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*Full Length Research Paper*

# Impact of Leucaena leucocephala on Soil Properties and Oil Palm Yield Over Time

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**The study investigated a long-term effect of *Leucaena leucocephala* a leguminous tree crop on the soil physico-chemical properties and its possible effect on the fresh fruit bunch (FFB) production of oil palm. *L. leucocephala* had a highly significant (P≤.01) effect on soil physico-chemical properties than the control. The soil under *Leucaena leucocephala* exhibited relatively high mean weight diameter, water retention, total soil available N, available P and Exchangeable cation, than the control, and thus enhanced fresh fruit bunch (FFB) production. Mean fresh fruit bunch yield, over a three year period, was significantly higher (P≤0.05), with FFB yields of 10.93 tons / ha in plots with *L. leucocephala* as against 6.8 tons / ha in the control plots.**

**Key words:** Long term (to be deleted), *Leucaena leucocephala*, physico-chemical properties, and fresh fruit bunch yields.

## INTRODUCTION

Maintenance of soil organic matter is very essential for the successful growth and yield of crops. There are thousand of farmers throughout the world (mostly poor resource farmers) that due to enormous constraints cannot afford the use of chemical fertilizers to enhance or maintain soil fertility (Conway, 1997) . Fertilizers have proved over the years to improve crop yields, but they are not without their short comings and problems. According to Kang and Mulongoy (1992) the use of fertilizers alone cannot maintain soil productivity, as these soils require a regular supply of organic matter. The maintenance of soil fertility in the tropics is a major agricultural challenge. In the tropical soils, the organic matter content has to be enhanced regularly in view of rapid oxidation and exhaustion (Asawalam, 2004). Nutrient availability depends greatly on the general soil conditions, soil life and organic matter content (Magdoff and Van Es, 2000). Agricultural production in low input system in the tropics relies largely on nutrient recycling and maintenance of soil fertility through biological processes. One of such biological system is alley cropping which utilizes perennial woody leguminous tree species to produce biomass and recycle nutrients in an important agro-forestry system thus hasten soil fertility restoration. Soil structure controls many aspects of productive potentials like air and heat flow into and out of the soil, water retention and movement as well as ease of root penetration and uptake of nutrients elements. Whereas soil texture cannot be changed economically over a short period of time, soil structure may be easily changed to advantage by proper management. Indices of soil structure include bulk density, porosity and soil aggregate size and stability. Evidences have shown that alley cropping has beneficial effects on the soil physico chemical properties (Arowolo, 2007). *Leucaena leucocephala* used in alley cropping contribute to soil fertility and food crop nutrition when theirpruning decomposed as liters. Attah-Krah (1990) reported that within six months, *L. leucocephala* fixed 250 kg N/ha. Also Kang and Mulongoy (1992) reported a range of 150 – 160 kg N/ha that was fixed by *L. leucocephala*. According to Kang et al. (1990) and Attah-Krah and Okali (1986) they observed that soils under *L. leucocephala* had a higher soil organic matter, total soil N, low soil temperature fluctuation, high soil moisture and soil

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**Table 1.** *Leucaena leucocephala* effect on soil chemical properties at various depths

| Soil depth (cm) | Organic Matter $gkg^{-1}$ | | pH | | Total N ($gkg^{-1}$) | | Bray p-1 mg $kg^{-1}$ | | K cmol $kg^{-1}$ | | Exch. Mg cmol $kg^{-1}$ | | Exch. Ca. cmol $kg^{-1}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LL | CC | LL | CC | LL | CC | LL | CC | LL | CC | LL | CC | LL | CC |
| 0 – 15 | 43.0 | 30.0 | 7.0 | 6.0 | 3.5 | 1.7 | 19.9 | 12.0 | 0.26 | 0.15 | 0.35 | 0.15 | 0.30 | 0.20 |
| 15 – 30 | 35.0 | 8.0 | 6.5 | 5.7 | 2.3 | 1.5 | 16.10 | 10.2 | 0.26 | 0.13 | 0.23 | 0.08 | 0.20 | 0.15 |
| 30 – 45 | 23.0 | 8.0 | 6.0 | 5.5 | 2.3 | 1.4 | 16.0 | 4.0 | 0.15 | 0.10 | 0.15 | 0.08 | 0.20 | 0.15 |
| 45 – 60 | 9.5 | 6.7 | 5.9 | 5.6 | 2.1 | 1.2 | 8.0 | 4.0 | 0.15 | 0.10 | 0.09 | 0.08 | 0.20 | 0.15 |
| *LSD 0.05* | 3.25 | | 0.123 | | 0.04 | | 1.23 | | 0.04 | | 0.15 | | 0.08 | |

