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EVALUATION OF NUTRIENT UPTAKE UNDER HIGHER DENSITY PLANTING OF COFFEE IN DERIVED SAVANNA ZONE OF NIGERIA

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ABSTRACT

This study was conducted at the Cocoa Research Institute of Nigeria (CRIN), Uhonmora sub-Station in Derived savannah zone of Edo State, Nigeria in 2007 to evaluate the nutrient uptake of coffee at different density of planting. Treatments comprising of four spacing (3.0 m x 3.0 m, 2.5 m x 2.5 m, 2.0 m, x 2.0 m and 1.5 m x 1.5 m) with plant populations of 1111, 1600, 2500 and 4444 plants/ha respectively were used. Randomised Complete Block Design (RCBD) was used for the experiment with four replicates. Coffee seedlings were up-rooted, oven dried, milled and analysed chemically to determine the nutrient uptake. Yield data of bunch obtained from plantain used as inter-crop as well as shade crop in all the treatments were recorded. Data collected were subjected to ANOVA and LSD was used to separate the means. The result obtained showed that planting at a spacing of 1.5 m apart recorded the highest N, P, K. Ca and Mg uptake and closely followed by 2.0 m without any significant difference (P < O.05) between them. The 3.0 m spacing gave the least values. Higher density did not affect the yield of the plantain as there was no significant difference among the treatments. Therefore, the close spacing of 1.5 m and 2.0 m apart could be recommended to the coffee farmers to enhance more plant population per hectare instead of the recommended spacing of 3.0 m apart.

INTRODUCTION

Previous studies have established that crop mixtures take up higher amount of nutrients per unit land area (Yen, 2006). Yen (2006), reported that one hectare of crop mixtures take up 40-60% more nutrients than 21/2 hectares of corresponding sole crop. In general, total uptake of nutrients in crop mixtures has been reported to increase with increasing population of individual intercrops in the mixture (Cam. 2007). Bada (2005), reported decline soil fertility and crop yields with increasing population of individual intercrops constituting the mixture and ascribe the decrease in soil fertility and crop yields to depletion of soil organic carbon. The present planting distance of 3.1 m apart with plant population of 1040 per hectare adopted by coffee farmers in Nigeria may not be the optimum spacing for highest coffee berry yield. For *Coffea arabica*, 3.0 x 3.0 (1111 trees/ha) was used as former East African standard while 2.74 m x 2.74 m (1329 trees/ha) and 2.74 x 1.37m (2658

trees/ha) respectively are common East African standard (Rene, 1992). Several factors are considered in spacing trials and these include vigour of the trees, type of planting materials, shade conditions, soil and climate. Soil management practices are very important in agricultural practices. As a result of several development projects, rural-urban labour shift and competition for agrarian land, agricultural practices focus on effective resource use seemed to be the panacea for farming venture.

The future of coffee production in Nigeria will be enhanced if the available land suitable for coffee production is utilized maximally through increase in plant population than the present plant population per hectare. Therefore, the objective of this trial was to evaluate the nutrient uptake of coffee under higher density planting through which the best density per land area could be determined.

MATERIALS AND METHODS

The field experiment was carried out at the Cocoa Research Institute of Nigeria (CRIN), Uhonmora sub-Station, Edo State in 2007 and 2008. Uhonmora is located in Derived Savannah Zone of Nigeria (Latitude 6^0 5' N and longitude 5^0 5' E) with an elevation of about 140 m above sea level. The soil of the experimental site was Ultisol.

Land preparation was done manually using cutlass. The experiment had four treatments comprising of spacing 1.5 m x 1.5 m (4444 plants/ha), 2.0 m x 2.0 m (2, 500 plants/ha), 2.5 m x 2.5 m (1600 plants/ha) and the control 3.0 m x 3.0 m (1111 plants/ha). The plot layout and planting were done in August 2007. Coffee seedlings planted in the field were obtained from the nursery of the Cocoa Research Institute of Nigeria (CRIN), Uhonmora sub-Station.

The experimental layout was a Randomized Complete Block Design (RCBD) replicated three times. Parameters considered were physical and chemical properties of the soil at the beginning of the trial. Also taken were data on plant height, plant diameter and leaf area. Coffee seedlings were uprooted on treatment basis, washed and freshly weighed. They were oven dried for 72 hours to a constant weight at 85^0 C. The dried plant were later milled and analysed for the major nutrients of N, P, K, Ca, Mg and the uptake calculated. The total Nitrogen was determined using macro kjeldahl procedure as described by Jackson (1965). The determination of Phosphorus was done by the Bray method as described by Bray and Kurtz, (1945). While exchangeable K, Ca and Mg were determined by extraction with 1 N ammonium acetate and the amount of K and Ca in the filtrate was determined using Flame photometer with appropriate filter. Mg was determined using a Perking Elmer Atomic Absorption Spectro-Photometer (AAS). Results obtained were subjected to statistical analysis of variance and LSD was used to separate the means that were significantly different.

