ISSN No:-2456-2165

The Draught Requirement of Disc Plough on Lithosols Soils of Adamawa State, Nigeria

Yahaya Abubakar[1]
E. K. Bwade[2]
M.S. Hussaini[3]
[1,2,3]Department of Agricultural and Bio-Environmental Engineering Technology, Federal Polytechnic Mubi, Adamawa State Nigeria

Abstract:- Field investigation was carried out on lithosols soils of Adamawa state Nigeria to determine the draught requirement of the soil under variable implement weight, disc spacing, tilt and disc angles of disc plough at constant speed of 7 km per hour. For the field experiment, the split- split- split plot design with three replications was used and randomized to reduce errors for the four factors. The tractor trace technique was used, and the draught is measured using a 20 kN mechanical dynamometer. The analysis of variance and Duncan's multiple test range was also used to analyze the significance of each treatment on draught. The results shows that the weight of implement, tilt and disc angles are significant on the draught of disc plough the effect of disc diameter is also significant on draught. There is no significant change in the physical appearance of the tilled soil and this may be attributed to the constant speed of 7km used for the operation. It was also recommended that, experiment on draught of disc plough or other implement should be conducted on vertisols soils of Adamawa state, Nigeria.

I. BACKGROUND OF THE STUDY

The preparation of land for agronomic purposes usually entails of tillage with various occurrences depending on,,// the nature and type of soil. Tillage is the most usual and necessary soil management exercise which is mostly performed to achieve many objectives, which include the eradication of weeds, attainment of favourable conditions for sowing, achievement of nominal emergence and upright growth of plants, preservation of soil organic matter and lessening of erosion, and elimination of hardpans or compacted layers to attain an appropriate water infiltration. It also integrates agrochemicals and agricultural residues into the soil [1]

The growth of any crop production in both quantity and quality rest largely on the improvement of soil and plant conditions. This can be accomplished by using the appropriate tillage tool. A tillage tool is a specific soil working component such as a plough bottom, a disc blade or a cultivator shovel among others. Disc plough is considered as an implement with individually mounted concave disc blades which cut, partially or completely invert soil slices to bury surface material, and pulverize the soil.

Disc plough is commonly used as a primary tillage implement in the normal course of land preparation for crop growth. It is mostly appropriate for the tillage of newly cleared land for agronomic purpose, stony or wet soils.

It cut through crop remains and squeeze the roots. Blades on disc ploughs are concave, usually representing sections of hollow spheres. The conventional plough disc is geometrically a section of a sphere cut off by a plane. The radius of curvature of the disc is the radius of the sphere. The edge of the disc is therefore a circle and the diameter of this circle is called the diameter of the disc. The diameter and the depth of concavity of the disc depend on the distance of the disc face plane from the center of the sphere and the radius of the sphere [2].

During field operations, a plough disc operates at mutually two angles with respect to the direction of travel in horizontal and vertical planes, which is referred to as the disc and tilt angles respectively. The radius of curvature of the disc causes the soil to move upward along its path across the disc surface producing the suction effect of an inclined plane. According to [3] an increase in the disc radius of curvature reduces the value of the vertical forces when the disc angle is between 11.46 - 17.18°.

Conventional tillage causes problem on dusty, fine sandy soils, particularly when dry; on very heavy sticky soils and on a loosed structure soils, principally those with soaring sodium content [4]. Soils with unfavorable chemical and physical properties that are inter-related are among the factors of negative effects on tillage systems. For example, soil saturation with sodium water results in decreasing its permeability and increasing its hardness at drying. Calcium decrease in acid soils is conducive to the same results with increase in hydrogen and aluminum, which is furthermore noxious to the plants. A large quantity of hydrogen ions and decrease in organic colloids result in deterioration of the soil quality which brings about hardships with its maintenance, that constituting increase in draught force requirement during tillage operation [5].

According to [6] all soil cutting and tillage implements move soils from one position to another. The soil materials collapse mechanically in the action, such that the mass of soil being moved does not maintain its original position and structural shape. The extent of the mass transfer and failure pattern of the mass depends on the shear characteristics of

ISSN No:-2456-2165

the soil. The extent of the resistance of these changes depends on the soil developed structural stiffness and the geometry of the tillage tool. [7] stated that, the disc geometry and the operational parameters which govern the soil handling capabilities are disc diameter, shape or radius of curvature, disc angle, angle of inclination, shape of the edge, operational velocity, and depth of cut and width of cut.

The tillage implements used in most part of the Adamawa state, Nigeria are the disc plough and harrow. These implements were imported in different specifications without considering the optimum adjustments required on the implements to produce a quality till, the draught requirement of the implements in relation to the soil conditions among others.

There are many factors that control the performance of tillage implements. These can be divided into three sections: soil, plough and operation factors. Soil variables include: soil moisture content, organic matter, soil bulk density and structure. Plough variables include: plough weight, disc angle and tilt angle, radius of curvature, disc spacing and disc diameter. Operation variables include: forward speed, width and ploughing depth [8]

The availability of data on tillage implements parameters is important in selecting suitable tillage implements and making suitable adjustments in specified soils. Farm managers and consultants use data of tillage implements parameter in specific soil types to determine the size of the tractor and type of tillage tool that was required.

The variations of tillage tool parameters are affected by the difference in soil conditions, type of tool, tool design and operational parameters. However, little work has been undertaken on the interactive effect variations of tillage tool parameters on the soils in Nigeria [9]. The need to established data on draught requirement of different implements on the soils of Nigeria is recommendations by [10]

This study will focus on the matrix combinations of the tillage tools and operational parameters on the soils of northern and central Adamawa with the view to develop a mathematical model that encompasses the interaction of tools geometry and its operational parameters for an effective and efficient tillage operation in the area of study. The aim of this work is to measure the effects of some soil physical properties (Cone index and bulk density) on draught using disc plough on the soils of the selected study area.

