replicate in treatment 2 that produce inflorescences. The percentage of flowering for all treatment of the banana plants from tissue culture had been showed in Figure 4.7.

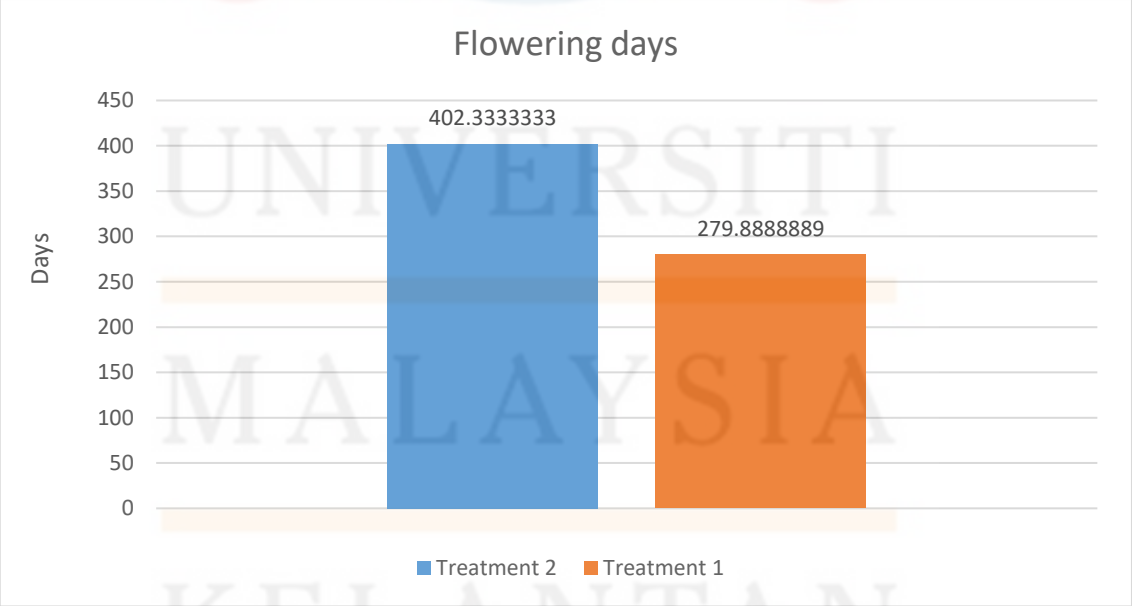


Figure 4.5: Mean of number of days to flower for treatment 1 & 2. Treatment 3 and 4 were excluded as none of the plants flower to the end at this research.

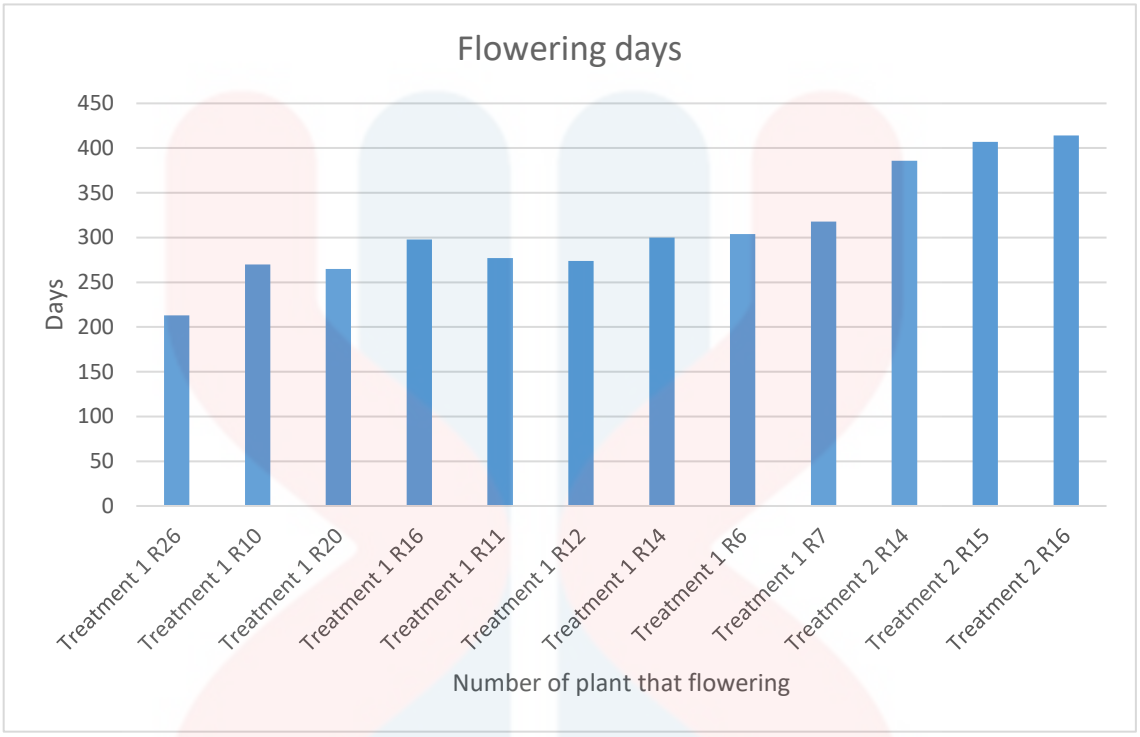


Figure 4.6: The number of flowering days for treatment 1 and 2 take time to start produces inflorescences.

