*Journal of Science and Multidisciplinary Research* **Volume 4, September 2012**

www.cenresinpub.org
ISSN 2277-0135

# EFFECTS OF FORWARD SPEED ON THE PERFORMANCE OF A DISC PLOUGH

[1]Kudabo, E.A and [2]Gbadamosi, L
[1&2] Department of Agricultural Engineering and Water Resources
Institute of Technology, Kwara State Polytechnic, Ilorin
E-mail: emmanuelkudabo1@yahoo.com

## ABSTRACT

The study was carried out on the effect of forward speed and depth of cut on the performance of a disc plough in silt clay loamy soil at soil moisture content of 7.3% (db) and bulk density of 1.73g/cm$^3$ at the departmental farm of Agricultural Engineering Department, Kwara State Polytechnic, Ilorin. The mounted disc plough was tested at three forward speeds of 7km/h, 10km/h and 12km/h, two different depth of cut of 15cm and 20cm were used. The result shows that Soil Inversion increased positively as forward sped and depth of cut increases. The travel reduction increased negatively in both depth of cut with increasing forward speeds. Higher percentages of small soil aggregates were produced at lower forward speed and 15cm depth of cut. The result further reveals that the rate of Fuel Consumption increases as the forward Speech increases.

**Keywords:** *Effect, forward speed, depth of cut, Disc Plough, Travel Reduction, Soil Inversion, Soil aggregate and Fuel Consumption.*

## INTRODUCTION

Soil Tillage is usually defined as the mechanical manipulation of the soil aimed at improving soil conditions for crop production. It is a process to modify soil properties by- Pulverization, cutting, inversion or movement of the soil resulting in improved soil conditions for optimal crop growth and yield (Grisso et al (1982). Three primary aims—are generally attributed to tillage operation as follows: Controls of weeds, incorporation of organic matter into the soil, and improvement of soil structure, (Gulvin et al, 1977). Tillage is the major event in the process of crop production, which consumes nearly 30 to 35 percent of the total energy requirements, (Manian et al 2000). Disc plough play a prominent role in tillage and under certain conditions they are reported to be advantageous over +other implements used for the same purpose, as they roll into the soil instead of sliding (Gulvin et al, 1977 and Kaul, et a!, 11985). Agarwal and Rajput (1964 & 1965) Observed that disc plough can be used in adverse soil condition and because of rolling action their unit draft is low if under adverse soil conditions. Disc Plough as primary tillage implements are used for the initial major soil working operations. Hann et a! (1989) studied disc configuration and performance and observed that the degree of soil inversion was reduced as the tilt angle was increased. Sharuddin et al (1996) reported that different speeds affected the soil aggregation as higher percentage of small soil aggregates were obtained at lower forward speeds than higher forward speeds. Keeping in view the need to evaluate the existing tillage tools and the importance of disc plough as initial soil working operations implement, it was decided to study the effects of forward speed on the performance of the disc plough.


*Corresponding Author: Kudabo, E.A*

## MATERIALS AND METHODS

### Materials and Equipment

An experimental plot measuring 120 x 1 50m was selected from the farm of the Department of agricultural Engineering, Kwara State Polytechnic, Ilorin. The farm during the study in October to November, - 2004 had an average weed height of 1.1 m and the farm has a very gentle scope. The instruments and machines used in the research work were: Massy Ferguson (MF) 435 diesel tractor, mounted disc plough, ranging poles, surveyor tape, stop Watch, Core soil sampler, soil samples containers, set of sieves, Weighing balance, Polythene bags, electric Oven, tool-box, measuring cylinder, calibrated wooden bar, meter square frame.

### Experimental Procedure

All Laboratory and field test carried out were done according to the recommendation of the regional Network for agricultural Machinery (RNAM, 1983). The experiment was conducted in a rectangular plot measuring 100 x 50m each. The performance parameters studied were. Soil inversion, soil aggregation, travel reduction and fuel consumption at three forward speeds and two depth of cut. A disc Plough with a radius of curvature of 63 cm, and a diameter of 60cm was selected for the experiment. It has a standard disc spacing of 55cm. and ground clearance of 67cm. The disc was set to 25°-tilt angle and 45°-disc angle respectively. A Massey Ferguson 4- cylinder diesel engine tractor (Model MF 435) with rated power of 72Kw at 2200rpm was used for the experiment. Two methods were adopted for measuring the fuel consumption in the experiment. The use of calibrated wooden bar, where the initial level of fuel in the tanked was taken before the operation of each sub plot. The final, level was noted after the completion of the operation and the difference in the two levels gave the fuel consumed for each sub plot. The second method is the refilling of fuel to the initial level before the operation with the aid of measuring cylinder of known volume or capacity. For each run in the sub plot, four locations were selected at random at which depth of cut and width of cut were measured. The depth of cut was measured from the furrow bottom to the surface 9f the unploughed coverage.