The study compares the effects of tool parameters (tilt angle, disc angle, weight of plough and disc spacing,) on soil parameters (bulk density and cone index).

The tillage implements to be considered are disc plough while the soils were Lithosols that is found in many corners of Adamawa State, Nigeria.

II. MATERIALS AND METHODS

Field experiments were conducted on the soils of Mubi North Local Government (10º 16' 06" N) and (13º 16' 01" E) of Adamawa state, Nigeria, to evaluate the performance of disc plough at different working parameters. Fig 1 showed the soil map of Adamawa state, Nigeria. According to the map, Lithosols soils is the predominant soil that is found in most part of the state. Soil particle size distribution analysis was conducted before starting the field experiment.

The equipment required for the field and laboratory operations consist of two conventional tractors, disc plough, a dynamometer for measuring draught of implement, hand penetrometer, an oven drier for analyzing moisture content of soil weighing balance, measuring tape, pegs camera, tin, polythene bags, soil sampling auger.

The draught estimation was performed using tractor trace technique. The draught force was measured using 20 kN mechanical drawbar dynamometer and the parameters of disc plough considered for this research include the disc and tilt angle, implement weight and disc spacing and these parameters were varied..

The change in the soil physical structure (bulk density γ and cone index c_i) of the soil after tillage was considered as the measure for attaining a good quality soil till.

- *Experimental Design and Layout*

The test was carried out using a disc plough. A plots was designed for the test on the selected site of considerations. For this operation, the treatments in each plot were; implement weight (w) in the main plot two (2) levels, disc spacing (s) in the sub plots, two (2) levels, tilt angle (β) in the sub-sub plot three (3) levels and disc angle (α) in the sub-sub-sub plot three (3) levels, and three replications for each test. The four (4) variables were combined in a factorial Split-Split-split-plot design (2 × 2 × 3 × 3) with three blocks.

Split-Split-Split plot design which is generally suitable for factorial experiments with three or more factor [11]. The cost of running a set of treatment in this design order is generally less than the cost of the same experiment when completely randomized. Also, the validity expectation in split-plot design is higher. One or two shortcuts may be taken by the experimenter in the interest of saving time and money. [12] It is not just less expensive than completely randomized, but often more efficient statistically [13].

The test with respect to disc plough, include; implement weight (w), disc spacing (s) in the sub plot, tilt angle (β) in the sub-sub plot and disc angle (α) in the sub-sub-sub plot. The total number of treatments for the test with disc plough was as follows; 36 treatments x 3 replications = **108 treatments** and the area required = 9 m x 2.5 m x 108 = 3,240 m^2 or **0.324 hectare**

ISSN No:-2456-2165

The Random-Number Technique (simple random sampling) was used for the randomization of factors for the main-plot, sub-plots and sub-sub-plots of the experimental design for disc plough. The moisture level considered for this experiment was the field moisture at least 24 hours after rainfall. The operational speed for this experiment is 7 km/hr since it was recommended that, the average speed of ploughing on loamy sand is about 7km/hr [14]

Soil properties were determined before and after tillage in each treatment. Draught and soil disturbance were measured during the tests. The physical field layout was achieved by using pegs and color tags, field measuring tapes and lines to mark out the sub plot and the strips.