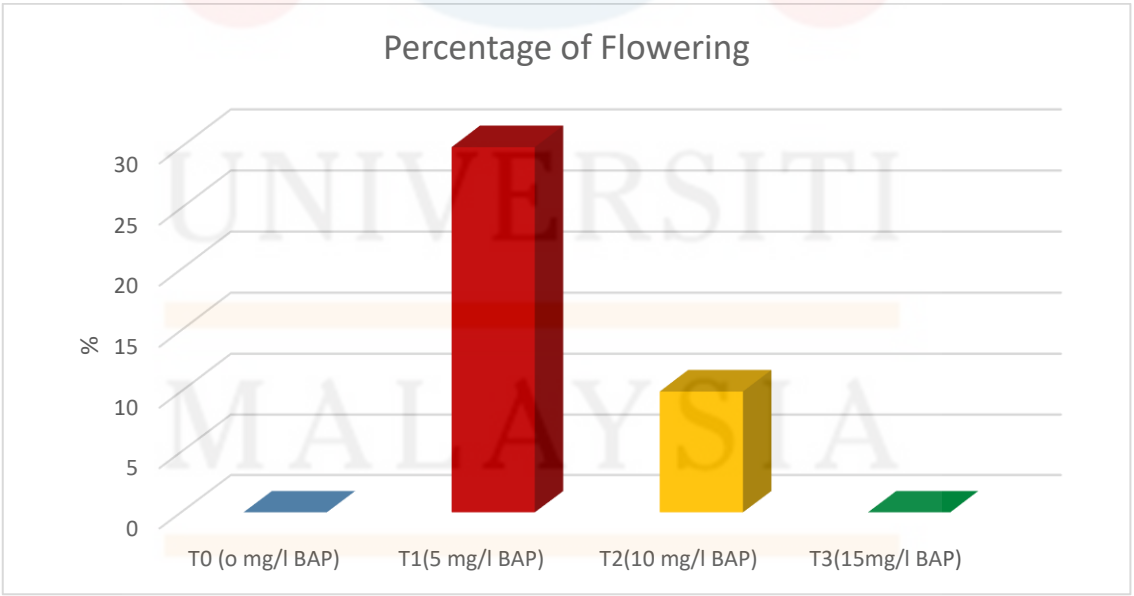


Figure 4.7: Percentage of the plants start flowering in four treatments.

4.1.6 Fruiting data

The mean of all parameter in treatment 1 and treatment 2 at fruiting stage were evaluated as shown in Table 4.6. For bunch weight (kg), treatment 1 (5 mg/L BAP) showed the highest weight compared to the treatment 2 (10 mg/L BAP). There was significance difference for bunch weight with ($p<0.05$). For the weight without bunch, treatment 1 (5 mg/L BAP) recorded the higher weight compared to the treatment 2 (10 mg/L BAP). There was significance difference for weight without bunch between treatment 1 and treatment 2 with ($p<0.05$). For bunch length (cm), treatment 1 (5 mg/L BAP) showed the highest length compared to the treatment 2 (10 mg/L BAP). There was significance difference between treatment 1 and treatment 2 with $p<0.05$. For the number of hand, the higher mean was treatment 1 (5 mg/L BAP) and there was no significance difference for the number of hand between treatment 1 and treatment 2 at $p>0.05$. For the number of finger, treatment 2 (10 mg/L BAP) showed the lowest number of finger compared to the treatment 1 (5 mg/L BAP) and there was significance difference for the number of finger between this treatment ($p<0.05$). For finger length (cm), treatment 1 (5 mg/L BAP) showed the highest length compared to the treatment 2 (10 mg/L BAP) and there were significance difference for finger length between this treatment ($p<0.05$). For the finger girth (cm), treatment 1 (5 mg/L BAP) recorded the higher girth compared to the treatment 2 (10 mg/L BAP) and there were significance difference for finger girth between this treatment since ($p<0.05$). The means and standard deviation between experiment and independent T-test was enclosed in Appendix A.

Table 4.6: Mean of all parameter in treatment 1 and treatment 2 at the fruiting stage.

Parameter	T1(5 mg/l BAP)	T2 (10 mg/l BAP)
Bunch Weight (Kg)	23.81[a]	17.0[b]
W/o Bunch (Kg)	21.68[a]	15.67[b]
Bunch Length (Cm)	84.5[a]	73.7[b]
Number Hand	8[a]	7.33[a]
Number Finger	141.25[a]	106[b]
Finger Length (cm)	16.23[a]	10.6[b]
Finger Girth (Cm)	12.4[a]	7.9[b]
Flowering Days	279.89[a]	402.33[b]

Different letters indicate values are significantly different (P≤0.05) by Independent T-test. Values are mean ± standard deviations based on at least thirty replicates.

4.2 Determination of the best concentration of BAP that can be apply in tissue culture towards banana *Musa acuminate* cv. Berangan at the field.

Plant growth regulator (PGR) had an important role during tissue culture since it can enhanced the growth performance of the plant by the development of the plant cells. Cytokinin is one the hormones that are often used in tissue culture because of its function to induce shoot formation and exogenous application of cytokinin may overcome the limitations in shoot growth due to root restriction (Di Benedetto, 2011; Di Benedetto, Klasman, & Boschi, 2010). In Malaysia, market demand towards banana was really high but conventional planting cannot fulfil that demand because of the slow growth performance in this method. Tissue culture application has facilitate the banana industries in Malaysia since this tissue culture plantlet perform better in term of growth in the field and thus resulting in less harvesting time and better yield (Njukwe, 2013).

