

**EFFECTS OF FERTILIZERS ON GROWTH AND LEAF NUTRIENT  
CONTENT OF CLONAL OIL PALM SEEDLINGS**

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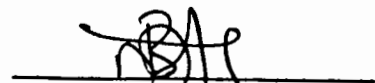
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23<sup>th</sup> August 2019



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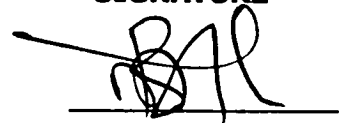
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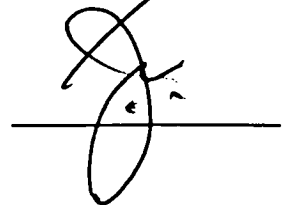
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## ABSTRACT

Clonal oil palm offers the potential for greater productivity because it is possible to establish uniform tree stands comprising identical copies (clones) of a limited number of highly productive oil palms. There is limited information on the most suitable fertilizer type, method and rates of application for these clonal seedlings. The same fertilizer type, method and rates of application for D x P seedlings was used by Sawit Kinabalu Sdn Bhd for clonal seedlings. This research was therefore conducted to investigate the effects of various types, methods and rates of fertilizers on the growth and leaf nutrient content of clonal palm seedlings. Two separated factorial completely randomized design polybag experiments were conducted at Gomantong Estate, Kinabatangan, Sabah. Experiment one showed no significant differences between all fertilizer application methods and rates on the vegetative growth of the seedlings. The results show that conventional fertilizer application was adequate to be recommended for the clonal palm seedlings in order to achieve standard vegetative growth before field planting. The results of experiment two also showed no significant differences between fertilizer ratio and rates on the vegetative growth and leaf nutrient content of the clonal palm seedlings. The results of the leaf nutrient content from the experiments was above the standard optimum nutrients required by oil palm seedlings. Symptoms of disorder known as white stripe that normally affect D x P seedlings was shown by the clonal palm seedlings. White stripe symptom was mostly observed on the clonal seedlings treated with higher rates of N. Based on foliar analysis results these clonal seedlings exhibited B deficiency as low as 10 (ppm) or below. Based on the result on these experiments the standard operating procedures for fertilizers (method of application, rate of application and NPK ratio) practiced by the industry is sufficient for the clonal seedlings. For experiment 1, based on the monetary cost benefit analysis the slow release fertilizer was RM0.05 cheaper than the conventional fertilizer per seedling. For experiment 2, with 10% increase in rate, the conventional ratio (F2) is cheaper than F1 by RM0.01 and for F3 by RM0.02 per seedling.



