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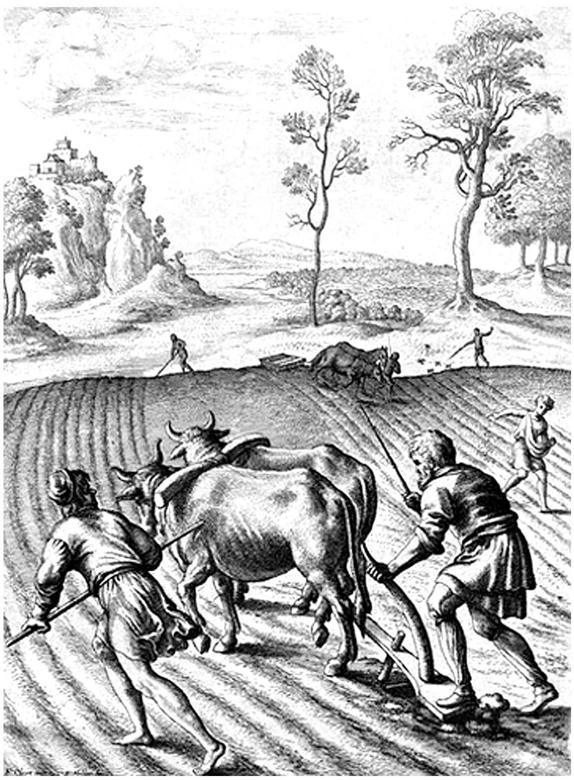

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Effects of Decaying Leaf Litter of *Tithonia diversifolia* (Hemsl.) A. Gray, *Vernonia amygdalina* Del. and Inorganic Fertilizer (NPK 15-15-15) on Growth and Development of Maize (*Zea mays* L.)

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Abstract: The effects of decaying leaf litter of *T. diversifolia*, *V. amygdalina* as organic fertilizer and inorganic fertilizer (NPK 15-15-15) and their combination effects on the growth and development of maize were studied in a Screen House. Twenty four experimental bags filled with 20 kg of loamy soil were laid out in a completely randomized design with six treatments and four replications for each treatment which include: 250 g of decaying leaves of *T. diversifolia* as mulch (T_1), 250 g of decaying leaves of *V. amygdalina* (T_2), 1.52 g of NPK (inorganic) fertilizer (T_3), a mixture of 250 g decaying leaves of *T. diversifolia* and 1.52 g of NPK (15-15-15) fertilizer (T_4), a mixture of *V. amygdalina* and 1.52 g NPK (15-15-15) fertilizer (T_5) and control (T_6). Significant growth as well as maize yields were obtained from T_3 treated maize groups and this was closely followed by T_4 seedlings. The study showed that the decaying leaf litter as organic fertilizer in maize production in a Screen House condition did not give better yield than NPK treatment alone.

Key words: *Tithonia diversifolia*, *Vernonia amygdalina*, NPK fertilizer, maize

INTRODUCTION

Maize (*Zea mays* L.) is one of the important staple and consumed food crops in Nigeria. Recently, there is great increase in the demand for maize resulting from the Federal Government of Nigeria ban on importation of some food crops like rice, wheat and maize. This has helped in improving the rate of consumption of local maize and as a result of that, there is need to steer up local maize production in order to meet up with its various demands (Iken and Amusa, 2004). Soil fertility influences maize production thereby necessitating its improvement for high productivity. Currently, emphasis is placed on the usage of inorganic fertilizers because they yield quick and positive results. On the other hand, it is known that optimum results in the yield and soil fertility can be obtained using balanced proportions of organic and inorganic fertilizers (Saouma, 1974). The relative ease of handling and applying inorganic fertilizers has greatly downplayed the use of organic fertilizers. A situation whereby the inorganic fertilizer is in short supply or the price is very high has thus made inorganic fertilizers out of the reach of poor resource farmers at a time when there need to step up food production (Uka, 1998). Therefore, this study aimed at assessing the suitability of the decaying leaf litter of *T. diversifolia*, *V. amygdalina* as an organic fertilizer as well NPK and their combination effects on the growth and development of maize.