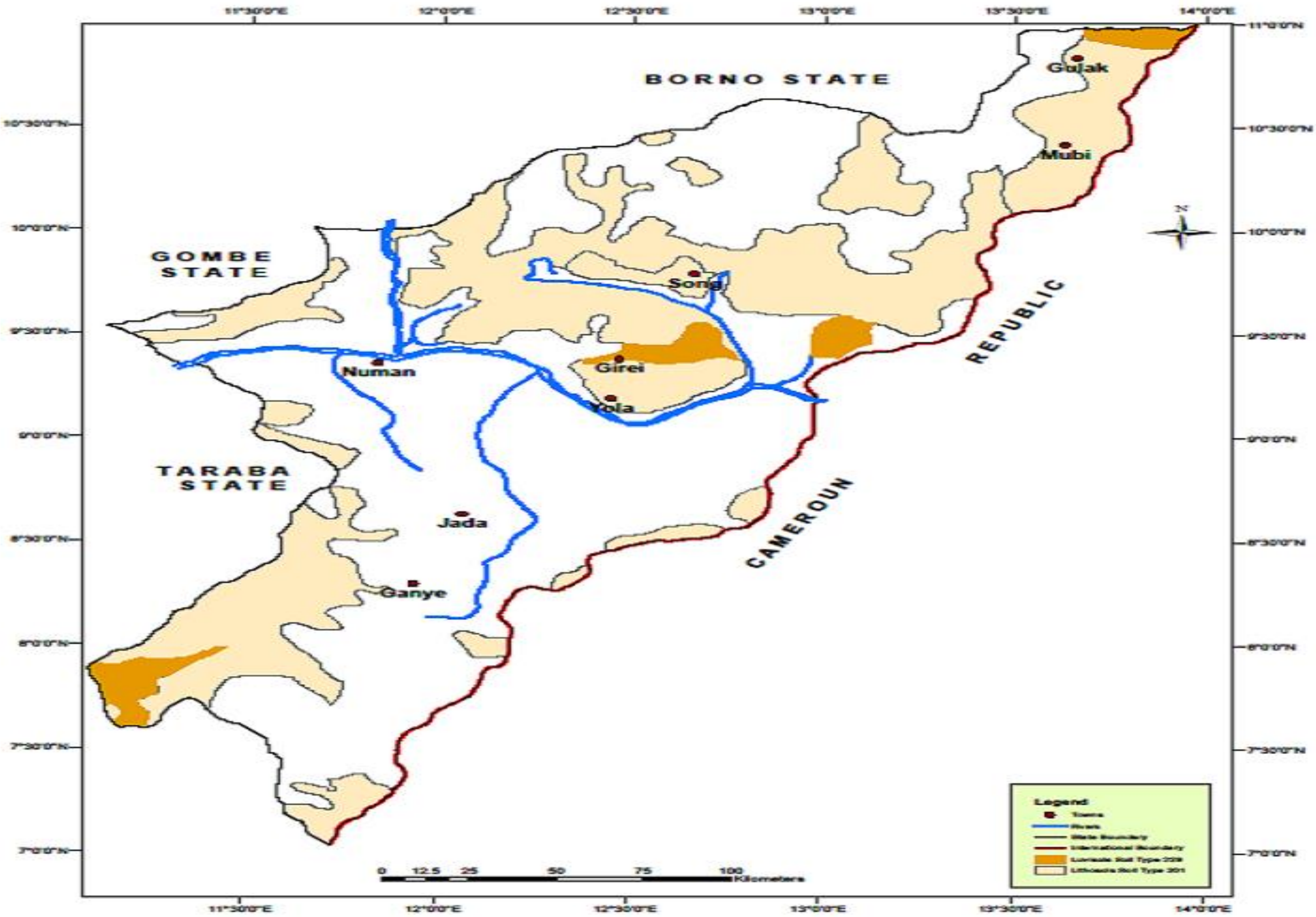

Fig 1 Soil Map of Adamawa State, Nigeria [15]

➢ *Determination of Soil Properties*

In order to define the initial soil conditions, soil samples were collected from each treatment to determine the soil parameters. Soil properties measured include: soil moisture content, bulk density, and cone index.

➢ *Determination of Soil Moisture Content*

The soil moisture content was determined gravimetrically. Soil sample for each treatment was taken before and after tillage operations, and placed in an air tight container. The sample was immediately taken to the laboratory and weigh with an accurate weight balance and then placed for an oven drying at a temperature of 110^0 C for 24 hours. The loss of weight in dryin g divided by the original weight of individual soil sample multiplied by one hundred percent (1 00%) pas shown in the equation below determines the moisture percentages of the soil samples on dry basis

$$\text{Mdb} = \frac{Ww}{Wd} - 1 \times (100) \quad [16] \qquad (1)$$

➢ *Where*

- *Mdb* = Moisture content of the soil (%db)
- *Wω* = Weight of moist soil (g)
- *Wd* = Weight of dry soil (g)

➢ *Determination of Bulk Density*

The bulk density determination was carried out on intact core samples as described by Blake and [17] at a depth of 0 – 20cm taken from each treatment before and after ploughing. Samples were oven dried in laboratory at 105^0c for 48 hours. The bulk density of the soil was determined from the following relationship.

$$P_s = \frac{Mds}{\pi r^2 h} \qquad (2)$$

- *Where*

- ρ_b = Bulk density (g/cm^3)
- Mds = Mass of oven dry soil sample (g)
- π = 3.142
- h = height of ring (m)
- r = radius of the ring (m)

- *Determination of Soil Penetration Resistance (Cone Index)*

The cone index of each treatment was determined using the hand-held penetrometer before and after tillage. The cone depth profile for each sub-plot was taken up to a maximum depth of the instrument [13].

- Determination of Machine Parameter.

Two E-375 MF tractors E-375 and E-435 were used. The machine parameters determined include the tractor speed and the drawbar pull.

- *Determination of Tractor Speed*.

Three (3) treatments of the tractor speeds were 5, 7 and 9 km/hr corresponding to S_1, S_2 and S_3 respectively. Before the actual experiments starts, the various revolutions per minute of the engine read off from the speedometer that corresponds to the chosen tractor forward speeds was determined. This is to ensure that the tractor attains such speeds before measurement at joint up pulls was taken under each soil moisture regime as in [18]

- *Determination of Drawbar-Pull*

The first step considered in determining the drawbar pull were:- A dynamometer was tied at one side by a towing cable to the drawbar of the front tractor and the other end of the dynamometer was tied to the front of the carrier tractor . The carrier tractor was towed at 5, 7 and 9 km/hr. The force (RR) required to move the tractor and plough in a lift position over the ground test for the three (3) speed levels was determined as follows;

The net draw bar pull was calculated using the following equation as used by [19]:

$$N.P = P - RR \qquad (3)$$

- *Where*

- N.P = Net draw bar force for ploughing (N)
- P = the recorded force when the plough is in action (N)
- RR = the force required to move both the tractor and the plough in a lifted position over the ground test (N)

To measure the drawbar-pull, the implement was pulled by the tractor, while the pulling was done at the required specified speed. The implements to be used are disc plough and disc harrow. The draw-bar pulls was measured using a draw-bar dynamometer and the draught of the implements was taken directly from the dynamometer reading.



Plate 1; the dynamometer Plate 2; dynamometer coupled for tractor trace method of draught measurement and Plate 3; draught measurement for disc plough using tractor trace technique

- *Determination of Power Requirement*

In order to calculate the power exerted by the tractor, the following observations was taken:

- Average draught from the dynamometer reading (N)
- Distance moved by the implement (m).
- Time taken by implement to cover a known distance (second).
- Power (P) developed by the power unit (tractor) was calculated as:

$$P = \frac{Force \times distance}{time} \text{ kW} \qquad (4)$$

- *Field Operation with Disc Plough*

The three bottoms fully mounted MF disc plough of measured weight 372 kg was used for the implement draught test and it was mounted on MF 375. A weight of 20 kg is being mounted and tied firmly to the top of the disc plough gang for the purpose of changing the weight of implement during field test. The normal weight of the implement w_1 = 372 kg while w_2 = 392 kg (normal weight of disc plough plus the added weight of 20 kg)

Also, the disc spacing of disc plough is adjusted by loosening the bolts and nuts and inserting a washer of required thickness between the disc blade and the disc

ISSN No:-2456-2165

holder and this could reduce or increase the spacing between the discs.

