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# Effects of Green Biomass of Tithonia (*Tithonia diversifolia*) on the Growth of Cocoa Seedlings

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***Abstract:***
*A screen house experiment was conducted in the University of Ibadan. The experimental design was a completely randomized design with 3 factors, soil at 2 levels, tithonia application at 3 levels and mycorrhiza application at 2 levels. The experiment was replicated 3 times making a total of 12 treatment combinations and 36 experimental units. Data analysis was done using analysis of variance (ANOVA). The soils used for the experiment were deficient in the major nutrient elements. In the topsoil the application of mycorrhiza with tithonia enhanced the performance of cocoa seedlings in the second experiment. Likewise, in the subsoil the cocoa seedlings performed better in terms of number of leaves and plant height in the second experiment which implies an enhanced performance due to the residual effect of the applied tithonia. Application of 5 t/ha tithonia with mycorrhiza to the soils gave the best performance in both the first and second experiment and would therefore be beneficial in raising cocoa seedlings.*

***Keywords****: Tithonia, fertility, organic farming, cocoa and soil*

## 1. Introduction

Cocoa production in Nigeria is limited by soil nutrient depletion. Cocoa seedlings are raised in the nursery using topsoil whereas most soils supporting cocoa are deficient in N and P (Egbe, 1989). Thus, young seedlings in the nursery suffer from macro and micro nutrient element.

Current soil fertility concepts are pointing towards organic farming. Organic resources often proposed as alternatives to mineral fertilizers include crop residue and animal manure. Jama *et al.* (2000) noted that organic resources grow on or near small holder farm. Some of these resources have relatively high nutrient concentration but little is known about their potential as nutrient sources to improve soil fertility and crop yield. One of such organic resources is the green biomass of tithonia (*Tithonia diversifolia* (Hemsley) A. Gray).

The reported uses of tithonia include fodder (Anette, 1996; Roothaert and Patterson, 1997; Roothaert *et al*., 1997), poultry feed (Odunsi *et al*., 1996), compost (Drechsel and Reck, 1998; Ng'inja *et al*., 1998), fuel wood, land demarcation and soil erosion control (Ng'inja *et al*., 1998). The green biomass of tithonia has been recognized to be high in nutrients and effective as a nutrient source for lowland rice (Nagarajah and Nizar, 1982) and maize (Gachengo, 1996; Ganunga *et al*., 1998; Jiri and Waddington, 1998).

Cocoa is grown on a wide range of soil type but soils with moderate to high fertility are better since fertilizer inputs are usually low. Soils use for raising cocoa seedlings must be free draining soils with good water holding capacity and have a pH range from 4.5 to 7.0.Opeke (2005) observed that cocoa is a tap-rooted plant and requires deep well-drained soils, free from iron concretions, high in nutrient content and topsoil rich in organic matter.

Our soils are being degraded due to erosion and human activities. There is therefore the need for an organic material that could serve as erosion control as well as help in improving the soil structure and productivity. The objective of this research was to investigate the effect of green biomass of tithonia on the growth of cocoa seedlings.

## 2. Materials and Method

The experiment was carried out in the screen house of the University of Ibadan, Ibadan Nigeria. Soil sample was collected from the teaching and research farm at two different depths; topsoil (0 - 15 cm) and subsoil (below 30cm). Five kg of the soils were air dried and sieved to pass through a 2-mm sieve and then weighed into the pot for planting. The experimental design used was completely randomized design (CRD) replicated three times. It was a factorial experiment with three factors, soil at two

levels (top and sub soil), tithonia application at 3 levels (0, 2.5 and 5.0 tonnes per hectare) and mycorrhiza application at two levels (with or without mycorrhiza) making a total of 12 treatment combinations.

The fresh biomass of tithonia were chopped (0, 6.25 and 12.5 g) and incorporated into the soil two weeks before planting while mycorrhiza was applied at planting. The fresh pod of cocoa (Amazon $F_3$) from which the seeds were extracted was obtained from Cocoa Research Institute of Nigeria.

Growth parameters taken at two weeks interval include number of leaves, plant height and stem diameter. The experiment was terminated twenty-one weeks after planting.

The soil used for the first experiment was used for a repeated trial in other to determine the residual effect of the applied tithonia and no other treatment was imposed.

All data were subjected to analysis of variance using SAS PROC GLM.

