Original Research Article

Optimum Spacing for Continuous Oil Palm (*Elaeis guineensis* Jacq.) and Food Crops Intercropping in Nigeria

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Abstract

This study was conducted at the Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Nigeria to investigate the effects of spacing of oil palm that will allow permanent intercropping of arable crops with oil palm. The experiment was laid out in randomized complete block design with three replications. The treatments were composed of four oil palm densities (77, 69, 56 and 46 palms per hectare) with maize, cassava and melon as food intercrops from 2010 to 2016. The parameters measured included oil palm canopy spread, oil palm fresh fruit bunch yield (FFB), maize grain yield, cassava tuber production, and melon yield. Data collected were subjected to analysis of variance and their means tested using the least significant difference at 5% level of probability. Results indicated that spacing significantly influenced fresh fruit and food crop yields. The wider the space between palms, the higher the food crop population that could be intercropped, and the yield from the food crops. However for the oil palm the higher the palm space the smaller or fewer the palm population which also influenced the fresh fruit bunch production. Highest maize grain yield (3.5 ton /ha), cassava tuber production (26.1 ton / ha), and melon yield (156.7 kg / ha) were obtained at the palm spacing of 9m x 24m from 2010 to 2016, while the least grain yield (1.8 ton / ha), cassava tuber production (15.5 ton / ha), and melon yield (87.6 kg / ha) were obtained at the palm spacing of 9m x 16m from 2010 to 2016. It was therefore concluded that for permanent or continuous intercropping of oil palm with food crops oil palm spacing of 9m x 24m should be adopted.

Keywords: Oil palm, food crops, intercrop, fresh fruit bunch yield

Introduction

Oil palm (*Elaeis ginnensis* Jacq.) production is a major activity in Nigeria and in the world as a whole. Oil palm cultivation in Nigeria is dominated by small-scale farmers who occupy about 70% of the estimated total land area of 145,500 hectares under oil palm cultivation (Nwawe *et al*., 2014). The remaining 30% of the oil palm production area is under cultivation by development estate and their affiliated small-scale out-growers who practice mono cropping. The standard 9.0m triangular spacing use for oil palm provides wide spaces between the palms. The length of time (about 3–4 years) needed for the oil palm to start producing is a major problem for the smallholders who have to invest considerable amounts of money and/or labour before deriving income from their oil palm plantations. Consequently, intercropping of oil palm with food crops is now the prevalent practice among the smallholder farmers.

A wide variety of food crops are intercropped with oil palm by this group of farmers. Productivity in a typical farmer's field is however low due to inappropriate agronomic practices (Okyere *et al*., 2014). However for various reasons among which are population pressure on available land, labour utilization and some economic reasons, the farmers would usually like to intercrop their palms continuously throughout the life of the palm. Under standard oil palm spacing of 9m triangular, it is possible to grow most food crops in the oil palm inter-rows for only the first 3 to 4 years of oil palm planting after which the palm canopy closes (Ugbah *et al.*, 2009).

Farmers that practice intercrops usually over prune the palms even up to the spear leaves to allow more light to reach the food crops, and persistently intercrop the oil palm with food crops at densities subjectively determined by them. Under this scenario, crop yields tend to be very low due to rapid depletion of soil nutrients, and soil degradation. Although growing conditions affect all agricultural systems, there is evidence to suggest that the complexity of intercropping can make that system more vulnerable to environmental stresses. Furthermore, if crop choices or timing differences in crop life cycles are not managed correctly, the two crops can compete with each other for water and nutrient resources with negative yield results (Fairhust and Hardter, 2005). Another major problem is the denseness of the crops which can make it physically more difficult to combat diseases, pests and weeds. If the crops in association are not well selected, some crops may act as host for transmitting potential pathogens to other crops. Thus, there is an urgent need for research on optimum spacing for oil palm and food crop continuous intercropping with a view to developing a sustainable and suitable oil palm-based farming system technology which will enable farmers to intercrop their oil palm plantations with food crops throughout the oil palm plantations' life span in order to increase productivity of the system, and increase overall yields of the oil palms and the component crops.