As the result for growth performance, treatment with 5 mg/L concentration of BAP showed the greatest performance compared to the negative control, 10 mg/L concentration of BAP and 15 mg/L concentration of BAP. The parameters that had been observed for the growth performance (leaf area, pseudostem height, leaf number and girth size) recorded that treatment 5 mg/L concentration of BAP overcomes other treatments in high rates. Besides that, the yield performance for treatment with 5 mg/L concentration of BAP indicated the highest yield produced compared with the other treatments. The parameters that had been observed for yield performance (bunch weight, weight without bunch, bunch length, number of finger, number of hand, finger length and finger girth) recorded that the treatment 5 mg/L concentration of BAP overcomes other treatments in high rates. So, this treatment with 5 mg/L concentration of BAP showed superior growth

compared to the other treatments and plants from this treatment can be selected as mother plant because selection of mother plant with superior characteristic is very important in ensuring high productivity (Singh, Uma, & Karihaloo, 2011).

Treatment with 15 mg/L concentration of BAP recorded the lowest growth performance as compared to other treatments. D'Amato (1978) reported that high concentration of BAP in tissue culture plants is often disadvantageous since it can cause various chromosomal abnormalities resulting in the production of non-true-to-type plants. Although BAP functioned to stimulate the shoot proliferation in bananas, it also has their mutagenic effects at high concentration that caused the production of off type plants. So, the treatment with 15 mg/L concentration of BAP showed inferior growth performance as compared to other treatments. Based on this study, it is not suggested to apply high concentration of BAP above 5mg/L at tissue culture for future experiment. Optimum concentration of BAP will produce higher rate of growth performance whether in the tissue culture or at the field.

In this experiment, there are a few variations that have been detected which include dwarfism, gigantism and variety of intermediate heights. Furthermore, the plants from negative control and 15 mg/L concentration of BAP had been identified as stunted as it has not achieved the flowering stage as expected. Visual screening during post-planting after 6 month at the field help to detect the off-type plants which can then be eliminated. Dwarfism is the most common variation accounting for 75% (Stover, 1987) while gigantisms is less common in the banana. In treatment with 5 mg/L concentration of BAP, plant in replicate 26 had been identified as giant due to its enormous growth and yield performance. This plant only take 213 days to start flowering and have large value of stem height and stem girth. The yield produce from this plants also showed positive abnormalities with heavier and bigger fruit.

Somaclonal variation is mainly caused by newly generation mutations that arise from tissue culture process (Sato, Hosokawa, & Doi, 2011b). Numerous stress factors including wounding, exposure during sterilization, tissue being incomplete and imbalance of media components such as high concentration of plant growth regulator (auxin and cytokinins) could trigger mutations in tissue culture. Since there is giant produced in treatment 1, it showed that the somaclonal variation had its advantage that can be useful in the industries. In micropropagation, somaclonal is undesirable but it can be useful source of new variability in fruit crops for next generation that hinders conventional breeding (Hammerschlag, 1992). This genetic of manipulation method is cheaper as compared to other method because it does not required 'containment' procedures. There are more plants species that can benefit from the tissue culture system and can be manipulated by somatic hybridization and transformation at the present time. Chimeric expression can be obtained if somaclonal are raised through cell culture (Evans, 1989). Somaclonal variation had been most successful in crops and ornamental plants and breeding process can also been done by exploitation of in-vitro that generated the variability.

From the findings of this study, the result supported the hypothesis which different concentration of BAP cause significant different on the morphological structure of banana plant produce. The selection for suitable concentration of BAP was 5 mg/L due to their dramatic performance in growth. The yield that produced from this treatment can fulfil the customer demands as it produced better grade of banana. This concentration of BAP can be apply in the tissue culture due to the higher percentage of success and also the plants that grow from this 5 mg/L BAP can undergo multiplication method to ensure this variety produce more type of plants but still need to improvise since the uniformity that come out from this treatment is low. Uniformity is an important factor to be focused

in banana plantation because the rate of banana yield depends on the growth performance of the banana. Thus, extra precaution are required in the application of BAP during tissue culture stage, as it has been shown to induce variation among the clones.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

As a conclusion, plants treated with 5 mg/L concentration of BAP during *in vitro* growth has higher growth and yield performance in the field compared to the plants that treated with 0 mg/L, 10 mg/L and 15 mg/L concentration of BAP. Plants treated with 5 mg/L of BAP showed superior growth in all parameters studied and the superior off-types in banana plants had come from plants in this treatment. In treatment 5 mg/L of BAP, plant in replicate 26 showed superior growth and yield performance. This plant can be selected for future cultivation to increase their variety and indirectly can fulfil the market and costumer demand that prefer faster growth rate and better yield as compared to the normal type of plant. This rare clone can improve the banana industries in Malaysia by using the clone as the mother plant for mass propagation. The clone can be included as potential variety for banana improvement programme. However, prior to its commercialization, it is important to further investigate its variance stability to produce consistent clone with uniform phenotype. Therefore, the study on growth and yield performance of *Musa acuminate* cv Berangan that were treated with different concentration of BAP in the field has shown significant impact to the commercial breeder as the result showed optimum usage of BAP concentration during tissue culture.

