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The Effect of Soil Compaction Caused by Motorized Traffic on The Growth Pattern of Egusi-Melon (Collocynthus Citrillus L.)

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Abstract: This study investigates the impact of soil compaction resulting from vehicular traffic on the root development and yield of egusi-melon (Collocynthus Citrillus L.). Egusi-melon, a vital crop in many regions, faces challenges from anthropogenic activities such as vehicular movement, leading to soil compaction. Soil compaction can impede root growth and ultimately affect crop yield. A 15x51m2 field was manually cleared with a cutlass and divided into three blocks of four plots each. The soil was compacted using a 35.5kN wheel tractor. Treatment consisted of 0, 1, 5, and 10 passes (wheel-wheel) of the tractor and was replicated three times. After these seedbeds were prepared where we planted the egusi-melon seeds, the seedling emergence and root development were measured after 1 and 3 weeks respectively. This was noticed by taking into account the number of seeds planted and the number germinated per plot. This was determined by observing the total number of germinated seeds per plot after 1 and 3 weeks. This was done by observing the seedling emergence after 1week and uprooting the plant washing the roots and then measuring with a meter rule after about 3 weeks. The results were recorded plot by plot. Through field experiments and root analysis, this study examines the extent of root growth inhibition caused by varying levels of soil compaction. Additionally, yield parameters including fruit quantity, size, and quality are evaluated to ascertain the consequential effects on crop productivity. The seedling emergence is relatively inversely proportional to the number of traffic. The root development was maximum (9.5cm) in the 0-pass treatment and lowest (2cm) in the 10-pass treatment. This result is similar to those of Dvorster and Polyak (1979) and Asoegwu (1987) and deviated slightly from those of Chancellor (1976) and Jagagrd (1975). The deviation is attributable to the extent of soil water status at the time of the traffic.

Findings from this research contribute to understanding the ecological consequences of vehicular traffic on agricultural lands and provide insights into potential mitigation strategies for sustaining egusi-melon cultivation amidst anthropogenic disturbances.

Keyword: Compaction, vehicular traffic, yield, root development, egusi-melon (collocynthus citrillus L.).

INTRODUCTION

Soil compaction is the process of applying pressure to the agricultural soil thereby disturbing the soil texture and structure and thereby compressing the soil.

The compaction of soil can also be defined as an increase in its dry density, and the closer packing of solid particles or reduction in porosity. Modern cropping systems are based on agricultural machinery and this machinery is responsible for most of the soil compaction.

The mechanization of crop production is increasing in most parts of the world. In many countries this trend is viewed with concern because of the compaction which results when wheels pass over soils used as a growing medium for crops (Soane, 1970; Barnes *et al.*, 1971; Eriksson *et al.*, 1974; Chancellor, 1976; Osuji 1988; Ohu *et al.*, 1991).

Vehicular traffic on agricultural mechanization i.e. a process by which any or all of the usual operations involved in agricultural production are carried out with mechanical assistance using either manually operated machinery or motorized and/ or automated machine units.

Among the numerous studies carried out to determine the efforts of wheel traffic on soils, parameters such as bulk density, soil strength, total porosity and hydraulic conductivity have been used as indicators of soil compaction (Gameda *et al.*, 1988), with bulk density being the most used (Raghavan *et al.*, 1978; De knipe *et al.*, 1981, Voorhess *et al.*, 1986; Cupta and Almares, 1987).

The mutual interaction between these parameters are affected by soil moisture content. As soil moisture content increases, the soil strength (cone index) decreases and dry bulk density increases. (Taylor *et al.*, 1981).

However, at a fixed moisture content a soil will have a higher strength at larger densities, which reflects the closer packing of solid particles. This compaction also alters the water content and movement in soils by modifying the void size distribution (Warkentin, 1971). This tends to reduce both the amount of water which is retained at low water suction pressure in the macro pores, and the saturated hydraulic conductivity of the soil. Ide *et al.* (1984) found that the reduction in total porosity resulting from compaction would lead to a shortage of oxygen for plant roots while the reduction in pore diameter would prevent the entrance of root tips and easy flow of gravitational water.

