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Factors Affecting Yield Achieved by Participants of the Quality Oil Palm Seedlings Assistance Scheme in Sabah and Sarawak

Rahmahwati, R*;
Zulkilfli, A M* and
Ramle, M*

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ABSTRACT

The Malaysian Government has set up various incentives to help oil palm smallholders, including the Quality Oil Palm Seedlings Assistance Scheme, which was implemented in the 9th Malaysian Plan. The scheme was initially implemented in Sabah and Sarawak in 2005, and then it was introduced in Peninsular Malaysia in 2007. It was hoped that the scheme will improve smallholder productivity through yield improvement by planting good quality oil palm seedlings. This study was, therefore, conducted in Sabah and Sarawak as both states account for half the oil palm cultivated in Malaysia. The main objectives of the study were to determine the current yields achieved by participants in the scheme, and the factors affecting their fresh fruit bunch (FFB) yield. This is a quantitative study which applied the questionnaire approach to gather data from the interest group. The data were analysed by using SPSS 21, and a descriptive study, cross tabulation analysis, test of differences and linear regression analysis were employed. About 70% of the respondents had a farm size less than 4.00 hectares. Of these, 42.1% obtained a FFB yield of less than 22.4 t ha^{-1} yr^{-1}, while 38.6% achieved yields between 22.5 and 28.9 t ha^{-1} yr^{-1}. Eight factors were evaluated, but the regression analysis identified only four factors which significantly influenced the production of FFB by the recipients of the quality oil palm seedlings. These factors were management of fertilisers, farm size, harvesting, and services provided by the TUNAS officers.

* Malaysian Palm Oil Board,
6 Persiaran Institusi, Bandar Baru Bangi,
43000 Kajang, Selangor, Malaysia.
E-mail: rahmahwati@mpob.gov.my

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INTRODUCTION

In Malaysia, the two categories of oil palm smallholders, the independent smallholders (ISH) and the organised smallholders, have made significant contributions to the oil palm industry. Over the last decade, oil palm yield produced by ISH has always been below the national average, and the main challenge is low productivity affecting their socio-economic well-being (Kushairi *et al.*, 2018). Independent smallholders generally produced low fresh fruit bunch (FFB) yields, between 13.0 and 14.5 t ha^{-1} yr^{-1} (Hamdan, 2013). In 2012, reports show that ISH can produce FFB yield up to 18.53 t ha^{-1} yr^{-1}, which is slightly lower compared to the national average of 20 t ha^{-1} yr^{-1} (Hamdan, 2013). Low yield of FFB by smallholders could be partly due to the planting of low quality oil palm seedlings, which can reduce yield by as much as 59% compared to standard quality seedlings (Tam, 1973). Some ISH are able to produce more than 30 t ha^{-1} yr^{-1} f FFB if they constantly practice the recommended good agricultural practices (GAP), including planting good quality seedlings (Suboh, 2000).

Realising that low FFB yields will affect national FFB production, the Malaysian Government has initiated incentives to help smallholders increase their income. These include the Quality Oil Palm Seedlings Assistance Scheme which was implemented in the 9th Malaysian Plan period which fell between 2006 and 2010. The scheme was launched by the Minister of Plantation Industries and Commodities on 14 November 2005, and was first implemented in Sabah and Sarawak, followed by Peninsular Malaysia in July 2007. The Government allocated a grant amounting to RM37.6 million for the scheme, and assigned MPOB to be the implementation agency (Economic Planning Unit, 2008).

Independent smallholders in Peninsular Malaysia who own less than five hectares, and those in Sabah and Sarawak owning less than seven hectares, are eligible to participate in the scheme. However, subsidised inputs are only provided for a maximum of five hectares. The components of this assistance scheme for one hectare include 148 oil palm seedlings between 12 and 14 months of age, and one 50-kg bag of phosphate fertiliser.

