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Full Length Research Paper

Effects of NPK fertilizer formulations on the growth and yield of three cocoa genotypes in Ibadan, Nigeria

Okinsolo E. Alfred[1]*, Aminabor D. K.[1], Okoye Destiny[2] and Boziengeni Murphy[3]

[1]Soils and plant Nutrition Section, Cocoa Research Institute of Nigeria, Ibadan, Nigeria.
[2]Agronomy/Farming systems section, Cocoa Research Institute of Nigeria, Ibadan, Nigeria. [3]Plant Breeding Section, Cocoa Research Institute of Nigeria, Ibadan, Nigeria.

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A field study was carried out at the Cocoa Research Institute of Nigeria, Ibadan (Lat.7° 25'N; Long. 3° 25'E) to evaluate the effect of NPK fertilizer formulations on the growth and yield of three cocoa genotypes in Ibadan, South-Western Nigeria. The treatments consisted of two NPK-liquid fertilizer types (Nutrico 1 and 2) applied at a rate of 10 ml/15 L water and NPK- solid fertilizer 15:15:15 (applied at 40 g/tree) and a control (no fertilizer application). The four treatments were applied to three cocoa genotypes (T65/17×N38, T65/35×T30/13 and T82/27×T16/17). The treatments were replicated three times in a randomized complete block design (RCBD). Results indicated that all the fertilizers irrespective of rates of application and types of NPK formulations enhanced the growth and yield parameters of cocoa relative to the control in the three genotypes. The effect of Nutrico 1 liquid fertilizer was comparable to NPK (15: 15: 15) on stem girth of cocoa and number of mature and ripe pods. Nutrico 1 liquid fertilizer significantly ($p<0.05$) enhanced the number of cherelles and mature pods in T65/35×T30/13 and T82/27×T16/17. The fertilizer treatments were not significant on the number of diseased pods in the three genotypes. It could be inferred that the NPK liquid-fertilizers particularly the Nutrico 1 is a very promising fertilizer that could improve the productivity of cocoa in Nigeria.

Key words: Cocoa, NPK fertilizers, productivity, nutrico, growth.

INTRODUCTION

Nigeria produces over 250,000 MT of dry cocoa bean annually and cocoa has the highest foreign exchange earnings among other agricultural produce. This level of productivity is largely dependent on natural soil endowment as fertilizers are not part of its production system. Previous effort indicated that more than 80% of farmers in Nigeria do not use fertilizers at all (Ogunlade et al., 2009). It is known that some farmers have phobia that fertilizer application lowers bean quality and has the tendency of quickening the death of their cocoa trees. Hence, the soils upon which cocoa are cultivated were maintained through litter fall (Ogunlade et al., 2006). Conventionally, the use of solid fertilizers of major nutrients of nitrogen, phosphorus and potassium are common with farmers in Nigeria. However the present scenario indicated that the use of liquid fertilizers either sole or in combination with other fertilizer types or pesticides is a possibility with great potential of producing immediate results in terms of quick absorption. Furthermore, previous government efforts were concentrated on provision of pesticides for production system. Cocoa production in Nigeria as it is being

*Corresponding author. E-mail: Alfred.okin364@yahoo.com.