➢ *Data Collection and Analysis*

The data to be collected was subjected to Analysis of variance ANOVA using Statistical Analysis System (SAS) software to evaluate the significance of each treatment in a split-split-split-plot design with a factorial treatment design of 2×2×3×3..

This is with a view to determine the interactive effects of disc angle, tilt angle, disc spacing and implement weight at constant soil moisture and depth of cut, and combine effect of disc angle, tilt angle, disc spacing and implement weight at a specified soil moisture and depth of cut on the penetration resistance, bulk density and drawbar pull of a tractor on the soil of the study areas of study.

➢ *Field draught*

The results obtained on draught in relation to tilt angle, disc angle, implement weight and disc spacing, using disc plough with respect to each treatment of the draught were subjected to analysis of variance and mean separation to examine the significance of individual parameter and the effect of their interactions on draught of disc plough

III. RESULTS AND DISCUSSION

➢ *Effects of Disc Plough Parameters on Draught*

Table 1 is the analysis of variance that evaluates the effects of disc plough parameters on draught force. The analysis of variance table shows the effects of implement weight (w), disc spacing (s)

Table 1 Analysis of Variance Table in Split-Split-Split Plot Design for Draught of Disc Plough

Source of variation	DF	SS	MS	F-Cal.	P ≥ 0.05
Replication	2	0.0005491	0.0002745	0.67	
Main Plot Factor					
W	1	0.0193068	0.0193068	46.83**	0.021
Residual	2	0.0008246	0.0004123	1.84	
Sub-Plot Factor					
S	1	0.0150285	0.0150285	67.18**	0.001
w × s	1	0.0100148	0.0100148	44.77**	0.003
Residual	4	0.0008948	0.0002237	0.74	
Sub-Sub Plot Factor					
Β	2	0.0048452	0.0024226	7.99**	0.004
w × β	2	0.0022820	0.0011410	3.76**	0.046
s × β	2	0.0024509	0.0012255	4.04**	0.038
w × s × β	2	0.0036446	0.0018223	6.01**	0.011
Residual	16	0.0048504	0.0003032	0.60	
Sub-Sub-Sub Plot Factor					
Α	2	0.0012735	0.0006368	1.26^{ns}	0.292
w × α	2	0.0012408	0.0006204	1.23^{ns}	0.031
s × α	2	0.0009394	0.0004697	0.93^{ns}	0.400
β × α	4	0.0027648	0.0006912	1.37^{ns}	0.257
w × s × α	2	0.0008977	0.0004488	0.89^{ns}	0.417
w × β × α	4	0.0030965	0.0007741	1.54^{ns}	0.206
s × β × α	4	0.0027861	0.0006965	1.38^{ns}	0.254
w × s × β × α	4	0.0027828	0.0006957	1.38	0.254
Residual	48	0.0241638	0.0005034		
Total	107	0.1046370			

w = implement weight ,S = disc spacing, β = tilt angle and α = disc angle

Tilt angle (β) and disc angle (α) on draught of disc plough under constant speed of operation, 7 Km/hr. The main plot factor is the implement weight (w) and has a significant effect on draught of disc plough. The variable in the sub plot is disc spacing (α). The analysis of variance table indicated that, the effect of disc spacing (α) is significant, and the effect of interaction between disc spacing and implement weight (α × w) is also significant on the draught of disc plough.

Moreover, in the sub-sub plot of the analysis table, the main factor is tilt angle (β). The analysis table indicated that tilt angle is highly significant on draught of disc plough. Also, the interaction between implement weight and tilt angle (β × w) is significant and the interaction between disc spacing and tilt angle (β × α) is also very significant. Similarly, the analysis of variance table indicated that, the interaction between implement weight, disc spacing and tilt angle (w × s × β) were highly significant on draught.

Disc angle (α) is the factor in the sub-sub-sub plot. The table shows that disc angle is not significant on the draught of disc plough. Also, the interactions of implement weight and disc angle (w x α), disc spacing and disc angle (S × α) and implement weight, disc spacing and disc angle (w x S x α), implement weight, tilt angle and, tilt angle disc angle, (w x β x α),

Disc spacing and disc angle (s x β x α) and the interactions of implement weight, tilt angle and disc angle (w x s x β x α) are not significant on the draught of disc plough. However, this may be as a result of the degree of moisture in the soil and the speed level selected for this work which make the change in disc angle (α) not significant on the draught.

Table 2 is mean separation which shows the effect of implement weight (w), disc spacing (s), tilt angle (*β*) and disc angle on draught of implement. It was indicated that, the weight of implement (w) is significant on draught. Draught increased from 5.78 KN to 5.80 KN with increase in implement weight from (372 Kg) to (392 kg) respectively. It was also revealed on the same table that, increasing the disc spacing of disc plough from 25 cm to 28 cm increased the draught of implement from 5.78 KN to 5.84 KN. That is an indication that disc spacing is significant on draught of implement. Similarly, draught (D) of disc plough increased from 5.78, 5.79 to 6.40 KN at 17º, 20º and 23º tilt angle (β) respectively.

