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EFFECTS OF SOIL UNDER THE CANOPY OF *AZADIRACHTA INDICA (NEEM)* AND *KHAYA SENEGALENSIS L (MAHOGANY)* AND INORGANIC FERTILIZER ON GROWTH AND DEVELOPMENT OF MAIZE (*ZEA MAYS*)

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Abstract - This experiment was conducted to evaluate the beneficial effects (if any) of *Azadirachta Indica (neem)* and *Khaya Senegalensis L (Mahogany)* tree litter on soil under the tree canopy for growth of maize and to determine the best tree species to use based on integrated farming system for crop production. Pots filled 2.5kg soil collected Under the two tree species and the sample from open space from a similar farm were arranged in a completely randomized design with three replication. Four seed of Maize cultivars (Oba98 & Oba super) were planted in the pots. The maize seeds germinated after five days and were thin to one per pot, adequate irrigation maintained to moist throughout the experimental period and compound fertilizer (NPK 15-15-15) corresponding to 200kg/ha^{-1} were applied (2weeks after days of sowing). The result revealed that Maize cultivars are grown on soil collected from under the canopy of the two tree species and fertilized NPK corresponding to 200kg/ha^{-1} substantially improved the plant height, leaf length and shoot and root dry weights than soil collected from the under tree species unfertilized and sandy-loam soil fertilized.

Key Words: Plant litter; *Azadirachta Indica (neem), Khaya Senegalensis L (Mahogany)*; Maize; Soil fertility

I. INTRODUCTION

Plant litter is the fastest way of adding organic matter and nutrients to the soil. (Hossain *et al*., 2011; Mason,1977; Park and Kang-Hyun, 2003). Microorganism play key role in decomposition and physical leaching of soluble components followed by

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microbial oxidation of refractory components (Mason,1977; Mahmmod *et al*., 2014; Valiela *et al*., 1985; Hasanuzzaman, 2014). The nutrient content of the plant litter added to the soil depends on individual species to another (Mahmmod *et al*., 2014; Benton Jones, 1998; Marchner, 1995). The quantity of nutrient accumulation to an ecosystem is reported to differ from individual species to another and supported by climate conditions (Mahmood and Saberi, 2005; Mahmmod *et al*., 2014; Seinwal *et al*., 2003). Suitable tree species choice established on nutrient cycling is important in agroforestry practice (Benton Jones, 1998). Plant litter comprises of different classes of organic compounds. Four major association of organic material has been reported in the litter: sugar, phenolics, hydrocarbon and glycerides, The solvable sugars, primarily mono and oligosaccharides are difficult to metabolize (Kruse *et al*., 2000). These compounds action depends on the concentrations (Einhellig, 1986) this can affect the plant growth when at higher concentrations and also when at a lower concentration, promote plant growth. This inhibitory behavior is attributed to the blockage or cessation of key physiological and metabolic processes of the plant. These allelochemicals on the other hand support growth and also trigger resistance to several abiotic stresses (Farooq *et al*., 2009a, 2009b). Comparative sizes of these combinations vary with the plant part (leaves, stems, roots, bark) and plant species. The plant litter value is measured using chemical contents of nitrogen, phosphorus, potassium and principal cell wall components, such as lignin, cellulose, and hemicelluloses that influence the litter decomposition and nutrient release (Swift *et al*., 1979).

