Growth, Yield and Economic Potential of Cavendish Banana Planted in Oil Palm Gaps

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ABSTRACT The mortality of a few trees leads to the emergence of palm gaps or unproductive areas in oil palm plantations. These areas offer the potential for integrating a secondary crop, such as, the Cavendish banana (*Musa acuminata* Colla). This banana is a well-established clonally propagated variety which is well known to local planters, but to date, little information is reported about its agronomy, yield, management, and economic potential as an intercrop in oil palm plantations. In the present study, Cavendish suckers were planted in palm gaps and the respective information was assessed. The suckers were collected from the mother plants in Kota Belud, Sabah. The suckers were planted in polybags for conditioning, and after a month, transplanted at 1.8 m × 1.8 m distance in palm gaps of the oil palm area in UMS Campus, Sandakan. The planting density was 10 saplings/(2.3 m x 6.0 m) gap. Weeds were machine-cut in the first 11 months, but after that, only when necessary. The weeds were also controlled with application of Glyphosate once/year. Fertilizer was applied once/year as 0.5 kg of NPK15:15:06, NPK15:15:15, and NPK12:12:17, respectively. Compost was added once/year as 1.5 kg of chicken dung and goat manure, respectively. Trees yielded fruits within seven to eight months of transplantation. The banana trees were 2.2±0.2 m tall at fruiting. The yield was 14.6±0.2 kg banana-hand/bunch. The banana hands were 2.0±0.1 kg/hand. There were seven banana hands per bunch, with a weight that ranged from 3.29±0.22 kg (top), 1.92±0.05 kg (middle) to 1.37±0.19 kg (bottom/last) per hand. The banana hands were sold at RM4.0/kg. The profit was RM56.0/bunch, or RM4.06/m^2/banana. The net profit was RM40.39/banana, or RM29.26/m^2, not accounting fruit processing and marketing costs, which was not so applicable in this study. In addition, the banana foliage shaded and thereby suppressed the growth of weeds, reducing the manpower and associated cost of weeding in the oil palm area.

KEYWORDS: Cavendish; *Musa acuminata*; Banana growth and yield; Oil palm integrated banana; Oil palm management.
Received 2 May 2022 **Revised** 28 June 2022 **Accepted** 30 June 2022 **In press** 30 June 2022 **Online** 8 July 2022

Original Article

INTRODUCTION

Oil palm is one of the important crops in Malaysia. In Sabah, 1.35 million ha of agricultural land has been planted with this crop. It contributed 16.1% of the RM85.4 billion gross domestic product of Sabah in 2021 (Fadzli, 2021). Oil palms, however, are prone to basal stem rot which has been attributed to *Ganoderma* infection and subsequent mortality due to this disease. The infected young palms die within one or two years, while the mature palms in around three or more years (Nur Akmal et al., 2020; Corely & Tinker, 2003). So far, identification of an effective treatment for this disease is still researched. Replanting in the affected areas is ineffective, as *Ganoderma* infection can still happen to the replanted palms even several years after the dead palms have been removed. *Ganoderma* can remain dormant in soils and lead to recurring infections even after many years (Nur Akmal et al., 2020). The threat by *Ganoderma* infection to the wellbeing of the oil palm industry will be a cause for concern over the next few years if not decades. That threat is there for a long period, but the future of the cropless spaces is another concern. Once the palms die, the affected areas are likely left palm-free for many years. These areas will still need to be cleaned from weeds and bushes to avoid the areas from becoming the homes for rats and other pests of oil palms. In other words, the cropless areas are not only unproductive but have financial implications for the plantation maintenance budget. To turn the cropless spaces to be monetarily productive, it is suggested that a secondary crop, such as, the Cavendish banana be introduced. This banana is considered to be a good choice for smallholder oil palm planters, especially for those who are facing a serious *Ganoderma* problem on their palms, to plant in oil palm gaps as a secondary crop, as it has a better average price per weight (RM7.50/kg as sold online). Cavendish banana is not new to this country. In 2000, there were already 31,000 ha of banana plantations in Malaysia of which almost half of the areas were cultivated with Cavendish banana and Pisang Berangan; the yield was 550,000 tonnes/year where 31,700 tonnes/year were exported (Hassan, 2002). The outlook of the banana industry in Malaysia, however, is a cause for concern. In 2017, the production was only 350,000 tonnes/year from 35,000 ha plantations, and the banana import cost increased steadily from just over RM0.10 million/year in 2010 to RM37.8 million/year in 2017, which was only RM2.6 million lower than the export value leading to a markedly small return in trade (KRI, 2019). It is possible that the expansion of Cavendish banana production by intercropping with palm oil could also reduce the banana import cost of the country. To date, however, little information is available about the growth performance, yield and economic potential of Cavendish banana production in oil palm gaps or even on local farms in Sabah. The present paper reports on data about that gap of knowledge based on the high-density planting of Cavendish banana.

