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Effect Of Soil And Tool Parameters On Soil Draught And Disturbance Of Sandy Soil

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***Abstract*—There is need to develop more sensitive instrumentation for capturing draught force data in soil bin experimentation. In this study an instrumentation consisting of data logger, voltage amplifier, and a load cell were designed, assembled, calibrated and interfaced with laptop for capturing draught force data of tillage tools in indoor soil bin experimentation. Draught requirements of tillage tools were investigated under various tillage parameters; Soil parameter (moisture content), tools parameter (tool type and rake angle), operational parameters (speed and depth). The type of soil used for the experimentation was loamy sand. Two rake angles (45° and 90°),and two soil conditions (dry and wet) were used for evaluating the draught of the tillage tools (sweeps).The results showed that draught force increased with increase in rake angle, increase in soil moisture content. Tools with flat profile surface had greater draught than those with ridged profile surface. Maximum draught of tools were 70 N (T1) under wet condition and 45° rake angle, 95 N (SF10) under wet condition and 90° rake angle, 95 N (SF20) under wet condition and 45° rake angle, and 90 N (SR20) under wet condition and 45° rake angle, Soil disturbance parameters also were higher under wet soil condition for both rake angles. Soil disturbance parameters except for the ridge to ridge distance and a maximum width of soil throw showed higher values for tools rake angle of 90°. The trend was the same under moisture conditions. Results analysis showed that the digital way of draught measurement was more sensitive and accurate than the analog we had used before. Draught increased with increase in tools rake angle and moisture content. Tools with high profile had lower draft requirement than plane surface tools. The study has provided another good facility in the study of soil tillage dynamics.**

Keywords—draught, instrumentation, soil bin; tillage tools, soil disturbance

1. INTRODUCTION

The application of soil bin for soil machine interaction research was initially established by several research institutes, like the National Tillage and Machinery Laboratory in the United States.

Soil-machine interaction tests are conducted in fields for development of a prototype machine or evaluation of an existing machine, so that the tests could emulate the actual farm situation. Several problems often limit field-testing. The problems come from two sources, the weather condition and the soil condition. Testing can only be conducted when the weather is suitable for farming operations. But weather condition and changes in climate affect farming operations [1]. But, controlling these parameters is essential for valid comparisons of measurements of tools or traction devices. [2] and these field conditions are beyond the control of researchers.

Soil bins provide several benefits to soil-machine interaction studies. If located indoor, tests can be conducted all year round without weather interruption. Soil bins also allow researchers to control soil type and soil moisture content [3]. Proper selection of tractors and implements need to be based on these performance parameters [4]. Therefore, this study will be on the development of an outdoor soil bin instrumentation system for soil dynamic studies.

2. Materials and Methods

2.1 Experimental Location

The experiment was carried on the soil bin of soil-tillage dynamics laboratory of the department of Agricultural Engineering. Federal University of Technology, Akure, Ondo State.

2.2 Description of Equipment

The equipment consisted of An indoor soil bin of 9.0 m length, 0.85 m width and 0.45 m depth; a soil processing trolley with a compaction roller, a tool carriage; a power transmission system with a 3.1kW electric motor as prime mover; a tool mounting frame, vertical and angle adjustment device; a profile meter for measuring soil disturbance parameters and a 5 tons load cell for measuring draught. The soil processing trolley with a compaction roller was used for leveling and compacting the soil to the required bulk density or penetration resistance (cone index) as desired for each test run. The soil was compacted by subjecting it to passes of the roller, The experimental tools used were 1cm narrow tine, 5cm narrow tine, 5cm flat sweep, 5cm ridged sweep, 10cm flat sweep, 10cm ridge sweep , 20cm flat sweep and 20cm ridge sweep

Fig.1. An overview of the soil tillage dynamics equipment used in the study of soil tillage dynamic studies

