

INNOVATION IN AGRICULTURAL SUPPORT ON SUSTAINABILITY FOR FRESH FRUIT BUNCH (FFB) OF ELAIS GUINEESIS IN MALAYSIA USING ARTIFICIAL DOMESTIC POLLINATION SYSTEM (ADOPSY™)

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Abstract

Sustainability of the Fresh Fruit Bunch (FFB) is one of the most important elements at the plantation level. Most of Oil Palm planters at this stage do not get the desired result of output production due to inconsistency of number of fresh fruit bunch on the plants. The main element to ensure plants producing FFB at a sustainable level is to keep the existence of the weevil for pollination. Nowadays it is hard to ensure the population of the weevil in right condition constantly due to misconduct of the biodiversity as well as ecosystem in the plantation areas. Weevil species (*Elaeidodius kamerunicus*) brought by an entomologist, Syed Anwar Rahman, from Cameroon to Malaysia managed to increase the number of fruit set in 1981. Hence, this research is carried out to determine the new method of pollination that should help planters to get sustainable output of FFB in term of quantity. The main purpose of the research is to get sufficient numbers of FFB at individual oil palm plant using Artificial Domestic Pollination System (ADOPSY™) that was invented by the researcher. Applied research base on case study undertaken in Felda Cawangan Tembangau 6, Pahang, under the management of Felda Global Venture (FGV). Data collection completed by the FGV staff by using standard format so called "Bancian tandan hitam" or Fresh Fruit Bunch Census Format without influences by the researcher, ensuring data corroborated. The data is analyzed to examine the development in term of production referring to the increased quantity of fresh fruit bunch. FGV was chosen due to its worldwide establishment among the biggest oil palm production conglomerate in Malaysia. The most vital finding of this research is to confirm that the technology (ADOPSY™) and supported product (PreMix-SP) used in this research, would produce sustainable output production of FFB. The research demonstrated the increasing value of production of FFB by implementing check and control method under treated test plot compared to untreated test plot for period of one year. This research will also facilitate opportunity profit by eliminating defect, referring to decreasing numbers of abortion in plantation production.

Keywords: Weevil, artificial pollination, male inflorescence, female inflorescence, abortion

Abstrak

Kelestarian atau kemampuan pengeluaran Buah Tandan Segar (BTS) adalah salah satu faktor utama didalam produktiviti pengeluaran kelapa sawit diperingkat ladang. Kebanyakan penanam kelapa sawit tidak memperolehi hasil yang diharapkan disebabkan ketidak mampanan pengeluaran hasil. Element utama didalam penentuan pengeluaran hasil sawit yang mampan adalah memastikan kewujudan serangga berfaedah sebagai agen pendebungaan. Masa kini, amat sukar untuk menentukan kehadiran atau populasi serangga berfaedah ini disebabkan kegagalan untuk