METHODOLOGY

Experimental Plot Establishment and Management

The banana plots were established in February 2021 in palm gaps in 1.43 ha (3.53 acres) oil palm area. The oil palms were planted in 2007 at 9.14 m (30 feet) planting distance. The palms were managed over the last four years following the procedures approved by the Malaysian Sustainable Palm Oil (MSPO) certification scheme. Within that oil palm area, the weeds were controlled by machine-slashing where-and-when necessary and one-round/year application of Glyphosate (1.98L/round). There were three major palm gaps (PG1–3) in the area. PG1 was vacant of three oil palm trees, PG2 of three trees (Figure 1(A)), and PG3 of four trees. PG1 was located at the periphery of the plantation, while PG2 and PG3 were within the oil palm area. PG1 and PG2 experienced short flood-periods and water logging of around 20 cm water-depth and up to one-week long during rainy seasons, before the drainage system was upgraded by end of 2021; the banana usually survived the flood. The banana suckers were planted once the weeds in the gaps were completely died after the routine weedicide program in the oil palms.

Cavendish Banana Planting and Maintenance

Ten Cavendish suckers were collected from the mother plants in Kota Belud, Sabah. The population in Kota Belud was established from tissue culture; it was brought in from Kedah, but the type or cultivar was unknown. The suckers were planted in polybags in the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan and some were repropagated through bulb cutting and slicing (Figure 1(B)). After showing a good recovery, the suckers were transplanted in PG1 at 1.8 m × 1.8 m distance, similar to the distance used in Australia as reported by Schelfhout (2014); it was a high-density planting with the target to reduce light penetration and plant photosynthetic activity below the banana canopy so that the weeds are not growing well. Approximately, there were 10 bananas/(2.3 m x 6.0 m) gap, or 3086 bananas/ha, extrapolated from the 1.8 m × 1.8 m planting distance. Once the banana in PG1 produced new suckers, the suckers, except for the largest one, were collected and planted in PG2 again at 1.8 m × 1.8 m distance. The largest suckers were retained as replacement trees. To expedite the plot establishment, a few suckers were purchased from a supplier in Lahad Datu, Sabah and planted in PG2. Again, new suckers from PG1 and PG2 were transplanted in PG3. Only a simple land preparation was carried out at every planting point: the soil particles were chopped and scraped with hoe to form about 20-cm high soil mound where in the middle was the hole for planting. Once planted, the bananas were maintained as described in Table 1; many of the tasks were carried out during leaf maintenance. Overall, 52 banana suckers were planted, of which 16 suckers were Cavendish where 14 suckers were in PG2. The rest were other cultivars: Pisang Raja (14), Pisang Budak (4), and Pisang Berangan (18). The Cavendish banana hands produced in this study were sold directly to customers at RM4.0/kg.

Table 1. Planting and maintenance of Cavendish banana planted in the oil palm gaps.