LL: *Leucaena leucocephala*
CC: Control

moisture retention than soil without *L. leucocephala*. Arowolo (2007) observed that erosion in plots with *L. leucocephala* was reduced by 83% when compared to the control treatment. Kang and Mulongoy (1992) reported that yields of crop could be maintained for many years at reasonable levels with the use of *L. leucocephala* without application of inorganic fertilizers. Despite these benefiting advantages, its adoption was on the lower side. There is a dearth of information on long term effect of *L. leucocephala* on soil properties supporting oil palm and its possible effect on yield. Thus this study was carried out to investigate the long-term effect of *L. leucocephala* on physico-chemical properties of soil supporting oil palms and their implication on oil palm fresh fruit bunch (FFB) production.

## MATERIALS AND METHODS

The study was carried out at the Main station of the Nigerian Institute for Oil Palm Research (NIFOR) in Ovia North East Local Government Area of Edo State, Nigeria. Fields 1 and 39 were used for these experiments. These fields were established with oil palm in 1987 with the view of establishing the compatibility of the oil palm and selected leguminous hedgerows. Also to determine the possibility of sustaining the performance of the crops and the economic viability of the oil palm based alley cropping. The fields were laid out as a randomized complete block design (RCBD) with three replicates, with control plots having no *L. leucocephala.* The palms were spaced at 9 x 14 m rectangular with 77 palms/ha. The inter rows were planted with *L. leucocephala.* At the beginning of the year before cropping season, the *L. leucocephala* are pruned down and their litters spread evenly to allowed proper decomposition before food crops are intercropped. Over the years the spacing between two rows were sequentially intercropped with maize, melon and cassava until later 2005. Inorganic fertilizers were not applied in both the *L. leucocephala* plots and the control plots.

Three pedons were sited on the top, middle and lower slope of each field. Bulk soil samples were taken at four depths (0 – 15, 15 – 30, 30 – 45, and 45 – 60 cm) using soil sampling augur. The samples collected were air-dried, crushed and sieved using 2mm sieve. The sieved soil samples were analyzed for organic matter using wet dichromate oxidation method of Walkey and Black (1934). Soil pH was determined in water suspension (1:1 soil to solution ratio) using a pH meter. Particle size distribution was determined by a combination of wet sieving and hydrometer techniques (Bouyoucous, 1951) method. Total nitrogen was determined with macro-kjeldhal apparatus as described by Bremner (1965). Available P was determined using Bray-1 method as described by Bray and Kurtz (1945). Exchangeable bases were measures by extraction with neutral N $NH_4OAC$. Potassium in the extract was determined by flame photometry, while the calcium and magnesium were determined by atomic absorption spectrophotometer. Mean weight diameter (MWD) was calculated as the accumulated sum of each fraction times the corresponding mean mesh size of the two sieves passing and retaining the fraction (Van Bovel, 1949). Dispersible clay and wet aggregate stability (WAS) were measured on the same sample by adopting the procedure described by Darwish et al. (1995). Oil palm yield of fresh fruit bunch (FFB) for 2004 to 2006 were obtained from Harvesting Division, NIFOR. Data obtained were subjected to analysis of variances (ANOVA) according to Steel and Torrie (1984) model. Mean of treatments were separated using the L east Significant Difference at 5% levels of probability.

## RESULTS AND DISCUSSION

Data on the effects of *L. leucocephala* on soil chemical properties are presented in Table 1. *L. leucocephala* had a highly significant effect ($P<0.01$) on soil chemical properties, both the physical and chemical properties of the soil were significantly improved by the *L. leucocephala* over the control. The soil nutrient contents, such as soil pH, organic matter, total available N, available P, exchangeable K, Mg and Ca were highly improved than the control. The soil pH was improved for relatively acidic to neutral and this is due to improvement of the soil structure due to the addition of humus from the decayed litters. The total N, available P and Exchangeable K, Mg and Ca were relatively higher in plots with *L. leucocephala* than the control. The improvement of the soil nutrient could be attributed to the fact that *L. leucocephala* apart of the ability of fixing N in the soil, through dead and decayed of fallen leaves significantly added high quantities of N and organic matter to the soil (Table 1). According to Magdof and Van Es. (2000), *L. leucocephala* also provided a favourable microclimate, which enhanced microfauna activities, thus enhancing soil water holding capacity and nutrient recycling by beneficial biological organism. The microclimate provided by the *L. leucocephala* trees allowed burrowing organism to burrow into the soil and