The smallholders participating in this scheme number 753 individuals from Peninsular Malaysia (covering 1177 hectares of oil palm), 1716 individuals from Sabah (covering 4522 ha) and 3228 individuals from Sarawak (covering 6777 ha). The scheme aims to improve the productivity of oil palm owned by the participants through yield improvement. FFB yield is estimated to increase from 7 to 10 t ha^{-1} yr^{-1} in the first year of harvest, and to further increase to between 20 and 30 t ha^{-1} yr^{-1} in the fifth year of harvest (Zulkifli *et al.*, 2015).

This study sought to determine the current yield achieved by the participants of the Quality Oil Palm Seedlings Assistance Scheme, and the factors affecting their FFB yields. Awareness and implementation of Good Agricultural Practices (GAP) among the participants were also determined.

In order to implement the concept and practice of sustainable palm oil in the smallholders sector, MPOB took the initiative of introducing the MPOB Good Agricultural Practices (GAP) certification programme for smallholders. GAP is an important element in the principle of the Roundtable on Sustainable Palm Oil (RSPO) and in Malaysian Sustainable Palm Oil (MSPO) certification. Adoption of GAP by farmers has been reported to be one of the key factors for increasing productivity. Application of GAP covers sustainable agricultural methods, such as integrated pest management (IPM), integrated fertiliser management and agricultural conservation (Mansor *et al.,* 2016). Jalani *et al.* (2002) discovered that inadequate agronomic inputs, improper management practices, shortage of skilled labour, low planting density and a lack of extension services are factors that affect productivity, profitability and competitiveness of oil palm smallholders.

A study was conducted by Zulkifli *et al.* (2015) to determine yield performance among 200 participants of the Quality Oil Palm Seedlings Assistance Scheme in Sabah and Sarawak. The study found that FFB yield produced by the participants was significantly higher than those by non-participants for both states. Out of 200 participants, 114 were able to produce FFB yield of more than 10 t ha^{-1} yr^{-1}. The average FFB yield among the participants was 7.29 t ha^{-1} yr^{-1}, higher than the average of non-participants which was 3.42 t ha^{-1} yr^{-1}. Therefore, the study concluded that the smallholdings of the participants of the Quality Oil Palm Seedlings Assistance Scheme were relatively better managed than those owned by smallholders who did not participate in the scheme.

GAP standards have been developed and implemented by the food industries, governments and NGOs, aiming to improve agricultural practices at the farm level for a wide range of commodity crops. GAP elements include the planting of high-quality seedlings, planting techniques, fertiliser management, and pest and disease management. Effective implementation of these GAP elements by smallholders is important for them to produce an

optimum yield of FFB (Norlian, 2013).

Previous research by Tiraieyari *et al.* (2010) showed that GAP were developed as a guideline to oil palm producers for managing their farm inputs, such as land and environment, and output handling. Extension agents have played an important role as the medium to transfer knowledge and concepts regarding GAP to the target group. A study conducted by Islam *et al.* (2012) found that awareness levels in GAP among smallholders are still low. The main constraint was the limited accessibility to GAP information, particularly on the requirements and standard practices. Farmers usually gathered knowledge on GAP from local agricultural agents, input suppliers, and sometimes from neighbouring farmers or their relatives.

A study by Wahid and Simeh (2009) concluded that some of the factors affecting FFB production are ripeness quality, moisture content of the fruit, age of the palms, type of soil, planting material, machinery, manpower and available technology. It is necessary for the Malaysian palm oil industry to improve the skills and knowledge among the oil palm producers, instead of focusing only on research and development, to ensure sustainability of the industry. Improving the upstream activities will guarantee the sustainability of the downstream activities. Research in Nigeria by Ibitoye *et al.* (2011) demonstrated that farmer behaviour affected their yield, as they were reluctant to accept the new technologies on planting material. They rejected the new hybrid planting material that was introduced to them, and insisted on planting their own readily available seed instead.

A study by Papenfus (2004) in Indonesia revealed that four main factors led to lower productivity among smallholders. The factors were the use of uncertified seed, improper planting distance, incorrect management practices and insufficient fertiliser application. For the first factor, the smallholders claimed that they had limited access to the certified seed from the Indonesian Oil Palm Research Institute (IOPRI). The farmers were also not aware of the consequences when they adopted incorrect planting distance, improper farm management practices and reduced amounts of fertiliser. It is well known that improper management practices in pruning, pest management (including weeds, pests and diseases), and fertiliser application will reduce FFB yield. Limited capital was one of the reasons why the smallholders failed to apply enough and suitable fertilisers.