From the above review, it may be summarized that tractor passes on the soil result in the following:-

- Poor nutrient and water up take by plants
- Soil structure degradation which are reflected in changes in soil physical properties such as dry bulk density, soil strength, soil porosity, permeability etc. with soil structure degradation, soil compaction due to traffic lowers the production potentials of the soil by exposing the soil to physio-chemical damages with a resultant poor nutrient uptake and poor growth and yield of crops.

Although compaction is detrimental to plant growth, but it can be ameliorated by any or all of the following:

- Avoid high machinery contact pressure especially during repeated passes in fields.
- Avoid moving on fields with machines when the top soil is moist, close to the "optimum" moisture content for compaction.
- Avoid excessive slipping of tractor lives during field operations, which could damage cultural programs that leave a healthy double soil density changes under the same weight.
- Manage cultural programs that leave healthy system of roots, and sufficient organic matter in the top soil (Mckyes, 1985).

So in this work, it is intended to assess the interactions of soil properties as they area affected by tractor wheel traffic.

Problem Statement

Soil compaction tends to reduce both the amount of water which is retained at low water suction pressure in the macro pores, and the saturated hydraulic conductivity of the soil. This can be controlled though by managing cultural programmes that leave healthy system of roots and enough organic matter in the top soil.

AIM AND OBJECTIVES

The aim of this work was to compare the root development of egusi-melon based on the level of soil compaction.

The objectives of this research were to:-

- Evaluate the rate at which the root growth responds to the tractor operation in the field.
- Determine the effect of different wheel passes of the tractor on the yield of egusi-melon (collocynthus citrillus L.).

Justification:

Heavy tractor traffic on soils results in compaction which degrades soil structure and cause poor nutrient and water uptake by plants. This movement hampers the soil structural stability as well as soil production potential. These justify the research project.

Soil compaction had been a very sensitive problem to agricultural production because it involves poor soil and water conservation and thus reduced crop growth and yield. In developing countries like Nigeria, mechanization is increasing and, although the vehicles used may be light, the low structural stability of many tropical soils combined with the high erosivity of rainfall together increase the chances of serious soil degradation by field traffic. Compaction from field traffic may occur in virtually all types of crop production (Soane and Van Ouiverkerk, 1981).

It modifies the pore volume and pore structure of the soil with changes in void ratio, total porosity, specific volume and dry bulk density. Changes in bulk volumetric properties may not be as important to plant growth as the associated increased strength and reduction of conductivity, permeability and diffusivity of water and air through the soil pore system (Soane 1985; Boone *et al.*, 1987; Guerif, 1988).

The soil properties to measure in compaction studies must be chosen by the researcher. The properties must strongly influence the way in which the soil responds to applied loads and the likely importance of the measured changes in subsequent crop growth. Bulk density had found application for comparing growth of different varieties of crops (Hakansson, 1973, Raghavan *et al.*, 1976) and for the comparison of the compacting effects of different wheel treatments over a range of soil types (Ljungara, 1977; Lamers, *et al.*, 1986). Changes in pore size distribution during compaction are important particularly with respect to large air-filled pores. Porosity and void ratio changes in a wide range of agricultural soils resulting from an applied mechanical stress have been reported by Larson *et al.* (1980) and Voinvail and Flocker (1991). Compaction reduces the diameter and continuity of pores and thus reduces the permeability and diffusion of gases and liquids in the soil (Grable, 1971; Ball, 1979). The cone resistance that measures soil strength is an important parameter affected by compaction. Compaction increases soil strength which not only increases soil cutting forces and energy required but will also impede the growth of plant roots. (Mckyes, 1985; Taylor *et al.*, 1981).

All these soil properties mentioned above are usually affected by both soil type and soil moisture content (Mulqueen, *et al.*, 1980).

It is widely though that second subsequent passes of a wheel produce less compaction than that caused by the first pass. This depends on the initial soil strength and its distribution with depth (Soane *et al.*, 1981).

Modern systems of crop production are tending to increase both the number of passes and the loads carried on the wheels of agricultural vehicles especially in seed bed preparation, spraying and harvesting operations (Soane *et al.*, 1982). During fertilizer distribution, secondary cultivation and sowing, soil strength is generally low as a result of the loosening during primary cultivation and the soil is usually moist making tractor to cause appreciable compaction Ljungars (1977) found that the soil moisture content and the number of wheel passes were the factors primarily responsible for the compaction resulting from seedbed traffic.

