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Comparative Evaluation of *Tithonia diversifolia* and NPK Fertilizer for Soil Improvement in Maize (*Zea mays*) Production in Ado Ekiti, Southwestern Nigeria

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Abstract: Green biomass of *Tithonia diversifolia* was incorporated into 3 groups of soil (degraded soil, used soil and fallowed soil) with the aim of finding its potential on soil fertility for maize (*Zea mays*) improvement. There was higher vegetative and reproductive growth of maize in the Tithonia incorporated soil. Early maize growth rate in terms of height and stem girth were better under tithonia applied soil than under the NPK fertilizer soils. Maize cob and grain yields were greatly increased by tithonia biomass than NPK fertilizer. Fallow + Tithonia gave cob and grain weight of 148.2 g pot^{-1},114.0 g pot^{-1} in 2003 and 147.5 g pot^{-1}, 115.1 g pot^{-1} in 2004. An increase of 94 and 88% grain yield was obtained with tithonia incorporation while 79 and 80% grain yield was obtained in the NPK fertilizer applied soils in 2003 and 2004, respectively under the degraded soil group. It was observed therefore, that degraded soils could be recovered for crop production at low cost with tithonia than high cost of NPK fertilizer.

Key words: *Tithonia diversiforlia*, *Zea mays*, degraded soils, fertilizer

INTRODUCTION

Majority of smallholder farmers lack financial resources to purchase sufficient fertilizer to replace soil nutrients exported with harvested crop products. This has resulted to a decline in soil fertility with a resultant yield reduction of staple food crops (Sanchez *et al*., 1997). Organic sources of fertilizer are often proposed as alternative to commercial mineral fertilizers. This includes crop resides and animal manure which cannot by themselves reverse soil fertility decline because of their insufficient quantities on most farms. Their processing and application can also be labour demanding (Palm and Roland, 1997). It had been observed that the introduction of leguminous cover crops such as *Mucuna prurience* and cowpea *Vigna unguiculata* enable sustainability of soil fertility (Noordwijk *et al*., 1997).

Tithonia diversifolia a shrub in the Family Asteraceae commonly called Mexican sunflower had been reportedly used as fodder (Anette, 1996). The green biomass of Tithonia has been recognized to be high in nutrients and effective as a nutrient source for low land rice (Niang *et al*., 2000). Little and Hills (1978) had reported the rapid decomposition of tithonia after soil incorporation. The present study was therefore, carried out to investigate the potentials of *Tithonia diversifolia* in soil fertility improvement for improved maize performance in Ado-Ekiti southwestern, Nigeria.

MATERIALS AND METHODS

Trial sites: The study was conducted at the Greenhouse of the Department of Plant science, University of Ado-Ekiti between May 2003 and July 2004. Ado Ekiti is located on latitude 7°40 N and longitude 5°15 E. The area has a bimodal rainfall with mean annual rainfall of 1367 mm and a daily temperature of 27°C. The area falls within the high forest zone where the rich tropical forests once thrived. The region has a tropical humid climate with distinct wet and dry seasons. The wet season is from late March to October with little dry season in July and August.

Soil preparation and analysis: Prior to planting, soil samples were collected, air-dried in the laboratory, ground and sieved through a 2 mm sieve. Particle-size distribution was determined by the hydrometer method (Bouyoucos, 1951). Soil pH was measured using the pH meter at 1:1 soil to water ratio. The percentage organic carbon was determined by the Walkey Black wet oxidation method (Walkey and Black, 1934) while percent total Nitrogen (N) was determined by the micro-kjeldahl technique (Jackson, 1962). The present organic matter was estimated by multiplying the percent organic carbon with a factor of 1.724. Available P was extracted by the Bray/method and determined colorimetrically (Bray and Kurtz, 1945). Exchangeable bases were displaced by NH_4+ from

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neutral/NH_4OAC solution as describe by Jackson (1958). Calcium (Ca) and Magnesium (Mg) were determined by the Atomic Absorption Spectrophotometer (AAS) and potassium (K) and sodium (Na) were determined by flame emission photometry. Cation Exchange Capacity (CEC) was determined by the neutral/NH_4OAC saturation method. Base saturation was calculated with reference to the NH_4OAC-CEC. Exchangeable acidity was extracted with IMKCL and determined by titration with NaOH solution.