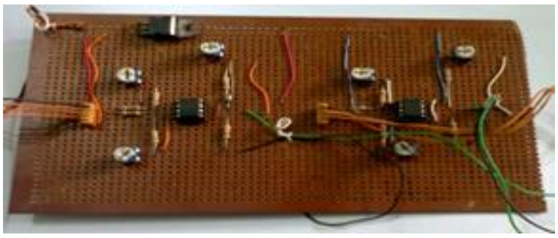

Fig. 2: An Amplifier

Fig. 3 Load-cell

Fig. 4: data loggers

2.3 Experimental Plan

Table 1: Condition and Parameters for Experiment

Parameters	**Experiment 1**	**Experiment 2**
Tools	1cm narrow tine ,5cm narrow tine 5cm flat sweep ,5cm ridged sweep 10cm flat sweep, 10cm ridge sweep 20cm flat sweep ,20cm ridge sweep	1cm narrow tine ,5cm narrow tine 5cm flat sweep ,5cm ridged sweep 10cm flat sweep, 10cm ridge sweep 20cm flat sweep ,20cm ridge sweep
Rake Angle	45˚ ,90˚	45˚ ,90˚
Soil condition	Dry soil	Wet soil
Cone Index	172kpa	689.5kpa

2.4 Experimental Procedure

2.4.1 Dry Soil Experiment

This was carried out by varying tillage tools of constant speed of 1.2 m/s, constant dry moisture condition of the soil and constant degree of compaction of 172kpa. The tillage tools used were1cm narrow tine ,5cm narrow tine, 5cm flat sweep, 5cm ridged sweep 10cm flat sweep, 10cm ridge sweep 20cm flat sweep and 20cm ridge sweep

The soil failure measurement was taken. The force readings as recorded and stored by the dater logger were downloaded to the computer for analysis

2.4.2 Wet Soil Experiment

This was carried out by varying tillage tools of constant speed of 1.5m/s constant wet moisture condition of the soil and constant degree of compaction of 690kpa.The soil was watered using a sprinkler like water can The tillage tools used were1cm narrow tine, 5cm narrow tine5cm flat sweep, 5cm ridged sweep 10cm flat sweep, 10cm ridge sweep 20cm flat sweep, and 20cm ridge sweep. The soil failure measurement was taken. The force readings as recorded and stored by the dater logger were downloaded to the computer for analysis The tillage tools used were1cm narrow tine, 5cm narrow tine 5cm flat sweep ,5cm ridged sweep 10cm flat sweep, 10cm ridge sweep 20cm flat sweep, 20cm ridge sweep. The soil failure measurement was taken. The force readings as recorded and stored by the dater logger were downloaded to the computer for analysis

2.4.3 The soil failure

. The parameters of the soil disturbance include: maximum Width of soil throw (TDW); maximum width of soil cut (Wfs); this is also known as width of Crescent; the ridge – to – ridge distance (RRD); the height of the ridge (hr); after plough Furrow depth (df) , the tool width (W).

and rupture distance, (f), defined as the distance ahead of the tine at which the distinct shear plane broke the surface (Godwin and Spoor, 1977). These parameters have been used to assess soil disturbance of tillage implements by researchers (Willat and Willis, 1965; Godwin and Spoor, 1977; Spoor and Godwin, 1978; Spoor and Fry, 1983; Wheeler and Godwin, 1996;

Taniguchi et al., 1999)