memelihara dan menjaga biodiversiti dan juga ekosistem ladang. Pada tahun 1981, Syed Anuar Rahman telah berjaya membawa masuk dari Cameroon ke Malaysia serangga berfaedah dari sepsis *Elaeiodius kamerunicus* bagi tujuan pendebungaan yang telah berjaya meningkatkan hasil sawit. Maka dengan itu, kajian ini adalah untuk menentukan satu kaedah pendebungaan buatan yang bersistem yang akan memberikan peningkatan hasil Buah Tandan Segar (BTS) dari segi jumlahnya. Tujuan utama kajian ini dilakukan ialah untuk memastikan bahawa setiap pokok kelapa sawit akan mengeluarkan Buah Tandan Segar (BTS) disebabkan oleh aplikasi pendebungaan buatan iaitu Artificial Domestic Pollination System (ADOPSY™) yang telah direka khas oleh penyelidik. Hasil penyelidikan ini berdasarkan kepada penyelidikan guna menggunakan kajian kes bagi menentukan penggunaan teknologi yang betul dalam aplikasi kecekapan peningkatan hasil di ladang, seterusnya dapat menghindarkan kecacatan pengeluaran iaitu mengurangkan jumlah bunga jantan. Penyelidikan guna ini telah dilakukan di Felda Cawangan Tembangau 6, Pahang di bawah pengurusan Felda Global Venture (FGV). Data-data telah dikumpulkan oleh kakitangan FGV sendiri dengan format piawaian yang diguna pakai iaitu Bancian Tandan Hitam atau *Fresh Fruit Bunch Census Format*, dengan ini menjadikan data-data tersebut sebagai data-data yang disokong dan telus. Data-data tersebut kemudiannya akan dianalisis bagi menyokong sebarang peningkatan pengeluaran dari sudut jumlah tandan buah segar yang dihasilkan. FGV telah dipilih sebagai subjek penyelidikan memandangkan ianya merupakan konglomerat yang dikenali dunia dan juga antara pengeluar hasil sawit terbesar di Malaysia. Objektif yang paling penting dalam penyelidikan ini adalah untuk menentukan sama ada teknologi yang digunakan iaitu Sistem Pendebungaan Buatan Domestik atau *Artificial Domestic Pollination System* (ADOPSY™) serta produk sokongannya iaitu PreMix-SP ini mampu untuk meningkatkan jumlah tandan buah segar atau tidak. Seterusnya, peningkatan jumlah tandan buah segar pasti akan meningkatkan hasil pengeluaran. Penyelidikan ini menunjukkan perubahan dalam jumlah penghasilan tandan buah segar selepas rawatan berbanding dengan pokok yang tidak dirawat dibuat bagi tempoh satu tahun. Penyelidikan ini juga akan membantu dari sudut peluang keuntungan atau *opportunity profit* dengan menghapuskan kecacatan pengeluaran di peringkat ladang.

Kata kunci: Serangga berfaedah, pendebungaan buatan, bunga jantan, tandan buah segar

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1.0 INTRODUCTION

Artificial Domestic pollination system (ADOPSY™) is a name given to a method of pollination, which is done by human instead of weevil as the agent of natural pollination. The word of 'domestic' is representing the same breed of pollen. The main problem is the shortage and inconsistent number of weevils that to carry out the pollination tasks effectively, hence the number of *FBB* decreasing tremendously throughout the year. Kevan and T.P. Phillips [1]. ADOPSY™ had been implemented as pilot initiative in 2007 at Felda Bukit Rokan Utara, Gemenceh, Negeri Sembilan where the technology showed a positive result that was, able to increase the number of *FBB* at the oil palm plantations. The implementation of ADOPSY™ was introduced to other plantation areas such as FELDA (Federal Land Development Authority), Felda Jelai 2, under management of Felda Technoplant, Negeri Sembilan, Cawangan gugusan Keruak, Besut, Terengganu under management of Federal Land Consolidation and Rehabilitation Authority (FELCRA). Nowadays, it is hard to ensure the populations of the weevils in the right condition due to the misconduct of the biodiversity, as well as the ecosystem in the plantation areas. Anders *et al.* [2]. Man-made pollination should be implemented widely to oil palm plantation to ensure sustainable output of *FBB* rather than waiting for the weevil to do pollination. It is found necessary to investigate new method to increase pollination activity to increase yield. C.I Aisagbonhi *et al.* [3]. Assisted pollination should be implemented to overcome the low numbers of fruit sets. In 1970, Malaysian Oil Palm Board (MPOB) had carried out

research that showed oil palm plant could be pollinated using hand pollination. In 1988 at MPOB, assisted pollination using an amount of pollen was carried to mature oil palm plant, age of 12 years using DXP clone. Man-made pollination can be achieved by using pollen that was collected from the male anthesis by human. This initiated the practice of assisted pollination, so called hand pollination in order to increase the pollination activities. Hartly [4].

Production of *FBB* is influenced by many factors such as carbohydrates supply, nutrient, water and pollinator and recent research found that the most significant factor in increasing the numbers of *FBB* is pollination activities. Mohd Hanif and Mohd Roslan Md Noor [5]. Inefficient pollination activities will decrease yield. Nowadays, planters depend on weevil to do pollination for their oil palm plants. This is the most natural method of pollination. Syed Anwar Rahman introduced weevil that could help pollination activity in oil palm in 1981. His team members brought the weevil, *Elaeiodobius kamerunicus*, in elevating pollination activities in Malaysia where first introduced at Unilever oil palm plantation. Syed R.A [6]. The initiative was a great success proved to have increased Malaysian oil palm production. At present, the population of this weevil is question.

