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Residual Effect of Intercropping on the Yield and Productivity of Oil Palm

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Authors' contributions

This work was carried out in collaboration between all authors. Author S. Anim Okyere designed the study, wrote the protocol, wrote the first draft of the manuscript and analysed data. Author F. Danso managed the literature searches, analyses of the study performed. Author I. Danso managed the experimental process, conducted and identified survey of food crops used and author E. Larbi set up of the trial and proof reading. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

The oil palm industry in Ghana is dominated by small scale farmers who normally intercrop oil palm with food crops (maize, cassava and plantain). A trial was conducted on a four year old oil palm field which had been intercropped with food crops for three years (1994-1997). Observations were carried out on the field from 1997-2007to find out the residual effect of the intercrop on the yield of oil palm. The field was compared with the standard system of cover cropping oil palm with *Pueraria* sp. The experiment was laid out in a randomised complete block design with 4 treatments and four replications. Each plot measured 35.2 x 22.7 m and had 12 palms. Vegetative and yield data were collected on the palms. There were no significant differences between the vegetative and yield data of the fields that were intercropped and sole cropped. Intercropping oil palm with maize, plantain and or cassava had no adverse effect on the growth, development and yield of the oil palm.

Keywords: Oil palm; intercropping; food crops; yield.

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1. INTRODUCTION

Oil palm (*Elaeis ginnensis* Jacq.) cultivation in Ghana is dominated by small scale farmers who occupy about 70% of the estimated total area of 145,500 hectares under oil palm cultivation [1,2]. The remaining 30% of the oil palm production area is under cultivation by development state and their affiliated small scale out-growers who practice monocropping. The development estates under plant the oil palm with *Pueraria sp*, a leguminous cover crop which is expected to suppress weed growth, control erosion, conserve soil moisture and ultimately improves fertility by fixing atmospheric nitrogen.

The standard 8.8 m triangular spacing use for oil palm provides wide spaces between the young palms. This leads to considerable waste of solar radiation and weed problem from transplanting to canopy closure which takes between three to five years [3].

Leguminous cover, *Pueraria sp* has a number of benefits; In spite of these benefits the small-scale farmers often do not plant them under the oil palm. They instead intercrop the oil palm with food and other cash crops for three to four years before the oil palm canopy closes. Some even remove fronds to make way for space to intercrop food crops [4].

Farmers may seem justified then by growing food and/or cash crops between oil palm trees until canopy closure. [4] identified a number of crops that the farmers intercrop with oil palm and the basis of their selection.

There is no information on the effect of the intercropping on the yield of oil palm after the intercropping is over and the oil palm takes full stand.

The objective of this study was:

> To assess the performance and yield of the oil palm which had been intercropped with food crops for three years.

2. MATERIALS AND METHODS

The trial was conducted on a field which had been intercropped from 1994 through to 1997 at the Oil Palm Research Institute (OPRI), Kusi (001.45W, 0600N and 150m above sea level). The average total rainfall is about 1600mm per annum, with daily maximum temperature of 32±2ºC. The daily sunshine is at least 5 hours. The experiment was conducted in a Randomised Complete Block Design with 4 treatments and four replications. Each plot measured 35.2 x 22.7 m and had 12 palm seedlings. Oil palm seedlings D x P (ex-OPRI) was planted at a spacing of 8.8 m triangular or the equivalent of 148 palms per hectare. The following crops were intercropped with oil palm seedlings transplanted in April 1994 and constituted treatments.

i. Oil palm + *Pueraria*: oil palm interrows were cultivated with a leguminous cover crop, *Pueraria phaseoloides*. The cover crop was seeded at 0.5 kg per plot in 1994 after transplanting the seedlings. This is the standard estate practice and served as control in this experiment.
ii. Oil palm + maize + cassava: oil palm interrows were intercropped with maize and cassava during the major season. The maize (var. Okomasa ex CRI) was planted in April 1994 at a planting distance of 0.7 x 0.5m with three plants per stand but

thinned to two plants one week after emergence resulting in a plant population of 3780 per plot. The cassava, a mixture of Nzema, Bosome Nsia and Ankra was planted in May 1994, two weeks after the emergence of maize and spaced at 1m within rows giving 945 plants per plot. The maize was harvested four months after planting while the cassava was harvested 10 months after planting. The cycle was repeated till 1997, after which the sited was adopted for this experiment.