Three soil categories were collected for the purpose of the experiment (i.e., degraded soil, cultivated soil and fallow soil). The degraded soil was collected from an industrial building site where the topsoil had been totally scraped in Ado-Ekiti. The cultivated soil was collected from a newly harvested maize plot at the Teaching ad Research farm, University of Ado Ekiti. The fallow soil was collected from a piece of land that had been under this years fallow at the experimental site of plant science department of the University of Ado Ekiti. Samples were taken from each soil types for chemical and physical analysis at the Department of crop production Laboratory of Federal University of Technology Akure (Table 1). Each of the three soil groups was either incorporated with Tithonia biomass or N.P.K. (15,15,15) fertilizer or left untreated.

Horticultural pots with 15 L capacity and a depth of 30 cm were filled with the soil groups accordingly. Green shoots of *Tithonia diversifolia* were collected from natural stands growing within the University community and incorporated at the rate of 250 g pot^{-1} (50 kg ha^{-1} equivalent). Tithonia was applied a Week Before Planting (WBP) while N.P.K. was incorporated at 2 Weeks After Planting (WAP), 4 seeds of maize (downy mildew resistant variety) were planted per pot and later thinned to two per pot at 2WAP. Plant height and girth were determined at 4 and 6 WAP, shoot and root biomass at 6 WAP and cob and grain yield were assessed. All data were statistically analyzed using Analysis of Variance (ANOVA) and treatment means compared using the Duncan's multiple range test.

RESULTS

The result of the analysis of soil used for the experiment were presented in Table 1, which gave particle size as sand ranges between 580 -623g kg^{-1}, silt as 99-180 g kg^{-1} and clay as 240-281g kg^{-1}. The pH of the soil ranges between 6.3-7.38, organic carbon content was 0.4-2.79% which is low for this soils (Nye, 1950) who worked on the relationship between Nitrogen responses on previous soil treatment and C/N ratio in soil of Gold coast savanna area reported that derived savanna soils have lower N status and wider C/N ratio than forest soils which greatly affect N availability. ECEC was 1.43-3.93 Cmol kg^{-1} range, while total N and available P were 0.02 -0.14% and 1.42 -5.15 mg kg^{-1}, respectively. The soil was sandy loam, Total N and available P content were low in (used and degraded soils) compared with critical levels of 0.1% for N (Adeoye, 1986) and a range of 10-12 mg kg^{-1} for available P (Adeoye and Agboola, 1985) obtained for soils in southwestern Nigeria (FMANR, 1990). Using the critical levels of 0.16-0.20 Cmol kg^{-1}, exchangeable K was high (Agboola and Obigbesan, 1974).

Table 1: Physico-chemical properties of the soils used

Soil parameters	Degraded soil	Used soil	Fallowed soil
pH (H_2O)	7.38	6.32	6.93
Org. C (%)	0.4	1.30	2.79
Org. matter	0.76	2.24	4.82
Total N %	0.02	0.07	0.14
Avail. P $mgkg^{-1}$	1.42	3.07	5.15
Exch. bases (Cmol kg^{-1})			
K	0.26	0.22	0.20
Na	0.07	0.11	0.12
Ca	2.10	0.70	0.90
Mg	1.50	0.40	0.60
Exch. acidity	0.26	0.21	0.24
CEC			
Sand g kg^{-1}	623	580	620
Silt g kg^{-1}	115	180	99
Clay g kg^{-1}	262	240	281