Good fertiliser management covering recommended rates, sources, timing and application methods will serve to achieve the agronomic, economic and environmental objectives (Goh *et al.,* 2009). In order to sustain good yields from oil palm, fertiliser inputs are necessarily between 50 and 60% of the total cost for field upkeep (Ramesh, 2013). To ensure efficient nutrient uptake by the palms for optimum FFB production, fertiliser application should follow the advice from competent agriculturists (Tarmizi *et al.,* 2008). Fertiliser application is based on crop requirements and can be gauged from soil and leaf nutrient levels. For good fertiliser management, records on the sites and dates of application, types and quantity of fertiliser applied, application methods and the names of the operator need to be kept (Mansor *et al.,* 2016).

Proper weeding or weed management is one of the important tasks in farm management to ensure optimum FFB production is achieved. Regular weeding is required during the early growing stage of the palms, mainly to minimise competition for moisture and nutrients from the weeds, and thus promote palm growth and improve FFB production (Suboh, 2000). In mature areas, weeding helps to facilitate harvesting of FFB and loose fruit collection. Besides weeds, integrated pest management (IPM) techniques are important elements to increase oil palm productivity (Yusof and Weng, 2003). The use of pesticides should be minimised and IPM should be practised by oil palm planters. They are only permitted to use chemicals that are officially registered under the Pesticides Act 1974 (Act 149) and Regulations, and the Food Act 1983 (Act 281). All the operators should have good knowledge on the handling of pesticides and be equipped with suitable personal protective equipment (PPE) in accordance with the Occupational Safety and Health Act 1994 (Act 514) Regulations.

A study found that harvesting of unripe fruit significantly reduced yield production by smallholders (Roseleena *et al.,* 2011). Some smallholders who harvested unripe fruit failed to distinguish between unripe and under-ripe fruit. This is mainly because they used colour as an indicator to determine ripeness of the bunch instead of loose fruit. They tended to harvest orange fruit bunches without checking whether the fruitlets in the inner part of the bunch are ripe or not. It has been demonstrated that the fruit bunches do not ripen uniformly. The colour of fruit bunch varies based on the location of the fruitlets in the bunch. When about 85% of the fruitlets are ripe and have a similar degree of maturity, the remaining 15% located at the inner part of the bunch will be unripe. The recommended way to determine fruit ripeness is based on the number of detached fruitlets

from the bunch, or loose fruit. The fruit bunch is fully ripened when 1 to 10 fruitlets are detached from the bunch. Only 77.9% of the smallholders used this loose fruit indicator to determine fruit bunch ripeness (Rahman *et al.*, 2008).

A number of new technologies have been introduced by MPOB to assist smallholders increase oil palm FFB production, and thus improve their livelihood. For example, a mechanical FFB cutting machine called Cantas, introduced in 2002, is able to increase the rate of harvesting FFB by two- to three-fold (Mohd Basri and Mohd Arif, 2009). It can reduce the labour requirement for harvesting by 50% with an additional saving of 30% in harvesting cost. The use of a mini tractor with a trailer for FFB evacuation can increase productivity from 18 to 24 t day^{-1}. This system can cover an area of 200 to 250 ha area whereas a wheelbarrow can only handle 1.8 to 2.5 t/day for the same area (Mohd Basri and Mohd Arif, 2009). Farm roads and harvesting paths must be properly constructed to facilitate evacuation of FFB from the field.

