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Effect of Neem tree canopy (*Azadirachta indica*) on some selected physical properties of soils in Kano University of Science and Technology teaching and research farm, Gaya

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ABSTRACT

The large-scale plantation of Neem trees have been used in the Sudan and Sahelian region of Nigeria to combat desertification, deforestation, soil erosion, and reduce excessive global warming. The research was aimed to investigate the effect of Neem tree canopy (*Azadirachtaindica*) on soil Bulk density and soil porosity in Kano University of Science and Technology Teaching and Research farm, Gaya, Kano State. The farm was divided into four quadrants, and three Neem trees were selected from each quadrant. Soil samples were collected at distances of 2m, 4m, 6m (from tree girth), and outside the Neem tree shades and were analyzed in the laboratory. Core samples were also taken from each sampling point and were analyzed for bulk density determination. The results of Bulk density show a significant difference ($P<0.05$) across the four quadrants, with Quadrant 4 having the highest Bulk density mean value ($1.61 gcm^{-3}$). There is no significant difference ($P>0.05$) in Bulk density across distances from Neem tree girth. However, bulk density mean value was found to be increasing across distances of 2m, 4m and 6m from tree girth. The results of soil porosity show no significant difference ($P>0.05$) across the four quadrants and across distances from Neem tree girth. The porosity mean values outside shade is found to be the least (36.5%). The low Bulk density mean values and high porosity mean values of the area found under the Neem tree canopy is suitable for alley cropping as well as possess good aggregate stability, hence, reduces the susceptibility of the soils to erosion. Further research should be done to study the macro and micronutrients composition of soils under the Neem tree canopy, which will aid in fertility management of the soils.

1.0 Introduction

Neem tree (*Azadirachta indica*) A. Juss is a hardy, fast-growing evergreen tree with a straight trunk, long spreading branches and moderately thick, rough, longitudinally fissured bark. Mature trees attain a height of 7-15 m (23-50 feet) (Ogbuewu, 2009). The tree starts producing the yellowish ellipsoidal drupes (fruits) in about 4 years, becomes fully productive in 10 years and may live for more than 200 years. The leaves are compound, imparipinnate, comprising 15 leaflets arranged in alternate pairs with terminal leaflets (Ogbuewu, 2009). The leaflets are narrow, lanceolate, up to 6 cm long. The flowers are abundant, sweet-smelling white panicles in the leaf axils. Seed propagation in nurseries followed by direct planting in the field is accepted to produce plantation stands (Ogbuewu, 2009). The one seed Neem fruit is yellow when ripe and is about one inch long (Ogbuewu, 2009).

Soil properties are strongly influenced by the vegetation characteristics under which the soils are located (Abubakar, 1995; Islam and Weil, 2000; Aweto and Dikinya, 2003; Ayoubi *et al*., 2011; Senjobi and Ogunkunle, 2011). For example, Tree canopies and litter protect soils from exposure to direct solar radiation, which raises soil temperature and causes evaporation of soil moisture and shrinking of organic matter and clay colloids, causing soils to compact (Aweto and Dikinya, 2003). In contrast to bare cultivated and degraded lands, soil losses from lands with good vegetation cover are usually negligible (Jaiyeoba and Leow, 1983).

Soil physical properties are more important now than ever before in sustainable agricultural productivity because of the shrinking global per capita arable land area (Brown, 1991; Engelman and LeRoy, 1995). It was 0.50 ha in 1950, 0.20 ha in 2000, and may be only 0.14 ha in 2050 and 0.10 ha in 2100 (Lal, 2000). Therefore, preserving and restoring world soil resources is crucial to meeting the demands of the present population without jeopardizing

the needs of future generations (Lal, 2000).
The study investigated the effect of Neem tree canopy on some selected physical properties of soil. After identifying the physical status of the soils under tree canopies, farmers and organizations concerned should be enlightened and geared towards the growing of Neem trees and the appropriate use of the soils under Neem tree canopies.

