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RESEARCH ARTICLE

EFFECT OF PLANTING DENSITIES ON GROWTH, DEVELOPMENT AND YIELD OF OIL PALM (*Elaeis guineensis* Jacq.) IN GHANA

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ABSTRACT

Variable planting density experiment was conducted on oil palm from 1998 to 2007. The study was to evaluate the effects of different plant spacing on growth, development and yield oil palm in Ghana. The experiment was laid out in randomized complete block design with five replications. The treatments were composed of four densities 116, 129, 148 and 173 palms per hectare. Growth parameters measured include leaf area, leaf area index, rachis length, frond dry weight and plant height. These parameters were generally not statistically significant (p=0.05). Fresh fruit yield were similar for all treatments until 10YAT where plots with 173 palms per began to produce significantly fewer bunches. For good growth and productivity oil palm should be planted at 8.84m triangular, equivalent of 148 palms/ha in the semi deciduous forest zone of Ghana.

INTRODUCTION

Among the agronomic practices that influence plant growth, development and yield, planting distance and therefore population per unit area stands prominent. Planting density refers to the number of plants in a fixed area of land. Donough and Betty (1991) defined planting density for oil palm as the number of palms that provides the highest yield in any given year. Choosing the best planting density for oil palm has always presented a dilemma as the density for maximum yield per unit area changes with the age of the palms (Henson and Dolmat, 2003) and topography (Corley and Tinker, 2003). When plants are grown together in a community they will affect each other and there will be ‘interference’ or ‘competition.’ In oil palm, planting density is a major issue as it determines competition between palms for light, water and nutrients. Studies have shown that excessive competition between palms for resources impacts mainly on fruit bunches than the amount of dry matter produced per palm, (Corley *et al*., 1977). Consequently variable density experiments in oil palm have been conducted (Corley, 1973; Goh, 1977; Breure and Corley, 1983) to identify the optimum planting density for optimum yield. In similar studies Alvarado *et al*., (2007) found that the best yield of fresh fruit bunch (FFB) per hectare were obtained with 139 palms/ ha to 164 palms/ ha in various cultivars. According to Henson and Dolmat, (2003), the optimum planting density may differ with site, soil, planting material and management input. Thus, there is no general method of predicting the best planting density for individual circumstances therefore density trials continues to be necessary. Therefore, manipulating planting density to promote good growth development and yield of fresh fruit bunch on the basis of performance of the yield components is necessary.The study was undertaken to evaluate the effects of different planting densities on the growth, fresh fruit yield and to identify the best planting density for oil palm under climatic condition in the semi- deciduous forest zone of Ghana.

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MATERIALS AND METHODS

Experimental site

The experiment was conducted from 1992 to 2007 at the Oil Palm research Institute, Kusi, in the semi deciduous forest zone of Ghana (06. 00N, 001.45W) about 500m above sea level.

Experimental design

The planting material was D x P (ex OPRI) oil palm seedlings planted to the field in 1992. The experiment was conducted in a randomized complete block design with four treatments and five replications. The treatments consisted of four planting distances; 10.06m, 9.45m, 8.84m and 8.23m triangular representing planting densities of 116, 129, 148 and 173 palms ha^{-1} respectively.

Cultural practices

The field was planted with *Pueraria phaseoloides* as cover crop to suppress weed growth. The soil fertility was amended with 1kg each of Ammonium sulphate, Muriate of potash and Triple super phosphate applied to each palm annually. From the third year onwards one kilogram (1kg) of Magnesium sulphate was applied to each palm annually. Ring weeding and interrows slashing were done as and when necessary.