Besides the technical aspects in managing the farms, another significant factor causing low productivity and profitability among ISH is limited knowledge of the oil palm industry. Today, the agricultural sector is becoming knowledge-intensive (Babu *et al.*, 2011). The latest knowledge helps farmers to be more efficient and effective in managing their farms and then to facilitate the adoption of up-to-date technologies which can increase yields and improve farmer livelihood. However, information such as new agronomic techniques to increase yield often fails to reach small-scale farmers (Hasnida *et al.*, 2014). Various studies have reported that educational levels of smallholders significantly influenced the attitude of the individual farmers in their willingness to adopt new agricultural methods (Serah *et al.*, 2012). Research on other crops show that participating in training programmes and extension activities have a significant correlation with knowledge among the farmers (Pillegowda *et al.*, 2010). Therefore, improvement of smallholder knowledge by effective extension services will help them improve their adoption of GAP for high-yield production.

METHODOLOGY

The study was conducted in 2015 in Sabah and Sarawak and involved participants of the Quality Oil Palm Seedlings Assistance Scheme. The sample population comprised 465 participants who had completed planting their oil palm seedlings in 2006. Proportionate sampling was conducted to ensure that the entire population of samples had equal chances of being selected to be part of the study. Based on the sampling table by Krejcie and Morgan (1970), the sampling size was 280 smallholders, consisting of 118 smallholders from Sabah and 162 from Sarawak.

This study applied the questionnaire approach to gather data from the participants. The questionnaire comprised six sections, which consisted of a total of 30 types of information covering participant demographic profiles and their farms, management of major routine activities, such as fertiliser application, weeding, pest and disease control, and harvesting of FFB. Cross Tabulation Analysis between the demographic and farm profiles of the smallholders against yield was performed to identify factors contributing to yield and subsequently the income of the smallholders. Linear regression analysis was also conducted to determine any significant relationship between identified independent variables and FFB yield.

RESULTS AND DISCUSSION

Descriptive analysis

Demographic profiles. The demographic profiles of the respondents involved in the study are summarised in *Table 1*. Most of respondents (90.7%) were married, while half of them (54.3%) were more than 51 years old. The average household had between 1 and 4 members per family (not counting the respondent). Level of knowledge was moderate, with 23.2% of the respondents not having received any formal education, while the majority or 73.2% had gone to primary and secondary schools; only 3.6% had gone for higher education such as to colleges. Almost 60% of the respondents had 1 to 10 years' experience in oil palm cultivation, and 73.7% of them claimed their monthly income to be less than RM2500/month.

Farm information. FFB production by the farmers was at the medium level, with 42.1% producing less than 22.4 t ha^{-1} yr^{-1}, and 38.6% producing between 22.5–and 28.9 t ha^{-1} yr^{-1} (*Table 2*). Interestingly, 19% of them were able to produce more than 29 t ha^{-1} yr^{-1}. About 70% of the respondents had a farm size less than 4.00 hectares, and this is in line with the standard definition of a smallholder. In Malaysia, a smallholder is defined as a farmer who owns less than 40.46 ha of farmland. 46.8% of the respondents grew their oil palm at a density of 148 palms/ha, following the standard practice of most plantations. Planting density also depended on soil type and topography. Only 21.8% of the farms was on peat soil. The maximum planting density was 160 palms/ha (Noormahayu *et al.*,

2009). For planting system, about 96.7% of the respondents applied the triangular system. 44.6% of the farms were located in flat areas. Most of the farms, *i.e.* 97.1%, were owned by the respondents, while the rest were rented farms.

Fertiliser management is one of the crucial tasks in managing oil palm because of cost considerations. Fertiliser itself makes up about 50%-60% of production costs in oil palm cultivation, whether for the plantations or the smallholders (Rahman *et al.*, 2008). In this study, the effectiveness of farmers in following the standard fertiliser application technology introduced by MPOB was evaluated (*Table 3*). The respondents employed 1 – 2 workers each. More than 73.0% of the respondents applied fertiliser between 2 and 3 times per year. Compound fertiliser was used mainly, with more than half of the respondents (52.9%) applying this type of fertiliser. For application method, 47.5% of the respondents applied fertiliser around the palms, while 48.9% used the pocket technique. Some (40.4%) applied a low amount of fertiliser, between 3 and 6 kg palm^{-1} yr^{-1}, which was lower than the standard requirements. About 40% of the respondents followed the recommended fertiliser application rate which is between 9 and 12 kg palm^{-1} yr^{-1}.

