Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.11, 2016

Comparative Performance of Mechanically Induced Compaction on Maize Growth for Two Soils of Nigeria

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The research is self-sponsored

Abstract
Experimental trials were conducted on two soils (loam and clay (iwo series)) to study the effect of mechanically induced compaction on the growth of maize in a greenhouse. The compaction levels were at five levels: 1.2gcm-3, 1.3gcm-3, 1.4gcm-3, 1.6gcm-3 and 1.8gcm-3. 30 compressed buckets were arranged in three rows in a completely randomized block design and a bucket for each soil as control. Plant parameters such as percentage emergence, plant height, leaf number, stem girth, root weight and cone penetration were measured. The results showed a significant difference in crop emergence, leaf number, plant height, stem girth, root weight and come penetration for the two soils at different compaction levels. Crop yield decreased over 50% in performance as compaction increased. The maximum average plant height of 108.93cm and 74.33cm were observed for both loam and clay soil respectively at 1.2gcm-3 and 1.6gcm-3.
Keywords: Comparative Performance, Maize Growth, Mechanically Induced Compaction, Soils of Nigeria

1. Introduction

Soil compaction occurs when soil particles are pressed together, reducing pore space between them; thus, reducing the rate of both water infiltration and drainage. Large pores are the most effective in moving water through the soil when it is saturated, thereby aiding the exchange of gases and aeration of the soil. Soil compaction increase soil strength, changes in pore species, size, distribution, also hinders easily penetration of crop roots through the soil.

The effect of compaction on plant growth and yield depends on the crop grown and the environmental conditions that crop encounters. Under dry conditions such compaction is beneficial, but under wet conditions, compaction decreases yields. Sufficient soil compaction establishes seed soil contact and enhances germination (Koyombo and Lai 1993). Excess compaction on the other hand is detrimental for maintaining a good root environment (Flowers and Lai1998). Fort (1990), reported that soil compaction affects tuber yield of potatoes. The grain yield of sorghum was reported to have increased with increase in the number of tractor passages up to a given point then decrease thereafter. (Kayombo and Lai (1993) concluded that moderate compaction in loose soils enhance better establishment, improves root growth and increase yield of maize. Slightly compacted soil can speed up the rate of seed germination because it promotes good contact between the seed as the soil. In addition, moderate compaction may reduce water loss from the soil due to the evaporation and therefore, prevents the soil around the growing seed from drying out. The roots growing through a medium texture soil with a bulk density near 1.2g cm-3 will probably not have a high degree of branching or secondary root formation; while excessive soil compaction impedes root growth and limits the amount of soil exposed by the roots and can decrease the plant's ability to take up nutrients and water (Giles, 1981).

Tillage is the most intensive operation of the operations of crop production in mechanized agriculture with little or no regard for the resulting effects on soil degradation and crop performance. The increased use of heavy agricultural machinery on agricultural lands compact the soil which affects the soil quality. The degree of compaction depends on the number of times the soil is subjected to vehicular traffic. The various types of soil compaction could be surface, sub-soil or deep compaction, surface crushing and plough pan or tillage pan. Aluko and Lasisi (2009), studied the effects of tillage methods on some properties of a tropical sandy loam soil under soybean cultivation and concluded that soil porosity, infiltration rate and hydraulic conductivity increased, while soil bulk density, penetration resistance and moisture content decreased as the degree of soil loosening by the tillage increased. Also, Yiljep and Yusuf (2000) studied the yield response of maize to tillage treatment under different fertility regimes and concluded that grain yield of maize reduced when some critical soil bulk density exceeded. Increase in soil bulk density increased maize grown yield up to optimum level 1.4Mg cm-3. Ajav and Oyelami (2002) studied the effect of mechanical induced compaction at four levels(1.2 gcm-3, 1.4gcm-3, 1.6gcm-3 and 1.8gcm-3)on soybean growth for two soils of Nigeria and observed a significant difference in crop emergence, leaf number, plant height and leaf elongation for the two soils. The shoot mass and diameter as well as root nodules were not significantly different at 5% level of significance for the two soils. The average maximum plant height of 18.1cm was observed at 1.2g/cm3.

The influence of composition in agricultural soils cannot be over emphasized since these soils serves as the growth medium capable of physically supporting plants as well as acting as reservoir for water and

nutrients for plant growth. Therefore, the objective of this study is to investigate the effects of mechanical compaction of two soils in Ibadan (Nigeria) on the yield of maize.

2. Materials and Methods

2.1 Treatments and Experimental Design

The experiment was carried out in a greenhouse at the Institute of Agricultural Research and Training, Moor Plantation, Ibadan. Located in degraded rainforest vegetation zone of Nigeria on latitude $7^0 22^1/_2{}^1$N and longitude $3^0 50^1/_2{}^1$E. Soil samples from two location loam and clay (Iwo series, up slope) were 50mm x 54m cylindrical cone. The samples were pulverized and thoroughly mixed. Different masses of 7.2kg, 7.8kg, 8.4kg, 9.4kg and 10.8kg were measured into bucket and compacted with a rammer of 4kg at five different levels i.e 1.2kg cm^{-3}, 1.3gcm^{-3}, 1.4gcm^{-3}, 1.6g cm^{-3} and 1.8gcm^{-3} in a plastic bucket of 60 cm^{-3} replicated three times. The buckets were arranged in three rows in a complete randomized block design.

