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Evaluation of Growth and Nutrient Uptake in Cocoa/Coconut Intercrop in Southwest Nigeria

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Abstract: A field trial to evaluate the growth and nutrient uptake of cocoa intercropped with coconut was conducted in Cocoa Research Institute of Nigeria (CRIN) Headquarters, Idi-Ayunre, Ibadan, Oyo State between 2019 and 2022. There were four treatments comprising of cocoa sole, cocoa/plantain, cocoa/coconut and cocoa/coconut/plantain intercrop. The experimental design was Randomized Complete Block (RCB) replicated three times. Result obtained showed that cocoa/plantain was significantly higher ($p < 0.05$) than all other treatments in all parameters considered and closely followed by cocoa/coconut, then cocoa sole with cocoa/plantain/coconut giving the least performance. The same trend was observed in the nutrient uptake. It was also observed in the trial that the two crops: cocoa and coconut did not show any deleterious effect on their growth when intercropped together. This showed that the two crops are compatible when grown on the same piece of land. Therefore, cocoa/coconut intercrop could be recommended to cocoa farmers in south west Nigeria to increase their revenue generation when coconut starts bearing fruit instead of sole planting of cocoa.

Key words: Cocoa, coconut, intercrop, growth, nutrient uptake.

1. Introduction

The cacao (*Theobroma cacao* L.) is a native to the undergrowth of the amazon forest [1]. Since its introduction in west Africa, farmers have grown cacao under shade trees in order to create light conditions that are similar to those found in native forest [2, 3]. To obtain this light condition, several techniques have been developed: under managed natural forest, under natural regrowth or under artificial shade [4]. Intercropping is a common agricultural practice in the tropics. It has been reported to increase crop diversity, biological stability of the ecosystem and labour efficiency [5], and that intercropping can stabilize socio-economic conditions and alleviate poverty. Many authors have described the physiological, environmental and economic values of trees in cacao growing systems [6-10]. They quote benefits such as shade for cacao, soil fertility maintenance, biodiversity conservation, protection against drought and additional income through sales of timber species, fuel wood and non-wood forest products. Agronomic practices in simplified orchards combining cacao and fruits trees such as coconut have been little documented. Besides, little has yet been reported about the relationship between growth and nutrient uptake in cacao/coconut intercrop. In Nigeria, intercropping in cocoa is usually carried out with arable crops to provide food and income to farmers before cacao starts bearing pods and it is done at juvenile stage of cacao, between 1-3 years before it closes canopy [11]. Again in Nigeria, cacao has been conveniently intercropped with oil palm, kola and citrus [10]. Intercropping cacao with coconut and palm trees is a common practice in Southeast Asia [11]. However, this has not been practiced in Nigeria. Therefore, the objective of this study was to evaluate the growth and nutrient uptake in cacao intercropping with coconut in Southwest Nigeria.

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2. Materials and Methods

2.1 Experimental Location

Field experiment was carried out at Cocoa Research Institute of Nigeria (CRIN) experimental farm, Ibadan. Ibadan lies between latitude 7°10′ N, 3°24′ E, 122 m elevation above sea level in the tropical rain forest ecosystem with mean solar radiation of 18 MJ/(m^2·day) and an annual rainfall of 2,000 mm with a bimodal pattern.

2.2 Acquisition and Preparation of Experimental Materials

Seedlings of cacao Tc1-Tc8 were collected from CRIN Seed Garden, while plantain suckers were purchased from local farmers. The coconut seedlings were obtained from coconut farmers in Calabar, Cross Rivers State.

2.3 Treatments and Experimental Design

The experimental plot of 30 × 120 m was mapped out and the following treatments were applied: cacao sole, cacao/plantain, cacao/coconut and cacao/plantain/coconut. The experiment was conducted by Randomized Complete Block Design and replicated three times.

