

Evaluation of Organic Fertilizer Potentials of Different Forms of Siam Weed (*Chromolaena odorata*) Phyto-residues for Improved Performance of Late Season Maize (*Zea mays*) under Guinea Savanna Ecoregion of Nigeria

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Abstract- Application of different organic residues to soils as amendments in diverse forms is a common agronomic practice, especially nowadays that the awareness on the needs for organic agriculture in the tropics is meaningfully increasing. However, there is dearth of information about the best form or nature of applying these phyto-residues which will ensure maximum utilization of their nutrients by crop plants. Field experiment was conducted during the late cropping season of the year 2015, at the Teaching and Research Farms, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, in Oyo state, Nigeria to evaluate different forms of siam weed (*Chromolaena odorata*) biomass for improved performance of maize (*Zea mays*). It was a split plot experiment with three (3) different forms of chromolaena biomass (composted, green and dried), as the main plot, while five (5) different rates (0.0, 1.5, 3.0, 4.0 and 6.0 tons ha⁻¹) were the sub plots. For referencing, NPK fertilizer application at the recommended rate of 400 Kg ha⁻¹ was also included as a treatment. The experiment was laid out in Randomized Complete Block Design (RCBD), replicated thrice. Data collected on growth and yield parameters were subjected to analysis of variance (ANOVA), at p<0.05. Forms of application of chromolaena biomass significantly influenced growth, yield and nutrient uptakes of maize, which increased significantly with increasing rates of application till 4.0 tons ha⁻¹, comparable to the control. Significantly higher grain and total dry biomass yields of 5.5 and 11.10 tons ha⁻¹ were obtained from application of composted chromolaena phyto-residues at 4.0 tons ha⁻¹, comparable to dried chromolaena application and the control. Two distinctive patterns or orders were observed in terms of maize growth / developmental responses to the applied treatments. The growth parameters followed the order; NPK fertilizer > green chromolaena > composted chromolaena > dried chromolaena > control, while the yield parameters followed the order; composted chromolaena ≥ green chromolaena > NPK fertilizer > dried chromolaena > control. Thus, 4.0 tons ha⁻¹ of chromolaena biomass, which could be applied as either green or composted plant residues, is therefore recommended in the study area.

Keywords: Maize, soil amendment, siam weed, forms of application, crop performance and guinea savanna

I. INTRODUCTION

Maize (*Zea mays*) is an annual monocotyledonous arable crop. It is often referred to as corn. It is a member of the grass family Poaceae. Globally, maize is ranked third in the order of importance amongst the cereals i.e. after wheat and rice (FAO, 2000). In Africa, particularly in Nigeria, maize is commonly found to be solely cropped (i.e. mono cropping), or under mixed cropping farming system in combination with other arable crops like cowpea, yam, cassava, soybean etc. It is commonly grown in the rainforest and savannah zones of Nigeria, and its popularity does not depend only on its versatility, but also on its adaptability and improved performance, under varying edaphic and

climatic conditions (Akanbi, 2002; Makinde and Ayoola, 2010). It grows on a wide range of climatic and soil conditions. Although a pH range of 6.0 to 7.0 is the most suitable for maize production, it can still perform reasonably at pH values ranging from 5.0. to 8.0, particularly when the soil is a well drained, well aerated loam or silt loam, with adequate organic matter content and essential nutrients (Akanbi et al., 2006). Maize is grossly consumed domestically and industrially all over the World. Its grains contain approximately 76 -88 % carbohydrate, 6-15% protein, 4.5-7.0% fat and 1.3% minerals as reported by Ogoke, (1999). The maize kernel is made up of 83% of total dry weight, 11% germ, 5% pericarp and 1% pedicel. The proteins in the endosperm of maize are of three types which are prolamine, albumin and glutelin (Okoruwa and Klingman, 1996). Maize is known to be relatively high in carbohydrate content which makes it to be widely suitable for human consumption, as well as for livestock feeding and raw materials for local industries, particularly in the breweries, edible oil, alcohol and starch producing industries (FAO, 2000). As earlier indicated, maize thrives under different soil and climatic conditions, but highly responsive to improved soil nutrition (Akanbi, 2002).