**3. Results and Discussion**

The top soil used for the experiment had the following values N (0.32 g/kg), available P (3.70 mg/kg), organic C (1.34 g/kg), exchangeable K (0.2 mg/kg), Mg (0.7 mg/kg) and Ca (1.4 mg/kg). The sub soil had the following values N (0.08 g/kg), available P (2.10 mg/kg), organic C (0.32 g/kg), exchangeable K (0.2 mg/kg), Mg (0.7 mg/kg) and Ca (1.1 mg/kg). All these values are low compared with the critical levels required for raising cocoa seedlings. The low levels of these nutrients in the soil suggest that the soil needs to be supplemented with these nutrients in order to raise good cocoa seedlings. The use of subsoil in this experiment is to evaluate the effect of soil degradation on cocoa since most of our soils are prone to degradation. The values of N, available P, organic C and Ca were higher in the topsoil than the subsoil which shows that the value decreases with depth, this corroborates the findings of Ibiremo *etal*., 2010.

Application of 2.5 and 5 t/ha tithonia with mycorrhiza significantly enhanced the number of leaves better than the application of tithonia at the same rate without mycorrhiza in the subsoil at 13 weeks after planting when the residual effect was examined (Table 1). Tithonia application at 2.5 t/ha without mycorrhiza application and 5 t/ha with mycorrhiza application significantly enhanced the number of leaves at 11, 13 and 15 weeks after planting compared with the application of 0 t/ha with mycorrhiza application in the topsoil in the first experiment, while the application of tithonia at the rate of 5 t/ha without mycorrhiza was significantly higher than the application of tithonia at the rates of 0 and 2.5 t/ha without mycorrhiza when examined at the 13 and 15 weeks after planting in the residual effect (Table I).In the subsoil the residual effect had higher number of leaves with all the treatment application except at 5 t/ha tithonia without mycorrhiza application. In the topsoil the residual effect also had higher number of leaves in all the treatments except at 2.5 t/ha tithonia without mycorrhiza application.

| | | | **FIRST EXPERIMENT (WAP)** | | | | **RESIDUAL EFFECT (WAP)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Soil | Tithonia (t/ha) | Mycorrhiza | 11 | 13 | 15 | Mean | 11 | 13 | 15 | Mean |
| Subsoil | 0 | M+ | 6.7 | 7.7 | 8.7 | 7.7 | 9.0 | 11.7 | 13.3 | 11.3 |
| | | M- | 6.7 | 7.0 | 9.3 | 7.7 | 8.3 | 10.7 | 13.3 | 10.8 |
| | 2.5 | M+ | 6.3 | 7.7 | 8.7 | 7.6 | 8.0 | 13.7 | 14.3 | 12.0 |
| | | M- | 6.0 | 9.0 | 10.3 | 8.4 | 9.0 | 12.0 | 13.7 | 11.6 |
| | 5 | M+ | 8.3 | 8.3 | 11.3 | 9.3 | 7.7 | 12.7 | 13.0 | 11.1 |
| | | M- | 8.0 | 10.0 | 12.0 | 10.0 | 8.0 | 8.7 | 11.3 | 9.3 |
| Mean | | | 7.0 | 8.3 | 10.1 | | 8.3 | 11.6 | 13.2 | |
| Topsoil | 0 | M+ | 5.7 | 6.7 | 8.3 | 6.9 | 8.0 | 11.7 | 16.3 | 12.0 |
| | | M- | 8.7 | 9.3 | 12.0 | 10.0 | 7.7 | 10.3 | 11.7 | 9.9 |
| | 2.5 | M+ | 8.3 | 10.0 | 12.0 | 10.1 | 8.0 | 13.7 | 14.0 | 11.9 |
| | | M- | 9.7 | 11.0 | 14.0 | 11.6 | 8.0 | 10.0 | 12.3 | 10.1 |
| | 5 | M+ | 10.3 | 11.3 | 16.3 | 12.7 | 10.0 | 13.3 | 15.7 | 13.0 |
| | | M- | 8.0 | 9.7 | 11.0 | 9.6 | 9.3 | 14.3 | 18.3 | 14.0 |
| Mean | | | 8.4 | 9.7 | 12.3 | | 8.5 | 12.2 | 14.7 | |
| **LSD** | | | | | | | | | | |
| Soil | | | 1.43 | 1.34 | 1.84 | | 1.20 | 1.29 | 1.78 | |
| Tithonia | | | 1.76 | 1.64 | 2.25 | | 1.47 | 1.58 | 2.18 | |
| Mycorrhiza | | | 1.43 | 1.34 | 1.83 | | 1.20 | 1.29 | 1.78 | |
| S × T | | | 2.48 | 2.32 | 3.18 | | 2.07 | 2.24 | 3.08 | |
| S × M | | | 2.03 | 1.89 | 2.60 | | 1.69 | 1.83 | 2.52 | |
| T × M | | | 2.48 | 2.32 | 3.18 | | 2.07 | 2.24 | 3.08 | |
| S × T × M | | | 3.51 | 3.28 | 4.50 | | 2.94 | 3.17 | 4.36 | |
| ANOVA | | | | | | | | | | |
| Soil | | | * | * | * | | ns | ns | ns | |
| Tithonia | | | ns | * | * | | ns | ns | ns | |

