Effects of Intercrops on Growth and Yield of Oil Palm in Rainforest Zone of Nigeria

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D.O.I: 10.56201/ijaes.v9.no1.2023.pg18.30

ABSTRACT

Experiments were conducted between 2014 to 2015cropping seasons in a 3 to 5 years old oil palm fields at Ohosu Sub-Station, Benin City, a rainforest zone of Nigeria. The experimens showed the effects of intercrops (Cassava, Maize and Pepper) on the growth and yield of oil palm. Data were collected on the growth and yields of oil palm in oil palm-intertcropping system. Alley cropping was not detrimental to the growth and yield of oil palm, in particular canopy cover (1.71, 2.52 and 2.86 m) and mean fresh fruit bunch yields (88.8, 89.9. 93.6 kg/plot). The overall biological advantage of the alley intercrops is high in oil palm fields of ages 3 to 5years. The sole and intercrops of cassava, maize and pepper appeared to have optimized use efficiencies of resources (space and nutrients) in the alleys of oil palm of different ages (3 to 5years).

INTRODUCTION

Intercropping is an important feature of the farming systems of the tropics. It is defined as the simultaneous growing of two or more species in the same field for a significant period of their growth. Intercropping systems offer crucial ecosystem service that supports food supplies and other livelihood activities. Such practices provide sustainable and stable yields, diversity of flora and fauna and lower risks of crop failure, and implement, sustain and enhance environmental quality, ecosystem services and livelihoods and sustainable landscapes (Ajayi *et al.*, 2016, Agele *et al.*, 2018a). Intercropping practices are reported to optimize ecological processes including the cycling of nutrients, maintains carbon stocks and its sequestration, conservation of soil water and modification of microclimate and reduce soil degradation (Vanlauwe *et al*., 2011, Agele *et al*., 2018a). Agroforestry involves growing trees in mixtures with arable (staple or food) crops simultaneously on a farm. Alley cropping is an agroforestry technique in which trees are planted in hedgerows, and annuals (arable or fodder) crops are planted in the "alley ways" between the hedge row plants. Alley cropping involves growing short duration trees and shrubs (hedge row plants) that are compatible with arable or fodder crops in the alleys (interrow spaces) of hedge row tree species. The trees provide other benefits such as reducing erosion, maintaining soil fertility and providing additional income to farmers and landowners, and offers opportunities for farmers in terms of income, crop diversity and food security in the early years of tree establishment (Vanlauwe *et al.*, 2011). The advantages of alley cropping are attributable to increases in long-term

sustainability by improving soil quality, increased economic diversity, carbon sequestration, farm yield, resource use efficiencies, and environmental resilience (Willey, 1995, Bedoussac and Justes, 2010, Vanlanwe *et al*., 2011, Malay *et al.*,2014).., 2008).

Research on intercropping has shown that fruit trees can be intercropped successfully with arable crops during the early stages (2 to 5 years) of establishment. Information is inadequate with respect to the performance of alley crops in the fruit tree-based agroforestry systems of the savanna agroecologies of Nigeria. There is therefore merit in research for enhanced understanding of performance of arable species such as cassava, maize and pepper as alley crops in the early years of oil palm and as alternative cash crop for fruit tree farmers and crop diversification during the early stages (establishment) of their growth. The optimum species combination in arable specie in the alleys of oil palm would optimize the benefits of competitive interactions based on resource availability and use by the intercrops and oil palm.

The present study aimed at improving understanding of compatibility of oil palm with some selected arable crops in oil palm-based intercropping, generated information on the impacts of intercropping on morphological and physiological traits associated with the productivity of cassava, maize and pepper in oil palm-based intercropping system in a rain forest agro-ecological zone of Nigeria, Findings will serve as useful input in the development of alley crops management practices to enhance crop productivity within the first 2 to 6 years of oil palm growth.

MATERIALS AND METHODS

The experiments were conducted in Nigerian Institute for Oil Palm Research, Ohosu NIFOR Substaion, Benin City, Edo State. The experiments were carried out during the rainy season 2014 and 2015.