2.2 Measurements

Immediately, following the compaction of the soil, maize grains (Downy mildew DRM) were planted in late September and the soil penetration resistance was taken using handheld cone penetrometer, number of germination counted after a week of planting, plant height at 6 and 12 weeks after planting (WAP) measured with the aid of ruler, stem girth using vernier caliper, number of leaves counted and cone penetration at 6 and 12 (WAP) were measured respectively. At the end of 12 weeks, the plants were cut at soil surface and separated into shoot and root components for measurement. The roots were weighed separately using a beam balance after each plant root was washed and left to dry at room temperature.

Data from soil and plant measurement for the compaction treatments were analyzed using analysis of variance (ANOVA) and Duncan multiple range test (DMRT). Based on the difference that existed between the five treatment means, the level of significance was fixed at 5 percent.

3. Results and Discussion

The analyses of data taken are summarized as shown in table 1 to 3. Table 1 show that there was an appreciable decrease in crop performance as soil compaction increased. The cone index and bulk density increased with increase in the level of compaction in both soils. Plant height, number of leaves, stem girth, cone penetration, percentage of emergence and root weight of plant in respect to compaction, duration and soil type are significant at 0.05 level. These results are in agreement with those reported by Bander et al, 1981 and Davies et al 1979, that compaction have much effect on plant growth.

Table 1: Effects of soil compaction on mean plant growth.

Bulk density/ mass	Plant height cm	Number of leaves/plant	Stem girth Cm	Root weight (g)	Emergence	Soil penetration $Kgha^{-1}$
Control (0)	193.00^a	13^a	1.965^a	23.48^a	96	968
1.2$gcm^3$7.2kg^{-1}	74.33^d	5.6^b	0.66^c	6.50^b	38.30	1250.28^c
1.3cm^{-3}7.8kg^{-1}	87.17^{cd}	5.9^b	0.64^c	6.31^b	40.00	1583.52^b
1.4gcm^{-3}8.4kg^{-1}	101.42^{bc}	5.82^b	0.89^c	9.05^b	40.00	1283.47^b
1.6cm^{-3}9.6kg^{-1}	108.92^b	5.52^b	1.31^c	13.70^b	40.00	1300.37^b
1.8cm^{-3}10.8kg^1	106.17^b	4.89^b	1.94^b	6.73^b	31.71	1833.67^a

The levels of soil compactions had a significant effect on maize emergence. The average minimum emergent (31.7%) was observed for both soils at 1.8g cm^{-3}. This is in agreement with the report of Kayombo and Lai (1993) and Yiljep and Yusuf (2000) that maize yield reduce with some soil critical bulk density is exceeded (1.4Mg cm^{-3}).

The average maximum plant height of 108.92 cm as against 193cm of the control was observed for both soils at 1.6gcm^{-3}. Also, average plant height of 85cm and 106.20cm as against 176.12 and 203.01cm of the control was observed for clay and loam soils respectively. The maximum performance on compacted soils at 1.6gcm^{-3} is not similar to that obtained by Ajav and Oyelami (2002) on soybean growth at 1.2gcm^{-3}. The poor growth observed on both compacted soils might be as result of changes in soil structure, decrease in pore spaces, low rate of exchange of gases, poor aeration and higher force required for roots to penetrate the compacted layers. This is in agreement with the findings of Hakansson (1985) that roots need to exert greater force to penetrate a compacted layer.

Table 2: Effect of Duration on mean Plant Growth

Week of planting (WAP)	Plant height (cm)	No of leaves/plant	Stem girth	Cone penetration ($kgha^{-1}$)
6	83.57^{b}	5.8^{a}	0.12^{a}	1396.8^{b}
12	107.63^{a}	5.2^{b}	0.10^{a}	1503.63^{a}

Table 3: Effect of Soil on mean Plant Growth

	Plant height	No of leaves/plant	Stem girth (cm)	Root weight (g)	No of emergency(%)	Cone penetration ($kgha^{-1}$)
Clay	85.0^{b}	4.72^{b}	0.99^{a}	10.04^{a}	38.00^{a}	1480.34^{a}
Loam	106.2^{a}	6.41^{a}	1.19^{a}	6.87^{a}	38.00^{a}	1142.18^{a}

Table 2 and 3 shows the effects of duration of plant growth for 6 WAP as 12 WAP respectively. As the number of weeks increased, there was decrease in the number of leaves, stem girth for both soil, both plant height, cone penetration resistance increased. The number of leaves on the average is 5.8 and 5.2 for week 6 and 12 respectively. The decrease in the number of leaves and stem girth might be as a result of reduction in oxygen level of the soil, reduction in soil water permeability, root growth penetration and very poor absorption of water and soil nutrient uptake. This is in agreement with the report if Kirkegaurad et al (1993) for pigeon pea.

Conclusion

The following conclusions were drawn for the study carried out.

(i) The performance of maize is yield decreased generally with increase in soil compaction.
(ii) Increase in the level of soil compaction led to increase in soil bulk density.
(iii) Plant height, number of leaves, stem girth and soil penetration were significantly affected by compaction in both soils.
(iv) The effect of soil compaction was more pronounced in maize shoot parameters then root parameters.
(v) Overall growth of maize in compacted loam soil was better than compacted clay for each level of compaction studied in a minute ratio.

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