Effect of Cocoa Pod Husk on Growth, Yield and Nutrient Status of Tomato in Southwest Nigeria

Ewulo, B.S*[1]; Ojeniyi, S.O[1]; and Odedina, S.A[2]

[1]***Department of Crop Soil and Pest management,*** *Federal University of Technology****, P.M.B 704, Akure, Ondo State, Nigeria***

[2]***Department of Crop Production, Federal College of Agriculture, Akure, Ondo State, Nigeria***

ABSTRACT

The use of cocoa pod husk in improving soil and tomatoes yield is of importance in Nigeria in view of the sizeable amount of cocoa pod husk generated and often wasted. In order to test the effectiveness of ground cocoa pod husk (CPH) as nutrient source for tomato: 0, 5, 10, 15, 20 and 25 t ha^{-1} CPH and N.P.K (15:15:15) fertilizer (NPKF) at 200 kg ha^{-1} were applied to soil. The treatments were applied to early and late crops grown at two sites at Akure, Southwest Nigeria. The test soils were deficient in organic matter, P, and Ca. Growth and fruit yield data were collected and leaf analysis was done. Leaf area, plant height and number of branches increased with level of CPH. Increase in growth parameters given by 20 t ha^{-1} CPH and NPKF were similar. Leaf P, K, Ca and Mg concentrations increased with level of CPH. Compared with NPK, 15, 20, and 25 t ha^{-1} CPH increased leaf K, Ca and Mg concentration. CPH application increased fruit weight, and increases by 10, 15, 20, 25 t ha^{-1} CPH and NPKF were significant ($p>0.05$). Increases in fruit yield by application of 5, 10, 15, 20, and 25 t ha^{-1} CPH and NPKF were 86, 503, 397, 658, 747 and 653% respectively.

Keywords: cocoa pod husk; tomato; NPK 15:15:15; soils; fertilizer

*correspondence author; bsewulo@yahoo.co.uk

INTRODUCTION

Tomato is an important vegetable in Tropical Southwest Nigeria; its production is about 600,000 tonnes annually from about 500 hectares (Ojeniyi *et. al*, 2007). This production is obtained in the region that is characterized by soils that are intensively weathered and are considered to have degenerated to a state of low activity clay minerals with low native fertility.

Continuous cultivation of the soil has led to the loss of chemicals such as nitrogen, phosphorus and potassium, which are vital for plant growth, that are not replaced with organic and chemical fertilizers. Chemical and biological soil properties of the surface horizons largely depend on soil organic matter (SOM) content, which is subjected to high rate of mineralization due to prevalent climatic condition in the region.

The 10 t ha^{-1} average yield of tomato in the region is lower than world average of 22 t ha^{-1} (Ojeniyi *et. al*, 2007). Among factors that contribute to lower yield is the low soil fertility and inadequate or non-use of fertilizers due to high cost and scarcity of the fertilizers, hence research attention shifted recently to the use of organic wastes, which pose environmental, and disposal problems. Agro industrial wastes such as Cocoa Pod Husk (CPH) or its ash have the potential of being used as manure since they contain nutrients (Adediran *et. al,* 2003).

The challenge of soil research effort is to develop soil management technique that is environmentally friendly, technically feasible and sustainable on low external input. It is also to ensure maintenance of adequate level and adequate supply of organic matter on soil surface, to encouraging soil faunal activity, favourable soil physical condition and replenish nutrients removed by cropping. A fundamental requirement for improving traditional farming system in the tropics is the maintenance of OM in soil surface through recycling of plant or animal manure. Nigeria produces annually about 8 million tones of CPH, which are often burnt into ashes to control spread of phytophtora black pod disease (Egunjobi, 1975). It is estimated that 6400-94000 tones of N are lost annually in CPH waste (Egunjobi, 1975). Analysis of CPH showed it had 1.83% N, 2.38% P, 4.12% K, 1.19% Ca, 0.44% Mg and 10% C (Odedina, 2002). CPH is of great manorial value, it increases dry matter yield of maize by 49% (Umoti *et. al,* 1991), and has nematicide and fertilizing effect on maize (Egunjobi, 1975).

