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Response of Cocoa to Different Fertilizer Regimes on Some Selected Soils of Southwestern Nigeria

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Abstract: Field experiments were conducted at four locations (Aisegba, Ayedun, Ikoro and Ise) in Ekiti State, Southwester Nigeria to determine the response of cocoa to different fertilizer regimes. Three fertilizer regimes were used (soil test value, Blanket and control). Significant ($p<0.05$) increase in number of cocoa pods were observed from all plots in all locations as a result of fertilizer application. The number of cocoa pods as determined by the different fertilizer regimes are in the order soil test> blanket > control, while for soil series it was in the order Makun series> Ondo series> Fagbo series. Number of cocoa pods produced from plots that received soil test rate fertilizer application almost doubled that of control. The effect of management (fertilizer application) in controlling cocoa production was observed to be very strong and even stronger than that of soil types at all experimental locations. The study recommends that farmers should use fertilizer rate based on soil test.

Key words: Cocoa, pod, fertilizer, management, ekiti

INTRODUCTION

Cacao tree is cultivated in the forest belt of Nigeria. Approximately ninety- eight percent of all cocoa is produced in the West, while the remaining two percent is produced east of the River Niger in Nigeria. Soil survey was carried out within the cocoa belts of Nigeria between 1951 and 1960. The survey revealed that about sixty two percent of the Nigeria Cocoa is grown on good or fairly good soils and the remaining thirty-eight percent on poor or very poor soil. Cocoa Research institute of Nigeria gave experimental evidence that the chemical and physical properties of soil decline with cultivation[1,2] and that two major factors are responsible for the decline in Cocoa yield, these factors are poor site selection and lack of fertilizer use.

The present study was carried out because of the need for better use of fertilizer by cocoa farmers with the aim of boasting cocoa production in some parts of Ekiti state, Southwestern Nigeria. The experimental sites covered a total of sixteen hectares (each site being four hectares). The trials were sited on suitable areas in farmers' farms at four Locations (Ise, Aisegba, Ayedun and Ikoro).

This present study was therefore designed to examine the influence of fertilizer use on cocoa production on some selected soils of Ekiti.

MATERIALS AND METHODS

Site description and soil analysis: The experimental sites covered a total of sixteen hectares (each site being four hectares). The selected sites are Ise (5^0 03'E,7^0 50'N), Aisegba (5^0 29'E,7^0 36'N), Ikoro (5^0 03'E,7^0 50'N) and Ayedun-Ekiti (5^0 35' E, 7^0 49'N), respectively. The mean rainfall of the location is approximately. 1300 mm per annual with bimodal distribution.

Surface soil samples (0-15 cm) were taken from each site. The soil sample were air-dried, crushed and sieved with 2 mm sieve. Routine analysis were done for particle size distribution using hydrometer method and p^H was measured using glass electrode p^H meter at 1:1 soil to water ratio. The percent organic carbon was determined by the Walkey Black wet oxidation method while percent Total N was determined by macro Kjedahl method. The percent organic matter was estimated by multiplying the percent organic carbon with a factor of 1.724. Available P was determined by the method of Bray and Kurtz[3] while the exchangeable cautions were determined by neutral normal NH_4OAC. The k and Na were then measured with the flame photometer while Mg and Ca were determined on the atomic absorption spectra photometer. The Exchangeable Acidity (EA) was determined by titration method. The Effective Exchange Capacity (EEC) was

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thus calculated as the sum of the exchangeable bases (K+Na+Ca+Mg) and EA exchangeable acidity in CmoI Kg^{-1} of soil. The percent base saturation was calculated as the sum of the exchangeable bases expressed as a percentage of ECEC (Effective cation Exchange capacity).

The micronutrients (Mn,Fe Cu and Zn) were determined by extracting with 0.1NHCL and read on the atomic absorption spectrophotometer.