practiced presently involves nutrients mining on annual basis without replacement thus leaving most cocoa soils depleted and degraded (Egbe et al., 1989; Ogunlade et al., 2009). This has placed Nigeria behind most other West African producing nations such as Ghana and Cote d'Ivoire in terms of productivity. Recent fertilizer study in Ghana and Cote d'Ivoire by Dutch Sustainable Initiative (IDH) shows that after one year of fertilizer application the foliage on degraded farms is widely rebuilt and that use of fertilizer can double cocoa production and can be one of the solutions for the problems cocoa farmers and companies face (Francois and Serge, 2012). It is estimated that the potential market in West Africa alone for fertilizer is over 1 million tons. This represents yearly revenue of at least US$500 million to the fertilizer industry and credit institutions. There is a clear business opportunity for the cocoa industry to further explore fertilizer use in order to improve production and quality of cocoa. The potential in Nigeria is quite higher than the two countries combined. However, the present Government through his Agricultural Transformation Agenda (ATA) which cocoa is one of the focal crops being considered through Cocoa Transformation Agenda (COcTA) has evolved a growth enhancement scheme (GES) in which farmers are given a little support in terms of fertilizer inputs among the other inputs. The farmers are given some bags of fertilizers (straight and compound fertilizers) at subsidized rates through voucher wallet systems (VWS). Hence, this has led to proliferation of different grades and types of fertilizers in the country which are never tested on cocoa but are currently being used by farmers. This is not only inimical to Nigerian cocoa plantations but the quality of our bean is at stake. Therefore, the present field study was carried out to evaluate the effect of NPK fertilizer formulations (solid and liquid) on the growth and yield of three cocoa genotypes in Ibadan, South-western Nigeria.

MATERIALS AND METHODS

The study was carried out in the Common Fund for Commodity (CFC) plot at the Cocoa Research Institute of Nigeria, Ibadan (Lat. 7° 25′N; Long. 3° 25′E) to evaluate the effect of NPK fertilizer formulations (solid and liquid) on the growth and yield of three cocoa genotypes. The soil was formed from the basement complex rocks and classified as Oxic-Paleustalf (USDA) and as Onigambari series (Smyth and Montgomery, 1962). The site is located on altitude of 122 m above sea level. The treatments consisted of two NPK-liquid fertilizers (Nutrico1-NPK 10:10:10 +TE and Nutrico 2- NPK 6: 0: 20 + TE) applied at a rate of 10mls/15L water and NPK-solid fertilizer 15:15:15 (applied at 40g/tree) and a control (no fertilizer application). The four treatments were applied to three cocoa genotypes (hybrids) namely A-T65/17×N38, B-T65/35×T30/13 and C-T82/27×T16/17.

Ten (10) trees per plot in three replications were used for the study. The treatments were replicated three times in a randomized complete block design (RCBD). Data were obtained on number of mature pods (NMP) - matures pods are pods above 3 months and have reached their maximum size and the seeds within are undergoing physiological maturation, number of ripe pods (NRP), number of diseased pods (NDP) which has to with pods infected by *Phytophthora megakarya*, number of cherelles (NC) and stem girth (SG) which was measured using measuring tape. Soil samples were collected randomly within the plantation before and after the trial and analyzed for both physical and chemical parameters using the methods described in International Institute of Tropical Agriculture Manual (IITA, 1982). The soil samples were air-dried, ground and sieved using 2.0 mm mesh. Soil pH was measured in water (1:1). Particle size distribution was carried out using the hydrometer method; while organic carbon was determined using chromic acid method. The regular microkjehldal method was used to analyse for total nitrogen. Available P in the soil was determined using ascorbic acid method. The Cation Exchange Capacity (CEC) of the soil was determined by using pH 7.0 buffer solution of calcium ammonium acetate, while EDTA titration was used to measure Ca^{2+}, Mg^{2+} and K^{+} according to IITA (1982). Analysis of variance was performed on all data to test the treatment effect on different parameters measured using a GenStat analytical package of 8th Edition. Standard error (SE) was used to separate the means.

RESULTS AND DISCUSSION

The initial physical and chemical properties of the soil used for the experiment is presented in Table 1. The results indicated that the soil contained 694 gkg^{-1} sand, 149 gkg^{-1} silt, and 156.45 gkg^{-1}clay. The soil was sandy loam, slightly acidic, low in Total N and available P. The exchangeable cations are moderately available. However, the clay + silt content value of 306 gkg^{-1} soil was less than 320 gkg^{-1}which is ideal for sufficient water holding capacity for sustainable cocoa production as determined by Egbe et al. (1989) for tree crops in Nigeria. Generally, the soil fertility status is low hence, the need for soil amendments and good agricultural practices for optimum productivity (Egbe et al., 1989; Ibiremo et al., 2010). Addition of Nutrico 1, 2 and NPK 15- 15- 15 however, is expected to enhanced the nutrient status of the soil. The fertilizers irrespective of rates of application and types of NPK formulations enhanced the growth and yield parameters of cocoa relative to the control in the three genotypes. NPK15-15-15 fertilizer seemed to give significant ($p < 0.05$) increase in the number of matured pods in genotype A (T65/17×N38) compared to the two liquid NPK fertilizers (Nutrico 1 and 2) at one month after fertilizer application (Table 2). However, at 3 and 6

