THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Evaluation of the Effects of Organic and Mineral Fertilizers with Mycorrhiza on the Dry Matter Yield and Nutrient Uptake of Theobroma Cacao in Ibadan, Nigeria

N. Taiwo
Principal Research Officer, Department of Soil and Plant Nutrition,
Cocoa Research Institute of Nigeria, Ibadan, Nigeria
O. Fagbola
Professor, Department of Agronomy,
University of Ibadan, Ibadan, Nigeria
O.S.O Akanbi
Chief Research Officer, Department of Soil and Plant Nutrition,
Cocoa Research Institute of Nigeria, Ibadan, Nigeria
B. A. Nduka
Principal Research Officer, Department of Agronomy,
Cocoa Research Institute of Nigeria, Ibadan, Nigeria

Abstract:
A greenhouse trial was conducted at Cocoa Research Institute of Nigeria, Ibadan, to evaluate the effects of organic and mineral fertilizers with and without Mycorrhiza on the dry matter yield and nutrient uptake of CRIN Tc-1 and F3 Amazon cocoa seedling in Ibadan. The treatments consist of cocoa pod husk (CPH), Tithonia diversifolia leaves (TD) , combination of CPH and TD (CPH+TD) and NPK fertilizer which were applied to F3 amazon and Tc1 hybrids of cocoa at two levels of mycorrhiza (with and without) inoculation, to supply 10Kg N/ha respectively and laid out in completely randomized design (CRD) in three replicates. All the fertilizer treatments with mycorrhiza were significantly ($p<0.05$) higher than the treatments without mycorrhiza for N uptake except for NPK and control. Application of sole CPH under mycorrhiza inoculation significantly ($p<0.05$) enhanced phosphorus uptake in TC1 relative to the control. Potassium uptake was significantly($p<0.05$) enhanced by CPH and CPH+TD without mycorrhiza. CPH with mycorrhiza gave the highest leaf and root dry matter yield (DMY) which were significantly higher than the control for Tc-1, while for F3Amazon, TD with mycorrhiza gave the highest root DMY relative to the control.
It can therefore be concluded that optimal and sustainable growth and dry matter yield of cocoa seedlings could be achieved by the use of organic fertilizer materials such as TD and CPH in combination with mycorrhiza.

Keywords: *Theobroma cacao, cocoa pod husk, Tithonia diversifolia, NPK fertilizer, arbuscular mycorrhiza*

1. Introduction

Cocoa *(Theobroma cacao)* is a tree crop of the humid lowland tropics and is cultivated in the forest belt of Nigeria. Tropical soils have an inherently low fertility status due to the low activity kaoliniltic clay type and soil organic matter (Obatolu and Agboola 1991). Soil organic matter is one of the most important indication of soil fertility hence the need to ensure a stable organic matter level. This can be achieved through the effective use of organic materials.

About 60% (Wet basis) of cocoa pod is made up of husk hence; cocoa farmers in Nigeria are handicapped on the best way of disposal of this large quantity of CPH on their farm. Cocoa pod husk (CPH) contains a sizeable amount of organic matter and inorganic nutrients as well (Akanbi *et a*l 2013 and Ipinmoroti et al 2011). CPH has relatively high Potassium content (Sukha, 2004) hence the need for research into the use of CPH in combination with other organic materials in cocoa production. There is also the need to examine the importance of those organic resources with high nutrient concentrations that grows around our community. *Tithonia diversifolia (Hemsley A. Grey)* biomass is one of these organic materials with a great potential for use as soil amendment. *Tithonia diversifolia* (TD) commonly known as Mexican sunflower is an annual, aggressive weed growing to a height of about 2.5m. *Tithonia* accumulates high concentrations of nutrients in their leafy biomass and this mineralizes rapidly when incorporated into the soil (Jama *et al*., 2000).

The mycorrhizal fungi are fundamental for the efficient nutrition process and appropriate development and production for most of the plants. Hence, the objective of this study was to evaluate the potentials of mycorrhiza in combination with organic resources (cocoa pod husk and *Tithonia diversifolia)* on cocoa seedling.

