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Soil fertility improvement by Tithonia diversifolia (Hemsl.) A Gray and its effect on cassava performance and yield.

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ABSTRACT
The effects of Mexican sunflower residue mulch on soil properties, growth and tuber yield of cassava were investigated and compared in a research conducted at the Federal College of Agriculture (FECA) and Aule in Akure South Local Government area of Ondo State Nigeria. The mulch was applied at 0, 5, 10, 15 and 20tha^{-1} and the replicated three times. In the tested soils which were sandy loam, soils were deficient in available P but adequate in soil organic matter, N, K, Ca and Mg. The pH was moderate. Soli organic matter, available P and exchangeable K and number of leaves were found to increase with mulch rate up to 20tha-^{1}. Soil temperature was reduced accordingly. Mulch increase cassava establishment and tuber weight significantly (at P>0.005). The 10tha-1 mulch gave highest tuber weight and increased tuber weight by 20% thus 10tha^{-1} is recommended.

KEYWORDS: *Mexican sunflower, soil properties, soil temperature, establishment, tuber weight.*

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I. INTRODUCTION

Soils in the tropics are degraded and low in organic matter thus the fertility status is regarded as inadequate. Improving and maintaining soil in the tropics is imperative. Maintaining it, will not only come from fertilizer application but adoption of resource –conserving technologies that can increase the organic matter, nitrogen use efficiency (NUE) and maintains the soil water status. The turnover of nutrients in soil-plant cycle results in negative nutrient balance thus a progressively poorer soil is available to grow crops. Meadow *et al.*, (1992)voiced the need for a regenerative agriculture which improves the use of soils and utilizes natural processes, similar needs have been noted in other studies, for example, the IFPRI 2020 Vision (IFPRI 2002) and the World Agriculture Towards 2015-30 (FAO 2002).

Cassava tuber is the second most important staple food crop in the sub-Saharan Africa (SSA) and in particular Nigeria, Ghana, Togo and Cameroon (IITA 1988). Cassava roots products are energy rich food widely consumed in Sub-Sahara Africa by about 40% of the population in Congo, Gabon, Mozambique and Zaire (Ojeniyi *et al.*, 2009). Being a hardy crop it is widely grown on soils of low fertility. Hence the performance of the crop is limited by soil fertility and NPK fertilizer is recommended for the crop (Howeler and Cadavid, 1990). However, due to high cost of fertilizer, farmers rarely use fertilizers rather they depend on organic wastes. For instance, improper use of NPK fertilizer was found to reduce tuber yield of cassava (Agbaje and Akinlosotu, 2005). Hence, some studies have been conducted on using plant residues as nutrient source for improving soil fertility in cassava production. Plant residue mulch such as *Chromolaena odorata* L. (Hullugalle *et al.*, 1991), rice husk and oil-palm bunch ash waste (Ojeniyi and Ighomrore, 2004, Ojeniyi *et al.*, 2009, Lal 1986; Ezekiel *et al*, 2009a, 2009b) have been used to improve yield and nutrient content of cassava. The mulch also minimizes surface soil crusting, reduces supra -optimal soil temperatures and improves water infiltration (Ojeniyi, 2009).Tithonia, commonly known as Mexican sunflower is an invasive, annual weed, growing aggressively along road path, abandoned farmlands and hedges all over Nigeria (Ayeni *et al.*, 1997). It is a shrub and it belongs to the family Asteraceae. Tithonia originated from Mexico, and it is now widely distributed throughout the humid and sub humid tropics in Central and South America, Asia and Africa (Sonke, 1997). It has been reported to grow and established in Kenya (Niang *et al.*, 1996), Malawi (Ganunga *et al.*, 1998), Rwanda (Drechsel and Reck, 1998) and Zimbabwe (Jiri and Waddington, 1998).

The reported uses of tithonia includes fodder (Anette, 1996; Roothaert and Patterson, 1997; Roothaert *et al.*, 1997), poultry feed (Odunsi *et al.*, 1996), animal feed (Farinu *et al*., 1999; Olayemi, 2006) fuel wood (Ng'inja *et al.,* 1998), compost (Drechsel and Reck, 1998; Ng'inja *et al.,* 1998), land demarcation (Ng'inja *et al.,* 1998), soil erosion control (Ng'inja *et al.,* 1998), building materials and shelter for poultry (Otuma *et al.,* 1998). In addition, extracts from tithonia plant parts reportedly protect crops from termites (Adoyo *et al.,* 1997) and contain chemicals that inhibit plant growth (Baruah *et al.,* 1994; Tongma *et al.*, 1997) control insects (Carino and Rejestes, 1982; Dutta *et al.,* 1993 Akanbi *et al*., 2007) and nematicide (Jama *et al*., 2000). Extracts of tithonia also have medicinal value for treatment of hepatitis (Lin et al., 1993; Kuo and Chen, 1997) and control of amoebic dysentery (Tona *et al.,* 1998).