Table 2 Effects of Implement Weight (w), Disc Spacing (S), Tit Angle (β) and Tit Angle (β) on Draught of Disc Plough

Variable	**Draught KN**	
Implement weight (W) Kg	w_1 = 372 kg	5.81854a
	w_2 = 392 kg	6.78180b
Disc spacing (S) cm	s_1 = 25 cm	5.80696a
	s_2 = 28 cm	6.40337b
Tit Angle (β) degree	β_1 = 17	5.78769b
	β_2 = 20	5.79386ab
	β_3 = 23	6.83394c
Disc Angle (α) degree	α_1 = 42º	5.79842a
	α_2 = 43º	5.79667a
	α_3 = 44º	6.79842c

This indicated the effect of disc angle (*α*) on draught of disc plough is insignificant. The table 3 shows the effect of interactions between tilt angle and disc angle in relation to draught of disc plough, at 17º tilt angle (β_1). The draught values of disc plough weighing 372 Kg (W_1) and that of 392 Kg (W_2) are 5.78 KN and 6.56 KN respectively. Similarly, at 20º and 23º tilt angle (β_2 and β_3), there is a coresponding increase in draught for the two disc plough W_1 and W_2 (372 Kg & 392 Kg) with an increase in tilt angle. Concequently, At disc spacing of 25 cm, the draught value of disc plough weighing 372 Kg recorded 5.76KN, there is an increase in the draught value from 5.80 KN to 6.40 KN with an increase in disc spacing to 28 cm with the same

Table 3 Effect of Interaction of Tilt Angle and Disc Spacing on Weight of Implement on Draught

Variable	**Implement Weight (w)**	
Tilt angle (deg.)	*Implement Weight (w_1) = 372 Kg*	*Implement Weight (w_2) = 392 Kg*
β_1 = 17º	5.76883c	6.656a
β_2 = 20º	5.78022bc	6.4075a
β_3 = 23º	5.79633ab	6.81156a
Disc spacing (S)		
S1 = 25 cm	5.76037b	5.80637a
S2 = 28 cm	5.80322a	6.4075a

Implement weight. But the interaction between S_1, S_2 (25 , 28) cm disc spacing and W_2 (392) Kg implement weight is not significant. Table 4 shows the effect of interaction of tilt angle and disc angle on the draught of disc plough.The mean separation indicated that, there is no significant difference in draught of disc plough for the interaction between tilt angles at 17º and 20º and disc angles at 42º and 43º respectively. But draught increased for interaction of tilt angle (β_3) 23º and disc angle (α_3) 44º.

Table 4 The Effect of Interaction for Tilt and Disc Angle (A) on Draught of Disc Plough

Disc angle (*α*) deg.	**Tilt angle (β1) = 17º**	**Tilt angle (β2) = 20º**	**Tilt angle (β3) = 23º**
α_1 = 42º	5.79342b	5.79342ab	5.80167ab
α_2 = 43º	5.80075ab	5.79342ab	5.80325ab
α_3 = 44º	5.79342ab	5.79692ab	5.81692a

On table 5 the effect of interaction of disc angle (α) and tilt ange (β) with respect to disc spacing (S) on draught of disc plough was presented, the table revealed that, there is no significant difference in the interaction of disc angles and disc spacing. However, draught values are higher for disc spacing (S_2) of 28 cm in all the interactions. .Also, the table shows the interaction of tilt angle (β) and disc spacing (S) on draught of disc plough. Draught increased for disc plough weighing 372 Kg (W_1) with increase in tilt angle, but, the increase in draught recorded with increase in tilt angle is negligiable for implement weighing 392 Kg (W_2). However, the heavier disc plough recorded higher draught in the interactions as indicated by mean separation. Table 8 shows the effect of interaction between disc angle (α) and simplement weight (w) on draught of disc plough. The mean separation reveaed that, there is no significant difference in the interaction of disc plough weighing 372 Kg (w_1) and 42º disc angle, and the interaction between disc plough weighing 392 (w_2) and 44º disc angle on draught of disc plough. Moreover, the effect of interaction of 392 implement weight (w_2) and 42º, 43º and 44º disc angles are not significant on draught of disc plough.

Table 5 Effect of Interaction between Disc Angle (A) and Tilt Angle (B) on Disc Spacing on the Draught of Disc Plough

Variable	**Disc Spacing (S)**	
Disc angle (α) (deg)	Disc spacing (S1) = 25 cm	Disc spacing (S2) = 28 cm
α_1 = 42º	5.77506b	5.9808a
α_2 = 43º	5.79028ab	5.9656a
α_3 = 44º	5.78478ab	6.0856a
Tilt angle (β)		
β_1 = 17º	5.77078c	5.80461a
β_2 = 20º	5.78083bc	5.80689a
β_3 = 23º	5.7985ab	5.80939a

Table 6 Effects of Interaction between Disc Angle (A) and Implement Weight (W) on the Draught of Disc Plough

Disc Angle (α) deg.	**Implement weight (W_1) = 372 Kg**	**Implement weight (W_2) = 392**
α_1 = 42º	5.77272a	6.80811ab
α_2 = 43º	5.789bc	6.80783ac
α_3 = 44º	5.78367c	6.80967a

Table 7 shows the interactive effects of implement weight (w), tilt angle (β) and disc angle (α) on draught of disc plough. It indicated that, the interactions between implement weight (w) of 372 Kg and 392 with 17º, 20º and 23º tilt angles and 42º, 43º and 44º respectively are significantly not different on draught of disc plough.

Table 8 shows the mean separation for the interactions of implement weight, disc angle and disc spacing on the draught of disc plough. It revealed that, all the interactions are significantly not different from one other on draught. Table 9 mean separation for the interaction of tilt angle (β), disc angle (α) and implement weight (w) on disc plough. It shows that, the interactions of (tilt angle β_1 with disc angle α_2) and tilt angle β_3 with disc angles (α_1, α_2 & α_3) are significantly not different while using implement weight (w_1) 372 Kg. Similarly, tilt angle β_1 with disc angle α_3, and tilt β_2 with disc angle (α_1, α_2 & α_3) are also not significantly different. This may be attributed to the speed level used in the field research.

