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EFFECT OF SIAM WEED (*CHROMOLAENA ODORATA* L.) RESIDUES, PHOSPHORUS FERTILIZER AND MANURE APPLICATION TIME ON SOIL PROPERTIES, GROWTH AND ROOT YIELD OF SWEET POTATO IN ACIDIC SOIL

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ABSTRACT: *Field experiment was conducted at Lower Niger River Basin Development Authority, Ejiba in 2016 and 2017 cropping seasons to investigate the effect of Siam weed (Chromolaena odorata L.) residues, phosphorus fertilizer and manure application time on soil properties, growth and root yield of sweet potato in acidic soil. Treatments constituted of 4 x 4 factorial arrangements in a Completely Randomized Block Design. Four levels of amendments which were 5t/ha Chromoleana odorata residues, 60 kg/ha phosphorus, 2.5t/ha Chromoleana odorata residues plus 30 kg/ha phosphorus, No Chromoleana odorata residue and no single superphosphate fertilizer (control) and four levels of time of application of the residues which were three (3) weeks before planting (3WBP), manure application at planting (ATP), manure application at three (3) weeks after planting (3WAP) and manure application at six (6) weeks after planting (6WAP). Data on soil pH, growth and yield parameters were collected and subjected to analysis of variance. Significantly different means were separated using Duncan Multiple Range Test at 5% level of probability. The results indicated that soil acidity increased in plots with mineral fertilizer alone in both years. Plot with combined application of Chromolaena odorata residues and phosphorus at reduce rate were better in all the growth and yield characters compared with plots with either Chromolaena odorata residues or phosphorus fertilizer alone. The least values of vine length shoot weight, number of primary branches, and number of tubers per plant, weight of tubers per plant and tuber weight per land area occurred in the control plots. When Chromolaena odorata residues were applied 3 weeks before planting, maximum growth and yield characters were observed. Manure Applied at three (3) weeks before planting gave best growth and yield of sweet potato in this experiment. Application of Chromolaena odorata residues at 2.5 t/ha combined with phosphorus at 30 kg/ha is therefore recommended to the sweet potato farmers for maximum production of sweet potato. Also, Chromolaena odorata residues should be applied into the soil three (3) weeks before planting as it gives maximum values performance parameters.*

KEYWORDS: Siam weed, *Chromolaena odorata*, phosphorus, manure, potato

INTRODUCTION

Sweet potato (*Ipomea batata*) rank third to cassava and yam in Nigeria as an important tuber crop, contributing to the people food requirement (Karam *et al.*,2009). It serves as

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famine relief crop and it importation increase the income of the farmers (Karam *et al.*, 2009). The productivity of the crop is becoming low mainly due to poor soil fertility. Declining soil fertility and high acidity are fundamental causes of declining crop yields (Sanchez *et al.*, 1997). As the soil pH declines, the supply of most plant nutrients decreases while aluminum and a few micronutrients become more soluble and toxic to plants. These problems, according to Harter (2007), are particularly acute in humid tropical regions that have been highly weathered. The use of agricultural waste has been found to improve the availability of nutrients in the soil, increase crop yields and activities of soil micro organisms due to amelioration of soil pH (Ano and Agwu, 2005; Kekong *et al.*,2010; Undie *et al*., 2013). (Okpara *et al*., 2007) report significant increase in plant height, number of branches per plant, leaf area index, crop growth rate, total dry matter and grain yield per unit area due to phosphorus application. Considering the low nutrient status of Savanna soils particularly, nitrogen and phosphorus as well as organic matter, there is the need for the use of organic fertilizers for increased and sustainable growth and yield of crops.

