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Soil productivity improving attributes of Mexican sunflower (*Tithonia diversifolia*) and siam weed (*Chromolaena odorata*)

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Abstract

In the present investigation, soils fallowed to Mexican sunflower (*Tithonia diversifolia*), siam weed (*Chromolaena odorata*), spear grass (*Imperata cylindrica*) and soil cropped to cassava were chemically analysed. Soil physical properties such as bulk density, total porosity and moisture content were also determined. The soils were also used to grow maize in screen house. Soils fallowed to *Tithonia* and *Chromolaena* had higher mineral values like nitrogen, phosphorus, potassium, calcium, magnesium and also organic matter. The plant morphological paramters like maize height, girth and leaf area were also found higher than cropped land and soil fallowed to spear grass. Soils under *Tithonia* and *Chromolaena* had more favorable physical properties compared with soils under cassava and spear grass as indicated by lower bulk density and higher total porosity. This can be adduced to the ability of the *Tithonia* and *Chromolaena* weeds to protect the soil, proliferate surface soil with their roots, and attract fungi, increase biomass and organic matter.

Key words: Soil productivity, Mexican sunflower, Siam weed, Spear grass, Cassava

Introduction

High cost of chemical fertilizers in tropical agriculture necessitated dependence on biological means of maintaining soil fertility and productivity. Mulching with residues of weeds such as siam weed and Mexican sunflower was found to increase yield of crops such as maize (Ojeniyi and Adetoro, 1993; Falade and Ojeniyi, 1997; Awodun and Ojeniyi, 1999) and soil nutrients content. The mulches have fertilizer effect also (Taiwo and Makinde, 2005).

Tithonia (Mexican sunflower) originated in Mexico, but is now widely distributed throughout the humid and sub-humid tropics in Central and South America, Asia and Africa. *Tithonia* is an aggressive weed growing to a height of about 2.5m and adaptable to most soils. It had been observed to be widely spread in Nigeria where it is found growing on abandoned/waste lands, along major roads and waterways and on cultivated farmlands. Evidence from other parts of the world suggests that *Tithonia* can be used for a wide variety of purposes. These include fodder, poultry feed, fuel, compost, land demarcation, soil erosion control, building materials and shelter for poultry (Nill and Nill, 1993; Liasu and Atayese, 1999). The stems and leaves of *Tithonia* had been reported to contain sesquiterpene lactones e.g. tagitinins (terpene) that prevents attack by termites (Adoyo et al., 1997) and possess antimicrobial properties. Hence, *Tithonia* with low lignin (6.5%), polyphenol (1.6%) and considerably high nitrogen (3.50%), phosphorus (0.37%) and potassium (4.10%) contents (Jama et al., 2000) has great potential for use as soil amendment. *Tithonia* has been found to produce high biomass and was reported as effective biomass for mulching and increasing yield of rice and tomato (Liasu and Achakzai, 2007) and is also effective as nutrient source for maize, beans and vegetables in Kenya, Malawi and Zimbabwe (Jama et al., 2000) and yam in Nigeria (Adeniyan et al., 2008). The abundance and adaptation of this weed species to various environment couples with its rapid growth rate and very high vegetative matter turn over makes it a candidate species for soil rejuvenation (Olabode et al., 2007).

Tithonia has received less research attention in Nigeria compared with siam weed as to its effect

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on soil properties and productivity. In the guinea savanna zone of Nigeria, Atayese and Liasu (2001) found that soil under *Tithonia* and siam weed had higher pH, porosity, moisture content, nitrogen, phosphorus, potassium, sodium, calcium, mycorrhizal fungi spores and earthworm cast density and lower bulk density compared with bare soil. The aim of this work was to investigate soil depth to which *Tithonia* and siam weed influence soil chemical properties in humid zone of southwest Nigeria, and relative effect of their natural fallows on soil properties and growth of maize. Soils fallowed to *Tithonia*, siam weed and spear grass were compared to determine their relative effect as soil improvers.

Materials and Methods

Two studies were carried out in separate phases. The first study investigated effect of *Tithonia*, siam weed and spear grass on soil properties and maize. The second study investigated effect of *Tithonia* and siam weed at different soil depths on the soil properties.

[a] In the first study, soil samples were collected from plots that were under three year fallow of *Tithonia*, siam weed and spear grass (i.e. soils that were naturally grown of *Tithonia*, siam weed and spear grass) and plots cropped to cassava for three years in the same locality. Ten samples were randomly collected with auger from fallow and cassava plots and later bulked into three per plot. The twelve samples were air dried and sieved using 2 mm sieve. Portions of soil samples were kept for chemical analysis before they were weighed into 4-litre polythene pots. There were three pots per treatment given 36 pots on the whole. Pots were laid out in screen house using randomized complete block design. They were wetted to saturation and allowed to drain for 3 days. Maize seeds were planted and thinned to one seedling per pot. Wetting was done at two days interval using watering can. Plant height, stem girth, ear leaf length (L) and width (W) were determined at 6 weeks after planting. Leaf area was calculated as product of L x W x 0.75 (Sinoquet and Andrieu, 1993; Olufayo et al., 1994).