Materials and Methods

The oil palm plantation was established in 1998 while the trial started in 2010 at the Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Edo State, Nigeria in the rain forest zone of Nigeria within Latitude 06. 33N to 07.25N and Longitude 005.45E to 005.37E about 149m above sea level. The old palms were cut down and the field replanted with NIFOR hybrid *tenera* extension oil palm to evaluate optimum spacing for permanent or continuous oil palm and food crops intercropping. Four planting density were tested and the trial was laid out as Randomized Complete Block Design (RCBD) replicated three times. The treatments consisted of four planting distances: A: 9m x 14m, B: 9m x 16m, C: 9m x 20m, D: 9m x 24m. Treatment A had 9 palms per plot, while the other treatments had 6 palms/plot each. Oil palm population per hectare were 77 palms, 69 palms, 56 palms and 46 palms/ha. Land preparation was done and the inter rows were intercropped with food crops. Within the inter rows, maize, melon and cassava were intercropped at recommended spacing of 1m x 1m per crop. Crop density per hectare was 27,600; 27,900; 28,500 and 30,500 for maize, 9,200; 9,300; 9,400 and 9,500 for melon and cassava respectively. Regular weeding was carried out as, and when, due while the palm bases were ring-weeded.

The oil palms were intercropped yearly from 2010 till 2017 with maize, cassava and melon.

Data were collected on yield of food crops and fresh fruit bunches (FFB) production of the oil palm. Harvesting of the fresh fruit bunch yield commenced in 2002 at intervals of two weeks. The number and weight of fresh fruit bunches (FFB) per palm were taken at each harvest and compiled into number of bunches per palm per year and consequently into ton/ha/year. Food crops were harvested, processed and weighed to obtain their actual yields. The data collected were subjected to analysis of variance (ANOVA) using Genstat 5 statistical package, 2007 model. Significant differences between means were estimated by the least significant difference at 5% level of significance.

Results and Discussion

Canopy Spread

The effect of canopy spread on available space for intercropping of food crops is presented in Table 1.

Table 1: Oil palm canopy spread (m).

Treatments (Spacing)	Canopy spread	Inter row free space
9m x 14m	4.65	6.00
9m x 16m	4.36	7.66
9m x 20m	4.19	11.62
9m x 24m	4.00	15.60
LSD ($P \leq 0.05$)	0.135	0.135

Plate 1: 9m X 20m (Palm inter-row intercropped with maize, melon and cassava).

Growth measurements of palms' canopy spread show that the palms did not differ significantly among the treatments. Arising from the canopy spread, measurement of free space available for intercropping showed that the free inter-row space had reduced drastically in 9m x 14m and 9m x 16m when compared with planting distance of 9m x 20m and 9m x 24m (Plate 1).

The palm canopy spread ranged from 4.00m to 4.65m, and had sufficient light penetration to allow adequate solar radiation to get down to the soil for the food intercrops. On hectare basis, land area shaded by oil palm canopy differed significantly between spacings, with a decline in the area as palm spacing widened. Available open space per hectare was lower at 9m x 14m spacing compared to the spacing beyond 9m x 16m. Effectively, therefore, about 6m to 16m spaces was still available for intercropping. The wider the planting distance the higher the spacing available for food intercrops. Results showed that the free space available for intercrops reduced as the palms aged due to palm frond development.

Fresh Fruit Bunches Yield (FFB)

Harvesting of fresh fruit bunches produced commenced in 2003. However, because of extensive replanting of the dead palms, only 7.5% of the palms were fruiting. These values increased from 7.5% to 99% by 2016. Fresh fruit bunch yields from 2010 to 2016 (FFB tons/ha) are presented in Tables 2, 3 and 4. Results of the statistical analysis showed that that density had significant ($P \leq 0.05$) effects on oil palm fresh fruit bunch yields. Bunch yield tended to be higher at a spacing of 9m x 14m at the early stages of fresh fruit bunch production. However, this was not significantly different ($P \geq 0.05$) from the planting densities of 9m x 20m and 9m x 24m. A similar finding was reported by Udosen *et al.* (2005). The number of bunches produced increased with palm until it got to its peak. Thereafter, there was a decline in bunch number production after 10 to 15 years of production. The mean bunch weight varied significantly ($P \leq 0.05$) with spacing, and tended to be heavier at a planting density of 9m x 24m, followed by planting density of 9m x 20m, while the lowest single bunch weight was obtained at a planting density of 9m x 14m. Planting density significantly ($P<0.05$) influenced oil palm fresh fruit bunch production. Fresh fruit bunch production was significantly ($P<0.05$) higher in planting density of 9m x 14m and 9m x 16m than at planting densities of 9m x 20m and 9m x 24m. This finding conforms with the finding of Larbi *et al.* (2013) that the wider the spacing, the fewer the palms population, which significantly reduced the fresh fruit bunches component thus reducing the oil palm fresh fruit bunch production.