Data Collection

Vegetative growth

Vegetative growth was measured using non destructive methodologies. Leaf area (LA), leaf area index (LAI), frond dry weight (FDW), height of palms and rachis length were taken annually.

i. Leaf area (LA) was estimated using the Hardon *et al.*, (1969) equation LA (m^2) = b (n x LW)
   Where:
   b= correction factor; (using a correction factor of 0.55)
   n = number of leaflets per leaf;
   LW = mean length x mid- width of largest leaflets.
ii. Leaf Area Index (LAI) was estimated by expressing the values obtained for leaf area as a ratio to the ground area. LAI was thus estimated as: $LAI = \frac{\text{Leaf area}}{\text{Ground area}}$
iii. Frond dry weight (FDW). A pair of calipers was used to measure the radius and depth of petiole, at the point of insertion of the lowest leaflet. The values obtained were put into the formula to estimate the frond dry weight using the method described by Corley et al., (1971) thus: FDW = 0.1026 width x depth + 0.2362 (kg)
iv. Plant height was determined using graduated measuring pole from the base of the palm to the point of insertion of the frond number 33.

YIELD OF OIL PALM

Weekly individual yield recording was carried out. The number of bunches and weight of fresh fruit bunch (FFB) per palm were taken at each harvest and compiled into number of bunches per palm per year and consequently into ton/ha/yr. The data collected were subjected to statistical analysis using (Genstat 5 statistical package, 2007). Analysis of variance (ANOVA) for the data was carried out. Significant differences between means were estimated by the least significant difference at 5% level of significance.

RESULTS

Vegetative growth

Canopy development is important as it determines the radiation interception which in turn determines productivity. Mean leaf area increased linearly as the palm aged with planting densities across the period. Smaller leaf area was recorded for palms planted at 173 ha^{-1}. The differences observed in the leaf area between the varying densities were statistically insignificant at (p=0.05).

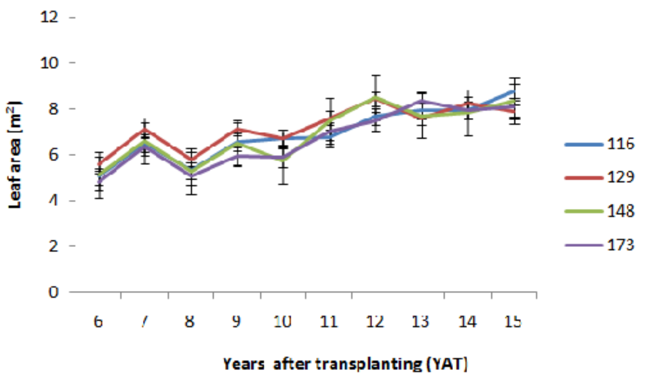

Figure 1. Effect of planting density on leaf area development

Leaf area index

Figure 2 shows the effect of planting density on leaf area index of oil palm. As would be expected, on a ground area basis higher densities resulted in increased leaf area index (LAI). The effect of varying densities on LAI was statistically significant at (p=0.05), from 8YAT upwards.

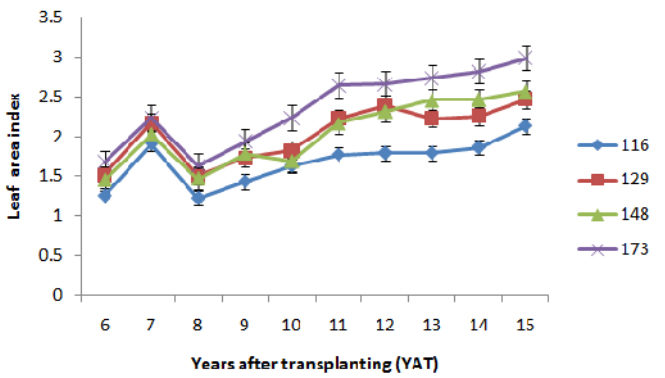

Figure 2. Effect of planting density on leaf area index

Frond dry weight

Figure 3 shows frond dry weight as affected by the various planting densities. Frond dry weight was significantly affected (p=0.05) Palms planted at 173 ha^{-1} produced frond dry weight comparable to all others except those planted at 129 ha^{-1}. Palms planted at 173ha^{-1} produced lighter fronds.