Activities	J	F	M	A	M	J	J	A	S	O	N	D
Planting		☑										
Fertiliser (chemical)				NPKY			NPKG			NPKB		
Fertiliser (organic)		☑										
Weeding (cut)		☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Weeding (weedicide)											☑	
Leaf pruning (frequency)		1	2	2	2	2	2	2	2	2	2	2
Base soil-mounding				☑			☑			☑		
Pest/Disease		☑										

*NPKY (NPK yellow 15:15:06), NPKG (NPK green 15:15:15), and NPKB (NPK blue 12:12:17) each at 0.5 kg/banana. Organic compost: 1 kg/banana of chicken dung and goat manure, respectively. These fertiliser applications follow the common practice applied in the studied oil palm area. Weedicide: Glyphosate, 0.15L for both PG1 and PG2. Leaf pruning: only old leaves were removed. Base soil-mounding: soil was mounded at the base of the banana clumps. Pest/Disease: 10 g/banana of Carbofuran. The banana bells (male bud) were removed once the last fully formed hands were opened.

Data Collection and Analysis

Growth and yield traits of the Cavendish banana in PG1 and PG2 were measured during fruiting and harvesting. Light intensity under the canopy was measured only during fruiting (340 days after the plot establishment) from 6:00 AM to 6:00 PM using a lux meter (HI-97500 Portable Lux Meter) at two-hour intervals. Information was recorded on the number of staff and time taken to carry out the project to estimate the labour load. Costs associated with the project were calculated. The bananas in PG3 were still young and thus not assessed. The data were analysed using descriptive statistics.

RESULTS AND DISCUSSION

Growth and Replacement Trees

The bananas trees were well established and productive (refer Figure 1(C) and Table 2). Seven to eight months after transplantation, the bananas flowered. At flowering, the banana trees were 2.19±0.23 m tall and had 3–5 suckers of different sizes. The second batch of bananas fruited 124 days (4 months) after the first bunch was harvested. The duration from shoot induction to harvest was 85 days. The mother plant in Kota Belud, Sabah was 2.8 m tall and flowered at the age of 7–9 months (Table 2). In West Malaysia, generally, Cavendish banana has been reported to be 1.8–2.0 m tall and flowers when 7–9 months old (Hassan, 2002). Jamaluddin (1996) reported also in Malaysia that the times to shoot (bloom) of Cavendish Goldfinger, Novaria (Grand Nain mutant), Williams, and Montel (semi-dwarf Grand Nain) cultivars were 11.0, 7.1, 7.4, and 8.2 months, respectively. In Australia, Cavendish 'Williams' was 3.4–3.5 m tall (2.5 m tall for first generation), flowered after 12 months old, with the first harvest was in 18 months, and the suckers produced new bunches when 12–16 months old (Newley et al., 2008). To date, little is reported about sucker production of various cultivars of Cavendish banana. The cavendish banana in this study is slightly taller than that in West Malaysia. Being planted in a high density, the banana in this study shaded one another. Plants in a crowded stand tend to grow taller as a result of light competition (Nagashima & Hikosaka, 2011).