3. Results

The results of this study are presented in Fig. 1 to 5

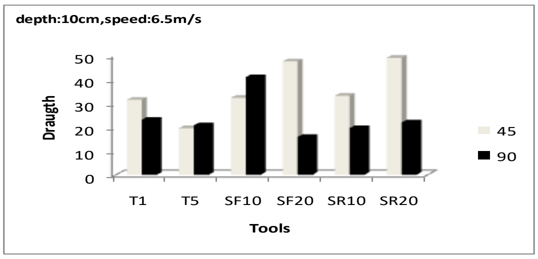

Fig 5: Effect of rake angle on draught for dry soil dry

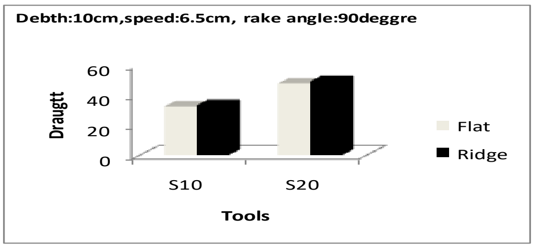

Fig. 6: Effect of tools profile on draught for Soil at 90 rake angle

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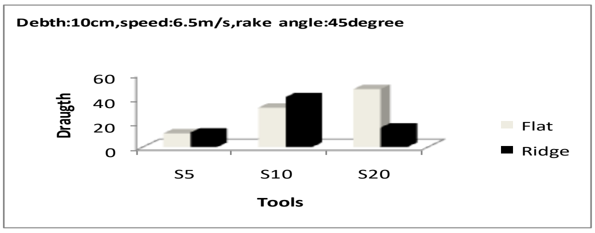


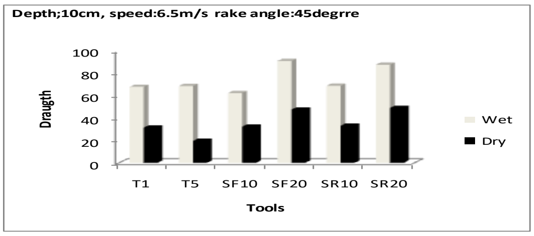


Fig. 7; Effect of Tool draught for dry soil at 45 rake angle

Fig. 8: Effect of moisture on draught at 45 rake angle

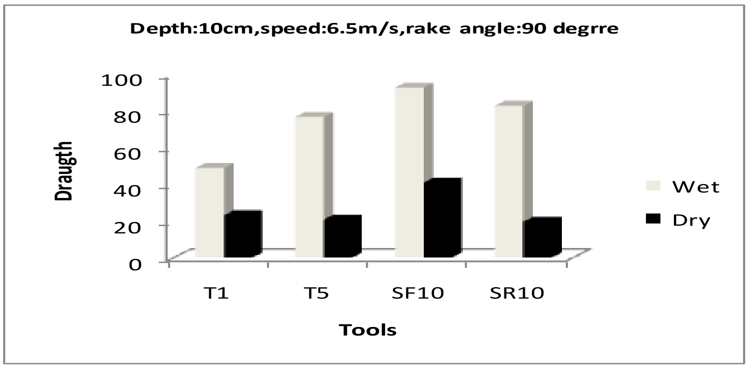
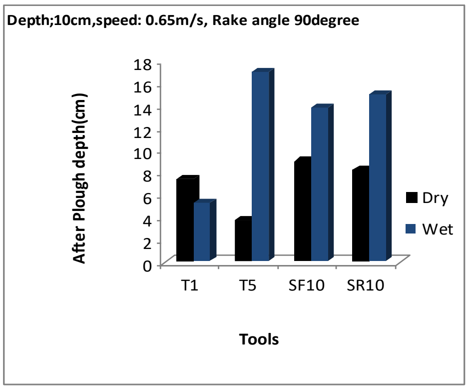


Figure 9: Effect of moisture on draught at 90 rake angle



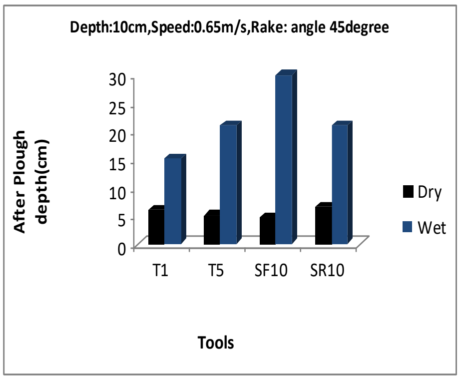
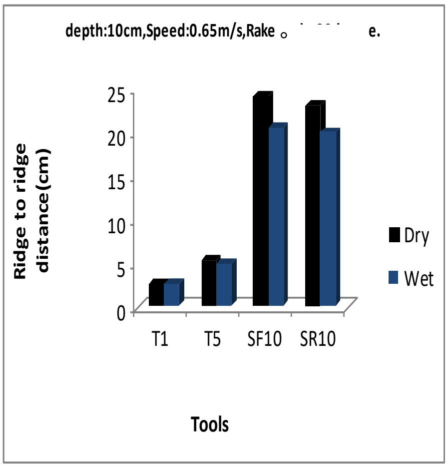