Organic sources can be an effective source of major nutrients (nitrogen (N), phosphorus (P), and potassium (K) when applied at optimum rates and can influence the temporal dynamics of nutrient availability, increase water use efficiency of crops (Carter *et al*., 1993), decrease soil P fixation and enhances P availability in the soils (Iyamuremye and Dick, 1996)

Phosphorus, an essential nutrient for crop growth and yield is deficient in most Nigeria soils. It plays a vital role in energy transformation and photosynthesis. Addition of P Fertilizer enhances root development, which improves the supply of other nutrients and water to the growing parts of the plants, resulting in an increased photosynthetic area and thereby more dry matter accumulation (Ali *et al*., 2010). It is the second most deficient plant nutrient element (Kamara *et al*., 2011). Crops need phosphorus for good seed and tuber formation (Iyamuremye and Dick, 1996). Phosphorus also promotes root growth, enhances nutrient and water use efficiency and increases yield. Due to the important role played by phosphorus in the physiological processes of plants, application of phosphorus to soil deficient in the nutrient leads to increase crop yield.

The objective of this study was to determine the effect of combined application of Siam weed residues, phosphorus fertilizer and time of application of the residues on soil pH, growth and root yield of sweet potato in acidic soil.

MATERIALS AND METHODS

Experimental area

Field experiments were conducted at Lower Niger River Basin Development Authority farm, Ejiba in 2016 and 2017 cropping seasons. Ejiba is located in the Southern Guinea Savanna Ecological Zone of Nigeria of Latitude 8˚18'N and Longitude 5˚39'E. The site is 453m above sea level. The major soil order within the experimental site is Ultisols (Ajiboye and Ogunwale, 2010).

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Treatment
Treatments constituted of 4 x 4 factorial arrangements in a Completely Randomized Block Design. Each treatment was replicated three times. Four levels of amendments were 5t/ha *Chromoleana odorata* residues, 60 kg/ha phosphorus, 2.5t/ha *Chromoleana odorata* residues plus 30 kg phosphorus, No *Chromoleana odorata* residue and no single superphosphate fertilizer (control) and four levels of time of application of the residues which were 3 week before planting (3WBP), manure application at planting (ATP), manure application at 3 weeks after planting (3WAP) and manure application at 6 weeks after planting (6WAP). Single superphosphate fertilizer was used as phosphorus source.

The experimental field plot size of 67 m x 14 m was laid out into three (3) blocks with 1m guard row between the blocks. Each block was sub-divided into sixteen (16) plots of size 5m x 4 m having 0.5 m guard between them. These two factors were tested on sweet potato variety Offa (a local variety). Urea (46% N) fertilizers were used to supply nitrogen at the rate 90kgN/ha. Weeding was done at 3 and 8 weeks after sowing. The same treatment was allotted to each plot for the 2 years of study.

Soil analysis
Before the commencement of the experiment, surface soil samples (0 - 5cm depth) were taken from each plot. The samples were bulked, air-dried and sieved through a 2mm sieve and analyzed for pre planting soil samples, particle size, soil organic matter, total N, P, K, Ca, and Mg. Soil samples were collected at 20 days intervals on per plot basis, the samples were analyzed for soil pH analyses. Soil pH was measured with a glass-electrode pH-meter on 1:1 soil solution mixture.

Determination of growth and yield parameters
Ten plants were randomly selected at the centre of each plot for data collection. Vine length and leaf area per plant were determined at 60 days after planting when the sweet potato plant reaches its peak growth, with a measuring tape from the ground level to the tip of the vine. Leaf area determination was done by using leaf area meter. At harvest, root tubers were removed, Number of tubers per plant was counted and their fresh weights recorded.

Data analysis
Data on soil pH, growth and yield parameters were collected and subjected to analysis of variance. Significantly different means were separated using Dumcan Multiple Range Test at 5% level of probability.