Akanbi, (2002) and Babajide et al. (2008) emphasized the essentials of stabilizing agricultural systems particularly in the humid and sub-humid tropics via regular and adequate maintenance of soil organic matter. This could directly link the relevance of the maintenance (as well as regular additional supply) of soil organic matter to soil nutritional status and crop productivity. Poor soil management practices which do not encourage maintenance / improvement of the soil organic matter had been reported to adversely influence the general soil health and crop productivity (Babajide et al., 2008; Babajide et al., 2012). Apart from the fluctuating weather conditions, the undesirable levels of most arable crops' yield in Nigeria today could be majorly traced down to abusive use of agro-chemicals, particularly chemical fertilizers and the undesirable cultural practices adopted by the tropical farmers. However, in the course of enforcing optimum crop performance out of the marginal tropical soils, farmers opted for incessant and abusive application of synthetic fertilizer materials, which overtime may have adverse effects on soil fertility conditions and induce more fatal threats to beneficial soil microbes, man and animals alike. The reported side effects of continuous agro-chemicals' application include soil acidity, eutrophication, toxic nitrate pollution of surface and underground waters, increased runoff etc. (Tejada et al., 2005; Olabode et al., 2007). Such undesirable soil conditions are currently a major concern and indeed a major threat to sustainable crop production. However, this demands more emphasis and researches on organic agriculture which totally disallows the use of any synthetic materials on agricultural lands. This promotes the usage of organic manures as soil amendments. Meanwhile, several organic materials have been reported as suitable soil amendments for increasing crop production and soil quality. These include green manure, cow dung, poultry droppings, municipal waste, compost, farmyard manure etc. (Nziguheba et al., 2002; Makinde and Ayoola, 2010). In addition, apart from supplying nutrients which could be slowly released to meet crop requirements, application of organic and biological materials had been reported to possibly supply growth-regulating substances which improved the physical, chemical and microbiological properties of the soil (Babajide et al., 2012; Babajide, 2014).

Amongst the reported potential organic fertilizer materials is Siam weed (*Chromolaena odorata*), which is a common tropical and sub-tropical weed. *Chromolaena odorata* is a flowering perennial shrub in the sunflower family; Asteraceae. Like Sunflower, Siam weed is a fast growing perennial plant, which is native to South America and Central America. The plant is known to grow aggressively and extensively by considerably outgrowing many other competing weeds surrounding it, even on marginal lands (Obatolu and Agboola, 1993; Ojeniyi and Adetoro, 1993). It was probably introduced to Nigeria in the late 1930s, via timber trading from Sri Lanka. It is currently regarded as a notorious weed in Nigeria. Siam weed is found to be predominant on many abandoned waste-lands, fallowing agricultural fields, beside highways, waterways and cultivated farmlands (Babajide, et al., 2010; Ojeniyi et al., 2012). Although, due to its attributed offensive odour and relatively high level of polyphenol which repels most livestock from consuming it, the plant is not yet successfully established as a potential natural forage but, *Chromolaena odorata* is relatively high in nutrients, particularly N and K, and could be applied as organic fertilizer (Ojeniyi et al., 2012). *Chromolaena* is not a legume, and does not biologically fix atmospheric nitrogen, it obtains its nutrients through effective retrieval of nutrients from the soil. *Chromolaena* phyto-residues are useful fertilizer materials that could be used by farmers for economic management of their farmlands, in order to ensure improved crop yield and conservation of soil moisture (Ojeniyi and Adetoro, 1993; Jamilah, 2011). Organic crop production involves the use of plant and animal materials / wastes such as farmyard manure, green manure or compost as a fertilizer. Compost can comprise of organic materials e. g. grasses, weed, crop trimmings, kitchen wastes and other residues. These are stimulated into a state of decomposition by the addition of water and manure (Akanbi, 2002). Organic manures (including green manure), generally improve soil Cation Exchange Capacity (CEC), ensures a slow release of its nutrients but maintains nutrients availability and soil fertility for a long period of time (Babajide et al., 2008; Babajide and Olayiwola, 2014). It is therefore reasonable to research into environment-friendly, organic-based low-input technology which may encourage the application of freely growing tropical weeds in

different forms, which will alleviate or totally eliminate usage of toxic and highly priced synthetic fertilizers. This experiment was designed to assess the organic fertilizer potentials of different forms of siam weed (*Chromolaena odorata*) biomass for improved performance of maize in the study area.

II. MATERIALS AND METHODS

2.1 Description of experimental site

This research was a field experiment conducted between August and November, 2015, at the Teaching and Research Farms, Ladoké Akintola University of Technology (LAUTECH), Ogbomoso, in Oyo state, Nigeria, to evaluate the response of maize to different forms of chromolaena phyto-residues. Ogbomoso is on latitude 8° 10' N and longitude 4° 10' E. This also falls under the southern guinea savanna ecoregion of the south-western Nigeria. Ogbomoso has bimodal rainfall distribution i.e. having the early rainy season which usually starts yearly from late March and ends in late July / early August. It is normally followed by a short dry spell in August. Finally, the late rainy season starts from August to November every year (Babajide et al., 2017). The soil sample used was an Alfisol belonging to Egbeda soil series (Smyth and Montgomery, 1962). The experimental site had been under cultivation of intercropped arable crops (yam and guinea corn), for more than five years, before this experiment was set up.