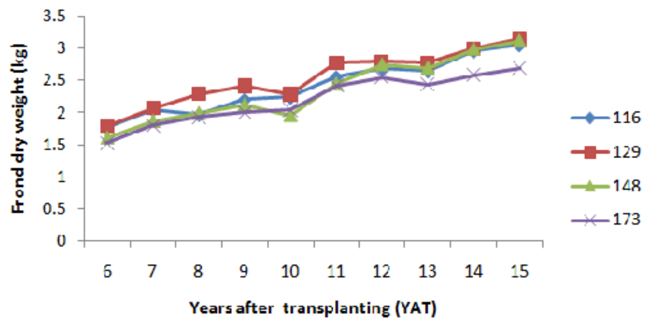

Figure 3. Effect of planting density on frond dry weight

Rachis length

Figure 4 shows the effect of planting density on rachis length. Generally, crowding results in etiolation. This was not evident in the present experiment, as no significant difference was observed in the rachis length recorded for the various planting densities during the period of study. As palm matures their fronds increase in length. Consequently, as density of oil palm per hectare is increased there is intensification in mutual shading, thereby reducing the amount of sunshine reaching the palms. By the 9th year after transplanting the rachis length has exceeded the mid point of interplant distance for palms planted at 129, 148 and 173 palms per hectare respectively. However, no clear differences were noted, hence, no significant mutual shading.

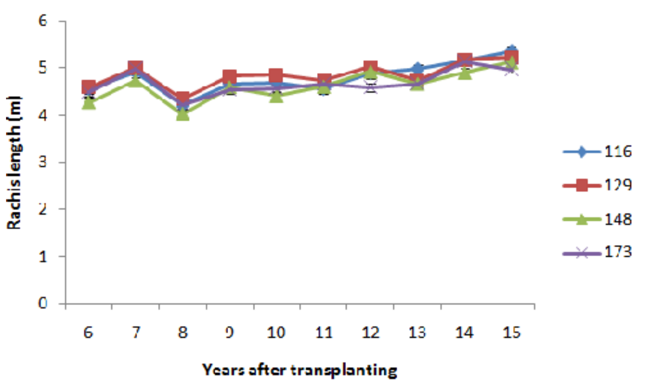

Figure 4: Effect of planting density on rachis length

Plant height

The linear growth in height of the palm was evident, ranging from 0.61m to 3.84m between 6YAT to 15YAT. Both the minimum and maximum heights were recorded for plot with the highest density (173 ha^{-1}). The differences in height in relation to varying planting densities were not significant (P=0.05)

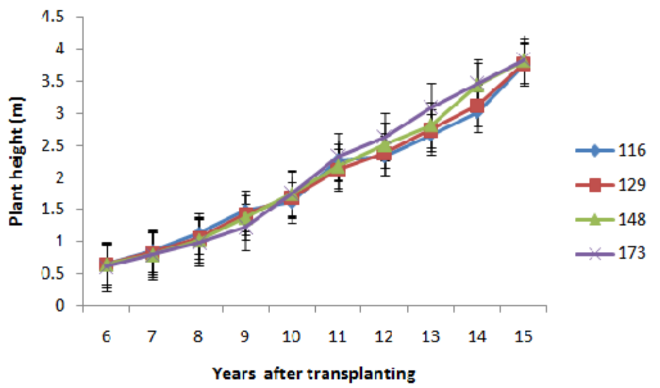

Figure 5. Effect of planting density on plant height

YIELD AND YIELD COMPONENTS

The average annual fresh fruit bunch (FFB) yield over a period of ten years for each palm were used to examine variability between the planting densities. The components of yield variation obtained from ANOVA are shown below:

Table 1. Effect of planting density on mean single bunch weight (kg)

Density/Ha	Years after transplanting (YAT)									
	6	7	8	9	10	11	12	13	14	15
116	9.46	13.24	11.96	15.32	19.04	24.75	20.33	19.01	21.87	19.35
129	9.04	13.47	15.20	14.62	18.82	20.30	21.03	22.01	18.20	23.55
148	8.85	12.40	14.14	14.48	18.08	21.11	20.64	20.19	20.75	21.31
173	8.74	12.80	15.43	15.37	17.70	20.92	22.06	20.80	20.02	19.55
LSD	0.99	1.69	5.45	3.63	2.88	7.73	4.03	5.18	4.91	6.05
CV%	7.2	4.7	7.0	8.1	2.3	14.9	7.6	15.1	5.6	20.5

