THE INFLUENCE OF COMPACTION ON THE VERTISOL SOIL PHYSICAL PROPERTIES AND ITS UTILISATION FOR COTTON PRODUCTION IN LAMURDE L.G.A OF ADAMAWA STATE

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Abstract

The response of cotton growth parameters and soil physical properties were investigated when the vertisol soil of Gyawana was subjected to compactive efforts from different traffic regimes. Thirteen - treatment combination of traffic regimes consisting of three tractor contact pressures of 2.90kgf / cm2, 2.25kgf / cm^2 and -1.34kgf / cm^2, four traffic,regimes of 5,10,15,20 and a control of zero traffic were employed in a factorial experiment using randomized complete block design. The soil physical properties measured were the soil bulk density and the penetration resistance, while the plant parameters measured were the days of appearance of first floral buds, plant height and cotton seed yield at different times representing different stages of growth of cotton. The measured plant parameters and the measured soil physical properties were all affected by increasing levels of tractor regimes at P> 0.05 and P> 0.01, irrespective of the tractor contact pressure. The outcome of the result in relation to verlisol soil management Tor Cotton production is discussed, and recommendations made as to the most suitable traffic regime application.

Introduction

The stress on soils exerted by off- road vehicle cause compaction of farmlands. The soil compaction on these farmlands during seedbed preperation has resulted in considerable reduction in crop yield (Philip and Khirkam, 1962; Feldma and Domier, 1970; Raghavan and Mckyes, 1978; Taylor and Burt, 11981; Ohu and Folorunsho, 1989). The magnitude of this compaction is a function of soil type, soil moisture content, frequency of use of vehicular traffic and tyre contact pressure (Raghavan Mckyes, Amir and Chase, 1976). Changes in soil strength and soil / water / air combination are some of the after effects of compaction which in turn affect crop growth and yield (De Roo, 1960; Carder, 1964; Fisked, 1968; Raghavan and Mckyes, 1977). Soil compaction also changes permeability of the soil and in extreme cases porosity, which prohibit the penetration of roots (Raghavan, 1977). The study of the soil compaction is before necessary in crop producing areas to maximize crop yield. The study was conducted in order to investigate the intensive traffic regimes by vehicular and wheel factor on the physical properties of the dark clay soil, and on the growth yield of the cotton. Information on the production in a dark clay soil as affected by intensity of traffic regimes are limited. The study is aimed at using result obtained to suggest the appropriate land preparation techniques that would be beneficial to cotton production in a dark clay soil

Materials and Methods

Experimental Procedure

The experimental designed used was randomized complete block design with four replications having fifty-two plots. The uniform gross plot size was 10 x 10m with alley of 5m -width separating one plot from the other and one replication from the other. Each replicate had thirteen plots comprising of the control and 12 traffic treatments.

The experiment was carried out at Gyawana Lamurde Local Government of Adamawa State, with the soil area classified as typical peliusteits and the colour of the A - horizon is dominantly clay (soil survey staff, 1975). The clay mineralogy is predominantly 2:1 layered silicate expanding clays (Tom Linson, 1965; Lombin and Esu, 1987).

The vehicles used for the treatment were 47kwh, 50kwh and 70kwh Steyr agricultural tractors. The numbers of traffic regimes used were 5,10,15,and 20. The vehicles produced various statistic weights of 2,285.40kg, 3837.40kg and 4,945.95kg respectively. The static rear axle loading were 131.322KN/$m^2$and 284.198KN/m on the order of arrangement described. The three tractors had the same rear tyre dimension of 16.9/14-30 where 16.9 "(429.26mm) is the section height and 14(355.6mm) is the section width and 30(762) is the rim diameter. These three tractors produced a ground contact patch of 1705.5cm^2. The resultant ground contact pressure of the three tractors were 131.32 kpa, 222'.50 kpa and 284.20 kpa which are equivalent to 1.34kgf/cm^2, 2.25kgf/cm^2, and 2.90kgf/cm^2 respectively. The fetters assigned to the tractors were Q, R and S.

The total of 12 treatment combinations were employed as shown in the Table 1. The treatments were imposed on the experimental plots when the soil moisture was below critical moisture content *of 27%* as previously determined. The experimental area was ploughed and harrowed in June, while the traffic treatment and planting of the area were imposed in the first week of July. Planting and cultural practices were done in accordance with the recommendation of AERLS (1983).