In research conducted by Mubarak *et al*. (2009), the findings reported that *Khaya Senegalensis L. (Mahogany)*litter has the chemical composition of N=32.9, P=2.4, K=33, Ca=14, Mg=2.0, C=450, C/N=137, Lignin=17.4, and cellulose=25.0, and *Azadirachta Indica (neem)*litter was reported to have N=46.9, P=3.6, K=7.7, Ca=9.3, Mg=2.8, C=420, C/N=9, Lignin=16.5, and cellulose=19.9. Research in Burkina Faso has revealed that mulching sorghum with neem litter enhanced sorghum yields by up to 422% of the unmulched control (Tilander, 1993). Laboratory studies indicated that *Azadirachta Indica(neem)* biomass contained nitrogen content of 2.07%, 0.12% of phosphorous, 0.20% of potassium, 0.61% of calcium and 0.22% of magnesium, the biomass was applied together with NPK fertilizer. One hundred and twenty (120) kg of NPK fertilizer/ha significantly produced the highest maize grain yield of 3t/ha than all the treatments. The same grain yield of 1.8t/ha was obtained for 6t/ha of biomass (T_1), 4t/ha of biomass plus 40 kg of NPK fertilizer/ha (T_5), and 3t/ha of biomass plus 60 kg of NPK fertilizer/ha (T_4) which recorded the second-highest maize yield. 3t/ha of biomass gave maize yield of 1.2t/ha. All the treatments were significantly different from the control. The control had the least grain yield of 0.5t/ha. The highest level of NPK fertilizer application (120 kg/ha) significantly produced the highest maize height (170.2cm). Also, 6t/ha of biomass (T_1), 3t/ha of biomass with 60 kg of NPK fertilizer/ha (T_4), 4t/ha of biomass with 40 kg of NPK fertilizer/ha (T_5), were not significantly different but were significantly higher than 3t/ha of biomass (T_2), and the control (Rafiu, 2012).

Table 1: Nutrient content of *Azadirachta indica (neem)* and *Khaya Senegalensis (Mahogany)* litter

SN	Plant species	N	P	K	Ca	Mg	C	C/N	Lignin	Cellulose
1	*Azadirachta indica (neem)*	46.9	3.6	7.7	9.3	2.8	420	9	16.5	19.9
2	*Khaya Senegalensis (Mahogany)*	32.9	2.4	33	14	2.0	450	13.7	17.4	25.0

Source: Mubarak *et al.* (2009)

Mukaromah *et al*. (2016) reported Mahogany (S. macrophylla King) litter concentration was concomitant with inhibition radicle seedling growth compared to control. In most of the research on resource quality characterization, decomposition, and nutrient release, the focus has been put on leguminous plant species which are known to have high-quality materials (Cadisch and Giller, 1997). Non-leguminous plant species like *Azadirachta Indica (neem)* and *Khaya Senegalensis L (Mahogany)* can improve soil fertility and organic matter status of the soils. (Table 1). Despite the considerable importance of non-leguminous plant species in improving soil fertility and organic matter status of

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soils, few attempts have been made to quantitatively determine the effects of Mahogany and neem litter as a nutrient source for maize production. To evaluate the effects Mahogany and neem have on food crops, surface soil under Mahogany and neem tree was used to grow Maize. The findings indicated that two months after planting, the crops produce five times higher biomass on the soil from the neem plantation than on the control. The trees had favorable effects on soil fertility and therefore improved crop yield (Verinumbe, 1991). *Azadirachta Indica (neem)*and *Khaya Senegalensis L (Mahogany)* is one of the most widely planted exotic species on nutrient-deficient soils in Northern Nigeria. *Azadirachta Indica (neem)* and *Khaya Senegalensis L (Mahogany)* has acclimatized well throughout Northern Nigeria and is popular as a source of firewood and as poles and rafters for building construction as well as the provision of shade. *Azadirachta Indica (neem)* and *Khaya Senegalensis L (Mahogany)* extracts are also valued for their medicinal properties in treating malaria and as an insecticide for protecting grain. The leaves, together with the twigs, can be applied as mulch or incorporated into the soil as organic input to provide nutrients to crops. However, little or no attempt has been taken to screen or prioritize the commonly planted tree species in the cropland agroforests as well as other types of agroforestry based on nutrient cycling. The objectives of this study were: (1) to determine the effectiveness of litter decomposition on soil as regard to maize production for two commonly planted horticultural agroforestry tree species *Azadirachta indica (neem)* and *Khaya Senegalensis L (Mahogany)* (2) to determine the best tree species to use based on integrated farming system for crop production.

II. MATERIALS AND METHODS

2.1 Experimental site

The experiment was conducted at the department of applied ecology screen House located at 10º 16' N, and 9º 47' 19º E of Abubakar Tafawa Balewa University Yelwa Campus, Bauchi State Nigeria.

2.2 Collection and planting of seeds

Seeds of OBA98 and OBA SUPER for the experiment were obtained from Bauchi State Agricultural Development Program (BSADP).

