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Research Article

EFFECT OF ROOT MAT MANAGEMENT AND PHOSPHATE FERTILIZER APPLICATION ON THE FIELD ESTABLISHMENT OF COCOA IN ONDO STATE, NIGERIA.

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ABSTRACT: A study was carried out to evaluate the effect of root mat management and P-fertilizer application on the field establishment of cocoa in Ondo State, Nigeria. Six treatment combinations were formed from two levels of root mat treatments (with and without root mat) and three types of phosphate fertilizer application (no P, Single Super phosphate and Sokoto Rock Phosphate). The root mat management (treatments) and phosphate fertilizer application were done during cocoa seedling transplanting. The treatments were arranged in a RCBD with three replications. The height, stem diameter, number of leaves and leaf area of the transplanted cocoa seedlings were regularly taken on a monthly basis. Seedlings with root mat intact (not removed) significantly ($p < 0.05$) consistently enhanced the height of cocoa seedlings at 3, 6, 9, 12, and 15 months after transplanting (MAT). Similarly, the stem diameter of cocoa seedlings at 3 MAT was significantly improved as a result of non-removal of root mat. However, the influence of root mat removal on the stem diameter of cocoa seedlings was not consistently higher than those with root mat intact at 6 and 9 MAT, it gave higher stem diameter through 12 and 15 MAT. Root mat removal did not significantly affect the number of leaves and leaf area of the cocoa seedlings throughout the period of study. P-fertilizer application did not show significant effect on the various growth parameters of cocoa seedlings throughout the period of study. Similarly, the pH, organic carbon and the level of available P accumulation of the soil were not significantly affected by phosphate fertilizers and root mat management. It can be concluded that the extra effort of removing the root mat of cocoa seedlings before transplanting and application of phosphate fertilizer did not confer any advantage in terms of growth on the transplanted cocoa seedlings on the field.

Keywords: Root mat, Phosphate fertilizer, field establishment, cocoa seedlings, growth

INTRODUCTION

Efforts are made on yearly basis by farmers to increase their hectarage through replanting and new planting of cocoa. However, poor seedling survival has greatly discouraged most farmers in many cocoa producing states in Nigeria. Field reports gave an average of less than 40% survival in most cases which has resulted in colossal wastes of resources of the farmers. The development of cocoa plantations is very essential because the subsector plays an important role in providing job opportunity, income source for farmers and foreign exchange to the cocoa producing nations [18]. Strategies are evolved by farmers to increase areas under cocoa cultivation which include various rehabilitation techniques such as gaping-up, coppicing, complete replanting and opening-up of new areas [4, 17]. However, many of these strategies had not translated to increased areas under cocoa in Nigeria. Recent interactions with farmers in Ile-Oluji and Wasimi cocoa producing communities in Ondo state indicated that farmers do remove the root mats at the base of polythene bags during transplanting. This enables the young seedlings to develop new roots which help the seedlings to commence growth within a very short period. This method looks very unconventional but they seem to get satisfactory results from it. Root mat management is a form of pruning which enhances proper balance between the root system and the crown is necessary for optimum growth [20].

Minimizing the imbalance imposed by transplanting should increase survival and speed restoration of the root:crown ratio, resulting in vigorous growth. Since root pruning has the potential to confine the root system to a relatively small volume, there is tremendous promise for using it to increase the number of absorbing rootlets moved with the tree [19]. Furthermore, fertilizer application enhances growth of cocoa seedlings [10]. In tropical and subtropical soils, the application of phosphorous is important for most crops because of its low availability, which is not unconnected with fixation. Phosphorus is the second most limiting nutrient after nitrogen in the nutrition of cocoa. Phosphorus is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next. Phosphorus plays an indispensable role as a universal fuel for all biochemical work in living cell and in particular root development which is very important to crop establishment in the field [8]. P-deficiency is often corrected through the use of inorganic phosphorus fertilizers such as single super phosphate (SSP), triple super phosphate (TSP), NPK fertilizers and other inorganic P-fertilizer sources. The application of these fertilizers on a long term basis often leads to reduction in pH and exchangeable bases thus making them unavailable to crops and productivity of crop declines [22]. In addition, the problem of affordability of these chemical fertilizers by resource – poor farmers and other attendant problems of fertilizers procurement and distribution make the use of rock phosphate as direct source of P and becoming an alternative compared to industrial fertilizer [14]. Due to the inherent advantage of the use of rock phosphate, research scientists and organisations have advocated the direct application of rock phosphate with a significant phosphate content of less soluble P such as phosphate rock to recapitalize the soils [1]. The practice by farmers in the state does not combine fertilizer application as a factor that can boost the growth of cocoa seedlings newly transplanted into the field [16]. Therefore, the current effort was to evaluate the effect of root mat management and phosphate fertilizer application on the performance of cocoa in the early years of establishment in the field.