iii. Oil palm + maize + plantain: the palm interrows were intercropped with maize and plantain during the major season in 1994. The maize was planted and harvested in the same manner and time as in the previous treatment and at the same planting density. The plantain, false horn variety, 'Apantu pa' was planted at 3 m triangular in the interrows of the oil palm thus giving 88 plantains per plot. The nearest plantain row with reference to the oil palm row was 1.2 m equidistant away from the oil palm rows. After the havesting of maize, the plantain was maintained up to the end of first ratoon of the crop that is January 1997.

iv. Oil palm + maize + maize: oil palm interrows were intercropped with maize in the major season and followed by maize in the minor season. The major season maize was planted in April and harvested in August as in treatment (ii). The minor season maize was planted in September 1994 and was harvested in December that same year. The spacing and plant population for both the major and minor season were the same as in treatment (ii). The cycle was repeated every year for three years.

The field was weeded two times in a season. The leguminous plots in treatment 1 were slashed and a circle of 1m around the palm was clean-weeded every three months. Plantain was mulched with chopped dried weeds at the pre-harvesting period. The pseudostem and leaves were used for mulching after harvesting. Fertilizer was applied to oil palm seedlings six months after transplanting and thereafter, in September every year. N was applied at 42g, P at 48g and K at 250g per tree [5]. No fertilizer was applied to the food crops (maize, cassava and plantain).

2.1 Data Collection

2.1.1 Agronomic analysis

Leaf area (LA), Leaf area index (LAI) and frond dry weight were taken once every year on the oil palm. These parameters were determined from the relationships below;

1. LA was computed using the equation by [6].

   $LA = b(n * LW)$
   Where:
   n= number of leaflets, LW= mean of length x mid-width for a sample of the largest leaflets and b = correction factor = 0.55

2. $\mathrm{LAI} = \frac{\textbf{leaf area}}{\textbf{Ground area}}$

3. FDW was obtained using formula developed by [7]. The width and depth of the petiole of the frond number 17 were measured with calipers and values obtained were put in a formula to estimate the Frond Dry Weight (FDW).

   FDW= 0.11026*W*D + 0.2362 (kg)

Where W= width of the petiole of frond 17
D= depth of the petiole of frond 17

4. The plant height was measured with graduated measuring pole from the base (ground level) of the palm to the point of insertion of leaf number 33.

5. Yield of oil palm

Weekly individual yield recording was carried out soon after the palm came into bearing. The weights and number of the fresh fruit bunches (FFB) harvested were recorded for individual palms at each harvesting round. The data obtained was used to estimate yield per hectare. The data obtained was analysed with GENSTAT 2012 discovery edition.

3. RESULTS

Fig. 1 shows the residual effect on palm height. Differences in height were observed among the treatments. The OP + Ma + Ma recorded the highest plant height, followed by Op + Pue. The height were in the order OP + Ma + Ma > OP + Pue > OP + Ma +Ca > OP +Ma + Pl except on the 8th year after transplanting that the order changed. In that year alone, the order was OP + Pue > OP + Ma + Pl > OP + Ma + Ma > OP + Ma + Ca. The height of the treatments did not vary significantly for all the periods of the trial.