2.2 Land clearing and preparation

Land clearing and preparation were carried out manually, following farmers' conventional practice, using hoe, cutlass, mattock, rake, e.t.c. After the cutting down of the vegetations on the field, land preparation was done by demarcating the experimental plot into desired number of plots for the construction of beds accordingly. Each plot size was 1.5m × 2.0m. The sowing spacing was 75cm x 25cm, while the spacing between the beds was 1.0m × 1.0m and between the replicates was 1.5m × 1.5m.

2.3 Soil sampling and analysis

After land clearing / preparation and harvesting, the soil samples were collected by placing the soil auger at a depth of 0-15 cm, across the farm plots, for laboratory analyses of the soil physical and chemical properties, which were later composited into one. The composite sample was then prepared for routine analyses following the procedures contained in I.I.T.A., (1982). From the collected soil samples, unwanted materials such as debris, steel, stone and other foreign particles were carefully removed. The composite auger sample was air dried, crushed and sieved through 2 mm and 0.5 mm meshes for the determination of particle size, pH (H₂O), total nitrogen (N), organic carbon, and available phosphorous (P), Iron (Fe), copper (Cu), zinc (Zn), the exchangeable cations (Ca, Na, Mg and K). The particle size analysis was carried out according to the Bouyoucos (1951) hydrometer method, using sodium hexametaphosphate as the dispersant. Soil pH was determined in a 1:1 soil: water ratio and 2:1 soil: KCl ratio (IITA, 1982). Available phosphorus was determined using Bray and Kurtz P-1 method (Page et al., 1982). Total nitrogen was determined by the micro Kjeldal method (Bremner and Mulvaney, 1989). The exchangeable K and Na were determined using the EEL flame photometer while Ca and Mg were estimated using Versenate titration method, and the organic carbon was determined using the Walkley and Black method (Nelson and Summers, 1982). The soil textural class was determined from the soil textural triangle.

2.4. Preparation of different chromolaena forms

The chromolaena biomass used was obtained from the fallowing arable plot at LAUTECH'S Teaching and Research Farms. Fresh chromolaena plants were cut green and shredded (into smaller fragments of less than 5 cm in length with stem girths were ranging from 1.9 - 4.3 cm). These were applied fresh to the soil and mixed thoroughly as green chromolaena-biomass at two weeks before sowing. Also, the dry chromolaena were prepared similarly (i.e. cut and shredded) like the green chromolaena, but in addition, were subjected to air drying for fourteen (14) days, to reduce the moisture content to about 6 %, before application at two weeks before transplanting. For the composted chromolaena, the compost was prepared mainly from chromolaena phyto-residues and cured poultry manure. The chromolaena stems used for compost making were cut green and treated as for the dry chromolaena above, while the cured poultry manure used was obtained from the layers' poultry section of the livestock production unit at the Teaching and Research Farms, LAUTECH, Ogbomoso. The chromolaena plant materials were first air-dried for fourteen (14) days were composted as contained in Babajide, (2010) thus; under the shade of *Gmelina arborea*-*Tectona grandis* plantation located at the opposite side of the Faculty of Agricultural Sciences, LAUTECH, Ogbomoso, a wooden frame of compost bin with a base of 3m (length) by 2m (breadth) and 5m height was erected. Wooden planks of about 10cm wide were nailed at interval of 30cm round the frame. It was a roofless structure with a door-like opening which allows entrance into the structure. The walls and the floor were not cemented to ensure proper ventilation into the structure and water drainage out of the structure as required. When the materials to be

composted were ready, the floor and the walls were carefully lined with a big jointed fertilizer sack on which ten (10) layers of siam weed biomass and cured poultry manure were laid in ratio 3:1 respectively. Each layer consists of 30kg siam weed biomass and 10kg poultry manure. At the completion of the layering, vertical insertion (through the core of the manure) of three plastic pipes of 2.5m long and 10 cm in diameter were carried out. This reduces excessive heating up of the manure. The layers were finally covered with a thin layer of good topsoil, to enhance microbial population of the compost. Adequate watering which allows even saturation of the manure layers with water was done immediately (Babajide, 2010; Babajide, et al., 2012). Stone, metals and other foreign / non-biodegradable materials were carefully removed from the manure before air drying for ten days.

2.5 Manure and phyto-residue samplings

Samples were randomly collected from both the siam weed plant materials and cured manure for laboratory chemical analyses using standard methods (IITA, 1982). Also, at maturity, samples were randomly collected from manure for laboratory chemical analyses using standard methods (IITA, 1982).