As a recommendation, crop improvement must be taken for the cultivar that showed high growth and yield performance in the field. Most of the plant in treatment 5 mg/L of BAP can be used as mother plant for mass propagation due to its positive variance shown. Field management also need to be improved such as infrastructure to protect the banana plant from other pest that can caused damage to the plant.

REFERENCES

Ali, M.R., Akand, M. H., Hoque M. E., Homayra Huq, Mehraj, H. and Jamal Uddin, A.F.M. (2015). *In vitro* regeneration and rapid multiplication of tuberose. Int. J. Bus. Soc. Sci. Res. 3(1): 35-38.

Broadly, R., Rigden, P., Chay-Prove, P., and Daniells, J. (2004). Subtropical Banana Grower's Handbook. Queensland Department of Primary Industries, pp 1-206.

Caussiol L (2001). Postharvest quality of conventionally and organically grown banana fruit. An M. Sc. Thesis Presented to Cranfield University, Silsoe. pp 160.

Chadha, K L. and Sahijram, L. (2000). Application of biotechnology to Musa. In: Chadha, K. L.; Ravindran, P. N.; Sahijram, L., eds. Biotechnology in horticultural and plantain crops. New Delhi: Malhotra Publishing House; 232-247.

Constantine, D., and Rossel, G. (2001). The Musaceae: An annotated list of the species of Ensete, Musa and Musella.

Daniells, J., and Evans, D. (2005). Better drainage for banana plantations. DPI&F Note, Queensland Department of Primary Industries & Fisheries

Daniells, J., Jenny, C., Karamura, D., and Tomekpe, K. (2001). Musalogue: *A Catalogue of Musa Germplasm. Diversity in the Genus Musa.* International Network for the Improvement of Banana and Plantain, Montpellier, France.

Daniells, J., and Lindsay, P. (2004). Plant spacing considerations for North Queensland bananas. DPI&F Note, Queensland Department of Primary Industries & Fisheries.

Di Benedetto, A. (2011). Root restriction and post-transplant effects for bedding pot plants. In: Ornamental Plants: Types, Cultivation and Nutrition. (Aquino, J.C., Ed.). Nova Science Publishers, Inc., New York, NY, USA. 47–79.

Di Benedetto, A., Tognetti, J. and Galmarini, C. (2010). Biomass production in ornamental foliage plants: Crop productivity and mechanisms associated to exogenous cytokinin supply. The American Journal of Plant Science and Biotechnology, 4, 1–22.

Escalant, J.V., Jain, S.M. (2004). Banana improvement with cellular and molecular biology, and induced mutations. Chapter 30. In: SM Jain, R Swennen, eds. Banana Improvement: Cellular, Molecular Biology, and Induced Mutations.

Espino, R.R.C., Jamaluddin, S.H., Silayoi, B., Nasution, R.E. (1992). *Musa L.* (edible cultivars). In: EWM Verheij, RE Coronel, eds. *Plant Resources of South-East Asia No. 2 Edible Fruits and Nuts.* PROSEA, Bogor, Indonesia.

Faisal, S.M., Haque, M.A. and Quasem, A. (1998). Field performance of in vitro plantlets aganinst normal suckers of banana (*Musa sapientum*) cv. Champa. Plant Tissue Cult. 8(2): 125-129.

Ferdousa, M.H. Masum Billahb, A.A. Mehrajc, H Taufiqued T. and Jamal Uddind A.F.M. (2008). BAP and IBA pulsing for *in vitro* multiplication of banana

cultivars through shoot-tip culture. Journal of Bioscience and Agriculture Research, Vol. 03, Issue 02: 87-95. www.journalbinet.com/jbar-journal.html.

Gowen S (1995). Bananas and plantains. Chapman and Hall, London. 567p.

Hammerschlag, F.A. (1992). Somaclonal variation. In: Hammerschlag, F. A.; Litz, R. E., eds. Biotechnology of perennial fruits. Wallingford: CAB International: 35-55.

Henriques, W., Jeffer, R.D., Lacher, T.E., & Kendall, R.J. (1996). Agrochemical Used In Banana Plantations In Latin America: Perspective on ecological risk, Environmental toxicology and chemical 16(1): 91-99.

H.P. Singh, S. Uma, R. Selvarajan and J.L. Karihaloo. 2011. Micropropagation for Production of Quality Banana Planting Material in Asia- Pacific. Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB), New Delhi, India. P. 92.

Hwang, S.; Tang, C.Y. (1996). Somaclonal Variation and Its Use For Improving Cavendish (AAA Dessert) Bananas In Taiwan. In: Frison, E. A.; Horry, J. P.; deWaele, D., Eds. New frontiers in resistance breeding for nematode, Fusarium and Sigatoka. Kuala Lumpuro: 173-181.

Hyam, R., Pankhurst, R. (1995) Plants and Their Names: A Concise Dictionary. Oxford University Press, Oxford.

Israeli, Y.; Reuveni, O.; Lahav, E. (1991). Qualitative Aspects of Somaclonal Variations In Banana Propagated By *In Vitro* Techniques. Sci. Hort. 48:71-88.

Johnson P.N.T., Brennan J.G. and Addo-Yobo F.Y. (1998). Air-drying characteristics of plantain (*Musa* AAB). *Journal of Food Engineering*, 37, 233-242.