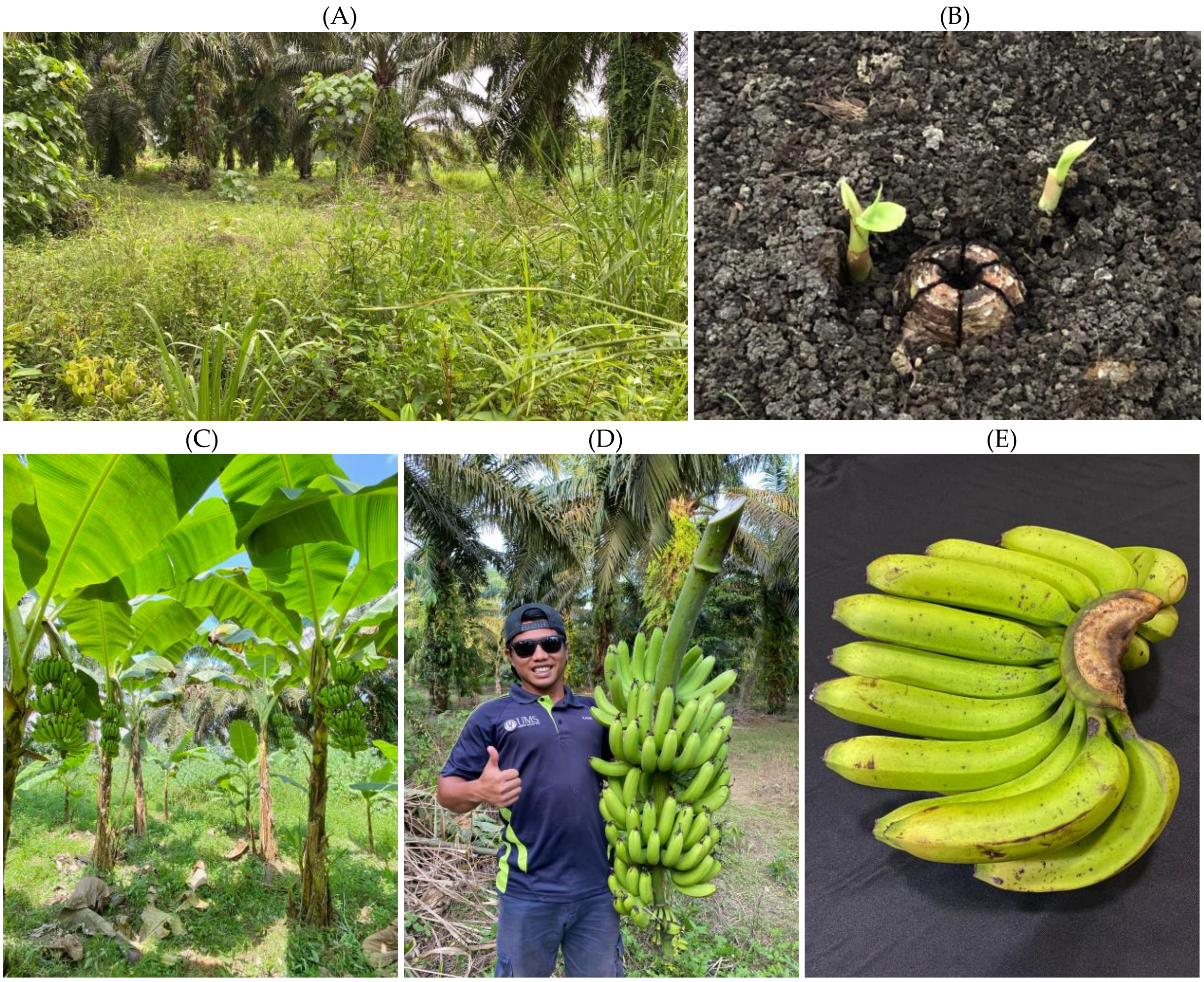

Figure 1. Cavendish banana production in oil palm gaps. A: Bulb cutting macro-propagation technique - the bulb was collected, gouged out of central meristem, and cut lengthwise halfway through to six equal sections to encourage lateral bud growth; B: Oil palm gap - it is usually densely covered by weeds; C: Cavendish banana planted in oil palm gap – the weeds on the ground failed to grow well; D: Cavendish banana bunch harvesting - it was harvested at 75% ripe; and E: Ripened Cavendish banana hand (colour index 2 to 3) – it was artificially ripened without an application of ethylene; it was wrapped in newspapers, packed in a plastic bag and left in non-air-conditioned room (c. 28°C).

The banana fruited at the age similar to that in West Malaysia but faster than that in Australia. The climate of Australia is not natural for banana; so, phenological adaptation, such as, change in maturity time, is expected. In terms of replacement, the banana in this study produced new suckers well and just at the right number, i.e., not too crowded. That means the clusters are less dense and do not provide a good hiding place for oil palm pests, such as, rats, or in other words, the Cavendish banana cultivar used in this study is a practical choice to be integrated with oil palms. Stem and corm borers were not found during this study, but a few attacks were found in the adjacent plot of Pisang Berangan.