2. Materials and Methods

The experiment was conducted in the greenhouse at the Cocoa Research Institute of Nigeria, Ibadan. Top soil (0-15cm) used for the study was collected from a cocoa plot, air-dried to pass through a 2mm sieve and 5kg soil was weighed into each pot. Representative soil sample was analyzed in the laboratory for routine physical and chemical properties. The pots were watered to field capacity and two cocoa beans sown directly into each pot. The experiment was factorial laid out in a completely randomized design and replicated three times. The three factors were mycorrhiza at two levels (with and without mycorrhiza), fertilizer types at five levels (CPH, CPH +TD, TD, NPK and the control) and cocoa varieties (F3 Amazon and Tc 1). There were 60 experimental units altogether. The fertilizer type used were Cocoa Pod Husk (CPH), *Tithonia diversifolia* leaves (TD), a combination of CPHand TD (CPH+TD) and NPK fertilizer. The organic materials were applied two weeks before sowing while NPK was applied two weeks after sowing. The seedlings were thinned to one per pot one week after emergence, watering was done three times a week. The experiment was terminated at six months after sowing. The plants were harvested and separated into leaves, stem and roots. The plant samples were oven dried at 70^0C until a constant weight was obtained, weighed, milled and analyzed for the nutrient content. The nutrient uptake was then calculated using the formula: Nutrient Uptake = Yield (Kg) × Nutrient Content (%).

All data generated were subjected to statistical analysis using ANOVA and significant means were separated using Duncan Multiple Range Test.

3. Results and Discussion

The physical and chemical properties of soil used for the greenhouse experiment are shown in Table 1. The soil was slightly acidic (pH 6.0). The critical soil nutrient recommended for optimum production of cocoa in Nigeria are: Organic Carbon (OC) -18g/kg^{-1}, Total Nitrogen (N) -1.0gkg^{-1} respectively (Egbe *et al*., 1989). Available Phosphorus - 5.5mgkg^{-1}, Exchangeable K - 1.2gkg^{-1}, Ca - 8.0cmolkg^{-1} and Mg - 0.8cmolkg^{-1} .However, the test soil was low in OC, N, P, K, Ca and Mg and the values fall below the critical level for optimum production hence the need for nutrient amendment.

The nutrient composition of the cocoa pod husk and the *Tithonia diversofolia* are also shown in table1. The CPH had 25.7g/kg N, 242.6g/kg OC, 2.9mg/kg P, 8.8cmol /kg K, 2.0cmol/kg Ca, 0.3cmol/kg Mg. While TD had 27g/kg N, 140g/kg organic carbon, 3mg/kg P, 4.1cmol/kg K, 9.8cmol/kg Ca and 0.35cmol/kg Mg. This shows their potential for use as fertilizers.

Soil Properties	Soil Nutrient Values	Soil Critical Values	CPH	TD
pH(1:1)	6.3			
Organic Carbon	14.6(g/kg)		242.6(g/kg)	140(g/kg)
N(g/kg)	0.7(g/kg)	1.0(g/kg)	25.7(g/kg)	27(g/kg)
P (mg/kg)	3.67(mg/kg)	5.5(mg/kg)	2.9(mg/kg)	3(mg/kg)
K	0.17(cmol/kg)	1.2(cmol/kg)	8.8(cmol/kg)	4.1(cmol/kg)
Ca(cmol/kg)	2.82(cmol/kg)	8.0(cmol/kg)	2.0(cmol/kg)	9.8(cmol/kg)
Mg	0.69(cmol/kg)	0.8(cmol/kg)	0.3(cmol/kg)	0.35(cmol/kg)
Na(cmol/kg)	0.21(cmol/kg)			
Exchangeable acidity(cmol/kg)	0.25(cmol/kg)			
Zn(mg/kg)	11.57(mg/kg)			
Cu(mg/kg)	2.81(mg/kg)			
Mn (mg/kg)	104(mg/kg)			
Fe(mg/kg)	67.9(mg/kg)			
Sand	748(g/kg)			
Silt(g/kg)	110(g/kg)			
Clay(g/kg)	142(g/kg)			
Texture	Sandy Loam			

Table 1: Properties of Soil and Organic Materials Used for the Experiment

The Tc1 cocoa hybrid treated with CPH fertilizer material under mycorrhiza inoculation gave the highest N uptake relative to the control (Table 2). Application of sole CPH with mycorrhiza inoculation significantly (P >0.5) improved P uptake in TC1 irrespective of other fertilizer type, this was closely followed by CPH+TD under mycorrhiza inoculation and TD sole. Conversely, TD sole and TD +CPH both with mycorrhiza produced significantly (P >0.5) higher P uptake in F3 Amazon cocoa seedling.