In the works of Buresh and Niang, 1997 and Jama *et al*., 2000 enumerate the potentials of Mexican sunflower (*Tithonia diversifoli*a; Fam) in supplying and maintaining soil nutrients after periods of decomposition. It has been used as an organic fertilizer for vegetable crops, its use as green manure resulted in an increase in maize (*Zea mays*) yield and it proved as an effective source of nutrients for lowland rice (*Oryza sativa*) (Jama *et al*., 2000, Nagarajah and Nizar; 1982 Nziguheba *et al.,* 2002; Sangakkara *et al.,* 2002). It was found as effective nutrient source for maize, beans and vegetables in Kenya, |Malawi and Zimbabwe (Jama *et al*., 2000) and yam in Nigeria(Adeniyan *et al*., 2008). Atayese and Liasu (2001) found that soil under tithonia and siam weed had higher pH, porosity, moisture content, N, P, K Na Ca, mycohorizal fungi spores and earthworm casts density and lower bulk density compared with bare soil. Similar observations were made by Ojeniyi *et al.,* (2012). In Nigeria, the potential of tithonia as source of nutrients and for increasing crop yield has not received adequate study compared with other plant residues. The aim of this work is to study effect of tithonia residue mulch on soil physic- chemical properties, growth and yield of cassava.

II. MATERIALS AND METHODS.

Field Experiments.

Experiments were carried out at Federal College of Agriculture Akure (FECA), Ado- Owo road Akure and Aule Village, both in Akure , Ondo State. The geographical location of both sites lies between, Latitude 7^0 5^1N, Longitude 4^0 55^1 and Latitude 7^0 5^1 and Longitude 5^0 53 ^{1} respectively, in the rainforest zone of Southwest Nigeria. The soil at both sites were classified as fine kaolinitic, isohyperthermic, Oxic Paleustaff or Ferric Luvisol (Adekiya and Ojeniyi 2002). The sites were cropped to maize and cassava for 6 and 5 years respectively before clearing and the land was manually cleared. The rainfall is between 1100 to 1500mm per annum and the average temperature is 24.0^{o}C.

Planting materials. : Cassava cuttings were obtained from the Federal College of Agriculture Research Farm. The cuttings were obtained from eight month species of Manihot spp. Five levels of tithonia residues were applied as mulch to cassava cuttings planted on heaps at 1x1m to give 1000 plants /ha. The mulch treatments were 0, 5, 10, 15, and 20t/ha replicated three times given fifteen treatments plots per site. Each plot was 25m$^{2.}$ Treatments were apportioned using a randomized complete block design.

Planting and harvesting operations: Planting of cassava sticks were done in April 2009 at each site and mulching were applied on heaps according to treatments - 28days later. Harvesting was done 36weeks after planting to determine tuber weight per plant. Before harvesting, number of leaves and establishment percent were evaluated.

Determination of soil chemical properties: Composite surface (0 to10cm) soil samples were collected using auger over each site before commencement of experiment and bulked. Also at harvest, samples were collected on heaps and bulked per plot. Samples were air dried, 2mm sieved. Mechanical analysis was done using the Bouyoucous hydrometer method (Klite, 1986). The organic matter (OM) was determined using dichromate method, total N by Micro-kjeldhal procedure, available P was extracted by Bray - 1 solution and determined using molybdenum blue colorimeter. The exchangeable cations (K, Ca, and Mg) were extracted using ammonium acetate, K was determined on flame photometer and Ca and Mg by atomic absorption spectrophotometer. The pH in soil – water 1: 2 ratios was determined using a pH meter.

Determination of soil physical properties : At harvest three steel core samples were collected to 10 cm depth on heaps per plot and used for determination of gravimetric moisture content. Soil bulk density was determined using the dry core samples. The soil temperature at 15:00hr was determined to 5cm depth and three readings were taken per plot at 4 weeks interval from 4weeks after planting (WAP)

III. RESULTS.

Table 1 presents the value of initial soil analysis for the sites of the experiments in 2009 before planting of cassava (stem cutting). The soil pH was observed to be moderate and suitable with pH 7.2 and 8.1, for Aule and FECA sites respectively.