The above agronomic evaluations need to be taken with caution, as the genetic antecedents of the cultivar planted in this study are not known and may not be similar to those cultivated in Australia, or in other parts of Sabah and Malaysia, and in addition, the climatic conditions in Australia are markedly different. It is widely known that there are differences in genetic potential of different cultivars and differences in growth as well as yield performance of the same cultivar at different geographical locations or different management regimes. In Malaysia, other than the four cultivars mentioned above, there are several other Cavendish cultivars, i.e., Cornel, Cabana/Sun King Banana, Mr Banana, and Grand Nain. While in Australia, there are Hybrids, Williams, Mons or Dwarf Cavendish, Ladyfinger, and Goldfinger (Newley et al., 2008). In Africa, there are, for example, Grand

Nain (2.88 m tall), Zelig (2.67 m), and Williams (3.48 m) (Fonsah et al., 2007). It is not known which of those cultivars is the one that was planted in the present study. Little information is published about each of those cultivars to provide the clues. Jamaluddin (1996) reported that in Malaysia, Goldfinger, Novaria, Williams and Montel heights were 211.0, 182.0, 184.0 and 182.6 cm tall, respectively. Fonsah et al. (2007) reported that the shortest in their research was Zelig. Zelig is only 25 cm taller than the 2.42 m height in this study, while it is only 13 cm shorter than the mother plant in Kota Belud. The mother plant has closely similar height to Grand Nain.

Yield

On average, the banana bunch was 15.6±0.2 kg/bunch, banana-hands per bunch was 14.6±0.2 kg/bunch, and banana hand was 2.0±0.1 kg/hand (Table 2). When extrapolated, the data indicate that the yield can be 45.1 (i.e., 14.6 x 3086) tonnes/ha/session, assuming that all saplings are of the same age during planting and fruit at the same time. There were seven banana hands per bunch, weighing from 3.29±0.22 kg (top), 1.92±0.05 kg (middle) to 1.37±0.19 kg (bottom/last) per hand (Table 2). The mother plants of the banana in Kota Belud, however, have produced 34 kg/bunch and 12 banana-hands/bunch (Table 2), indicating the genetic potential of the banana cultivar used in this study.

Table 2. Growth and yield traits of Cavendish banana planted in oil palm gaps (PG1 and PG2).

Banana traits	PG1 (Average ±SD)	PG2 (Average ±SD)	Overall in PG (Average ±SD)	Mother plant in Kota Belud*
Plant height (m)	2.0±0.1	2.3±0.1	2.2±0.2	2.8
Leaf length (cm)	–	180.0±14.1	180.0±14.1	–
Leaf width (cm)	–	87.0±14.1	87.0±14.1	–
Sucker count	2.5±0.7	4.0±1.0	3.3±1.1	–
Planting to shoot (days)	188.5±16.3	244.3±24.0	216.4±39.5	–
Shoot to harvest (days)	78.0±7.1	92.7.0±7.6	85.3±10.4	–
Banana bunch length (cm)	65.0±7.1	74.0±6.5	69.5±6.4	97
Banana bunch width (cm)	36.0±8.5	29.7±6.5	32.8±4.5	41
Banana bunch weight (kg)	15.5±3.8	15.7±2.3	15.6±0.2	34
Banana hand count	7.0±0.0	7.7±0.6	7.3±0.5	12
Banana finger count	15.1±0.8	14.9±1.5	15.0±0.2	25
Banana hand length (cm)	15.6±0.5	15.6±0.9	15.6±0.0	16
Banana hand width (cm)	27.0±0.0	25.3±3.2	26.1±1.2	32
Banana hand total weight (kg)	14.5±2.3	14.8±2.2	14.6±0.2	23
Banana (top) hand weight (kg)	3.45±0.49	3.13±0.23	3.29±0.22	3.5
Banana (middle) hand weight (kg)	1.95±0.21	1.88±0.16	1.92±0.05	1.9
Banana (bottom) hand weight (kg)	1.50±0.14	1.23±0.25	1.37±0.19	1.1

*For comparison: Record was limited for calculation of average ± SD. The banana hand size (length ⊚ width) and weight, or the banana bunch size and weight, can be used to calculate the volume and weight of packing-box, or cargo, respectively.