Kader A.A. (1999). Fruit Maturity, Ripening and Quality Relationships. Proceeding of International Symposium on effect of Pre- and Post-Harvest Factors on Storage of Fruit. Ed. L. Mitchalczuk, Act Hortculture, 485, ISHS, 203- 208.

Kalloo, G. (2002). Banana and plantation research in India - a perspective. Global Conf. on Banana and Plantain, October 28-31, Bangalore, India.

Karp A. The role of growth regulators in somaclonal variation. Br Soc Plant Growth Regul Annu Bull. 1992; 2: 1–9.

Karugaba A., and Kimaru G. (1999), Banana Production in Uganda, An Essential Food And Cash Crop. RELEMA –Techinical Handbook No. 18, ISBN 9966- 896-39-2.

Kishor, H., Abhijith, Y.C. and Manjunatha N. (2017). Micropropagation of Native Cultivars of Banana. *Journal of Pure & Applied Bioscience, 5(5),* 1559 – 1564. http://dx.doi.org/10.18782/2320-7051.5209.

Larkin, P.J.; Scowcroft, W.R. (1982). Somaclonal Variation - A Novel Source of Variability From Cell Cultures For Plant Improvement. Theor. Appl. Genet. 60:197-214.

Madhulatha, P., Anbalagan, M., Jayachandaran, S. and Sakthivel, N. (2004). Influence of Liquid Pulse Treatment With Growth Regulators On In Vitro Propagation Of Banana (*Musa* Sp. AAA). Plant Cell Tissue Organ Cult. 76: 189-192.

Marriott, J. (1980) Banana – Physiology and Biochemistry of Storage and Ripening For Optimum Quality. CRC Critical Reviews in Food Science and Nutrition 13, 41-88.

Martin KP, Pachathundikandi S, Zhang CL, Slater A, and Madassery J. (2006). RAPD Analysis of a Variant of Banana (*Musa Sp*.) Cv. Grande Naine and Its Propagation via Shoot Tip Culture. *In Vitro* Cell Dev. Biol. Plant, 42:188-192.

Nelson, S.C., Ploetz, R.C., and Kepler, A.K. (2006). *Musa species* (bananas and plantains). In: CR Elevitch, ed. *Species Profiles for Pacific Island Agroforestry.* Permanent Agricultural Resources, Holualoa, Hawai'I.

Njukwe, E., Ouma, E., Van Asten, P.J.A, Munchunguzi, P. and Amah, D. (2013). Challenges and Opportunities for Macropropagation Technology for Musa among Smallholder's Farmers And Small Medium-Scale Enterprise. In: G, Blomme, P. Van Asten and B. Van lauwe. Banana System in The Humid Highlands Of Sub-Saharan Africa: Enhancing Residence And Productivity. pp. 66-71. CABI.

Ogazi, P.O. (1996). Plantain: Production, Processing and Utilization. Paman and Associates publishers, Okigwe, Nigeria. pp. 1-29.

Rowe, P. and Rosales, F.E. 1996. Bananas and plantains. P.167–211. In: J. Janick and J.N. Moore (eds.), Fruit Breeding. Vol. 1: Tree and Tropical Fruits. John Wiley & Sons Inc., New York.

Samuel, J.C.; and Singh, H.P. (2002). Developmental Efforts for Promoting Microirrigation In Banana. Global Conf. On Banana and Plantain, October 28-31, Bangalore, India.

Sato M, Hosokawa M, and Doi M (2011b) Somaclonal Variation Is Induced De Novo Via The Tissue Culture Process: A Study Quantifying Mutated Cells In Saintpaulia. PLoS ONE 6:e23541. doi:10.1371/journal.pone.0023541.

Shirani S, Mahdavi F, and Maziah M (2009). Morphological Abnormality among Regenerated Shootsof Banana and Plantain (*Musa* Spp.) After *In Vitro* Multiplication with TDZ and BAP From Excised Shoot Tips. Afr. J. Biotechnol. 8(21): 5755-5761.

Simmonds, N.W., and Shepherd, K. (1955). The Taxonomy and Origins of the Cultivated Bananas. *Journal of the Linnean Society of London (Botany)* 55: 302-312.

Smith, M.K., Hamill, S.D., Becker, D.K., and Dale, J.L. (2005). Musa spp. Banana and Plantain. Chapter 13.1. In: RE Litz, ed. Biotechnology of Fruit and Nut Crops. CAB International, Wallingford, UK. pp 366-391.

Turner, D.W., Fortescue, J. A., and Thomas, D.S. (2007). Environmental physiology of the bananas (Musa spp.). *Brazilian Journal of Plant Physiology*, *19*(4), 463-484.

Vuylsteke, D., Ortiz, R., Ferris, S.B. and Crouch, J.H. 1997. Plantain improvement. Plant Breed. Rev. 14:267–320.

Wills, R.B.H. (1990). Postharvest technology of banana and papaya in ASEAN: An Overview. *ASEAN Food Journal*. 5: 47-50.