The travel reduction was determined by taking the time required for the tractor to cover the 60m distances with no load and with load for e4ach treatment combination. The presence of weeds before ploughing operation and after ploughing were noted, using quadrant method. The dimension of quadrant is 1m x 1m (1m2). The data obtained was used for soil inversion determination at different speed. In evaluating the soil aggregation, the size distribution, quantity, and stability of the aggregates were considered. Direct dry sieving of soils, as occurred in the sieve has been used to evaluate the distribution of clods and aggregates. The percentage of duds retained on the sieve is an appropriate measure of soil aggregation (Lambe 1956) as reported by Bukhari et al (1996). The target speeds and depth of cut of 7, 10, and 1 2km/hr and 15 and 20cm respectively were chosen respectively. The tractor was operated in a gear range best suited for each target speed. Some soil properties were determined. These include soil moisture content and soil bulk density. Core samples collected at 15cm depth were used in the evaluation of soil bulk density and moisture content after drying for 24hrs at constant Temperature of $115^0$c. Four core samples were collected from each of the three plots at each sampling.

## RESULTS AND DISCUSSIONS

The results obtained from the experiment carried out on the effects of the forward speed on the performance of disc plough are shown in Tables 1 to 5.

### Field Characteristics

The percentage by Mass of Soil particles in sieve analysis as indicated in Table 1 reveal that the soil type of experimental field is silt clay loamy based on the soil classification triangle. The soil moisture content was 7.3% db and the soil bulk density was determined to be 1.73g/km$^3$.

**Table 1: Sieve Analysis Test Results**

Total Weight of Soil= 1.29kg

| S/No | Sieve Size | Weight of Retained Soil (gm) | Percentage by Mass (%) |
|---|---|---|---|
| 1 | 2.00mm | 185 | 14.34 |
| 2 | 1.70mm | 32 | 2.48 |
| 3 | 1.00mm | 87.9 | 6.82 |
| 4 | 710mm | 205 | 15.89 |
| 5 | 355μm | 361 | 27.98 |
| 6 | 250μm | 120.8 | 9.36 |
| 7 | 150μm | 112.0 | 8.68 |
| 8 | 106μm | 63.8 | 4.95 |
| 9 | 75μm | 36.2 | 2.81 |
| 10 | 35μm | 26.3 | 2.04 |
| 11 | Last pan | 60.0 | 4.65 |

The results of the measurements of the performance of the effect of the forward speed and depth of cut on the work quality produced by the disc plough on the field are discussed as follows:

### Travel Reduction

The data on travel reduction of the disc plough are tabulated on Table 2. It show that at forward speed of 7km/hr, 10 and 12km/hr and at the depth of cut of 15cm, the average travel reduction were -25.6, -29.1 and 34.8 respectively while at the depth of cut of 20cm, the average travel reduction were -39.2, -45.4 and -50.0 for the forward speed of 7km/hr, 10km/hr and 12km/hr respectively.

**Table 2: Travel Reduction at different forward speeds and depths of cut**

| Observation sped km/hr (Average of three replicate) | Travel reduction at 15cm depth of cut | Travel reduction at 20cm depth of cut |
|---|---|---|
| 7 | -25.6 | .39.2 |
| 10 | -29.1 | -45.2 |
| 12 | -34.8 | -50.0 |

The result showed that the disc plough produced a prominent negative travel reduction, which affect the timeliness of operation but improved the traction of the tractor. The travel reduction increased negatively with increase in the forward speed, the negative increase in travel reduction may be as a result of rolling resistance of the tractor tyres and the rolling action of the disc that oppose the rotational movement for the increased speed. Increasing the depth of cut from 15cm to 20cm had a more pronounced negative effect on the travel reduction.

**Table 3: Soil inversion at different forward speed and Depth of cut**

| Observation sped km/hr (Average of three replicate) | Travel reduction at 15cm depth of cut | Travel reduction at 20cm depth of cut |
|---|---|---|
| 7 | 75 | 80.4 |
| 10 | 80.6 | 83.1 |
| 12 | 87.7 | 88.6 |

There was increased in the percentage of soil inverted as the forward speed was increased. It may be as a result of the disc ability to turn and throw the soil when at higher speed than at lower speed. Also, the depth of cut has a significant effect on the soil inversion as the disc has more voluminous soil to turn over that enhanced weed coverage. At 20cm depth of cut, the crop residue, weeds and other materials were mostly covered. Thus, increase in speed and depth of cut has a greatly positive effect on the coverage of weeds.