Fig. 10 (a)



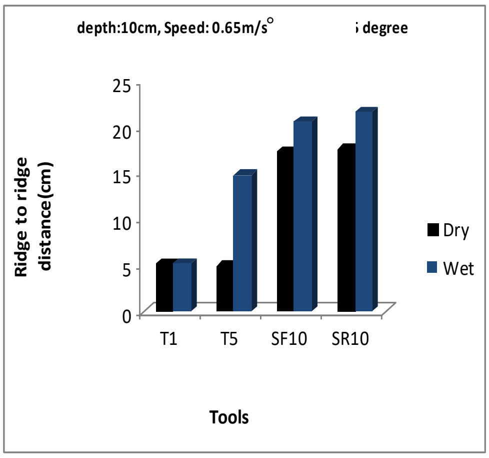
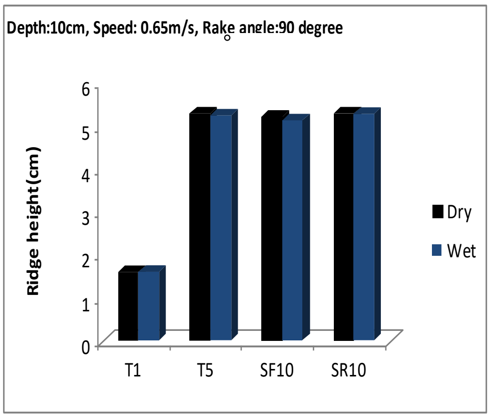


Fig. 10(b)



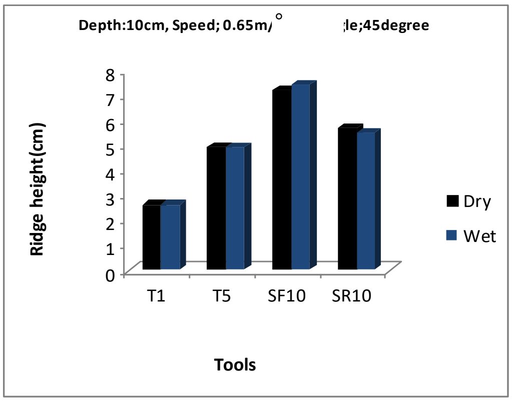
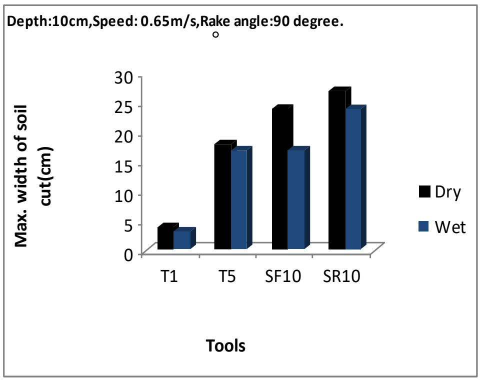


Fig.10(c)



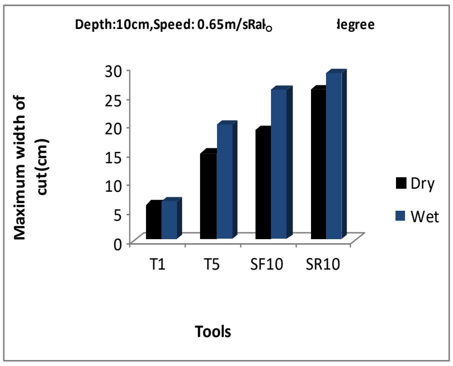
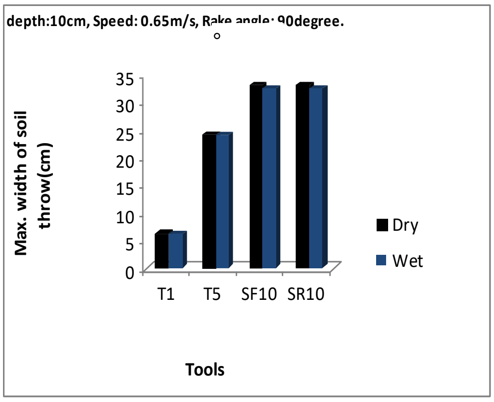


