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Field Establishment and Early Nut Yield of Cashew (*Anacardium occidentale* Linn.) as influenced by Plant Density and Maize Intercrop in the Rainforest Agroecological zone of Nigeria

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ABSTRACT
Cashew (Anacardium occidentale) is a commodity tree crop traded world-wide for its kidney-shaped nuts. The plant usually grown at wide spacing of between 6 m x 6 m and 20 m x 20 m attained maximum nut yield in about 15 – 20 years of age. The wide spacing of the crop can be reviewed to obtain substantial yield at earlier year of establishment. Therefore, a field study was carried out to determine the effects of high plant density and intercropping with maize on field establishment and early nut yield of cashew in the rainforest agroecology of southwestern Nigeria. It was a 3x3 factorial experiment in randomized complete block design with 3 replicates. It involved three cashew planting densities: 6 x 6 m - C_1 (277 plants/ha), 4.5 x 4.5 m – C_2 (493 plants/ha) and 3 x 3 m – C_3 (1,111 plants/ha) intercropped with maize at three densities: zero (M_0; sole Cashew), 53,333 (M_1) and 80,000 (M_2) plants/ha to give 9 treatment combinations. Growth of cashew was monitored monthly for a period of 3 years starting from 2 months after the first maize was planted which was 3 months after transplanting (MAT) of cashew. Within 6 MAT, neither plant density of cashew nor intercrop with maize had effect on height of cashew. However, between 9 and 24 MAT, cashew grown at 3 x 3 m were tallest when compared with other treatments. Plant density and maize intercrop did not affect survival percentage of cashew transplants. Cashew plants flowered at 18 MAT and 55% of intercropped cashew grown at 3 x 3 m with maize at 80,000 plants/ha produced flowers while other treatments had between 0 and 33.3 flowering percentage and the differences were significant. Sole cashew plants grown at 3 x 3 m produced highest nut yield of 5,443.9 kg/ha at 24 MAT, followed by sole cashew grown at 4.5 x 4.5 m and 6 x 6 m with 1,380.4 kg/ha and 1,108.0 kg/ha respectively. Intercropped cashew grown at 6 x 6 m with maize at 80,000 plant/ha produced lowest nut yield of 387 kg/ha and the differences were significant. Early fruit yield is obtained from sole planting at high densities, although competition may arise at later stages of growth this may be managed by pruning and other farm practices.

Keywords: Cashew, Planting Density, Maize Intercrop.

INTRODUCTION

Cashew *(Anacardium occidentale* L.), *a* crop of considerable economic importance to Nigeria and other tropical countries (Ezeagu, 2002; ACI, 2015) and a member of the family Anacardiaceae, provides useful products and by-products that are useful for food, medicine and industrial raw materials. It is equally a beautiful ornamental plant, provide shade and also quite useful in control of soil erosion (Akinwale, 1995) and protection of watersheds and dams. The cultivation of cashew in the early 1950s in the Eastern Nigeria was principally to control erosion, which was ravaging in that part of the country. The realization of cashew as a potential revenue-earning commodity led to the establishment of commercial plantations by the defunct Eastern and Western Nigerian governments (Umeh, 2007). At present, cashew is cultivated in 27 States of Nigeria (FMA&WR, 2007; NEPC, 2015). The numerical strength of cashew farmers is increasing yearly while the area of land cultivated to the crop is considerably increasing (Topper *et al.*, 2001). The production has increased from 30,000 Metric tonnes (MT) in 1990 to 836,500 MT in 2012 from estimated land area of 366,000 ha (FAOSTAT,2013). Besides the fruit, cashew nut shell liquid contained in cashew nuts, are an invaluable industrial raw materials (Fetuga *et al.*, 1975; Ohler, 1979). The cashew of commerce is a small to medium-sized tree thought to have originated from a short-growing ecotype of *A. occidentale* that occurs amongst the low vegetation of the Restinga in coastal north-eastern Brazil (Mitchell and Mori, 1987). A taller growing ecotype is in the llanos of Colombia and Venezuela, and the Caatinga (dry thorn forest) and the Cerrado vegetation of the savannas of the Amazon basin (Mitchell and Mori, 1987).