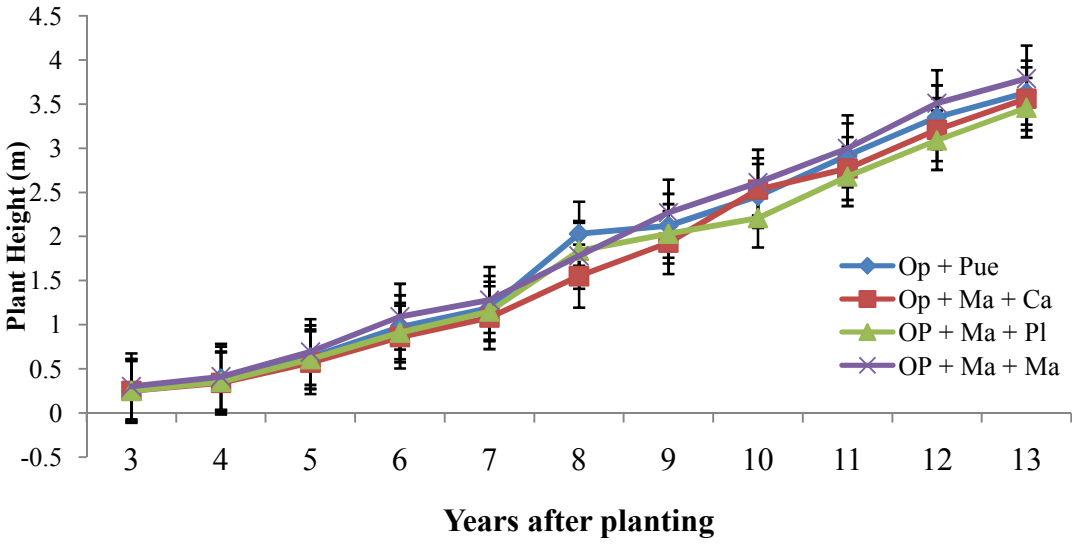

Fig. 1. Effect of food crops intercrop on the height of oil palm

Fig. 2 shows the accumulation of frond dry weight from the year 1997 to 2007. In general, frond dry weight increased with age during the experimental period. The frond dry weight three years after planting was in the order OP + Ma + Pl **>** OP + Ma + Ma **>** OP + Pue **>** OP + Ma + Ca. There was no significant difference (P≤0.05) between the treatments. However, in most of the years, the order was OP + Ma + Ma > OP + Ma + Pl > OP + Pue > OP + Ma + Ca.

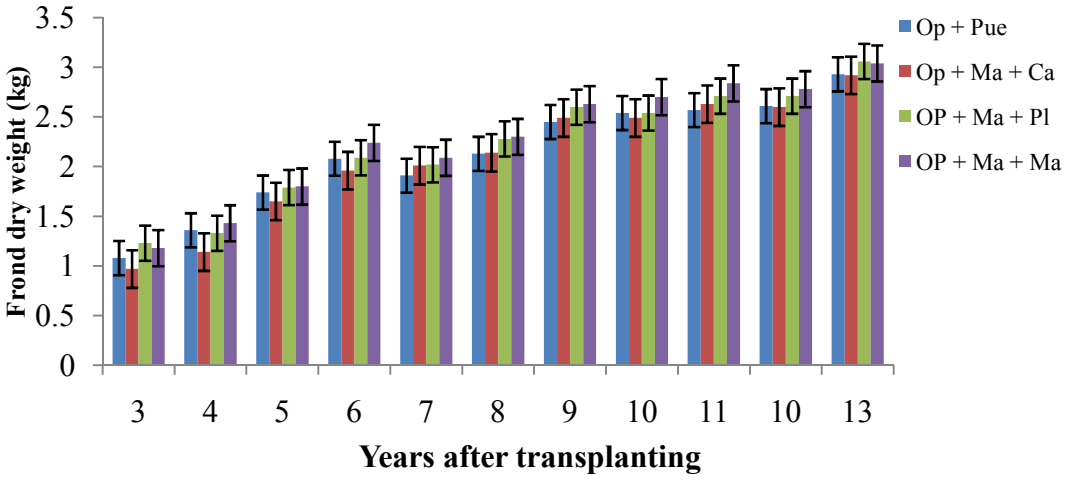

Fig. 2. Effect of food crops intercrop on palm dry matter accummulation

The leaf area and leaf area index showed a linear increase with increase in age (Figs. 3 and 4). There were no significant differences ($P<0.05$) between the treatments. In few occasions that Oil Palm + *Pueraria* performed better than the other treatments, leaf area of this treatment was lower in most of the occasions. From 8 to 12 years after planting, oil palm and maize plus maize intercrop produced relatively larger leaf area than the other treatment. At the 5th and 7th year after planting, oil Palm plus maize and plantain had largest LA. The leaf area index (LAI) increased with increasing palm age (Fig. 4). However it was not significantly different from the other treatments. The LAI varied with the various treatments.