Weed management is another important task in oil palm cultivation as weed growth will lead to yield reduction because of competition for nutrients with the palms. Improper weed management causes not only yield reduction but also loss in profit. In this study, the efficiency of smallholders in conducting weeding activities was also evaluated (*Table 4*). Weeding in smallholdings was commonly conducted by hiring between 1 and 2 workers. Almost half of the respondents (54.6%) carried out weeding 1 to 2 times per year. Most of them (97.1%) preferred to use chemical approaches in controlling weeds in their farms.

Serious infestation by pests and diseases can cause a major reduction in the number of fruit bunches produced by the palm. How smallholders dealt with pests and diseases in their farms was evaluated in this study (*Table 5*). It was found that 64.6% of the

TABLE 1. DEMOGRAPHIC PROFILES OF SMALLHOLDERS INVOLVED IN THE QUALITY OIL PALM SEEDLINGS ASSISTANCE SCHEME

Profile	Category	Percentage
Marital status	Single	5.4
	Married	90.7
	Divorced	3.9
Age (years)	<20	1.4
	21 - 30	3.6
	31 - 40	12.5
	41 - 50	28.2
	>51	54.3
Education	Did not attend school	23.2
	Primary school	36.4
	Secondary school	36.8
	College	3.6
Monthly income	<RM 1000	22.1
	RM 1000 - RM 2500	53.6
	RM 2501 - RM 3500	16.4
	RM 3501 - RM 4500	6.4
	>RM 4501	1.4
Experience (years)	1 - 10	58.2
	11 - 20	13.6
	21 - 30	16.8
	31 - 40	2.5
	>41	0.7
	No experience	8.2
Family size (persons), not including respondent	1 - 4	56.1
	5 - 7	17.5
	8 - 10	20.0
	>10	1.1
	0	5.4

TABLE 2. INFORMATION ON FARMS OF SMALLHOLDERS WHO PARTICIPATED IN THE QUALITY OIL PALM SEEDLINGS ASSISTANCE SCHEME

Variable	Category	Percentage (%)
Yield (t ha^{-1} yr^{-1})	< 22.4 (lower) 22.5 - 28.9 (medium) >29 (higher)	42.1 38.6 19.3
Land (ha)	0.01 - 2.00 2.01 - 4.00 >4.01	30.0 38.6 31.4
Total palms/ha	136 148 160 120	42.1 46.8 8.9 2.1
Planting system	Triangular Square 2 lines Others	96.7 1.0 2.1 0.3
Soil type	Coastal Inland Peat	6.4 71.8 21.8
Topography	Flat Undulating Hilly	44.6 33.9 21.4

TABLE 3. FERTILISER MANAGEMENT BY SMALLHOLDERS WHO PARTICIPATED IN THE QUALITY OIL PALM SEEDLINGS ASSISTANCE SCHEME

Variable	Category	Percentage (%)
Type of fertiliser used	Mixture Compound Straight Others	38.9 52.9 5.7 2.5
Application method	Applied around the palm Pocket Applied at the harvesting path Others	47.5 48.9 1.1 2.5
Number of workers involved	1 - 2 3 - 4 >5	78.9 19.6 1.4
Frequency of application (times per year)	2 - 3 < 2 >3	73.2 17.1 9.6
Fertiliser rate (kg $palm^{-1}$ yr^{-1})	3.00 - 6.00 (poor) 6.01 - 9.00 (medium) 9.01 - 12.00 (good)	40.4 20.0 39.6

respondents claimed that their palms had been attacked by pests, such as rats and rhinoceros beetles. About 60% of them noticed disease infection in their farms. Seventy-eight respondents reported that the *Ganoderma* disease infected their palms, but only eight respondents knew how to control *Ganoderma* using the sanitation method. 55% of the respondents noticed unhealthy palm appearance, such as yellowing leaves, stunted palms and yellowish tips of the leaves.