The effect of CPH +TD and CPH both with mycorrhiza (+M) inoculation produced similar effect on the K uptake in Tc1although CPH with mycorrhiza gave a higher K uptake. The two treatments were significantly higher than the control. Also TD +M, CPH+TD+M and TD without mycorrhiza (-M) recorded similar effects on K uptake in F3 Amazon cocoa seedlings (Table2). Calcium uptake for CPH+TD, CPH, TD and control was significantly higher than that of NPK. Inoculation with mycorrhiza significantly affected the Ca uptake in Tc1 variety with CPH and CPH +TD and the control. Also, Mg uptake by Tc 1was the highest for CPH+TD fertilizer material under mycorrhizal inoculation and was significantly higher than NPK and control.

Variety	Fertilizer	Mycorrhiza	N	P	K	Ca	Mg	Fe	Zn
Tc1	CPH+TD	M+	53.11abc	6.89ab	35.25ab	5.49a	1.47a	3.54b	0.87ab
Tc1	CPH+TD	M-	28.6def	4.67bc	26.7bcde	4.48ab	0.83abc	2.27bcde	0.52cdef
Tc1	CPH	M+	68.34a	8.76a	41.78a	5.33ab	0.83abc	2.17bcde	0.96a
Tc1	CPH	M-	30.19def	3.01c	15.9de	0.37h	0.86abc	3.10bc	0.55bcdef
Tc1	TD	M+	61.03ab	4.88bc	32.95abc	4.65abc	0.86abc	3.72b	0.53bcdef
Tc1	TD	M-	39.89cde	6.41ab	30.8abc	5.00ab	1.04ab	2.26bcde	0.76abcd
Tc1	NPK	M+	46.08bcd	4.3bc	24.44bcde	0.4h	0.19cde	6.33a	0.54bcdef
Tc1	NPK	M-	32.75cdef	5.61bc	21.01cde	1.72efgh	0.71bcde	3.89b	0.55bcdef
Tc1	CTRL	M+	19.72ef	3.25c	24.95bcde	0.4h	0.59cde	0.92def	0.39f
Tc1	CTRL	M-	18.85f	4.91bc	13.67e	0.35h	0.63cde	2.07bcde	0.48def
F3	CPH+TD	M+	32.2def	4.62c	23.62bcde	3.27cde	0.77abcde	2.37bcde	0.58bcdef
F3	CPH+TD	M-	26.94def	3.44c	20.34cde	3.68cd	0.53cde	0.87ef	0.53bcdef

Variety	Fertilizer	Mycorrhiza	N	P	K	Ca	Mg	Fe	Zn
F3	CPH	M+	36.68cdef	2.28defg	22.52bcde		0.41e	1.17cdef	0.41f
F3	CPH	M-	28.54def	2.87c	15.05de	2.28def	0.84abcd	1.17cdef	0.51cdef
F3	TD	M+	43.56bcd	5.19bc	28.11bcd	0.35h	0.71bcde	2.58bcde	0.75abcde
F3	TD	M-	31.07def	5.00bc	23.53bcde	1.33fgh	0.80abcde	3.93b	0.64abcdef
F3	NPK	M+	53.01abc	4.63bc	21.87bcde	2.69def	0.74bcde	2.67bcde	0.85abc
F3	NPK	M-	37.3cdef	3.41c	21.49cde	2.43defg	0.67bcde	3.54b	0.78abcd
F3	CTRL	M+	27.23def	4.52bc	26.72bcde	1.29fgh	0.56cde	0.03f	0.56bcdef
F3	CTRL	M-	20.96ef	3.44c	21.46cde	1.04fgh	0.45ed	1.18cdef	0.42f

Table 2: Effects of CPH, TD, CPH+TD and NPK with Mycorrhiza on Nutrients Uptake (mg/plant) by Cocoa Seedlings
CPH=Cocoa Pod Husk; TD=Tithonia diversifolia; M+=with Mycorrhiza; M-= without Mycorrhiza;
CTRL = Control

The Dry Matter Yield (DMY) followed the order leaf> stem>root (Table 3). The shoot DMY was higher than the root DMY. CPH with mycorrhiza gave the highest leaf and root DMY which was significantly higher than the control for Tc-1. While for F3 Amazon, TD with mycorrhiza gave the highest root DMY which was significantly higher than the control. CPH +TD, CPH in combination with mycorrhiza gave the highest TDMY which was significantly higher than the control for both Tc1 and F3 Amazon. This could be as a result of increased microbial activities that led to increased mineralization of organic matter from the natural source in the soil and availability of nutrients in the soil for the plant use leading to increased dry matter accumulation as indicated by Akanbi et al 2013. In Tc1, inoculation with mycorrhiza significantly increased the root DMY and the TDMY for CPH +TD, CPH. This observation is consistent with that of Akanbi *et al* (2014) who reported an increase in cocoa seedling growth and dry matter yield using cocoa pod ash and oil palm bunch ash.