MATERIALS AND METHODS

Study area: The study was carried out in the Screen House of the Department of Botany, University of Ibadan, Ibadan, Oyo State, Nigeria. The area lies between latitude 3.53°E and 7.26°N and altitude of 185m above sea level (Akin-Oriola, 2003; Chukwuka and Uka, 2007) with a mean daily temperature of 24.6°C. Twenty four experimental bags perforated at the base, containing 20 kg of loamy soil were laid out in a completely randomized design with six treatments and four replications. The treatments include: 250 g decaying leaves of *T. diversifolia* as mulch (T_1), 250 g decaying leaves of *V. amygdalina* (T_2), 1.52 g NPK (inorganic) fertilizer (T_3), a mixture of 250 g decaying leaves of *T. diversifolia* and 1.52 g NPK (15-15-15) fertilizer (T_4), a mixture of *V. amygdalina* and 1.52 g NPK (15-15-15) fertilizer (T_5) and control (T_6) which did not receive any leaf litter or NPK. Each of the treatments received 5 seeds of maize Downy Mildew Resistant variety also known locally as '*Auba super*' and was regularly watered with about one litre volume of water at alternate day interval. The experimental soil

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samples were analyzed for nutrient status prior to the experiment for their physical and chemical properties. At 4 Weeks After Sowing (4 WAS), the experimental bags were thinned down to one seedling per bag and treatment. The initial growth parameters such as leaf breadth, leaf length, plant height, stem girth were taken on a weekly basis while the dry weight (yield) was taken after harvest and drying. The maize was harvested after 3 months of planting. All the data obtained during the experiment were subjected to descriptive statistics and Duncan's multiple range test ($p\leq 0.05$) was used to separate the means with SPSS V.16 software.

RESULTS

Soil physico-chemical analysis: The result of the soil analysis is as shown in Table 1.

Effects of treatments on plant height (cm): Table 2 shows the effects of each of the treatments on the plant height.

Table 1: Physiochemical analysis of soil

Property	Values
Sand (%)	89.400
Silt (%)	3.400
Clay (%)	7.200
pH	6.800
Total nitrogen (mg kg^{-1})	2.580
Organic carbon (%)	4.820
Exchangeable acidity (Cmol kg^{-1})	0.050
Cation exchange capacity (Cmol kg^{-1})	6.360
Ca	2.230
Mg	2.870
Na	0.560
K	0.698
Zinc (mg kg^{-1})	13.450
Copper (mg kg^{-1})	0.590
Iron (mg kg^{-1})	9.400
Manganese (mg kg^{-1})	69.900

There was increase in plant height with age in all the treatments. On weekly basis, it was observed that there were no significant treatment effects in the plant height among the treatments in week 4, 6, 7, 8, 9, 10 and 11 after sowing except in 5 week after sowing where the highest plant height was observed in T_4 (72.75±1.31), T_6 (72.75±1.89) and T_3 (72.25±1.11) and these were found to be significantly higher ($p\leq 0.05$) than T_5 (72.25±1.80), T_1 (69.25±0.48) and T_2 (68.25±0.85) respectively in this order.

Effects of treatments on stem girth (mm): Table 3 shows the effects of each of the treatments applied on the maize stem girth. The treatments showed significant effects in stem girth at 4 WAS and 8 WAS. The treatments were not significantly different from one another in all other weeks. At 4 WAS, T_3 was observed to give the highest stem girth (6.90±0.21 mm) and this was followed by T_6 (6.60±0.18 mm) and then T_4 (6.31±0.36 mm). The lowest stem girth at 4 WAS was recorded in T_5 (6.09±0.21 mm). At 8 WAS however, the highest stem girth was still recorded in T_4 groups (12.08±0.30 mm) while the lowest stem girth was found in T_1 (10.23±1.17 mm).

Effects of treatments on leaf length (cm): Table 4 shows the effects of treatments applied on the leaf length. All the treatments were not significantly different from one another in all the weeks except at 6 WAS and 10 WAS, where the highest leaf length was observed in T_3 (77.25±5.02) and T_5 (92.50±4.33) respectively and the lowest leaf length was found in T_6 (64.25±4.52) and T_1 (81.75±3.12) respectively.

Effects of treatments on leaf breadth (cm): Table 5 shows the effects of treatments applied on the leaf breadth.