Oil Palm plant is monoecious which means both male and female flower are produced by the same plant. This unique plant will obviously be able to produce female or male inflorescence at the same tree. D.C Forero *et al.* [7]. Planters of course would like to have more female flowers rather than male flowers produced by the plants because, female flowers will produce fruits. In fact, the oil palm plant still needs

male flower which carries pollens for pollination to take place and thus turning the female flowers to fruits. Before Syed introduced weevil, in the past, planters assumed that oil palm plant is pollinated fully by wind circulation as known as anemophilous plants. Barbara Gemmill et al. [8].

This applied research base on case study was conducted to prove that the decreasing potential yield was because of lack of pollination activities in plantation area due to low population of weevil. The valuable weevils were not appearing for pollination task effectively hence cause to low yield. Yield is calculated by weight (quality) multiply by numbers (quantity) of fresh fruit bunch, and this case study research also determined the quality of fresh fruit bunches that are produced by adopting ADOPSY™. The element of controls for examples, fertilizer, and plantation maintenance are considered constant. Figure 1 shows common view of aborted anthesis in oil palm plantation due to lack of pollination activities and Figure 2 shows numbers of inflorescences were turned into abortion instead fruit bunch.



Figure 1 Aborted anthesis in Oil Palm



Figure 2 Inflorescences were turned into abortion instead fruit bunch

2.0 MATERIAL AND METHOD

Male anthesis inflorescences enrich with pollen were collected from the plantation for fermentation process using *PreMix-SP*, a product invented by researcher for a medium of pollen germination. *PreMix-SP* is a germination medium containing glucose, water and phototropic bacteria to ensure the pollen stay fresh under anaerobic fermentation.

Quantity usage of male anthesis inflorescences is depending on the size of anthesis. In average, 4 numbers of anthesis should be use for an area of 4 hectares having plants ages between 4 to 15 years. An anaerobic fermentation using hermetic tank is essential to avoid from possibility of contamination during fermentation process. Only viability and reliability of pollen should be carefully taken on site. The oil palm is considered a good pollinizer because it contains plentiful pollen, compatible and viable. Appiah et al. [9].

Fermentation solution using *PreMix-SP* will be left for 1 day but not more than 7 days for germination process. This paramount stage will ensure all pollen at spikelet spreading all over the medium. This processes is solved the issue of pollen storage. K.A Myint et al. [10]. Fermented solution then will be sprayed using Mist Blower at bunch area of oil palm and all over the leaf. The solution contains glucose, which was appeared from fermented process using industrial crude sugar and beneficial microbes. The fermented solution can be used in seed treatment and make organic sprays to accelerate photosynthesis process. S.Sivasubramanian et al. [11].

The technique of spraying at individual plant is vital since using a wrong technique will not give any desired result. This procedure is an innovation to the earlier method of hand pollination. Hand pollination is the method where pollen is collected and then applied straight away by puffing directly to young petals. The practice of hand pollination seems halted due to labor intensive that cause noneconomic to pursue now days in this rapid growth of plantations.

Male inflorescences begin to open from the base of the spikelet and all flowers remain open within 2 days, and may take up to 4 days during wet weather. Most pollen is shed during 2 or 3 days following the start of anthesis, and production ceases within 5 days. Hartley [4]. During anthesis, the strong scents generated will attract weevil to propagate pollination, by transference of pollen to the female inflorescence. This finding from Hartley, the period of pollination, is the most important factor for artificial domestic pollination system to be implemented. Knowing the period of 'ready to pollen' for inflorescence for being recipient is paramount important for application. That makes intervals of the process of spraying the pollen has decided for 4 intervals per year. In reality no one knows the right time of 'ready to pollen' will be, this is because of the individual plant behavior most likely depends on geographical area cultivated and also on soil condition and changing of weather. However, to avoid from these potential problematic conditions, the

interval of implementation of 4 times per year of artificial domestic pollination system has proven able to eliminate those uncertainties.