Experiment comparing various type of CPH viz, burnt, old, fresh and rotten showed rotten and old as having highest level of N, while burnt CPH had about four times the value of K observed in other preparations. Consequently the rotten and the old produced the tallest maize plants, taller than mineral fertilizer (Egunjobi, 1975; Oladokun, 1986). It was also indicated that all CPH preparations compared favourably with NPK fertilizer. Vegetable farmers in Nigeria depend largely on organic sources of plant nutrients and agro wastes, hence the need for this study.

The aim of the present work is to compares the effect of CPH treatments and NPK fertilizer on performance and nutrient status of tomato (*lycopersicum esculentum*) in southwest Nigeria.

MATERIALS AND METHODS

Two experiments were carried out at two sites in Akure, Southwest Nigeria; Akure lies between latitude 7^0 30'N and longitude 3^0 52' E in the tropical rainforest belt. There are two rainy or cropping seasons namely April to July (early season) and Mid-August to November (late season).

The soil at Akure is classified as Alfisol (Oxic tropuldalf). The two sites of study were Federal College of Agriculture (FECA) and Federal University of Technology (FUTA). The soil at the two sites had been cropped continuously to cassava and maize for 3 and 5 years respectively. Sites were manually cleared (with cutlass) ploughed and harrowed before planting of tomato.

Six levels of air-dried ground cocoa pod husk (0, 5, 10, 15, 20, 25 t ha^{-1}) and NPK (15:15:15) fertilizer at 200 kg ha^{-1} were applied by ring method to two week old tomato (V-Roman Var) seedlings in May in each site. The same was repeated for late crop in August. Single seedlings were transplanted at 75 X 75 cm in each 5m X 5m plot, given 66 plants per plot. The seven treatments were replicated 3 times in a randomized complete block design. Plants were staked and weeding operation carried out manually three times before harvest.

Growth and Yield Data

Data were taken on plant height, number of branches and leaf area at 10 weeks after treatment application using 10 plants selected per plot. Leaf area was measured with a leaf area meter (Lamba instrument cooperation model 1, 3 1000). The diameter number and weight of ripe fruits were evaluated between 72 and 90 days after treatment application.

Leaf Analysis

At 40 days after treatment application, four leaves sample per plant were collected, oven dried at 80 ^{0}C and ground. Total N was determined by Micro-kjeldahl method. For P, K, Ca and Mg, leaf sample was ashed and extracted with nitric-sulphuric-perchloric acid mixture. The P was determined using molybdenum blue colorimetry, K by flame photometer, and Ca and Mg by atomic absorption spectrophotometer (Tel and Hagarty, 1984).

Total Soil Analysis

Sandy clay loamy surface (0-15 cm) soil samples collected at FUTA and FECA sites before commencement of the experiments were air-dried and 2 mm sieved in preparation for chemical analysis. Particle size analysis was determined by hydrometer method (Day, 1965), Total N by Kjeldahl method, Organic matter by Walkley-black wet oxidation method (Walkley and Black 1934), available P was extracted with Bray-1 solution and determined colorimetrically (Bray and Kurtz, 1945). The cations were extracted using ammonium acetate and determined as described for leaf analysis. The pH in 2:1 water-$CaCl_2$ was determined (Carter, 1993). Plant data were pooled for early and late tomato at each site and subjected to analysis of variance for determination of least significance difference for treatments means at P>0.05.

RESULTS

Initial soil analysis data are shown in table 1 for FECA and FUTA sites of study. The soil were slightly acidic, low in organic matter (OM), total N, available P and exchangeable Ca, the concentration of exchangeable K and Mg were adequate for crop production (Akinride and Obigbesan, 2000). FECA site was had more exchangeable K, Ca and exchangeable Mg and was more acidic than FUTA site. FUTA site had more OM, Total N and available P than FECA site. The textural class of topsoil at FECA was loamy and that of FUTA clay loamy.