## **ABSTRAK**

### **KESAN BAJA TERHADAP PERTUMBUHAN DAN KANDUNGAN NUTRIEN PADA POKOK KELAPA SAWIT KLON**

*Pokok sawit klon menawarkan potensi untuk pengeluaran tandan yang lebih tinggi kerana mampu untuk menyeragamkan semua anak benih yang mempunyai entiti yang sama daripada sumber pokok kelapa sawit yang sangat produktif. Maklumat mengenai jenis baja, kaedah dan kadar penaburan baja yang sesuai untuk anak benih klon ini adalah terhad. Rekomendasi jenis baja, kaedah dan kadar baja untuk anak benih D x P masih menjadi asas dan digunapakai oleh Sawit Kinabalu Sdn Bhd untuk anak benih klon. Oleh itu, penyelidikan ini dijalankan untuk mengkaji kesan pelbagai jenis, kaedah dan kadar baja pada pertumbuhan dan kandungan nutrien bibit kelapa klon. Dua rekabentuk eksperimen polybag secara rawak yang berasingan telah dijalankan di Ladang Gomantong, Kinabatangan, Sabah. Eksperimen satu menunjukkan tiada perbezaan yang signifikan antara semua kaedah penggunaan baja dan kadar pertumbuhan anak benih klon. Keputusan menunjukkan bahawa aplikasi baja konvensional sudah mencukupi untuk mencapai piawaian pertumbuhan vegetatif sebelum penanaman ke ladang. Eksperimen dua juga tidak menunjukkan perbezaan yang signifikan antara nisbah baja dan kadar pada pertumbuhan vegetatif dan kandungan nutrien daun anak benih klon. Kandungan nutrien daripada analisis daun juga menunjukkan piawaian nutrient berada pada tahap yang ideal. Simptom yang dikenali sebagai jalur putih yang biasanya berlaku pada anak benih D x P dikenalpasti berlaku pada anak benih klon. Simptom ini kebanyakannya dikesan pada anak benih klon dimana penaburan N yang berlebihan dan daripada analisis daun dikesan apabila kekurangan B pada dibawah atau pada aras 10 (bpj). Berdasarkan keputusan kedua-dua eksperimen, standard baja (kaedah, kadar dan nisbah NPK) yang diamalkan oleh industry adalah mencukupi untuk pertumbuhan anak benih klon. Berdasarkan analisis faedah kos sebibit, baja SRF adalah RM0.05 lebih murah daripada baja konvensional. Manakala eksperimen dua, dengan kadar peningkatan 10%, nisbah konvensional (F2) adalah lebih murah daripada F1 sebanyak RM0.01 dan untuk F3 sebanyak RM0.02 untuk satu bibit.*

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## LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

<b>ANOVA</b>	-	Analysis of Variance
<b>Bpj</b>	-	<i>Bagian Per sejuta</i>
<b>CIRP</b>	-	Christmas Island Rock Phosphate
<b>CoPN</b>	-	Code of Good Nursery Practices
<b>CPO</b>	-	Crude Palm Oil
<b>CRD</b>	-	Completely Randomized Design
<b>DM</b>	-	Dry Matter
<b>FAO</b>	-	Food and Agriculture organization
<b>FELCRA</b>	-	Federal Land Consolidation & Rehabilitation Authority
<b>Hp</b>	-	Horse Power
<b>L</b>	-	Length
<b>LCP</b>	-	Legume Cover Plant
<b>LA</b>	-	Leaf Area
<b>LAI</b>	-	Leaf Area Index
<b>LDW</b>	-	Leaf Dry Weight
<b>LSD</b>	-	Least Significant Difference
<b>MAT</b>	-	Month after Treatment
<b>MOP</b>	-	Muriate of Potash
<b>MPOB</b>	-	Malaysian Palm Oil Board
<b>MS</b>	-	Malaysian Standard
<b>OER</b>	-	Oil Extraction Rate
<b>R</b>	-	Replication
<b>RP</b>	-	Rock Phosphate
<b>SAS</b>	-	Statistical Analysis System
<b>SKB</b>	-	Sawit Kinabalu Sdn Bhd
<b>SOA</b>	-	Sulphate of Ammonia
<b>SOP</b>	-	Standard of Procedures
<b>SRF</b>	-	Slow Release Fertilizer
<b>TE</b>	-	Trace Elements
<b>VM</b>	-	Vegetative Measurement
<b>W</b>	-	Width

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Oil Palm and clonal industry overview

Oil palm (*Elaeis guineensis*) is a tropical tree crop which is mainly grown for its industrial production of vegetative oil. Oil palm is a typical crop of the rainy tropical lowlands. The tree requires deep soil, relatively stable high temperature and continuous moisture throughout the year. Soil fertility is less important than the physical soil properties. Dry periods of more than three months do not specifically damage vegetative growth, but seriously affect the production and quality of the fruit bunches. Oil palm yield is not only determined by vegetative growth and production, but also by the way pests and diseases can be controlled or eradicated. The oil palm tree (*Elaeis guineensis*) is a member of the family *palmae*, subfamily *Cocoideae* (which also includes the coconut), genus *Elaeis*. Male and female inflorescences occur on the same tree in alternated cycles of the same sex, and are only differentiated after approximately two years. This process is influenced by moisture and temperature conditions, fertilization and other secondary ecological factors (Corley and Tinker, 2003).