Table 2: Effects of treatments on plant height (cm)

	Weeks after sowing (WAS)							
Treatments	4	5	6	7	8	9	10	11
T_1	51.50±1.44^a	69.25±0.48^{ab}	127.50±9.37^a	187.50±8.77^a	193.75±8.88^a	197.75±7.53^a	201.75±7.18^a	206.25±7.49^a
T_2	51.25±1.44^a	68.25±0.85^b	126.75±19.06^a	175.75±21.02^a	182.25±17.37^a	186.50±19.12^a	193.50±18.09^a	199.00±16.84^a
T_3	50.50±2.10^a	72.75±1.11^a	143.50±10.23^a	197.00±10.54^a	199.00±12.01^a	205.00±11.50^a	211.33±9.96^a	205.33±5.04^a
T_4	49.25±1.31^a	72.75±1.31^a	135.75±8.47^a	184.25±9.25^a	188.25±8.80^a	193.25±8.01^a	200.75±8.30^a	205.50±8.70^a
T_5	50.00±0.82^a	72.25±1.80^{ab}	127.75±10.23^a	174.00±15.19^a	177.75±13.51^a	185.75±13.33^a	192.25±12.19^a	200.00±10.34^a
T_6	49.50±0.87^a	72.75±1.89^a	136.00±6.42^a	162.25±28.49^a	169.00±27.87^a	174.25±28.06^a	178.75±27.95^a	183.00±28.00^a

T_1: *T. diversifolia*, T_2: *V. amygdalina*, T_3: NPK, T_4: NPK+*T. diversifolia*, T_5: NPK+*V. amygdalina*, T_6: Control, Mean±SEM (n = 4). Column with the same letter are not significantly different at $p\leq 0.05$ using Duncan multiple range test

Table 3: Effects of treatments on stem girth (mm)

	Weeks after sowing (WAS)							
Treatments	4	5	6	7	8	9	10	11
T_1	6.28±0.25^b	7.90±0.77^a	9.21±0.79^a	9.95±1.17^a	10.23±1.08^b	10.51±1.19^a	10.78±1.21^a	10.97±1.17^a
T_2	6.19±0.18^b	7.75±0.68^a	9.91±1.55^a	10.75±1.32^a	11.07±1.22^{ab}	11.54±1.32^a	12.16±1.65^a	12.84±1.68^a
T_3	6.90±0.76^a	7.64±0.50^a	10.45±1.12^a	11.27±1.08^a	12.08±0.30^a	12.34±0.54^a	12.75±0.53^a	13.10±0.41^a
T_4	6.31±0.36^{ab}	7.88±0.23^a	10.44±0.57^a	10.73±0.92^a	11.10±1.26^{ab}	11.31±1.33^a	11.45±1.31^a	11.98±1.56^a
T_5	6.09±0.21^b	7.14±0.54^a	9.95±0.57^a	10.34±0.62^a	10.84±0.81^{ab}	11.00±0.80^a	11.30±0.56^a	11.80±0.73^a
T_6	6.60±0.18^{ab}	6.40±2.73^a	10.06±1.28^a	10.58±1.31^a	10.74±1.25^{ab}	10.82±1.26^a	11.34±1.50^a	11.85±1.58^a

T_1: *T. diversifolia*, T_2: *V. amygdalina*, T_3: NPK, T_4: NPK+*T. diversifolia*, T_5: NPK+*V. amygdalina*, T_6: Control, Mean±SEM (n = 4). Column with the same letter are not significantly different at $p\leq 0.05$ using Duncan multiple range test

Table 4: Effects of treatments on leaf length (cm)