2.3 EXPERIMENTAL Procedure

Soil sample for the experiment was collected 15cm deep directly under the roots and 100cm away from of *Azadirachta Indica (neem)* and *Khaya Senegalensis L (Mahogany)*trees in the agricultural research farm of Abubakar Tafawa Balewa University. The soil sample collected for each tree species was mixed (15cm deep and 100cm away), the sample of sand-loam soil was collected from the same farm in open space. 2.5kg of the soil sample was filled in pots arranged in a completely randomized design with three replication. The maize seed was sterilized in 10% Na-hypochlorite solution for 20 minutes to prevent fungal growth and then washed with distilled water (Di salvatiCarafa *et al.*, 2008). Three maize seeds were directly planted in each pot after the pots containing the soil were wet with water. The maize seeds germinated after five days and were thin to one per pot, adequate irrigation maintained to moist throughout the experimental period and compound fertilizer (NPK 15-15-15) corresponding to 200kg/ha^{-1} were applied (2weeks after days of sowing). The experimental layout was as follows:

T_1: OBA98 in *Azadirachta Indica* +NPK. (200kg/ha^{-1})
T_2: OBA98 in *Azadirachta Indica* –NPK
T_3: OBA Super in *Azadirachta Indica*+NPK (200kg/ha^{-1}).
T_4: OBA Super in *Azadirachta Indica* –NPK
T_5: OBA98 in *Khaya Senegalensis L* +NPK (200kg/ha^{-1})
T_6: OBA98 in *Khaya Senegalensis L* –NPK
T_7: OBA Super in *Khaya Senegalensis L*+NPK (200kg/ha^{-1})
T_8: OBA Super in *Khaya Senegalensis L* -NPK
T_9: OBA98 in Sandy-loam+NPK (200kg/ha^{-1})
T_{10} OBA Super in Sandy-loam+NPK (200kg/ha^{-1})

2.4 Data collection

2.4.1 Plant height: The plant height was recorded using a measuring tape. It was measured from the soil surface to the highest point of the arch of the uppermost leaf whose tip was pointing down Guzaman and Lamkey, 2000 [9].

2.4.2 Leaf length: Leaf length was measured to the nearest millimeter from the leaf tip to the point at which the lamina is attached to the petiole Ismail *et al*., 2009

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2.4.3 Dry shoot and root mass: After 45days sowing, the maize plant harvested and the soil was washed off the roots, then separated from the shoots with sharp knife and was put into brown envelope for oven drying at 70^{o} C for 48hours to a constant weight, shoot and root dry weight mass was measured using digital weighing balance and recorded. (Kyari *et al*., 2019).

2.5 Statistical analysis

Data collected were subjected to ANOVA using Minitab version 16. The difference between treatments was tested on plant height, leaf length, shoot and root dry weight.