Field experiment, experimental design and data analysis: At each experimental site selected for the study the experimental materials was demarcated into three experimental plots. Each experimented plot being 10x10 m in size. Each plot was pegged round and labeled for easy identification. The experiment was a single factor experiment (fertilizer being the only factor which effect was tested). A complete Randomized Design was used with three fertilizer treatments level which were applied two weeks after the application of the insecticides. The experimental sites were regarded as replications. The fertilizer treatments were as follows:

T_1 = Control (No fertilizer application)
T_2 = Blanket fertilizer recommendation (305 kg ha^{-1} urea and 250 kg ha^{-1} NPK)
T_3 = Specific Fertilizer recommendation based on soil test (150.25 kg ha^{-1} urea + and 125 kg ha^{-1} NPK)

An average fertilizer of 3.08 kg urea + 2.5 kg NPK was applied for the blanket recommendation per plot (100m^2) while an average of 2.75 kg fertilizer mixture (1.50 kg urea + 1.25 kg NPK) was applied to each plot (100 m^2) for the specific fertilizer based on soil test.

All the treatments were replicated four times to give a total of twelve experimental plots. Five cocoa trees were selected randomly from each plot for data collection and analysis. Average plot population was ten trees. Data were collected at two weeks interval for a total of eight weeks. Parameter taken was number of mature pods per plot. The data collected were analyzed using analysis of variance, T-test and Rank correlation.

RESULTS AND DISCUSSION

Soil fertility evaluation: The result obtained from the analysis of the soil from the different locations in Ekiti state are shown in Table 1. The soils are generally high in sand, with values between 612.0-732 g kg^{-1} soil. The silt + clay contents ranged between 228-388 g 1 Kg soil. These values are generally high and were considered adequate for the growth of cocoa and it falls within the range of values recommended for cocoa soil by Egbe[4]. Egbe *et al.*,[5] recommended that the best soils for cocoa are those with 350-550 g kg^{-1} clay + silt in all the horizons and the most favourable texture corresponding to 200-250 g kg^{-1} clay + silt in the top 20 cm. Values of 725, 203 and 73.5 g kg^{-1} of sand, clay and silt respectively have been reported to be optional for the top 0-30 cm soil depth for plantation crops like cocoa, coffee, kola and cashew[6]. Their values were similar to those obtained in this study.

The soils are slightly to moderately acidic. The P^H was above 6.0 as recommended by Egbe[4] as good for cocoa soil. The disparity not with standing, the values still fell within the range recommended for tree crops.

The organic carbon of the soils ranged between 10-18.7 g kg^{-1} soils. These values are low for cocoa. [7] reported a range of 19.0-32 g kg^{-1} soils, which they considered low to support sustainable growth and production of crops like cocoa, cashew and Kola over a long period of time.

The soil N contents were between 0.06 and 0.37 g kg^{-1} soil. This shows a drastic reduction to a value recommended by Adepetu,[8] as the optimum at which no additional N would be added. The obtained values were considered low when compared with the critical value for cocoa[5], recommended 0.90 g kg^{-1} of N as the critical level for cocoa.

The available P contents were found to be between 0.90 and 8.0 I mg kg^{-1} soil. These values from the old cocoa plots were marginally lower compared to what cocoa plants needed. The cocoa plots in all these locations must have exhausted the soil of most of the P-contents. This is so because it has been asserted that P is the most limiting of all the nutrient elements for cocoa.

The potassium contents of the soils were between 0.05-0.21 cmoI kg^{-1}. The values were also marginally low to what cocoa plants needed.[5] recommended that the critical level of K required by cocoa to be 0.3 cmo kg^{-1}. The cocoa plants must have mined much of the K in the soil and this might have been lost through harvests.

The soil Ca contents ranged between 3.34-3.99 Cmol kg^{-1}. The values are considered adequately low and inadequate for optional performance of cocoa[9]. recommended 12 ppm of Ca as the medium requirement for cocoa while[5] recommend 5.00 cmo kg^{-1} as the critical level of ca nutrient requirement. The soil my level was between 2.51-3.37 cmol kg^{-1}. These values are considered adequate for the good production of cocoa

The soils micronutrients contain the quantities which are within the contents adequate for cocoa production[5]. Tabe 1 shows a high content of cu in all the cocoa soils in Ekiti state. This high deposit must have been as a result of previous spray of Cu SO_4 (fungicide Component). This may be a problem in future if these locations are to be put