In Malaysia, the yield was reported to be 20–30 kg/bunch (Hassan, 2002), but a few local farmers reported it in social media to be 25–40 kg/bunch. Jamaluddin (1996) reported, also in Malaysia, that weights/bunch of Goldfinger, Novaria, Williams and Montel cultivars were 26.2, 22.1, 20.9, and 22.9 kg, and yields/ha were 34.9, 29.5, 27.9, and 30.2 tonnes, respectively. In Australia, the average of Cavendish 'Williams' yield was 40–43 tonnes/ha, depending on the sites, where in some areas it was 52–118 tonnes/ha with bunch weight of 25–56 kg/bunch (Schelfhout, 2014). The common yield in Australia at 2500–3333 banana-trees/ha was 60.3–71.5 tonnes/ha (Schelfhout, 2014). In Africa, the yield was 47.92–65.92 tonnes/ha, 30.51–32.55 kg/bunch, and 7.9–9.4 hands (Fonsah et al., 2007). The yield/banana in the present study was found to be markedly lower as compared to the yields that have been reported by other studies conducted in Malaysia and Australia. Even the yield of Cavendish

'Williams' reported by Jamaluddin (1996) is still markedly lower than that in Australia. If the banana in this study achieves the bunch weight and hand number of the mother plants, the expected yield/area can be 104.9 tonnes/ha. It could also be possible that the weight/hand will be increased and be almost the same for all hands when the hands are reduced to only five per bunch. The extrapolated data in this study indicate the possibility that the yield/ha could match that in Australia, but this view has to be taken with caution for the factors stated earlier on the differences in genetic potential and climatic condition. The difference in the hand number could not be explained, but as will be commented below, perhaps there is an issue in nutrient supply balance in this study to support a production of large-size bunch of the banana. The contribution of the organic compost to the growth and yield of the banana in this study is not yet clear, but it is well accepted that organic matter can increase plant nutrient uptake, which eventually lead to a better growth and yield.

Economics and Return on Investment (RoI)

At RM4.0/kg, the average profit was RM58.40/bunch (1 bunch = 1 banana tree = 14.6 kg/banana-hands), or about RM42.32/m². It was RM62.40/bunch when the bunch stalk was not removed. At RM7.50/kg, which is the average price of Cavendish banana advertised online, the income can be RM109.50/banana or RM79.3/m². The annual costs of labour and chemicals to maintain 52 bananas were RM936.84, i.e., RM18.01/banana (refer Table 3 and Table 4), excluding the cost for fruit processing and marketing, which was not calculated in this study. Thus, the net profit estimated for the Cavendish banana was RM40.39/banana or RM29.26/m².

Table 3. Expenditure for labour.

Activities	Number of staff	Hour/ round	Round / year	Cost (RM)/hr	Total cost (RM)	Cost (RM)/ banana
Planting	2	8	1	6.75	108.00	2.08
Fertilizer Application	1	1	3	6.75	20.25	0.39
Leaf maintenance	1	1	24	6.75	162.00	3.12
Fruit maintenance	1	0.5	3	6.75	10.13	0.19
Weed control (manual)	2	1	11	6.75	148.50	2.86
Weed control (chemical)	1	1	1	6.75	6.75	0.13
Pest and disease control	1	1	1	6.75	6.75	0.13
Banana-base soil maintenance	2	8	3	6.75	324.00	6.23
Total (RM)					**786.38**	**15.12**

*The costs for fruit processing from picking to packing and for marketing were not included because this study did not involve these tasks and there was no specific cost can be calculated.

Table 4. Expenditure for fertilizers, weedicides and energy.

Materials	Quantity	Number of bananas	Round/ year	Cost (RM)/ item	Total cost (RM)	Cost (RM)/ banana
Glyphosate (L/two plots)	0.15	–	1	11.50	1.73	0.03
NPK Yellow (kg/tree)	0.50	52	1	1.60	41.60	0.80
NPK Green (kg/tree)	0.50	52	1	1.60	41.60	0.80
NPK Blue (kg/tree)	0.50	52	1	1.60	41.60	0.80
Carbofuran (kg/tree)	0.005	52	1	40.00	10.4	0.20
Petrol (L/two plots)	0.60	–	11	2.05	13.53	0.26
Total (RM)					**150.46**	**2.89**

The profit is expected to be lower when the cost for fruit processing and marketing is included and much lower when monoculture farming of Cavendish banana is considered, as land preparation requires a significant amount of financial investment. In the present study, the advantage was that land preparation cost was not applicable, as the work was carried out when the oil palm area was established in 2007. It has to be noted as well that the RM4.0/kg was an end user price. It will be markedly lower when the bananas are sold to intermediaries. Other factors are supply and age of saplings, which will affect the total fruiting banana stems/area and the profit/ha. The supply is limited by the number of suckers produced by the mother plants (will not be a problem for saplings produced using tissue culture technique) and the age is different between saplings. So, the banana trees at the same area will not shoot (fruit) at the same time. Generally, the data indicated that integrating a Cavendish banana production in oil palm plantation, namely, in oil palm gaps can be profitable, depending on the strategies to address the aforementioned factors.