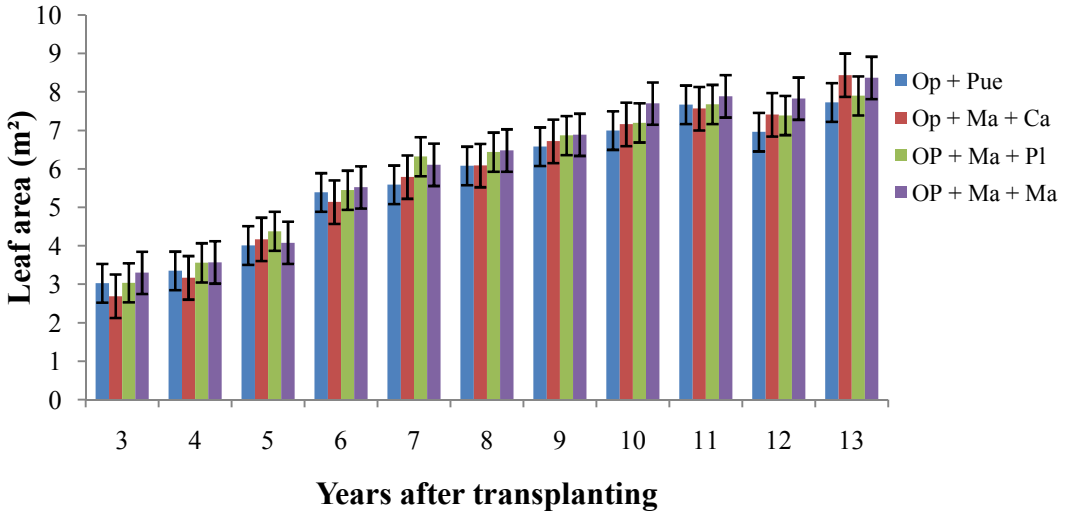

Fig. 3. Effect of intercropping oil palm with food crops on Leaf area of oil palm

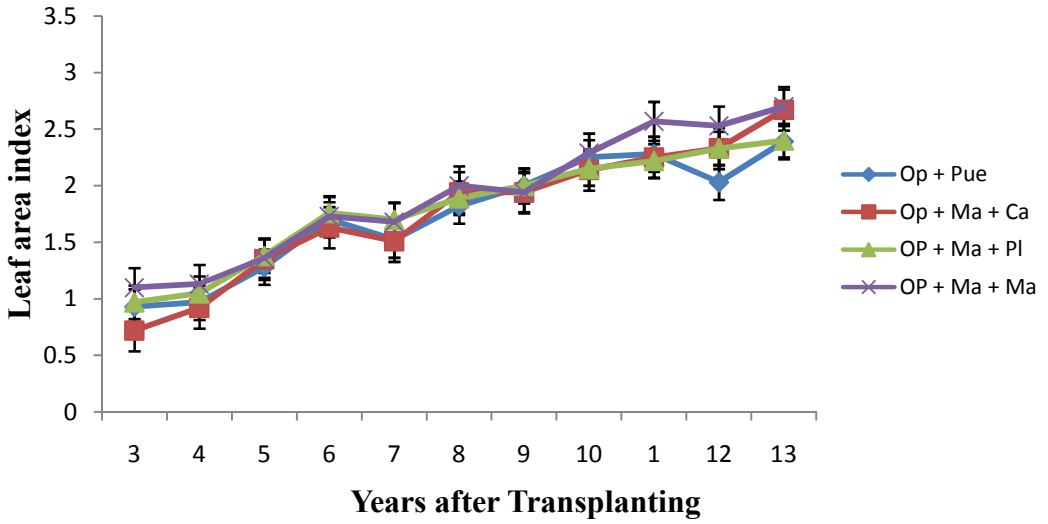

Fig. 4. Effect of intercropping on LAI of oil palm

3.1 Yield and Yield Components

There were no significant differences between the yields of oil palms planted at the same year (Fig. 7). There was an increase in bunch weight with palm age (Fig. 5). From the 4th to 10th year after transplanting, OP + Ma + Pl recorded relatively higher single bunch weight than the other treatments. This was followed by OP + Ma + Ca. In that same period, OP + Pue and OP + Ma + Ma recorded the lowest single bunch weight. In the 11th and 13th year, all the four treatments recorded almost the same value for the single bunch weight, but on the 12th year, the trend was OP + Ma + Pl>OP + Pue >OP + Ma +Ca >OP + Ma + Ma.