Variety	Fertilizer	Mycorrhiza	leaf DMY(g)	Stem DMY(g)	Root DMY(g)	TDMY(g)
Tc1	CPH+TD	M+	15.73ab	6.07a	3.73ab	25.53a
Tc1	CPH+TD	M-	11.43abcd	1.8c	1.36e	14.58bc
Tc1	CPH	M+	16.10a	4.02abc	5.00a	25.12a
Tc1	CPH	M-	8.61cde	2.63bc	1.37e	12.64bc
Tc1	TD	M+	10.39cd	4.84abc	2.21bcde	17.44abc
Tc1	TD	M-	12.86abc	4.7abc	3.11bcd	20.67ab
Tc1	NPK	M+	9.83cd	4.27abc	2.22bcde	16.52abc
Tc1	NPK	M-	9.8cd	3.72abc	2.27bcde	15.45bc
Tc1	NO	M+	7.46de	2.67abc	1.47de	11.63bc
Tc1	NO	M-	8.15cde	2.27abc	1.90cde	12.32bc
F3	CPH+TD	M+	10.7cd	3.93abc	2.49bcde	17.12abc
F3	CPH+TD	M-	7.9de	2.57abc	1.38e	11.85bc
F3	CPH	M+	7.9de	3.02abc	2.57bcde	13.48bc
F3	CPH	M-	7.67de	2.07abc	2.11bcde	11.94bc
F3	TD	M+	11.01bcd	3.53abc	2.97bcde	17.51abc
F3	TD	M-	10.92cd	5.42ab	2.19bcde	18.53abc
F3	NPK	M+	11.04bcd	4.73abc	2.77bcde	18.54abc
F3	NPK	M-	11.20bcd	2.63bc	3.20bc	17.03abc
F3	CTRL	M+	8.20cde	4.26abc	1.60cde	12.91bc
F3	CTRL	M-	4.87e	3.10abc	1.30e	10.43c

Table 3: Effects of CPH, TD, CPH+TD and NPK with Mycorrhiza on Dry Matter Yield of Cocoa Seedlings CPH=Cocoa Pod Husk; TD=Tithonia diversifolia; M+=with Mycorrhiza; M-= without Mycorrhiza; CTRL = Control

4. Conclusion

The study shows that application of organic materials and mycorrhiza increased the nutrient uptake as well as the total dry mater yield of cocoa. Hence, CPH, CPH +TD could serve as an alternative for NPK which is expensive and not readily accessible to low income farmers.

5. References

i. Akanbi OSO, Famaye, A.O., Ojeniyi S. O., Nduka B. A., Taiwo N., Olasupo F.O., Azeez O. M., Edibo G. O. and Gbemisola D. O. (2013): Growth Response of Cashew seedlings to Applied Organic Fertilizer of animal and Plant Origin on a Degraded soil in Ibadan, Southwest, Nigeria. International Research Journal of Agricultural Science and Soil Science. 3:93-9

ii. Akanbi OSO, Famaye, A.O., Olaniyi O. O.,Ipinmoroti R. R., Iloyanomon C. I., Nduka B. A. and Adeosun S. A.(2014). Comparative effects of cocoa pod husk and oil palm bunch ash on nutrient uptake, growth and dry matter yield of cocoa (*Theobroma cacao)* in Ibadan, Southwest Nigeria. Agricultural Science, 5:1046-1052.

iii. Egbe, N. E., Ayodele E. A. and Obatolu, C. R. 1989: Soils and Nutrition of Cocoa, Coffee, Cashew, Kola and Tea. Progress in Tree Crop Research. Pp 28 - 38

iv. Ipinmoroti R.R. Akanbi O.S. O., Daniel M. A., Adebowale L. A., Adewoye G. A, Makinde E. A., Kayode C.O. (2011): Potentials of NPK and organic fertilizers on growth performance of cashew (*Anacardium occidentale* L.) seedlings on degraded typic alfisol soils in Ibadan. Journal of Agricultural Science and Technology.

v. Jama B.,C. A. Palm, R. J. Buresh, A. Niang, C. Gachengo, G. Nziguheba and B. Amadalo (2000): *Tithonia diversifolia* as a green manure for soil fertility improvement in western Kenya: A review. *Agroforestry Systems* 49: 201–221.