Table 7 The Interactive Effects of Implement Weight (W), Tilt Angle (B) and Disc Angle (A) on Draught of Disc Plough

Implement Weight (W) Kg	**Tilt Angle (β) deg.**	**Disc Angle (α) deg.**		
		α_1 = 42º	α_2 = 43º	α_3 = 44º
W_1 = 372 Kg	β_1 = 17º	5.74550c	5.79600ab	5.76500abc
	β_2 = 20º	5.78033abc	5.77483abc	5.78550abc
	β_3 = 23º	6.79233ab	6.79617ab	6.80050ab
W_2 = 392	β_1 = 17º	5.80683ab	5.80550ab	5.80733ab
	β_2 = 20º	5.80650ab	5.80767ab	5.80833ab
	β_3 = 23º	6.81100a	6.81033a	6.81333a

Table 8 The Effect of Interactions of Implement Weight, Disc Angle and Disc Spacing on Draught of Disc Plough

Implement weight (W) Kg	**Disc angle (α) deg.**	**Disc Spacing (S) cm**	
		S_1 = 25 cm	S_2 = 28c
(W_1) = 372 Kg	α_1 = 42º	5.74389c	5.80156ab
	α_2 = 43º	5.77433bc	5.80367ab
	α_3 = 44º	5.76289c	5.80444ab
(W_2) = 392	α_1 = 42º	5.80622ab	5.81000a
	α_2 = 43º	5.80622ab	5.80944a
	α_3 = 44º	5.80667ab	5.81267a

ISSN No:-2456-2165

Table 9 Effect of Interactions of Implement Weight (W) and Disc Spacing on Tilt Angle (B) and Disc Angle (A) in Relation to Draught (D) of Disc Plough

Implement weight (W) kg	**Disc angle (α)**	**β1 = 17°**	**β2 = 20°**	**β3 = 23°**
W_1 = 372 Kg	α_1 = 42°	5.74550c	5.79600ab	5.76500abc
	α_2 = 43°	5.78033abc	5.7748abc	5.78550abc
	α_3 = 44°	5.79233ab	5.79617ab	5.80050ab
W_2 = 392	α_1 = 42°	5.80683ab	5.80550ab	5.80733ab
	α_2 = 43°	5.80650ab	5.80767ab	5.80833ab
	α_3 = 44°	5.81100a	5.81033a	5.81333a
Disc spacing (S) cm				
S_1 = 25 cm	α_1 = 42°	5.74933c	5.79717ab	5.76583bc
	α_2 = 43°	5.78117abc	5.77483abc	5.78650abc
	α_3 = 44°	5.79467ab	5.79883ab	5.80200ab
S_2 = 28 cm	α_1 = 42°	5.80300ab	5.80433ab	5.80650ab
	α_2 = 43°	5.80567ab	5.80767ab	5.80733ab
	α_3 = 44°	5.80867ab	5.80767ab	5.82183a

Figure 2 shows the effect of interactions between disc spacing (S) implement weight (W) and tilt angle (β) on cone index. The mean separation indicated that, the effect of implement weight is significant on cone penetration, but the effects of disc spacing (S) and tilt angle are significantly not different on cone index. Furthermore, in the interaction between disc spacing (S) implement weight (W) and disc angle (α) on the same table, implement weight (w) is clearly significant on cone index, but the effect of disc angle (α) and disc spacing (s) are significantly not different on cone index. Effect of interaction between tilt angle (β), implement weight (W) and disc angle (α) and the interaction between tilt angle (β), implement weight (W) and disc spacing on cone index are presented on figure 3. All interactions according to the results by mean separation are significantly not different.

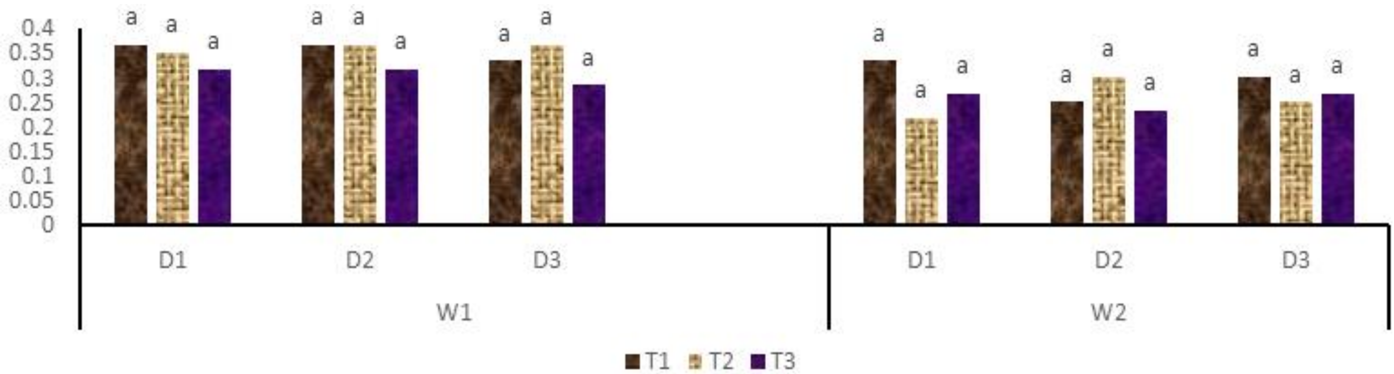

Fig 2 The Interactive Effects of Implement Weight (W), Tilt Angle (β) and Disc Angle on Cone Index of the Soil using Disc Plough