The tolerance of cashew to wide rainfall variations of between 600 mm and 3,000 mm per annum and its flourishing growth in soils that appear poor to some other crops (Falade, 1978), facilitated the extensive cultivation of the crop in many agro-ecological zones of the tropics (Anonymous, 1999; Ayodele *et al.*, 2001). Although cashew can survive in many agro ecological zones, the crop is fraught with field establishment problems leading to conclusion that cashew does not transplant well on the field (Adenikinju *et al.*, 1989; Adenikinju, 1996). The crop's establishment failure has been attributed to non-understanding of the appropriate nursery periods of cashew seedlings which often lead to transplanting of overgrown seedlings. Besides, the wide spacing of planting cashew on the field 6 x 6 m (277 plants/ha) - 20 x 20 m (25 plants/ha) often results in early weed infestation and low early nut yield. Though, such wide spacing affords opportunity for intercropping cashew with other crops as reported for oil palm (Aya and Lucas, 1976) and cocoa (Adenikinju, 1988; Adeyemi, 1989), however, the plant population per hectare is rather too low. Therefore, studies on increasing plant population coupled with intercropping of cashew with food crop is necessary to encourage farmers to be increasingly interested in cultivating cashew as they can easily rely on the produce from the intercropped food crops prior to fruiting in cashew.

The study therefore evaluates the effect of different plant densities of cashew intercropped with varying densities of maize on field establishment and early nut yield of the crop.

MATERIALS AND METHODS

The study was carried out within 3 years at the headquarters of Cocoa Research Institute of Nigeria (CRIN), Ibadan, located in southwest Nigeria (7^o 13'N, 3^o 51'E), altitude 122 m above sea level with an annual rainfall of between 1,250 mm and 1,500 mm, and an annual average temperature of 27^oC (CRIN, 2007). The rainfall pattern is bimodal with peaks in June/July and September. The climate is monsoon-type with rainforest agro-ecology. The months of December to February were periods of dry season during which there was virtually no rain. The experimental site was one of the thickly forested areas within CRIN that had not been cultivated before. All trees were manually felled, cross-cut into logs and packed.

The planting materials were jumbo nut-size (weighing 16 g and above) of cashew and maize variety (ACR94-DMR-ESR-Y) obtained from International Institute of Tropical Agriculture (IITA), Ibadan. The first maize planting in the intercrop was done a month after cashew seedlings were transplanted into the field in order to allow cashew recover from transplanting shock and subsequently in the second and third year during rainy periods. Weeding was regularly carried out once a month and 300 kg/ha of NPK 15-15-15 was applied to maize in split doses at 2 and 6 weeks after planting of maize. A fungicide (funguran) was sprayed on cashew against twig die-back infection (Hammed and Adedeji, 2008).

The experiment was 3x3 factorial laid out in randomized complete block design with three replicates, consisting of cashew transplanted at three plant densities [6x 6 m (C_1); 4.5x4.5 m (C_2); and 3x3 m (C_3)] intercropped with maize at three densities [0 (M_0); 53,333 (M_1); and 80,000 (M_2) plants/ha] of maize. The treatment combinations are:

- cashew at 6 x 6 m Sole (C_1M_0),
- cashew at 6 x 6 m + maize at 53,333 plants/ha (C_1M_1),
- cashew at 6 x 6 m + maize at 80,000 plants/ha (C_1M_2),
- cashew at 4.5 x 4.5 m Sole (C_2M_0),
- cashew at 4.5 x 4.5 m + maize at 53,333 plants/ha (C_2M_1),
- cashew at 4.5 x 4.5 m + maize at 80,000 plants/ha (C_2M_2),
- cashew at 3 x 3 m Sole (C_3M_0),
- cashew at 3 x 3 m + maize at 53,333 plants/ha (C_3M_1), and
- cashew at 3 m x 3 m + maize at 80,000 plants/ha (C_3M_2).