RESULTS AND DISCUSSION

The condition of the experimental site before the experiment is presented in Table 1. The results indicated the soil to be sandy clay loam with pH range of 6.2 and 6.7. The bulk density range between 1.36 and 1.51 g/cm^3. The soils had total porosity that range between 38.4 and 40.6%. The soils are low in organic matter (1.56 – 1.96 %), low in soil nutrients, such as nitrogen, available phosphorus and exchangeable cat ions. Amendment in the form of organic residues would benefit both the soils and crops. Decline soil fertility and high

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acidity are fundamental cause of declining crop yields (Sanchez *et al*., 1997). The composition of the Siam weed used in the experiment is presented in Table 2. The residues contain the essential nutrients required for the growth and development of crops. Considering the low nutrients status of savanna soils particularly nitrogen and phosphorus as well as organic matter, there is the need for the use of organic fertilizers for increased and sustainable growth and yield of crops ((Ano and Agwu, 2005). Organic sources can be an effective source of major nutrients (nitrogen (N), phosphorus (P) and potassium (K) when applied to the soil and can influence the temporal dynamics of nutrient availability (Paul and Beauchamp, 1993), increase water use efficiency of crops (Carter et al., 1992), decrease soil P fixation and enhance P availability in the soils (Iyamuremye and Dick, 1996).

Table 3 presents the effects of siam weed residue, single superphosphate fertilizer and timing of application of manure on the soil pH. The results indicated that soil acidity increased in plots with mineral fertilizer alone in both years. Significant increase in soil pH occurred in plots with *Chromolaena odorata* residues application either singly or in combination with phosphorus at reduce rate at 80 days after sampling (Table 3). Ano and Agwu (2005), Kekong et al. (2010) and Undie (2013) reported that application of agricultural waste such as plant residues reduces soil acidity level by ameliorating soil pH level.

Timing of siam weed residue application significantly affects soil pH level at 30 days samplings. Siam weed residue continued to improve the soil pH level upto 60 days after siam weed application after which soil pH begin to decline. The implication of which indicate that siam weed residues total mineralization occurred within 60 days of application. This may be due to the low C/N ratio (11.34) which indicated that rate of mineralization could be high. Application of siam weed residues at time of planting improve soil pH better at 80 days sampling. The increase in soil pH due to application of organic matter in this study is consistent with the results reported by Cong and Merckx (2005) and Narambuye and Haynes (2006). The increase in the soil pH can be attributed to the high ameliorating effect of siam weed on soil ph when applied three (3) weeks before planting.

Effect of siam weed residues, single superphosphate and time of application of the residues on growth and yield characters of sweet potato are presented in Table 4. Significant difference was observed in vine length, shoot weight, number of primary branches, and number of tubers per plant, weight of tubers per plant and tuber weight per land area. Plot with combined application of siam weed residues and phosphorus at reduce rate were better in all the growth and yield characters compared with plots with either siam weed residues or phosphorus fertilizer alone. The least values of vine length shoot weight, number of primary branches, and number of tubers per plant, weight of tubers per plant and tuber weight per land area occurred in the control plots. Potato performed best in terms of growth and yield with integrated application of organic and inorganic sources of nutrients. Kang and Balasubramanian (1990) found that high and sustainable crop yields could be obtained with judicious and balanced fertilizer combined with organic residues as amendment.

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Adeniyan and Ojeniyi (2005) also reported a higher growth and yield characters of maize from a combine used of NPK fertilizer and poultry manure than the sole applications. The better performance of sweet potato with combined application of siam weed residues and phosphorus fertilizer could be attributed to better nutrient use efficiency. Murwira and Kirchmann, (1993) have observed that nutrient efficiency of crop increase through a combined application of organic manure and mineral fertilizer. Among the sole application plots, plots with siam weed residues were better compared with plots with phosphorus fertilizer alone. This could so because siam weed residues supplies all the major nutrients (macro and micro nutrients) required for the growth and development of crops while phosphorus fertilizer furnished the soil with phosphorus alone. Growth and yield of potato was least in the control plots. Padwick (1983) observed that many tropical soils show nutrients deficiency problems in phosphorus and nitrogen and consequently a decrease in crop yield. This could be responsible for the low yield of sweet potato in the control plots.