Table 1. Physical and chemical characteristics of Onigambari-Ibadan soil.

Soil properties	Unit	Value
Physical		
Sand	gkg^{-1}	694.00
Silt	"	149.55
Clay	"	156.45
Textural class		Sandy loam
Chemical		
pH(H_2O) 1:1	-	6.66
Organic carbon	gkg^{-1}	1.81
Total Nitrogen	"	0.65
Available phosphorus	$mgkg^{-1}$	8.87
Exch. Bases		
K^+	$cmolKg^{-1}$	0.67
Ca^{2+}	"	2.07
Mg^{2+}	"	2.01
Na^+	"	0.55
Exch. Acidity		
Mn^{2+}	$mgkg^{-1}$	0.03
Al^{3+}	"	0.13
H^+	"	0.04
ECEC	"	5.14
Base saturation	%	96.76

Table 2. Influence of NPK fertilizer sources on the number of mature pods (NMP) of cocoa.

Treatment	Genotype A			Genotype B			Genotype C		
	NMP1	NMP3	NMP6	NMP1	NMP3	NMP6	NMP1	NMP3	NMP6
T_1-Nurico 1	0.25	3.25	4.40	1.67	0.25	3.50	1.06	1.92	6.31
T_2-Nutrico 2	0.50	2.83	8.20	1.50	0.50	2.67	2.92	1.58	3.64
T_3-NPK 15-15-15	1.42	2.92	5.30	0.67	0.17	5.42	3.08	2.42	2.83
T_4-Control	1.17	2.83	5.00	0.92	0.33	5.75	1.83	2.50	7.17
SE	0.27	0.77	4.34	0.85	0.25	2.49	1.53	1.34	2.48
CV (%)	26.45	23.70	29.70	15.78	21.67	17.34	31.4	7.50	19.9

T1-= Nutrico 1 (NPK 10:10:10 +TE), T2= Nutrico 2(NPK 6:0 : 20 + TE), T3= NPK 15: 15: 15 (40g/tree), T4=Control (no fertilizer application), Genotype A- T65/17xN38,Genotype B- T65/35xT30/13 and Genotype C-T82/27xT16/17,NMP=Number of mature pods , TE=Trace Elements.

months, the effect of different fertilizer application was not significant on the number of matured pods. Similarly, the influence of the fertilizer application was not significant on the number matured pods across the other genotypes B and C (T65/35×T30/13 and T82/27×T16/17). Nutrico1 increased the number of matured pods of genotype A by 11 and 18% compared to the control and NPK 15-15-15 at three months after fertilizer application respectively. At six months after fertilizer application, Nutrico 2 liquid fertilizer gave the highest number of matured pods in genotype A (Table 2). In genotype B, Nutrico 1 increased the number of matured pods at one month after fertilizer application by 81 and 149% compared to the NPK 15-15-15 and control respectively (Table 2). In genotype A, NPK fertilizer formulations did not significantly affect the number of ripe cocoa pods at 1 month after application (Table 3).

Conversely at 3 month after application, NPK (15-15-15) significantly ($p<0.05$) enhanced the number of ripe cocoa pods compared to the control and Nutrico 1. The number of ripe cocoa pods in genotype A was increased by 40% as a result of application of Nutrico 1 at 6 months after application, although this increase was not significant. In genotypes B and C (T65/35×T30/13 and T82/27×T16/17), the effect of NPK fertilizer formulations did not significantly affect the number of ripe pods of

Table 3. Effect of NPK fertilizer formulations on the number of ripe cocoa pods (NRP).