| | | | FIRST EXPERIMENT (WAP) | | | | RESIDUAL EFFECT (WAP) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mycorrhiza | | | ns | ns | ns | | ns | * | ns | |
| S × T | | | ns | ns | ns | | ns | * | * | |
| S × M | | | ns | ns | ns | | ns | ns | ns | |
| T × M | | | ns | ns | ns | | ns | ns | ns | |
| S × T × M | | | ns | ns | ns | | ns | ns | ns | |

*Table 1: Effect of green biomass of tithonia on the number of leaves of cocoa seedling under screen house conditions*
*ns - not significant, * - p<0.05, WAP- Weeks after planting, S- Soil, T – Tithonia, M- Mycorrhiza,*
*ns – not significant,* - p<0.05, ns - not significant, * - p<0.05, WAP- Weeks after planting, S- Soil, T – Tithonia, M- Mycorrhiza*

In the subsoil application of tithonia at 2.5 t/ha without mycorrhiza had significantly higher (18.50 and 25.60 cm) plant height than the application of tithonia at the same rate with mycorrhiza application (14.30 and 19.17 cm) at 11 and 15 weeks after planting respectively (Table 2). At 11 weeks after planting application of tithonia at 0 t/ha with mycorrhiza had significantly lower plant height than all other treatment except the application of tithonia at 2.5 t/ha with mycorrhiza in the topsoil (Table II). Plant heights were significantly better with the application of tithonia at 0 t/ha without mycorrhiza (18.97 cm) and 5 t/ha without mycorrhiza (19.93 cm) than the application of tithonia at 2.5 t/ha with mycorrhiza (15.27 cm). At 13 weeks afterplanting application of tithonia at 5 t/ha without mycorrhiza to the topsoil had significantly higher plant height than the application of tithonia at 0 t/ha with mycorrhiza. At 15 weeks after planting application of tithonia at 0 t/ha with mycorrhiza had significantly lower plant height compared with the application of tithonia at 0, 2.5 and 5 t/ha without mycorrhiza (Table II).In the topsoil the residual effect had higher plant height in all the tithonia application with mycorrhiza application but lower plant height in all the tithonia application without mycorrhiza application when compared with the first experiment (Table II).

| | | | FIRST EXPERIMENT | | | | RESIDUAL EFFECT | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Soil | Tithonia (t/ha) | Mycorrhiza | 11WAP | 13WAP | 15WAP | Mean | 11WAP | 13WAP | 15WAP | Mean |
| Subsoil | 0 | M+ | 15.70 | 17.20 | 19.50 | 17.47 | 20.17 | 22.33 | 26.83 | 23.11 |
| | | M- | 16.93 | 18.40 | 19.83 | 18.39 | 16.67 | 18.67 | 22.50 | 19.28 |
| | 2.5 | M+ | 14.30 | 17.53 | 19.17 | 17.00 | 17.50 | 19.00 | 22.67 | 19.72 |
| | | M- | 18.50 | 20.73 | 25.60 | 21.61 | 17.33 | 21.40 | 24.00 | 20.91 |
| | 5 | M+ | 16.83 | 21.67 | 24.00 | 20.83 | 18.33 | 21.50 | 25.77 | 21.87 |
| | | M- | 17.17 | 21.33 | 22.17 | 20.22 | 17.33 | 20.00 | 21.17 | 19.50 |
| Mean | | | 16.57 | 19.48 | 21.71 | | 17.89 | 20.48 | 23.82 | |
| Topsoil | 0 | M+ | 14.47 | 17.93 | 19.17 | 17.19 | 16.17 | 18.83 | 23.00 | 19.33 |
| | | M- | 18.97 | 22.43 | 24.93 | 22.11 | 18.17 | 21.00 | 22.67 | 20.61 |
| | 2.5 | M+ | 15.27 | 19.17 | 22.00 | 18.81 | 16.50 | 19.33 | 23.50 | 19.78 |
| | | M- | 18.47 | 20.77 | 26.33 | 21.86 | 16.67 | 18.67 | 20.83 | 18.72 |
| | 5 | M+ | 18.10 | 21.83 | 23.67 | 21.20 | 19.00 | 22.33 | 27.83 | 23.06 |
| | | M- | 19.93 | 23.00 | 26.00 | 22.98 | 19.00 | 22.00 | 24.83 | 21.94 |
| Mean | | | 17.53 | 20.86 | 23.68 | | 17.58 | 20.36 | 23.78 | |
| **LSD** | | | | | | | | | | |
| Soil | | | 1.396 | 1.994 | 2.032 | | 2.342 | 2.897 | 3.589 | |
| Tithonia | | | 1.708 | 2.441 | 2.488 | | 2.867 | 3.548 | 4.395 | |
| Mycorrhiza | | | 1.396 | 1.994 | 2.032 | | 2.342 | 2.897 | 3.589 | |
| S × T | | | 2.415 | 3.454 | 3.519 | | 4.056 | 5.017 | 6.214 | |
| S × M | | | 1.974 | 2.821 | 2.873 | | 3.311 | 4.097 | 5.075 | |
| T × M | | | 2.415 | 3.454 | 3.519 | | 4.056 | 5.017 | 6.214 | |
| S × T × M | | | 3.416 | 4.885 | 4.976 | | 5.735 | 7.096 | 8.789 | |
| ANOVA | | | | | | | | | | |
| Soil | | | ns | ns | * | | ns | ns | ns | |
| Tithonia | | | ns | * | * | | ns | ns | ns | |
| Mycorrhiza | | | ** | ns | * | | ns | ns | ns | |
| S × T | | | ns | ns | ns | | ns | ns | ns | |
| S × M | | | ns | ns | ns | | ns | ns | ns | |
| T × M | | | ns | ns | ns | | ns | ns | ns | |
| S × T × M | | | ns | ns | ns | | ns | ns | ns | |