Fig. 10(d)



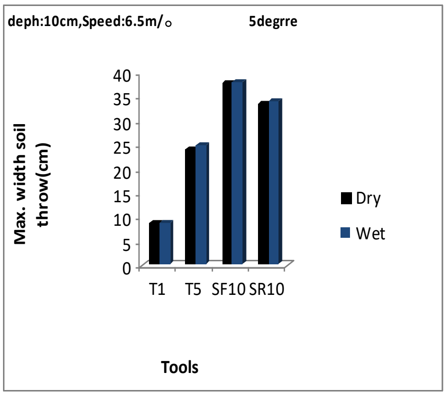


Fig. 10(e)

Fig. 10: Effect of Moisture on Soil Disturbance parameters

(a) After plough depth (b) Ridge – to – ridge distance (c) Ridge height (d) maximum width of soil cut (e) Maximum width of soil throw

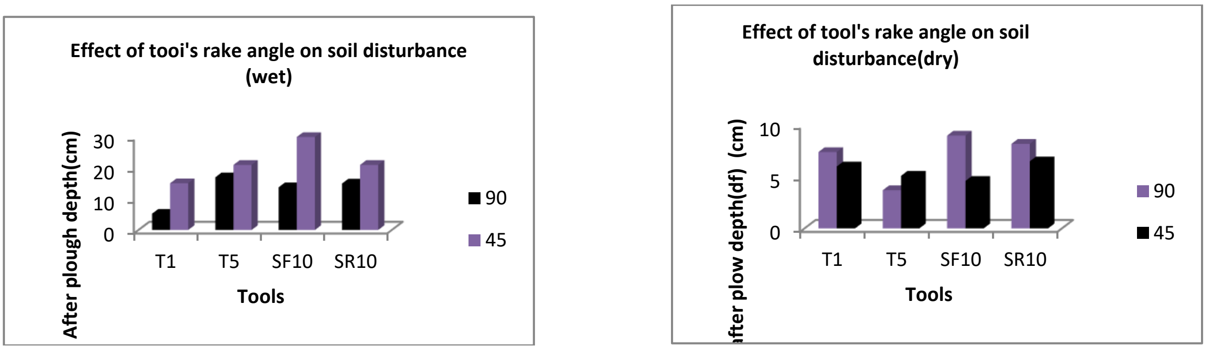


Figure 11(a)

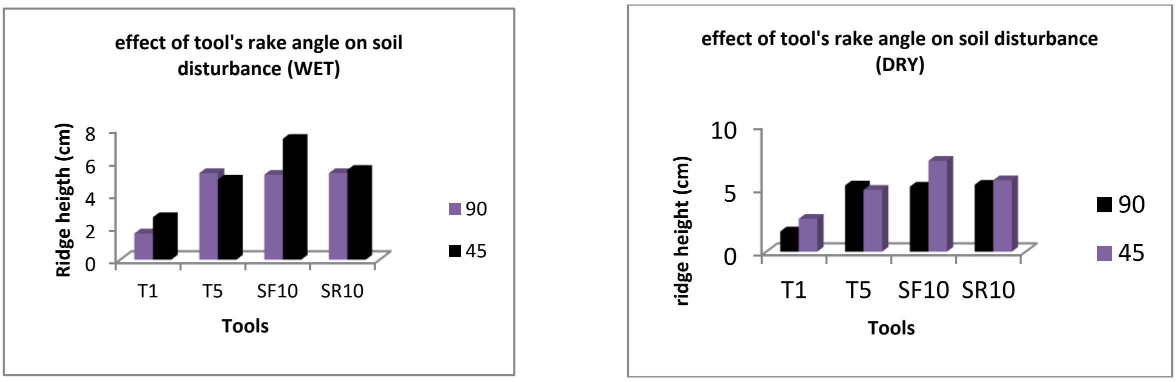


Fig. 11(b)