The experiments were conducted on existing 3, 4 and 5years old oil palm fields. using Tenera (hybrid) .

Pre-cropping soil sampling and analysis

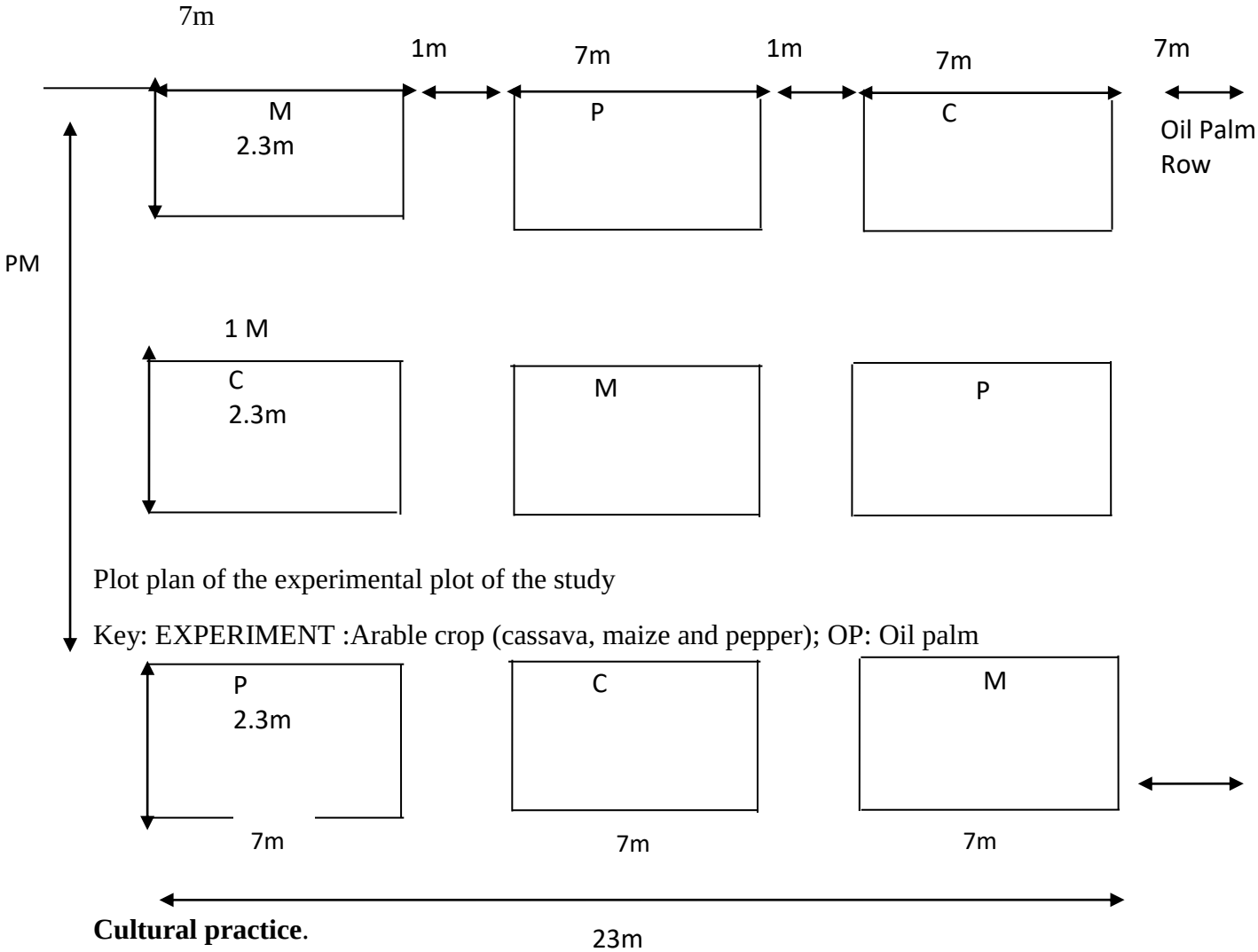
Soil samples were collected randomly from the experimental locations prior to land preparation. Core samples were taken to a depth of 10-20cm with soil auger, mixed, bulked and air-dried. The samples were crushed, sieved through 2mm sieve to remove stones and other debris and subjected to routine laboratory analysis.