MATERIALS AND METHODS

The experiment was carried out at Owena Substation of Cocoa Research Institute of Nigeria (CRIN) Ibadan between years 2007 and 2009 in the new cocoa demonstration plot. This trial involved six treatment combinations formed from two levels of root mat treatments (with and without root mat) and three types of phosphate fertilizer namely: no P application, application of SSP and SRP both at 30 Kg P_2O_5/ha. The root mat treatments was done during transplanting in which the root mat layer below the seedlings and the tap roots are carefully removed with the aid of sharp razor blade or knife before placing the seedlings into the planting holes already dug for the purpose. The phosphate fertilizer was equally applied at during transplanting. The treatments were arranged in a randomized complete block design (RCBD) with three replications. The parameters taken included plant height which was determined by means of metre rule which involved measuring the vertical distance of each seedling from the basal region (soil surface) to the tip of the plant/ crown point [13], while the stem diameter was determined by placing a vennier calliper at 5cm above the base of the seedlings. The number of leaves was done by physical counting of the leaves on each of the seedlings while the leaf area of the transplanted cocoa seedlings was determined by measuring the length and breadth of the leaf and multiplied it by 0.6 [2] as amended by [6]. These were regularly taken on monthly basis for 18 months. Watering was done twice a week during the two dry seasons. Topsoil samples were collected randomly with the aid of soil auger at 0 – 30 cm depth for the pre-cropping analysis. The samples were bulked together and mixed thoroughly, air dried at room temperature and analysed for various elements. At the end of observational period (18 months), soil samples were collected and analyzed to determine the physical and chemical characteristics of the soil using the analytical methods of IITA 1979 manual. Analysis of variance was performed on all data to test the treatment effect on different parameters measured using a SAS analytical package of 9.20 version.

RESULTS AND DISCUSSION

The initial soil characteristics indicated that the soil of Owena was sandy loam that was moderately acidic with a pH of 6.20 (Table 1). The organic carbon and total nitrogen were low. The available P of 10 mg/Kg was just at critical level for good cocoa production according to [21]. Similarly, the exchangeable K of 0.18 cmol/Kg soil was inadequate for cocoa soils [7]. The soil used for this trial was only moderate in fertility and will require some amendments for optimum productivity. The height of young cocoa in the field was not significantly affected by phosphate fertilizer application at 3, 6, 9 and 12MAT (Fig. 1). However, at 15 and 18MAT, SRP enhanced the height of young cocoa significantly ($p< 0.05$) by 26% and 43% respectively compared with the height of cocoa under SSP application. The height of young cocoa with its root mat untouched but without P application was significantly ($p< 0.05$) higher than those seedlings without root mat or without P application at 15 MAT. The influence of phosphate fertilizer types and root mat treatment (with or without) on the height of young cocoa was not significantly different at 3, 6, 9 and 12 MAT. However, at 15 MAT, the effect was almost the same except SSP application to cocoa seedlings without its root mat gave the least height compared with other treatment combinations (Fig. 1). The apparent lack of response to P- fertilizer application at the earlier months might be due to the initial soil P level that was not far removed from the critical level for cocoa production [10]. [5] had earlier found that most Nigerian soils show no response to phosphate fertilizer application if the initial soil test value is below 15mg/kg. The height of young cocoa at 3 and 6 MAT was significantly ($p< 0.05$) depressed in an order of 65% and 55% respectively as result of root mat removal compared with the cocoa seedlings with their root mat intact (Fig. 1).

Table 1: Some initial physical and chemical characteristic of Owena soil.

Soil properties		Owena value
Physical properties		
Sand (g/kg)		715.00
Silt (g/kg)		153.00
Clay (g/kg)		132.00
Texture		Sandy loam
Chemical properties		
PH (H_20)		6.20
Organic Carbon g/kg		14.30
Total N (g/kg)		0.85
Available P (mg/kg)		10.09
Exchangeable cations		
K cmol/kg		0.28
Ca cmol/kg		4.24
Mg cmol/kg		1.05
Exchangeable Acidity	cmol/kg	0.28
Cu (mg/kg)		5.32
Mn (mg/kg)		2.23
Zn (mg/kg)		6.55
ECEC(mg/kg)		5.57
Base Saturation (mg/kg)		95.02