Harvesting FFB is the hardest task carried out by the farmers, especially in determining bunch ripeness. Poor quality FFB, such as a high percentage of under-ripe and over-ripe fruitlets, and long-stalked fruit bunches, will affect the price guaranteed by the mills or fruit dealers. In this study, only three aspects related to

TABLE 4. WEED MANAGEMENT BY SMALLHOLDERS WHO PARTICIPATED IN THE QUALITY OIL PALM SEEDLINGS ASSISTANCE SCHEME

Variable	Category	Percentage (%)
Weed control	Yes No	100 0
Approach in weed control	Mechanical Biological Chemical	43.9 1.7 97.1
Number of workers involved	1 - 2 3 - 4 >5	79.3 19.3 1.4
Frequency (per year)	1 - 2 3 - 4 >5	54.6 40.7 4.6

TABLE 5. PEST AND DISEASE MANAGEMENT BY SMALLHOLDERS WHO PARTICIPATED IN THE QUALITY OIL PALM SEEDLINGS ASSISTANCE SCHEME

Variable	Category	Percentage (%)
Occurrence of pest attacks	Yes No	64.6 35.4
Type of pest	Rat Rhinoceros beetle Caterpillar Others	51.07 25 11.78 5
Occurrence of diseases	Yes No	54.5 42.5
Type of disease	*Ganoderma* Others	27.9 29.6
Approach to overcome Ganoderma infestation	Removal of palm Trunk injection Sanitation Do nothing Others	26.9 16.7 10.3 43.6 2.6
Unhealthy palms	Yes No	55 45
Unhealthy symptoms	Yellowing leaves (N deficiency) Stunted palms (P deficiency) Orange spots (K deficiency) Yellowish leaf tips (Mg deficiency) Wrinkled leaves (B deficiency)	41.4 11.4 23.6 26.4 17.5

TABLE 6. HARVESTING PARAMETERS OF SMALLHOLDERS WHO PARTICIPATED IN THE QUALITY OIL PALM SEEDLINGS ASSISTANCE SCHEME

Variable	Category	Percentage (%)
Harvesting cycle in a month	Once (every 25 days) Twice (every 15 days) Others	40.4 57.9 1.8
Trim long stalk	Yes No	100 0
Loose fruit collection	Yes No	100 0

harvesting were evaluated (*Table 6*). These were harvesting cycle, long stalk management, and loose fruit collection. Only 57.9% of the respondents harvested FFB twice per month, while the others harvested once a month. The respondents were highly aware of the need to trim the bunch stalk and to collect loose fruit in their farms.

Cross Tabulation Analysis

Cross tabulation analysis between independent variables and a dependent variable is shown in *Table 7*. In this study, the frequencies of independent variables falling in the yield categories were calculated. Yield was grouped into three categories, namely low, medium and high, following the Oil Palm Biology Facts and Figures (Kushairi *et al.*, 2013). The analysis determines which of the factors contributed to yield production and subsequently the income of the smallholders. For farm size, farmers with a farm of less than two hectares tended to produce low FFB yield, and this was proven as none of these farmers produced high yield. It is well known that the amount of fertiliser applied has a positive effect on the production of FFB. In other words, farmers will be able to produce more FFB when they apply fertiliser more frequently. This study found that the 28 farmers who fertilised their palms using 9 to 12 kg palm^{-1} of fertiliser a year produced higher yield. The 89 farmers who produced low yield applied less than 6 kg fertiliser to each palm in a year. For pest and disease management, it was found that most of the farmers who obtained low yield had farms which were attacked by pests or diseases. It is assumed that all these farmers in this study were not aware of the significance of this factor rather

