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 comparative efforts from different traffic regimes. Thirteen treatment combination of traffic regimes consisting of three tractors contact pressures of 2.90kgf/cm2, 2.25kgf/cm2 and 1.34kgf/cm2, four 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 vertisol soil; management for cotton production is discussed, and recommendations made as to the most suitable traffic regime application.

Introduction

The stress on soils exerted by off-road vehicles cause compaction of farmlands. The soil compaction on these farmlands during seedbed preparation has resulted in considerable reduction in crop yield (Philip and Khirkan, 1962; Fcldman and Donnier, 1970; Raghavan and Mckyes, 1978; Taylor and Hurt; 1981; Oh LI and Foforunsho, 1989).The magnitude of this compaction is a function of soil type, soil moisture content, frequency of use of vehicular traffic and tyro 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 (DeRoo, 1960; Gardner 1964; Frisked 1968; Raghavan and Mckyes, 1977). Soi! compaction also changes permeability of the soil and in extreme cases porosity, which prohibit the penetration of roots (Raghavan 1977). The study of soil compaction is therefore 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 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 results obtained to suggest the appropriate land preparation techniques that would be beneficial to cotton production in a dark clay soil.

Material and Methods

The experimental design used was randomized complete block design with four replications having fifty-two plots. The uniform gross plot size was 10m 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 twelve treatments. The experiment was carried out at Gyawana in Lamurdc Local Government of Adamawa State, with the soil area classified as typical pelkistert 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 (Tomlimson, 1965; Lombin and Esu, 1987).

The vehicles used for the treatment were 47kWh, SOkWh and 70kWh steyr agricultural tractors. The numbers of traffic regimes used were 5, 10, 15 and 20. The vehicles produced various static weights of 2,285.40kg, 3837.40kg and 4,945.95kg respectively. The static rear axle loading were l31.322KN/m^2,222.50KN/m^2 and 284.198KN/nr on the order of the 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 (762mm) is the rim diameter. These three tractors produced a ground contact patch of 1705.5 cm^2 The resultant ground contact pressure of the tractors were 131.32kpa, 222.50kpa and 284.20kpa which are equivalent to 1.34kgf/cm^a, 2.25kgf/cm^2 and 2.90kgf/cm^2 respectively. The letters assigned to the tractors were Q, R and S.

A total of 12 treatments 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 treatments 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: Treatment Combination and the Number of Traffic Regimes

Code	Ground contact Pressure Kg/cm^2	No of traffic Regimes	Resulting Ground contact pressure (kgf/cm^2)
Q	34	egimes of Q	70
R	25	egimes of R	.25
05S	2.90	5 regimes of S	14.50
IOQ	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
I5R	2.25	15 regimes of R	33.75
15S	2.90	1 5 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	20trcgimes of S	58.00
0	0	0 regimes	0

Where
Q = is the steyr 786 with 1.34gf/cm^2 content pressure R = is the steyr 8073 with the 2.25kgf/cm^2 contact pressure S = is the steyr 8075 with 2.90kgf/cm pressure Q = is the control.

Moisture was below the critical moisture content of 27% as previously determined. The experimental area was plough 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).

Measurements of Soil Physical Properties and Plant Growth Parameters

The soil bulk density and the penetration resistance of the soil were measured before and after the traffic treatment applications. Readings were taken 2'Mirs 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 0-20cm from each plot 24hrs 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 antithesis has taken place leaving well mature bolls and 140 days when lint mature and balls 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, !980). Mean comparison for parameters with significant F values was carried out using the Duncan's new multiple range test (Duncan, 1955). Linear and multiple regression were used to complete predictive models (Gomez and Gomez, 1984).

Results

Tables 2 to 11 are the outcome of the statistical analysis when collected data were subjected to analysis of variance.