Table 1. Pre- cropping physic- chemical properties of test soils.

Parameters	Aule	FECA
Sand %	56.8	52.6
Silt %	16.1	20
Clay %	27.1	27.4
Bulk Density (gcm-3)	1	1
pH (H2O)	7.2	8.1
Organic Carbon (%)	2.26	1.99
Organic Matter	3.9	3.43
Nitrogen (%)	0.34	0.22
Available P (mg kg-1)	9.1	5.3
Exchangeable K (cmol kg-1)	0.27	0.27
Exchangeable Ca (cmol kig-1)	3.6	2.8
Exchangeable Mg (cmol kg-1)	1	1.2

Table 2 presents the effects of tithonia mulch on the physic-chemical properties of the experimental sites (FECA and Aule). It was observed that, soil treated sunflower mulch at 20t/ha increased the soil moisture contents of by about12.86% compared with the control at FECA and by about 8.86 % at Aule. Also, bulk density of soils at both sites of the experiments were reduced with tithonia mulch, at FECA sites, the untreated plots had1.24gcm3 as against 1.09 gcm^3 on soil treated with 20t/ha of tithonia mulch. Thus, bulk densities on soils treated with 20 t/ha compared with the untreated soils (control) were reduced by about 2.59% and 3% for FECA and Aule sites respectively. At FECA, mulching with tithonia significantly increased the organic matter of soils treated with it in respective of the tones of mulch used compared with the control though there was no significant difference observed when 10 and 15 t/ha of the mulch was used. The increased in organic matter produced by 20 t/ha was 11.2 % more than the untreated soil (control). In addition, there were significant differences in nitrogen and phosphorus added to the soil on soils treated with sunflower compared with the control (untreated soil) at both FECA and Aule sites. Relative to control, the percentage increased of added nitrogen for FECA were 4.17%, 10.95%, 13.55% and 17.71% for 5, 10, 15 and 20t/ha of tithonia mulch respectively. For Aule sites, 4.6%, 7.24%, 11.8% and 13.82% more nitrogen were released into the soil from 5, 10, 15 and 20t/ha of tithonia mulch applied to the soil respectively. Potassium, calcium and magnesium values were not significant different on both sites of the experiments but there were some increases produced by the tithonia mulch.

Table 2. Effects of Mexican sunflower mulch on the Physicochemical Properties of soil at FECA and Aule.

Mulch (t/ha)	Moisture content (%)	Bulk density (gcm-3)	pH (H20)	Organic matter (%)	N %)	P	K	Ca	Mg
							cmolkg-1		
			FECA						
0	6.55a	1.24a	5.68a	2.16d	0.21d	14.49d	0.43a	2.14a	1.14a
5	6.83a	1.19a	6.16a	3.60c	0.29d	20.71c	0.57a	2.63a	1.48a
10	7.24a	1.15a	6.40a	3.81b	0.42c	29.73b	0.62a	3.17a	1.59a
15	10.12a	1.13a	6.43a	3.93b	0.47b	35.20a	0.60a	5.62a	2.58a
20	12.05a	1.09a	6.75a	4.15a	0.55a	36.80a	0.51a	2.76a	1.34a
			AULE						
0	8.30a	1.26a	5.79a	2.05c	0.19d	11.96c	0.40a	1.27c	0.55a
5	8.79a	1.18a	6.04a	3.57b	0.26c	18.17b	0.64a	2.12b	0.89a
10	9.26a	1.04a	5.98a	3.64b	0.30b	19.70b	0.49a	2.63a	1.18a
15	10.86a	1.09a	5.97a	3.90ab	0.37a	23.71a	0.46a	3.24a	1.27a
20	2.72a	1.09a	6.00a	4.00a	0.40a	28.32a	0.44a	2.69a	1.40a

The effects of tithonia mulch on soil temperature at the different weeks after planting (WAP) at both sites (FECA and Aule) is as indicated on table 3. Reduction in soil temperature increases with the increase in the rates of mulch materials applied on both sites compared with the control (untreated plots) at FECA and Aule sites. Compared with the control, temperature reductions were significantly highest at 20t/ha in all the weeks observed (4, 8,12,16,20,24,28,32 and 36) at FECA and Aule sites. Percentage reduction for instance, at weeks 28 for FECA and Aule sites were 0.47%, 1.67%, 3.16% and 4.45% for 5,10,15 and 20 t/ha of tithonia mulch for FECA and 0.38%, 1,68%,2.96% and 4.44% 0f 5, 10, 15 and 20t/ha of tithonia mulch for Aule respectively.