APPENDIX

ONE WAY ANOVA

A. GROWTH PERFORMANCE

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
AL27	Between Groups	235472128.479	3	78490709.493	19.617	.000
	Within Groups	464123914.036	116	4001068.224		
	Total	699596042.515	119			
AL30	Between Groups	293521898.550	3	97840632.850	19.187	.000
	Within Groups	591513933.510	116	5099258.047		
	Total	885035832.059	119			
AL33	Between Groups	371653106.094	3	123884368.698	22.203	.000
	Within Groups	647240455.924	116	5579659.103		
	Total	1018893562.018	119			
AL36	Between Groups	463765146.951	3	154588382.317	25.134	.000
	Within Groups	713473908.200	116	6150637.140		
	Total	1177239055.151	119			
AL39	Between Groups	539588471.150	3	179862823.717	28.282	.000
	Within Groups	737706659.095	116	6359540.165		
	Total	1277295130.245	119			
AL42	Between Groups	583935452.718	3	194645150.906	30.694	.000
	Within Groups	735609876.820	116	6341464.455		
	Total	1319545329.538	119			
AL45	Between Groups	623253390.560	3	207751130.187	33.428	.000
	Within Groups	720924753.989	116	6214868.569		
	Total	1344178144.549	119			
AL48	Between Groups	664369700.918	3	221456566.973	36.699	.000
	Within Groups	699986514.376	116	6034366.503		
	Total	1364356215.294	119			
H27	Between Groups	115375.538	3	38458.513	30.568	.000
	Within Groups	145942.125	116	1258.122		
	Total	261317.663	119			
H30	Between Groups	161667.493	3	53889.164	30.819	.000
	Within Groups	202832.939	116	1748.560		
	Total	364500.432	119			
H33	Between Groups	198423.292	3	66141.097	29.865	.000
	Within Groups	256900.547	116	2214.660		
	Total	455323.839	119			

	Between Groups	234833.863	3	78277.954	30.863	.000
H36	Within Groups	294207.114	116	2536.268		
	Total	529040.977	119			
	Between Groups	255769.187	3	85256.396	34.290	.000
H39	Within Groups	288418.490	116	2486.366		
	Total	544187.677	119			
	Between Groups	255784.246	3	85261.415	35.733	.000
H42	Within Groups	276780.586	116	2386.040		
	Total	532564.832	119			
	Between Groups	259428.046	3	86476.015	38.088	.000
H45	Within Groups	263366.598	116	2270.402		
	Total	522794.644	119			
	Between Groups	259342.831	3	86447.610	39.106	.000
H48	Within Groups	256428.927	116	2210.594		
	Total	515771.759	119			
	Between Groups	16.825	3	5.608	3.440	.019
N27	Within Groups	189.100	116	1.630		
	Total	205.925	119			
	Between Groups	18.067	3	6.022	5.094	.002
N30	Within Groups	137.133	116	1.182		
	Total	155.200	119			
	Between Groups	16.492	3	5.497	5.345	.002
N33	Within Groups	119.300	116	1.028		
	Total	135.792	119			
	Between Groups	21.092	3	7.031	6.851	.000
N36	Within Groups	119.033	116	1.026		
	Total	140.125	119			
	Between Groups	1.167	3	.389	.299	.826
N39	Within Groups	150.800	116	1.300		
	Total	151.967	119			
	Between Groups	7.892	3	2.631	3.427	.019
N42	Within Groups	89.033	116	.768		
	Total	96.925	119			
	Between Groups	22.167	3	7.389	6.637	.000
N45	Within Groups	129.133	116	1.113		
	Total	151.300	119			
	Between Groups	5.692	3	1.897	1.791	.153
N48	Within Groups	122.900	116	1.059		
	Total	128.592	119			
	Between Groups	6262.142	3	2087.381	35.722	.000
G27	Within Groups	6778.384	116	58.434		
	Total	13040.526	119			
G30	Between Groups	8687.934	3	2895.978	35.796	.000

	Within Groups	9384.696	116	80.903		
	Total	18072.630	119			
	Between Groups	8703.330	3	2901.110	35.996	.000
G33	Within Groups	9349.028	116	80.595		
	Total	18052.358	119			
	Between Groups	8584.209	3	2861.403	33.584	.000
G36	Within Groups	9883.350	116	85.201		
	Total	18467.559	119			
	Between Groups	8091.708	3	2697.236	33.979	.000
G39	Within Groups	9208.138	116	79.380		
	Total	17299.846	119			
	Between Groups	7423.742	3	2474.581	34.122	.000
G42	Within Groups	8412.522	116	72.522		
	Total	15836.264	119			
	Between Groups	6829.357	3	2276.452	36.747	.000
G45	Within Groups	7186.209	116	61.950		
	Total	14015.566	119			
	Between Groups	6435.651	3	2145.217	40.730	.000
G48	Within Groups	6109.628	116	52.669		
	Total	12545.279	119			

Homogeneous Subsets

1. Leaf area

1.1.Initial week (week 27)

AL27

	Treatment	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	15mg of BAP	30	738.4986	
	Control	30	1010.4152	
	10mg of BAP	30	1219.6211	
	5mg of BAP	30		4200.4670
	Sig.		.788	1.000
Duncan[a]	15mg of BAP	30	738.4986	
	Control	30	1010.4152	
	10mg of BAP	30	1219.6211	
	5mg of BAP	30		4200.4670
	Sig.		.385	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

1.2.Last week (week 48)