Table 2: Effect of Tithonia and NPK fertilizer on plant height of maize

	Plant height (cm) in 2003		Plant height (cm) in 2004	
Traetments	4WAP	6WAP	4WAP	6WAP
Degraded soil	25.4d	48.6e	23.9e	49.5e
Used soil	30.5c	64.4d	31.1d	78.7d
Fallow soil	37.1ab	97.2ab	40.4a	103.0a
Degraded + Tithonia	38.5a	95.9b	38.7ab	98.4b
Used + Tithonia	38.1a	99.7a	40.0a	101.3ab
Fallow + Tithonia	39.0a	100.3a	40.1a	105.4a
Degraded + NPK	30.3c	69.4c	33.5c	86.5c
Used + NPK	36.4b	98.5ab	36.8bc	99.5b
Fallow + NPK	38.8a	100.7a	42.4a	104.9a

Mean with the same letter in each column for each year are not significantly different ($p<0.05$) by DMRT

Table 2 and 3 show the effects of treatments on plant height and stem girth, respectively. The tallest plants were observed in the pots filled with fallowed soil + tithonia both at 4 and 6 WAP, these were not significantly different from those recorded for fallowed soil + NPK, used soil + tithonia, degraded soil + tithonia and fallowed soil. There were 51 and 97% plant height increase in degraded soil + tithonia over degraded soil. Tithonia improved degraded soil more than NPK did in respect of plant height and girth. At 4 and 6 WAP. At stem girth of maize was better increased in all the three groups of soil collection when incorporated with green tithonia biomass.

The effects of tithonia and NPK on the shoot and root biomass of maize are presented in Table 4. Maize shoot biomass collected from the fallowed soil receiving NPK fertilizer application was highest while the least was

Table 3: Effect of Tithonia and NPK fertilizer on stem girth (cm) of maize in 2003 and 2004

	Stem girth in 2003		Stem girth in 2004	
Treatments	4WAP	6WAP	4WAP	6WAP
Degraded soil	2.2f	3.7f	2.0e	3.6d
Used soil	3.2e	5.6e	3.4d	6.0c
Fallow soil	5.4bc	9.7ab	5.7b	9.1b
Degraded + Tithonia	4.7cd	9.0cd	5.2bc	8.5b
Used + Tithonia	5.5b	9.4abc	5.8b	9.5ab
Fallow + Tithonia	6.8a	9.7a	7.0a	9.9a
Degraded + NPK	4.3d	8.9d	5.0c	8.5b
Used + NPK	4.9cd	9.2bc	5.6bc	8.9b
Fallow + NPK	6.2ab	10.0a	6.8a	9.9a

Mean with the same letter in each column for each year are not significantly different ($p<0.05$) by DMRT

Table 4: Effect of Tithonia and NPK fertilizer on shoot and root biomass of maize

	Shoot biomass (g pot^{-1})		Shoot biomass (g pot^{-1})	
Treatments	2003	2004	2003	2004
Degraded soil	127.0g	119.3f	100.0b	136.4b
Used soil	213.1f	216.2e	176.3a	179.2a
Fallow soil	380.0d	400.1c	192.3a	186.2a
Degraded + Tithonia	340.2e	390.5c	190.1a	190.1a
Used + Tithonia	407.1cd	421.4bc	192.1a	194.0a
Fallow + Tithonia	550.1b	546.2a	196.3a	193.1a
Degraded + NPK	345.0d	343.2d	190.0a	189.3a
Used + NPK	428.0c	436.5b	199.2a	190.0a
Fallow + NPK	586.1a	569.1a	199.1a	198.0a

Mean with the same letter in each column for each year are not significantly different ($p<0.05$) by DMRT