2.6 Treatments and experimental design

A total of fourteen (14) treatments tested were introduced namely: three (3) different forms of morphologically modified chromolaena biomass (composted, green and dried), applied at four (4) different rates (1.5, 3.0, 4.0 and 6.0 tons ha⁻¹) each, the referential application of NPK 15:15:15 fertilizer (at the recommended rate of 400 Kg ha⁻¹) and the control (which received no fertilizer application). The experiment was laid out in Randomized Complete Block Design (RCBD), replicated three times.

2.7 Seed propagation and cultural practices

Seeds of a Downy mildew resistant variety (DMR-L-SR-Y) obtained from the International Institute of Tropical Agriculture (IITA), Ibadan was used. Four seeds were sown per hole at a spacing of 75 cm x 25 cm. The emerged seedlings were later thinned to one per stand at two weeks after sowing. Although the experiment was a late season or dry season experiment, the weather conditions were really favourable enough, and the trial was purely a rain-supported. Hence, no artificial watering was employed throughout the experiment. Manual weeding was done using hoes. Manure was incorporated into the soil at two weeks before sowing. This was done by carefully burying the plant residues in the respective plots during land preparation. Application of NPK 15-15-15 fertilizer was done at the rate of 400kg Nha-1 at three (3) weeks after sowing, to the respective plots only.

2.8 Data collection

Data were collected on some maize growth and yield parameters. Data collection on growth parameters commenced at ten week after sowing (10 WAS) on: plant height, stem circumference, leaf length and leaf width. Plant height was determined by using measuring tape placed at the above ground base of the plant and allowed to run to the plant's tip), stem girth (by using venier calipers place at the 20cm height of each plant, the value obtained was referred to as the stem diameter, which was later converted to girth or circumference by a fomular: πD (i.e.3.142 multiplied by the original diameter (D) value as obtained from the reading with the venier calipers). Also determined were leaf length and leaf width. The leaf length was by directly placing the measuring tape on the base of selected leaf and run it on the surface of the leaf to the apex, while the leaf width was determined by placing the measuring tape horizontally at exactly 10cm point from the base of each of the selected leaves. However, at the termination of the experiment, the yield parameters measured were ear fresh weight, cob dry weights, grain dry weight, above ground and below ground biomass dry weights, using Mp 600H electronic weighing balance.

2.9 Plant Sampling and Analysis

Harvesting of maize cobs commenced on 92nd day after sowing. Harvesting was done manually by plucking with hands. Immediately after the termination of the experiment, the harvested plant samples were first weighed, using an electronic weighing balance of model Citizen Mp 600H, to determine the sample dry weights. The samples were later oven dried at 80°C for 72 hours to a constant weight, according to the procedures described by IITA (1982) and Babajide et al (2012), followed by the determination of nutrient concentrations and uptakes. Total N was determined by micro-Kjeldahl method. The P was determined using vanadomolybdate colorimetry, and K by flame photometry. The nutrients accumulated in plant parts were then calculated as; Nutrient uptakes = % Nutrient content X sample dry weight (Ombo, 1994; Gungula, 1999).

2.10 Statistical analysis

Data collected on growth and yield parameters were subjected to analysis of variance (ANOVA), at $p < 0.05$ (SAS, 2015). Significant means were separated using Duncan Multiple Range Test (DMRT).