Three maize plantings were done within three years of the experimental period. Data collection, on cashew, started 2 months after intercropping with maize which was 3 MAT and continued on monthly basis until reproductive stage was attained by the cashew transplants. Data collected on plant height (cm) with a 2-meter ruler, stem circumference (cm) with Vernier caliper, number of leaves, total leaf area (cm^2) (product of number of leaves and leaf area per plant) canopy area (cm^2) using relation πr^2; r being obtained from the average diameter of the cashew plant canopy or crown taken with a meter ruler), survival percentage, flowering percentage and nut yield per tree and expressed in kg/ha were analyzed using descriptive statistics and analysis of variance (ANOVA) at p=0.05. Treatment means were compared with Duncan Multiple Range Test.

RESULTS

Growth of cashew seedlings at various plant densities as affected by maize intercrop:

Plant height

At 3 and 6 months after transplanting (MAT), plant density and intercropping with maize had no significant effects on height of cashew plants. At 9 MAT there was a significant difference in the height of cashew plants with sole cashew spaced 3 x 3 m recording the highest height (161.7 cm) while intercropped cashew spaced 4.5 x 4.5 m with 80,000 plants/ha maize recorded the lowest (108.1 cm). At 12 MAT, sole cashew spaced 3 x 3 m remained tallest while cashew spaced 6 x 6 m and intercropped with maize at 53,333 plants/ha were significantly shorter (Table 1). In the second year of intercropping, the tallest cashew plants were those grown sole at 3 x 3 m. The shortest were those spaced 6 x 6 m with maize at 53,333 plants/ha. The sole cashew spaced 3 x 3 m were significantly taller than other treatments at 18, 21 and 24 MAT. Cashew plants spaced 6 x 6 m with maize at 53,333 plants/ha were shortest at 18, 21 and 24 MAT. In the third year of intercropping, the sole cashew grown at 3 x 3 m were not significantly different from cashew grown at 6 x 6 m and intercropped with maize at 53,333 plants/ha (Table 1).

Table 1: Effects of planting density of cashew and maize intercrop on plant height (cm) of cashew on the field.

Treatments	Months after transplanting								
	3 (Aug)	**6** (Nov)	**9** (Feb)	**12** (May)	**15** (Aug)	**18** (Nov)	**21** (Feb)	**24** (May)	**27** (Aug)
C_1M_0	73.8	86.1	128.3ab	190.0ab	210.8ab	225.0ab	296.8ab	346.3ab	388.6
C_1M_1	74.0	80.9	108.2b	150.7b	181.0b	184.0b	237.0b	266.7c	361.6
C_1M_2	79.7	90.2	121.4ab	177.2ab	201.8ab	227.8ab	291.2ab	308.0ab	378.2
C_2M_0	74.2	93.8	120.9ab	161.5b	185.2b	213.8ab	270.2b	290.0bc	380.1
C_2M_1	66.5	86.5	121.8ab	164.1b	206.7ab	221.2ab	279.5ab	295.3bc	365.1
C_2M_2	63.3	76.7	108.1b	164.3b	187.5b	203.3b	260.8b	283.0bc	362.2
C_3M_0	79.3	103.3	161.7a	230.7a	251.7a	280.5a	353.0a	385.8a	405.5
C_3M_1	78.8	96.8	124.7ab	203.0ab	205.8ab	237.2ab	304.3ab	337.2ab	371.2
C_3M_2	75.0	95.6	135.2ab	175.5ab	196.7b	218.2ab	298.7ab	315.2ab	380.0
	ns	ns							ns

Means with same letters along a column are not significantly different at P<0.05 by Duncan Multiple Range Test. ns = not significant at P<0.05

Number of leaves

Plant spacing and intercropping with maize did not have significant effect on number of leaves recorded at 6 MAT of cashew. However, at 9 MAT, there was a significant difference in number of leaves, cashew grown at 3 x 3m intercropped with 80,000 plants/ha maize produced higher number of leaves (248.5) compared with the leaves produced by sole cashew grown at 6 x 6m which gave lowest value (119.0). Conversely, at 12 MAT, sole cashew grown at 3 x 3m gave highest number of leaves (550.2 leaves) followed by its intercropped

