Reprint **ISSN 1994-1978 (Web Version)**

Journal of Soil and Nature (JSN)

(*J. Soil Nature*)

Volume: 5 **Issue: 1** **July 2011**

***J. Soil Nature* 5(1): 6-10 (July 2011)**

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http://ggfagro.com/ejournals/current issues

JSN** issn 1994-1978, HQ:1-34 Central Place, Saskatoon, Saskatchewan, s7n 2s2, Canada

ISSN-1994-1978 (Online)
J. Soil Nature 5(1):6-10(July 2011)

RESPONSE OF COCOA (*THEOBROMA CACAO*) SEEDLINGS TO VARYING LEVELS OF PHOSPHATE FERTILIZERS IN IBADAN, NIGERIA

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Accepted for publication on 15 July 2011

ABSTRACT

Iloyanomon CI, Akinrinde EA, Oluwasemire KO (2011) Response of cocoa (*Theobroma cacao*) seedlings to varying levels of phosphate fertilizers in Ibadan, Nigeria. *J. Soil Nature* 5(1), 6-10.

A screen house investigation was carried out at Cocoa Research Institute of Nigeria Ibadan (CRIN) to evaluate the response of cocoa seedlings to varying levels of phosphate fertilizers. The treatments were a factorial combination of two cocoa varieties (T12/1233 and T63/970), two phosphate fertilizers types (single super phosphate (SSP) Sokoto rock phosphate (SRP) with a no phosphorous fertilizer control) and four rates of phosphorous fertilizer (0,4,8 and 16 kgP/ha). These twenty four treatments were arranged in a completely randomized block design with four replicates. Parameters assessed were plant height, number of leaf, stem diameter, stem, root, leaf ,shoot dry matter and total dry matter. Results indicated that SSP applied at the rate of 16kgP/ha significantly (P<0.05) increased number of leaves and stem diameter by 39% and 30%, respectively when compared with no fertilizer control. Similar observation was made on stem diameter with SSP applied at the rate of 16kgP/ha significantly (P<0.05) enhancing stem diameter when compared with all other treatments. SRP had no effect on the growth of cocoa. Cocoa variety T12/1233 was superior to T63/790 in plant height, leaf and shoot dry weight with increases of 21%, 21% and 22% respectively. In soils with low available P of less than10mg/kg, 16kgP/ha is recommended.

Key words: *cocoa seedling, single superphosphate, sokoto rock phosphate*

INTRODUCTION

Cocoa bean is an important export crop which contributes to agricultural exports of Nigeria. In 1961, Nigeria produced 197,000 metric tons of beans (FAOSTAT 2011), next in production only to Ghana. The advent of the oil boom, led to the neglect of the agricultural sector, hence by 1999, production had increased to only 225,000 metric tons with Nigeria being the 4th largest producer (FAOSTAT 2011). Despite government's effort to resuscitate the industry by 2009 production has increased to only 370,000 metric tons with countries such as Cote'd' Ivoire producing 1,221600 metric tons (FAOSTAT 2011). Reasons for this decline in yield are numerous among which are aging cocoa plantations, many of which are 30-50 years old and depletion of soil nutrient due to continuous harvesting of cocoa beans without nutrient replenishment. There is therefore need to rehabilitate these moribund cocoa plantations and establish new ones.

The rehabilitation of these moribund cocoa plantations and establishment of new cocoa plantation is challenging. The low nutrient status of cocoa producing soils is a major challenge. Phosphorous (P) is one of the most limiting nutrients in cocoa, and most arable lands in the tropics are deficient in P (Kummer 1988). The conventional commercial phosphate fertilizers such as single super phosphate and triple super phosphate have their use limited due to high cost and unavailability at periods of peak demand. This coupled with the need to conserve scarce foreign exchange has necessitated the search for alternate source of fertilizer, which are more available and environmentally friendly.

Deposits of Rock Phosphates can be found in five sedimentary basins in Ogun, Sokoto, Delta, Imo and Anambra States of Nigeria of which Ogun and Sokoto rock phosphate have been found to be in commercial quantity with high elemental P (Adegoke *et al.* 1989). The use of this rock phosphate as P source is a promising alternative. This is because they are relatively available and more environmentally friendly. This coupled with their liming ability has made them an attractive alternative. Limited work has been done on the use of rock phosphate on cocoa in Nigerian soils, hence, the need to asses Sokoto rock phosphate as an alternative P source. 4-5kgP/ha has been recommended for cocoa seedlings in the year of planting on cleared arable land, there is need to asses this rate and other rates to determine the most effective rate for cocoa seedlings hence the need for this study. (i) To evaluate the effectiveness of Sokoto Rock phosphate as alternative nutrient source of Phosphorous for cocoa seedlings. (ii) To evaluate the effect of varying rates of phosphate fertilizers on growth of cocoa seedlings.