Table 1: Physical and chemical properties of surface soil samples of studies area

Location	PH (H_2O) 1.1	P (ppm)	g kg^{-1} Org. C	g kg^{-1} Total N	Ca (cmol kg^{-1}	Mg (cmol kg^{-1}	K (cmo kg^{-1}	Na (cmo kg^{-1}	Fe (ppm	Mn (ppm	Zn (ppm)	Cu (ppm)	EA (Pmo kg^{-1})	CEC Cmol kg^{-1}	Bs %	Clay	Silt g kg^{-1} soil	Sand	Textural class
Aisegba	6.88	1.14	15.2	0.37	3.50	3.37	0.21	0.82	00.41	80.6	25.36	9.66	1.31	9.87	86.7	4.8	18.0	7720	Ls
Ayedun	6.58	8.01	18.7	0.06	3.99	2.50	0.10	0.58	71.12	64.3	20.54	7.47	1.22	8.13	85.0	6.8	20.0	73.2	LS
Ise	6.70	0.90	14.7	0.36	3.46	3.14	0.17	0.76	93.12	64.5	24.06	9.37	0.81	9.04	86.5	88	240	672.0	LS
Ikoro	6.40	7.87	10.0	0.24	3.33	2.88	0.05	0.66	86.95	53.9	19.84	8.74	0.60	8.33	92.8	128.0	260	612.0	LS

to new cocoa plantation. Defects as a result of this had been reported for soils under cocoa plantation with long history of cu-rich fungicide spray.

INFLUENCE OF FERTILIZER APPLICATION AND LOCATION

(Soil types) on number of cocoa pods: Fertilizer application and Location (soil types) significantly ($p<0.05$) influenced number of cocoa pods produced (Table 2 and 3). From Table 2 and 3, it was observed that the soil test fertilizer regime gave the highest number of cocoa pods in all the locations (132, 107, 70 and 53) followed by the blanket recommendation (107, 85, 52 and 42) while the control gave the least (62, 60, 46 and 36). In all the sites, there was an Increase in number of pods right from the second week after fertilizer application up to the eight week (Table 2).This shows that in respective of age and Location (soil types), there has been a tremendous response to fertilizer application by the different cocoa plantations. At eight week, number of cocoa pods obtained for the soil test almost doubled that of control (Table 2 and 3).This result agreed with the findings of Wessel[10] who concluded that fertilizer application based on soil test can increase the yield of cocoa to about 50% of the usual yield. It also confirmed the finding of other workers[2,11-13] who all said that the soil test fertilizer regime still remains the solid basis for applying fertilizer to the soil since it gave the highest number of cocoa pods as a result of the positive response by cocoa using this fertilizer regime. Student T test was used to compare number of cocoa pods produced from the different fertilizer regims. A significant difference ($T = 4.90$; $p<0.05$) was obtained between no of pods produced from soil test and control and soil test and blanket ($T = 7.83$: $p<0.05$). When the comparison was made between control and blanket fertilizer regimes, there was no response. This is not unexpected since fertilizer application based on blanket did not consider the nutrient in the native soil before application. This application of blanket regimes may either cause nutrient imbalance or nutrient antagonism. This finding corresponds with the results obtained by previous workers[6] who said that blanket fertilizer regimes would not give maximum yield of cocoa.

Table 2: Influence of fertilizer regime on number of cocoa pods

	No of weeks			
Fertilizer regimes	2	4	6	8
Control	30_b	50_c	54_c	70_c
Blanket	50_a	61_b	69_b	106_b
Soil test	56_a	79_a	91_a	136_a

Means in the same column followed by different alphabets are significantly different at 5% level of probability according to DMRT

Table 3: Influence of locations (soil types) and fertilizer regimes on number of cocoa pods

			Fertilizer regimes		
Location	Soils series	Age of cocoa (yrs)	Soil test	Blanket	Control
Ayedun	Makun	60	134_a	107_a	62_a
Ikoro	Ondo	50	107_b	85_b	60_a
Aisegba	Ondo	26	70_c	52_c	46_b
Ise	Fagbo	16	53_d	42_d	36_c

Means in the same column followed by different alphabets are significantly different at 5% level of probability according to DMRT

From all the discussions above, it is obvious that fertilizer application is best done after a soil test has been carried out to determine the native nutrient of the soil which reveals the nutrient status of the soil. The results of this present study agree with the results of previous workers[14] on soil fertility and fertilizer use in Nigeria with special reference to cocoa.