2.0 Materials and methods

2.1 Site description: The experimental field study was conducted at the University Research, Teaching and Commercial farm, Kano University of Science and Technology Wudil in Gaya. The site is located at latitude 11º55'5" N and longitude 9º0'40" E with an elevation of 415m above sea level. This area has a mean annual rainfall of 773.4 mm. The soil of the area is generally sandy loam, dark brown, with high content of silt (Adamu; Muhammad and Adam, 2014).

2.2 Soil Sampling: The experimental site was divided into four (4) quadrants, and a systemic random sample was taken from the site. In each of the four quadrants, three Neem trees were selected at random and samples were collected at 2m, 4m, 6m distance from the tree girth and local control was also taken outside the tree shade using a soil auger at adepth of 0 – 20cm, making a total of 48 samples. At each sampling point, a core sampler was used to take samples for bulk density determination making 48 core samples. The collected samples were air-dried and kept carefully in well-labelled polythene bags, each without allowing mix-up and then taken to the laboratory for analysis.

2.3 Laboratory Analysis

2.3.1.Soil Bulk density: From undisturbed soil samples,Bulk density isanalyzed using the core method calculated by dividing the the oven-dried mass at 105°C by the volume of the oven dry core (Grossman and Reinsch, 2002). The core samples soils were oven-dried, and the Bulk density (BD) was calculated by dividing the mass of the oven-dried soil (in grams) by the respective volume (in cm^3) as it exists naturally under field conditions.

$$Bulk\ density = \frac{mass\ of\ oven\ dried\ soil}{volume\ of\ soil}$$

2.3.2. Total porosity: Total porosity was determined from the values of Bulk density and Particle density (Brady and Weil, 1996). Using the formula below:

$$Total\ porosity = \left\{1 - \left(\frac{Bulk\ density}{particle\ density}\right)\right\} * 100$$

The data collected were subjected to Analysis of Variance (ANOVA) to statistically compare the difference among treatments using GenStat 17th edition statistical software. Statistical differences between means were tested using the Tukey-Kramer Honest Significant Difference (HSD) (at P>0.05).

3.0 Results and Discusion

3.1 Effect of Neem tree canopy across the distance from tree girth on soil Bulk density of KUST Research farm:

The results of the effect of shading across distances from tree girth on Bulk density are presented in Table 1. The table shows that there is a significant difference in Bulk density across the four quadrants. Quadrant 4 has the highest Bulk density (1.61gcm^{-3}), while Quadrant 1 has the least Bulk density (1.50gcm^{-3}). There is no significant difference in Bulk density means across distances from tree girth. However, the 2m distance from the tree trunk has the least Bulk density (1.52gcm^{-3}), and the Bulk density increases slightly with an increase in the distance under the tree shade. There is no significant difference in Bulk density for interaction between quadrants and distance from tree girth.

3.2 Effect of Neem tree canopy across the distance from tree girth on Soil porosity of KUST Research farm:

The effect of shading across distances from tree girth on soil porosity is presented in Table 2. The table shows that there is no significant difference in the porosity mean of the four quadrants. Quadrant 1 has the highest porosity (43.1%), while Quadrant 2 has the least porosity (37.6%). Distance from tree girth has no significant difference in porosity mean value. 6m distance from tree girth has the highest porosity (44.5%), while the soil outside tree shade has the lowest porosity mean value (36.5%). The interaction between quadrants and distance has no significant difference in mean porosity values.

