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ORIGINAL ARTICLE

Effect of Inoculation with *Glomus mosseae* on Nutrient Extraction and Dry Matter Accumulation by Tithonia Hedges Growing on an Ultisol in Ogbomoso, Nigeria

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ABSTRACT

The effects of arbuscular mycorrhiza (AM) fungi on absorption of mineral nutrients i.e. N.P.K. supplied as chemical fertilizer. N.P.K. 20:10:10 and dry matter accumulation by Tithonia were investigated in a field experiment. The field experiment was a two way factorial design and the two factors were fertilizer application and *Glomus mosseae* inoculation in a completely randomized block design (CRBD) with *Glomus mosseae* as block to give four treatments each replicated three times. The treatments are: Fertilized and inoculated (F+M+) fertilized and uninoculated (F+M-), unfertilized and inoculated (F-M+) and unfertilized and uninoculated (F-M-). Harvests were in two consecutive trials each lasting three months. Leaf biomass yield after the first three months of growth was highest in tithonia grown in unfertilized and inoculated soils and lowest in those in unfertilized and uninoculated soils. In the second trial, it was highest in fertilized and inoculated and lowest in unfertilized and uninoculated soils. The trend was the same for leaf nutrient yield. *Glomus mosseae* contributed more to leaf biomass yield in unfertilized than fertilized plants during the first trial but its contribution was vice versa during the second trial. Fertilizer contribution was negative in inoculated and positive in uninoculated plants during the first trial. It was positive in both inoculated and uninoculated plants during the second trial and generally higher than in the first trial. Soil nutrient content i.e. nitrogen N, and potassium K, increased while soil phosphorus P, decreased. Thus biomass production and nutrient absorption by Tithonia hedges was enhanced by *Glomus Mosseae* and fertilizer application.

Key words: *Dry matter accumulation, Glomus mosseae, inoculation, NPK 20:10:10, nutrient extraction*

Introduction

Efficiency of nutrient use when the source is inorganic is usually low in tropical soil. Most of the nutrients applied are either lost through erosion or leaching and volatilization. The rate of release of minerals from inorganic fertilizer is faster than the rate at which they are absorbed by plant root. Tropical soils are low activity clay soils, not able to retain nutrients because of low (CEC) cation exchange capacity. Inorganic fertilizers are expensive, not easily affordable by subsistence farmers. Nutrients from organic sources such as leaf mulch are not easily leached, slowly released and they are never fixed to form appatite (Muller Samman and Kotshi 1994). Young, (1976), made a conclusion that with available technology, it is still impossible to grow food crops on the soils of tropical region without either degradation of soil or use of inputs at an economic level.

However, in a sustainable agricultural system, incorporating mycorrhizal technology with agroforesty practices will therefore provide a panacea in the balancing of nutrient absorption with nutrient replenishment (Liasu, 2001). *Tithonia diversifolia* has aroused research interest because of its ability to extract relatively high amount of nutrients from the soil. *Tithonia* (Hemsley. Gray) is a Mexican shrub, which belongs to the family

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of asteraceae (compositae). The concentrations of N.P.K in the green leaf biomass are relatively high (Jama *et al*, 2000) and nutrients are rapidly released in plant available forms during decomposition. (Nziguheba *et al*,1998 and Garchengo *et al*, 1999). *Tithonia* was probably introduced to Nigeria by colonial settlers at first used as a cover crop. However, *Tithonia* has continued to replace common weeds on road sides as well as farmlands in the humid savanna (Akobundu, 1987; Akobundu and Agyakwa 1987) and open spaces in the forest region (Liasu and Atayese, 1999). *Tithonia* is now "widely distributed" throughout the humid and sub-humid tropics in central and south America, Asia and Africa.In natural ecosystem especially on disturbed but fallowing stands, the Tithonia community has been known to thrive in the humid tropics with its phenological development synchronized with rainfall pattern in an annual rhythm that provides protection of the underlying soil against erosion (Liasu and Atayese, 1999). The rate of nutrient absorption is high and for most part of its growing cycle, nutrients are retained in the plant body even at the peak of litter fall as the leaf litter is devoid of nutrients.