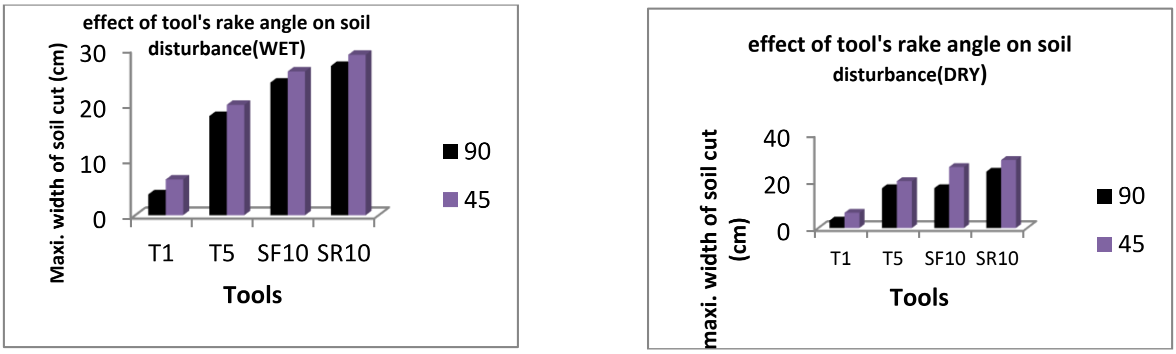


Fig.11 (c)

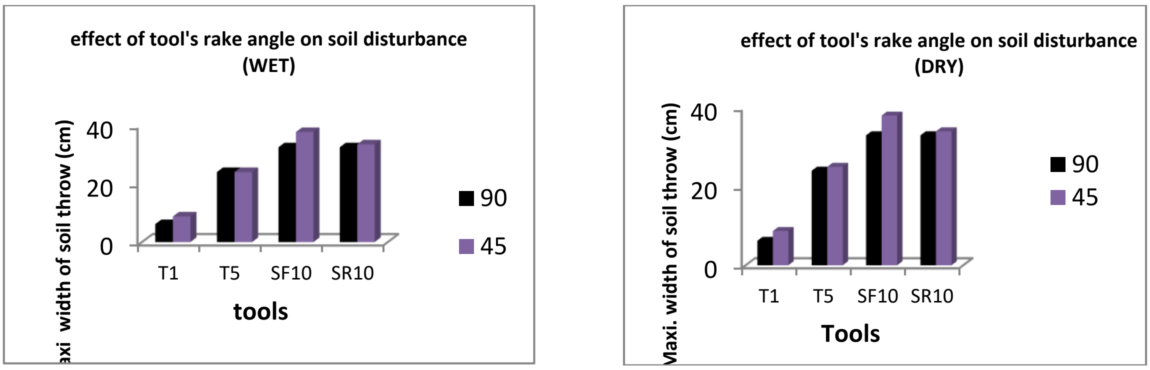
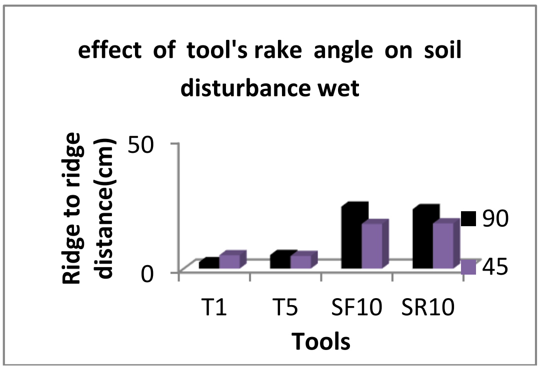


Fig. 11 (d)



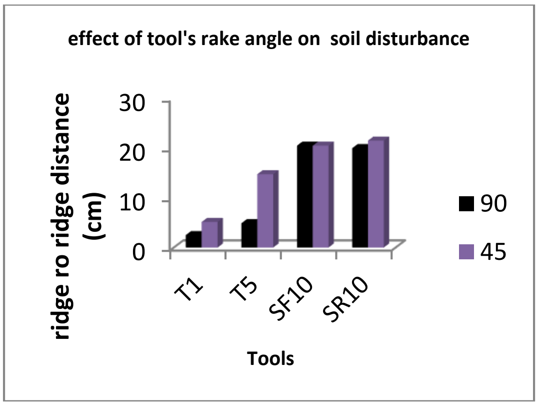


Fig. 11 (e)