The theoretical potential yield in oil palm is the maximum oil yield that can be obtained by simulation models. The yield potential is defined as the yield of the cultivar, adapted to the environment in which it is planted, with an adequate supply of nutrients and water with no pest and disease stresses (Evans and Fisher, 1999). Ginting *et al.*, (1993) reported that a selection of clones, planted on an area of 99 ha, could be harvested 24 months after field planting. The reported fruit bunch production for the first two years was 29% greater than in conventional D x P palms. The vegetative characters of the clones showed greater homogeneity with narrow leaf



pinnae and a lower leaf area index (LAI) than D x P materials. Clones produced 11.3 and 13 tonnes ha<sup>-1</sup> fruits bunch as compared to 8.7 and 10.2 tonnes ha<sup>-1</sup> for D x P palms in the first and second year of harvesting respectively in a trial by FELDA (Maheran and Abu Zarin, 1995). Clonal oil palm offers potential for greater productivity because it is possible to establish uniform tree stands comprising identical copies (clones) of a limited number of highly productive oil palms (Fairhurst and Mutert, 1999). In addition, improved standards of field agronomy have a greater effect on productivity. Cloning of the oil palm is a process in which identical or true-to-type 'photocopies' of a selected palm (ortet) are reproduced by developing plantlets from the leaf tissue of tenera oil palms with desirable characteristics such as high yields or oil products per hectare, precocity, diseases resistance, drought tolerance and small height increments. Greater amounts of fertilizer nutrient inputs are required to sustain higher yields in donal oil palm, but donal oil palms also use fertilizer nutrients more efficiently than D x P seedlings (Woo *et al.*, 1994). Therefore, in spite of the greater cost of clones compared with D x P material and their greater fertilizer requirements, clones offer a large economic advantage over D x P material. On average, the donal planting materials have been shown to have additional 10-15 % oil compared with D x P materials (Soh *et al.*, 1995). In 2009, production of donal oil palm in Malaysia was 2.53 million ramets and needs to be increased (Kushairi *et al.*, 2010).

Based on an overview of the Malaysian oil palm industry reported by MPOB and published in 2017, the Malaysian oil palm industry showed a sterling performance in 2017. Crude palm oil (CPO) production and fresh fruit bunch (FFB) yield witnessed significant increases following recovery from the impact of the El-Nino phenomenon a year earlier. According to Malaysian Palm Oil Board statistics (2018), higher palm oil prices and improved export demand helped push export earnings to RM77.85 billion, up from RM67.92 billion in 2016. Oil palm planted area in 2017 reached 5.81 million hectares, an increase of 1.3% as against 5.74 million hectares the previous year. Sarawak overtook Sabah as the largest oil palm planted state, with 1.56 million hectares or 26.8% of the total Malaysian oil palm planted area, followed by Sabah with 1.55 million hectares or 26.6% and Peninsular Malaysia with 2.70 million hectares or 46.6%.



In 2017, CPO production increased by 15.0%, reaching 19.92 million tonnes as against 17.32 million tonnes in 2016. The increase was due to higher FFB processed, up by 17.7% arising from higher FFB production that increased by 12.4%. CPO production in Peninsular Malaysia, Sabah and Sarawak increased by 19.0%, 7.6% and 15.1% to 10.58 million tonnes, 5.22 million tonnes and 4.13 million tonnes, respectively. The FFB yield improved significantly in 2017 by 12.4% to 17.89 tonnes per hectare as against 15.91 tonnes per hectare in 2016. FFB yield for Peninsular Malaysia increased by 18.6% to 18.70 tonnes per hectare as against 15.77 tonnes per hectare in 2016. Sabah's FFB yield registered an increase of 7.3% to 18.35 tonnes per hectare as against 17.10 tonnes, while that of Sarawak was equally higher at 16.13 tonnes per hectare, up by 8.5% compared to 14.86 tonnes per hectare in 2016. Total exports of oil palm products rose 2.9% to 23.97 million tonnes in 2017 from 23.29 million tonnes exported in 2016. Similarly, total export revenue increased sharply by 14.6% to RM77.85 billion as compared to the RM67.92 billion in 2016 due to higher export volume and price. In 2017, palm oil export earnings alone increased by 11.3% to RM46.12 billion as against RM41.44 billion in 2016. Palm oil export volume in 2017 increased by 3.2% to 16.56 million tonnes (Malaysian Palm Oil Board, 2017).