Treatment	Genotype A			Genotype B			Genotype C		
	NRP1	NRP3	NRP6	NRP1	NRP3	NRP6	NRP1	NRP3	NRP6
T_1-Nurico 1	0.92	0.05	0.22	1.08	0.25	1.92	1.17	0.08	0.08
T_2-Nutrico 2	0.75	0.16	1.08	0.75	0.50	1.83	1.14	0.25	0.35
T_3-NPK 15-15-15	1.25	0.25	1.42	1.75	0.57	2.58	1.67	0.17	0.08
T_4-Control	2.17	0.08	1.58	0.50	0.33	3.08	1.25	0.08	0.33
SE	0.91	0.07	1.29	1.02	0.25	0.70	0.91	0.19	0.31
CV (%)	14.2	15.00	20.6	20.56	12.43	22.67	21.50	19.10	10.11

T1-= Nutrico 1 (NPK 10:10:10 +TE), T2= Nutrico 2(NPK 6 : 0 : 20 + TE), T3= NPK 15: 15: 15 (40 g/tree), T4=Control (no fertilizer application), Genotype A- T65/17xN38,Genotype B- T65/35xT30/13 and Genotype C-T82/27xT16/17, NRP=Number of ripe pods, TE= Trace Elements.

Table 4. Number of diseased pods of cocoa (NDP) as affected by the application of NPK fertilizer sources.

Treatment	Genotype A			Genotype B			Genotype C		
	NDP1	NDP3	NDP6	NDP1	NDP3	NDP6	NDP1	NDP3	NDP6
T_1-Nurico 1	1.25	0.17	0.25	1.67	0.25	0.33	0.78	0.08	0.08
T_2 T2-Nutrico 2	0.25	0.33	0.02	0.67	0.25	0.58	1.92	0.33	0.39
T_3-NPK 15-15-15	1.08	0.75	0.50	0.75	0.08	0.25	2.58	0.02	0.08
T_4 T4-Control	1.50	0.42	0.25	0.25	2.17	0.50	2.00	0.28	0.33
SE	0.54	0.40	0.16	0.82	1.25	0.42	1.39	0.21	0.31
CV (%)	23.67	18.89	24.56	12.56	25.12	18.98	23.50	17.30	16.10

T1-= Nutrico 1 (NPK 10:10:10 +TE), T2= Nutrico 2(NPK 6 : 0 : 20 + TE), T3= NPK 15: 15: 15 (40g/tree), T4=Control (no fertilizer application), Genotype A- T65/17xN38,Genotype B- T65/35xT30/13 and Genotype C-T82/27xT16/17, NDP= Number of diseased pods, TE= Trace Elements.

cocoa within the period of evaluation (Table 3). Specifically, NPK 15-15-15 consistently improved the number of ripe cocoa pods at 1, 3 and 6 months after application in genotype B compared to other NPK fertilizer formulations and the control. In genotype C, the effect of NPK fertilizer formulations did follow a particular trend on the number of cocoa pods at 1, 3 and 6 months after application. In genotype A (T65/17×N38,), the number of diseased pods (NDP) of cocoa was not significantly affected by NPK fertilizer formulations at 1 and 3 months (Table 4). However, at 6 months after fertilizer application, the number of diseased pods increased significantly ($p<0.05$) under NPK 15-15-15 treatment.

Nutrico 2 significantly ($p<0.05$) reduced the incidence of pod rot across the period of study. Similarly, the number of diseased pods was reduced as a result of application of Nutrico 1 and 2 in genotypes B and C (T65/35×T30/13 and T82/27×T16/17) across the periods of study. This trend indicated that Nutrico 1 and 2 were performing the dual roles of fertilizers and fungicides, this could be associated with the potassium content in the two liquid fertilizers. Hence, they could be used in combination with regular fungicides to reduce the prevalence of pod rot in cocoa (Agbede, 2009). NPK fertilizer formulations did not significantly affect the number of cherelles produced by the three cocoa genotypes across the period of study (Table 5).

