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Agronomic assessment of three spice plants as understorey crops in oil palm (*Elaeis guineensis* Jacq.) plantation

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ABSTRACT

Utilization of land with intercrop plants can support the productivity of the land. The wide spacing of oil palm plants can be used to plant intercrops. Spice plants such as red ginger, turmeric, and cardamom are examples of intercropping plants under the shade of oil palm. This study aimed to determine the adaptability of red ginger, turmeric, and cardamom as understorey plants of different oil palm ages. The research was carried out from February to November 2021 at Sekernan, Muaro Jambi, Jambi. The study consisted of three experiments to investigate three spice plants. Each experiment used a randomized complete block design (RCBD) with oil palm ages as treatments, namely 0, 5, 10, 15, and 20 years. Variables observed included light intensity, plant height, tiller number, leaf number, and rhizome weight. The red ginger and turmeric were considered as adaptive plants to understorey conditions due to the yield of > 60% in 15-year-old oil palm trees than those grown in non-shade conditions. Production levels of red ginger and turmeric were determined by the number of tillers and leaves. The cardamom plant under oil palm shade produced a better yield than that in control. This implies that all three spices are suitable as intercrop plants under oil palm plantations.

Keywords: cardamom; low light intensity; red ginger; shade stands; turmeric

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INTRODUCTION

Indonesia is one of the countries that have the largest area of oil palm plantations in the world. Oil palm plantations in Indonesia are managed by three agencies: large state-owned plantations, large private plantations, and smallholder plantations. Farmers generally plant oil palms in Indonesia with a spacing of 9 m x 9 m x 9 m (an equilateral triangle system). The long spacing between oil palm plants creates available space for intercrop plants (Wardhana et al., 2014). In general, intercropping practice in oil palm is recommended at the immature stage (below 3 years after planting), however, in the mature stage, field intercropping is still possible by selecting appropriate species of intercrop plants (Asima et al., 2017).

Farmers have experienced intercropping under oil palm fields using food crops, especially when the plants are immature, such as rice, corn, and soybeans. The practice is especially to earn cash during the immature field for new plantation or rejuvenation periods, especially in smallholder plantations (Agustira et al., 2018). Nevertheless, intercropping in mature oil palm plantations (until 10 years old) is rarely done because of deep shading, but after 10 years some farmers do due to the availability of sunshine to soil ground (Yudistina et al., 2017).

Some plant species that require shade as a place to grow are from the Zingiberaceae family, such as red ginger, turmeric, and cardamom. These three plants have experienced a decline in production from year to year due to reduced agricultural land due to land conversion, especially on the island of Sumatra, where agricultural land has turned into oil palm plantations. Land conversion occurred from 2016 to 2020 due to the demand for these three plant commodities. The decreased harvested area resulted in reduced yields (Lestari et al., 2022). The decline in the production of the three plants stimulates the government to import from other countries. In 2019, the Indonesian government imported ginger about 21.75 thousand tonnes, while the import of turmeric in 2018 reached 1.59 thousand tonnes/ha (BPS, 2019). Therefore, it is necessary to investigate the growth of red ginger, turmeric, and cardamom plants as the understorey of mature oil palm stands of different ages. The research aimed to determine the adaptability of red ginger, turmeric, and cardamom as understorey plants of different oil palm ages.

MATERIALS AND METHODS

The research was carried out at the farmer's oil palm plantation KM 64, Sekernan District, Muaro Jambi Regency, Jambi Province, with an elevation of ± 25 m above sea level from February to November 2021. The spice plants used red ginger, turmeric, and cardamom. The plant material of red ginger (*Zingiber officinale* var. *rubrum*) and turmeric (*Curcuma longa*) originated from the rhizome of a plant that was harvested 48 weeks after planting obtained from a local farmer (Muaro Jambi Regency). Cardamom (*Amomum compactum* Soland ex. Maton) material used separation of tillers obtained from farmers in Tasikmalaya Regency in West Java.