Treatments	Weeks after sowing (WAS) 4	5	6	7	8	9	10	11
T_1	24.50±0.87^a	46.00±0.82^a	68.75±3.15^{ab}	72.75±2.43^a	76.25±3.68^a	79.25±3.73^a	81.75±3.12^b	84.75±2.95^a
T_2	24.50±1.19^a	46.50±1.32^a	68.25±3.97^{ab}	77.75±3.57^a	82.50±2.10^a	86.75±2.17^a	90.50±2.18^{ab}	95.00±3.34^a
T_3	23.25±0.48^a	48.00±1.47^a	77.25±5.02^a	76.33±3.76^a	76.00±2.08^a	80.00±2.00^a	82.33±4.67^{ab}	86.67±5.24^a
T_4	24.50±0.65^a	49.50±0.65^a	71.25±0.63^{ab}	74.50±1.55^a	77.75±1.93^a	82.50±2.10^a	86.25±2.25^{ab}	91.00±1.68^a
T_5	23.75±0.75^a	47.25±1.11^a	73.25±4.07^{ab}	77.00±3.54^a	81.00±3.74^a	87.25±4.52^a	92.50±4.33^a	93.00±9.03^a
T_6	25.25±0.48^a	46.75±1.60^a	64.25±4.52^b	76.00±2.12^a	78.00±2.04^a	81.50±2.47^a	85.25±2.56^{ab}	90.25±2.06^a

T_1: *T. diversifolia*, T_2: *V. amygdalina*, T_3: NPK, T_4: NPK+*T. diversifolia*, T_5: NPK+*V. amygdalina*, T_6: Control, Mean±SEM (n = 4). Column with the same letter are not significantly different at p≤0.05 using Duncan multiple range test

Table 5: Effects of treatments on leaf breadth (cm)

Treatments	Weeks after sowing (WAS) 4	5	6	7	8	9	10	11
T_1	2.45±0.06^{ab}	3.05±0.03^d	4.30±0.15^a	4.83±0.21^a	4.90±0.24^{ab}	4.85±0.22^a	5.00±0.20^a	5.38±0.31^a
T_2	2.35±0.03^b	3.35±0.10^{bc}	4.53±0.21^a	4.93±0.15^a	5.30±0.12^a	5.15±0.12^a	5.25±0.14^a	5.75±0.32^a
T_3	2.43±0.03^{ab}	3.63±0.06^a	4.63±0.24^a	4.73±0.27^a	4.97±0.23^{ab}	4.83±0.17^a	5.43±0.07^a	5.67±0.17^a
T_4	2.48±0.05^{ab}	3.58±0.09^{ab}	4.83±0.12^a	5.25±0.13^a	5.05±0.03^{ab}	5.05±0.05^a	5.18±0.12^a	5.80±0.12^a
T_5	2.48±0.06^{ab}	3.55±0.10^{ab}	4.50±0.20^a	4.63±0.24^a	4.73±0.23^{ab}	4.88±0.13^a	5.00±0.20^a	5.55±0.26^a
T_6	2.53±0.03^a	3.28±0.06^c	4.75±0.32^a	4.68±0.20^a	4.25±0.60^b	4.75±0.14^a	4.90±0.14^a	5.25±0.14^a

T_1: *T. diversifolia*, T_2: *V. amygdalina*, T_3: NPK, T_4: NPK+*T. diversifolia*, T_5: NPK+*V. amygdalina*, T_6: Control, Mean±SEM (n = 4). Column with the same letter are not significantly different at p≤0.05 using Duncan multiple range test

Table 6: Effects of treatments on yield of maize

Treatment	Cob dry weight (g)
T_1	32.15±1.38^b
T_2	33.70±1.52^{ab}
T_3	36.13±0.63^a
T_4	34.13±0.59^{ab}
T_5	32.13±1.06^b
T_6	32.78±0.55^b

T_1: *T. diversifolia*, T_2: *V. amygdalina*, T_3: NPK, T_4: NPK+*T. diversifolia*, T_5: NPK+*V. amygdalina*, T_6: Control, Mean±SEM (n = 4). Column with the same letter are not significantly different at p≤0.05

There was a progressive increase in the leaf breadth across all the treatments applied as the weeks progressed. At 4 WAS, the highest leaf breadth of (2.53±0.03 cm) was observed in T_6 and this was found to be significantly higher compared to other treatments. At 5 WAS, T_3 gave the highest leaf breadth of (3.63±0.06 cm) while the lowest was recorded in T_1 (3.05±0.03 cm). At 6, 7, 9, 10 and 11 WAS, the treatments showed no significant effect on the leaf breadth in all the groups except in week 8, where the highest leaf breadth (5.30±0.12) was recorded in T_2 and which was found to be significantly higher compared to T_1, T_3, T_4, T_5 and T_6 ($p \leq 0.05$).