Table 1: Soil properties at FECA and FUTA before experiment

Property	FECA	FUTA
Sand (%)	46.00	44.10
Silt (%)	28.20	25.20
Clay (%)	25.80	30.70
O.M (%)	1.47	1.53
Total N (%)	0.13	0.14
Available P (mg kg^{-1})	5.80	10.50
Exch. K (cmol kg^{-1})	0.44	0.31
Exch Ca (cmol kg^{-1})	1.77	1.23
Exch Mg (cmol Kg^{-1})	0.98	0.50
p^{H}	6.10	6.30

Data are means for early and late tomato crops

Application of CPH with respect to tomato growth parameters in table 3 showed an increase relative to non-application (control) at FECA and FUTA sites respectively. Leaf area, plant height and number of branches tended to increase with level of CPH from 0, 5, 10, 15, 20 to 25 t ha^{-1}. At FECA increase in leaf area given by 10 to 25 t ha^{-1} CPH were significant (P>0.05) likewise increase in number of branches given by 15, 20 and 25 t ha^{-1} CPH. The increases in plant height were not significant. At FUTA the increases in growth parameters by 10, 15, 20 and 25 t ha^{-1} CPH were significant. Increases in tomato growth parameters given by 20 t ha^{-1} CPH and NPKF were similar at both sites of study and 20 and 25 t ha^{-1} CPH gave higher values of leaf area compared with NPKF. At FUTA 15, 20, and 25 t ha^{-1} gave higher values of leaf area, plant height and number of branches compared with NPKF.

Compared with the control, application of different levels of CPH to soil increased the number and weight of tomato fruits at FECA and FUTA sites (Table 3). The number of fruits increased with levels of CPH between 0 to 25 t ha^{-1}, although the effect of CPH on number of fruits was not significant. The increase in fruit weight (yield) given by 10, 15, 20, 25 t ha^{-1} CPH and NPKF were significant (P>0.05). The value of fruit yield given by 20 and 25 t ha^{-1} CPH and NPKF were similar, hence the 20 t ha^{-1} gave optimum yield and is recommended, although the 25 t ha^{-1} CPH had highest fruit yield. The mean increases in fruit yield given by 5, 10, 15, 20 and 25 t ha^{-1} CPH and NPKF were 86, 503, 397, 658, 747 and 653% respectively.

Table 3. Effect of Cocoa pod husk and NPK fertilizer (NPKF) on growth and yield of tomato at FECA and FUTA site

Cocoa husk t ha^{-1}	Leaf area (cm^2)		Plant height (cm)		No of branches		No of fruits/plant		Fruit yield t ha^{-1}	
	FECA	FUTA	FECA	FUTA	FECA	FUTA	FECA	FUTA	FECA	FUTA
0	80.20	79.50	50.00	49.60	4.30	4.60	10.10	9.00	7.90	5.30
5	82.10	81.20	55.00	58.60	5.80	6.80	10.60	9.50	12.70	11.90
10	94.20	91.50	58.90	59.20	7.70	8.80	10.20	9.70	40.50	39.10
15	91.20	93.60	62.40	62.40	9.60	10.60	10.40	9.40	37.80	32.70
20	116.20	110.10	66.00	68.60	11.80	12.50	10.60	10.50	50.60	48.50
25	113.20	114.20	68.50	69.60	13.40	14.30	11.40	12.60	58.60	53.20
NPKF	100.10	91.40	69.30	60.00	12.80	12.50	14.00	15.40	50.60	48.70
Lsd (0.05)	3.20	4.20	NS	5.60	4.70	4.30	NS	NS	12.00	10.20