Nutrient Management and Weed Control

Fertilizer was applied as 0.5 kg NPK15:15:06, 0.5 kg NPK15:15:15, and 0.5 kg NPK12:12:17 per banana once a year. Compost was added once a year as 1.0 kg chicken dung and 1.0 kg goat manure per banana. In other words, each banana received 0.21 kg N/year, 0.091 kg P/year, and 0.16 kg K/year. In Australia, for 50 tonnes/ha production of Cavendish 'Williams', the plants (2500–3333/ha) require (per ha/year) 2000 kg Potassium sulphate (43% K), 1400 kg UAN (Flexi-N: 42.2% N) (or at least 260 kg N/ha, which is equivalent to 56 kg Urea/ha/month), 160 kg Magnesium sulphate, 160 kg Monoammonium phosphate (MAP: 27% P and 12% N), 48 kg Zinc sulphate, 40 kg Manganese sulphate, 4 kg Iron sulphate, 4 kg Copper sulphate, and 530 kg Calcium nitrate (24% Ca, 17% N, and 59% O) (Schelfhout, 2014). For the farm in Australia, each banana received 0.21–0.28 kg N/year, 0.013–0.017 kg P/year, and 0.26–0.34 kg K/year. It appears that the fertiliser application rate in this study, at least for N, matches the rate used by commercial farms. However, the bananas have nutrient imbalance issue, for instance, have received higher P but lower K supply compared to that on the commercial farms. Fertiliser application in Table 1 has to be modified for example Monoammonium phosphate and Potassium sulphate are used so that the supply of P and K can be balanced.

The weeds were machine-cut every month during the first 11 months, but after that, only when necessary. Glyphosate was applied once/year to reduce further the growth of weeds in the plots. Over time, the bananas grew bigger, shaded and suppressed the weeds on the ground from having an effective photosynthetic activity to grow well (Figure 1(C)). The light intensity under the banana canopy (Table 5) was lower than the ideal rate for effective photosynthesis. Plant photosynthetic activity in open area peaks around 10:00 AM of which the ambient photosynthetic photon flux density (PPFD) during that period is around 600–700 μmol/m²/s (Ibrahim & Jaafar, 2011). The peak is achieved at 2:00 PM in glasshouse condition (Ibrahim & Jaafar) where they may be shading, but the PPFD values (Table 5) are expected to have not supported the weeds to have an effective photosynthetic activity. At the edge of the plots, PPFD was still high, such as, in location A (Table 5), but this involved only a small part of the plots. With the reduction of effective photosynthetic activity, the weeds had less energy to grow, and weedicide was not markedly required, which eventually reduced the cost of weeding.

Table 5. Light intensity (μmol/m²/s) under the canopy of Cavendish banana planted in oil palm gap.

Time	Locations in Palm Gap 2 (PG2)			Average (±SD)
	A	B	C	
6:00 AM	1.11	0.92	1.11	1.05±0.11
8:00 AM	57.90	65.68	66.05	63.21±4.60
10:00 AM	462.50	196.10	94.72	252.11±189.96
12:00 PM	1929.55	197.77	200.73	776.01±998.99
2:00 PM	1594.70	175.01	162.25	643.98±823.37
4:00 PM	194.25	53.65	106.38	118.09±71.03
6:00 PM	7.22	3.70	4.07	4.99±1.93
Average (±SD)	**606.75±810.79**	**98.97±88.34**	**90.76±74.86**	**265.49±295.56**