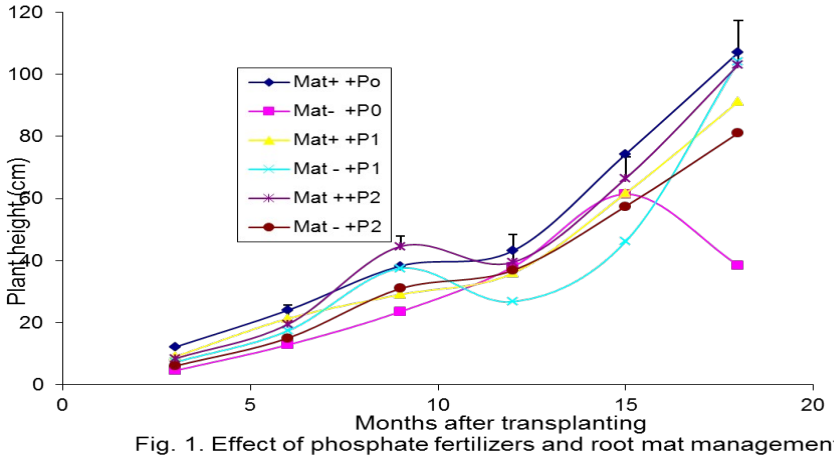

Fig. 1. Effect of phosphate fertilizers and root mat management on height of ccocoa seedlings

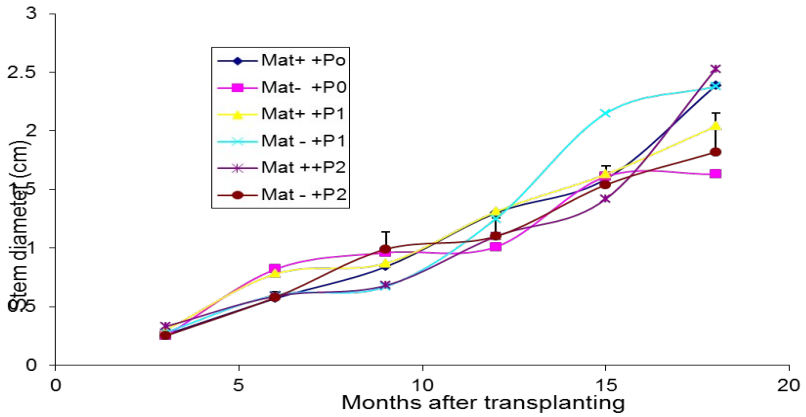

Fig. 2. Effect of phosphate fertilizers and root mat management on stem diameter of ccocoa seedlings

Similarly, at 9 and 12 MAT, there was no significant depression of height due to root mat removal. However at 15 MAT, there was a significant depression of the height of cocoa. Seedlings with root mat intact consistently enhanced the height of cocoa seedlings at 3, 6, 9, 12, and 15 MAT (Fig. 1). Similarly, the stem diameter of cocoa seedlings at 3 MAT was significantly improved as a result of non-removal of root mat (Fig. 2). However, the influence of root mat removal on the stem diameter of cocoa seedlings was not consistently higher compared with those with root mat intact at 6 and 9 MAT but it gave higher stem diameter at 12 and 15 MAT. The depression in height and stem diameter of cocoa is consistent with the findings of Geister *et al* (1984) and Toliver *et al* (1980) in which root pruning caused significant reduction on the growth of Golden delicious apple trees and three bottomland hard wood respectively. The stem diameter at 3MAT of cocoa with root untouched and SRP application was significantly ($p< 0.05$) higher than those with root mat removed with or without P – fertilizer application. The influence of phosphate fertilizer application on the stem diameter of cocoa in the field at 3, 6, 9, and 12 MAT was not significant. However, SSP application to cocoa with or without root mats increased (significantly) the stem diameter of cocoa with 64 and 45 % compared with cocoa under SRP and the control (no P application) respectively at 15MAT.

The superior performance of cocoa seedlings under SSP application could be because of its availability compared with slow releasing SRP. This finding is consistent with views expressed by [9] which plants receiving SSP treatment were significantly larger than those receiving only rock phosphate treatment.

This finding is similar to the results obtained by [18] and [3] in which application of rock phosphate did not translate into increase in the height and stem diameter of cocoa seedlings in Indonesia and Malaysia respectively. Root mat removal did not significantly affect the number of leaves and leaf area of the cocoa seedlings throughout the period of study (Tables 2 and 3).

Table 2: Influence of root mat management and phosphate fertilizer application on the number of leaves of cocoa seedlings in the field.

Treatment	Months After Transplanting					
	3	6	9	12	15	18
$MAT^{+} + P_0$	5.83	6.63	8.50	13.40	30.40	34.04
$MAT^{-} + P_0$	2.28	6.84	11.90	8.30	23.70	62.17
$MAT^{+} + P_1$	4.48	6.65	13.10	19.00	25.10	26.03
$MAT^{-} + P_1$	4.70	9.05	15.00	12.80	29.20	22.10
$MAT^{+} + P_2$	5.72	5.98	9.00	15.30	36.60	28.09
$MAT^{-} + P_2$	6.36	9.67	13.10	12.90	24.40	30.04
SE (0.05)	1.96	3.14	4.12	6.70	9.68	13.04

P_0= No P application, P_1= SSP application and P_2= SRP application
MAT^{-} = Without Root mat and MAT^{+}= with Root mat

Table 3: Influence of root mat removal and phosphate fertilizers on the leaf area of cocoa seedlings in the field.