Steel core samples collected from plots in triplicate were used for determination of bulk density, gravimetric moisture content and total porosity. Total porosity was calculated from bulk density and particle density of 2.65 g/cm^3.

[b] In the second study, soil samples were collected in triplicate from 0-5, 5-10 and 10-15 cm depths in a pit dug at each plot dominated by *Tithonia*, siam weed and cropped to cassava to determine their chemical properties at different depths.

Soil chemical analysis

Air-dried 2 mm sieve soil samples collected from the two studies were subjected to routine chemical analysis. Total N was determined by micro Kjeldahl approach and available P was determined by molybdenum blue colorimetry. Excgangeable K, Ca and Mg were extracted using ammonium acetate, K was determined on flame photometer and Ca and Mg by atomic absorption spectrophotometer (Okalebo et al., 1993).

Results and Discussion

Compared with soil cropped to cassava and fallowed to spear grass, *Tithonia* and *Chromolaena* had significantly higher (p= 0.05) values of soil N, P and K (Table 1). Cropped soil had least values of the chemical properties. Compared with soil cropped to cassava, *Tithonia* and *Chromolaena* increased soil N by 206 and 189%, respectively. The percentage increases for available P were 41 and 41%, respectively while the percentage increases for exchangeable K were 57 and 33%, respectively. Soil N and P between soils fallowed to *Tithonia* and *Chromolaena* were not statistically different from each other, but soil fallowed to *Tithonia* was significantly higher (p= 0.05) than *Chromolaena* in K by 18%. The influence of *Tithonia* and *Chromolaena* fallow in increasing the soil nutrient contents had been widely reported (Obatolu and Agboola, 1993; Ademiluyi and Omotoso, 2008; Chukwuka and Omotayo, 2009). This was attributed to the conversion of biomass to organic matter, which increased the levels of these nutrient elements, indicating that fallow improved soil properties.

Table 1. Effect of weed fallow on soil chemical properties.

Fallow	N %	P mg/kg	K cmol/kg
Chromolaena	0.52	8.2	0.40
Tithonia	0.55	8.2	0.47
Spear grass	0.25	6.0	0.21
Cassava	0.18	5.8	0.30
LSD (0.05)	0.19	0.64	0.08

Table 2 shows data on values of soil chemical properties at 0-5, 5-10 and 10-15 cm depths. Soils fallowed to *Tithonia* and *Chromolaena* had higher values of N, P, K, Mg, Ca and organic matter than cropped soil at 0-5 and 5-10 cm depths. At 10-15 cm depth soils under weed fallows also had higher values of N, P, Ca and organic matter. The parameters reduced in the order *Tithonia*, *Chromolaena* and cassava soils. However, when K and Mg are considered at 10-15 cm depth, cassava soil had highest K content and relatively high Mg content. This could be due to leaching of the cations in the more exposed cassava soil. The fallow plants (*Tithonia* and *Chromolaena*) increased soil chemical properties to 15 cm depth. Generally soil nutrients reduced with depth from 0 to 15 cm depth. The findings that soil nutrients reduced with depth from 0 to 15 cm depth could be attributed to higher concentration of organic matter in the upper soil layer than in the sub soil layers since organic matter is known to be ultimate determinant of soil fertility in most tropical soils (Obatolu and Ibiremo, 1999).

Table 2. Effect of fallowing on soil chemical properties at different depths.

Fallow/depth (cm)	N %	P mg/kg	K cmol/kg	Ca cmol/kg	Mg cmol/kg	OM %
Chromolaena / 0-5	0.52	8.2	0.40	4.1	1.20	2.94
Tithonia / 0-5	0.55	8.3	0.47	3.8	0.93	2.96
Cassava / 0-5	0.25	6.1	0.31	2.2	0.39	1.59
LSD (0.05)	0.10	1.1	0.01	0.36	0.29	0.96
Chromolaena / 5-10	0.32	8.3	0.33	3.2	0.50	2.94
Tithonia / 5-10	0.41	8.4	0.38	3.2	0.86	2.96
Cassava / 5-10	0.20	6.1	0.22	2.0	0.26	1.59
LSD (0.05)	0.12	0.7	0.10	0.5	0.25	0.69
Chromolaena / 10-15	0.32	6.5	0.28	2.6	0.41	2.03
Tithonia / 10-15	0.29	5.9	0.33	2.9	0.65	2.37
Cassava / 10-15	0.16	5.5	0.53	1.7	0.61	1.20
LSD (0.05)	0.11	0.6	0.10	0.6	NS	0.52