Data are means for early and late tomato crops

DISCUSSION

Initial soil analysis data showed that experimental soils at FECA and FUTA were slightly acidic, low in organic matter (OM), total N, and exchangeable Ca. At FECA site the soil was also low in available P. At both sites, the soils were adequate in exchangeable K and Mg. The values of the chemical properties were assessed relative to critical levels set for crop production in different ecological zones of Nigeria. An evaluation of fertility status of soils in Nigeria established that 3% OM, 0.15% total N, 10 mg kg^{-1} available P, 0.16-2.0 cmol kg^{-1} exchangeable K, 2.0 cmol kg^{-1} exchangeable Ca, 0.40 cmol kg^{-1} exchangeable Mg were adequate for crop production (Akinrinde and Obigbesan, 2000). Therefore there is need to return organic wastes to the soils to boost level of organic matter which in turn is expected to increase availability of other nutrients. Potential crop yield can not be obtained and yield sustained where soil organic carbon (SOC) is below 1% (King *et. al,* 2005). Soil aggregates are considered unstable where SOC is less than 2% (King *et. al,* 2005).

Organic matter is a natural supply of plant nutrients when it degrades and it is also known to be a major source of cation exchange and retention. Adding organic materials to the soil is of particular importance in the tropics because the clay content of soil is mainly kaolinitic. At Akure in southwest Nigeria the diffractogram for > 2 micron fraction of the soil showed prominent kaoilinite peaks with the absence of any trace of other clay mineral types (Jegede, 2004). Organic matter accounts for more than 80% of the cation exchange capacity and serves as one of the major means of improving the soil fertility and water holding capacity (Adetunji, 1997). Therefore the present study in which nutrients and organic matter are recycled through addition of agro waste (Cocoa husk) to the soil is pertinent considering the low O.M and cation status of the soil. Hence pervious studies reported positive response of tomato and vegetable yield to organic waste manures such as brewery waste, animal waste, wood ash and sawdust (Adediran *et al,* 2003).

Because of the low O.M and cation status of the soils, there is need to investigate the use of crop waste such as cocoa pod husk (CPH), which has received little attention. This is more due to the cost of chemical fertilizer that is beyond the reach of most tomato producers who are mainly small plot holders in rural areas (Adediran *et al,* 2003).

Also the problems of soil acidity, soil physical degradation and nutrient inbalance; a condition in which any of the essential element is lacking or present in improper proportion such that normal plant growth will not occur, are often associated with continuous use of chemical fertilizers (Umoti *et. al*, 1991) in vegetable production.

The use of organic wastes is expected to ensure more balanced nutrient supply to soil and tomato plants since it is a natural source of macro and micro nutrients (Adediran *et al,* 2003). This is in contrast to NPK compound fertilizers often made available to farmers in Nigeria and other developing countries.

This work found that CPH treatments increased nutrient status of tomato plants as indicated by leaf analysis. Leaf P, K, Ca and Mg tended to increase with level of CPH between 0 to 25 t ha^{-1}. This finding indicates that agro waste (CPH) has a source of O.M decompose to release these nutrients into soil for tomato uptake. On decomposition of the ground CPH, the organic forms of N and P in its tissue should have mineralized to release the inorganic forms taken up by plant roots. Therefore CPH had fertilizing effect on the soil and tomato plant (Egunjobi, 1975). Post harvest analysis of soil showed that CPH increased K, Ca, and N significantly when compared with control (Egunjobi, 1975). Therefore CPH acted as fertilizer. It was also noted that plants in CPH amended plot grew more vigorously.

The NPK fertilizer also increased uptake of N, P, K, Ca and Mg as indicated by leaf analysis. While the increase uptake of N, P and K could be adduced to nutrient supplied directly from the fertilizer, the improved N, P, K, Ca and Mg can also be adduced to enhanced growth of tomato, which stimulated uptake of nutrients. Also increased availability of fertilizer nutrients in soil should have enhanced microbial activity leading to degradation of O.M to release nutrients including the cations.