The roots of *Tithonia* have been found to form symbiotic association with A.M fungi (Atayese and Liasu, 2001). A.M. fungi may be responsible for the ability of Tithonia to extract nutrients from soils with low fertility.

This research was therefore aimed at shedding light on reduction of dependence on fertilizer. In addition, the study will provide information on promotion of sustainable land use i.e. to maximize outputs with minimum external inputs (lower cost for agricultural production) as well as how to reduce or eliminate environmental pollution which arises from excessive use of chemicals.

Materials and methods

Site description

The experiment was conducted on a piece of fallowing land within the premises of Ladoke Akintola University of Technology, Ogbomoso. Nigeria. The site is on latitude 8^0 05^1 N and longitude 4^0 11^1 E. The city has a tropical hinterland type of climate whose total annual rainfall is between 100cm and 150cm. The climate consists of two well-defined seasons, rainy and dry seasons. The rainy season is characterized by a bimodal rainfall pattern in which a longer spell of heavy rain starting around March /April and peaks at July is separated by a short break of uncertain rainfall (August break) this is followed by a short spell of heavy rain which peaks between the end of September and the beginning of October. The dry season sets in towards the end of November and last till the end of March. (Osundina and Liasu, 1996). The experimental site lies within the transitional zone of the forest and savanna belt of Nigeria. The soil is classified as highly weathered ultisol with ferric concretion. It has sandy–clay-loam texture (LAUTECH Agronomy department soil unit) with a mean bulk density of 1.6 and soil porosity o.39 (Table 1). The soil has a pH of 6.9 at a depth of 0 - 7.0cm.

Experimental design and treatments

A one meter by one meter square plots of Tithonia endemic land already seeded with Tithonia was mapped out. The experiment was a two way factorial design in which two factors mycorrhizal inoculation (*Glomus mosseae*) and fertilizer application were combined in a completely randomized block design (CRBD) to get four treatments with each treatment in three replicates. The four treatments are:
Fertilized and inoculated designated as F+M+
Fertilized and uninoculated designated as F+M-
Unfertilized and inoculated designated as F-M+
Unfertilized and uninoculated designated as F-M-.

The experiment commenced with the arrival of rains. In the first trial, fertilizer N.P.K 20:10:10 equivalent to 40kg per hectare was added to all fertilized plots. Mycorrhizal *Glomus mosseae* (50kg/ha) were supplied to each inoculated plot. The Tithonia community was allowed to grow under natural conditions for three months before they were harvested, after which they were dried, weighed and the weight of dry matter recorded. The soil sample from each replicate was collected after the first harvest. The harvested plot was allowed to fallow during which fresh growth of Tithonia vegetation was monitored and the experiment repeated on the same plots. The second batch of Tithonia weed population was harvested, dried, weighed and dry matter weight recorded after 3 months of growth..

Sampling and Analysis

Soil samples collected before the commencement of the experiment and the one from each plot after the first harvest were oven dried at 80^0c for 48 hours. Thirteen soil samples of 60g each were grounded with mortal in the laboratory and passed through 2mm mesh. The analysis was done at 11TA. PH was determined

using a corning model 7 pH meter. The soil samples were analyzed for total N, P, K, by kjeldahl digestion with concentrated tetraoxo sulphate (vi) (sulphuric acid) N and P by a technical autoanalyser while k, was determined by flame photometer (11TA, 1982).

Plant samples harvested were oven dried at 80^0c for 24 hours, then ground to pass through 2mm mesh and analyzed for total N, P, K, by Kjeldahl digestion with tetraoxosulphate (vi) acid (Sulphuric acid). N. was determined by microkjeldahl method (Bremmer, 1960), K by a Perkin Elmer model 403 Atomic Absorption Spectrophotometer (AAS) IITA () and P by molybdenum blue method Murphy and Riley (1962).