Fig. 11: Effect of Rake Angle on Soil Disturbance parameters for dry and wet soils
(a) After plough depth (b) Ridge height (c) Maximum width of soil cut (d) Maximum width of soil throw (e) Ridge to ridge distance

4. **Discussion**

The instrumentation system was developed with 5 tonnes load cell, load cell amplifiers for the measurement of soil/tool interaction of forces and moment and a data logger .The load cell was connected to load cell amplifier and also to the data logger and laptop in order to boost resulting voltage, data acquisition, storage and processing.

4.1 Effect of Moisture Content on Draught of Tillage Tools

The effect of moisture content (mc) of the soil on the drought of the tillage tools is presented in in Fig. 10 & 11. It shows that the draught force increase with increase in moisture content; this is in agreement with the findings of Gupta and Surendranat[5, 6] as presented in Fig.10. However the response of the draught of the tillage tools to change in rake angle in the experimental results showed that draught of wide blade, (SF10) was higher in tool rake of 90°.

4.2 Effect of Tool Profile on Rake Angle

The effect of tools profile on the drought of tillage tools is presented in Fig. 11 for tools rake angles 90° and 45° respectively, 100mm working depth and 0.65m/s forward speed Fig. 10 showed that tools with flat profile indicated increased in drought while tools with ridge profile indicated lower in draught at tools rake angle of 90°. The same trend was observed for 45° tool rake angle experiment but the extent of increase was not as high when compared with tool rake angle of 90°. This is in line with the explanation that the draught increases with increase in rake angle of tool [7].

4.3 Effect of Moisture Content on Soil Disturbance

The effect of soil moisture content on soil disturbance is presented in Fig. 9 for both tool's rake angles of 45° and 90°,100 mm operating depth and 0.65 m/s forward speed . There was a general common trend between the parameters under tools rake angle of 45° that showed high soil disturbance length, except for soil disturbance parameter like 'after plough depth for 45° and 90° tool rake angle that show high length of soil disturbance. In Fig. 10 it was observed that generally tool rake angle 45° indicated higher soil disturbance. Comparing both tool rake angles 45° and 90° observations of the shape of the loose surface after the passage of a tool showed that loose soil is thrown further to the sides. The maximum width of soil throw decreased with increase in moisture content but increase with increase in tool's width, this is clear being that the soil particles or aggregates were heavier and highly held by cohesive forces within and therefore would not flow or move like when they had lesser water content. It also follows that draught increase with increase in moisture content as the cohesion of the soil increased with moisture content [7]. Draught also increased with tools width but less than proportionally, similar to the findings of Mckyes and Maswaure[8].

5. Conclusion and Recommendations

A digital instrumentation system has been developed, tested and found suitable for evaluation of draught of tillage tools. The result have shown that the analog way of soil measurement can be made digitalized. The results showed that draught force increased with increase in tools rake angle and increase in soil moisture content. Tools with flat profile surface had greater draught than those with ridged profile surface. Maximum draught of tools were 70N (T1) under wet condition and 45° tools rake angle, 95N (SF10) under wet condition and 90° tools rake angle, 95N (SF20) under wet condition and 45° tools rake angle, and 90N (SR20) under wet condition and 45° tools rake angle, Soil disturbance parameters also were higher under wet soil condition for both rake angles. Soil disturbance parameters except the ridge to ridge distance and maximum width of soil throw showed higher values for tools rake angle of 90°.

The trend was the same under moisture conditions.

The following recommendations ware made;

i. More studies should be carried out with other types of tools and in other types of soil under various conditions.

ii. Other items of equipment such as penetrometer (with GPS) soil profile mater as required in this type of studies.

iii. More studies to investigate soil implement and operational parameters.

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