Table 2: ANOVA Table For Pooled Soil **Dry Bulk Density Measurement Mg/m^3**

Source of Variation	Degree of freedom	sum of squares	mean square	computed F
Main-plot factor				
Replication	3	2.8926	0.9642	
Treatment	12	75.7113	6.309	43.784*
Error of Treatment	36	5.186	0.144	
Sub-plot factor				
Soil-Bulk Density (S. B. D)	6	42.9	7.165	201.535*
Interaction of T.T 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			

Where:

* = Significant at the 5% level.
NS= Not Significant
** = Significant at the 1% level
S.E = Standard error.

Table 3: Mean Values of Pooled Soil Bulk Density For Different Traffic Regimes (Me/in^3)

Treatment	Mean Values (Mg/m^3)
Control	1.1 1
05 Q	1.3 ijk
05 R	1.4 ghij
05 S	1.5 fghi
10 Q	1.6 efgh
10 R	1.7 efg
10 S	1.8 cdef
15 Q	1.8 cdef
15 R	1.9 bcd
15 S	2.1 bc
20 Q	2.1 bc
20 R	2.2 ab
20 S	2.9 a

Means with same letter are not significantly different at 5% level using DMRT (Duncan's new multiple range test).

Table 4: ANOVA Table for Pooled Penetration Resistance **Reading and Traffic Treatment (MPa)**

Source of Variation	Degree of Freedom	Sum of Snuares	Mean Souare	Computed F
ain-plot factor				
plication Traffic		)701 329.922		
eatment Error of	l2 36	℩15	꞉34 27.493 0.234	7.624*
atment Sub-plot ctor		0.992 59.136	.165 0.821	.927* 12.904*

n. Resistance :eraction of T. T x n, Res.	
S.E	0.210

Where:

* = Significant at the 5% level. NS^Not significant S.E= Standard Error.

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

Sampling Reading	Soil Dry Bulk Density (^J				Fen- Resistance (MPa)			
Period	β_{01}	β_{11}	r^2	P> F	β_{02}	β_{12}	r^2	P> F
1	1.091	0.00061	0.048	0.565^{ns}	1.06	0.00067	0.202	2.759^{ns}
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	0.0644	0.809	46.614*
5	1.095	0.030	0.865	70.43*	1.523	0.062	0.772	37.29*
6	0.927	0.0316	0.889	88.105*	1.390	0.061	0.812	47.448*
7	0.911	0.028	0.897	95.889*	1.233	0.058	0.877	79.161*

Where: |3$_{01}$ = Intercept in the regression equation tor son Density.
pn - Slope in the regression equation for ground contact pressure. p$_{u2}$ = Intercept in the regression equation for penetration resistance P]i = Slope in the regression equation for ground contact pressure, ns = not significant. r2 = Linear correlation coefficient * = Significant at the 5% level.

Table 6: ANOVA Table for Days of Appearance of Floral Buds

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	computed F
Replication	3	1.467	0.487	
Treatment	12	126.423	10.535	9.971*
Error	36	38,0391.057		
Total	51	165.923		
S.E		0.727		

Where: * = Significant at the 5% level.
S.E = Standard Error.

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

Source of Variation	Degree of Freedom	Sum of Squares	Mean Squares	Computed F
Main-plot factor				
Replication	3	1606.464	535.549	
Tra. Treatment	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*
Interaction (T. T) x (Pt height)	60	3405.8086	56.764	0.40^{ns}
Error of sub-plot	195	32007.05	164.139	
Total	311	34736.45		
S.E	8.993.			

Where:

* = Significant at the 5% level.
Ns = Not significant
S.E. = Standard Error.

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

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

Means in same column with same letters are not significantly different at the 5% level using Duncan's new multiple range test (DMRT).