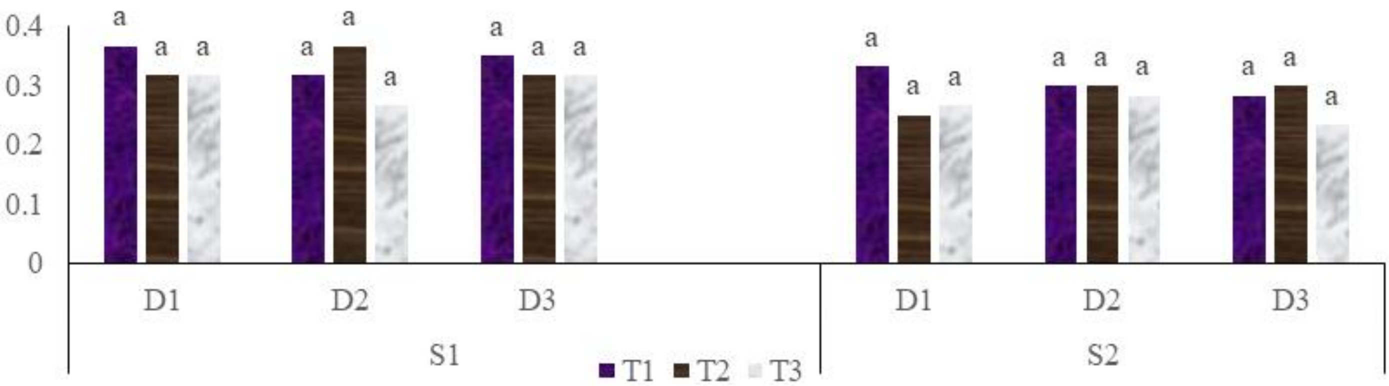

Fig 3 Effects of Interactions of Tilt Angle (B), Disc Angle (A) and Disc Spacing (S) on Cone Index Using Disc Plough

The effect of interaction between, implement weight (w) disc angle (α) and tilt angle (β) and the effect of interaction between disc spacing (S) disc angle (α) and tilt angle (β) on soil bulk density are presented on table 4. The mean separation also indicated that the values recorded are significantly the same on bulk density. Similarly, figure 5 the interactions between disc spacing (s) disc angle (D) and Tilt angle (T) on soil bulk density are significantly the same. It was observed that, at an optimum speed of tillage operation with disc plough, the bulk density of the soil will maintain an optimum value even when the disc parameters were altered if the alteration is within the allowable range of the parameter.

ISSN No:-2456-2165

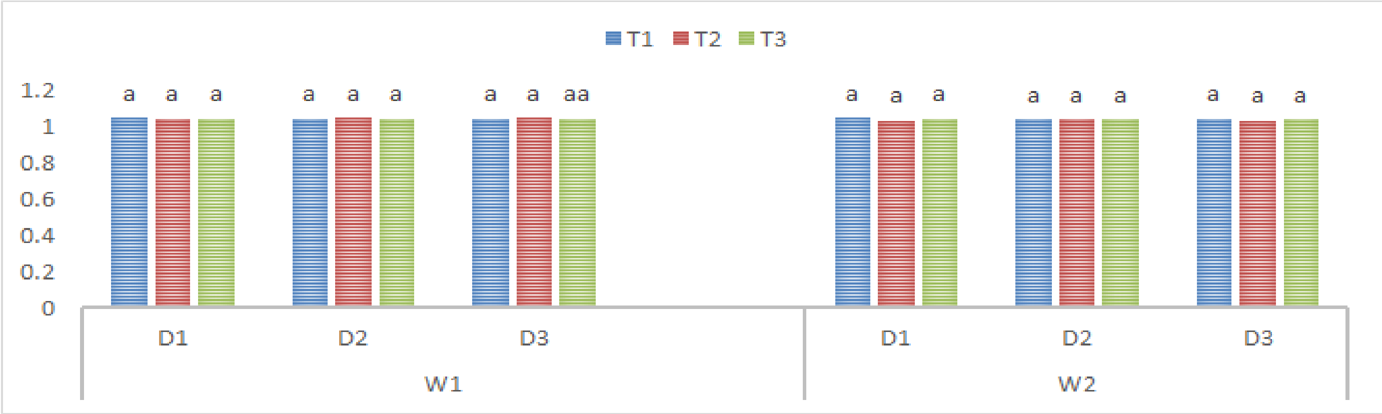

Fig 4 Effect of Implement Weight (W), Disc Angle (D) and Tilt Angle (T) on Soil Bulk Density (BD) Using Disc Plough

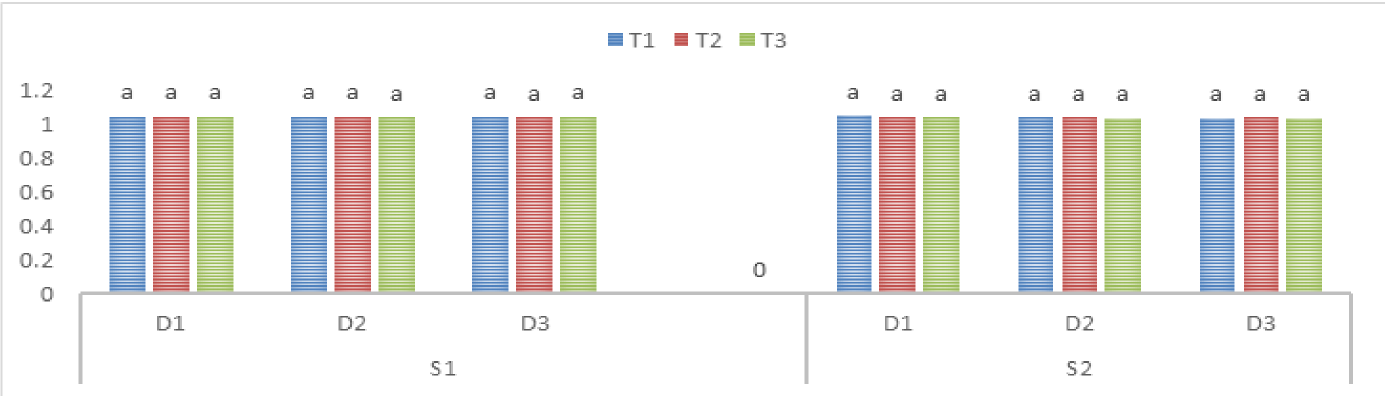

Fig 5 Effects of Interactions between Disc Spacing (S), Disc Angle (A) and Tilt Angle (B) on Soil Bulk Density (BD) Using Disc Plough

The implement geometric parameters consider for this work include; implement weight, disc spacing, disc and tilt angles for disc plough while, the speed of operation is constant at 7 Km/hr.

