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Intercropping immature oil palms with food crops: Effects on oil palm growth

Lotte S. Woittiez[a*], Marieke Smit[a], Jusrian Saubara Orpa Yanda[b], Rosa de Vos[a], Maja Slingerland[a]

a Wageningen University & Research, Plant Production Systems Group, Wageningen, The Netherlands. *Email lotte.woittiez@wur.nl
b Arconesia, Bengkulu, Indonesia

Introduction

Oil palms take 3−4 years to start producing after replanting, and in the unproductive years, there is a lot of empty space available between the palms. Farmers regularly plant food crops in the available space, but this practice was long discouraged by agronomists and extensionist, because they worried about potential negative effects on the future productivity of the palms. For this reason, there is little research available about intercropping in immature oil palm fields. The research that is available (full review in preparation) mostly focuses on the productivity of the intercrop, without reporting the effects on the oil palms. Exceptions include a.g. Erhabor & Filson (1998) who report that intercropping in Nigeria decreases the sex ratio in oil palm (which is a key determinant of yield in the young mature phase) with 6−17%. In contrast, Rocha et al. (2020) report that in Brazil, intercropping with pineapple, banana and cassava in the immature phase did not result in reductions in oil palm yield at 10 years after planting.

In this paper, we present some results from a three-year oil palm intercropping project with smallholders and a large company in Bengkulu, Indonesia. The research is part of the Sustainpalm project (www.sustainpalm.org) which aims to increase income and biodiversity and decrease GHG emissions in palm oil production systems. We address the following research question: What are the effects of intercropping with watermelon and/or banana on the vegetative growth of immature oil palms?

Material and Methods

Our field research consisted of two parts: 1) A one-time observational study in smallholder fields (monoculture vs intercrop; n = 29), and 2) Observations in an intercropped block of a large-scale plantation. In the smallholder fields, oil palm and intercrop densities and other management practices were not recorded. In the large plantation, 11.3 ha were intercropped with watermelon in the first year after replanting, and bananas were established on 15 ha (partly overlapping with the watermelon area) in the following year (Figure 1, 2). Intercrops in the plantation were managed by farmers who were recruited by the company PT Arconesia. Watermelons were planted at a density of 2.500 plants ha^{-1}and bananas at a density of 1.500 plant ha^{-1}. Before watermelon planting, interrows were ploughed and 1 t ha^{-1} chicken manure was applied. When planting banana, 20 kg solid mill waste was applied as fertilizer per planting hole, and 10 t ha^{-1} empty fruit bunches were applied between banana plants at four months after planting. The farmers followed Standard

Operating Procedures for intercrop management, including irrigation, fertilizer application, and regular weeding. The oil palms were planted at standard density (140 palms ha^{-1}) and did not receive any water or fertilizers in the first two years. We established monitoring plots in an imbalanced pseudo-replicated design with four treatments: watermelon followed by monoculture (WM, n = 4), watermelon followed by banana (WB, n = 4), monoculture followed by banana (MB, n = 6) and monoculture followed by monoculture (MM, n = 9; Table 1). In year 3, we fertilized all the plots, and we added unfertilized control plots (one for each treatment apart from MM, where we added two).

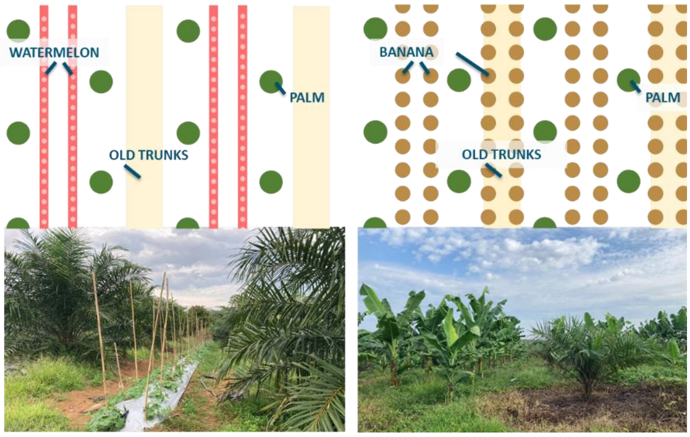

Figure 1: Field layout for intercropping with watermelon (left) and banana (right).