Table 3: Effects of Mexican sunflower mulch on soil temperature at different weeks after planting at FECA and Aule.

Mulch (t/ha)	4	8	12	16	20	24	28	32	36
				Weeks after planting					
FECA									
0	37.0a	37.1a	34.8a	34.5a	35.2a	35.3a	34.0a	35.0a	35.0a
5	35.5b	35.3b	34.2b	32.5b	33.1b	33.2b	33.4b	33.5b	35.5b
10	33.9c	33.5c	32.5c	30.8c	31.1c	31.1c	31.1c	31.3c	32.4c
15	31.8d	31.6d	30.4d	28.4d	29.1d	21.1d	29.1d	29.8d	30.3d
20	29.7b	29.1b	27.6d	26.4e	27.1e	27.1e	27.1e	27.2e	27.4e
AULE									
0	37.2a	37.9a	35.8a	34.6a	35.2a	35.3a	34.0a	35.0a	35.0a
5	35.8b	36.7b	35.7b	33.5b	35.5b	33.2b	33.4b	35.5b	35.5b
10	34.4c	33.8c	33.3c	31.3c	32.1c	31.1c	31.4c	34.2c	32.1c
15	38.8d	34.8d	33.4d	29.6d	29.6d	29.1d	29.4d	29.6d	30.3d
20	32.6b	31.12d	33.2d	25.5e	27.2e	27.1e	27.1e	27.4e	27.5e

Figure 1, showed the establishment percentage at both FECA and Aule sites. It was observed that, 0.5% higher rates of established cassava were recorded for Aule site over that of FECA site.

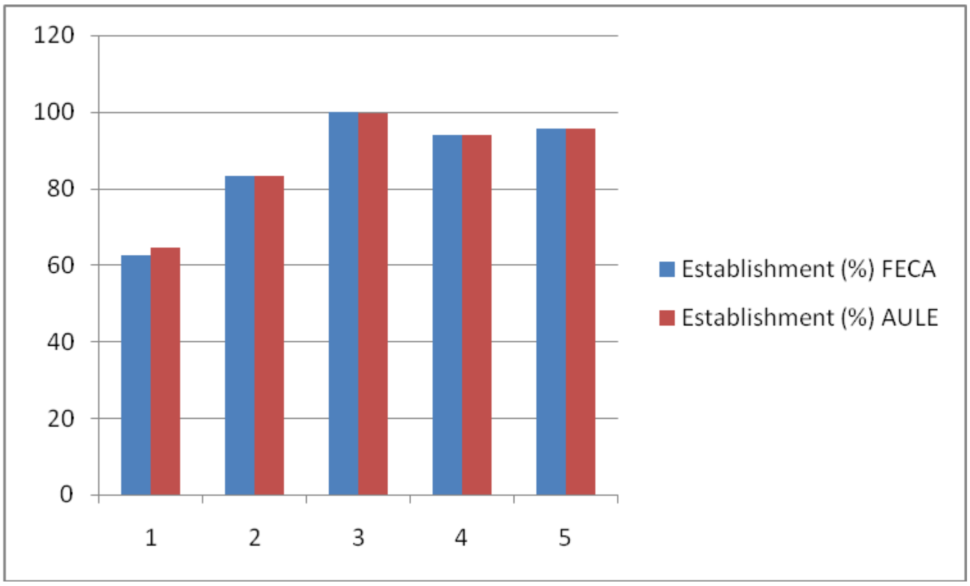

Figure 1: Establishment's percentage of cassava stands at FECA and Aule sites.

Numbers of leaves per plant were observed to be more at Aule site compared to FECA site. 4.98% more number of leaves were produced at Aule site over that of FECA site.