Physical conditions of soils under *Tithonia* and *Chromolaena* respectively were better than that of soil under cassava and spear grass (Table 3). Soils under *Tithonia* and *Chromolaena* had significantly lower (p= 0.05) soil bulk density and significantly higher (p= 0.05) total porosity compared to soils fallowed to spear grass and cropped to cassava. Soil under spear grass had the highest moisture content which was significantly higher (p= 0.05) compared to soils under *Chromolaena* and cassava, but not statistically different from soil under *Tithonia*. Cassava soil had least total porosity and highest soil bulk density, and it also had least moisture content. The quick growing weeds should have returned biomass and enhanced organic matter which is known to enhance soil physical and chemical properties. Hence soils under the weeds had relatively high values of nutrients content.

Table 3. Effect of weed fallow on soil physical properties.

Fallow	Bulk density g/cm^3	Moisture content %	Total porosity %
Chromolaena	1.1	28.2	58
Tithonia	1.0	35.7	62
Spear grass	1.3	37.5	51
Cassava	1.4	20.2	47
LSD (0.05)	0.08	7.2	5

Table 4 shows the effect of weed fallow on maize growth. Maize plant height, stem girth and leaf area were significantly affected by weed fallow. Soil under *Tithonia* had the highest maize plant height, stem girth and leaf area which were significantly higher (p= 0.05) compared to soils fallowed to *Chromolaena*, spear grass and cropped to cassava. Soil under *Chromolaena* fallow produced maize plant height, stem girth and leaf area which were significantly higher (p= 0.05) than soils fallowed to spear grass and cropped to cassava. Soil cropped to cassava had the least maize plant height, stem girth and leaf area which were significantly lower (p= 0.05) when compared to soils dominated by *Tithonia*, *Chromolaena* and spear grass. In the overall performance, maize height, girth and leaf area increased in order of cassava, spear grass, *Chromolaena* and *Tithonia* soils. The more improved soil physical and chemical properties under *Tithonia* and *Chromolaena* fallows led to better growth of maize compared with maize grown to cassava and spear grass soils. Fallowing soil to weeds improved soil physical and chemical properties and maize performance as opposed to cropping. The better performance of maize growth under *Tithonia* fallow compared to other organic sources could be attributed to its higher nutrient concentrations and a faster rate of decomposition of nutrient release.

This agrees with the findings of Nziguheba et al. (1998) that *Tithonia* is a high quality organic source in terms of nutrient release and supplying capacity. Lower C/N ratio of *Tithonia* (8:1) compared to moderate C/N ratio of *Chromolaena* (12:1) (Olabode et al., 2007) and relatively high C/N ratio of spear grass (20:1) indicates a faster decomposition. Palm and Rowland (1997) also listed high N and P contents and high soluble fraction and moderate lignin content resulting in high biodegradation as the strong points of *Tithonia* as source of organic matter.

Table 4. Effect of weed fallow on maize growth.

Fallow	Plant height (cm)	Leaf area (cm^2)	Stem girth (cm)
Chromolaena	76.6	158	3.2
Tithonia	106.0	267	4.4
Spear grass	69.4	106	2.8
Cassava	48.9	63	2.1
LSD (0.05)	18.8	27	0.7

Tithonia and *Chromolaena* serve as protective cover against erosion and are agents of nutrient cycling and supply. Atayese and Liasu (2001) found that soils under *Tithonia* and *Chromolaena* contained arbuscular mycorrhizal fungi spore which enhanced absorption of nutrients from soil to biomass. *Tithonia* is known to be rich in N, P and Ca (Taiwo and Makinde, 2005; Liasu and Achakzai, 2007). Because of the ability of the weeds to protect the soil, proliferate surface soil with their roots, attract fungi, increase biomass and organic matter; the fallows were able to improve soil structure and porosity, reduce bulk density, and increase soil fertility and maize growth.

Conclusion

Mexican sunflower and siam weed respectively reduced soil bulk density and increased total porosity and soil water content. They also increased the soil nutrient levels and subsequently produced high growth of maize. This study has shown that *Tithonia* and *Chromolaena* have high fertilizing and sound potentials for building soil organic matter to adequate levels that will meet nutritional needs of crops as well as improve the nutrient element status of arable fields when bush fallows are dominated by such organic resources than when such fields are taken over by grasses like spear grass. *Tithonia* and *Chromolaena* are potential soil improvers and are therefore recommended for use as fallow plants in rainforest zone of southwest Nigeria for enhanced productivity.

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