The cassava stems (30572) were obtained from National Root Crop Institute, Umuidike in Abia State. The maize (SAM maize) were obtained from National Cereal Research Institute, Mina, Niger State. Pepper (chilli) were obtained from NIFOR vegetable garden.The experiment was 3x3 factorial combination of ages (3, 4 and 5years) of oil palm plantations and 3 species of arable crops arranged in a split-plot design interrow spaces (alley) between oil palm plants constitute the main plot and arable crops species as sub-plot treatment. Treatments were replicated 3times. The planting space for oil palms was 9 x 9m triangular with eigth (8) stands per plot. The total population of three (3) ages of the oil palms were 864 plants. The plots were spaced by 1m between plots and replicates (interrow) and 1m at the borders.Strip intercropping system was adopted in the experiments. Spacing of cassava, maize and pepper was 1mx1m given a plant population of 141 plants per plot.

The cassava, maize and pepper were planted in the 3 different ages of oil palm plots, having

eight (8) oil palm trees each and replicated 3 times (24 trees or palms). Strips intercropping

Experment : Plot layout and treatment allocation scheme



Plot plan of the experimental plot of the study

Key: EXPERIMENT :Arable crop (cassava, maize and pepper); OP: Oil palm

Cultural practice.

Weeding and other cultural practices were carried out manually using hoe and cutlass in all the plots. Maize was weeded once while cassava and pepper were weeded 2 times before the termination of the experiments as recommended to avoid weeds competing with the crops and insect attacks.

Data collection

Climatic data: Climatic variables of rainfall (rain guage), relative humidity, and solar radiation (Gun-Bellani radiation integrator) were collected from NIFOR Metrological station. NIFOR. The canopy extent or diameter were measure in the field using meter (m) tape rule temperature (minimum and maximum) of air and soil surface were monitor fortnightly using soil thermometers inserted to 5cm depth for 15 minutes at each measuring dates. For air temperature, the thermometer was suspended in the air for 15 minutes at each measuring dates. Soil moisture content was measured by gravetric method using core sample collected at the plots at 0-10 and 10-20 cm depth and oven dried at105℃for 24 hours until constant weights were attained. Fresh core sample were weighed to determine the initial soil weight

before oven drying and later weighed again for oven dry weight.

The moisture content (dry weight basis). θd was calculated using the following formula:

$\theta d = Wwt - Wwd$

Where: θd is the soil moisture content on dry weight basis, Wwt is the weight of wet soil and crucible, Wwd is the weight of dry soil and crucible ,

Soil data

Soil samples from the experimental plots were taken at the beginning and end of the experiments for routine analyses of physical (particle size distribution) and chemical properties (pH, Nitrogen (N), organic carbon (OC), cation exchange capacity (CEC), exchangeable calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), and phosphorus (P) on a depth of 0-10 and 10-20cm and moisture content was determined in the laboratory.

Oil palm canopy development

Oil palm data collections include number of leaves, canopy extent and number of fresh fruit bunch and weigth of fresh fruit bunch(FFB). These data were collected quarterly.

Canopy extent

The canopy extent was recorded in meters and the canopy spread is calculated using the multiplication values of the palm measured in two dimensions 'North-South spread' and 'East-West spread' as:

Cs = NS x EW

where:Cs = canopy spread, NS = North-South, EW = East-West, Canopy volume (m^3)

The canopy volume was calculated according to the equation of Turell (1965) as:

CV = 0.5236 x H x D

where:CV = canopy volume (m^3), 0.5236 = constant, H = palm height, D = palm diameter,

The ground coverage of the oil palm by canopy was worked out using the procedure used by Tripathy *et al*. (2015).

where R is the radius of canopy (m) obtained as:

$$R = \frac{D1 + D2}{3}$$

where: D1 = canopy spread in E-W direction (m), D2 = canopy diameter in N-W direction (m)

3 = number of replications.