RESULTS AND DISCUSSION

The soil physical and chemical properties of the site used for the study before cropping are presented in Table 1. The soil was sandy clay in texture, with a pH of 5.7. The soil Organic Carbon and total Nitrogen were 0.85 and 0.07% respectively. The exchangeable bases K, Ca, Mg and Na were 0.05, 2.56, 0.06 and 0.03 cmol/kg soil respectively. The soil organic carbon, available P, exchangeable Mg, Ca, K and N were below the critical values (Egbe *et al., 1989*).

Table 1: Soil Physical and Chemical Properties of the experimental sites at the beginning of the experiment

Soil properties	Uhonmora
pH (H_2O)	5.70
% Organic carbon	0.85
% Total Nitrogen	0.07
Available P (mg/kg) soil	7.31
Exchangeable K ($cmolkg^{-1}$)	0.05
Exchangeable Ca ($cmolkg-^{1}$)	2.56
Exchangeable Mg ($cmolkg^{-1}$)	0.06
Exchangeable Na ($cmol^{-1}kg$)	0.03
Sand (g/kg)	804.0
Silt (g/kg)	90.0
Clay (g/kg)	106.0
Soil classification	Ultisol

Table 2 presents data on average yield of plantain bunches (t/ha) used as an intercrop as well as shade crop under high density planting of coffee in Derived savannah zone of Nigeria. The result indicated that planting at a spacing of 3 m x 3 m with plant population of 1111 plants/ha recorded the highest average bunch yield of 60.4 tons per ha; this was closely followed by 60.3, 60.2 and 60.2 t/ha which were recorded for 2.5 m x 2.5 m, 2.0 m x 2.0 m and 1.5 m x 1.5 m respectively with plant population of 1,600, 2,500 and 4444 plants/ha respectively. However, there were no significant difference ($P < 0.05$) among them.

Table 2: Average yield of plantain t/ha at Uhonmora

Spacing (m)	Yield (Bunch) t/ha
3.0m x 3.0m	60.4
2.5m x 2.5m	60.3
2.0m x 2.0m	60.2
1.5m x 1.5m	60.7
Mean	60.28
LSD (P= 0.05)	0.15

The influence of higher density planting on coffee seedling height (cm) is shown on Table 3. Increasing coffee population at a closer spacing (1.5 m x 1.5 m) resulted into a significant increase in coffee plant height (cm) compared to other three spacings considered (Table 3). Similar trend was observed throughout the trial except at 6 months after transplanting where wider spacing of 3.0 m apart recorded the highest plant height (55.00 cm). The difference was significantly ($p> 0.05$) better than the rest.

Table 3: Plant height (cm) of Coffee as influenced by higher density planting

	Months after transplanting						
Spacing	**3**	**6**	**12**	**18**	**24**	**30**	**36**
1.5m apart	41	52	65	82	106	125	149
2.0m apart	41	51	62	75	94	111	132
2.5m apart	40	52	60	72	89	105	119
3.0m apart	40	55	60	73	90	105	120
Mean	41	52	62	76	95	112	130
LSD (P = 0.05)	0.5	2.3	3.4	6.2	10	13.1	19.3

Tables 4 and 5 present data on the effect of higher density of coffee on the stem diameter and leaf area of coffee respectively. Planting at a closer spacing of 1.5 m x 1.5 m recorded the highest leaf area and stem diameter values respectively. The observation was similar to the values recorded for the plant height and nutrients uptake respectively. The higher density planting of 1.5 m apart was significantly ($P < 0.05$) in leaf area and stem diameter than the wider spacing of 2.0 m, 2.5 m and 3.0 m apart respectively.