Table 1: Treatmen^Combination and Uie Number of Traffic Regimes

Code	Ground Contact Pressure kg/cm^2	No of Traffic Regimes	Resulting Ground Contact Pressure (kgf/cm^2)
05Q	3.34	5 regimes of Q	^6 J Q ~
05R	2.25	5 regimes of R	11.25
05S	2.90	5 regimes of S	14.50
10Q	1.34	10 regimes of Q	13.40
10R	2.25	10 regimes of R	22.50
10S	2.90	10 regimes of S	29.00
15Q	1.34	15 regimes of Q	20.10
15R	2.25	15 regimes of R	33.75
15S	2.90	15 regimes of S	43.50
20Q	1.34	20 regimes of Q	26.80
20R	2.25	20 regimes of R	45.00
20S	2.90	20 regimes of S	58.00
0	0	0 regimes	0

Where

Q= is the steyr 786 with] .34kgf/cm^2 content pressure R=is the steyr 8073 with 2.25 kgf/cm^2 contact pressure S= is the steyr 8075 with 2.90 kgf/cm^2 pressure O = is the control.

Moisture was below the critical moisture content of 27% as previously determined. The experimental area was ploughed and harrowed in June, while the traffic treatment and planting of the area were imposed in the last week of July. Planting and cultural practices were done in accordance 'with the recommendation of AERLS (1983).

Measurement of Soil Physical Properties and Plant Growth Parameters

The soil bulk density and the penetration resistance of the soil were measure before and after the traffic treatment applications. Readings were taken 24hrs after every major rainfall by randomly taking four readings from every plot. Measurements were taken six times during the growing season, at levels of 0-20cm depths. Five undisturbed core samples of the soil were collected at the depth of 0-20 cm from each plot 24 hrs after every major rainfall for each soil bulk density determination using the procedure of Blake and Hartage (1986).

The plant growth parameters measured were the number of days required for the appearance of the first floral buds, the plant height measured at 40,60,80,100, and 120 days when anthiesis has taken place leaving well mature bolls and 140 days when lint matured and bails began to show signs of splitting. Harvesting was done when the bolls started splitting. All lint collected from each plot were bagged and weighed for analysis.

Data collected for both soil and crop parameters were statistically analyzed, using analysis of variance for randomized complete block design with measurement overtime (period) to determine F values (Little and Hill, 1978; Steel and Torie, 1980). Mean comparison for parameters with significant F values was carried out using Duncan's new multiple range test (Duncan 1955.) Linear and multiple regression were used to complete predictive models (Gomez and Gomez, 1984).

Results and Discussion

Influence of Traffic Regimes on Soil Bulk Density

The effect of traffic regimes on soil bulk density readings when analysis of variance was performed showed significant differences at (PO.05 (Tables 2). The mean value of the pooled soil bulk density measurements showed significant differences (P< 0.01) between treatment means and treatment effect using DMRT (Table 3). Obviously, soil bulk density was affected by external loading brought about by the traffic treatment. This is in line with reports from other researchers (Raghavan et al., 1983; Ohu and Folorunsho, 1989) on the effect of external leading on soil bulk densities.

A simple linear regression gave the relationship between the pooled sampling periods of soil bulk density and traffic treatment as

$$X_d=1.123+0.027(np)$$

(n=364/=0.8

Where

X(]=pooled soil bulk density (Mg/nr) n= number of observations r^2=coefficient of correlation

Table 2:ANOVA Table for Pooled Soil Pry Bulk Density Measurement (Mg/m^3)

Source of Variation	Degree of Freedom	Sums of Squares	Mean Square	Computed F
Main - plot factor				
Replication	*3*	2.8926	0.9642	43
Traffic Treatment	12	75.7113	6.309	43.794
Error of Treatment	*36*	5.186	JLJ±L__ |	
Sub -plot factor				
Soil-Bulk density (S.B.D)	6	42.988	7.165	201.535
Interaction of (T.Treatment) x (S.B.D)	72	12.556	0.174	4.905
Error	*234*	8.319	0.0356	
Total	*363*	147.725		
	S.E.	0.159		

Table3: Mean Values of Pooled Soil Bulk Density for Different Traffic Regimes (Mg/m^a)

Treatment	Mean Values (Mg/m")
Control	1.11
05Q	1.3ijk

05R	1.4ghij
053	t.Sfghi
10Q	1 .6efgh
10R	1.7efg
IOS	l.Scdef
15Q	l.Scdef
15R	1.9bcd
15S	2.1bc
20Q	2.1 be
20R	2.2ab
20S	2.9a

Means with same letter are not significantly different at 5% level using DMRT.