MATERIALS AND METHODS

The experiment was conducted in the screen house of Cocoa Research Institute of Nigeria (CRIN). The treatments were a factorial combination of two cocoa varieties (T12/1233 and T63/970), two types of phosphate fertilizers (Single Superphosphate (SSP), Sokoto rock Phosphate (SRP) with a no fertilizer control) and four rates of phosphate fertilizers (0, 4, 8 and 16kgP/ha). These twenty four treatments were arranged in a completely randomized block design with four replications. The soil used for the experiment was an alfisol, collected from 0-15cm depth of an old moribund cocoa plantation within CRIN. The soil was air-dried passed through a 2mm sieve and 5kg weighed into plastic pots. A sub-sample of the soil was taken and analyzed for some of its physical and chemical properties.

Soil pH was determined in 0.01M $CaCl_2$ in water using soil solution ratio of 1:2. Organic carbon by chromic acid method (Allison 1965). Particle size analysis was determined by hydrometer method (Gee and Or, 2002) and soil texture determined by using a textural triangle. Total Nitrogen was determined by Microkjeldah method (Bremner 1960). Available P determined by Bray-I method (Bray and Kuntz, 1945) and P in the extract determined colorimetrically by Molybdenum blue method as modified by Murphy and Riley (1962).

Exchangeable bases (K, Ca, Mg and Na) were extracted by reacting with ammonium acetate, and K and Na in the filtrate determined using a flame photometer. Ca and Mg were read using an Atomic absorption spectrophotometer (AAS) (Pratt 1965a). Exchangeable acidity was determined by filtration titration method (Mclean 1965). Cation exchange Capacity (CEC) and ECEC were determined.

Data were collected monthly for seven months on plant height, number of leaves, stem diameter, stem, root and leaf dry matter and total dry matter were taken at 2, 4 and 7 months after planting (MAP). At these periods, the plants were harvested, roots washed, detached into root, leaf, and stem, oven dried and weighed.

Data collected was subjected to analysis of variance (Gomez and Gomez, 1984) and means were separated using Duncan multiple range test.

Physical and chemical properties of the experimental soil are shown on table 1.

Table 1. Physical and chemical properties of the experimental soil

Parameters	Value
pH	6.43
OC (g/kg)	14.7
N(g/kg)	1.00
P(mg/kg)	3.12
K(cmol/kg soil)	0.16
Ca(cmol/kg soil)	3.00
Mg(cmol/kg soil)	2.45
Na(cmol/kg soil)	0.73
Exch acidity (cmol/kg soil)	0.69
CEC (cmol/kg soil)	3.81
Zn (mg/kg soil)	3.00
Cu (mg/kg soil)	5.17
Mn (mg/kg soil)	4.60
Fe (mg/kg soil)	5.13
Sand (g/kg)	700
Silt (g/kg)	160
Clay (g/kg)	240
Textural Class	Sandy Loam

The experimental soil was sandy loam, slightly acidic with a pH of 6.4. This pH is adequate for cocoa production. The soil was low in fertility with N, P and K values of 1g/kg, 3.12 mg/kg and 0.165 cmol/kg soil respectively. The P and K values fell below the soil critical values of 10 mg/kg P and 0.3 cmol/kg K required for cocoa (Egbe *et al*. 1989). The N content of 1g/kg was slightly above the soil critical value of 0.9g/kg required for cocoa. The organic carbon was 14.7g/kg. This was also below the recommended 20% required by cocoa. The soil was from a moribund cocoa plantation.

RESULTS AND DISCUSSION

Effect of phosphate fertilizer on number of leaves was significant ($P<0.05$) only at 7months after planting (MAP) (Table 2). At 7 MAP, increasing SSP rate from 0 to 4kgP/ha had no significant effect on number of leaves.