treatment with 470.5 leaves, while sole cashew grown at 6 x 6 m produced lowest number of leaves (260.2 leaves) (Table 2). In the second year, cashew grown at 3 x 3m with maize population of 80,000 plants/ha had 635 leaves followed by sole cashew grown at 3 x 3m with 618.4 leaves. The sole cashew grown at 4.5 x 4.5 m produced lowest number of leaves (434.4 leaves) and the differences were significant. Sole cashew grown at 3 x 3 m produced highest number of leaves of 1024.3 and 1114.2 leaves at 18 and 21 MAT respectively, while at 24 MAT, intercropped treatment with 80,000 plants/ha of maize had 1141.0 leaves. Within the same periods, sole cashew grown at 4.5 x 4.5 m produced lowest number of leaves which were 917.0, 942.7 and 962.7 leaves respectively.

Table 2: Effects of planting density of cashew and maize intercrop on number of leaves of cashew on the field.

Treatments	Months after transplanting							
	3 (Aug)	6 (Nov)	9 (Feb)	12 (May)	15 (Aug)	18 (Nov)	21 (Feb)	24 (May)
C_1M_0	59.3	64.0	119.0c	260.2b	481.6ab	973.8	988.3	1,098.3
C_1M_1	56.3	67.0	136.8bc	262.3b	492.6ab	941.3	960.0	980.0
C_1M_2	55.7	64.2	145.0bc	328.0b	503.0ab	935.5	982.0	1,112.0
C_2M_0	59.8	68.7	147.2bc	307.3b	434.4b	917.0	942.7	962.7
C_2M_1	78.2	79.5	168.2bc	314.8b	529.0ab	953.8	947.2	1,113.2
C_2M_2	57.5	64.0	139.8bc	303.3b	473.6ab	970.6	981.0	1,081.0
C_3M_0	60.7	86.2	191.3ab	550.2a	618.4a	1,024.3	1,114.2	1,115.0
C_3M_1	55.8	64.2	132.2bc	304.3b	483.6ab	916.3	991.2	1,102.8
C_3M_2	64.7	77.8	248.5a	470.5a	635.0a	1,035.5	1,101.0	1,141.0
	ns	ns				ns	ns	ns

Means with same letters along a column are not significantly different at P<0.05 by Duncan Multiple Range Test. ns = not significant at P<0.05

Stem circumference

The stem circumference of cashew plants, whether sole or intercropped, increased with time over the period of data collection and was not significantly influenced by the cropping system (Table 3).

Total leaf area

Throughout the period of intercropping, the cropping system did not significantly influence total leaf area of cashew plants except at 3, 12 and 15 MAT which falls in the months of August, May and August (of the following year) respectively. The lowest value of leaf area ($0.40m^2$) was obtained in intercropped cashew spaced 4.5 by 4.5 m with maize at 53,333 plants/ha. This was different from highest total leaf value of 0.94 m^2 in sole cashew grown at 6 x 6 m. The period of 12 and 15 MAT incidentally fell in the second rainy season. Total leaf area value (at 12MAT) of sole cashew grown at 3 x 3 m was 164.5% significantly higher than cashew grown at 4.5 x 4.5 m with maize at 53,333 plants/ha that had least value, while at 15 MAT, intercropped cashew grown at 3 x 3 m with

Table 3: Effects of planting density of cashew and maize intercrop on stem circumference (cm) of cashew on the field.

Treatments	Months after transplanting								
	3 (Aug)	**6** (Nov)	**9** (Feb)	**12** (May)	**15** (Aug)	**18** (Nov)	**21** (Feb)	**24** (May)	**27** (Aug)
C_1M_0	5.4	6.8	8.3	12.6	19.4	20.2	21.4	22.5	25.2
C_1M_1	4.8	6.9	7.8	11.0	18.0	18.8	20.0	22.8	25.6
C_1M_2	4.8	6.5	7.8	12.3	19.7	22.0	22.8	23.1	26.1
C_2M_0	5.2	7.1	8.2	11.8	17.4	18.7	20.8	22.0	24.8
C_2M_1	5.8	7.7	9.0	13.4	19.3	21.8	22.0	23.2	25.8
C_2M_2	4.5	6.5	7.9	11.9	17.0	18.4	20.8	22.6	24.8
C_3M_0	5.9	7.6	9.5	14.5	19.6	22.6	23.0	24.1	27.7
C_3M_1	5.3	7.1	8.3	12.7	19.2	21.6	22.6	24.1	26.7
C_3M_2	5.1	7.3	8.7	13.6	19.1	22.0	23.5	24.7	26.9
	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns = not significant at P<0.05

Table 4: Effects of planting density of cashew and maize intercrop on total leaf area (m^2) of cashew on the field.