With reference to location (soil type), there was significant ($p<0.05$) difference in number of cocoa pods obtained for all the four sites (Table 3). Ayedun site recorded the highest number of cocoa pods using the three fertilizer regimes (134,107 and 62). This is quickly followed by Ikoro, Aisegba and Ise (Table 3). These number of cocoa pods may be considered low when compared with results obtained by previous workers[4,14]. The reason for these low yields can be attributed to so many factors such as:

- The age of these plantations(15-60 years)
- Land use and cultural management practices employed by the different farmers at the different experiment of locations
- The different soils encountered on the farmers field, that is soil with different properties.

The difference in no of cocoa pods on farmers field may largely depend on management and soil properties. Climatic differences may come in where there are variations in climatic parameters, but in the study of this

Table 4: Correlation between number of cocoa pods and fertilizer regimes

Locations	Coefficient of linear correlation (r values)	
Aisegba	0.42	NS
Ayedun	0.58	*
Ise	0.24	NS
Ikoro	0.70	*

Key: * = Significant at 0.05 NS= Not Significant

study, climatic variables within all the Experimental sites experienced almost similar trend. The differences in no of cocoa pods observed in this study apart from the management system (fertilizer application) employed may have resulted from differences in the physical, chemical and morphological properties of the soil series and the land use histories of the site. This is in agreement with the observation made by Onasanya and Ogunkunle[15-17]. This has been attributed to the fact that soil differ in their ability to provide plant nutrient because of the materials from which the soils have been derived (parent materials) are different from long continued use of fertilizer and cropping (management)

Difference between fertilizer regimes and locations (soil types) were statistically significant ($p<0.05$) (Table 3). In all locations, the soil test fertilizer regime was superior to and more desirable than the blanket recommendation rate and the control in terms of no of cocoa pods produced.

From Table 4, it was observed that when fertilizer was correlated with number of pods at the different location, only at Ayedun and Ikoro were positive correlation obtained ($r = 0.58$ and 0.70; $p<0.05$). This is because the two soils at these locations responded positively to fertilizer application. This is expected because both Ayedun and Ikoro soils have lower average base saturation (Table 1) when compared with soil of Ise and Aisegba. Hence the soils of these sites with lower base saturation which is deficient in exchangeable based responded more to fertilizer than the other two soils. This is the reason why the Ayedun and Ikoro soils responded very well to fertilizer application and gave the highest number of cocoa pods (Table 3)

CONCLUSION

Field studies were carried out in four locations (Aisegba, Ayedun, Ise and Ikoro) within Ekiti state, southwestern Nigeria to determine the influence of fertilizer application on cocoa production. Three fertilizer regimes were used namely soil test rate (150.25 kg/ha urea+125 kg/ha NPK), Blanket recommendation (305 kg/ha Urea and 250 kg/ha NPK) and lastly control. The result obtained showed that fertilizer application significantly ($p<0.05$) increased number of cocoa pods in all the locations. Plots that received fertilizer application with soil test rate gave the highest number of cocoa pods at all experimental locations. In most studies number of cocoa pods produced from plots with soil test fertilizer application doubled that of control. This study has confirmed further that fertilizer recommendations based on soil test value is the solid basis for determining the adequate level of nutrients that could replenish the soil as well as satisfy the need of the crop. The number of cocoa pods as determined by the different fertilizer regimes are in the order of soil test>blanket>control. Experimental Location (soil types) also significantly influenced the number of cocoa pods produced. The number of cocoa pods as determined by the different locations are as follows-Ayedun (Makum serie)> Ikoro (Ondo serie)> Aisegba (Ondo series) > Ise (Fagbo series). The effect of management (fertilizer application) in controlling cocoa production was observed to be very strong and even stronger than that of soil in this study.

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