Table 5: Effect of Tithonia and NPK fertilizer on cob and grain yield of maize

	Cob yield g pot^{-1}		Grain yield g pot^{-1}	
Treatments	2003	2004	2003	2004
Degraded soil	28.0e	32.3e	0.00d	0.00d
Used soil	100.5cd	99.4d	88.7bc	86.5bc
Fallow soil	140.6a	141.2b	111.6a	111.5a
Degraded + Tithonia	105.5c	107.7c	93.5b	88.2b
Used + Tithonia	145.8a	146.8a	112.5a	116.3a
Fallow + Tithonia	148.2a	147.5a	114.0a	115.1a
Degraded + NPK	99.4d	100.5cd	78.9c	80.1c
Used + NPK	139.6ab	140.4b	109.3ab	114.4a
Fallow + NPK	132.4b	139.6b	110.0a	113.6a

Mean with the same letter in each column for each year are not significantly different ($p<0.05$) by DMRT

in the degraded soil. Fallowed soil + tithonia gave comparable shoot biomass figures with fallowed soil + NPK in 2004. Tithonia biomass improved degraded soil than NPK as it gave greater shoot biomass in 2004. The root biomass gave comparable figures except in the degraded soil, which was significantly lowest.

Table 5 presents the effect of tithonia biomass and NPK fertilizer on maize cob and grain yield. The highest cob and grain yield were recorded in the fallow + tithonia pots while the least was in the degraded soil. Degraded soil receiving tithonia biomass gave higher maize cob and grain yield than degraded soil receiving NPK fertilizer. Also, fallowed sol + tithonia gave higher cob yield of 148.2 and 147.5 g than fallow soil + NPK yield of 132.4 and 139.6 g in 2003 and 2004, respectively. Used soils incorporated with either tithonia or NPK resulted into cob and grain yields that were not significantly different. There was total crop failure of zero grain yields in the degraded soils. Tithonia biomass application into the degraded soil led to 93.5 g and 88.2 g grain yield while NPK application produced 78.9 and 80.1 g in 2003 and 2004, respectively.

DISCUSSION

The results of this trial clearly show that green biomass of *Tithonia diversifolia* can improve soils for increase maize performance. The low level of nutrient in degraded and used soil as observed in Table 1 accounted for their poor maize performance. The fact that about 84 and 78% of grain yield in fallow land was produced in degraded soil incorporated with tithonia biomass as against total failure in degraded soil show the importance of tithonia as organic fertilizer. Also, the lower improvement of (71 and 74%) in 2003 and 2004 result affected by NPK fertilizer further proved relevance of Tithonia in soil improvement for maize performance. The reason for these may be attributed to the high Nitrogen concentration and rapid decomposition of green tithonia biomass (Little and Hills, 1978). It had been reported that the green leaf biomass of tithonia is high in nutrients, averaging about 3.5%N, 0.37%P and 4.1%K on dry matter basis (Jama *et al*., 2000). The N concentration in tithonia leaves is higher than the critical level of 2.0 to 2.5%, below which net immobilization of N, would be expected (Palm and Roland, 1997). The P concentration is also higher than the critical level of 0.25% for net P mineralization (Blair and Roland, 1978; Palm and Roland, 1997).

Higher vegetative and reproductive growth observed in the tithonia applied soils than in the NPK fertilizer applied soils could be attributed to higher organic matter production by tithonia which was capable of releasing early N concentration due to rapid decomposition of green tithonia biomass (Jama *et al*., 2000). From this trial it may be concluded that tithonia as fallow plant can be ploughed into the soil before planting for increased maize yield. Where the means of mechanical ploughing is lacking fresh tithonia can be used to mulch the farmland. This can release nutrients to the soil as tithonia decomposes rapidly due to its low lignin content of 6.5% and total extractable polyphenol's concentration of 1.6% (Little and Hills, 1978). These concentrations are below levels that significantly reduce decomposition.

From the result of this trial, it is apparent that *Tithonia diversifolia* is capable of increasing the fertility of the soil when the green biomass is incorporated into the soil. One salient advantage here is the ability of this plant to reclaim degraded soil for cropping.

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