AL48

	Treatment	N	Subset for alpha = 0.05		
			1	2	3
Tukey HSD[a]	15mg of BAP	30	1438.5950		
	Control	30	2848.9639	2848.9639	
	10mg of BAP	30		3757.1925	
	5mg of BAP	30			7769.5678
	Sig.		.123	.482	1.000
Duncan[a]	15mg of BAP	30	1438.5950		
	Control	30		2848.9639	
	10mg of BAP	30		3757.1925	
	5mg of BAP	30			7769.5678
	Sig.		1.000	.155	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

2. Pseudostem height of plants in all four treatment

2.1.Initial week (week 27)

H27

	Treatment	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	15mg of BAP	30	41.8200	
	10mg of BAP	30	48.0900	
	Control	30	48.8700	
	5mg of BAP	30		117.5900
	Sig.		.868	1.000
Duncan[a]	15mg of BAP	30	41.8200	
	10mg of BAP	30	48.0900	
	Control	30	48.8700	
	5mg of BAP	30		117.5900

	Sig.		.473	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 30.000.

2.2.Last week (week 48)

H48

	Treatment	N	Subset for alpha = 0.05		
			1	2	3
Tukey HSD[a]	15mg of BAP	30	73.6800		
	Control	30	94.8833	94.8833	
	10mg of BAP	30		118.2200	
	5mg of BAP	30			196.6033
	Sig.		.305	.224	1.000
Duncan[a]	15mg of BAP	30	73.6800		
	Control	30	94.8833	94.8833	
	10mg of BAP	30		118.2200	
	5mg of BAP	30			196.6033
	Sig.		.083	.057	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 30.000.

3. Number leaf for plants in all four treatment

3.1.Intitial week (week 27)

N27

	Treatment	N	Subset for alpha = 0.05		
			1	2	3
Tukey HSD[a]	15mg of BAP	30	4.8000		
	Control	30	5.0333	5.0333	
	5mg of BAP	30	5.5333	5.5333	
	10mg of BAP	30		5.7333	
	Sig.		.123	.152	
Duncan[a]	15mg of BAP	30	4.8000		
	Control	30	5.0333	5.0333	
	5mg of BAP	30		5.5333	5.5333
	10mg of BAP	30			5.7333
	Sig.		.480	.132	.545

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 30.000.

3.2.Last week (week 48)

N48

	Treatment	N	Subset for alpha = 0.05
			1
Tukey HSD[a]	Control	30	5.7000
	10mg of BAP	30	5.7333
	15mg of BAP	30	5.7667
	5mg of BAP	30	6.2333
	Sig.		.191
Duncan[a]	Control	30	5.7000
	10mg of BAP	30	5.7333
	15mg of BAP	30	5.7667
	5mg of BAP	30	6.2333
	Sig.		.068

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 30.000.

4. Girth size of plants in all four treatment

4.1.Initial week (week 27)

G27

	Treatment	N	Subset for alpha = 0.05	
			1	2
Tukey HSD[a]	Control	30	18.4200	
	15mg of BAP	30	19.1300	
	10mg of BAP	30	21.0300	
	5mg of BAP	30		36.0633
	Sig.		.551	1.000
Duncan[a]	Control	30	18.4200	
	15mg of BAP	30	19.1300	
	10mg of BAP	30	21.0300	
	5mg of BAP	30		36.0633

Sig.		.216	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 30.000.

4.2.Last week (week 48)

G48

	Treatment	N	Subset for alpha = 0.05		
			1	2	3
Tukey HSD[a]	10mg of BAP	30	37.3933		
	Control	30		42.4867	
	15mg of BAP	30		44.2700	
	5mg of BAP	30			57.2600
	Sig.		1.000	.777	1.000
Duncan[a]	10mg of BAP	30	37.3933		
	Control	30		42.4867	
	15mg of BAP	30		44.2700	
	5mg of BAP	30			57.2600
	Sig.		1.000	.343	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 30.000.

B. YIELD PERFORMANCE

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
BW	Equal variances assumed	1.313	.278	5.593	10	.000	6.81111	1.21781	4.09766	9.52456

	Equal variances not assumed			8.994	9.995	.000	6.81111	.75727	5.12369	8.49853
WOB	Equal variances assumed	2.614	.137	4.466	10	.001	6.01111	1.34598	3.01209	9.01013
	Equal variances not assumed			7.406	9.866	.000	6.01111	.81168	4.19925	7.82297
BL	Equal variances assumed	.860	.376	3.444	10	.006	10.80000	3.13546	3.81376	17.78624
	Equal variances not assumed			5.801	9.652	.000	10.80000	1.86182	6.63123	14.96877
NOH	Equal variances assumed	.682	.428	1.936	10	.082	.66667	.34427	-.10040	1.43374
	Equal variances not assumed			1.789	3.077	.169	.66667	.37268	-.50276	1.83610
NOF	Equal variances assumed	1.267	.287	4.547	10	.001	39.11111	8.60204	19.94458	58.27765
	Equal variances not assumed			8.080	8.226	.000	39.11111	4.84035	28.00233	50.21989
FL	Equal variances assumed	2.279	.162	3.313	10	.008	5.63333	1.70020	1.84506	9.42161