*Table 2: Effect of green biomass of tithonia on the plant height (cm) of cocoa seedlings under screen house conditions*
*ns – not significant,* - p<0.05, ns - not significant, * - p<0.05, WAP- Weeks after planting, S- Soil, T – Tithonia, M- Mycorrhiza*

At 11 weeks after planting application of 2.5 t/ha tithonia with mycorrhiza to the subsoil had significantly lowerstem diameter compared with the application of tithonia at 2.5 and 5 t/ha tithonia without mycorrhiza (Table III). For the subsoil, the residual effect had higher stem diameter with tithonia at 0 t/ha with and without mycorrhiza application but at 2.5 t/ha tithonia application the residual had higher stem diameter with mycorrhiza application but lower stem diameter without mycorrhiza application when compared with the first experiment. While at 5 t/ha tithonia application the residual effect had lower stem diameter with and without mycorrhiza application compared with the first experiment (Table III). In the topsoil when the residual effect was examined at 11 weeks after planting application of tithonia at 5 t/ha with mycorrhiza had significantly higher (0.46 cm) stem diameter than the application of tithonia at 2.5 t/ha without mycorrhiza (0.36 cm). At 13 weeks after planting the residual effect of the application of 5 t/ha tithonia with mycorrhiza gave significantly higher stem diameter than all other treatments except the application of tithonia at the same rate without mycorrhiza (Table III). The residual effect of the application of tithonia at 5 t/ha with mycorrhiza in the topsoil at 15 weeks after planting gave significantly higher stem diameter compared with the application of tithonia at 0 t/ha with mycorrhiza and 2.5 t/ha without mycorrhiza. In the topsoil the residual effect had lower stem diameter in all the treatments applied except at 5 t/ha tithonia application with mycorrhiza compared with the first experiment (Table 3).