Table 2. Effect of planting density on number of bunches per palm per year

Density/Ha	Years after transplanting (YAT)									
	6	7	8	9	10	11	12	13	14	15
116	14.36	10.64	9.24	6.05	8.23	8.62	7.06	5.66	6.44	11.14
129	13.86	9.44	8.74	4.73	6.24	6.72	5.66	5.07	5.07	9.07
148	12.86	10.11	9.30	5.46	6.55	6.89	6.05	5.74	5.88	9.21
173	12.52	9.21	8.57	4.26	5.66	6.10	5.29	4.76	4.14	8.60
LSD	4.48	2.77	1.43	1.27	2.13	2.44	1.75	1.41	2.06	3.60
CV %	8.2	8.1	17.7	17.6	21.9	14.9	30.3	15.2	15.7	26.8

Table 3. Effect of planting density on fresh fruit bunch yield (t/ha)

Density/Ha	Year after transplanting(YAT)										
	6	7	8	9	10	11	12	13	14	15	Mean
116	11.09	11.79	12.42	11.72	9.52	17.00	14.56	12.43	9.97	11.76	12.23
129	11.68	11.79	12.29	11.48	8.26	11.70	13.22	11.17	10.95	10.95	11.35
148	11.84	12.52	13.80	13.24	10.31	14.76	14.90	13.10	12.07	12.91	12.95
173	13.89	16.52	16.52	15.18	9.30	15.96	15.96	13.44	11.65	10.42	13.88
LSD	5.52	4.12	4.24	3.46	2.76	6.23	5.57	4.07	2.97	3.75	
CV%	13.0	8.8	18.5	17.0	20.4	26.8	27.2	8.6	10.2	23.9	

Single bunch weight increased steadily from 6YAT to 11YAT (Table 1) with heaviest bunch (24.75kg) recorded for the lowest density (116 ha^{-1}). Thereafter, the bunch weight declined. Such a decline was however not observed in the other planting density regimes. The variations in single bunch weight observed in this study were statistically insignificant (p=0.05). Number of bunches produced per palm was highest for all treatments at 6YAT (Table 2). This however, inversely declined gradually with the age of palm. Yield differences was not significant until 10YAT, where significant difference (p=0.05) was observed between the lowest density (116 ha^{-1}) and the highest density (173 ha^{-1}). Palms planted at 173/ha produced much fewer bunches. This difference however did not translate into fresh fruit bunch produced per hectare. Table 3 shows the yield of fresh fruit bunch (FFB) in t/ha for various planting density regimes. In this study, density of 173 palms per ha was found to yield the highest quantity of FFB compared to the other density regimes. The average yield for the densities of 116 palms/ ha, 129 palms/ ha, 148 palms/ ha and 173 palms/ ha were 12.24, 11.21, 12.95 and 13.88 t/ha/yr respectively. The difference in yield between the various planting densities was small and therefore statistically insignificant.

DISCUSSION

There were fluctuations in vegetative growth for leaf area index and frond dry weight parameters. Frond dry weight showed significant variability at (p=0.05) resulting from lower cross-sectional area of petioles. There was however no increase in rachis length contrary to (Henson and Mohb, 2003; Alvarado *et al*., 2007) in their observation that the first growth variable that seemed to be affected by interplant competition with increasing density was leaf length. In high density planting of oil palm the availability of sunlight could become a limiting factor in growth and development of the oil palm.