3.0 RESULT AND DISCUSSION

Censuses on *FBB* were carried out and the raw data represents the numbers of *FBB* appeared at individual plant. Plants have been identified as at specific row and each has individual identity (ID) by number with in each plot. There were 6250 plants of 50 hectare Yangambi breed ages of 15 year treated area implemented by *ADOPSY™*. This applied research is based on case study, mainly to find out the increase in numbers of *FBB* due to the treated (applying *ADOPSY™*) compared to untreated plot. There were 21 plots involved in the case study under Block 29 which consist of almost 100 hectare in total. To avoid from any data discrepancy, data from each treated and untreated were taken for 2 hectares (500 plants) respectively for further evaluation of 1 hectare (125 plants) for finding.

Raw data was quantitative referring to numbers of *FBB* recorded in every 4 month per year and first recorded on mid of March 2013. Implementation of *ADOPSY™* started early June 2013 and ended in March 2014. *ADOPSY™* has 4 intervals per year, which means every 3 month. Last bunch census recorded was in April 2014. The raw data was then analyzed using SPSS software for any pattern changes from the behavior of the treated plant.

Earlier, in 2012 series of industrial symposium were conducted to disseminate knowledge on artificial domestic pollination system throughout the country especially targeted to plantations operators. The main objective of the industrial symposium is to gathered information and collected opinions, comments and feedback from the subject matter experts. The finding from the questionnaires sampled taken from 100 participants from the series of industrial symposium were analyzed.

3.1 Finding from Industrial Symposium

The purpose of Industrial Symposium is to deliver the firsthand knowledge of the whole *ADOPSY™*'s concept to technical and nontechnical. Participants are among the plantation operators in Malaysia. They are from higher management to medium range such as CEO, General Manager, Plantation Advisors, Plantation Coordinators, Senior Agronomists and Managers.

Participants have been provided with questionnaire survey to establish their anonymous feed- back referring to question developed to ensure these key plantation industry players are able to understand this new system. The most paramount important is for them to accept and believe in confidence the whole concept and willing to implement the system on their plantations. Questionnaire was developed in a way that the

participant may answer in easily using Likert-scale answers. The questionnaire's result had been analyzed by (the techniques besides the tool) SPSS and only the most important characters will be discussed in this short article.

The reliability of the data from questioners was evaluated using Cronbach's alpha. The reliability test is paramount before further analysis and discussion. The most commonly used indicator of internal consistency is Cronbach's alpha coefficient. Ideally, the Cronbach's alpha coefficient of scale should be above than 0.7. In this case study the Cronbach's alpha coefficient was 0.813.

3.1.1 Demography

A few of the respondents (19%) had lower level of education college certificates. 2 percent of the respondent have higher education, Master or PhD. 37 percent had diploma and 42 percent were degree holders. It is important to know the level of education that the plantation operators possessed as the right technical approach need to be determined. The participants were also asked if their qualification has any relation to agriculture and 84 percent said yes and 16 percent participants' qualifications were not link to agriculture. As mentioned, levels of participants were mix with management and finance. The most important aspect of this finding is to determine the level of confidence from participant about the system. Result showed none of them reject the *ADOPSY™* as a system as shown in Figure 3.

Frequency

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid yes	84	84.0	84.0	84.0
no	16	16.0	16.0	100.0
Total	100	100.0	100.0	

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid certificate	19	19.0	19.0	19.0
diploma	37	37.0	37.0	56.0
degree	42	42.0	42.0	98.0
others	2	2.0	2.0	100.0
Total	100	100.0	100.0	

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid neither agree nor disagree	15	15.0	15.0	15.0
agree	62	62.0	62.0	77.0
strongly agree	23	23.0	23.0	100.0
Total	100	100.0	100.0	

Figure 3 Education background and acceptance of respondents

3.1.2 Concern on Sustainability of Production

From the result shown in Figure 4, obviously 100 percent of the plantation operators are concern about low number of *FBB*. None of them shows rejection of the whole concept and ready to implement the system. The result shows plantation operators understood and accepted the technical aspects revealed to them about the system.