Table 4: Effect of higher density planting of coffee on stem diameter (cm)

	Months after transplanting						
Spacing	**3**	**6**	**12**	**18**	**24**	**30**	**36**
1.5 m apart	0.93	1.01	1.48	1.59	1.68	1.76	1.81
2.0 m apart	0.94	0.97	1.41	1.48	2.40	1.63	1.66
2.5 m apart	0.72	0.82	1.06	1.13	1.20	1.26	1.29
3.0 m apart	0.79	0.85	1.22	1.28	1.34	1.40	1.43
Mean	0.85	0.1	1.29	1.37	1.44	1.50	1.55
LSD (P = 0.005)	0.50	0.12	0.26	0.28	0.30	0.31	0.37

Table 5: Leaf Area (cm^2) of Coffee as influenced by higher density planting

	Months after planting						
Treatments (m)	**3**	**6**	**12**	**18**	**24**	**30**	**36**
1.5	123.53	178.68	268.52	336.9	426.74	471.66	606.42
2.0	123.53	168.45	235.83	303.21	370.59	437.97	505.27
2.5	112.30	157.22	224.6	280.75	348.13	415.51	527.81
3.0	112.30	157.22	224.6	269.52	336.9	404.28	516.59
Mean	117.15	165.39	238.38	279.60	370.59	432.35	539.02
LSD (P = 0.05)	10.32	16.42	33.05	47.27	63.59	47.27	72.97

The nutrients uptake of Coffee (g/plant) at different spacing and densities is presented in Table 6. Planting at a higher density and at a closer spacing of 1.5 m x 1.5 m recorded the highest N, K and Ca uptake. This was closely followed by 2.0 m x 2.0 m and 2.5 m x 2.5 m respectively. There were no significant differences in the amount of N uptake by the plant irrespective of planting density used.

The amount of P, K and Ca uptake by the coffee plant at higher density of 4444 and 2,500 plant/ha was significantly ($p \leq 0.05$) different from the low density planting of 1111 and 1600 plants /ha at the first growing season respectively. No significant ($P < 0.05$) difference was observed for planting distance of 1.5 and 2.0 m apart. Similar trend was observed for N, P, K and Ca during the second growing season.

Table 6: Nutrient Uptake (g/kg plant) of Coffee seedlings as influenced by higher density planting

	2007				2008			
Spacing	**N**	**P**	**K**	**Ca**	**N**	**P**	**K**	**Ca**
3.0m x 3.0m	0.36	0.32	2.21	2.52	0.39	0.33	2.34	2.54
2.5m x 2.5m	0.40	0.34	2.27	2.51	0.42	0.37	2.33	2.53
2.0m x 2.0m	0.42	0.38	2.24	2.56	0.48	0.49	2.37	2.58
1.5m x 1.5m	0.43	0.36	2.35	2.57	0.49	0.49	2.38	2.59
Mean	0.40	0.35	2.31	2.54	0.45	0.42	2.36	2.56
LSD (P< 0.05)	0.05	0.04	0.06	0.05	0.08	0.13	0.04	0.05

Planting at a spacing of 2.0 m x 2.0 m with plant population of 2,500 plants/ha recorded the highest phosphorous uptake from the soil in the first cropping season. In all, the least values were observed in 3.0 m x 3.0 m with plant population of 1111 plants/ha for all nutrient elements considered.

Similar trends were observed in the second cropping season with coffee planted at a closer spacing with the highest planting densities recording the highest nutrients element uptake. While those planted at wider (3.0 m x 3.0 m) spacing with thinner population recorded the least. This observation was in agreement with the finding of Osundare (2008), who observed that soil nutrients status was affected by increasing maize population density in cassava/maize mixture after cropping. The decrease in soil N, P, K and Ca associated with higher density planting of coffee/plantain in a derived Savannah zone agreed with the findings of Kurtz (2004) and Crick (2007), who reported a significant reduction in soil organic carbon and other soil nutrients following cassava/maize mixture cultivation at different population densities.

CONCLUSION

Based on result of the current findings, higher density planting at 1.5 m and 2.0 m apart could therefore be recommended to coffee farmers in Nigeria instead of the wider spacing of 3.0 m apart that they are currently using.

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REFERENCES

Crick, A.P. (2007). Effects of inclusion of certain tropical legumes intercrop mixtures of soil fertility in the humid tropics. *Soil fertility Research* 6(6): 801-807.

Osundare, B. (2008). Effect of increasing maize (*Zea mays*) population density in cassava maize mixture on a major soil nutrients and performance of cassava *Manihot esculenta* in South-western Nigeria. *Nigerian Journal of Soil Science* (18): 2008. Pp. 60-67.

Kurtz, B.T. (2004). Influence of Cassava-based intercropping system on soil organic carbon dynamics in tropical Agriculture. *Tropical Farming System* 3: 304-309.

Bada, K.T. (2005). Influence of varying maize population in a yam/maize mixture on soil nutrient yield of yam. *Journal of Plant Nutrition, Research*7 (4) 651-656

Yun, E.A. (2006). Effects of mixed cropping on soil fertility. *Soil Fertility Management,* 8 (5): 543-548.

Cam, F.K.N. (2007). Studies on the effect of Cassava-based intercropping systems on soil fertility in the humid tropics. *Soil Fertility Research* 6 (6) 801-807.