Treatments	Months after transplanting							
	3 (Aug)	**6** (Nov)	**9** (Feb)	**12** (May)	**15** (Aug)	**18** (Nov)	**21** (Feb)	**24** (May)
C_1M_0	0.9a	0.8	1.8	6.3ab	8.9ab	12.3	13.1	16.5
C_1M_1	0.6ab	0.9	1.8	4.2ab	8.9ab	12.5	12.8	16.0
C_1M_2	0.6ab	0.8	1.9	4.7ab	9.1ab	12.5	13.2	15.3
C_2M_0	0.7ab	1.0	2.3	5.4ab	8.2ab	11.8	12.8	16.6
C_2M_1	0.4b	0.8	1.7	3.1b	10.3ab	12.2	12.8	15.5
C_2M_2	0.7ab	0.8	2.0	5.0ab	8.2ab	11.8	12.2	15.1
C_3M_0	0.7ab	1.0	2.4	8.2a	10.2ab	13.1	13.6	16.8
C_3M_1	0.6ab	0.9	1.8	4.1ab	7.6b	12.8	13.5	16.0
C_3M_2	0.7ab	0.8	2.2	4.8ab	12.1a	13.0	13.6	16.3
		ns	ns			ns	ns	ns

Means with same letters along a column are not significantly different at P<0.05 by Duncan Multiple Range Test. ns = not significant at P<0.05

80,000plants/ha maize had significantly highest total leaf area value which was 59.8% higher than cashew of same plant density but intercropped with 53,333plants/ha maize.

Canopy area

Plant density of cashew and maize intercrop did not have effects on canopy area of cashew plants until 12 MAT (Table 5). At this period of intercropping, canopy area of sole cashew grown at 3 by 3 m was 125.6% and 120.2% higher compared to that of intercropped cashew grown at 4.5 by 4.5 m and 3 by 3 m with maize grown at 80,000 plants/ha respectively, (Table 5). At 15 MAT, sole cashew planted at 3 by 3 m had 42.6% canopy advantages over cashew grown at 6 by 6 m intercropped with maize at 53,333 plants/ha. Closely following the highest plant canopy value were the intercropped cashew grown at 3 by 3 m and 4.5 by 4.5 m with maize at 53,333 plants/ha whose canopy area ranged from 4.00 to 4.15 m^2. At 18, 21, 24 and 27 MAT, cashew plants grown at 3 x 3 m intercropped with maize at 80,000 plants/ha gave the highest value for canopy area while sole cashew grown at 4.5 x 4.5m had lowest canopy area (Table 5).

Table 5: Effects of planting density of cashew and maize intercrop on canopy area (m^2) of cashew on the field.

Treatments	Months after transplanting								
	3 (Aug)	**6** (Nov)	**9** (Feb)	**12** (May)	**15** (Aug)	**18** (Nov)	**21** (Feb)	**24** (May)	**27** (Aug)
C_1M_0	0.1	0.2	0.4	0.9ab	3.6ab	4.0c	4.0cd	4.1b	6.9ab
C_1M_1	0.1	0.2	0.5	1.0ab	3.0b	4.5bc	5.2abcd	5.5ab	7.7ab
C_1M_2	0.1	0.2	0.5	1.0ab	3.5ab	5.0abc	5.1abcd	5.2ab	6.9ab
C_2M_0	0.2	0.2	0.5	1.0ab	3.0b	3.3c	3.4d	3.5b	5.6b
C_2M_1	0.1	0.3	0.4	1.3ab	4.0ab	6.3a	6.9a	7.9ab	9.0ab
C_2M_2	0.1	0.2	0.3	0.8b	3.6ab	4.0c	4.9bcd	4.6b	6.6ab
C_3M_0	0.1	0.3	0.6	1.9a	4.3a	5.5ab	5.9abc	6.0ab	8.0ab
C_3M_1	0.1	0.2	0.4	1.0ab	4.0ab	6.0a	6.0ab	6.3ab	8.1ab
C_3M_2	0.1	0.3	0.6	0.8b	4.2ab	6.9a	7.1a	8.0a	9.0a
	ns	ns	ns						