Yield data

Palm yield traits: yield per palm (Y, Kg) were computed from the harvest data. Number of fresh fruit bunches (FF) and weight of fresh fruit bunch/palm and total palm yield/experimental plot.The growth and yield data were collected from ten tagged plants randomly selected from the experimental plots. Thus, the following traits were measured.

Harvest index (HI) = $\frac{\text{Economic yield}}{Biological\ yield}$

Threshing percentage (%) = $\frac{\text{EcSeed weight+seed}}{weight\ of\ seed}$

At final harvesting cassava tuber weight, maize seed weight and pepper fruit weight for each individual plant was according to estimate – the intra- land variability. Biomass yield, dry above ground biomass at harvest and final yield were determined from the sample plants.

The growth and yield data collected from the strip intercrop species

Cassava	Maize	Pepper
Number of leaves	Number of leaves	Number of leaves
Plant height (m)	Plant height(m)	Plant height(m)
Shoot biomass(g)	Leaf area(m^2)	Root biomass(g)
Tuber weight(g)	Root biomass(g)	Shoot biomass(g)
Number of tuber per stand	Shoot biomass(g)	No of seedlings per stand
Tuber yield(kg)	Cob weight(g)	Fruit yield(g)
Harvest index (HI)	Seed weight(g)	Harvest index (HI)
Average air temp(oC)	No of seed per cob	
Average soil temp(oC)	Seed yield(g)	
	Harvest index (HI)	

RESULT

Effects of strip intercropping of cassava, maize and pepper in oil palm alleys on the performance of oil palm

Strip intercropping of cassava, maize and pepper in oil palm alleys of 3,4 and 5years old did not affect the growth and yield performance of oil palm in Ohosu (NIFOR substation) (Table 1). Canopy extent (ground coverage) of oil palm affected cassava, maize and pepper performance. Conversely, the presence of the strip intercrops in the alleys of palms of different ages did not significantly affect growth of oil palm. The number of leaves increased as the age of oil palm increased, 5 years old oil palm produced the highest number of leaves. The average number of leaves per palm of 3, 4 and 5 years old was 16, 18 and 35 respectively. The canopy spread of oil palm differed significantly under the intercropped.

Generally, in 2014 and 2015 experiments, the component crops did not affect the number of leaves and canopy extent of oil palm across the ages. In 2014 and 2015 fresh fruit bunches were harvested from 4 and 5years old oil palm only (Table 1). The 3 year old oil palms was not mature for FFB production. The Fresh Fruit Bunch (FFB) were harvested quarterly in all the experimental plots. In 2014 and 2015 the average number of FFB harvested per palm

from the 4 and 5 years old oil palm plots were 12 and 10. The number of FFB increased with decrease in age of oil palm while weight of FFB increased with age of oil palm.The records obtained from sole cropping were the same for intercropped. The presence of the component crops in the sysem did not affect development and yield performance of oil palm.

Table 1. Effects of cassava, maize and pepper intercrops on the growth and yield of oil palm (Ohosu substation: 2014 and 2015 experiments)

Variable	3 years	4years	5years	Means	LSD (0.05)
2014					
No of leaves	17.97	38.7	39.96	23.05	1.13
Canopy extent (m)	1.51	2.53	2.96	1.76	0.25
No of bunch (FFB)/Palm (kg)		12.23	9.71	9.71	
Weight of bunch (FFB)/Palm (kg)		89.8	98.68	98.68	
2015					
No of leaves	17.85	38.7	39.95	19.24	0.92
Canopy extent (m)	1.56	1.68	2.36	1.74	0.27
No of bunch (FFB)/Palm (kg)		12.23	9.58	9.58	
Weight of bunch (FFB)/Palm (kg)		89.8	98.68	98.68	