TABLE 7. CROSS TABULATION ANALYSIS BETWEEN DEMOGRAPHIC AND FARM PROFILES OF SMALLHOLDERS AGAINST FFB YIELD

Variable	Yield category		
	Low (<22.4 t ha^{-1} yr^{-1})	Medium (22.5-28 t ha^{-1} yr^{-1})	High (>29 t ha^{-1} yr^{-1})
Farm size (ha)			
0.01 - 2.00	52	32	0
2.01 - 4.00	42	46	20
4.01 - 6.00	24	30	34
Frequency of fertiliser application (kg palm^{-1} yr^{-1})			
3.00 - 6.00 (poor)	89	11	13
6.01 - 9.00 (medium)	9	34	13
9.01 - 12.00 (good)	20	63	28
Pest and disease management			
Yes	112	92	48
No	6	16	6
Frequency of weeding			
1 - 2	74	55	24
3 - 4	38	46	30
>5	6	7	0
Harvesting			
Poor	44	61	8
Good	74	47	46
High cost of production			
Disagree	2	2	0
Neutral	34	28	22
Agree	82	78	32
Weather			
Bad	36	24	17
Neutral	69	64	34
Good	13	20	3
TUNAS services on farm management			
Not satisfied	3	2	0
Neutral	62	52	20
Satisfied	53	54	34

than other factors, thus they were inefficient in handling pest and disease infestations in their farms. How much this factor influenced FFB production among the farmers was measured in the regression analysis.

Of the 118 farmers in the low yield group, 74 of them conducted weeding only one or two times per year, while 38 weeded three to four times a year. Based on these results, the best weeding frequency was between three and four times per year. A good harvesting programme did not guarantee an improvement in FFB yield. Various factors associated with high FFB production include planting material, good agronomic practices, pest and disease management, soil nutrients and others. Harvesting conducted twice a month is good for avoiding under-ripe and over-ripe fruit. In the low yield group, a large number of farmers (74 farmers) practised this harvesting frequency.

The farmers agreed that if they were able to tolerate the prices of inputs and if these inputs were easily accessible to them they will tend to produce higher yield. Nevertheless, 32 farmers who considered the prices of inputs to be high were able to achieve high production, while none of the respondents who did not consider the prices at all were able to achieve high yield. In terms of weather conditions, 77 farmers revealed that the weather conditions at their farms were bad, *i.e.* they experienced long droughts and floods, hence half of them were unable to get high yields. Yet, 17 farmers claimed to get higher yield in bad weather conditions. For the TUNAS services on farm management, 141 farmers were satisfied with the services provided, stating that the knowledge from and coaching by their TUNAS officers were good enough to help them better manage their farms. Therefore, the findings from this aspect of the study are in contrast with yield production. 107 farmers were grouped into low and medium FFB production categories, while only 34 farmers reached the maximum FFB production. Drought and floods will reduce efficiency in harvesting and transporting FFB to the mill or collection centre. Drought and floods also lead to stress in the palms, and directly cause reductions in production volume.

The cross tabulation analysis on farm management showed that the farmers who practised GAP effectively tended to produce higher yields than those farmers who did not perform efficient farm operations, such as weeding, pruning, harvesting and others.

Regression analysis

A test of difference was conducted to check the variations in the data for every variable, and only the significant variable was used for further analysis. This test is important to reduce the number of variables in the study so that only the important variables are included in the regression analysis which determines the relationships between those variables and the dependent variable. The linear regression analysis showed that the independent variables, which were fertiliser application, farm size, frequency of harvesting and TUNAS services on farm management, were positively correlated with the yield produced by the smallholders who participated in the scheme (*Table 8*). The regression R^2 value of 0.66 indicates that the variables in this test influenced 66% of the yield produced, while the remaining 34% was caused by other factors that were not evaluated in this study. The study revealed that weeding frequency, cost of production, weather, as well as pest and disease management did not affect the production of FFB by the smallholders who participated in this scheme in Sabah and Sarawak.

The quantity of fertiliser applied had the largest positive relationship with FFB production, followed by farm size, frequency of harvesting and TUNAS services on farm management. Therefore, inadequate fertiliser was the main factor affecting the yield of FFB produced by the participants of the scheme. The same finding was reported by Alwarritzi *et al.* (2015), where smallholders in Miri, Sarawak, showed serious fertiliser management inefficiency in applying only between 200 and 800 kg per hectare in their mature palm areas. Therefore, the farmers were urged to apply fertilisers at the recommended application rate so as to increase their oil palm production. A study by Ali Zulhusni *et al.* (2017) reported that the main factor affecting FFB yield of smallholders was insufficient fertiliser application as the majority of them applied less than 4 kg $palm^{-1}$ yr^{-1} to both mature and immature palms. They also showed that fertiliser had a significant positive relationship with FFB production. Cramb and Sujang (2012) recommended that the amount of fertiliser for mature palms should be about 1000 kg ha^{-1}. Their results demonstrate that fertiliser was an important factor in enhancing smallholder productivity. Insufficient application of fertiliser will cause a significant reduction in FFB production.