Means with same letters along a column are not significantly different at P<0.05 by Duncan Multiple Range Test. ns = not significant at P<0.05

The plant survival percentage

There were no significant effects of the cropping system on mortality of cashew transplants on field. 100% survival were recorded for all the treatments till 12 MAT with the exception of sole cashew at 4.5 x 4.5 m and cashew at 3x 3 m grown with 80,000 plant/ha that recorded low mortality (11.10%) which occurred one month after transplanting but before maize was introduced. No further loss in cashew stands were recorded throughout the period of study (Table 6).

The cashew yield parameters:

Flowering percentage

Flowering started at 18 MAT, at which period, cashew grown at 3 by 3 m intercropped with maize at 80,000 plants/ha

Table 6: Effects of planting density of cashew and maize intercrop on survival percentage of cashew on the field.

Treatments	Months after transplanting				
	1 (June)	3 (Aug)	6 (Nov)	9 (Feb)	12 (May)
C_1M_0	100.0	100.0	100.0	100.0	100.0
C_1M_1	100.0	100.0	100.0	100.0	100.0
C_1M_2	100.0	100.0	100.0	100.0	100.0
C_2M_0	88.9	88.9	88.9	88.9	88.9
C_2M_1	100.0	100.0	100.0	100.0	100.0
C_2M_2	100.0	100.0	100.0	100.0	100.0
C_3M_0	100.0	100.0	100.0	100.0	100.0
C_3M_1	100.0	100.0	100.0	100.0	100.0
C_3M_2	88.9	88.9	88.9	88.9	88.9
	ns	ns	ns	ns	ns

Note: ns = not significant at $P<0.05$

Table 7: Effects of planting density of cashew and maize intercrop on flowering percentage and nut yield (kg/ha) of cashew on the field.

Treatments	% flowering		Nut yield (kg/ha)
	18 (Nov)	**21** (Feb)	**24** (May)
C_1M_0	22.2bc	44.4bc	1,108.0b
C_1M_1	11.1cd	22.2de	664.8bc
C_1M_2	22.2bc	33.3cde	387.8c
C_2M_0	0.0d	11.1e	1,380.4b
C_2M_1	33.3b	66.7ab	542.3bc
C_2M_2	22.2bc	33.3cde	887.4bc
C_3M_0	22.2bc	88.9a	5,443.9a
C_3M_1	0.0d	33.3cde	888.8bc
C_3M_2	55.5a	55.5bc	1,222.1b

Means with same letters along a column are not significantly different at $P<0.05$ by Duncan Multiple Range Test.

had significantly higher percentage of flowering of 55.5% while those grown at 4.5 x 4.5 m intercropped with maize at 53,333 plants/ha had 33.3%. Sole cashew at 4.5 x 4.5 m and intercropped cashew grown at 3 x 3 m with maize at 53,333 plants/ha did not flower at this period of time. At 21 MAT, all cashew plant flowered with sole cashew grown at 3 by 3 m having significant highest (88.9%) flowering percentage followed by intercropped cashew grown at 4.5 by 4.5 m with maize grown at 53,333 plants/ha having 66.7%, while sole cashew grown at 4.5 by 4.5m

had lowest flowering percentage (11.1%) (Table 7).

The nut yield (kg/ha)

Unlike the flowering percentage, the sole cashew plants grown at 3 by 3 m (1,111 plants/ha), gave significantly highest nut yield of cashew per hectare (5,443kg/ha), while the lowest nut yield was obtained in an intercropped cashew of 6 by 6 m with maize at 80,000 plants/ha (387.8kg/ha) (Table 7).