Table 2: Bunch number production per palm per year as affected by plant density from 2010 to 2016

	Bunch Number per palm						
Treatments	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
9m x 14m	8	9	10	9	11	10	9
9m x 16m	8	10	11	9	10	11	10
9m x 20m	9	9	11	11	10	8	10
9m x 24m	9	10	9	8	11	12	11
Mean	**9**	**10**	**10**	**9**	**11**	**10**	**10**
LSD ($P \leq 0.05$)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 3: Single bunch weight (kilogram) per bunch as affected by plant density from 2010 to 2016

Treatments	Single bunch weight (kg)						
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
9m x 14m	13.4	13.6	15.6	16.0	14.8	18.4	17.4
9m x 16m	14.0	14.5	16.5	16.7	15,7	18.7	18.1
9m x 20m	15.2	14.8	16.9	17.0	19.0	20.1	18.6
9m x 24m	13.6	14.0	17.0	18.5	20.2	22.5	19.5
Mean	**14.1**	**14.2**	**16.5**	**17.1**	**17.4**	**19.9**	**18.4**
LSD ($P \leq 0.05$)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4: Fresh fruit bunch yield affected by planting density from 2010 to 2016

Treatments	Fresh fruit bunch yield (MT/ha/year)						
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
9m x 14m	8.3	9.4	12.0	11.1	12.5	14.2	12.1
9m x 16m	7.7	10.0	12.5	10.4	10.8	14.2	12.5
9m x 20m	7.7	7.4	10.4	10.5	8.5	11.3	10.4
9m x 24m	5.6	6.4	7.04	6.8	8.2	11.4	9.9
Mean	**7.3**	**8.3**	**10.5**	**9.7**	**10.8**	**12.8**	**11.2**
LSD ($P \leq 0.05$)	**Ns**	**1.2**	**2.0**	**2.7**	**2.7**	**2.7**	**2.7**

Effect of Planting Density on Food Crops Yield from 2010 to 2016

Effects of oil palm spacing on arable food crops yield from 2010 to 2016 are presented in Table 5. Food crop yields were significantly ($P \leq 0.05$) affected by oil palm spacing. Maize grain yield, cassava tuber production and melon production increased as oil palm spacing increased. This is because as palm spacing increased, the inter-row spacing of the palms became wider to accommodate more food crop stands as intercrops, and as the closure of the palms' canopies increased, less space became available between palms for the intercrops. Moreover, the smaller the palm density, the more the amount of solar radiation that reaches the intercrops, and this will enhance photosynthesis of the food crops, and translate to higher yields of the food crops. This finding is in agreement with the findings of Jose and Utulu (2001) in their work on determination of standard spacing for oil palm permanent intercropping.

Highest maize grain yield (3.5 ton/ha), cassava tuber production (26.1 ton/ha), and melon yield (156.7 kg/ha) were obtained at the palm spacing of 9m x 24m from 2010 to 2016, while the least grain yield (1.8 ton/ha), cassava tuber production (15.5 ton/ha), and melon yield (87.6 kg/ha) were obtained at the palm spacing of 9m x 16m from 2010 to 2016. However, this was not significantly different from oil palm spacing of 9m x 20m (Table 5). The food crops yields generally increased yearly. However, because there was no addition of external inputs such as fertilizers, cassava yield started to decline from 2014, while maize grain yield dropped in 2012, 2014 and 2015. Melon yield also dropped in 2013 and then started to increase again. In 2016 however, melon was not cultivated because of late harvest of cassava which caused a little delay in planting operations. The significant differences observed among the food crops yield can be attributed to variations in planting density of the palms.