III. RESULTS AND DISCUSSION

It was inferred from the results obtained from the soil physicochemical laboratory analyses that the soil was acidic with a pH (H₂O) value of 6.10. Also, it was texturally sandy-loam; sand (85.24 %), silt (9.60 %) and clay (5.16 %), grossly low in the major essential nutrient concentrations with total N (0.26 gkg⁻¹), extractable P Bray 1 (1.41 mgkg⁻¹), Organic carbon was 2.32 g kg⁻¹ and the exchangeable bases (in Cmol kg⁻¹) were K⁺ (0.24), Ca⁺ (0.19), Mg²⁺ (0.42) and Na⁺ (0.28). These results are in line with the reports of Olabode et al., (2007) and Babajide et al., (2008) that the soils in the study area are marginal and grossly low in essential nutrient concentration, and therefore require additional nutrients' supply, in order to ensure dependable soil nutrition for improved crop performance. All the forms of chromolaena biomass tested were mildly acidic in nature, with the pH values ranging from 6.62 to 6.71 (Table 2). However, the nutrient concentrations determined in the different forms of chromolaena biomass investigated were relatively high, comparable to most of the commonly used organic manures. Organic carbon was highest (44.20gkg⁻¹) in composted chromolaena, followed by 42.60gkg⁻¹ in green chromolaena biomass, while the least organic C (38.50gkg⁻¹) was found in dried chromolaena biomass. Other macro and micro nutrient elements determined followed similar trend (Table 2). These results are in support of earlier researchers who reported that organic manures are reservoirs of nutrients, and could be used as dependable alternatives to synthetic fertilizers, by supplying both the major and minor nutrients in required quantities to meet crop needs for improved growth and yield (Nziguheba et al., 2002; Bahman et al., 2004). Irrespective of forms of chromolaena applied, growth and yield parameters of maize significantly ($p < 0.05$) increased with increasing rates of chromolaena biomass application (Table 3). The steady increments were observed in all forms of application till application rate of 4.0 tons ha⁻¹ after which, the values either diminished or constant (Table 3). Although, the significantly ($p < 0.05$) higher values were mostly observed in the growth and yield parameters of maize plants which received any form of chromolaena biomass at 4.0 tons ha⁻¹, the values were not significantly different from one another, especially between those plants which received either the composted or the green biomass (Table 3). Generally, two distinctive patterns or orders of maize growth / developmental responses were observed in response to the applied treatments. The growth parameters followed the order; NPK fertilizer > green chromolaena > composted chromolaena > dried chromolaena > control, while the yield parameters followed the order; composted chromolaena \geq green chromolaena > NPK fertilizer > dried chromolaena > control. Significantly higher grain and total dry biomass yields of 5.5 and 11.10 tons ha⁻¹ were obtained from applications of composted chromolaena phyto-residues at 4.0 tons ha⁻¹, which were not significantly different from those obtained from the green biomass application, but are comparable to dried chromolaena application and the control, which received no application of chromolaena biomass (Table 3 and 4). These results are apparently corroborating the findings of Akanbi (2002) and Babajide and Olla, (2014) that organic manures could be used successfully as either an absolute or complete alternatives or supplements to synthetic fertilizers, as the chromolaena biomass applied in different forms compete effectively and successfully with the NPK fertilizer, as significantly higher or statistically similar growth and yield parameters were observed in both organically fertilized and synthetically fertilized maize plants. In terms of nutrient uptakes, application of any fertilizer material significantly influenced nutrient uptakes in maize, irrespective of application rates. The highest N uptake of 7.8gkg⁻¹ was observed in NPK fertilized plants, the value was not significantly different from application of all chromolaena phyto-residues applied especially at 4tons ha⁻¹, but significantly higher than those of the plants which received lower dosages of chromolaena phyto-residues and the control. P uptake was highest in plants which received green chromolaena application at 4.0 tons ha⁻¹, but the value was not significantly different from those obtained from other forms of chromolaena biomass at similar rate, but higher than those at lower levels of biomass application and the control (Table 5). NPK fertilizer had the highest level of K uptake, but the value obtained was not significantly different from those obtained from other forms of chromolaena biomass at same rate of application, but higher than those at lower rates (Table 5). These results are in support of some earlier researchers' like Kumar et al, (1999); Ogbalu, (1999); Folorunso and Ojениyi, (2003); Babajide et al. (2012); Babajide and Oyeleke, (2014) and Babajide et al. (2017), who reported that application of different fertilizers which contain dissimilar nutrient concentrations and of dissimilar sources or origins, may improve soil nutrition, nutrient uptakes and arable crop performance.

IV. CONCLUSION

Maize responded well to siam weed biomass application at different levels, comparable to the control, which received no organic or inorganic fertilizer materials. Siam weed phyto-residues (applied in any of the forms investigated) are potential organic fertilizers, which may be suitable for arable crop production. Regardless of rates

of application, the nutrient uptakes, growth and yield parameters of maize steadily increased significantly with increasing rates of application of all forms of chromolaena biomass, till the application rate of 4.0 tons ha⁻¹ after which, the values remained either constant or diminishing. Most of the significant increments could be reasonably attributed to either the green and composted biomass of chromolaena applied at 4.0 tons ha⁻¹. Thus, 4.0 tons ha⁻¹ of chromolaena biomass, which could be applied either as green or composted plant residues, is therefore recommended, for supplying adequate nutrients required for optimum maize production in the study area. This will favour organic maize production, which may totally eradicate incessant application of harmful chemical fertilizers, which are also known to be highly priced and unaffordable for the resource-poor tropical farmers.