Influence of Traffic Regimes on the Penetration Resistance

Results obtained showed that the traffic regimes influenced penetration resistance. The pooled analysis showed there were significant differences ($P<0.05$) due to treatment effect and between treatment means (Table 4).

It was observed that for all treatment imposed penetration resistance kept increasing as the product of the number of traffic regimes and contact pressure increased. This followed the same pattern as the soil bulk density, which is in line with the findings of (Edward et al, 1979; Freebain et al, 1986; Grevers etal. 1986; Oni and Adeoti, 1986).

The linear regression equations gave the relationships (Table 5).

Table 4. ANOVA Table for Pooled Penetration Reading and Traffic Treatment (MPA)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Squares	Computed F
Main - plot factor	3	0.0701	0.234	
Replication				
Traffic Treatment (T.T)	12	329.922	27.493	117.624
Error of Treatment				
	36	8.415	0.234	
Sub - plot factor				
Pen. Resistance	6	180.992	30.165	473.927
Interaction (T.T) x (Pen. Re.)	72	59.136 '	0.821	12.904
Error				
Total	234	14.894	0.064	
	S.E.			
	363	593.428		

0.210

Table 5: Linear Regression Coefficients for Individual Sampling Reading Period for Dry Bulk Density and Penetration Resistance

Sampling Reading Period	Bo	B,	r^2	P<F	Bo	B_2	r^2	P<F
1.	1.091	0.00061	O.048	0.565	1.060	0.00067	0.202	2.759

2.	1.434	0.0324	0.897	75.11	1.571	0.067	0.815	48.410
3.	1.263	0.033	0.912	112.94	•1.537	0.065	0.810	46.9034
4.	1.151	0.032	0.888	87.43	1.517	0.06444	0.809	46.614
5- .-	1.095	0.030	0.865	70.430	1.523	0.062	0.772	37.29
6.	0.927	0.0316	0.889	88.105	1.390	0.061	0.812	47.4483
7.	0.911	0.028	0.897	95.889	1.233	0.058	0.877	78.161

Where

B_0 = Intercept in the regression equation Bf = Slope in the regression equation

hp = ground contact pressure **Influence of Traffic Regimes on** Days **of Appearance of Floral Buds and Plant Height**

Tables 6 and 7 shows that there were significant differences ($P<0.01$) due to treatment effect between days of appearance of the flora! buds, and plant height brought about by the traffic regimes. The mean comparisons of the days of appearance of floral buds (Table 8) indicated significant differences ($P<0.05$) using DMRT. The observed shorter days for the first floral buds to appear in moderately compacted plots than the heavily compacted plots could be due to less pressure exerted on the soil and better availability of nutrients to the crops as suggested by Wayne and Teare (1983).

Generally, results obtained showed that decreased plant heights and reduced increased number of days of appearance of floral buds were observed in plots with higher number of traffic regimes and contact pressure.

Soil bulk density is very important to cotton plant development, and an attempt was made to predict plant height in terms of traffic regimes and soil bulk density using multiple regressions. The attempt yielded an equation:

$P_h = 298.569 + 0.242 \text{ In } X_d - 18.29 \text{ In (np)}$ ($n = 312, R^2 = 0.813$)

Where

PI, = plant height in cm In >i_d = logarithmic value of soil bulk density. I_n (np) " logarithmic value of the product of traffic regimes and the ground contact pressure R = Coefficient of determination.

Table 6: ANQVA **Table for Days of Appearance of Floral Buds**

Source of Variation	Degree of Freedom	Sums of Squares	Mean Square	Computed F
Replication	3	1.461	0.487	
Treatment	12	126.423	10.535	9.971
Error	36	38,0391.057		
Total	51	165.923		
S.E	0.727			

Table 7:ANOVA **Table for Pooled Plant Height and Traffic Treatment**

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F
Main - factor Replication	3	1606.464	535.549	
Traffic Treatment (T.T)	12	5756.549	479.671	3.2004
Error	36	5395.6305	149.879	
Sub -plot factor Plant height	5	299189.241	59837.848	364.55 NS
Interaction (T.T) x (Plant ht)	60	3405,8086	56.764	0.40
Error of sub -plot	195	32007.05	164.139	
Total	311	34736.45		
S.E	8.993			

Table 8: Mean Values of Days Appearance of First Floral Buds for the Different Traffic Regimes

Treatment	Appearance of Floral Buds
Control	37.25a
05Q	34.75cd
05R	32.75 ij
058	32.00kl
10Q	34.50de
10R	35.25c
10S	34.50de
15Q	33.00fgh
15R	32.00kl
15S	32.751J
20Q	33.00fgh
20R	34.50de
20S	36.25b..