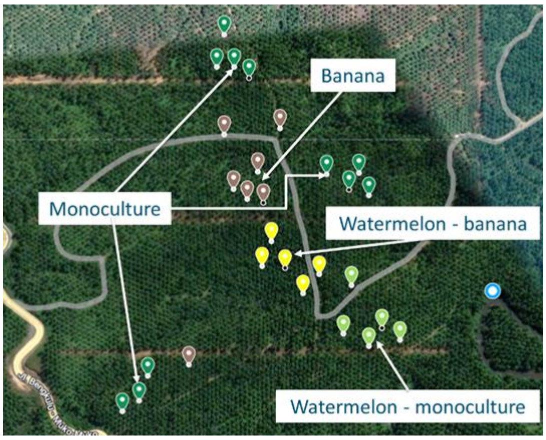

Figure 2: Position of plots within the landscape (Google Maps).

Table 1: Overview of treatments, number of plots and number of palms

Treatment	Intercrop before	Intercrop now	# Plots	# Palms
MB	None (monoculture)	Banana	7 (6 f, 1 n)	7 × 6 = 42
WB	Watermelon	Banana	5 (4 f, 1 n)	5 × 6 = 30
MM	None (monoculture)	None (monoculture)	11 (9 f, 2 n)	11 × 6 = 66
WM	Watermelon	None (monoculture)	5 (4 f, 1 n)	5 × 6 = 30

A plot consisted of six palms on which we carried out individual measurements. We collected four vegetative growth variables for the oil palms at different time points (in total five times over 25 months). Palm height was measured from the soil to the tip of the highest leaf; frond number was counted (living, green fronds only); frond length was measured from the start of the rachis to the tip of frond 9; and frond size was calculated on the basis of leaflet length, leaflet width and leaflet count of frond 9, using the following formula:

$$Frond\ size = 0.455 \times n \times l \times w - 0.245, \qquad \text{Eq. 1}$$

Where frond size is in m^2, n = total number of leaflets on the frond, l = average lengths of six leaflets (m) and w = average width of six leaflets (m; Corley & Tinker 2016: 93).

For the large plantation, even though the design was pseudo-replicated and confounded (watermelons and bananas were cultivated in lower-lying areas close to a water source; Figure 2), we analysed the data as if it were a split plot design with three factors: Intercrop year 1 (watermelon or monoculture), intercrop year 2−3 (banana or monoculture) and fertilizer (yes or no). We used a mixed model with different vegetative growth variables (palm height, frond number, frond length, frond size) as continuous response variables; three binary fixed factors (intercrop year 1, intercrop year 2, fertilizer yes/no); and one random factor (plot). Values with $p<0.05$ were considered significant, with caution as mentioned above (pseudo-replication and confounding).

Results and Discussion

No differences in oil palm vegetative growth were observed between monoculture and intercropped smallholder fields (Figure 3). Fertilizer application in the large-scale plantation had a significant positive effect on frond size only (data not shown). This effect may be larger in future, as the effects of nutrients on growth take time to unfold. Oil palms fronds were significantly larger and longer in plots that were intercropped previously with watermelon (Figure 4). This may be due to the capture of additional resources (water, nutrients) by the palm, but results were strongly confounded with the position in the landscape; watermelons were cultivated in low-lying areas where irrigation water is accessible. Considering that the past years were quite dry, it is likely that the position in the landscape provided the oil palms with a hydrological advantage. This may be the only explanation for the apparent positive effect of the watermelon treatment, or it may have amplified a true causal effect of watermelon cultivation on oil palm growth.

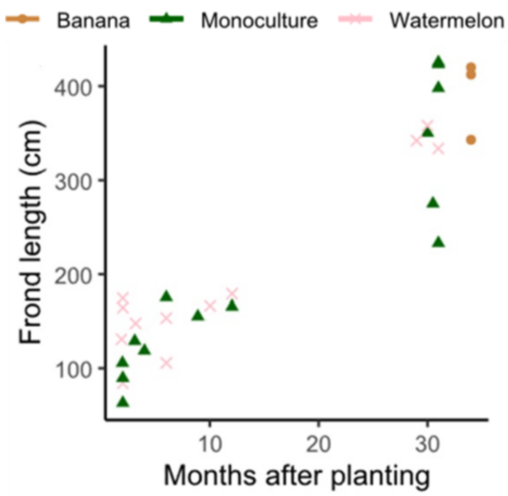

Figure 3: Response of frond length to palm age (months after planting) and intercropping treatment (with banana, watermelon, or control = monoculture); n = 29 smallholder fields.