DISCUSSION

Effects of strip intercropping on the growth and yield of oil palm

Cassava, maize and pepper were strip intercropped into the alleys of oil palm of 3,4 and 5 years of age. The oil plam trees across the ages had not closed canopy, which may elicit low competition for both above-ground and below-ground resources for the alley crops. According to Heywood (2007) and NIFOR (2011), oil palm trees may grow up to as much as 15 meters tall and its roots extend 20-60cm from the trunks. Cassava, maize and pepper (component crops) were grown simultaneously in the oil palm alley as intercrops. The measured growth attributes of oil palm plants within the 3-5 years age include, number of leaves, canopy extent, number of fresh fruits bunch (FFB) and weigh of fresh fruits bunch (FFB). The results showed that there was increase in growth parameters measured at three months interval, before and after introducing the cassava, maize and pepper as intercrop in the study. In particular, there were developments and increases in the production of oil palm . Harvesting of fresh fruit bunch (FFB) was done only on 4 and 5years old palms. while the 3 years old had flowered and produce small bunch which are discarded after harvest because of it has high percentage of sluge and very low in special palm oil (SPO) content (NIFOR,

2011). The FFB were harvested at 3 months interval and the number of FFB obtained 4 and 5 were not affected by the component crops. The increase in number of FFB is based on the age of oil palm in the order 4 < 5years old palm trees.

The average FFB produced by 4 and 5 years old palm were within the range of 10-16 and 8-16 per palm respectively in line with NIFOR record on oil palm production. The number of bunches diminishes with the age of palm but the weightof the bunch increases as the oil palm gets older. The FFB recorded on 4 and 5years palms from the plots in 2014 and 2015 experiments were not significantly affected by the intercrop species. The yield of FFB obtained from 5 years old oil palm plot was significantly higher than what was obtained for 4years old oil palm. Average FFB yield from 4 and 5 oil palm plots per palm were 8.98 and 9.28kg/palm.The results obtained from the FFB of oil palm of 4-5 years old palm plots were of NIFOR standard. For oil palms of 3 to 5 years old, the leaves (canopy) had not completely formed and completecanopy cover over land (ground coverage) may not have created shade overlap over the alleys to restrict space and solar radiation interception for the alley crops. This is consistent with the report of Hartley (1988) that 1 to 6 years old oil palm produced no deleterious effects for alley crops. McGilchrist (1965) evaluated maize, yams and cassava, and shade-resistant cocoyam as alley crops in oil palm up to 12 years old. For the first 2 or 3 years after field establishment, good yields of the alley crops and growth of oil palm were obtained. Similar results were obtained for cocoyam (*Xanthosoma sagittifolium*) in a more recent experiment at Benin City, Nigeria. The report showed yields of cocoyam and oil palm fresh fruit bunch (FFB) were satisfactory and concluded that intercropping oil palm with cocoyam was successful during the first 5 years of oil palm establishment.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The introduction of arable/staple food crops such as cassava, maize and pepper in the alleys of oil palm at the early stage of its establishment (2–6 years old) on the field will conseve the soil, provide food and income to the farmer during the intial period of establishment of oil palm in plantation (before full canopy closure). Tthe intercrop mixtures of cassava, maize and pepper in the alleys of oil palm of different ages (4 to 5 years old) exhibited some levels of compatibility and complementarity, low competitive interactions and high efficiencies in utilization of land (space), light and other growth resources. Oil palm growth and development was not affected by the presence of alley crops of cassava, maize and pepper.
Strip intercropping of cassava, maize and pepper in the alleys of 3, 4 and 5 years oil palm plants in the rainforest zone had no detrimental effects on the growth and yield of oil palm

Recommendations

1. Adoption and inclusion of cassava, maize and pepper during the early period of oil palm establishment in plantation before full canopy closure by farmers in the rainforest zone of Nigeria should be further promoted as environment-friendly and ecological agriculture and land use for agiculture
2. The competitive interactions among these arable/staple food crops in oil palm-based intercropping system of the rainforest agroecology was not detrimental in terms of growth and yields of the intercrops and oil palm plants.

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Plate 1: Maize plot with oil palm

Plate 2: Pepper plot with oil palm

Pltae 3: Data collection

Plate 4: Cassava plot with oil palm

Plate 5: Harvested Fresh Fruit Bunch (FFB) from 4 years Oil Palm Field

Plate 6: Harvested Fresh Fruit Bunch (FFB) from 5 years Oil Palm Field

Plate 7: Harvested Fresh Fruit Bunch (FFB) from 6 years Oil Palm Field