**Soil Aggregation**

**Table 4: Soil Aggregation produced at different speeds and depth of cut**

| Soil Aggregation at depth of cut of 15cm | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Speeds | Sieve Size (mm) | | | | | | | | | |
| (km/hr) | 75 | 63 | 50 | 37.5 | 31.5 | 25 | 16 | 12.5 | 8 | Under 8 |
| 7 | 24.85 | 16.50 | 5.18 | 4.25 | 3.20 | 3.05 | 3.52 | 8.05 | 9.13 | 20.57 |
| 10 | 18.89 | 10.63 | 9.93 | 7.01 | 7.36 | 4.52 | 4.37 | 5.75 | 7.32 | 32.90 |
| 12 | 17.56 | 11.60 | 7.61 | 5.41 | 5.73 | 6.10 | 6.14 | 3.44 | 6.39 | 30.01 |
| Soil Aggregation at depth of cut of 20cm. | | | | | | | | | | |
| 7 | 26.4 | 15.47 | 8.40 | 7.30 | 6.15 | 6.44 | 5.09 | 4.47 | 6.10 | 17.20 |
| 10 | 21.37 | 11.60 | 8.07 | 7.45 | 6.37 | 5.69 | 8.26 | 2.83 | 6.80 | 21.76 |
| 12 | 21.37 | 10.63 | 8.73 | 6.57 | 7.52 | 7.50 | 4.97 | 6.17 | 6.38 | 20.08 |

It is seen from Table 4 that the clod percentage produced by the disc plough as the forward speed is increase, the bigger clod percentage was decreasing and smaller clod percentage increased. The increase in speed that causes a decreased in bigger clod percentage may be as a result of vibrating effect of implement associated with increase in the operating speed of the tractor. More clods breaks to smaller ones as the disc with higher speeds throw soil. The improved soil aggregation was attainable at higher operations speed. Furthermore, the soil aggregation produced by the disc-plough at depth of cut of 20cm indicated increased in the percentage of soil retained in the larger sieve than that retained in the larger sieve at 115cm depth of cut. It show that bigger clods at the deep depth of soil tends harder to break than the clods at shallow depth and more force is likely required to break soil clods at deep depth because the volume of the plough of soil would increase. Figure 1 further illustrates the data of Table 4.

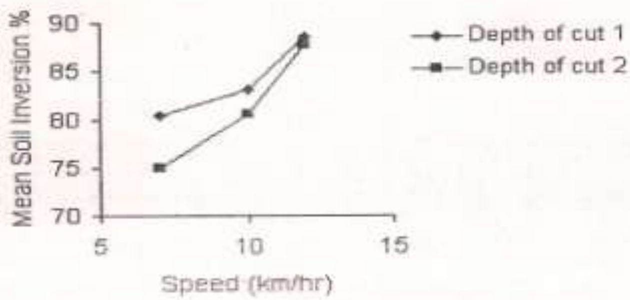


Fig 1: Soil Inversion in Relation to forward Speed

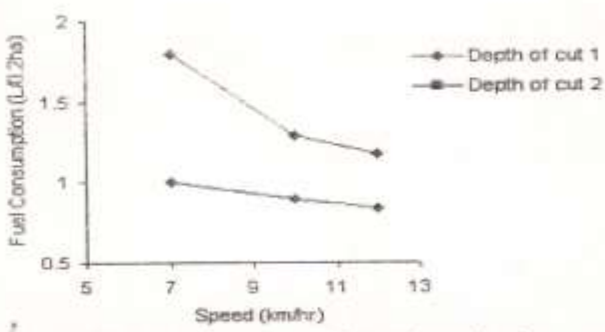


Fig 2: Fuel Consumption at different forward speed and Depth of cut of 15cm and 20cm.

## Fuel Consumption

**Table 5: Fuel Consumption at Different Forward Speeds and Depth of Cut**

| Speed of Operation Average Of Three Replicates (km/hr) | Depth of Cut of 15cm Volume (liter/ha) | Depth of Cut of 20cm Volume (liter /ha) |
|---|---|---|
| 7 | 5 | 9 |
| 10 | 4.5 | 4.45 |
| 12 | 4.2 | 5.90 |

The data on Table 5 shows that the fuel consumption decreased with increase in the forward speed. But with the depth of cut, the fuel consumption was higher at the depth of cut of 20cm that at the depth of cut of 115cm. The reason for the decreased in forward speed probably indicated that lesser load of work are engaged and the quantity of fuel supplied by the fuel injection pump to overcome the work has to conform with the gravity of work while at higher depth of cut, as the disc has to pulled more volume of soil at 20cm than at 15cfm depth of cut imply higher fuel consumption at higher depth than at lower depth of cut. Imply higher fuel consumption at higher depth than at lower depth of cut.
Fig. 2 further illustrates the result.

## CONCLUSION AND RECOMMENDATION

The effect of forward speed on the performance of disc plough was studied. The conclusions drawn from the study were:

i. Negative travel reduction was obtained in all treatment of disc plough operations.
ii. The soil inversion was increased as the speed was switched over from gear to gear at the depth of cut of 20cm.
iii. Different speeds and depth of cut affected the soil aggregation. Higher percentages of small soil aggregates were obtained at lower forward speed.
iv. The fuel consumption increased significantly as ploughing depth increased and decreased as the forward speed increased.

Based on the above it can be recommended that the tractor should be operated at higher forward speed and at depth of cut of 15cm.

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