Mycorrhizal fungi/ fertilizer contribution

Percentage arbuscular mycorrhizal fungal (e.g. *Glomus mosseae*) contribution to leaf biomass / nutrient levels in tithonia growing in fertilized and unfertilized plots was calculated using the formula

$$\%\ AM_{contri.} = \frac{\text{Biomass / nutrient of fertilized plants – unfertilized}}{\text{Biomass / nutrient of unfertilized plants}} \times 100$$

Percentage N P K fertilizer contribution to leaf biomass / nutrient levels is given by the formula

$$\%\ NPK_{contri.} = \frac{\text{Biomass / nutrient of Inoculated plants – uninoculated}}{\text{Biomass / nutrient of uninoculated plants}} \times 100$$

Results and discussion

Chemical analysis of soil samples collected before and after the first harvest of Tithonia plants showed an increase in nutrient content i.e. N and K, in all the four treatments except for P which showed a decrease (table 1).

Table 1: The nutrient content of soils at the experimental site before and after the first harvest of Tithonia grown on inoculated and uninoculated soils, with or without inorganic (NPK) fertilizer.

Soil sample	Soil nutrient content (%)			CEC meq100^{-1}	pH
	N	P	K		
(Before experiment)	0.11	17.66	0.13	4.16	6.9
(After experiment) Treatments					
F+M+	0.13	13.91	0.18	4.82	6.6
F+M-	0.16	13.91	0.18	4.25	6.8
F-M+	0.14	14.72	0.11	4.86	6.7
F-M-	0.14	15.41	0.2	4.31	6.5

Key:
Fertilized and inoculated (F+M+), Fertilized and uninoculated (F+M-),
Unfertilized and inoculated (F-M+), Unfertilized and uninoculated (F-M-).

During the first trial, biomass yields were similarly high in inoculated plots irrespective of fertilizer application with the lowest yields from plots that were neither fertilized nor inoculated (Table 2). The leaf biomass yield of first trial was higher than that of second trial in all the four treatments. Yield reduction was drastic in all plots except the fertilized and inoculated where it was marginal when compared with the first trial.

Table 2: Effect of soil mycorrhizal inoculation and fertilizer application on leaf biomass yield of Tithonia during the 1st and 2nd planting trials.

Trials	Biomass yield (t/ha-) in plots with different treatments			
	F+M+	F+M-	F-M+	F-M-
1st	45.3a	42.4a	46.3a	37.9a
2nd	36.5b	28.7b	27.7b	23.8b

*Key:
Fertilized and inoculated (F+M+), Fertilized and uninoculated (F-M+),
Unfertilized and inoculated (F-M+), Unfertilized and uninoculated (F-M-).
Means within same column followed by same letters are not significantly different at P>0.05 according to Duncans Multiple Range Test DMRT.

Mycorrhizal inoculation actually contributed more to biomass yield in unfertilized than fertilized soils during the first trial (table 3) but contribution was vice versa during the second trial. Fertilizer contribution to biomass yield is negative in inoculated soils during the first trial but positive in uninoculated soils (table 4). However, the contribution is positive in both inoculated and uninoculated plots in the second trial and

higher than in the first trial. Mycorrhizal contribution to nutrient content of tithonia was predictably lower during the first trial than in the second trial in all treatment plots (table 5). Inorganic fertilizer application actually inhibited phosphorus absorption by inoculated tithonia plants during the first trial (table 6).

Table 3: Mycorrhizal contribution to leaf biomass yield in *Tithonia* weeds grown on fertilized and unfertilized soils during the 1st and 2nd trials of experiment.

Trials	*Tithonia* growing in	
	Fertilized soil	unfertilized soil
1st	6.8	22.2
2nd	27.2	16.4

Table 4: Fertilizer contribution to leaf biomass yield of Tithonia grown on inoculated and uninoculated soils during the 1st and 2nd trials of experiment.

Trials	*Tithonia* growing in	
	Inoculated soils	uninoculated soils
1st	-2.3	12.1
2nd	31.8	20.6

Table 5: Fertilizer contribution to nutrient absorption by Tithonia hedges grown on inoculated and uninoculated soils during the first and second trials.

Tithonia growing in	Nutrient content					
	N		P		K	
	1st	2nd	1st	2nd	1st	2nd
inoculated soil	5.5	26.9	2.5	39.3	6.1	40.9
Uninoculated soil	16.0	22.7	6.1	31.8	17.2	22.2

Table 6: Mycorrhizal contribution to nutrient absorption by *Tithonia* hedges during the first and second trials.