2.4 Soil Sample Collection and Analysis

Soil samples were collected randomly from the experimental site with the aid of soil auger at 0-30 cm depth for the pre-cropping soil analysis. The samples were bulked together and mixed thoroughly, air dried at room temperature, sieved with 2 mm sieve and analyzed for various elements. Particle analysis was determined using the hydrometer method [12], organic matter by potassium dichlomate oxidation [13]; soil pH by pH meter (1:1). Organic matter was determined by Walkley-Black acid digestion method [14]. The nitrogen (N) was determined by Kjeldal method [15]. Available P determination was done by the Bray method [16]. Exchangeable K and Na were determined by flame photometer.

2.5 Data Collection

Morphological parameters (plant height, stem diameter and leaf area) of cacao were determined at 3 months interval for 24 months. At 24 MAT (months after transplanting), cacao seedlings were uprooted on treatment basis. They were washed, weighed and oven dried to constant weights at 70 °C. The dried plants were milled and analysed for N, P, K, Ca. The result obtained was subjected to Analysis of Variance, and least significant difference (LSD) was used to separate the significant means.

3. Results and Discussion

Result of physical and chemical properties of the study location at the beginning of the experiment is shown in Table 1. The soil was sandy loam belonging to Onigambari series and an Alfisol (Soil survey staff, 1999). The silt+clay contents of the soil (18.5%) at the experimental site were far below the 32% estimated to be adequate for soils considered to be ideal for tree crops production, especially cacao [17]. Based on the established critical levels for soils in Southwest Nigeria, the soil was acidic with pH of 6.4 and low in organic carbon (0.84) [18]. Available P was also low (7.25 mg/kg). This level of P is considered inadequate for cacao [17, 19].

Effect of cacao intercrop on growth parameters of cacao is presented in Tables 2-4. Coconut/plantain intercrop gave the highest plant height, stem diameter and leaf area at 3, 6, 9, 12, 15, 18 and 24 MAT, respectively. When compared with the cacao/coconut intercrop, cacao/plantain increased the growth parameters of cacao seedlings at 3, 6, 9, 12, 15, 18, 21 and 24 MAT by 2.5%, 2.2%, 19.9%, 6.2%, 5.1%, 2.3%, 6.4% and 7.9% for plant height; 5.9%, 8.1%, 12.4%, 7.55, 6.9%, 5.0%, 10.3% and 15.8%; for stem girth, 4.0%, 3.4%, 4.3%, 11.1%, 6.0%, 5.0%, 7.1% and 8.2% for leaf area of cacao (Tables 2-4). This finding could be due to the fact that cacao seedlings which could have been suppressed by plantain shade were not directly positioned under the plantain suckers,

but in between which was 150 cm apart. This is in agreement with Famaye et al. [10]. There were no significant ($p > 0.05$) differences among the treatments in the first 3 and 6 months of transplanting. However, from 9 months there were significant ($p < 0.05$) differences in the intercrops. The least plant height, stem diameter and leaf area were recorded in cacao/coconut/plantain. This could have been due to much competition for light at upper surface and nutrient at the root sphere which agrees with earlier report of Famaye [20]. The results equally show a significant ($p < 0.05$) increase in cacao/plantain, closely followed by cacao/coconut in almost all the morphological parameters compared to cacao/plantain/ coconut and sole cacao. This higher increase in growth in these crop combinations compared to sole cacao agrees with earlier information that intercropping cacao with coconut and palm trees is a common practice in Southeast Asia [11].

Table 5 shows data on leaf nutrient uptake of cacao intercrop in years 2019 and 2020 rainy seasons. When compared with cacao/coconut/plantain, cacao/plantain increased leaf N, K and Ca by 17%, 2% and 3%; and N, P, K, and Ca by 28%, 77%, 10% and 5% in 2019 and 2020, respectively. Generally, while the least N uptake was recorded in cacao/coconut/plantain, cacao/plantain had the highest nutrient uptake, closely followed by cacao/coconut. The increase observed in both cacao/plantain and cacao/coconut intercrops might have been due to better shading that reduced evapotranspiration and enhanced microbial activities as well as lesser root competition than cacao/plantain/coconut intercrop as earlier reported by Famaye [20].