Intercropping with banana did not have a significant effect on vegetative growth, but the palms in the watermelon-banana treatment were significantly higher. Fertilizer, mulch and water inputs to the banana rows may lead to positive effects on the oil palms, but competition for light is a serious concern. We know that oil palms are very sensitive to light competition (e.g. Breure, 1982) and we caution that intercropping with tall species may lead to reductions in yield in the young mature period. Rapid increase in height may be a sign of vigorous growth, but it can also be a sign of etiolation. In addition to light competition, intercropping practices sometimes include the removal of lower palm fronds to increase space for the intercrop. This practice is explicitly prohibited in the Standard Operating Procedures of PT Arconesia, because pruning of fronds leads to reductions in intercepted radiation. Lower fronds in immature palms are net contributors of assimilates, provided that they are green, and removing them may lead to reductions in future yield. In conclusion, the overall effects of intercropping on palm growth and yield depend on the balance between additional resources that become available to the palm (water, nutrients) and competition with intercrops (light, water and nutrients). Intercropping is usually coupled with better management of weeds, pests and diseases, and it may enrich the soil microbiome, but intercrops may also act as hosts of pests or diseases. How all these interacting factors balance out remains an open question that urgently requires further research.

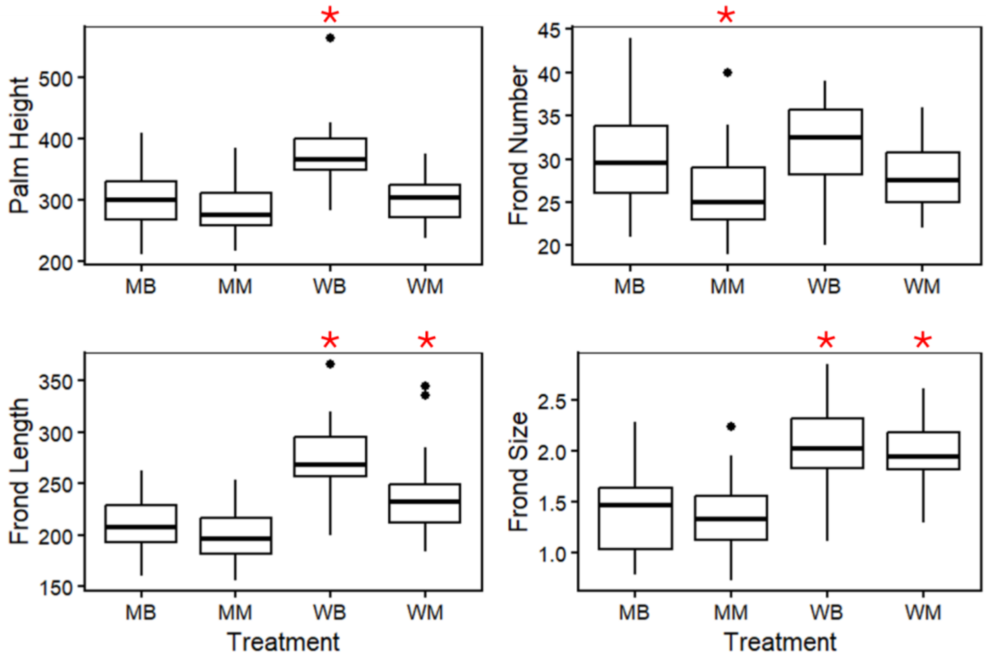

Figure 4: Palm height (cm), frond number, frond length (cm) and frond size (m2). MB = monoculture – banana, MM = monoculture – monoculture, WB = watermelon – banana, WM = watermelon – monoculture. Red stars indicate significant differences between treatments at $p<0.05$.

Conclusions and Outlook

Our data are inconclusive but suggest that intercropping does not necessarily reduce oil palm growth and may even promote it. Results from literature generally confirm these trends, but studies are patchy and often too short. In our study site, the watermelon and banana were irrigated and received ample nutrients, but in more nutrient or water limited conditions, the intercrop may compete with the oil palm for these resources. In addition, competition for light is a serious concern, especially when intercropping with a tall species or when lower fronds are pruned. Rigorous long-term studies on the multiple interacting effects of intercropping on oil palm growth and productivity are urgently required.

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