It was observed that CPH at 5 t ha^{-1} and above tended to give similar leaf N at FECA and leaf P at FECA site. However CPH at 15, 20 and 25 t ha^{-1} gave higher leaf K Ca and Mg content than NPKF at both sites of study, the latter ascertain that CPH is an effective source of the cations. Previously, an analysis of CPH indicated that the value of K is the highest (Moyin-Jesu, 2007 ; Odedina, 2002). It is a source of K fertilizer and has been used successfully as a source of K for maize, its ash contain up to 37-50% K (Umoti *et. al*, 1991). It is calculated that the Nigeria's level of cocoa production could yield a total amount of 7000 metric tones of potash annually. This amounted to about 42.4% of total annual consumption of potash fertilizer in Nigeria.

Study on the use of organic wastes in production of Arabica Coffee in Nigeria indicated that CPH treatment has increased leaf Ca and Mg content compared to NPKF

(Moyin-Jesu, 2007). Another response of soil fertility and okra (*Abelmoschus esculentus*) to plant residue manure also found out that CPH increase soil nutrient content, pH and O.M, it enhances pod Ca content of okra than NPKF, it also increases leaf N, P, K, Ca and Mg content of okra (Moyin-Jesu, 2006 ; Moyin-Jesu, 2007).

The increase in nutrient availability to tomato plant due to application of CPH to soil led to significant ($p>0.05$) increase in growth and fruit yield of tomato (Table 3). The increase in leaf area, numbers of branches and fruit weight were significant relative to value recorded for the control. This was especially so, if CPH was applied at 10 t ha^{-1} and above. The increase recorded in cases of plant height and numbers of fruits were not significant. The fruit yields given by 20 t ha^{-1} CPH, 25 t ha^{-1} and NPKF were similar. Hence the 20 t ha^{-1} CPH was optimum and recommended. Other studies have reported significant increase in yield and growth of crops such as okra, coffee and maize (Egunjobi, 1975; Moyin-Jesu, 2006; Moyin-Jesu, 2007). Aside from improved availability of macronutrient such as Fe, Zn, Cu which are contained in CPH (Moyin-Jesu, 2006 ; Moyin-Jesu, 2007), nutrient deficiency symptoms of maize were controlled by application of CPH and treated plants were also tolerant to a fungus disease (leaf streak) (Egunjobi, 1975).

CPH was also noted to have nematicide effect on maize, although its major effect was in soil fertility improvement. It is noted in the present study that growth parameters such as leaf area, plant height and number of branches increased with level of CPH, this indicate additive effect of nutrients released with increased level of CPH. It also shows that nutrients were released to the soil by CPH and thus led to enhanced growth of tomato. Experiment conducted in Southwest Nigeria confirm that application of N, P, K Ca and Mg fertilizer to tomato increased its yield (Agbede and Aduayi, 1975 ; Sobulo *et. al,* 1975). Therefore these nutrients released from CPH to nutrient deficient soil on which the present study was conducted certainly increased growth and fruit yield of tomato significantly.

CONCLUSION

The huge cocoa pod husk being generated on cocoa farms which is largely wasted can be air-dried and crushed by the farmers. This could be returned to soil as manure for food crops and vegetables such as tomato, which is often produced on small-scale basis, and thereby allow nutrients locked up in agro waste to be recycled. It will also reduce expenditure on scarce and expensive chemical fertilizer. The present study ascertain cocoa husk as an effective source of macronutrients that are made available for crop uptake leading eventually to significant increase in crop growth and yield.

This work also highlights other functions of CPH in crop management. It is recommended for use at optimum rate of 20 t ha^{-1}. The use of CPH as manure would also serve the purpose of environmental sanitation and crop hygiene, since the pod harbours pathogenic fungus (*Phytophtora palmivora*), which causes black pod disease of cocoa. Compared with the commonly available NPK fertilizer, CPH manure would ensure more balanced plant nutrition through release of macro and micronutrients. Cations released would also serve to control soil acidity, which is a major feature of soil in the humid tropics.

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