Table 1: The Physico-chemical properties of the Soil Sample used

Soil Properties	Values
pH (H ₂ O)	6.10
Total N (gkg ⁻¹)	0.26
Organic carbon (gkg ⁻¹)	2.32
Available P (mgkg ⁻¹)	1.41
Exchangeable K (cmolkg ⁻¹)	0.24
Fe (mg kg ⁻¹)	2.36
Cu (mg kg ⁻¹)	2.44
Zn (mg kg ⁻¹)	2.30
Exchangeable Na (cmol kg ⁻¹)	0.28
Exchangeable Ca (Cmol kg ⁻¹)	0.19
Exchangeable Mg (Cmol kg ⁻¹)	0.42
Sand (%)	85.24
Silt (%)	09.60
Clay (%)	05.16
Textural class	Sandy loam

Table 2: Chemical properties of different forms of Chromolaena odorata biomass used for the experiment

Properties	Gc	Dc	Mc
pH (H ₂ O)	6.62	6.58	6.71
N (%)	3.59	3.14	3.40
P (%)	0.48	0.40	0.45
K (%)	2.26	2.20	2.28
Ca (g/kg)	7.84	7.62	8.26
Mg (g/kg)	3.66	3.50	4.62
Fe (g/kg)	12.32	12.40	12.60
Zn (mg/kg)	110.62	100.80	124.20
Cu (mg/kg)	28.90	25.61	30.02
Organic C (g kg ⁻¹)	42.60	38.50	44.20

Gc = Green chromolaena, Dc = Dried chromolaena, Mc = Matured chromolaena compost

Table 3: Effect of different forms of Chromolaena odorata biomass application and inorganic fertilizer on selected growth parameters of maize

Treatments	Plant height (cm)	Stem girth (cm)	No. of leaves plant-1	Leaf Area (cm ²)
Control				
0.0 tons ha ⁻¹	104.60d	2.30d	6.00c	320.60c
Green Chromolaena				
@ 1.5 tons ha ⁻¹	148.82c	4.02bc	10.00bc	549.20b
@ 3.0 tons ha ⁻¹	217.40b	4.10bc	12.00a	736.50a
@ 4.0 tons ha ⁻¹	256.60a	5.89a	12.00a	740.50a
@ 6.0 tons ha ⁻¹	255.80a	5.89a	12.00a	730.60a
Dried Chromolaena				
@ 1.5 tons ha ⁻¹	167.40c	3.70bc	8.00bc	489.20b

@ 3.0 tons ha-1	177.20c	4.00bc	11.00a	724.80a
@ 4.0 tons ha-1	235.20a	5.30a	12.00a	740.50a
@ 6.0 tons ha-1	236.60a	5.60a	12.00a	736.60a
Composted Chromolaena				
@ 1.5 tons ha-1	144.20c	3.60bc	8.00bc	522.30b
@ 3.0 tons ha-1	216.30b	5.10a	11.00a	718.40a
@ 4.0 tons ha-1	252.30a	5.80a	12.00a	720.40a
@ 6.0 tons ha-1	249.30a	5.10a	12.00a	722.20a
NPK Fertilizer				
@ 400 kg ha-1	256.80a	5.99a	13.00a	726.40a

Means followed by the same letters within the same column are not significantly different at $p < 0.05$, using DMRT.

Table 4: Effect of different forms of Chromolaena odorata biomass application and inorganic fertilizer on selected yield parameters of maize

Treatments	Weight of 100 grains plant-1 (g)	Grain Yield (tons ha-1)	Total Dry Biomass Yield (tons ha-1)
Control			
0.0	20.40d	0.65d	1.20e
Green Chromolaena			
@ 1.5 tons ha-1	24.50c	2.72c	2.90d
@ 3.0 tons ha-1	41.85ab	4.88ab	8.82b
@ 4.0 tons ha-1	55.20a	5.45a	10.88a
@ 6.0 tons ha-1	45.40ab	5.40a	10.9a
Dried Chromolaena			
@ 1.5 tons ha-1	22.20c	2.70c	2.78d
@ 3.0 tons ha-1	39.80ab	4.00b	6.86c
@ 4.0 tons ha-1	42.50ab	4.20b	8.20b
@ 6.0 tons ha-1	43.80ab	4.85ab	8.28b
Composted Chromolaena			
@ 1.5 tons ha-1	26.80c	2.90c	2.95c
@ 3.0 tons ha-1	43.45ab	4.70ab	8.70b
@ 4.0 tons ha-1	56.69a	5.50a	11.10a
@ 6.0 tons ha-1	54.64a	5.48a	10.86a
NPK Fertilizer			
@ 400 kg ha-1	44.8ab	4.8ab	9.90ab

Table 5: Influence of different forms of Chromolaena odorata biomass application and inorganic fertilizer on the nutrient uptakes of maize

Treatments	Nutrient Uptakes (gkg-1)		
	N	P	K
Control			
0.0	1.92d	0.36d	0.80c
Green Chromolaena			
@ 1.5 tons ha-1	3.78bc	0.46c	1.74b
@ 3.0 tons ha-1	5.20b	0.82ab	1.84b
@ 4.0 tons ha-1	7.20a	0.88a	2.24a
@ 6.0 tons ha-1	6.40ab	0.85a	1.98ab
Dried Chromolaena			
@ 1.5 tons ha-1	2.20c	0.32c	1.72b
@ 3.0 tons ha-1	3.80bc	0.58ab	1.84b
@ 4.0 tons ha-1	6.50ab	0.65ab	1.92ab
@ 6.0 tons ha-1	6.60ab	0.68ab	2.06ab
Composted Chromolaena			