Effects of treatments on maize cob dry weight (g) (yield): Table 6 shows the effects of treatments applied on the maize cob dry weight. It was observed that the cob dry weight (g) of T_3 groups (36.13±0.63 g) was significantly higher ($p \leq 0.05$) compared to other treatments. This was closely followed by T_4 (34.13±0.59 g). The lowest cob dry weight (g) was however recorded in T_5 (32.13±1.06 g).

DISCUSSION

Maize plant height: As shown in Table 2, there was a rapid growth and development between the fifth week after sowing (5 WAS) and the eight week after sowing (8 WAS), at this stage the seedlings are passing through the logarithmic phase of growth, after which their growth were stabilized (stationary phase) leading to the death phase. In between these weeks, the tissues of the maize plants were still soft and tender which made them to be able to obtain as much nutrients and water as possible from the soil aiding their rapid growth and development. After 8 WAS, the plants had been stabilized in height and there were no much significant effects of the treatments. However, T_4 group gave the highest mean plant height, followed by T_3 and then T_6 (control). It was not surprising that T_4 ranked first. This may be due to the combining effects of both organic and inorganic fertilizer. T_3 maize seedlings did well because NPK is only a chemical that does not need to be in a home field advantage before it would dissolve to release its nutrients unlike *T. diversifolia* which is organic manure. Likewise, the volume of water used to wet the plants was enough to make the T_4 seedlings thrive better. Achieng *et al.* (2001) reported similar findings in maize plant height in a maize field treated with *T. diversifolia.* Groups treated with the decaying leaf litter of *Vernonia amygdalina* (T_2) and the one containing its mixture with NPK (T_5) gave the least performance. This means that T_2 and T_5 do not really have significant effects on the height of maize plant. However, at 4-5 WAS, treatments with the decaying leaf litter of *V. amygdalina* were poor in height compared to other treatments. This is also in line with the study of Liasu and Achakzai (2007). They reported that tomato plants subjected to mulching and fertilization with *T. diversifolia* exhibited the highest plant height and number of leaves per plant when compared with other treatment combinations. Ademiluyi and Omotoso (2007) also reported that early maize growth rate in terms of height were better under *T. diversifolia* applied soil than under the NPK fertilizer soils.

Maize stem girth: Group treated with NPK fertilizer (T_3) gave the best performance with respect to the stem girth followed by control (T_6) and then those treated with NPK+Ti (T_4). It was observed that the group treated with decaying leaf litter of *V. amygdalina* alone (T_5) showed some surprising growth in girth of maize plant when used as mulch. Other treatments were not significantly different from one another. This study disagreed with Ademiluyi and Omotoso (2007) who reported that stem girth were better under *Tithonia* applied soil than under the NPK fertilized soils.

Maize leaf length: Decaying leaf litter of *V. amygdalina* with NPK fertilizer (T_5) had more positive influence on the development of maize leaf length. The group treated with NPK (T_3) gave the best results with respect to leaf length and followed by NPK+Ve (T_5). Treatments with NPK+Ti (T_4) including those treated with *T. diversifolia* alone (T_1) did not have significant effect on maize leaf length.

Maize cob dry weight: The result obtained for the mean dry weight of cobs is similar to that of the plant height. T_3 and T_4 seedlings gave the best yield with respect to dry weight of cobs. This is in consonance with the study of Achieng *et al.* (2001) that reported that *T. diversifolia* and NP treatments were not significantly different for cob yield. Result of this study agrees with that of Ademiluyi and Omotoso (2007). They reported that there was higher vegetative and reproductive growth of maize in the *T. diversifolia* incorporated soil. Maize cob and grain yields were greatly increased by *T. diversifolia* biomass than NPK fertilizer.

CONCLUSION

NPK treatment gave the best result in terms of the growth and development of maize. This was closely followed by *T. diversifolia*+NPK treatment. We therefore conclude that degraded soils could be recovered for crop production at low cost with *T. diversifolia* than with the high cost of NPK fertilizer. We also conclude that the decaying leaf litter of *V. amygdalina* could positively influence the leaf breadth development in maize. However, considering the cost of inorganic fertilizer to farmers, a combination of *T. diversifolia* and NPK fertilizers will be a wise strategy in soil fertility restoration.

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