Significant difference were observed in vine length, shoot weight, number of primary branches, and number of tubers per plant, weight of tubers per plant and tuber weight per land area. Plots with siam weed residues application 3WBP recorded the highest values of vine length shoot weight, number of primary branches, and number of tubers per plant, weight of tubers per plant and tuber weight per land area. This was followed by plots with siam weed residues application at planting, then plots with siam weed application at 3WAP followed, while the least values of vine length, shoot weight, number of primary branches, and number of tubers per plant, weight of tubers per plant and tuber weight per land area were observed in plots with siam weed residues application at 6WAP.

The highest values of growth and yield characters were obtained when residues was applied at 3WBP while the least values in both years 2016 and 2017 were observed in plots with 6WAP. This was attributed to the synchrony in the time of availability of sufficient amount of nutrients from siam weed residues in the soil proportional with the demand of the plant uptake. Thus applying siam weed at 6WAP is perhaps wastage as the potato does not have the capacity to use the nutrients in any significant amount at this stage of growth. This result is corroborated by that of Cassman *et al.* (2002) who reported that synchrony between crop demand and nutrient is necessary to improve nutrient use efficiency and better growth of plants. Kolawole (2014) also reported similar result using poultry manure applied at 2WBP improves maize grain yield and nutrient uptake compared with poultry manure applied at 2WAP and at planting.

CONCLUSION

The study revealed that application of siam weed residue significantly improves soil pH. Growth and yield performance of sweet potato were found to be improved when siam weed residues and phosphorus were combined at reduce rates. When siam weed residues were applied 3 weeks before planting, maximum growth and yield characters were observed. Application of siam weed residues at 2.5 t/ha combined with phosphorus at 30 kg/ha is therefore recommended to the sweet potato farmers for maximum production of sweet

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potato. Also, the siam weed residues should be applied into the soil 3 weeks before planting as it gives maximum values performance parameters.

Table 1. Properties of the soils at the sites of the experiment

	2016	**2017**
Particle size (g kg^{-1})		
Sand	607	672
Clay	216	156
Silt	177	172
Soil texture	Sand clay loam	Sand clay loam
Soil pH1:2.5 soil: water	6.2	6.7
Bulk density (g/cm^3)	1.36	1.51
Total porosity (%)	38.4	40.6
Organic matter (%)	1.58	1.96
T0tal N (%)	0.18	0.21
Available P(mgkg^{-1})	2.01	2.56
Exchangeable cation (cmolkg^{-1})		
K	0.28	0.48
Ca	2.54	1.78
Mg	2.93	1.43
Na	1.66	1.87

Table 2. Chemical composition of siam weed *Chromoleana odorata* L used in the experiment

Properties	Siam weed shoot
Organic carbon (%)	46.96
Total N (%)	4.14
C:N	11.34
Phosphorous (%)	1.48
Potassium (%)	1.67
Calcium (%)	1.15
Magnesium (%)	0.67

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Table 3.Effect of Siam weeds residues, single superphosphate fertilizer and time of application of the manure on soil pH

Treatment	SOIL pH							
	2016				2017			
	Sampling dates				Sampling dates			
	20	40	60	80	20	40	60	80
CH_0P_0	5.48	5.47	5.24	5.18	6.21	6.18	6.15	6.04
CH_5P_0	5.49	5.51	5.73	6.11	6.30	6.33	6.47	6.66
CH_0P_{60}	5.44	5.44	5.40	5.32	6.24	6.25	6.24	6.18
$CH_{2.5}P_{30}$	5.48	5.51	5.67	5.88	6.21	6.23	6.28	6.36
LSD	ns	ns	0.21	0.36	0.04	0.11	0.07	0.24
3WBP	5.40	5.64	5.67	5.61	6.40	6.56	6.73	6.70
APT	5.37	5.34	5.96	6.22	6.28	6.27	6.53	6.87
3WAP	5.48	5.46	5.69	6.06	6.24	6.23	6.31	6.36
6WAP	5.36	5.40	5.34	5.78	6.21	6.22	6.24	6.33
LSD	ns	0.11	0.19	0.24	0.06	0.13	0.28	0.09
Fer x AT	ns	ns	ns	ns	ns	ns	ns	ns