The fertilizers used were urea (300 kg ha^{-1}), SP-36 (200 kg ha^{-1}), KCl (200 kg ha^{-1}), and cow manure (20 tons ha^{-1}). The equipment used a lux meter to measure the level of light intensity, with the formula: Shade level (%) = (Intensity in no shade, Io (control) - shaded, Ii): Io x 100% in oil palm stands.

The study consisted of three experiments, using three spices as separate experiments. Each experiment used a randomized complete block design (RCBD) with oil palm ages as treatments, namely 0, 5, 10, 15, and 20 years.

The experiment was initiated with ginger and turmeric rhizome nurseries, while cardamom was grown from sprouted saplings. Land preparation was done using a hoe. After that, the soil was mixed with cow manure at 5-10 kg/planting hole, followed by making trial plots and drainage. Red ginger and turmeric were planted with a spacing of 50 cm x 50 cm with a hole depth of 10 cm, while cardamom was planted with a spacing of 1 m x 1.5 m with a depth of 3-5 cm.

Plant maintenance was done by watering, replanting, stockpiling after two months, pest control, and fertilizer application. Harvesting was done when the red ginger plants were nine months old with all the leaves falling off, while the color of turmeric leaves changed from green to yellow, and the stems were dry out.

Red ginger, turmeric, and cardamom plants were considered adaptive to shade if plant height, number of leaves, number of tillers, and production (rhizome weight) were greater than or equal to 60% compared to control in full sunshine. For example, the change in number of tillers (%) = (Number of tillers under shade - Number of tillers in control) x 100%/control.

Data were analyzed using ANOVA (analysis of variance) and correlation tests between variables using R Studio version 4.0.0. If the treatment had a significant effect, a post hoc test was carried out using Duncan's Multiple Range Test (DMRT) at the 5% level.

RESULTS AND DISCUSSION

Microclimatic conditions under stands

The older the oil palm stand, the lower the intensity of light and the greater the level of shade under the canopy of the oil palm (Table 1). Herdiawan et al. (2022) stated that the decrease in sunlight intensity is in line with the age of the oil palm. Suryana et al.

(2019) showed that the sunshine-blocking level for 5-year-old oil palms was around 55%, while 10-year-old oil palms had 64% of sunshine blocked by a canopy of oil palm trees.

Table 1. Light intensity and level of shade on the understorey of various ages of oil palm stand.

Oil palm age (year)	Light intensity (lux)	Level of shade (%)
0	99,466.5	0
5	40,781.3	58.99
10	33,022.9	66.79
15	30,934.6	68.89
20	28,944.8	70.98

Agronomic characteristics of plant height, number of leaves, and number of saplings

Plant height of red ginger and turmeric increased at 4-28 WAP, while cardamom increased at 8-28 WAP (Tables 2, 3, and 4). The highest red ginger and turmeric plant height was obtained at the 15-year-old plantation, but the value was similar to the plants grown in 5 years and 20-year-old oil palm stands (Table 2 and Table 3).

Table 2. Plant height of red ginger grown as the understorey of different ages of oil palm.

Oil palm age (year)	Plant height (cm)						
	4 WAP	8 WAP	12 WAP	16 WAP	20 WAP	24 WAP	28 WAP
0	13.70c	17.93c	25.58b	32.89b	43.94bc	47.34b	47.68b
5	16.99bc	31.04ab	47.86a	50.98a	52.81abc	59.18ab	66.77a
10	16.84bc	25.72bc	30.47b	32.89b	36.60bc	43.43b	47.42b
15	20.32ab	32.37ab	48.26a	57.22a	70.70a	73.76a	78.68a
20	22.98a	33.39a	48.62a	54.49a	57.61ab	57.56ab	62.73ab
F test	*	*	*	*	*	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at the 5% level.

Table 3. Plant height of turmeric grown as the understorey of different ages of oil palm.

Oil palm age (year)	Plant height (cm)						
	4 WAP	8 WAP	12 WAP	16 WAP	20 WAP	24 WAP	28 WAP
0	13.36b	23.56d	32.80c	46.29c	53.31b	61.12ab	63.16ab
5	23.84a	42.18ab	66.48a	72.70a	74.94a	71.70a	74.83a
10	26.71a	34.30c	40.29c	46.81c	49.86b	48.56b	50.93b
15	29.12a	48.99a	71.37a	77.03a	77.87a	73.65a	75.79a
20	23.57a	36.28ab	55.16b	59.13b	59.23b	55.47b	50.13b
F test	*	*	*	*	*	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at the 5% level.