Compaction by wheel traffic was found by Raghavan *et al.* (1979) to delay germination and early growth of maize silage. Root distribution of maize has been found to be closely associated with both the number of passes and the contact pressure of types running over the soil either before or after seedling (Raghavan and Mckyes, 1978).

Past works on the effect of soil compaction on soil physical properties and crop yield

There has been conflicting records of yield response to vehicular traffic. Chancellor (1976; Jaggard (1975) found a decrease in yield of wheat, sorghum, and maize when heavy traffic was used prior to or during seedbed operations. While Eriksson *et al.* (1974) and Dvortear, Polyak (1979) reported increase and decrease in yield respectively due to wheel traffic, most research depend to a considerable extent on the soil water status at the time of the traffic. Recent work on grains have shown exponential decrease in yield with increase number of tractor wheel passes (Canarache *et al.*, 1988; Osuji 1988; Ohu, 1991). In non-cereal crops, the passage of tractor wheel in ridges, as with potatoes, carrots and sugar beat may cause reduction in root and tuber growth (Campbell, 1980). These non-cereal crops are generally more sensitive to compaction than those of cereals. However, as with cereals soil water status influence their response. Wheel traffic effects on vegetable crops (Vomocil, Flocker, 1965), ornamental bulbs (De Faan and Vender Valk, 1970) and fore species (Greacen and Sands 1980) have been reported with yield reduction. The effects of wheel traffic upon soil properties are predictable but the crop response is variable. However, despite the large amount of reported work on the effect of wheel traffic on cereal and non cereal crops, none has been reported on egusi-melon except for those of tillage induced compaction on the crop (Asoegwu, 1987).

Many researches have used several numbers of wheel passes in their works. Bonsu (1991) used 0,2,8 and 14 passes, Osuji (1988) used 0, 2,5, 10 and 15 passes and Ragharan *et al.* (1976) used 1, 5, 10 and 15 passes, Canarache *et al.* (1988) used 0,1,3,5, 10, 20 and 30 passes and Daniel *et al.* (1988) used 0, 1,3,5 and 10 passes. In view of the fact that mechanization sequence is different in South Eastern Nigeria, 0, 1,5 and 10 passes of the tractor wheel were used in this work.

Field Preparation/ Methodology

A piece of land at Umunahu, Uratta in Owerri was manually cleared using cutlass and piled. The soil was leveled by the use of rake and measured in three blocks of four plots each. The field measured 15x 51m2. The field was divided into three blocks, leaving a head land of 3m wide between blocks. Each plot measured 1x10m2. A4 – cylinder Steyr 768 tractor having two rear tires inflation pressure of 40 psi with a weight of 35.5KN and tire size of 16.9/14-30 (6 ply rating) and this very tractor was to make passes on the field leaving a portion as control. The number of passes were 0, 1,5 and 10 replicated three times and the mean value recorded.

Cultural Operation of the Soil

Seed beds were prepared and egusi-melon (colocynthus citrullus L.) seeds were planted three per hole of about 2cm diameter and 3cm deep. These holes were dug using ordinary sticks. The displaced soil was used to cover the seeds. These seeds were planted at different passes of 0,1,5, and 10 and were observed after 3 weeks for root development. At harvest the fruits were weighed and after a week the fruits were broken and the seeds washed and dried and weighed and result recorded.

Seedling emergence: After planting the egusi-melon seeds, the seedling emergence was observed after 1 week, 3 weeks. This was noticed by taking into account the number of seeds planted and the number germinated per plot. This is normally expressed in percentage.This was determined by observing the total number of germinated per plot after 1 week.

For 20 seeds planted, if 18 germinated after 1 week for 5 passes;

$$\% \text{ seedling emergency} = \frac{18}{20} \times \frac{100}{1} = 90\ \%$$

RESULTS AND DISCUSSION

Table 1: Seedling emergence (After 1 week).