The annual yield varied with CV ranging from 8 to 30 among the various treatments. Table 1 shows that bunch number was the main determinant of fresh fruit bunch (FFB) yield as there was no significant effect of density on mean bunch weight. The variations were more pronounced on bunch number component of FFB yield than single bunch weight. This validates earlier reports (Broekmans, 1957; Sparnaaij, 1960; and Hartley, 1988) that single bunch weight is generally less affected by environmental factors than bunch number. Mean bunch number declined with palm age while the bunch weight increased. The difference in bunch number was observed to be statistically significant (p=0.05) between 116 and 173 palm per hectare. This according to Henson et al., (2004), female inflorescence decreased with increasing density, while male and aborted flowers increase. Other reports (Corley, 1973; Breure, 1988; 2003) have shown that yield per hectare for palms above seven years have been found to decline once density exceed 150 to 180 palms per hectare. The results validate Corley et al (1977) earlier assertions that when competition between palms reduces the amount of dry matter produced per palm, amount of dry matter used for vegetative growth is less affected than the amount used for fruit bunches. The trough observed in FFB yield between 9YAT and 11YAT might have been caused by less in rainfall recorded around the period.

Conclusion

The commercial value of oil palm resides in the possibility of increasing productivity by augmenting planting density. The yield differences observed in this trial was small and may not show the advantages of the different planting densities. The ultimate measure of viability of the planting density in oil palm is the monetary outcome. In this study, the average yield of FFB for palms planted at 173/ha is slightly higher than others; the significant decline in bunch numbers observed may erase this advantage in the long term. On the hand palms planted at 148/ha showed stability in FFB production over the period of study and it is therefore recommended.

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REFERENCES

Alvarado, A., Chinchilla, C. and Rodriguez J. (2007). Comparative performance of two oil palm varieties (Deli x AVROS and Deli x Ghana) planted at different densities at two locations. ASD oil palm papers 30, 28-34. 2007.

Breure, C. J. (1988b). The effect of palm age and planting density on the partitioning of assimilates in oil palm (*Elaeis guineensis*). Experimental Agriculture, 24: 53-66.

Breure C. J.; Menendez, T. and Powell M. S. (1990). The effect of planting density on the yield components of oil palm (*Elaeis guineensis*). Experimental Agriculture, Vol. 26, (1), 117-124.

Breure, C. J. (2003). The search for yield of oil palm - basic principles. *The Oil Palm. Management for Large and Sustainable Yields* (Fairhurst, T and Hardter, R eds.). Potash &Phosphate Institute/Potash Institute of Canada and I nternational Potash Institute. pp. 59- 98.

Broekmans A. F. M. 1957. Growth, flowering and yield of the oil palm in Nigeria. J. W. Afr. Inst. for Oil Palm Res. 2: 187-220.

Connor, D.J., Sands, R. and Strandgard, M. (1989). Competition for water, light and nutrients in agroforestry associations of Pinus radiata and pasture. In: Meteorology and Agroforestry (ed. Reifsnyder, W.S. and Darnhofer, T.O.), Proc. of an International Workshop, Nairobi 9–13 February, 1987, 451–462. ICRAF.

Corley, R. H. V. (1973). Effects of plant density on growth and yield of oil palm. Experimental Agriculture, *9*: 169-180.

Donald, C.M. (1963). Competition among crop and pasture plants. Adv. Agron. 15, 1–118.

Goh, K.H. (1982). Analyses of oil palm spacing exper iments. In The Oil Palm in Agriculture en the Eighties (Pushparajah, E. and Chew, P. S., eds). Pp 393-414.

Hartley C.W.S. (1988). The Oil Palm. 3rd Ed. London. Longman

Henson, I. E. and Mohd, T. D. (2003). Physiological analysis of an oil palm density trial on a peat soil. Journal of Oil Palm Research Vol. 15 (2), 1-27

Jahan, S. and Hamid, A. (2006). Effect of population density and planting configuration on canopy development and reproductive effort in mungbean (*Vigna radiata* (L.) Wilczek) Research Journal of Agriculture and Biological Sciences, 2(3): 122-126,

Sparnnaij, L. D. (1960). The analysis of bunch production in the oil palm. J. W. Afr. Inst. Oil Palm Res. 3: 109-180.

Smith, B. G., Donough, C. R., and Corley R. H. V. (1996)

Taylor, M., Chinchilla, C. and Rodriguez, W. (2008) Leaf Architecture and estimates of leaf area and leaf dry weight in young compact oil palm clones (*Elaeis guineensis Jacq*.) ASD oil palm papers No.32, 27-47.

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