Frequency

IS UNSUSTAINABLE PRODUCTION OF FFB IS YOUR CONCERN

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid yes	100	100.0	100.0	100.0

GOOD SYSTEM

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid neither agree nor agree	5	5.0	5.0	5.0
agree	59	59.0	59.0	64.0
strongly agree	36	36.0	36.0	100.0
Total	100	100.0	100.0	

NEED TO BE IMPLEMENTED

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid nethier agree nor agree	6	6.0	6.0	6.0
agree	65	65.0	65.0	71.0
strongly agree	29	29.0	29.0	100.0
Total	100	100.0	100.0	

Figure 4 Statistics selected result from Industrial Symposium

3.2 Finding from Raw Data (FFB Census)

Raw data was collected and first recorded using Excel datasheet, which was then analyzed using (the technique) SPSS software. Bunch census has been recorded to determine the change behavior of individual plan due to treatment (applying *ADOPSY™*).

The data was first analyzed for reliability before further analysis and discussion. According to Pavot et al. [9] the satisfaction with Life Scale has good internal consistency, with a Cronbach alpha coefficient reported of 0.85. In this case study, the Cronbach alpha coefficient was 0.869.

Figure 5 shows the result before treatment at first interval. There were 11 valid parameters calculated representing the highest quantities of *FBB* of 11 bunches appeared at 1 plants respectively while 34 plants did not produced any *FBB*.

➔ Frequencies

[DataSet4]

Statistics

UNTRTDFirst

N	Valid	125
	Missing	0

UNTRTDFirst

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 0	34	27.2	27.2	27.2
1	31	24.8	24.8	52.0
2	21	16.8	16.8	68.8
3	22	17.6	17.6	86.4
4	10	8.0	8.0	94.4
5	4	3.2	3.2	97.6
6	2	1.6	1.6	99.2
11	1	.8	.8	100.0
Total	125	100.0	100.0	

Figure 5 First data for untreated plot on Mac 2013

In this case study, other operation parameters are assumed constant, for example usage of fertilizers, pruning, plantation maintenance and effect of weather. Both treated and untreated plants are in the same area of study. From the result 34 numbers of plants were not producing any bunch at all. Overall plants studied under this case study was 500 plants, which means 250 plants represent 2 hectares treated and 250 plants represent 2 hectares untreated. There were only 125 plants analyzed under treated plot and another 125 plants were analyzed under untreated plot. Each plot was 1 hectare with 125 plants. The final conclusion describes the tangible findings on the treated plot compared to the untreated plot. This approach of data collection will overcome any data discrepancy that could arise. Treatment has been carried out early March 2013 where the analyzed data for treated plot is shown in Figure 6 below representing first treatment at first interval.

➔ **Frequencies**

[DataSet4]

Statistics

FIRSTINTVL		
N	Valid	125
	Missing	0

FIRSTINTVL

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 0	34	27.2	27.2	27.2
1	23	18.4	18.4	45.6
2	28	22.4	22.4	68.0
3	19	15.2	15.2	83.2
4	12	9.6	9.6	92.8
5	4	3.2	3.2	96.0
6	2	1.6	1.6	97.6
7	2	1.6	1.6	99.2
8	1	.8	.8	100.0
Total	125	100.0	100.0	

Figure 6 Result from data collected at first interval

Data collected from first interval of treatment and during this period, ADOPSY™ has been carried out in early March 2013. The first interval data was recorded in the middle of March 2013. From the result 34 numbers of plants were not producing any *FBB* at all. This means that the “non-producing plant” (plant not producing *FBB*) is having the same behavior as the plants in the untreated plot. During the first intervals of the treatment the highest number recorded was only 1 plant producing 8 numbers of *FBB*. The application of ADOPSY™ at this stage did not produce any effect as the pollinated female inflorescences if any have not turned into bunch.

Figure 7 below shows impressive development of *FBB* in numbers. As the result after second interval of ADOPSY™ result from data after four month treatment shows that there were 4 plants produced the highest numbers, 13 *FBB*, while only 6 plants were not producing any fruit. Total number of *FBB* at second intervals was recorded as 767 which means an increased by 69% from the first interval, the data recorded as 238 numbers of *FBB*.