| | | | **FIRST EXPERIMENT** | | | | **RESIDUAL EFFECT** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Soil | Tithonia | Mycorrhiza | 11WAP | 13WAP | 15WAP | Mean | 11WAP | 13WAP | 15WAP | Mean |
| Subsoil | 0 | M+ | 0.43 | 0.45 | 0.50 | 0.46 | 0.42 | 0.46 | 0.50 | 0.46 |
| | | M- | 0.40 | 0.47 | 0.52 | 0.46 | 0.44 | 0.50 | 0.55 | 0.50 |
| | 2.5 | M+ | 0.37 | 0.42 | 0.52 | 0.44 | 0.43 | 0.46 | 0.52 | 0.47 |
| | | M- | 0.49 | 0.51 | 0.56 | 0.52 | 0.41 | 0.48 | 0.50 | 0.46 |
| | 5 | M+ | 0.45 | 0.50 | 0.62 | 0.52 | 0.41 | 0.45 | 0.55 | 0.47 |
| | | M- | 0.47 | 0.49 | 0.57 | 0.51 | 0.39 | 0.44 | 0.49 | 0.44 |
| Mean | | | 0.43 | 0.47 | 0.55 | | 0.42 | 0.47 | 0.52 | |
| Topsoil | 0 | M+ | 0.47 | 0.50 | 0.54 | 0.50 | 0.38 | 0.43 | 0.43 | 0.41 |
| | | M- | 0.42 | 0.48 | 0.60 | 0.50 | 0.43 | 0.45 | 0.53 | 0.47 |
| | 2.5 | M+ | 0.39 | 0.46 | 0.57 | 0.47 | 0.39 | 0.42 | 0.54 | 0.45 |
| | | M- | 0.41 | 0.47 | 0.60 | 0.49 | 0.36 | 0.40 | 0.44 | 0.40 |
| | 5 | M+ | 0.42 | 0.45 | 0.55 | 0.47 | 0.46 | 0.57 | 0.60 | 0.54 |
| | | M- | 0.45 | 0.51 | 0.63 | 0.53 | 0.44 | 0.50 | 0.53 | 0.49 |
| Mean | | | 0.43 | 0.48 | 0.58 | | 0.41 | 0.46 | 0.51 | |
| **LSD** | | | | | | | | | | |
| Soil | | | 0.041 | 0.047 | 0.050 | | 0.035 | 0.047 | 0.055 | |
| Tithonia | | | 0.050 | 0.055 | 0.061 | | 0.044 | 0.058 | 0.067 | |
| Mycorrhiza | | | 0.041 | 0.047 | 0.050 | | 0.035 | 0.047 | 0.055 | |
| S × T | | | 0.071 | 0.079 | 0.085 | | 0.061 | 0.082 | 0.096 | |
| S × M | | | 0.055 | 0.064 | 0.070 | | 0.050 | 0.067 | 0.079 | |
| T × M | | | 0.071 | 0.079 | 0.085 | | 0.061 | 0.082 | 0.096 | |
| S × T × M | | | 0.096 | 0.111 | 0.120 | | 0.088 | 0.117 | 0.134 | |
| ANOVA | | | | | | | | | | |
| Soil | | | ns | ns | ns | | ns | ns | ns | |
| Tithonia | | | ns | ns | ns | | ns | ns | ns | |
| Mycorrhiza | | | ns | ns | ns | | ns | ns | ns | |
| S × T | | | ns | ns | ns | | ns | * | ns | |
| S × M | | | ns | ns | ns | | ns | ns | ns | |
| T × M | | | ns | ns | ns | | ns | ns | ns | |
| S × T × M | | | ns | ns | ns | | ns | ns | ns | |

*Table 3: Effect of green biomass of tithonia on the stem diameter (cm) of cocoa seedling under screen house condition*
*ns – not significant,* - p<0.05, ns - not significant, * - p<0.05, WAP- Weeks after planting, S- Soil, T – Tithonia, M- Mycorrhiza*

The higher values recorded in the residual effect may be attributed to microbial activities as a result of the applied tithonia and mycorrhiza, this was clearly evident in the topsoil with plant height having higher residual values with mycorrhiza application but lower values without mycorrhiza application (Table II). Application of organic materials like tithonia has been reported to help in reducing the soil P adsorption capacity (Easterwood and Sartain, 1990), increasing the pH (Kretzschmar *etal*., 1991) and increasing soil biological activity (Smith *etal*., 1993). All this benefit of organic materials must have contributed to the enhanced performance of the cocoa seedling especially with regards to the residual effect.

Under the subsoil, the control (0 t/ha) had a comparable mean residual effect with other treatments in the parameters observed. The number of leaves was highest (12 cm) at 2.5 t/ha tithonia application with or without mycorrhiza. The mean

height was highest (23.11 cm) at 0 t/ha with mycorrhiza application. The mean stem diameter was highest (0.50 cm) at 0 t/ha without mycorrhiza application.

**4. Conclusion**

Application of mycorrhiza with tithonia enhanced the performance of cocoa seedlings in the second experiment. In the topsoil and subsoil the cocoa seedlings performed considerably better in the growth parameters examined in the second experiment which implies an enhanced performance due to the residual effect of the applied tithonia. Application of 5 t/ha tithonia with mycorrhiza to the soils gave the best performance in both the first and second experiment and would therefore be beneficial in raising cocoa seedlings and could serve as an alternative to the use of inorganic fertilizer in raising cocoa seedlings.

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