**Table 2.** *Leucaena leucocephala* effect on some selected soil properties.

| Treatment | Bulk density g/cm$^3$ | Total porosity % | Infiltration rate cm/min | Dispensable clay Kg-$^{1}$ | Mean weight diameter mm | Wet aggregate stability gKg$^{-1}$ | Particle size distribution % | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Clay | silt | Sand |
| *Leucaena leucocephala* | 0.8 | 69.8 | 0.86 | 0.93 | 1.06 | 0.26 | 20.8 | 12.9 | 65.3 |
| Control | 1.3 | 50.9 | 0.54 | 1.06 | 0.87 | 0.13 | 22.8 | 10.9 | 66.3 |
| *LSD* 0.05 | 0.016 | 2.11 | 0.13 | 0.03 | 0.03 | 0.04 | 7.5 | 8.5 | 10.5 |

**Table 3.** Oil palm mean bunch number (MBN), single bunch weight (SBW) and fresh fruit bunch (FFB) production as influenced by *Leucaena leucocephala* between 2004 to 2006.

| Treatment | Mean bunch number/palm | | | Mean single bunch weight Kg/palm | | Fresh fruit bunch (FFB) t / ha | | |
|---|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2006 | | 2004 | 2005 | 2006 | Mean |
| *Leucaena leucocephala* | 6.5 | 7.0 | 7.3 | 15.3 | 8.6 | 10.3 | 13.9 | 10.93 |
| Control | 4.5 | 5.3 | 4.0 | 10.2 | 6.2 | 6.7 | 7.6 | 6.8 |
| *LSD* | 0.57 | 1.67 | 2.17 | 2.13 | 0.36 | 1.55 | 1.57 | 1.23 |

aid in degradation of fallen litters and also loosing the soil structures which will aid aeration and rooting of the crops.

Table 2 shows long-term effect of *L. leucocephala* on soil physical properties. *L. leucocephala* had a highly significant ($P \leq 0.01$) effect on soil physical properties. Soil structure controls many aspects of productive potentials like air and heat flow into and out of the soil, water retention and movement as well as ease of -- penetration and uptake of elements. Indices of soil structures include bulk density, porosity and soil aggregate size and stability. These were highly improved by *L. leucocephala* than the control. Soil with *L. leucocephala* had high water retention capacity, high porosity, and infiltration rate than the control. This may be attributed to improved soil structure due to *L. leucocepha.* The mean ) which is a measure of soils ability to withstand wind erosion and other soil parameters such as wet aggregate stability, total porosity infiltration rate were significantly affected by *L. leucocephala* over the control. Soil water and the physical properties related to its storage play significant role in determining how a soil should be managed and the productive potential of the soil. Soil with *L. leucocephala* had higher organic matter than the control, thus retained more water than the control. This enhanced proper nutrient utilization, because the available water provide medium for dissolution and assumption of the minerals nutrient. *L. leucocephala* also provides a favourble environment for biological organisms, which help in nutrient recycling.

Soil fauna, especially earthworms are important for the recycling of soil nutrients and the decomposition and mineralization of crop residues (Asawalam, 2004). Shading provided by *L. leucocephala* enhanced the activities of these micro-organisms because they are sensitive to ultra violet radiation. Visual observation shows a high cast formation in plots with *L, Leucocephala* than the control plots.

Table 3 shows that fresh fruit bunch (FFB) production were significantly higher ($P<0.05$) in plots with *L, leucocephala* than the control. This high performance of palms in *L. leucocephala* could be attributed to improved soil structure and nutrient as influenced by *L. leucocephala. L. leucocephala* increased mean FFB yield in 2004 by 38.7%, in 2005 FFB yield increased by

53.7% and in 2006, it increased by 82.9% over the control.

## Conclusion

The result of this study shows that *L. leucocephala* had tremendous impact on the soil properties and thus increased the efficiency of nutrient used and minimized nutrient loss from the agro-system. Oil palm fresh fruit bunch yields were significantly increased by *L. leucocephala* over the control for the 3 year period. Thus it is a cost-effective way to improve the productivity of small, resource poor farmers.

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