@ 1.5 tons ha-1	3.80bc	0.36c	1.76b
@ 3.0 tons ha-1	5.68ab	0.78ab	1.88b
@ 4.0 tons ha-1	7.60a	0.86a	2.25a
@ 6.0 tons ha-1	7.14a	0.78a	2.24a
NPK Fertilizer			
@ 400 kg ha-1	7.8a	0.85a	2.26a

Means followed by the same letters within the same column are not significantly different at $p < 0.05$, using DMRT.

V. REFERENCES

- [1] Akanbi, W. B. 2002. Growth, Nutrient uptake and yield of maize and okra as influenced by compost and nitrogen fertilizer under different cropping systems. Ph. D. Thesis, Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria pp. 232.
- [2] Akanbi, W.B; Oyediran, G.O; Ogunrinde, J.O; Babajide, P.A. and O.A Olaniran 2006. Organic Fertilization of maize; Effect of plant residue compost rates on performance of maize. International Journal of Applied Agricultural and Apicultural Research (IJAAAR), LAUTECH, Nigeria. Vol. 3 (2); 116-122.
- [3] Babajide, P. A. 2010. Response of Sesame (*Sesamum indicum* Linn.) to Integrated Nutrient Management Approach in an Alfisol, in Oyo State, Nigeria (Ph.D. Thesis), University of Ibadan, Ibadan, Nigeria. 173 pp.
- [4] Babajide, P. A., Akanbi, W. B., Olabode, O. S., Olaniyi, J. O. and Ajibola, A.T. 2012. Influence of pre-application handling techniques of *Tithonia diversifolia* Hemsl. A. Gray residues on growth, seed yield and oil content of sesame (*Sesamum indicum* L.), in south-western Nigeria. Journal of Animal and Plant sciences: Biosciences Vol.15 (2): 2135-2146.
- [5] Babajide, P.A. 2014. Contributions of bio-organo-chemical nutrient management approach to growth, yield and phytochemical composition of sesame (*Sesamum indicum* Linn.), under low fertile alfisol conditions. International Journal of Current Microbiology and Applied Sciences. ISSN:2319-7706. Vol.3 .No.3 (8): 957- 976.
- [6] Babajide, P.A. and Olla, N.O. 2014. Performance of indigenous *Celosia argentea* variety and soil physico-chemical properties as affected by dual application of compost and single N-mineral fertilizer, in southern guinea savanna vegetation zone of Nigeria. Journal of Biology, Agriculture and Healthcare. ISSN 2225-093X. Vol. 4 (19): 69-74.
- [7] Babajide, P.A. and Olayiwola, A.O. (2014). Influence of composted phyto-residues and harvesting frequency on growth and forage potentials of grain amaranth (*Amaranthus cruentus*) under oxic paleult soil conditions. Journal of Natural Science Research. Vol. 4 (17): 115-121.
- [8] Babajide, P.A. and Oyeleke, O.R. (2014). Evaluation of Sesame (*Sesamum indicum* Linn.) for optimum nitrogen requirement under usual farmers' practice of basal organic manuring in the savanna ecoregion of Nigeria. Journal of Natural Science Research. Vol. 4 (17): 122 - 132.
- [9] Babajide, P.A., Modupeola, T.O., Yusuf, R.O., Oyatokun, O.S. and Gbadamosi, T.S. (2017). Evaluation of proportionate combinations of indigenous rice bran and mineral fertilizer for improved performance of tomato (*Lycopersicon lycopersicum*) under low fertile soil conditions. Asian Journal of Soil Science and Plant Nutrition. Vol. 1 (1):1-8.
- [10] Babajide, P.A.; Olabode, O.S.; Akanbi, W.B.; Olatunji, O.O and Ewetola E.A (2008). Influence of Composted *Tithonia*-biomass and N-Mineral Fertilizer on Soil Physico-Chemical Properties and Performance of Tomato (*Lycopersicon lycopersicum*). Research Journal of Agronomy Vol. 2 (4): 101-106.
- [11] Bahman E., Daniel G. and John E. G. 2004. Residual effects of manure and compost application on corn production and soil properties. Agronomy Journal. Vol. 96; 442- 447.
- [12] Bouyoucos, G. J. (1951). A recalibration of the hydrometer method for making mechanical analysis of soils. Agronomy Journal 43: 434-438.
- [13] Bremner, J.M. and Mulvaney C.S. (1989). Total Nitrogen in methods of soil Analysis Part 2. In: Page et al., American Society of Agronomy, Madison W.Pp. 595-624.
- [14] Folorunso, O.O. and Ojeniyi, S.O. 2003. Effect of sole and amended plant residues on soil nutrient content and yield of okra. Asset series A. Volume 3 (4):45-53
- [15] Food and Agriculture Organization (2000). Corporate document repository on maize in human nutrition. Journal of tropical Agriculture on tripartite hypothesis. Euphytica 1:271-279.
- [16] Gungula, D. T. (1999). Growth and nitrogen use efficiency in maize (*Zea mays* L.) in the Southern Guinea Savannah of Nigeria. Ph D. Thesis, University of Ibadan. Pp 181.
- [17] Jamilah (2011) Effect of type and dose of *C.odorata* compost and Guano for Growth and Yield of Corn on Typic Paleudult. J Imiah Ekotrans 11:71-78.
- [18] Kumar, V. Ghosh, B. C. and Bhat, R 1999, Recycling of crop wastes and geen manure and their impact on yield and nutrient up take of wetland rice. Journal of Agricultural Science 132:149 - 154.
- [19] Makinde E.A. and Ayoola, O.T. (2010). Growth, yield and NPK uptake by maize with complementary organic and inorganic fertilizers. African Journal of Food, Nutrition and Development Volume 10, No..3; Rural outreach programme.
- [20] Nelson, D.W. and Summer, L.E. (1982). Total carbon, organic carbon and organic matter. In: A.L.Page (ed). method of soil analysis part 2. Agronomy monograph, No.9 AM soil Agron. Madison,W.I. Pp 539-579.
- [21] Nziguheba, G., R. Merckx, C. A. Palm A. and. Mutuo, M. 2002. Combined uses of *Tithonia diversifolia* and inorganic fertilizers for improving maize production in a phosphorus deficient soil in western Kenya. Agoforestry System, 55: 165-174.