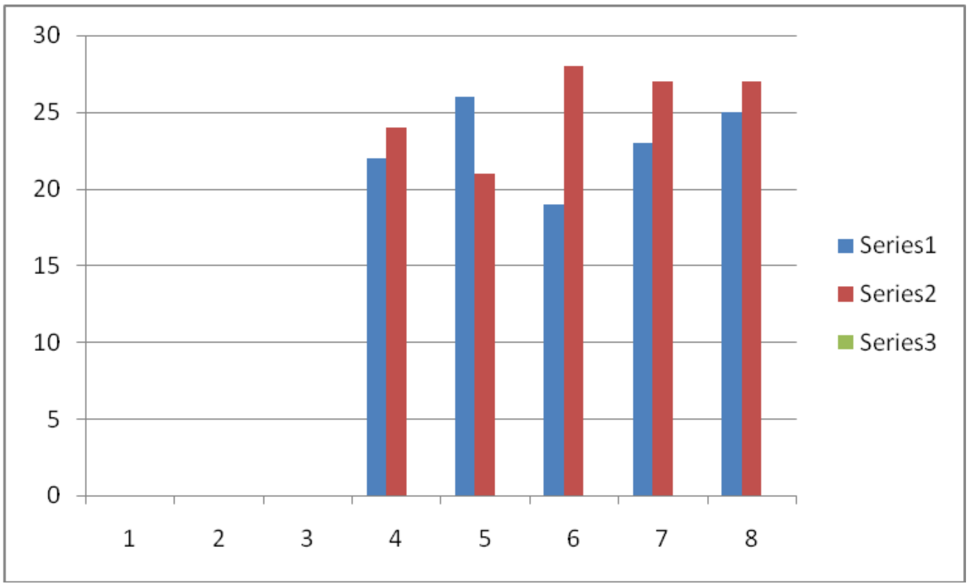

Figure 2: Effect of tithonia on the number of leaves per plant at FECA and Aule sites.

Mean tuber cassava tuber yield produced at a in Aule sites was 4.2% higher than what was produced at FECA sites (Figure 3). Tithonia mulch, significantly (P<0.05) increased fresh tuber weight of cassava at both experimental sites (FECA and Aule). While 10t/ha mulch rate recorded the highest mean tuber weight of 2.6kg of cassava at FECA, also at Aule 10t/ha mulch produced the highest mean tuber weight of 2.7kg. Relative to control (untreated plot) increases produced by tithonia mulch at FECA were 1.8%, 5.3%, 0.9% and 4.4% for 5, 10, 15 and 29t/ha of tithonia mulch respectively. While at Aule increases were only produced with 10 and 15 t/ha having 2.4% and 0.8% respectively.

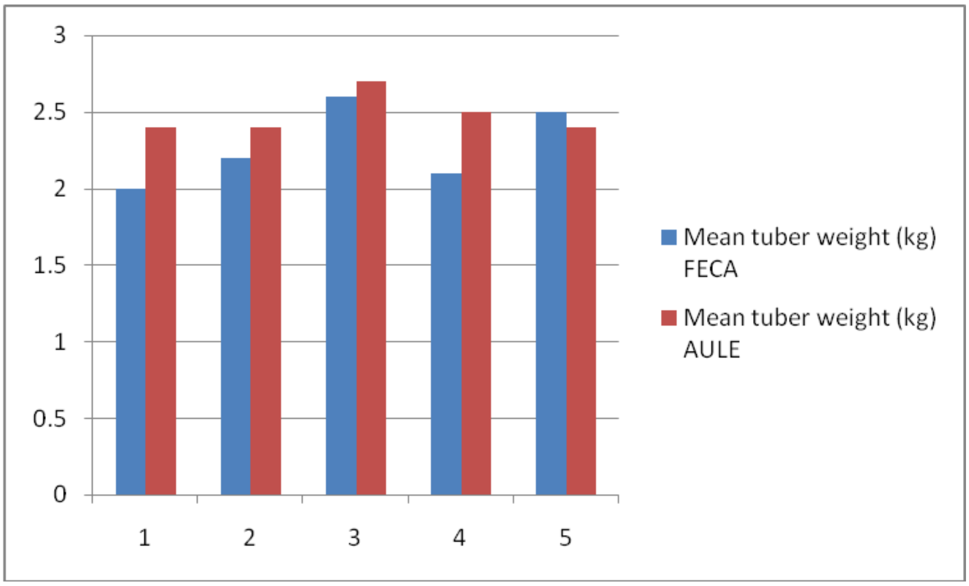

Figure 3. Effects of Mexican sunflower mulch on mean tuber weight of cassava tuber in kilogram.

IV. DISCUSSION.

The soils were adequate in organic matter (OM), nitrogen, potassium, calcium, magnesium but low in available phosphorous. The critical values set for soils for OM, N, K, Ca, Mg and P for soils in southwest Nigeria are 35%, 0.15%, 15mg/kg, 0.15cmol/kg, 2.5Cmol/kg and 0.40Cmol/kg respectively(Akinrinde and Obigbesan 2002; Adeleye *et al.*, 2010). Deficiency in available P can be attributed to P-fixation by Fe components of the soil (Akinrinde and Obigbesan, 2000).