Studies by Tipi *et al.* (2009) and Madau (2011) found that the FFB yield of farmers can be increased when their farm size was at least 5 ha. In terms of individual farm efficiency, Tipi *et al.,* (2009) and Madau (2011) concluded that bigger farms were more productive than smaller farms. Various other workers concluded that larger

TABLE 8. REGRESSION ANALYSIS BETWEEN INDEPENDENT VARIABLES AND FFB YIELD

Independent variable	R^2 = 0.66		Remarks	Relationship
	Beta	Significant		
Fertiliser	0.435	0.00	Accepted	Positively correlated
Farm size	0.367	0.00	Accepted	Positively correlated
Harvesting	0.337	0.02	Accepted	Positively correlated
TUNAS services	0.148	0.00	Accepted	Positively correlated
Weeding	-0.021	0.67	Rejected	Not correlated
Pests and diseases	0.080	0.12	Rejected	Not correlated
Cost of production	-0.043	0.38	Rejected	Not correlated
Weather	0.052	0.29	Rejected	Not correlated

farms were able to get higher profits as they possessed economies of scale in land (Sidhu and Bhatia, 1993). Larger farms usually had access to capital and market, which resulted in lower production costs and higher returns (Hall and Weiss, 1967).

Harvesting is another influential factor in oil palm production among the scheme's participants in Sabah and Sarawak. Based on the distribution analysis, the majority of farmers in the low and high yield categories conducted good harvesting practices. Harvesting frequency should be maintained at twice a month. All loose fruit should be collected and the FFB stalk trimmed to less than 5 mm. The farmers in the study should continue to adopt good harvesting practices to avoid harvesting over-ripe and under-ripe fruit. It is also recommended that the farmers harvest only ripe FFB to enjoy the higher price guarantee at the mills or collection centres. Other studies have also concluded that harvesting was one of the main factors affecting the production of quality FFB by smallholders (Roseleena *et al.,* 2011; Rahman *et al.,* 2008).

The TUNAS services, especially on oil palm management, had the smallest positive relationship with FFB yield. This indicates that the services provided by TUNAS officers in transferring technologies as well as knowledge played a minor role in increasing FFB yield by the recipients. Therefore the extension services by TUNAS officers in this area should be continued to ensure that high farm productivity among the smallholders is achieved.

CONCLUSION

The present study found that 90.7% of the respondents were married and that the majority of them were more than 50 years old. Most of the farmers had attended primary and secondary schools, and had experience in oil palm cultivation for at least one to 10 years. In terms of monthly income, it was found that most of them earned at least RM1000 to RM2500 from their farms.

The average yield achieved by the participants of the scheme was 23 t ha^{-1} yr^{-1}, which is higher than the average yield of individual smallholders in 2015, reported as only 17.33 t ha^{-1} yr^{-1}. The majority of the farmers in this study had farms less than 4 ha, or not exceeding 6 ha. Application of fertiliser by farmers in the study area was between 2 and 3 times a year, and the majority applied less than 6 kg $palm^{-1}$ yr^{-1} of fertiliser. The study also revealed that most farmers conducted very few weeding operations, *i.e.* only once a year. Most of the farmers followed a harvesting frequency of twice a month as to ensure that they produced quality FFB.

Linear regression analysis identified four factors which significantly influenced the production of FFB by the participants of this scheme in Sabah and Sarawak. Insufficient fertiliser application was the strongest determinant as it was found that only 40% of the farmers followed the recommended fertiliser application rate. This was followed by farm size, harvesting practices, and services provided by the TUNAS officers.

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