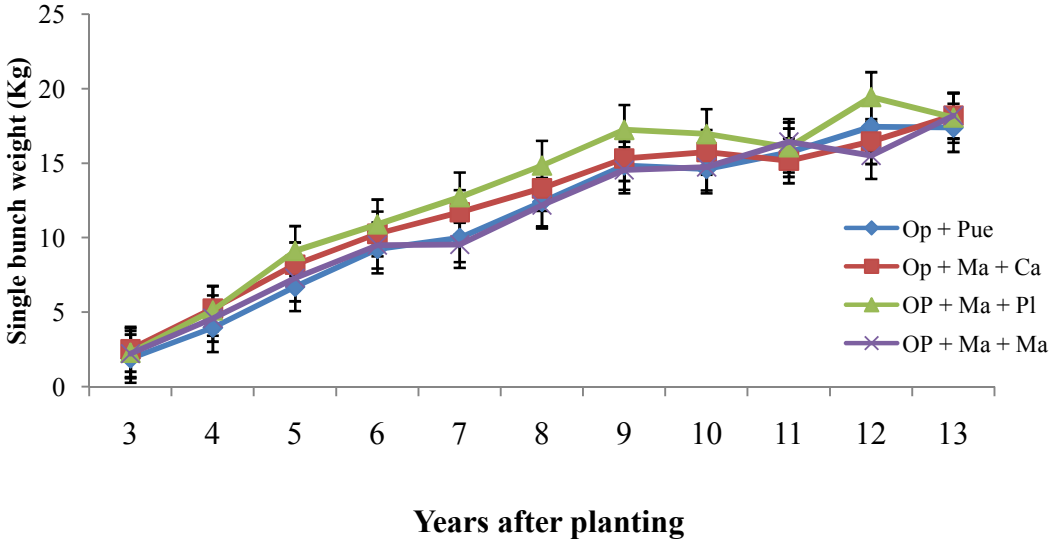

Fig. 5. Effect of food crops intercrop on the single bunch weight of the oil palm

The effect of intercropping on the number of bunches per palm per year is shown in Fig. 6. The number of bunches per palm per year increased initially and decreased with age. The yield became somewhat stable at 10 and 13 years stage with mean values around 4.0 – 6.0 bunches/palm/year. There were no significant differences between the number of bunches of the palms of the same year. The number of bunches produced and the single bunch weight per tree greatly influenced the yield of fresh fruit bunches.