2.6 Results and Discussion

The trees play an important role in improving soil fertility and which can lead to an improvement in crop yield output (Verinumbe, 1991). It is equally important to identify tree species with good biomass in the farm vicinity to reduce the labor cost of improving soil fertility. Such plant species be supposed to have the ability to add to phosphorus availability to crops because organic inputs contain low phosphorous contents (Palm *et al*., 1997). The results of our present study as shown in table 2, showed that in the plant height, T_1: OBA98 planted in *Azadirachta Indica* soil+NPK(200kh/ha^{-1}) recorded 107.73cm, while T_2: OBA98 in *Azadirachta Indica* soil –NPK recorded 77.63cm, also T_3: OBA Super in *Azadirachta Indica* soil +NPK recorded 100.37cm, T_4: OBA Super in *Azadirachta Indica* soil –NPK was 77.63cm, T_5: OBA98 in *Khaya Senegalensis L* soil +NPK it was 98.63cm, T_6: OBA98 in *Khaya Senegalensis L* soil –NPK was 96.93cm, T_7: OBA Super in *Khaya Senegalensis L* soil +NPK90 has 17cm, T_8: OBA Super in *Khaya Senegalensis L* soil –NPK was 78.37cm, T_9: OBA98 in Sandy-loam soil +NPK7 recorded 76.33cm, and T_{10} OBA Super in Sandy-loam soil +NPK 58.57cm. Comparing between the treatments, maize cultivar OBA98 ($T_{1)}$ planted in the soil collected under *Azadirachta Indica (neem)* tree with application of 200kg/ha^{-1} NPK significantly recorded higher mean plant height than all the treatments. The results of the research found that plant height was higher in the soil collected under the two tree species (*Azadirachta Indica* and *Khaya Senegalensis L.)* with the addition of 200kg/ha^{-1} NPK. Although it was closely followed by soil collected under the tree but without the addition of NPK as compared to sandy-loam soil with the addition of 200kg/ha^{-1} NPK. The higher plant height recorded in the soil collected under the trees could be due to the decomposed litter that was added to the soil by the plants. The results of our experiment agree with the report of Verinumbe, (1991) that trees had favorable effects on soil fertility and therefore improved crop yield. However, in the leaves length T_1: OBA98 planted in *Azadirachta Indica* soil+NPK(200kh/ha^{-1}) recorded 83.77cm and T_2: OBA98 in *Azadirachta Indica* soil –NPK 65.20cm, while T_3: OBA Super in *Azadirachta Indica* soil +NPK recorded 82.07cm, and T_4: OBA Super in *Azadirachta Indica* soil –NPK was 60.27cm, then T_5: OBA98 in *Khaya Senegalensis L* soil +NPK 82.03cm, T_6: OBA98 and *Khaya Senegalensis L* soil –NPK65.20cm. Also T_7: OBA Super in *Khaya Senegalensis L* soil +NPK was 77.83cm and T_8: OBA Super in *Khaya Senegalensis L* soil –NPK 63.27cm, T_9: OBA98 in Sandy-loam soil +NPK59.47cm, and T_{10} OBA Super in Sandy-loam soil +NPK 59.47cm. Maximum leaf length value was recorded in T_1 followed by T_3, T_4, and T_7 where the soil sample was collected under the trees canopy with application of 200kh/ha^{-1} of NPK. More also, maize cultivars raise on soil samples collected directly under the tree canopy without application of NPK gave appreciable leaf length when compared to those raised on sandy loam with 200kh/ha^{-1} of NPK (Table 2). Here, our study found that the integrative effects of soil organic matter and inorganic fertilizer has improved on maize productivity and we also found that combined application of both organic and inorganic sources of nutrients can improve growth and other yield-related attributes of maize (Table 2). The outcome of the findings also showed that *the Azadirachta Indica* tree is a good species that can be integrated with maize on the same land in terms of maize production. Our results corrugate with the findings reported by Mubeen *et al.* (2013), that combined application of organic and inorganic fertilizers is considered a good option to enhance nutrient recovery, plant growth, and ultimate yield otherwise higher N and P application rates are required to attain better yield in maize.

Furthermore, in the dry shoot mass T_1: OBA98 planted in *Azadirachta Indica* soil+NPK(200kh/ha^{-1}) recorded 25.63g and T_2: OBA98 in *Azadirachta Indica* soil –NPK 8.70g, while T_3: OBA Super in *Azadirachta Indica* soil +NPK recorded 26.63, and T_4: OBA Super in *Azadirachta Indica* soil –NPK was 8.70g, then T_5: OBA98 in *Khaya Senegalensis L* soil +NPK 17.97g, T_6: OBA98 and *Khaya senegalensis L* soil –NPK 6.30g. Also T_7: OBA Super in *Khaya Senegalensis L* soil +NPK was 9.63g and T_8: OBA Super in *Khaya Senegalensis L* soil –NPK 11.63g,