➔ **Frequencies**

[DataSet4]

Statistics

SECINTVAL		
N	Valid	125
	Missing	0

SECINTVAL

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 0	6	4.8	4.8	4.8
1	3	2.4	2.4	7.2
2	5	4.0	4.0	11.2
3	9	7.2	7.2	18.4
4	16	12.8	12.8	31.2
5	12	9.6	9.6	40.8
6	19	15.2	15.2	56.0
7	20	16.0	16.0	72.0
8	8	6.4	6.4	78.4
9	8	6.4	6.4	84.8
10	6	4.8	4.8	89.6
11	7	5.6	5.6	95.2
12	2	1.6	1.6	96.8
13	4	3.2	3.2	100.0
Total	125	100.0	100.0	

Figure 7 Result from data collected at second interval treated

Figure 8 describe the pattern of development due to implementation of ADOPSY™ in a period of one year of the case study. The graph clearly shows that there was no sign of improvement in numbers of *FBB* in first interval, middle of March 2013. Hartley [2] mentioned that most pollen is shed during 2 or 3 days following the start of anthesis, and production ceases within 5 days, it means that the recipients (receiving inflorescences) appearance was not clearly defined as *FBB* yet at first time bunch census was recorded.

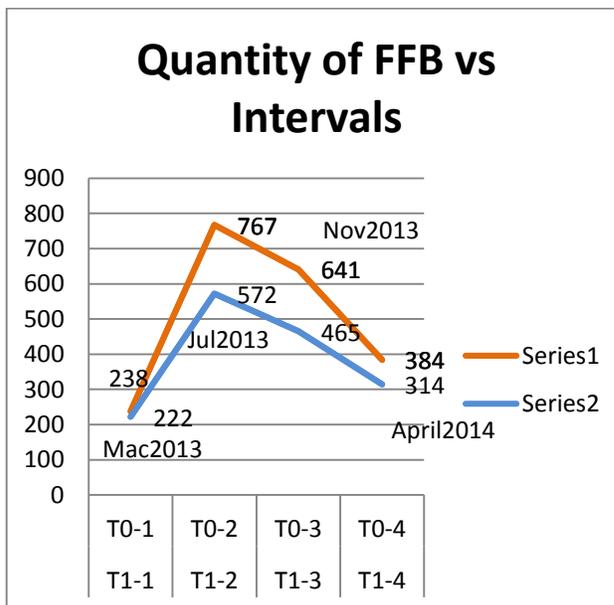


Figure 8 Line Graph shows overall result of fruit development (comparing treated to untreated plots)

Second interval (applying ADOPSY™) was carried out in early June 2013 while second bunch census was carried out in July 2013. The long period of 4 month after first interval produced more numbers of FBB from first interval where the FBB turned to maturity. There were lower but also increasing in numbers of FBB at the untreated plot. Weather (uncontrolled element) that was assumed as constant was affecting both plots. In this study the changes in weather improves both plots. If the weather did not change, the improved data will only recorded in the treated plot, but not the untreated plot. As shown in Figure 8, the difference in the total FBB in the first interval was 16, but in the second interval were 195.

There are two major factors that are considered in explaining the findings. First is the crop and second is the yield. Those two items are related and interdependent in calculation but have different meaning. Referring to the data, under untreated case, total quantity of FBB produced on 1 hectare was 1573 in numbers, while the quantity of FBB produced after ADOPSY™ treatment was 2030 in numbers. Both set of data were represented 1 hectare each taken on the same area of plantation under case plot in Block 29.

Data collected was the number of FBB on the plant. To calculate the yield, the average weight of FBB for a year is considered due to yield is crop (quantity) multiply by weight (quality). Average weight recorded was 15kg per bunch, for both treated and untreated plot, means that, there was no change on quality of FFB and as the result, the yield calculated as 23.6 ton per hectare per year for untreated plants. The result shows that, for treated case plot, the yield calculated using the average of FBB produced was 30.5 ton per hectare per year during the period. This figure brings to the conclusion that, there was an increase of 6.9 ton per hectare or about 29% increase of fresh fruit bunch.