Tithonia growing in	Nutrient content (%)					
	N		P		K	
	1st	2nd	1st	2nd	1st	2nd
Fertilized soil	17.2	22.2	11.4	34.5	2.9	40.9
Unfertilized soil	44	18.2	21.2	27.5	13.8	22.2

Table 7: Effect of mycorihizal inoculation and fertilizer application (NPK) on total nutrient yield of leaf biomass of Tithonia hedges in t/ha- during 1st and 2nd trials.

Inoculation and Fertilizer Treatment	Tithonia leaf nutrient yield during 1st and 2nd trials (%)					
	N		P		K	
	1st	2nd	1st	2nd	1st	2nd
F+M+	3.4a	3.3a	0.39a	0.38a	3.5a	3.1a
F+M-	2.9b	2.7b	0.35b	0.29b	3.4a	2.2b
F-M+	3.6a	2.6b	0.40a	0.28b	3.3a	2.2b
F-M-	2.5b	2.2c	0.30c	0.22c	2.9b	1.8c

*Key:
Fertilized and inoculated plot (F+M+), Fertilized and uninoculated plot (F+M-)
Unfertilized and inoculated plot (F-M+),Unfertilized and uninoculated plot (F-M-)
Means within same column followed by same letters are not significantly different at P>0.05 according to Duncans Multiple Range Test DMRT.

Generally, leaf biomass yield in inoculated plots during the experiment was higher than that of uninoculated plots (table 6). In the first and second trials, leaf nutrients yield of tithonia grown in both fertilized and unfertilized plots especially N and K were promoted by AM inoculation.

The fact that soil phosphorus P levels after the experiment decreased when compared with the recorded level before experiment shows that phosphorus is mined from soil by tithonia hedges which agrees with (Jama *et al* 2000) who stated that Tithonia growing in soils with low nutrients tend to withdraw phosphorus from the soil. The higher leaf biomass yield of tithonia hedges during the first trial was due to the fact that the tithonia hedges benefited from the rich deposit of organic nutrients already accumulated within the debris of the previous year's biomass deposition while on the other hand the second trial growth was somehow hampered by the low level of soil nutrients as a result of mining during the first trial. The absence of apparent manifestations of mycorrhizal promotion of leaf biomass yield of tithonia grown in both fertilized and unfertilized plots during the first trial underscores the fact that under field conditions, mycorrhizal inoculation effectively promotes plant yields only in infertile soils (Barea *et al*, 2005). The addition of organic phosphorus (Jama *et al* ,2000) from previous year's deposition of tithonia plant debris which is rich in phosphorus added

to that supplied through inorganic fertilization created sufficient P levels to inhibit mycorrhizal promotion of phosphorus absorption (Barea, *et al*, 2005). The fact that leaf biomass yield in inoculated plots during the experiment was higher than that of uninoculated plots shows that AM inoculation improves leaf productivity of plants (Osonubi *et al*, 1992; Atayese, 1993). In the first and second trials the significantly higher value of leaf nutrients yield especially N was due to the established fact that A M inoculation promotes nitrogen uptake by plants (Osonubi *et al*, 1992; Atayese *et al*, 1993; Atayese, 1994; and Okon, 1996). The same explanation is valid for potassium K. The values of tithonia leaf N in fertilized and inoculated treatment plots in this work were greater than that recorded in similar experiments in Kenya by Jama *et al* (2000) during the first trial but lower in the second trial). The leaf content of N P and K appeared to be sustained at near optimum levels jointly and severally by NPK fertilizer application and AM inoculation i.e. *Glomus mosseae*, with phosphorus being the critical factor. However, phosphorus content is still above the minimum threshold as in general, tithonia leaves will supply phosphorus at a level above the ethical threshold of above 0.25% below which most P immobilization is thought to occur (Jama *et al* 2000).

Conclusion

Mycorrhizal inoculation had positive effect on nutrients absorption and dry matter accumulation by Tithonia hedges grown in soils with or without supplementation with NPK fertilizer.

Mycorrhizal contribution to leaf biomass yield in the first trial was more pronounced in unfertilized soil than in fertilized soil while in the second trial it was vice versa.

The addition of NPK fertilizer could assist in preventing nutrient mining and consequently permanent soil nutrient depletion that may occur as a result of continuous use of *Tithonia* for biomass transfer of nutrients.

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