Plant height at the understorey of the 15 years old oil palm, irrespective of species species, was higher than other treatments. However, red ginger, turmeric, and cardamom plants under the shade of 10-year-old oil palms were lower than those of 5 and 15-year-old oil palm plants (Tables 2, 3, and 4). Low spiced growth under the 10-year-old palm plantation is likely affected by soil conditions. Soil of 10 years old is categorized as S3 category for growing oil palm meaning marginal soil because located at slope land. Slope land is categorized as less suitable for growing oil palm plantations because of the high leaching of nutrients and high erosion. According to Ariyanto et al. (2022), the steeper

land slope level stimulates runoff and high soil erosion leading to low nutrient content in the soil.

In the present experiment, likely, decreasing light intensity by shading of oil palm canopies was not consistently responded to by red ginger, turmeric, and cardamom plants. Azis et al. (2023) stated that increasing the shade did not affect the height of the red ginger plant. Red ginger, turmeric, and cardamom are probably shade-loving plants.

Table 4. Plant height of cardamom grown as the understorey of different ages of oil palm.

Oil palm age (year)	Plant height (cm)					
	4 WAP	8 WAP	12 WAP	16 WAP	20 WAP	24 WAP
0	12.13	18.13c	19.81b	35.12b	41.83b	41.93b
5	20.06	33.62ab	47.66a	58.77a	64.24a	76.36a
10	12.19	21.56c	27.17b	34.50b	37.86b	43.49b
15	21.47	38.07a	48.17a	56.28a	60.74a	69.24a
20	18.38	25.46bc	29.30b	36.52b	42.39b	47.01b
F test	ns	*	*	*	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at the 5% level, ns not significant.

The tiller numbers of red ginger (Table 5) and turmeric (Table 6) without shade were significantly higher than the plant under the oil palm stand. The percentage reduction in tiller number compared to control plants in red ginger plants ranged from 54.5%-80.1%, while for turmeric plants, it ranged from 59.1%-84.8%. The tiller number under shade was lower than plants without shade because of the lower light intensity. The species probably allocates assimilate more on increasing leaf area and plant height. In rice, Santoso and Sutarman (2021) and Alridiwirsah et al. (2015) state that the number of tillers of upland rice grown in the shade is 60% lower than under full sunshine. Since the number of tillers affects the weight of the rhizome in red ginger and turmeric plants, the reduction of tiller number should be considered in intercropping under the oil palm plantation.

Cardamom plants with the highest number of tillers were found under oil palm stands aged 5 and 15 years; those values were significantly different from those without stands and 20 years old, but not significantly different to cardamom grown under stands 5 and 10 years old (Table 7). The tiller number of cardamom under shade increased by 66.9%-242.9% compared to plants without shade. In contrast to red ginger and turmeric, cardamom grew well in 50-70% shade or planted under tree stands, indicating that cardamom might adapt to shading conditions. Indrajaya and Siarudin (2015) reported that cardamom grown as an intercrop in *jabon* tree (*Neolamarckia cadamba*) could grow well compared to cardamom plants without shading.

Table 5. Tiller number of red ginger grown as the understorey of different ages of oil palm.

Oil palm age (year)	Tiller number				
	12 WAP	16 WAP	20 WAP	24 WAP	28 WAP
0	2.67a	4.00a	8.45a	11.78a	19.55a
5	2.33a	3.22a	4.22b	6.56b	8.66b
10	1.11b	1.00c	2.22c	3.22c	3.89b
15	1.87ab	2.67ab	4.89b	6.78b	8.89b
20	0.90b	1.55bc	2.33c	3.00c	3.89b
F test	*	*	*	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at 5% level.

Table 6. Tiller number of turmeric grown as the understorey of different ages of oil palm.