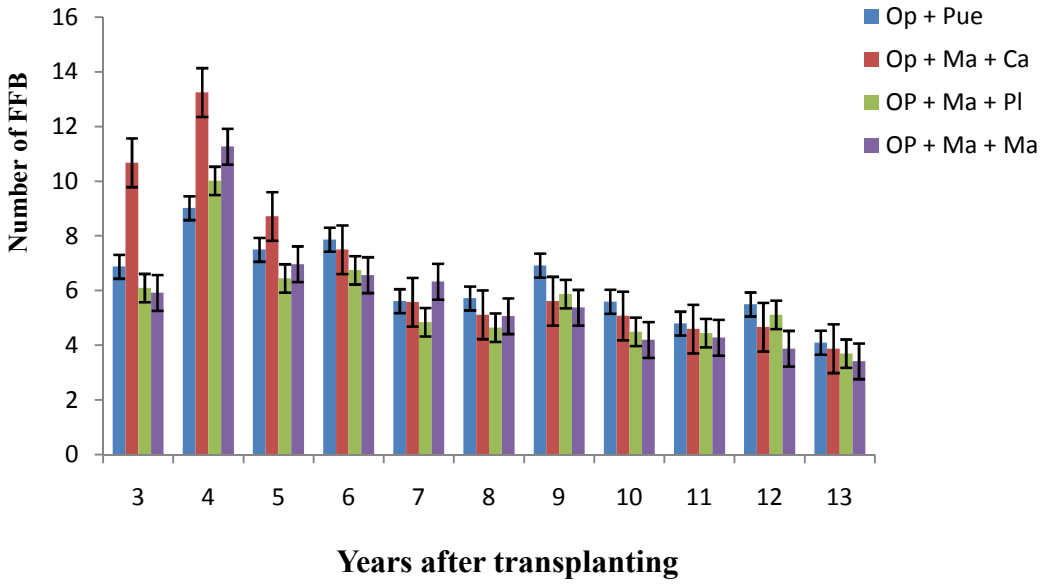

Fig. 6. Effect of food crops intercrop on the Number of bunches/palm/year

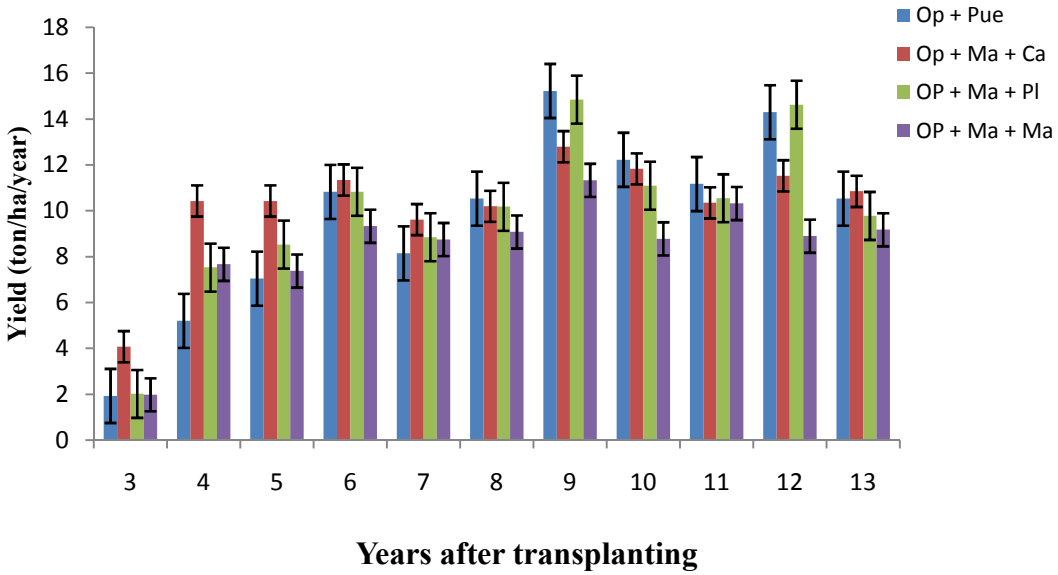

Fig. 7. Effect of food crops intercropped with oil palm on the yield of oil palm

There was linear increase in tonnes per hectare with increased in age, Fig. 7. Even though there were no significant difference between the various treatments, at the 3rd, 4th, 5th, 6th and 7th year, oil palm with *Pueraria* cover crop gave high yields as compared to those that were intercropped. The intercrop affected the yields of the oil palm for the first 5 years after the intercropping was over.

4. DISCUSSION

Growth and yield of oil palm intercropped with food crops.

It is very difficult to do away with intercropping oil palm with food crops especially among the small scale oil palm farmers. [8] indicated that it is profitable to intercrop oil palm with food crops especially for the first three to four years when the palms are not fruiting as compared to sole cropping. It is therefore important to educate farmers on the proper way to do this intercropping.

Oil palm productivity is influenced by total dry matter production of the palm. The dry matter production is highly dependent on the photosynthetic rate of the palm [9]. The results from this study also indicated that there was no adverse residual effect on the growth, development and yield of the oil palm which were previously intercropped with food crops. This suggests that the intercrops did not absorb excessive nutrient from the field that would affect the nutrient requirements of the palms.

The differences in the growth and yield of oil palm were apparently stronger in the first three years after the intercropping. These could be attributed to the decomposition of crops residues after harvesting. Moreover the regular weeding of intercropped field and its eventual decomposition of weeds might have had added advantage to the growth of oil palm even though that was not significant. The low yield obtained just after the intercropping was over from the fields that were intercropped may be due low sex ratio obtained from the intercropped fields. [10] indicated that intercropped fields produced more male inflorescence as compared to sole cropping. Despite the numerous advantages of the *Pueraria* cover crop there may be competition between the *Pueraria* cover crop (leguminous cover) and the oil palm as had been pointed out by [11]. There is therefore the need to quantify the competition effect on oil palm with other plants association whether cover crop or food crops.

As pointed out earlier by research by [8], it is profitable to intercrop oil palm with food crops especially for the first three to four years when the palms are not fruiting as compared to sole cropping. Farmers are able to get enough money from the intercrop to sustain their family and also to maintain the farm. [12,13] also pointed out that there is no adverse effect of early inter-cropping oil palm with maize, cassava and plantain.

5. CONCLUSION

Oil palm can successfully be intercropped with food crops. Yields differences obtained from oil palm intercropped with food crops compared to oil palm monocrop were not significant. It is advisable to follow the cropping system developed in order to gain the full benefit of the oil palm-food crops intercrop. The relative advantage of intercropping oil palm with food crops, suggests that intercropping systems may be most suitable for small-scale producers with limited resources to purchase large land to develop oil palm and food crops separately.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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