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T_9: OBA98 in Sandy-loam soil +NPK was 3.77g, and T_{10} OBA Super in Sandy-loam soil +NPK 7.30g (Table 2). Substantial improvement in shoot dry weights was observed T_3, T_4, and T_5 by the application of inorganic fertilizer (Table 2). From the finding, it was deduced that the maximum shoot dry weight was obtained in the soil collected under *Azadirachta Indica* tree species and fertilized with 200kh/ha^{-1} NPK. Improved plant height and leaf area in plants by organic manure applications have been reported (Boateng *et al.*, 2006; Muhammad & Khattak, 2009). In the dry shoot mass, T_1: OBA98 planted in *Azadirachta Indica* soil+NPK (200kh/ha^{-1}) recorded 2.90g and T_2: OBA98 in *Azadirachta Indica* soil –NPK 3.63g, while T_3: OBA Super in *Azadirachta Indica* soil +NPK recorded 5.07g, and T_4: OBA Super in *Azadirachta Indica* soil –NPK was 3.60g, then T_5: OBA98 in *Khaya Senegalensis L* soil +NPK 4.87g, T_6: OBA98 and *Khaya Senegalensis L* soil –NPK 3.13g. Also T_7: OBA Super in *Khaya Senegalensis L* soil +NPK was 3.07g and T_8: OBA Super in *Khaya Senegalensis L* soil –NPK 4.50g, T_9: OBA98 in Sandy-loam soil +NPK was 1.33g, and T_{10} OBA Super in Sandy-loam soil +NPK 3.13g. The maximum root dry mass was recorded in T_3 although not fertilize with NPK but collected under *Azadirachta Indica*, then T_5 and T8 raised on the soil sample collected from under trees species of *Azadirachta Indica* and *Khaya Senegalensis L* fertilized with 200kh/ha^{-1} of NPK, followed by T_2 and T_3, Better root growth is responsible increased nutrient uptake in plants (Aziz *et al*.,2006). The findings could suggest that the addition of organic matter by the tree litter may the reason for improved root matter. The improved shoot and root growth by the addition of organic manure (Muhammad &Khattak, 2009; Boateng *et al.*, 2006; Hirzel *et al.*, 2007) might be attributed to improved soil P and K availability (Marschner, 1995).

Table 2: Effects of tree litter on soil under canopy soil and inorganic fertilizer on some agronomic characters of Oba98 and Oba Super Maize cultivars.

SN	Maize Cultivars	Soil used (kg/pot)	Treatments	Plant height (cm/pot)	Leaf length (cm/pot)	Dry shoot Mass (kg/pot)	Dry root mass (kg/pot)
1	OBA98 (T_1)	*Azadirachta Indica*	200kg/ha^{-1}	4.64±107.73^{a}	3.53±83.77^{a}	3.51±25.63^{a}	0.52±2.90^{a}
2	OBA98 (T_2)	*Azadirachta Indica*	- NPK	25.59±77.63^{ab}	14.32±60.27^{bc}	0.87±8.70^{bc}	1.44±3.63^{a}
3	OBA Super (T_3)	*Azadirachta Indica*	200kg/ha^{-1}	4.24±100.37^{ab}	1.90±82.07^{ab}	4.62±26.63^{a}	3.55±5.07^{a}
4	OBA Super (T_4)	*Azadirachta Indica*	- NPK	25.59±77.63^{ab}	14.32±60.27^{bc}	1.22±8.70^{bc}	1.73±3.60^{a}
5	OBA98 (T_5)	*Khaya senegalensis*	200kg/ha^{-1}	11.11±98.63^{ab}	6.96±82.03^{ab}	1.17±17.97^{ab}	1.62±4.87^{a}
6	OBA98 (T_6)	*Khaya senegalensis*	- NPK	11.20±96.93^{ab}	4.85±65.20^{ab}	3.61±6.30^{c}	2.30±3.13^{a}
7	OBA Super (T_7)	*Khaya senegalensis*	200kg/ha^{-1}	19.72±90.17^{ab}	10.19±77,83^{ab}	0.31±9.63^{bc}	0.47±3.07^{a}
8	OBA Super (T_8)	*Khaya senegalensis*	-NPK	13.32±78.37^{ab}	6.39±63.27^{abc}	8.02±11.63^{bc}	0.79±4.50^{a}
9	OBA98 (T_9)	Sandy-loam	200kg/ha^{-1}	1.53±76.33^{ab}	0.47±59.47^{bc}	0.85±3.77^{c}	0.70±1.33^{a}
10	OBA Super (T_{10})	Sandy-loam	200kg/ha^{-1}	3.00±58.57^{b}	0.91±41.97^{c}	2.21±7.30^{c}	1.04±3.13^{a}

Means that do not share a letter are significantly different. – means no inorganic fertilizer. OBA98 (Obasanjo Maize bread), OBA Super (Obasanjo maize bread).

III. CONCLUSION

The soil collected under the canopy of *Azadirachta Indica* (*neem*) and *Khaya senegalensis* (*Mahogany*) tree combined with NPK fertilizer produced substantial plant height, leaf length, shoot, and dry weight. This showed that maize can be integrated with the tree species with the application of fertilizer to improve crop production.

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