Oil palm age (year)	Tiller number				
	12 WAP	16 WAP	20 WAP	24 WAP	28 WAP
0	1.67a	2.56a	3.67a	6.44a	8.44a
5	1.33ab	1.78ab	1.90b	2.11bc	2.33bc
10	1.00b	1.22b	1.44b	1.11c	1.33c
15	1.50ab	1.61b	2.22b	3.44b	3.45b
20	0.00c	1.00b	1.17b	2.11bc	1.28c
F test	*	*	*	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at 5% level.

Table 7. Tiller number of cardamom grown as the understorey of different ages of oil palm.

Oil palm age (year)	Tiller number		
	20 WAP	24 WAP	28 WAP
0	1.78	1.67b	1.33c
5	1.67	2.89ab	4.56a
10	2.00	2.78ab	3.00ab
15	2.56	3.78a	4.56a
20	1.11	1.56b	2.22bc
F test	ns	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at the 5% level, ns not significant.

The number of leaves of red ginger and turmeric at different ages of stands was significantly different (Table 8 and Table 9). Entering the age of 20 WAP, the plants grown without shade got the highest leaf number and were significantly different from those of the 5, 10, 15, and 20-year-old stands. Fewer tillers of ginger under shading (Table 5) could be the cause of fewer leaves of shaded plants compared to the control (Table 8).

Table 8. Leaf number of red ginger grown as the understorey of different ages of oil palm.

Oil palm age (year)	Leaf number						
	4 WAP	8 WAP	12 WAP	16 WAP	20 WAP	24 WAP	28 WAP
0	1.56c	4.89b	15.00bc	34.11a	70.11a	127.11a	203.00a
5	3.00ab	8.33a	18.44ab	32.89a	44.44bc	62.44bc	71.67bc
10	2.22bc	5.89b	11.33c	16.78b	20.67c	35.22c	40.78c
15	3.56a	7.89a	21.22a	33.23a	57.67ab	79.11b	106.00b
20	3.78a	7.33a	17.33ab	25.33ab	36.78bc	37.22c	30.67c
F test	*	*	*	*	*	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at the 5% level.

Table 9. Leaf number of turmeric grown as the understorey of different ages of oil palm.

Oil palm age (year)	Leaf number						
	4 WAP	8 WAP	12 WAP	16 WAP	20 WAP	24 WAP	28 WAP
0	1.89	4.22	7.67ab	13.00	21.89a	27.67a	42.78a
5	2.56	5.44	7.67ab	11.11	15.57b	15.56b	14.67b
10	3.00	3.89	6.56b	10.78	10.44b	7.11c	7.00c
15	3.11	5.44	9.44a	12.33	12.89b	14.22b	14.78b
20	2.89	4.56	8.56a	10.11	11.22b	8.56c	5.00c
F test	ns	ns	*	ns	*	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at the 5% level, ns not significant.

Leaf growth of red ginger and turmeric under shade from 4 to 12 WAP was higher than plants without shade (Table 8 and Table 9). This is because red ginger and turmeric plants require high shade levels at the beginning of the growth period. Hazizah et al. (2021) stated that shade could protect the young leaves of the ginger plant from direct sunlight during early growth. The number of leaves of red ginger and turmeric plants after entering the age of 16 to 28 WAP by planting under oil palm shade stands a lower number than the number of leaves without stands (Table 8 and Table 9). The number of leaves is in line with data on the number of tillers. At 16 to 28 WAP, the number of tillers on plants without oil palm stands was higher, leading to the plants without stands to be more leaves than the plants under shading. Samanhudi et al. (2018) showed that the number of tillers determines the leaf number of the turmeric. Arisma et al. (2022) stated that the leaf number of red ginger is proportional to the tiller number. Setiawan (2019) stated that the leaf number of the torch ginger (*Etlingera elatior*) under 75% shading is lower than that under 65% shading.