Table 2. Effect of phosphate fertilizer levels on number of leaves, plant height (cm), stem diameter (cm) and leaf dry matter (g)

	No of leaves		Plant height (cm)		Stem diameter (cm)		Leaf dry matter (g)	
Treatments	4 MAP	7 MAP	4 MAP	7 MAP	4 MAP	7MAP	4 MAP	7 MAP
Variety								
T 12/1223	23	31	50.40a	64.2a	0.93	1.02	7.70	15.63a
T 63/970	24	29	43.75b	57.2b	0.86	0.99	7.73	12.92b
SE +	0.90	1.37	1.09**	1.73**	0.05	0.02	0.42	0.68**
Fertilizer rates								
No fertilizer	23	28c	48.77b	61.6	0.98	0.98bc	6.72b	13.35
SSP 4 kgP/ha	25	30bc	52.27a	63.8	0.99	1.05b	9.33a	16.33
SSP 8 kgP/ha	23	31b	43.51c	55.2	0.99	0.98bc	7.24b	15.30
SSP 16 kgP/ha	28	39a	50.92ab	67.5	0.87	1.27a	9.25a	15.13
SRP 4 kgP/ha	20	26c	43.06c	60.3	0.77	0.87d	9.20a	12.05
SRP 8 kgP/ha	24	30c	45.15c	55.8	0.79	0.93bc	7.21b	14.38
SRP16 kgP/ha	22	28c	44.17c	59.5	0.78	0.93bc	6.05c	14.50
SE +	1.80	2.74*	2.18*	3.46	0.10	0.05**	0.84*	1.37
Interaction								
Variety x fertilizer	NS	NS	NS	NS	NS	NS	NS	NS

Means with the same letter(s) within the same treatment group and month are not significantly different (P<0.05) using Duncan multiple range test

Abbreviations

NS Not Significant
* Significant at 5% level of probability
* * Significance at 1% level of probability
MAP Months after planting
SE Standard Error
SSP Single Super phosphate
SRP Sokoto Rock Phosphate

Further increase of SSP to 8kgP/ha and 16kgP/ha resulted to significant (P<0.05) increases of leaf number by 11% and 39% respectively when compared with no fertilizer control. 16kgP/ha as SSP significantly increased number of leaves by 23% 21%, 50%, 23% and 39% when compared with SSP applied at the rate of, 4kgP/ha, 8kgP/ha and SRP applied at the rate of 4kgP/ha, 8kgP/ha and 16kgP/ha respectively. SRP at all levels had no effect on num3333ber of leaves. There was no significant different between the two cocoa varieties (Table 2).

Response of plant height to phosphate fertilizer was significant (P<0.05) only at 4 MAP (Table 2) with SSP applied at the rate of 4 and 16 kg P/ha significantly increasing plant height when compared with other treatments except 16kgP/ha as SSP. All SRP treatments depressed plant height. This effect was not observed at 7 MAP. Cocoa variety T12/1233 proved superior to T63/970 in plant height (Table 1) with height increases of, 15% and 12%, at 4 and 7 MAP respectively. None of the interactions was significant.

Significant (P<0.05) response of stem diameter to phosphate fertilizer was observed at 7 MAP (Table 2). Increasing SSP rates from 0 to 8kgP/ha had no significant (P<0.05) effect on plant diameter (Table 1). Increasing of SSP rate from 8kgP/ha to 16kgP/ha significantly increased stem diameter, with increases of 30% and when compared with no fertilizer control. SSP applied at the rate of 16kgP/ha increased stem diameter by 21% and 30% when compared with SSP applied at the rate of 4 and 8kgP/ha respectively. Similarly, SSP applied at the rate of 16kgP/ha increased stem diameter by 46%, 37% and 37% respectively when compared with SRP applied at the rate of, 4kgP/ha, 8kgP/ha and 16kgP/ha respectively. SRP at the rate of 4kgP/ha depressed stem diameter, (Table 2), while SRP at the rate of 8 and 16kgP/ha had no effect on stem diameter. There was no significant difference between the two cocoa varieties.

Phosphate fertilizers had no significant effect on leaf dry matter (Table 2), root length, root dry matter, stem dry matter, and shoot dry matter and total dry matter (Table 3).

Cocoa Variety T12/233 had significantly (P<0.05) higher leaf dry matter when compared with variety T63/970 (Table 2) with increase of 21%.