4.0 CONCLUSION

In economic point of view, based on the present price of FFB during the research, which was RM650 per ton, would bring the gross profit of RM 4, 4550.75 per hectare. After deduction of cost of the ADOPSY™ application which was RM1440.00 per hectare per year opportunity profit gain for the first year of implementation of the system could be achieved RM 3,015.75 per hectare per year. FGV has an average of 350,000 hectare of land cultivated by oil palm. Considering FVG would implement the artificial domestic pollination system (ADOPSY™) for whole area, FGV will gain on opportunity profit for first year of RM 1,055,512,500.00. According to Dr. Yusuf Basiron (2007), who was the Chief Executive Officer of Malaysian Palm Oil Council (MPOC), he stressed that "in the end, it is about producing more on a less land, which is vital for a sustainable agriculture". Yusuf Basiron. [12].

This case study also indicates that the increase of crops by quantity will of course increase in yield. Plantation operators normally measure the quality of FFB. The quality of FFB is subjective to land area of plantation and also varies according to management point of view. Management decides on usage of any type of fertilizer, pruning intervals and so on. This case study has successful materialized the tangible finding by increasing the quantity of fresh fruit bunch. The increased in terms of the numbers of fresh fruit bunch produced by the plant after the ADOPSY treatment, are also depicted by sample of plant in Figure 9(a) and Figure 9 (b).



Figure 9 (a) Oil Palm after treatment by ADOPSY™, eventually increase numbers of FFB



Figure 9 (b) ADOPSY™ is mean artificially increase pollination activity

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References

- [1] Kevan, P. G. and T. P. Phillips. 2001. The Economic Impact Of Pollinator Decline: An Approach To Assessing The Consequences. *Conservation Ecology*. 5(1): 8.
- [2] Anders S. Barod, Melanie Hagen, and Finn Borchsenius. 2011. Twenty-Five Years Of Progress In Understand Pollination Mechanisms In Palm (Arecaceae). *Annals of Botany*. 108: 1503-1516
- [3] C. I. Aisagobonhi, Norman Kamarudin, C. O. Okwuagwu, Mohd Basri Wahid, Tervor Jackson and V. Adaigbe. 2004. Preliminary Observation on a Field Population of The Elaidobius Kamerunicus in Benin City, Niegeria. *International Journal of Tropical Insect science*. 24(3): 255-259.
- [4] Hartley, C. W. S. 1988. *The Oil Palm (Elaeis guineensis)* Jacq. Longman Scientific & Technical. 761.
- [5] Hohd Hanif Haron and Mohd Roslan Md. Noor. 2002. Fruit Set and Oil Palm Bunch Component. *Journal of Oil Palm Research*. 14(2): 24-33.
- [6] Syed, R. A., Law, and Corley, R. H. V. 1982. Insect Pollination Of The Oil Palm: Introduction, Establishment And Pollinating Efficiency Of Elaiedobious In Malaysia. *The Planters*: 58: 547.
- [7] D. C. Forero, P. Hormaza and H. M. Romeo. 2012. Phenological Growth Stage Of African Oil Palm (*Elaeis guineensis*). *Annal of Applied Biology*. 160 (2012): 56-65.
- [8] Barbara Gemmill, Connal Eardley, Peter Kwapong. 2004. African Pollination Initiative. Workshop on Solitary Bees: Conservation, Rearing and Management for Pollination. *International Journal Of Tropica Insect*. April 26-30.2004. ICIPE and CABI.
- [9] Appiah, S. O. and Agyei-Dwarko. 2013. Studies On Entomophil Pollination Towards Sustainable Production And Increased Profitability In The Oil Palm. *Elixir Agriculture*. 55(2013): 12878-12883
- [10] K. A. Myint, M. Y. Raffii, S. A Sheikh-Abdullah, N. M. Lwin, A. Mohd Din and M. A. Latif. 2012. Determination Of The Optimum Pollen Germination Medium For Different Fruit Forms Of Oil Palm (*Elaeis guineensis*). *Journal of Animal & Plant Sciences*. 14(1): 1855-1865: ISSN 2071-7024.
- [11] S. Sivasubramanian and S. Karthick Raja Namasivayam. 2013. Evaluation Of Phenol Degradation By Effective Microorganism (EM) Technology With EM-1. *Academic Journals*. 7(32): 4117-4122.
- [12] Yusof Basiron. 2007. Palm Oil Production Through Sustainable Plantations. *Eur. J. Lipid Sci. Technol*. 109(2007): 289-295.