	Equal variances not assumed			5.124	9.654	.001	5.63333	1.09949	3.17155	8.09512
FG	Equal variances assumed	1.376	.268	4.990	10	.001	4.50000	.90185	2.49055	6.50945
	Equal variances not assumed			6.876	7.295	.000	4.50000	.65447	2.96501	6.03499
PH	Equal variances assumed	1.210	.297	4.470	10	.001	37.02222	8.28275	18.56710	55.47734
	Equal variances not assumed			5.784	6.098	.001	37.02222	6.40037	21.42174	52.62270
GS	Equal variances assumed	2.962	.116	8.791	10	.000	17.08889	1.94398	12.75743	21.42035
	Equal variances not assumed			12.417	7.828	.000	17.08889	1.37620	13.90323	20.27455
FD	Equal variances assumed	.922	.359	-6.482	10	.000	-122.44444	18.88863	-164.53093	-80.35796
	Equal variances not assumed			-9.220	7.979	.000	-122.44444	13.28057	-153.08334	-91.80555

Descriptives

			N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
							Lower Bound	Upper Bound			
BW	5mg of BAP		9	23.8111	2.02018	.67339	22.2583	25.3640	21.60	28.50	
	10mg of BAP		3	17.0000	.60000	.34641	15.5095	18.4905	16.40	17.60	
	Total		12	22.1083	3.53874	1.02155	19.8599	24.3567	16.40	28.50	
	Model	Fixed Effects			1.82672	.52733	20.9334	23.2833			
		Random Effects				3.78310	-25.9606	70.1772			22.45409
WOB	5mg of BAP		9	21.6778	2.24041	.74680	19.9556	23.3999	19.20	26.40	
	10mg of BAP		3	15.6667	.55076	.31798	14.2985	17.0348	15.10	16.20	
	Total		12	20.1750	3.33115	.96162	18.0585	22.2915	15.10	26.40	
	Model	Fixed Effects			2.01897	.58283	18.8764	21.4736			
		Random Effects				3.32645	-22.0915	62.4415			17.16090
BL	5mg of BAP		9	84.5000	5.22757	1.74252	80.4817	88.5183	75.10	95.40	

	10mg of BAP		3	73.7000	1.13578	.65574	70.8786	76.5214	72.90	75.00	
	Total		12	81.8000	6.63078	1.91414	77.5870	86.0130	72.90	95.40	
	Model	Fixed Effects			4.70319	1.35769	78.7749	84.8251			
		Random Effects				5.93474	6.3920	157.2080			53.40444
	5mg of BAP		9	8.0000	.50000	.16667	7.6157	8.3843	7.00	9.00	
	10mg of BAP		3	7.3333	.57735	.33333	5.8991	8.7676	7.00	8.00	
	Total		12	7.8333	.57735	.16667	7.4665	8.2002	7.00	9.00	
NOH	Model	Fixed Effects			.51640	.14907	7.5012	8.1655			
		Random Effects				.35224	3.3577	12.3090			.16296
	5mg of BAP		9	145.1111	14.41739	4.80580	134.0289	156.1933	120.00	176.00	
	10mg of BAP		3	106.0000	1.00000	.57735	103.5159	108.4841	105.00	107.00	
	Total		12	135.3333	21.54629	6.21988	121.6435	149.0232	105.00	176.00	
NOF	Model	Fixed Effects			12.90306	3.72479	127.0340	143.6327			
		Random Effects				21.65122	-139.7715	410.4382			727.84198
	5mg of BAP		9	16.2333	2.80713	.93571	14.0756	18.3911	12.60	21.40	
FL	10mg of BAP		3	10.6000	1.00000	.57735	8.1159	13.0841	9.60	11.60	
	Total		12	14.8250	3.52191	1.01669	12.5873	17.0627	9.60	21.40	

	Model	Fixed Effects			2.55029	.73621	13.1846	16.4654			
		Random Effects				3.09123	-24.4528	54.1028			14.42189
	5mg of BAP		9	12.4000	1.46458	.48819	11.2742	13.5258	10.70	14.60	
	10mg of BAP		3	7.9000	.75498	.43589	6.0245	9.7755	7.10	8.60	
	Total		12	11.2750	2.40950	.69556	9.7441	12.8059	7.10	14.60	
FG	Model	Fixed Effects			1.35277	.39051	10.4049	12.1451			
		Random Effects				2.49529	-20.4306	42.9806			9.71833
	5mg of BAP		9	314.5556	13.30311	4.43437	304.3299	324.7812	300.50	335.50	
	10mg of BAP		3	277.5333	7.99396	4.61531	257.6752	297.3914	269.10	285.00	
	Total		12	305.3000	20.51062	5.92091	292.2682	318.3318	269.10	335.50	
PH	Model	Fixed Effects			12.42413	3.58654	297.3087	313.2913			
		Random Effects				20.48783	44.9775	565.6225			651.02049
	5mg of BAP		9	72.7556	3.16943	1.05648	70.3193	75.1918	69.00	78.00	
	10mg of BAP		3	55.6667	1.52753	.88192	51.8721	59.4612	54.00	57.00	
GS	Total		12	68.4833	8.21361	2.37106	63.2647	73.7020	54.00	78.00	
	Model	Fixed Effects			2.91597	.84177	66.6078	70.3589			

Random Effects				9.52822	-52.5842	189.5509			144.12553

APPENDIX B

Figure B.1: The giant banana plant (T1R26) in the field.

Figure B.2: Wrapping the fruit with plastic bag during flowering stage

Figure B.3: Process of separating the combs from the bunch

Figure B.4: Measurement of fruit length of banana

Figure B.5: Measurement of fruit girth of banana

Figure B.6: Technique that apply in measuring the yield performance