## **1.2 Nursery Management Overview**

In the oil palm plantation, the first and most important point of emphasis is the planting material, namely plants, germinated seed, ungerminated seed or clonal ortets. These should only be purchased from a reputable supplier. The ideal nursery site is on level or gentle sloping land, near a reliable water source but above the flood level, and has a soil source suitable for bag-filling nearby. The nursery system is meant to provide a controlled and conducive environment for oil palm seedlings to grow, especially during the young and critical age period. Two types of nurseries are the single stage nursery and the two-stage nursery. Both practices can be done in either polythene bags or in the field. In the pre-nursery stage, any unsuitable and unhealthy seedlings for oil palm replanting purposes are detected and removed (Sawit Kinabalu Policy, 2014). Therefore, the pre-nursery is a process of preparing and selecting oil

palm seedlings so that in the end, only the best seedlings or ramets will go through to the next stage, which is the nursery stage. Mulching in the nursery stage has been found to be beneficial. Water is essential for large number of physiological processes that take place within the seedlings, and the maintenance of an unrestricted water supply to seedlings requires constant vigilance to prevent over-watering and waterlogging. A modest and balanced fertilizer supply is also very important. A disease that is very common in the nursery is leaf spots. Pest that attack seedlings include night flying beetles, crickets, grasshoppers and leaf cutting ants. Thus, spraying of fungicide and insecticide is a common practice in the nursery (Sawit Kinabalu Policy, 2014).

### **1.3 Justification**

The yield potential for oil palm's 20 year productive life is fundamentally defined during the first 12 months, from seed planting in the nursery until the planting at the field (Turner and Gillbanks, 2003). A major precondition for the development of any tree crop is the provision of good quality uniform planting material selected for vigour and correctly planted at the appropriate planting density. While mistakes in upkeep can be corrected, negligence in nursery selection has a detrimental effect on yields throughout the productive life of the stand and cannot be corrected easily. Much greater uniformity is to be expected once clonal material is introduced, but as long as seedlings are raised from seed, a good nursery and ruthless culling are the cornerstones for the development of high yields and efficient fertilizer utilization.

Fertilizer application is among the most important tasks in oil palm cultivation. It is costly and constitutes about 25% of the operational cost during the nursery period (Sawit Kinabalu Policy, 2014). To ensure healthy palm growth and to prepare the palm to sustain high yields during the productive years it is essential and important to ensure that fertilizer application is done correctly and that all palms receive adequate and balanced nutrition.

The principles of the nutrient budget have served us well as evidenced by the high productivity of oil palm despite it being grown largely on weathered, degraded soils in the tropics. This deficiency must be addressed quickly to understand the various phenomena seen in the fields, such as pre-mature frond desiccation, relationship between pest and diseases and palm nutrition, the root system and its mechanism for nutrient uptake, and the roles of plant nutrition in climate change amongst others and develop new directions for studying plant nutrition and better, practical fertilizer use technology. Recent agronomic data are now available and these experiments are conducted with later generation of planting materials and current recommended management practices on more diverse soil types and environments, which are probably more relevant to the oil palm industry today. Consequently, it appears logical to conduct another meta-analysis of these data. The palm oil mills should be regarded as large stores or reservoirs of nutrients/fertilizers and carbon/organic matter. The current methods to utilize these resources are still tedious, laborious, cumbersome and limited to specific areas. Technology, techniques and equipment are now available and there are hardly any reasons why these studies cannot be undertaken successfully. What is needed is creativity and ingenuity to solve our problems. Thus, the future of effective fertilizers, fertilizer use efficiency and fertilizer management, and the consequent productivity of oil palm reside in continuous generation of new applicable sciences, adoption of new technologies and designing new methods to implement them correctly and efficiently, and reducing the uncertainties related to fertilizer management (Ng *et al.*, 1999).