Table 1: Effect of Neem tree canopy across distances from tree girth on Soil bulk density of KUST research farm

Treatments	Bulk density (gcm^{-3})
Quadrants	
1	1.50b
2	1.59ab
3	1.56ab
4	1.61a
F.Pr	0.046
S.E.D	0.0372
Distances from tree trunk	
2m	1.52
4m	1.59
6m	1.60
Outside shade	1.56
F.Pr	0.12
SED	0.0372
Interaction	
Quadrant * Distance	NS

Note:
NS means not significant

Table 2: Effect of Neem tree canopy across distance from tree girth on Soil porosity of KUST research farm

Treatments	Soil porosity (%)
Quadrants	
1	43.1
2	37.6
3	40.5
4	41.8
F.Pr	0.658
SED	4.54
Distances from tree trunk	
2m	42.2
4m	39.7
6m	44.5
Outside shade	36.5
F.Pr	0.349
SED	4.54
Interaction	
Quadrant * Distance	NS

Note:
NS means not significant

4.0. Discussion

4.1 Effect of Neem tree canopy across distances from tree girth on soil Bulk density of KUST research farm

The significant difference in Bulk density means across the four quadrants may have resulted from the different land uses of the quadrants. Quadrant 4, having the highest bulk density value, has been subjected to cropping for a long time. This is in agreement with the findings of Woldeamlak and Stroosnijder (2003) and Mulugeta (2004), which revealed that the Bulk density of cultivated soils is higher than the Bulk density of forest soils. Mulugeta (2004) also stated that soil Bulk density increased in the 0-10 and 10-20cm layers related to the length of time the soils were subjected to cultivation. Sanchez (1976) also explained that many soil physical properties change with changes in the land use system and its management. Even though the effect of shading across the distance from tree girth has been found to be statistically not significant, the Bulk density mean values increases slightly with an increase in the distance under tree shade. The Bulk density values between 0.9 and 1.4gcm^{-3}are considered low, according to Esu (2010). The results on Bulk density are within the range expected in most mineral soils (Hillel, 1980) and are less than the critical limits for root restriction (1.75 – 1.85gcm^{-3}) (Soil survey staff, 1996). The moderate Bulk density that enhances root growth is 1.3 – 1.5 gcm^{-3} (Tracy *et al.*, 2012), but it also depends on the soil texture and the content of organic matter (Guimaraes*et al.,* 2002).

4.2 Effect of Neem tree canopy across distances from tree girth on soil porosity of KUST research farm

Quadrant 1, having the least Bulk density mean value, has higher porosity mean value (43.1%). This coincides with the findings of Foth (1990), who described that the total porosity of soils generally lies between 30% and 70% and in soils with the same particle density, the lower the Bulk density, the higher is the percentage of total porosity. The effect of shading across distances from tree girth on both soil Bulk density and particle density was found to be not significant. These two factors are responsible for the rise or fall in Bulk density as proven by Hillel (1980) that Particle density affects porosity of the soil, soil aeration and rate of sedimentation of particles and Barauah and Barthakulh (1997) came to the conclusion that measurement of soil Bulk density is required for the determination of compactness, a measure of soil structure, for calculating soil pore space and an indication of aeration status and water content. This explains why the effect of shading across distances from tree girth on soil porosity was also found to be not significant statistically. In general, the porosity of the soil in the area is marginally suitable for crop productionbecause, according to Essoka and Esu (2001), the porosity of about 50 % is best for crop production while those below 40 % are unsatisfactory.

5.0 Conclusion and Recommendation

The results show that the effect of Neem (*Azadirachta indica*) tree canopy on soil Bulk density and soil porosity is not significant statistically, however, Bulk density mean value was found to be increasing across distances of 2m, 4m and 6m from tree girth. The porosity mean values outside shade is found to be the least. Based on these research findings, Bulk density should be reduced by limiting soil compaction and adding organic manure (especially residues of animal origin since the canopy region has a plant source; tree litter). Alley cropping, especially with legumes, will provide protection and conservation benefits, significantly improve the marginally good porosity of the soils, hence alleviating the effects of soil compaction and improve crop production through diversification of farm income.Finally, further research should be done to study the macro and micronutrients composition of soils under the Neem tree canopy, which will aid in fertility management of the soils.

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