Treatment	Months After Transplanting					
	3	6	9	12	15	18
MAT+ + P0	148.00	73.00	217.00	170.00	222.00	235.00
MAT-+ P0	94.00	92.00	118.00	224.00	214.00	243.00
MAT++ P1	111.00	166.00	190.00	222.00	272.00	177.00
MAT-+ P1	122.00	97.00	161.00	191.00	218.00	259.00
MAT++ P2	120.00	119.00	241.00	358.00	218.00	252.00
MAT-+ P2	60.00	96.00	134.00	223.00	287.00	200.00
SE (0.05)	36.10	43.80	55.80	85.60	69.10	47.8

P0= No P application, P1= SSP application and P2= SRP application
MAT - = Without Root mat and MAT += with Root mat

P-fertilizer application did not show significant effect on the number of leaves and leaf area of cocoa seedlings throughout the period of study. On a cumulative basis, the influence of root mat treatments on the stem diameter of cocoa was not significant at 3, 6, 9, 12 and 15 MAT. This indicates that root mat removal did not confer negative influence on the stem diameter of young cocoa newly transplanted to the field. Specifically, at 15MAT, cocoa without root mat gave an increase of 22% on the stem diameter of cocoa over those with root mat un-removed.

The influence of root mat treatment and phosphate fertilizer application was not significant on the stem diameter of cocoa at 6 and 9 MAT. The influence of root mat treatment (with or without) and phosphate fertilizer application did not significantly affect the number of leaves of young cocoa at 3, 6 and 9 MAT. However, the number of leaves of cocoa at 12 MAT was significantly ($p< 0.05$) enhanced as a result of non-removal of root mat and SRP application.

The trend was slightly different at 15 MAT in which the number of leaves of cocoa was significantly ($p< 0.05$) higher under root mat removal in conjunction with SRP application compared with its counterpart without phosphate fertilizer application (Table 2). The leaf area of cocoa was not significantly affected by root mat treatment (with or without) and phosphate fertilizer application throughout the period of the study. However, the lack of significant effect of application of phosphate fertilizers to some growth parameters of cocoa in this trial is contrary to the results obtained in Malaysia in which phosphate fertilizers significantly promoted the growth and nutrient uptake of cocoa seedling [15]. This could be attributable to nature of the Malaysian soils which are mostly Ultisols and Oxisols that are seriously deficient in P. Phosphate fertilizers did not significantly affect the sand, silt and clay fractions of the soil (Table 4).

Table 4: Influence of root mat removal and phosphate fertilizers on some soil physical and chemical characteristics.

Treatment						
	Sand mg/kg	Silt mg/kg	Clay mg/kg	pH	Organic carbon mg/kg	Available P mg/kg
MAT+ + P0	641.30	165.60	159.70	6.00	15.40	5.37
MAT-+ P0	648.00	158.90	166.40	6.17	11.00	7.14
MAT++ P1	608.00	198.90	146.40	6.20	15.50	5.94
MAT-+ P1	638.00	175.60	173.10	6.35	17.20	5.31
MAT++ P2	654.70	172.30	186.10	6.30	14.40	7.35
MAT-+ P2	634.70	165.60	199.70	6.33	15.90	6.72
SE (0.05)	6.58	5.73	7.76	0.07	0.86	0.36

P0= No P application, P1= SSP application and P2= SRP application
MAT - = Without Root mat and MAT += with Root mat

The sand fraction ranged from 608 to 654 g/kg soil while the silt and the clay ranged from 159 to 198 and 146 to 200g/kg soil respectively. Similarly, the pH of the soil was not significantly affected by phosphate fertilizers. The ranged from 6.00 to 6.35. However, the organic carbon of the soil was significantly ($p < 0.05$) reduced in the control (root mat was removed and no phosphate fertilizer was not applied) compared to other treatments. SSP application without root mat gave the highest organic carbon accumulation compared to other treatment combinations. Conversely, the level of available P accumulation was not significantly enhanced as a result of root mat management and phosphate fertilizer application. The available P ranged from 5.31 to 7.35 mg/kg soil which was lower than the initial P value. This could be due to losses during the trial.

CONCLUSION

The above results had shown that the extra effort of removing the root mat of cocoa seedlings before transplanting did not confer any advantage in terms of growth on the transplanted cocoa seedlings compared with those seedlings with their roots untouched.

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