B11 100%	B21 100%	B31 0%
B12 100%	B22 0%	15m B32 80%
B13 80%	B23 90%	B33 90%
B14 5%	B24 80%	B34 90%
51m		

Table 2: Effect of traffic density on seedling emergence (after 1 week)

	Tractor density			
Number of tractor passes	0	1	5	10
Seedling Emergence	93.33%	96.67%	80%	1.67%

Table 3: Layout of the experimental plots

2.4m 0 Pass	1 Pass	10 Pass
2m 1 Pass	10 Pass	5 Pass
5 Pass	0 Pass	1 Pass
10 Pass	5 Pass	0 Pass
10.3m	51m	

Table 4: Effect of traffic density on root development (after 3 weeks)

	Tractor density			
Number of tractor passes	0	1	5	10
Root development	9.5cm	9.8cm	8.0cm	2.0cm

The results obtained from this experiment were represented in tables as shown above.

Table 5: Yield of egusi-melon

Tractor Passes	No of Fruits Per Plot	Average No of Fruits per Plot	Weight of Fruits Per Plot (kg)	Weight of dry Seeds (kg)	Average Wt of Dry Seeds Per Plot (kg)
0	20,18,18 (56)	19	10.20 0.3 (9) 8.50	0.16 0.16 0.17	0.16
1	17,20,16 (53)	18	8.82 9.90 (9.10) 8.56	0.15 0.15 0.12	0.14
5	10,10,9	10	5.35 5.90 (5.60) 5.40	0.10 0.10 0.11	0.10
10	3,5,7 (15)	5	3.02 3.83 2.94 (3.30)	0.10 0.10 0.10	0.10

Table 6: Effect of traffic intensity on sizes of fruits

Fruit Size Category	0 Pass	1 Pass	5 Passes	10 Passes
Size A	27	28	13	1
Size B	25	16	12	6
Size C	10	9	8	8
Total	62	53	33	15

Key:
Size A=S1 greater than 14
Size B=11 less than S2 greater than 14
Size C= S3 less than11cm

Relationships between seedling emergence and wheel traffic.

Seedling Emergence: The percentage seedling emergence was calculated after one week of planting the egusi-melon seeds on the treated plots.

From Table 2, the percentage seedling emergence decreased with increased traffic intensity. This is because compaction increases the soil strength and the cutting force therefore impending seedling emergence. The percentage seedling emergence was maximum (93.33%) in the 0 pass treatment and lowest (1.67%) in the 10 passes treatment. This result is similar to those of Dvorster and Polyak (1979) and Asoegwu (1987) and deviated slightly from those of Chancellor (1976) and Jagagrd (1975). The deviation is attributable to the extent of soil water status at the time of the traffic.

The conflicting records were mainly on cereals which are not so sensitive to compaction as against non-cereals (egusi-melon). Soil water status at the time of compaction must have been responsible for these differences.

We found out that compaction controls seedling emergence which in turn controls root development. The deviation observed in 5 and 10 passes treatment could be as a result of soil water status during the time of compaction.

Root development: After 3 weeks of planting the seeds, the root development was measured by uprooting the plants and measuring the length of the roots. Before this the roots were washed to remove the clogs of soil and the result recorded.

Relationships between root development and wheel traffic

From Table 4 below the root development decreased with increased traffic intensity. This is because compaction increases the soil strength and the cutting force therefore impending root development. The root development was maximum (9.5cm) in the 0 pass treatment and lowest (2cm) in the 10 passes treatment. This result is similar to those of Dvorster and Polyak (1979) and Asoegwu (1987) and deviated slightly from those of Chancellor (1976) and Jagagrd (1975). The deviation is attributable to the extent of soil water status at the time of the traffic

The conflicting records were mainly on cereals which are not so sensitive to compaction as against non-cereals (egusi-melon). Soil water status at the time of compaction must have been responsible for these differences.

Sizes of fruits and yield: We found out that fruit sizes control seed yield and both are governed by compaction. Deviation observed in 5 and 10 passes treatment could be as a result of soil water status at the time of compaction.

CONCLUSION

From the results so far got, it is found out that soil compaction as a result of farm motorized traffic affects soil physical properties thereby affecting the growth pattern of egusi-melon (Collocynthus citrilus L.)

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