Legend:
CH_0P_0 = no chromolaena odorata residues, no phosphorus (control), CH_5P_0 = chromolaena odorata residues alone at5t/ha, CH_0P_{60} =phosphorus at 60kg/ha and $CH_{2.5}P_{30}$ = chromolaena odorata residues alone at 2.5 t/ha and phosphorus at 30kg/ha 3WBP= application Three (3) weeks before planting, APT= application at planting, 3WAP=application Three (3) weeks after planting and 6WAP= application six (6) weeks after planting

Table 4. Effect of Siam weeds residues, single superphosphate fertilizer and time of application of the manure on growth character of sweet potato

Treatment	Growth characters of sweet potato					
	Vine length(m)		Shoot weight		Number of 1^o branches	
	2016	2017	2016	2017	2016	2017
CH_0P_0	1.31	1.59	07.71	08.11	4.46	5.14
CH_5P_0	2.56	2.48	17.75	16.66	7.56	7.32
CH_0P_{60}	2.13	2.41	16.34	18.42	6.44	6.13
$CH_{2.5}P_{30}$	2.64	2.94	18.14	19.42	7.21	7.36
LSD	0.46	0.32	2.41	3.61	1.71	0.96
3WBP	2.82	2.68	18.49	17.66	6.41	6.23
APT	2.82	2.63	17.13	16.32	6.27	5.16
3WAP	1.94	2.07	12.74	13.31	4.87	5.21
6WAP	1.29	1.41	08.41	10.16	3.96	3.78
LSD	0.41	0.62	3.44	4.11	1.44	1.48
Fer x AT	ns	ns	ns	ns	ns	ns

Legend:

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CH_0P_0 = no chromolaena odorata residues, no phosphorus (control), CH_5P_0 = chromolaena odorata residues alone at5t/ha, CH_0P_{60} =phosphorus at 60kg/ha and $CH_{2.5}P_{30}$ = chromolaena odorata residues alone at 2.5 t/ha and phosphorus at 30kg/ha
3WBP= application Three (3) weeks before planting, APT= application at planting, 3WAP=application Three (3) weeks after planting and 6WAP= application six (6) weeks after planting

Table 5. Effect of Siam weeds residues, single superphosphate fertilizer and time of application of the manure on root yield of sweet potato

Treatment	**Yield characters of sweet potato**					
	Number of tubers/plant		Weight of tubers/plant (kg)		Weight per land area (t/ha)	
	2016	2017	2016	2017	2016	2017
CH_0P_0	3.4	4.3	1.06	1.33	10.1	13.3
CH_5P_0	4.5	4.2	1.62	1.51	16.2	15.1
CH_0P_{60}	5.1	5.4	1.94	2.21	19.4	22.1
$CH_{2.5}P_{30}$	8.4	6.9	3.44	2.83	34.4	28.3
LSD	2.41	1.66	0.49	0.44	4.88	5.11
3WBP	7.4	6.9	2.67	2.48	26.7	24.8
APT	6.3	6.9	2.27	2.48	22.7	24.8
3WAP	5.3	5.6	1.91	2.02	19.1	20.2
6WAP	4.9	3.6	1.76	1.30	17.6	13.0
LSD	1.17	1.24	0.38	0.56	3.97	4.51
Fer x AT	ns	ns	ns	ns	ns	ns

Legend:
CH_0P_0 = no chromolaena odorata residues, no phosphorus (control), CH_5P_0 = chromolaena odorata residues alone at5t/ha, CH_0P_{60} =phosphorus at 60kg/ha and $CH_{2.5}P_{30}$ = chromolaena odorata residues alone at 2.5 t/ha and phosphorus at 30kg/ha
3WBP= application Three (3) weeks before planting, APT= application at planting, 3WAP=application Three (3) weeks after planting and 6WAP= application six (6) weeks after planting

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