#### **1.4 Significance of the study**

Fertilizer management plays a pivotal role in the productivity and profitability of the oil palm. At times of high fertilizer costs and/or low palm oil prices, questions about how fertilizer rates can be trimmed and risks managed will be frequently asked. Unfortunately, there are no general quick fixes and individuals have to assess for themselves the risks they are willing to take (Murrell, 2009) and falling back to the guiding principles of fertilizer management of oil palm. Based on the experiments, a

few recommendations can be suggested to planters or individuals who use the new planting material of clonal palm to improve vegetative growth and achieve optimum nutrient uptake for better field planting. Greater amounts of fertilizer nutrient inputs are required to sustain higher yields in clonal oil palm, but clonal oil palms also use fertilizer nutrients more efficiently than D x P seedlings, (Woo *et al.*, 1994). This study will assess the different fertilizer requirements between D x P and clonal palms at nursery stage. The purpose of this study is to determine the fertilizing method and best rate of fertilizer application for clonal ramets where currently there are no standards or guidelines of recommended fertilizing practice for clonal ramets. In addition, the symptom of disorder known as white stripe affecting D x P seedlings at 6 to 12 months old is unknown for ramets. A likely explanation for this symptom is nutrient imbalance (Gillbanks, 2003). This study could assist agronomists to recommend the appropriate fertilizer applications for clonal ramets instead and to review the new fertilizer rate requirements for the D x P for excellent growth, cost effectiveness, culling rate and age for field planting. A good management especially in fertilizer application for optimum nutrient uptake will determine the yield potential of the oil palm at first year of harvest. The capacity of the nursery area can be maximally utilized if the culling rate is reduced. The labour requirements also thus indirectly reduced as well as the cost of production.

This study can provide the fertilizer recommendations to the industry especially for the clonal palm at the nursery stage. Appropriate methods of fertilizer application and accurate ratio of NPK will determine the optimum yield per hectare during the first year of harvesting. Optimum fertilizer will supply sufficient nutrients in balanced proportion to ensure healthy vegetative growth and optimum economic yields and to minimize waste related to over-fertilizing. By using appropriate methods and ratio of fertilizer application, the potential yield of clonal palms which is 10%-15% higher than conventional D x P material mentioned by Soh *et al.* (1995) can be achieved.

## **1.5 Objectives**

The main objectives of the study are:

- a. To compare the effects of fertilizer application methods and rates on the growth of ramets at the nursery stage.
- b. To compare the effects of different NPK ratios and application rates on the growth of ramets and leaf nutrient content at the nursery stage.
- c. To estimate the monetary cost benefit for the fertilizer management options.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Oil Palm seedlings and clonal ramets morphologies

The seedling develops from the small embryo located in the kernel close to one of the micropyles, with the young shoot and root, or plumule and radicle, emerging through the micropyle as a button-shape organ. After emergence, faster development is shown initially by the radicle, which rapidly develops a secondary root system from the main elongation. For the early development phase, the young seedlings derives its nourishment from the nutrient reserves stored in the kernel. Inorganic nutrients can be absorbed by the new root system, but organic nutrition, other than utilisation of seed resources, is delayed until the emergence of the first leaf, when assimilation through photosynthesis can occur. The first green leaf becomes pronounced about one month after germination, with a new leaf produced at intervals of a little under one month for the first six months (Turner and Gillbanks, 2003).

Production of oil palm clones has been technically possible since the late 1970's. Unfortunately, the high cost and technical problems related to the development of abnormalities proved to be severe constraints on the rapid development of this approach to oil palm planting (Turner and Gillbanks, 2003). Techniques have been developed to provide the necessary procedures for large scale, rapid multiplication of selected individual palms. The tissue culture technique involves taking small pieces of plant tissue from a selected palm or ortet and growing them on a nutrient medium (Sawit Kinabalu Biotech Policy, 2014). Many tissues were initially tried, with experimentation continuing on different tissues, including pollens and anthers. The greatest success has been found when using tissue carefully extracted from the region of the meristem, without killing the ortet. The excised tissues develop into a callus, which is a mass of disorganised cells.