The experiment was conducted on a split-split-split plot of 2 x 2 x 3 x 3 design and the plots were randomized to check and reduce the level of error in the research. The tractor trace technique was used to measure the force and power requirement of the implements. Draught of implement, is measured for each treatment during the study.

It was revealed that, draught increased significantly with change in disc angle, tilt angle and disc spacing, but is more significant with increase in implement weight.

It was further discoverer that, at 7 km/hr which was used as the constant speed for the study, the slight change in parameters such as disc angle, tilt angle, disc spacing and implement weight does significantly change the values of cone index and bulk density. Thus, at this operational speed, the optimum soil condition required could be attained at within the varying parameters of the disc plough. For further studies on tillage implement draught requirement in the study area, this study recommends that, the same study be conducted on vertisols soils. The soil is a very complicated soil as described by [20], it's a hard and very sticky clay which swells and expands when wet and also, shrinks and crack when dried. A vast of it is found in many parts of Adamawa, very fertile and but unproductive because of its difficulty during tillage. It is recommended that, the draught requirement in relation to the moisture level and depth of ploughing of the soil should be studied and a prediction model should be developed for the soil.

I wish to express my sincere acknowledgment and appreciations to Tertiary Education Trust Fund (TETFund) for sponsoring this research on tillage tools used on the soils of Adamawa state, Nigeria.

REFERENCES

[1]. Mazuchowski J.Z., Derpsch R. (1984). Guía de preparo do solo par culturas anuaisme canizadas. ACARPA, Curitiba, 65: 2.
[2]. Monjurul Alam Md. (1989) Soil Reaction Forces on Agricultural Disc Implements; A Thesis Submitted in Fulfillment of the Requirements for the Degree of Doctor of Philosophy In Agricultural Engineering The University of Newcastle
[3]. Gill, W. R., Bailey, A. C. and Reaves, C. A. (1981). "Harrow disc curvature influence on soil penetration", ASAE paper NO. 81-1532.
[4]. Morgan, R.P.C (1998). Soil Erosion and Conservation, Organic Conservation. Pp 164 -211.
[5]. Hristo Beloev (2007) Factors Affecting the Tillage Systems; Journal of Engineering Annals of Faculty of Engineering, Hunduora.

[6]. Ijioma C.I. and E mckyes (1995) effect of tillage tool geometry on soil structural stiffness. international agrophysics, 9: 25 – 36
[7]. Gill, W. R., Reaves, C. A. and Bailey, A. C. (1978) "The effect of geometric parameters on disc forces", ASAE paper No. 78-1535
[8]. Panagraphi, B; Mishra, J.N. and SwainS. (1990). Effect of implement and soil parameters on penetration depth of a disc plough. AMA. 21 (2) : 9 – 12.
[9]. Onwualu, A.P., Akubou, C.O. and Ahaneku, L.E. (2006). Fundamentals of Engineering for Agriculture, Immaculate Publications Limited.
[10]. Ani A O., Akubuo C. O. And Edigbo E. U. (2007) Tractability Condition for Disc Ploughing on a Loamy Sand Soil in the Ilorin Agro-Ecological Zone, Nigerian Journal of Technology,26 (2): 5 – 12
[11]. Gomez, K.A. and Gomez A.A. (1984) Statistical Procedures for Agricultural Researches, 2nd Edition, John Wiley and Sons. Inc., New York, Pp134
[12]. Ganju, J. and Lucas, J.M. (1997). Bias in Test Statistics when Restrictions in Randomization Are Caused by factors. Communications in Statistics" Theory and Methods 26: 47-63
[13]. Ju, H. L. and Lucas, J. M. (2002). Lk factorial Experiment With Hard-To-Change and Easy-To-Change Factors". Journal of Quality Technology 34:411-421
[14]. Ahaneku, I. E., Onwualu, A. P.; James, D. and Ani, A.O. (2003). Effect of Soil Moisture and Tools Speed on Draught and Power Requirement of Disc Plough; Proceedings of the 4th International Conference and 25th Annual General Meeting of the Nigerian Institute of Agricultural Engineers (A Division of Nigerian Society of Engineers). 25: 40 – 46.
[15]. A.A. and Tukur A.L. (1999) Adamawa in Maps, Paraclete Publishers (A Division of Paraclete and sons) Paraclete Publishing House, Yola, Nigeria, 1st Adebayo Edition, 27 – 29
[16]. James, L.G. (1988). Principles of Farm Irrigation System Design. New York John Willey Krieger Publishing Company
[17]. Blake, S.R. and Hartage, K.H. (1986) Bulk Density Core Method, In Method of Soil Analysis Part I Physical and Mineralogical Properties. Klute, A. (eds) Agronomy Monograph 9, American Society of Argon Madison, Wisconsin PP.363 – 366.
[18]. Mohamed, A. F. and El- Maksoud, A. (2001) Laboratory Determination of Soil Strength Parameters in Calcareous Soils and Their Effects on Chiseling Draught Prediction. Trans of ASAE. Vol. 28 No. 2: 420-424
[19]. Mohamed, A. F. and El- Maksoud, A. (2001) Laboratory Determination of Soil Strength Parameters in Calcareous Soils and Their Effects on Chiseling Draught Prediction. Trans of ASAE. Vol. 28 No. 2: 420-424
[20]. Lombin G. and Esu I.E (1988) Characteristics and Management Problems of Vertisols in The Nigerian Savannah, FAO Coporate Document Depository.