Table 5: Effect of oil palm spacing on food crops yield from 2010 to 2016

	2010	2011	2012	2013	2014	2015	2016
Treatments	**Maize Grains (ton/ha)**						
9m x 14m	1.4	1.8	1.3	1.8	1.75	1.6	1.7
9m x 16m	1.7	1.9	1.2	2.0	1.90	1.65	2.0
9m x 20m	2.5	3.0	2.6	3.1	3.0	2.4	3.2
9m x 24m	2.8	3.0	2.7	3,2	2.8	2.7	3.5
	Cassava (ton/ha)						
9m x 14m	15.5	17.3	18.5	20.1	14.5	13.6	12.5
9m x 16m	17.8	19.0	20.5	22.4	16.4	15.1	14.0
9m x 20m	25.0	27.0	29.1	31.4	24.7	20.5	18.9
9m x 24m	26.1	27.8	30.5	32.5	25.0	22.1	20.3
	Melon (kg/ha)						
9m x 14m	87.6	96.7	108.8	45.9	56.9	109.4	-
9m x 16m	100.6	129.3	151.6	65.8	98.3	114.0	-
9m x 20m	166.4	174.0	186.5	78.9	112.7	140.3	-
9m x 24m	156.7	201.6	192.0	88.5	123.8	145.2	-
LSD ($P \leq 0.05$)	**Maize = 1.13; Cassava = 9.26; Melon = 10.16**						

Conclusion

Intercropping of oil palm with food crops is the prevalent practice among the smallholder farmers in Nigeria. A wide variety of food crops are intercropped with the oil palm by this group of farmers. Productivity in a typical farmer‘s field is however low due to inappropriate agronomic practices. The palm canopy spread ranges from 4.00m to 4.65m while the inter-rows space available for food crop intercrops ranges from 6.00m to 15.7m. Thus, with this wider space, light penetration is enough for the food intercrops. The high fresh fruit bunch yields of oil palm and food crops yields obtained from 2010 to 2016 in this study are a clear demonstration that oil palm can be intercropped with food crops at a suitable planting density. 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. In conclusion for oil palm sole cropping, standard spacing of 9m triangular should be adopted. For small-scale subsistence farmers who want to intercrop oil palm with food crops however, oil palm spacing of 9m x 20m should be adopted.

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References

Fairhust, T. and Hardter, R. (2005): Oil palm: Management for large and sustainable yields. *A publication of International Potash Institute.* Pp 124.

Jose, A. and Utulu, S.N. (2001): Determination of optimum oil palm spacing for continuous intercropping with food crops. *Nigerian Institute for Oil Palm Annual Report* 28: 38-39.

Larbi, E., Anim-Okyere, S., Danso, F., Danso, I., Afari, P., Nuertey, B. N. and Asamoah, T. E. O. (2013): Effect of planting densities on growth, development and yield of oil palm (*Elaeis guineensis* Jacq.) IN GHANA. *International Journal of Current Research* 5(10):2997-3000.

Nwawe, C. N., Akintola, J O., Ikpi, A.E. and Rahji, M.A.Y. (2014): Economic analysis of oil palm and food crop enterprises in Edo and Delta states, Nigeria. *International Journal of Agricultural Economics and Rural Development* 6 (1): 29-37.

Okyere, S.A., Danso, F., Larbi, E. and Danso, I. (2014): Residual Effect of Intercropping on the Yield and Productivity of Oil Palm. *International Journal of Plant and Soil Science* 3(7): 854-862.

Udosen, C.V, Utulu,S.N. and Ugbah, M.M.(2005): The performance of oil palm and different food combinations in a four year sequential intercropping in a rain forest/derived savanna Traditional Zone of Nigeria. *Journal of Agriculture, Forestry and the Social Sciences* 4(2): 178 – 189.

Ugbah, M.M., Utulu, S.N. and Nwawe, C. N. (2009). Determination of optimum spacing of oil palm for continuous intercropping with food crops. *International Research and Development Journals* 6(2): 1117-1669.