It was also observed that, tithonia reduced bulk density, this is likely attributable to increases in soil organic matter due to decomposition of the plant residue. Organic matter is known to reduce soil compaction (Adekalu and Osunbitan, 1995), increase soil aggregation and thus improve soil porosity (Osunbitan and Adekalu1999). Also, increased organic matter and associated improvement in soil structure should have enhanced infiltration of rain water leading to improved retention and availability of water in the soil (Okunade *et al.,* 2005). The mulch also increased significantly soil moisture and this should have led to enhanced leaf production, nutrient uptake and good establishment of cassava stands. Soil temperature was also reduced with tithonia mulch, this is a confirmation of the work carried out by Adeniyan et al., (2008) and Akanbi and Ojenyi (2007) where tithonia and siam weed increased organic matter; N, P, K, Ca, Mg and reduced soil temperature, bulk density, increased soil moisture content, leaf N and K, growth and tuber yield of yam at Akure, Southwest Nigeria. In a related study by Ojeniyi and Ighomore (2004), it was reported that, application of weed mulches applied to cassava increased soil and plant nutrients and yield of cassava. Other studies such as Awodun and Ojeniyi (1998), Agele *et al*., (2004) and Awodun *et al.,* (2007) reported that mulched derived from siam weed, grasses and *Glicicidia sepium* improved soil physical properties, nutrient availability and performance of crops such as cowpea, maize and tomato. However, in other studies conducted using *tithonia, panicum* and chromolaena (Olabode *et al.,*2007), it was reported that *Tithonia* was superior to *Chromolaena* in N, P and K and *Panicum* in N, K and Ca contents while *Panicum* was higher in Mg and P contents. Similarly, *Tithonia* N concentration (1.76%) was comparable to those of poultry and swine manure (1.78 and 1.69% respectively). With respect to P, the value obtained in *Tithonia* (0.82%) was not significantly different (P=0.05) from what was obtained in swine (1.32%) manure but was significantly higher than that of cattle (0.52%) manure. *Tithonia* was significantly higher in K (3.92%) than poultry (1.80%), cattle (0.95%) and swine (0.77) manures. Of the organic materials considered, *Tithonia* had the least tissue Mg concentration (0.005%) while cattle manure had the highest (0.86%).

Tithonia mulch was able to increase tuber weight of cassava at both sites of field of experiments. This is similar to the results obtained by Olabode *et al*., 2007, Ademiluyi and Omotosho, 2007 and Akanbi *et al.*, 2007, who obtained better crop yields for both compost and/or tithonia. Also, better growth and yield of okra resulted from soil treated with freshly crushed and dried ground *Tithonia*. Okra yields were 40 and 43% higher than the ashes treated and the control respectively when treated with crushed *Tithonia* 35 and 38% superior when treated with dried tithonia. (Olabode *et al*., 2007) In some cases, maize yields were even higher with incorporation of tithonia biomass than with commercial mineral fertilizer at equivalent rates of N, P and K. In addition to providing nutrients, tithonia incorporated at 5 t dry matter ha^{-1} can reduce P sorption and increase soil microbial biomass. Because of high labor requirements for cutting and carrying the biomass to fields, the use of tithonia biomass as a nutrient source is more profitable with high-value crops such as vegetables than with relatively low-valued maize. The transfer of tithonia biomass to fields constitutes the redistribution of nutrients within the landscape rather than a net input of nutrients. External inputs of nutrients would eventually be required to sustain production of tithonia when biomass is continually cut and transferred to agricultural land (Jama *et al.*2000b).However, proper management of tithonia, by processing into tithonia compost will further improve the manural effects and even give better yield as suggested by Akanbi *et al.*, 2007 who reported higher shoot yield of *Telfaria occidentalis* with tithonia composts.

V. CONCLUSION.

Soil treated with Mexican sunflower mulch relative to control had reduced bulk density, day time temperature and increased soil moisture content, organic matter and available phosphorus. Cassava stands establishment, leaf production and increased tuber yield was enhanced by tithonia mulch application. Tithonia was effective in improving soil quality and performance of cassava in Akure, Southwest Nigeria. The optimum rate of application was 10t/ha for the production of cassava on the test field. However, there is need to investigate into integrated use of tithonia with other types of organic manure.

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