However, at 6 months after application NPK 15-15-15 improved the number of cherelles by 24 and 45% compared to the control and Nutrico 1 respectively. In genotype C, similar trend holds in which NPK 15-15-15 enhanced the number of cherelles by 16 and 53% compared to the control and Nutrico 1. However, in genotype B, Nutrico 2 improved the number of cherelles by 16 and 50% compared to the control and Nutrico1 respectively. Haggai and Aliyu (2006) made similar observation that NPK liquid fertilizer gave comparable effect on the growth and yield of maize to solid NPK fertilizer. The stem girth of the three cocoa genotypes was not significantly affected by NPK fertilizer formulations across the period of study (Table 6). The genotypes were of similar age of over 14 years as such the influence of fertilizer may not be easily apparent as earlier reported by Ibiremo et al. (2011a). However, genotype C gave the least mean stem girth of 38 cm while genotype A and B gave 46 cm. It could be inferred that the NPK liquid-fertilizers particularly the Nutrico 1 is a very promising fertilizer that could improve the productivity of cocoa in Nigeria.

Table 5. Effect of NPK fertilizer sources on the number of cherelles (NC) of cocoa.

Treatment	Genotype A			Genotype B			Genotype C		
	NC1	NC3	NC6	NC1	NC3	NC6	NC1	NC3	NC6
T_1-Nurico 1	3.42	8.20	9.30	6.50	8.80	5.80	3.55	14.80	7.70
T_2 T2-Nutrico 2	3.92	8.80	13.90	6.83	11.10	11.70	5.89	12.90	7.80
T_3-NPK 15-15-15	3.67	11.80	16.80	4.58	9.90	4.10	3.92	10.90	16.20
T_4 T4-Control	3.50	12.30	12.80	4.00	13.80	9.80	4.92	15.00	13.60
SE	0.16	4.15	4.90	2.79	4.14	5.80	2.01	5.26	5.86
CV (%)	13.21	15.57	12.55	20.70	23.89	15.67	16.50	12.86	14.33

T1-= Nutrico 1 (NPK 10:10:10 +TE), T2= Nutrico 2 (NPK 6 : 0 : 20 + TE), T3= NPK 15: 15: 15 (40g/tree), T4=Control (no fertilizer application), Genotype A- T65/17xN38,Genotype B- T65/35xT30/13 and Genotype C-T82/27xT16/17, NC= Number of cherelles, TE=Trace Elements.

Table 6. Influence of NPK fertilizer sources on the stem girth (SG) of cocoa trees.

Treatment	Genotype A			Genotype B			Genotype C		
	SD1	SD3	SD6	SD1	SD3	SD6	SD1	SD3	SD6
T_1-Nurico 1	44.20	40.60	45.90	46.11	48.10	47.42	39.45	32.50	43.00
T_2 T2-Nutrico 2	44.40	38.50	45.00	41.85	42.80	41.92	37.29	35.40	38.10
T_3-NPK 15-15-15	49.30	50.50	51.00	47.29	48.20	48.78	39.29	39.30	39.30
T_4 T4-Control	42.20	43.70	43.80	44.99	46.50	46.83	38.35	37.70	35.00
SE	4.56	7.42	5.19	4.51	2.90	2.72	2.34	5.23	4.83
CV (%)	12.56	17.12	11.88	14.66	13.44	18.64	5.72	12.51	4.73

T1-= Nutrico 1 (NPK 10:10:10 +TE), T2= Nutrico 2 (NPK 6:0:20 + TE), T3= NPK 15: 15: 15 (40 g/tree), T4=Control (no fertilizer application), Genotype A- T65/17×N38, Genotype B- T65/35×T30/13 and Genotype C-T82/27×T16/17, SD=Stem girth, TE=Trace Elements.

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