DISCUSSION

Usually, the farmers in the tropics interplant tree crops with arable at early stage of field establishment before canopies of such tree crops close up. This practice had been well established in oil palm (Aya and Lucas, 1976), cocoa (Adeyemi, 1986) and coffee (Famaye, 2000). The wider spacing of cashew plant, compared to other tree crops enhances its intercropping with arable, especially, at early stage of field establishment. Besides, tolerance of cashew plants to varying environmental conditions lends the crop to intercropping with an array of arable crops based on ecological differences. The extensive shoot and root systems of cashew plants has been reported to contribute to the adaptation of the crop to different ecological conditions (Akinwale, 1995). The increasing nut yield of cashew with age makes the crop amenable to high density of planting coupled with a guiding principle of high plant density in tree crops that the greater the amount / extent of leaf growth / canopy growth before the plants come in contact with one another, the more extensive the root system is and less likely the plant suffer from drought (Milthorpe, 1961) .

Therefore, effect of plant density and intercropping with maize began mostly after 9 months of intercropping, with the plant height, canopy area, number of leaves and total leaf area being mostly affected. The observations indicated that, under high plant density of cashew and maize intercrop, the young transplants reacted to the shading effects of the cropping system at the early establishment stage of cashew. The competition with the adjacent cashew plants and maize intercrop in the closed planting treatment for survival and/or light might have resulted in taller cashew caused by etiolation. The sole cashew plants at 3 x 3 m (1,111plants/ha) were tallest due to competition for light among the adjacent cashew stands. This view might have premised earlier reports that cashew cultivation does not require shade (Adenikinju *et al*., 1989; Adenikinju, 1996). Decrease in the increasing rate of the plant's canopy area of cashew grown sole at 3 x 3 m was noticed especially, in the second year of intercropping. This is attributable to competition effects resulting from stand density due to interplant canopy contact. However, maize intercrop had no effects on such cashew plant parameters like stem circumference and survival percentage. This agrees with the reports that cashew plants tolerate intercropping with crop like plantain, in trials carried out in Western and Eastern Nigeria (Komolafe, 1980; Adeyemi, 1986; 1987; 1989). The non-response of stem circumference and survival percentage of cashew plants to stand density of cashew and maize intercrop is connected with the tolerance of cashew to varying ecologies (Falade, 1978). The observations in this trial that intercropped and sole (non-shaded) farming system cashew had optimum growth performance might have premised the popular report that cashew cultivation does not require shade (Adenikinju *et al.*, 1989). However, the canopy area of intercropped cashew grown at 3 x 3 m with

maize at 80,000 plants/ha which rapidly increased in the second year of intercropping is an indication of competition among the adjacent cashew plants for light. This is because cashew is aggressive in growth performance and suppresses adjacent plants without discrimination. This suppression varied among cashew densities and between densities of the intercrop and it is supported by earlier reports that the interplant and intraplant competitions are subjected to the variations in stand density (Donald, 1963).

The maximum cashew nut yield per hectare obtained from cashew plants grown at 3 x 3 m (1,111plants/ha) compared to that of cashew grown at 4.5 x 4.5 m (493plants/ha) and 6 x 6 m (277plants/ha) was one of the major agronomic advantages of high plant density especially in tree crops. While explaining the planting density-yield interactions, Mitchell (1970) emphasized that the interactions depend on whether the crop yield is in the vegetative or reproductive stages. It was further explained that, if the seed yield is desired, there is an optimum plant density and that the density can be too high and if the vegetative materials constitute the crop yield, the response of yield to plant density is asymptotic. Therefore, in cashew since the product of the reproductive stage (nuts) constitutes the crop yield, there would be an optimum planting density that gives maximum nut yield. This explains the improved nut yield harvested from cashew plants grown at 3 x 3 m (1,111plants/ha).

CONCLUSION

The improved cashew nut yield of 5.6 t/ha was obtained from sole cashew plants grown at 3 x 3 m (1,111 plants/ha) as against 1.4 t/ha and 1.1 t/ha harvested from cashew plants grown at 4.5 x 4.5 m (493 plants/ha) and 6 x 6m (277 plants/ha) respectively, at early periods of nut harvest. Therefore, for sole cropping, closer density can be considered especially for early fruit yield. The competition that may result later can be managed by canopy pruning and stand thinning, the resultant wood will be useful as fuel wood or used to make charcoal.

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