The cardamom at 28 WAP under shaded stands produced more leaves than without shading, except those under 20-year-old oil palm plantation (Table 10). Cardamom produced more leaves under shading than under full sunshine because the plants under full sunshine exhibited stunting. The stunting growth of cardamom with yellowing in leaves under direct sunshine has been reported by Vijayan et al. (2018). Cardamom is likely sensitive to photo-oxidative because many cardamom leaves exposed to the full sunshine became yellowing, a symptom of sunburn. The optimal shading for growing cardamom is 30 to 70% as indicated by a high number of healthy leaves (Alqamari et al., 2017). The large number of leaves on plants under shade is a process of adaptation of cardamom plants to low sunlight intensity (Nurcholis et al., 2022).

Table 10. Leaf number of cardamom grown as the understorey of different ages of oil palm.

Oil palm age (year)	Leaf number					
	8 WAP	12 WAP	16 WAP	20 WAP	24 WAP	28 WAP
0	1.00	1.83c	2.67c	3.11d	6.11c	8.56c
5	1.89	4.33ab	8.00ab	13.89ab	21.67a	30.33a
10	1.78	3.44b	5.56bc	11.00bc	15.00ab	21.67ab
15	2.11	5.22a	9.89a	16.67a	23.56a	32.78a
20	1.67	3.67b	5.22bc	8.11cd	10.67bc	16.11bc
F test	ns	*	*	*	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT at the 5% level, * significant at the 5% level, ns not significant.

Table 11 shows that the rhizome production per plant, red ginger, and turmeric had reached the adapted criteria level of 60 % of the control or outside understorey of the oil palm stand. It can be seen that the Turmeric plants grew well with production yields of more than 60% of the control plants, namely at the age of stands 5 and 15 years, while the red ginger plants were only suitable at 15-year-old oil palm plantation. In their research, Gunawan and Rohadi (2018) explained that planting large white ginger, small white ginger, and red ginger under *tusam* trees (*Pinus merkusii*) decreased ginger production by up to 50%. Sharangi et al. (2022) stated that shade levels that are too high (>50%) can reduce the production of turmeric plants. Ratri et al. (2015) stated that shading up to 50% on turmeric plants was not significantly different in yield to those without shade. Bachli and Irundu (2016) pointed out that ginger under mahogany stands with a shade intensity of 25-50% had lower ginger production.

Table 12 shows high and significant correlations between leaf number and tiller number with rhizome products for red ginger and turmeric. The leaf number and the tiller number had a positive and significant correlation with the production of red ginger plants, with a value of 0.97 for the leaf number and 0.93 for the tiller number. Plant height, leaf number, and tiller number were positively and significantly correlated with the

production of turmeric plants with a correlation value of 0.64, 0.87, and 0.88, respectively. Meanwhile, the tiller number of cardamom was positively correlated with plant height (0.87) and leaf number (0.97).

Table 11. Rhizome weight per plant of red ginger and turmeric grown as the understorey of different ages of oil palm.

Oil palm age (year)	Rhizome weight per plant (g)	
	Red ginger	Turmeric
0	16.18a	18.57a
5	9.09bc	12.08b
10	5.71c	5.90c
15	9.95b	11.65b
20	6.20c	5.58c
F test	*	*

Note: Means followed by the same letter in the same column are not significantly different based on the DMRT test at the 5% level.

Table 12. Correlation test for important variables of red ginger, turmeric, and cardamom plants grown as the understorey of different ages of oil palm.

Variable	Correlation		
	Plant height	Leaf number	Tiller number
Red ginger rhizome weight	0.04ns	0.97*	0.93*
Turmeric rhizome weight	0.64*	0.87*	0.88*
Tiller number of cardamom	0.87*	0.97*	--

Note: * significant at 5% level, ns not significant

CONCLUSIONS

Based on the rhizome production per plant, red ginger and turmeric grown under shading of oil palm met adaptation criteria > 60% yield relative to control without shading. There was a strong correlation between the tiller number and leaf number of both red ginger and turmeric. Red ginger and turmeric were suitable plants as intercrops under stands of oil palm plantations aged 5 and 15 years. Based on growth characteristics, cardamon was also considered an adaptive species as the understorey in oil palm cultivation especially in areas aged 5 to 20 years. Further research is needed to increase rhizomes of red ginger and turmeric, and fruit production of cardamom under oil palm plantation.

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