Table 3. Effect of phosphate fertilizer levels on root length (cm) root dry matter (g), stem dry matter (g), shoot dry matter (g) and total dry matter (g) in Ibadan, Nigeria

	Root length (cm)	Root dry matter (g)		Stem dry matter (g)		Shoot dry matter (g)		Total dry matter (g)	
Treatments	7 MAP	4 MAP	7 MAP	4 MAP	7 MAP	4 MAP	7 MAP	4 MAP	7 MAP
Variety									
T 12/1223	41.8	2.00b	11.44	3.79	16.17	11.49	31.8a	13.49	42.8
T 63/970	43.6	2.46a	9.96	3.79	13.33	11.30	26.1b	13.75	36.7
SE±	1.96	0.15*	0.75	0.24	1.15	0.56	2.33	0.68	2.23
Fertilizer rates									
No fertilizer	43.5	1.95	9.55	3.42	14.17	10.13	27.5	12.09	38.95
SSP 4 kgP/ha	36.9	2.38	11.67	4.10	16.33	13.35	32.7	15.73	44.33
SSP 8 kgP/ha	43.1	2.66	12.50	3.84	15.33	11.12	30.8	13.78	38.3
SSP 16 kgP/ha	45.5	2.52	14.08	4.48	17.58	13.72	32.7	16.25	46.9
SRP 4 kg/ha	41.6	2.17	8.92	4.64	11.75	12.25	23.8	14.41	32.8
SRP 8 kgP/ha	42.0	2.33	9.00	4.04	14.33	11.30	28.7	13.63	39.4
SRP 16 kgP/ha	48.4	1.87	10.33	2.97	13.50	9.13	28.0	11.00	38.3
SE ±	3.91	0.31	1.49	0.48	2.30	1.11	4.66	1.37	4.45
Interaction									
Variety X fertilizer	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means with the same letter(s) within the same treatment group and month are not significantly different ($P<0.05$) using Duncan multiple range test

Abbreviations

NS Not Significant
* Significant at 5% level of probability
* * Significance at 1% level of probability
MAP Months after planting
SE Standard Error
SSP Single Super phosphate
SRP Sokoto Rock Phosphate

There was no significant difference between the two cocoa varieties in stem dry matter, root length and total dry matter (Table 3). At 7 MAP Cocoa variety T12/1223 was superior to T63/970 in leaf dry matter (Table 2) and shoot dry matter (Table 3) with increases of 21% and 22% respectively. T63/970 had significantly ($P<0.05$) higher root dry matter than T12/1223 at 4 MAP with increases of 23% (Table3), but this effect was not observed at 7 MAP.

The positive response of cocoa seedlings to SSP applied at the rate of 16kgP/ha could be attributed to the fact that P is important for meristematic growth and an important component of nucleic acid, protein, amino acids, lipids and chromosome (Better crop, 1999). Its presence therefore enhanced growth. Increasing P levels to 16kgP/ha therefore increased P availability to the plants. This coupled with the quick release of P_20_5 from SSP increased nutrient availability and P uptake, hence better growth in form of stem diameter and leaf number. The soil was also deficient in P. This is reflected in the low P status of the soil (3.2mg/kg) which was well below the soil critical value 10mg/kg required for cocoa. This indicates the importance of P at the early growth stage of cocoa.

Similar observation was made by Mohd. Yusuff *et al.* (2007) in Malaysia on soils with 3ppm, where it was observed that P fertilizer applied as calcium monosulphate increased the number of leaves, plant height and stem diameter of cocoa seedlings in the nursery. Similarly, Mainstone *et al.* (1973) reported increase in stem diameter, plant height and fresh weight of stem and root on application of P fertilizer.

In contrast, SRP at all levels had no effect on growth of cocoa seedlings levels. Similar observation was made by (Aisueni and Ekhator, 2009) in a green house where SRP alone did not significantly enhance oil palm growth in the green house. Imogi *et al*. (2009) also observed that oil palm trees on the field treated with SRP and crystallizer had no effect on palm growth and yield until after 5 years of SRP, when significant increase of branch number and palm yield was observed.

The non-response of cocoa seedlings to SRP at all levels could be attributed to slow release of P in SRP due to low solubility and slow mineralization of SRP. Khasawreh and Doll (1978) and Kennedy and Smith, (1995) observed that rockphosphate was sparingly soluble and had low effectiveness particularly in non acidic soil. The P_2O_5 in SRP was therefore not available during the period of the experiment, but might be available for longer period on the field for tree crops like cocoa. Rockphosphate is therefore a source of P for long term soil improvement (Hue 2011).

CONCLUSION

Cocoa variety T12/223 was superior to T63/223 in plant height, leaf and shoot dry weight. On soils of moribund cocoa plantation or previously cropped lands with low soil available P, 16kg P ($37kgP_20_5$)/ha could be applied as SSP. The use of SRP application could be beneficial for longer period on the field for tree crops such as cocoa. There is need to carry out evaluation of SRP on the field.

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