Table 9: ANOVA Table for Dry Cotton **Seed Yield**

Source of Variation	Degree of Freedom	Sum Squares	Mean Square	Computed F
Replication	3	0.4893	0.1631	
Tra. Treatment	12	205.806	17.151	24.148*
Error	36	25.5676	0.7102	
Total	51	231.863		
S. E	0.596			

* = Significant at the 5% level.
ns = Not significant

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

Treatment	Mean Values (kg/ha)
Control	356.87 abc
05 Q	361.36 a
05 R	347.67 c
05 S	336.71 cdef
10 Q	346.3 cd
10 R	343.7 cde
10 S	335.4 cdefg
15 Q	336.9 cdef
15 R	331.6 efgh
15 S	312.4 efghi
20 Q	310.7 efghijk
20 R	301.8 efghijkl
20 S	332.4 ijklm

Means with same letters are not significantly different at the 5% level using Duncan's **new** multiple range test (DMRT).

Table 11: Interaction Between Soil Bulk Density and Dry Cotton Seed Yield (kg ha)

Source of Variation	Degree of Freedom	Sums of Square	Mean Square	Computed F
Treatment Factor A (Dry Seed Yield)	12	426	216	9.817**
Factor B (Soil Bulk Density)	12	324	162	7.363**
Interaction ($F_A x F_B$) (D.S.Y x S.B.D)	24	72	18	0.818^{ns}
Error	118	396	22.002	
Total	156	1020		

S.E 0.596

Where: * = Significant at the 5% level
** = Significant at the 1% level
ns = Not significant
$F_{AB} = 0.818 < Fev = 4.58*$

Discussion

Influence of Traffic Regimes on soil Bulk Density

The effect of traffic regimes on soil dry bulk density readings when analysis of variance were performed showed significant differences at (P< 0.05) Table 2. The mean values of the pooled soil dry 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. Thus it is in line with the reports from other researchers (Raghavan et al. 1983, Ohu and Folorunsho, 1989) on the effect of external loading on soil bulk densities.

A simple linear regression gave the relationship between the pooled sampling periods of soil hulk densitv and traffic treatments as:

$$\lambda_d = 1.123 + 0.027\ (np)$$
$$(n = 364,\quad r^2 = 0.897)$$

Where: λd = Pooled soil dry bulk density (mg/m^3)
n = Number of observations
np = Ground contact pressure
r^2 = Coefficient of correlation

Influence of Traffic Regimes on the Penetration Resistance

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

It was observed that for all treatments imposed penetration resistance kept increasing as the product of the number of traffic regimes and the tyre 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; Oni and Adeoti, 1986). The linear regression analysis also indicated that as the number of traffic regimes increased, the ground contact pressure on the soil also increased resulting in increased compaction (Table 5).

Influence of Traffic Regimes on Days of Appearance of Floral Buds and Plant Height

Table 6 and 7 show that there were significant differences (P< 0.01) due to treatment effect between days of appearance of the floral 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 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 regression. The attempt yield an equation:
Ph = 298.569 +0.242 In yd - 18.29 In (np) (n=312, R^2 = 0.813) Where; P], = Plant height in cm. In 7^ = Logarithmic value of soil bulk density In (np) = Logarithmic value of the product of Traffic Regimes
And the ground contact pressure. R = Coefficient of determination.

From the analysis, 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 seed yield and soil bulk density was observed to be not significant ('fable 1 1). 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 = 4.59 showed that the interaction (FAB = 0.818) was significant at P< 0.01.

Recommendations
Tile effect of repeated traffic regimes on the vertisol 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 seedbed preparation.
c. Confinement of machinery wheel traffic to specified tracks.
d. Avoiding 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 uneven distribution, because a tyre with very stiff carcasses acts like a rigid wheel, and the ground pressure is determined by the properties of the soil, dimensions of tyre, and the load. **Conclusion**
The results obtained established the fact that soil compaction as a result of machinery traffic affected the cotton growth performance thereby reducing the final yield. Increased soil bulk densities were obtained in plots with higher traffic regimes, while reduced soil bulk densities were obtained in plots with low traffic regimes. However decreased penetration resistance readings were observed in plots treated with low traffic regimes and in the control plots. The obtained results further concluded that care should be taken during seedbed preparation so that optimum growth and yield of cotton can be obtained.

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