Means in same column with same letters are not significantly different at 5% level using DMRT

Influence of Traffic Regimes on Dry Cotton Yield

The analysis of variance for the dry cotton yield indicated that the traffic regimes had a significant effect on yield (Table 9). The pair wise mean comparisons showed that there was statistical significant difference (PO.01) between treatment means (table 10).

A predictive model for soil bulk density, traffic regimes and dry cotton seed yield was obtained by using multiple regression analysis, and model obtained was $C_y = 51.363 + 0.242/uj - 0.098(np)$

$(n = 54, R^2 - 0.809)$

Where

C_y = Dry cotton seed yield kg/l00m
A-d = Dry bulk density
n_p = Product of the number of traffic regimes and the contact pressure n = number of observations. R - coefficient of determinations.

The coefficient of determination showed that the variation in the seed yield could be accounted for by a function of the soil bulk density and the traffic regime, The interaction between dry cotton shield yield and soil bulk density was observed to be not significant (Table 11). The least dry cottonseed yield was recorded in plots with heavy traffic regimes while plots with lesser traffic regimes had high yields. An obtained critical value of F = 4.58 showed the interaction (FAB = 0.818) was significant at P<0.01.

Table 9: ANOVA Table for Dry Cotton Seed Yield

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F
Replication	3	0.4893	0.1631	
T. Treatment	12	205.806	17.151	24.148
Error	36	25.5676,	0.7102	
Total	51	231.863'		
. S.E	0.596			

Table 10: Mean Values of Dry Cotton Seed Yield at Different Traffic Treatments

Treatment	Mean Values kg/ha
Control	356.87cab
05Q	361. 36a
05R	347.67c
05S	336.71cdef
10Q	346.3cd
10R	343.7cde
10S	335.4cdefg
15Q	336.9cdef
15R	331.6efgh
15S	312.4efghi
20Q	310.7efghijk
20R	301.8efghijk!
20S	332.4ijklm

Means with same letters are not significantly different at the 5% level using DMRT.

Table 11: Interaction Between Soil Bulk Density and Dry Cotton Seed Yield kti/ha

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F
Treatments				
Factor A (Dry Seed Yield)	12	426	216	9.817 xx
Factor B (Soil Bulk density)	12	324	162	7.363 xx
Interaction (DSY x S.B.D)	24	72	18	0.818 N.S
Error	118	396	22.002	
Total	156	1020		
S.E	0.596			

xx = significant at 1%
N.S - not significant.
x ButF_{afa}=0.818<F_{cv}
= 4.58

Recommendations

The effect of repeated traffic regimes on the vertiso! *soil* during seedbed preparation in cotton production can be reduced by observing the following; -

a. Determining what maximum load in terms of tractor size would be needed.
b. What are the desirable soil conditions at the time of seed bed preparation.
c. Confinement of machinery wheel traffic to specified tracks.
d. Avoid the use of tyres with stiff carcasses.
e. A moderately flexible pneumatic tyre with a moderate inflation pressure of the same magnitude as the tyre inflation pressure.

Stiff carcasses may cause a somewhat higher average ground pressure than the inflation pressure, and an un even distribution, because a tyre with a very stiff carcass acts like a rigid wheel, and the ground pressure is determined by the properties of the soil, dimensions of the tyre, and the load.

Conclusion

The results obtained established the fact that soil compaction as a result of machinery traffic affected the cotton performance thereby reducing the final yield. The soil bulk density increased soil bulk densities were obtained in plots with low traffic regimes and in the control. The penetration resistance was observed to be high for plots with high traffic regimes. However decreased penetration resistance readings were obtained in plots treated with low traffic regimes and in the control plots. The obtained results further conclude that care should be taken during seedbed preparation so that optimum growth and yield of cotton can be obtained.

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