## **2.3 Type and stages of oil palm nursery**

There are two types of nurseries, single-stage nursery and double-stage nursery. For each type, planting is done in polythene bags. Double stage nursery, as compared to the single stage nursery are preferred, because they require less space and irrigation, and allow for more efficient upkeep and selection, especially during culling (Sawit Kinabalu Policy, 2014). However, the double stage nursery involves transplanting pre-nursery seedlings to the main nursery, which if done improperly, may cause transplanting shock (Heriansyah, 2001). In the one stage nursery, germinated seeds are planted directly into large polythene bags. On the other hand, in the double-stage nursery, the germinated seeds are planted in small polythene bags first called pre-nursery, followed by transplanting to large bags after three or four months. In the main nursery, three months old seedlings or ramets are transplanted directly into the large polybag (Sawit Kinabalu Policy, 2014; Malaysian Palm Oil Board, 2013).

### **2.3.1 Pre-nursery stage**

The pre-nursery methods to be adopted depend on the stage at which the planting material is distributed to the nursery. Pre-nurseries can comprise baskets or beds (less commonly used) and polythene bags. Fertile topsoil which is sufficiently free-draining, to prevent 'puddling' or sealing of the surface, is required. A mixture of good structured soil and sand is usually used in Malaysia, in suitable proportions. The use of too much sand will cause the soil to break during transplanting to the nursery. A polythene bag of 25 cm x 10 cm lay-flat size is currently used. The bags are filled to within a centimetre from the top (Sawit Kinabalu Policy 2014).

### **2.3.2 Main nursery stage**

Pre-nursery seedlings are transplanted into main nursery polybags measuring 40 cm x 45 cm, 500 gauge, black UV stabilized and containing soil prepared in the same manner as for the pre-nursery. A 25 cm deep hole is made with a trowel or a cylindrical core

cutter in each main nursery polybag. The seedling is then transplanted after removing the pre-nursery polybag. Temporary shade and watering should be applied immediately following transplanting to reduce transplanting shock. Also, a 2.5 cm deep layer of disease free mulch should be uniformly spread around the seedling soon after transplanting to prevent soil erosion, to regulate soil moisture and soil temperature, and to suppress weed growth in the polybag (Sawit Kinabalu Policy, 2014).

## **2.4 Seedling quality control at nursery stages**

Seed requirements, delivery schedules and transport logistics must be planned and coordinated with other nursery and estate operations (Seed Production Unit Policy, 2014). Insist on the best quality planting material, whether it is seed, pre-germinated seed or clonal ramets. The seed order, including transport and delivery details, must be completed no later than nine months before nursery planting is scheduled (Sawit Kinabalu Policy, 2014). If the estate planting programme is planned to continue for many years, the orders can be pre planned up to four years in advance. All planting material must be purchased from a reputable supplier and be free of diseases and pests. The progeny details and origin should also be known (Sawit Kinabalu Biotech Policy, 2014). In pre-nurseries, exposure to sunlight at midday should not exceed 75% until the last two weeks before transplanting. In the main nursery, the seedlings should not be exposed to more than 50% sunlight until the four-leaf stage, when shade should be progressively removed. Keep the polybags completely free of weeds which might otherwise compete with the oil palm seedlings for nutrients, moisture and sunlight. Ground weeds are controlled to provide hygienic conditions and to assist drainage. Weeds in drains are controlled to allow rapid flow of excess water out of the nursery after irrigation or rainfall (PPBOilPalms Manual, 2007).

### **2.4.1 Methods of fertilizer application**

Based on Sawit Kinabalu Policy, 2014 for nursery practices, the first four months after transplanting from the pre-nursery, a N P K Mg fertiliser of 15:15:16:4 composition is



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