- [22] Obatolu, C. R. and A. A. Agboola. 1993. The potential of Siam weed (*Chromolaena odorata*) as a source of organic matter for soils in the humid tropics. In: K. Mulongoy and R. Merckx (Eds.), pp.89-99. *Soil Organic Matter Dynamic and Sustainability in Tropical Agriculture*, IITA/K.U. Leuven, John Willey and Sons, New York.
- [23] Ogbalu, O. K. 1999. The effect of different traditional sources of nutrients on the infestation of pepper fruits by the pepper fruitfully, *Artherigona orientalis* (Schiner) in Nigeria. *Journal of Agronomy and Crop Science* 182: 65-71.
- [24] Ogoke, I. J. (1999). Response of soybean to phosphorus and its residual effect on subsequent maize performance in the Nigeria moist savanna. Ph.D. Thesis University of Ibadan, Ibadan, Nigeria 162p.
- [25] Ojeniyi, S. O. and A. O. Adetoro. 1993. Use of *Chromolaena* mulch to improve yield of late season okra. *Nig. J. Tech. Edu.* 10:144-149.
- [26] Ojeniyi, S. O., Odedina, S. A. and Agbede T. M. 2012. Soil productivity improving attributes of Mexican sunflower (*Tithonia diversifolia*) and siam weed (*Chromolaena odorata*). *Emir. Journal Food Agric.* Vol. 24 (3): 243-247
- [27] Okoruwa A.E., Klingman J.G. 1996. Nutrition and quality of maize. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. *Research and Training* (2nd edition) Guide 33.
- [28] Olabode, O.S; Ogunyemi Sola, Akanbi, W.B; Adesina, G.O and P.A. Babajide 2007. Evaluation of *Tithonia diversifolia* (Hems.l) A Gray for Soil Improvement. *World Journal of Agricultural Sciences* 3 (4); 503-507.
- [29] Ombo, F. I. 1994. Self sufficiency in local fertilizer production for Nigeria. In *Proceeding for the 3rd African Soil Science Conference*, (August 20 – 23, 1994) at University of Ibadan, Ibadan. Nigeria. P. 112 114.
- [30] Page, A.L., Miler, R.H. and Keeney D.R. 1982. *Method of Soil Analysis Part 2, Chemical and Microbial Properties*. ASA Madison.
- [31] SAS (2016). *Sas Institute Inc., Cary Nc., U.S.A. (Software Statistical Programme 2016)*.
- [32] Smyth, A. J. and Montgomery, R. F. 1962: *Soils and land use in Central Western Nigeria*. Govt. of Western Nig. Press, Ibadan pp. 265.
- [33] Tejada, M., Benitez, C. and Gonzatez, J. L. 2005. Effects of Application of Two Organomineral Fertilizers on Nutrient Leaching Losses and Wheat Crop. *Agron. Journ.* 97; 960-967