Fruit Management and Postharvest Considerations

Based on the experience in this study, regular customers were available and not an issue. However, they commented about the long ripening-period after purchase. Cavendish banana was suitable to be harvested between 12 and 15 weeks after blooming (Mustaffa et al., 1998). On average, the banana in this study was harvested at 13 weeks after blooming (Figure 1(D)), which was well within of that range, meaning the bunch was harvested at the appropriate maturity level. A test indicated, however, that when ripened using the conventional method, the first banana hand, i.e., the one that at the top of the banana bunch, ripened in five days and the last or bottom banana hand in 12 days. It is thus expected that customers who bought the bottom banana hand will complain about the ripening period. Biologically, the age of the banana hands exhibits variation from the top to bottom of the bunch. Observation in the field revealed that the interval between the opening of each hand was two days. It means that if there are seven banana hands, the bottom hand is likely to be 14 days younger than the top hand. Customers also commented about the texture of the banana skin, which was rough with pale brown dots or blotches – not smooth and shiny as usual. This mark maybe due to the situation that the bunch was exposed to rain and sunlight during the developmental period. The banana bunches were not wrapped with plastic sheets as was usually practiced on many commercial farms. Another comment was that the skin did not turn to bright yellowish colour (Figure 1(E)), dissimilar to that was usually seen for Cavendish banana. It is known that a good postharvest facility, such as, the use of ethylene, is required to induce the Cavendish banana to ripe properly and to attain a nice yellowish skin (DOA Sarawak, 2022). Cavendish banana skin turned yellowish when ripened at 18°C but not at 27°C (Ding et al., 2005). Also, there was a comment that once ripened, the banana tended to become overripe and half-spoiled in three days, which means naturally ripened Cavendish is likely suitable only for local or the most within district markets as compared to those ripened under controlled conditions of temperature and Ethylene. Overall, these comments indicate that a guide on the proper fruit management in the field, including wrapping the bunch and reducing the hands to only five or six per bunch, and a proper postharvest facility for the fruits are important to support a good quality production of Cavendish banana. A company in Keningau has established a Cavendish plantation that produces high-quality banana to set an example of monoculture commercial farm in Sabah.

CONCLUSION

The present study indicated that intercropping Cavendish banana with palm oil production by planting in oil palm gaps is potentially profitable. The expected net profit can be RM40.39/banana or RM29.26/m^2 at 1.8 m × 1.8 m planting distance, depending on the land preparation cost, selling price, marketing strategies, and approaches to address challenges, such as, lower fruiting banana stems/ha. In addition to that benefit, the bananas will also shade and suppress the weeds on the ground from growing well and reduce the cost of weeding. The findings will have a positive impact on the management of oil palm plantation, because in any oil palm areas, death of a few trees can happen at any time. The trees die because of disease or pest attack, or blown down by a strong wind. That creates cropless gaps, which is unproductive and thus undesirable. Replanting the same crop in those gaps can be impractical. The disease left in the soils by the dead plants, especially *Ganoderma*, will infest the replanted plants. Also, the matured plants will shade the replanted one and suppress the latter from growing well. As this study has shown, planting a secondary crop in the gaps, such as the Cavendish banana, can turn the areas monetarily productive. This study is also hoped to give an idea for B40 families living adjacent to large oil palm plantation and the plantation owner to collaborate in order to use oil palm gaps for Cavendish banana production. The families can be the contract farmers especially when the plantation owner does not want to hire plantation workers for the banana production. Future work is recommended to produce and publish an agronomy and postharvest manual suitable for the conditions in Sabah to guide and support many more local farmers to produce Cavendish banana competitively for export purposes. The true identity of the locally planted Cavendish is also important to be verified to ensure that the manual produced is specific to the genetic potential of the respective cultivars.

ACKNOWLEDGEMENTS

We would like to thank the Farm Crop Unit of the Faculty of Sustainable Agriculture's (FSA) Farm Division for establishing and maintaining the experimental plots and for measuring the main data. Thanks also to the FSA postgraduate students especially Ms. Rosie Laiza Henny for measuring the additional data. This project was partially funded under the UMS internal grant (SDK0178-2020) associated with improvement of crop production and student financial wellbeing during Covid-19 pandemic and beyond.

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