Table 1 Soil physical and chemical properties of the experimental site at the beginning of the experiment.

Soil properties	Values
pH (H_2O)	6.4
Organic carbon (%)	0.84
Total N (%)	0.08
Available P (mg/kg soil)	7.25
Exchangeable K(mg/kg soil)	0.44
Exchangeable Ca (mg/kg soil)	2.45
Exchangeable Mg (mg/kg soil)	0.03
Exchangeable Na (mg/kg soil)	0.01
Sand (%)	81.5
Silt (%)	8.2
Clay (%)	10.3
Soil classification	Alfisol

Table 2 Plant height of cacao intercropped with plantain and coconut.

	Months after transplanting							
Treatments	3	6	9	12	15	18	21	24
Cacao sole	38.26	38.74	56.60	78.41	82.50	85.47	90.68	100.71
Cacao/plantain	38.53	39.68	57.07	86.25	88.46	93.02	99.81	112.87
Cacao/coconut	37.56	38.83	45.91	80.91	84.00	90.91	93.46	103.93
Cacao/coconut/plantain	36.25	37.14	40.23	72.30	80.13	84.12	87.57	90.48
Mean	35.63	38.60	49.95	79.47	83.77	83.38	92.88	102.00
LSD ($p < 0.05$)	5.59	1.69	13.17	9.21	5.53	6.78	8.28	14.72

Table 3 Stem diameter of cacao intercropped with plantain and coconut.

	Months after transplanting							
Treatments	3	6	9	12	15	18	21	24
Cacao sole	0.67	0.72	1.57	1.78	1.80	1.93	1.98	2.04
Cacao/plantain	0.68	0.74	1.78	1.87	1.91	2.00	2.24	2.40
Cacao/coconut	0.64	0.68	1.56	1.73	1.78	1.90	2.01	2.02
Cacao/coconut/plantain	0.60	0.63	1.37	1.49	1.51	1.84	1.89	1.93
Mean	0.65	0.69	1.57	1.72	1.75	1.92	2.03	2.10
LSD ($p < 0.05$)	0.06	0.08	0.27	0.26	0.27	0.11	0.24	0.33

Table 4 Leaf area of cacao intercropped with plantain and coconut.

	Months after transplanting							
Treatments	3	6	9	12	15	18	21	24
Cacao sole	136.10	153.60	216.87	258.73	275.40	284.32	301.80	323.30
Cacao/plantain	138.91	155.29	224.86	284.38	292.12	298.24	320.32	345.41
Cacao/coconut	133.42	150.07	215.24	253.24	274.86	285.16	298.93	320.80
Cacao/coconut/plantain	230.52	148.35	201.52	243.35	257.94	280.53	290.36	301.73
Mean	134.74	151.83	214.58	262.43	275.08	287.06	302.85	322.81
LSD ($p < 0.05$)	5.72	5.05	15.51	28.59	22.19	12.27	20.06	28.43

Table 5 Nutrient uptake (g/plant) of cacao intercropped with plantain and coconut.

Treatments	N	P	K	Ca
Cacao sole	0.5	0.41	2.51	2.60
Cacao/plantain	0.54	0.40	2.56	2.64
Cacao/coconut	0.51	0.40	2.53	2.61
Cacao/coconut/plantain	0.45	0.36	2.53	2.55
Mean	0.50	0.39	2.53	2.60
LSD ($p < 0.05$)	0.06	0.04	0.04	0.06

4. Conclusion

From the results of this research, it could be concluded that cocoa/coconut intercrop as well as cocoa/plantain could be recommended to cocoa farmers instead of sole cocoa planting. This would increase the revenue base of the farmers when coconut and plantain would start bearing fruit from the intercrop as against only cocoa beans harvestable from sole cocoa planting. The two intercrops would equally maximize the available land as the nutrient uptake (N-uptake) was higher in both combinations than in sole cocoa.

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