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ENERGY REQUIREMENT AND ENERGY UTILIZATION EFFICIENCY OF TWO PLOW TYPES FOR PULVERIZATION OF HEAVY SOIL

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ABSTRACT

Two plow types namely moldboard plow and disc plow were used at three plowing depths and three forward speeds in silty clay soil to investigate their energy requirement and energy utilization efficiency to pulverize the soil. The moldboard plow had lower mean weight diameter and specific energy at all the three plowing depths and forward speeds than the disc plow. The moldboard was more was more efficient in energy utilization than the disc plow at all plowing depths and forward speeds. The higher forward speed had higher advantages over the lower forward speed in regard to the mean weight diameter and the energy efficiency except in case of the specific energy where the contrary occurred while the deeper plowing depth dominated the shallow depth in all the parameters under test. However, when the mean weight diameter and the higher productivity in the field are important than the lower specific energy the plows should the used at higher forward speed rather than lower forward.

For lower mean weight diameter and higher energy utilization efficiency the moldboard and disc plows are highly recommended to be used at deeper plowing depth and higher forward speed.

INTRODUCTION

Energy required for soil breakup is related to the desired degree of pulverization . The amount of energy required to produce a given degree of pulverization depends primarily upon the soil strength and the energy utilization efficiency of the implement (1). Soil strength is related to the nature of the soil and to its physical condition. Clay soils have higher breakup energy requirements than sandy soils or loams (4, 5) particularly. Cultural practices, climate and other factors influence the physical condition.

Soil strength increases considerably as the soil dries out, particularly with clays and clay loams, thereby increasing the pulverization energy requirement when plows are used to manipulate them (6). The plowed soils or that exposed to moderate or excessive cultivation practices are weak which require less energy for pulverization comparing with virgin soil or the soil which exposed to limited cultivation practices (7).

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To determine the energy utilization efficiency of a tillage implement when the primary objective is soil breakup, the equivalent energy represented by a reduction in clod size must be determined experimentally. This has been done by applying energy to the soil in a controlled manner and measuring the effect in terms of clods size. Researchers (3) developed a drop-shatter method in which soil samples are dropped from a known height onto a rigid surface and the kinetic energy expended in falling is related to the resulting mean-weight diameter. The energy required by a plow to break up the soil compared with equivalent energy input determined by the drop-shatter method to determine the energy utilization factor of the plow.

This research was conducted to investigate the energy requirement of moldboard and disc plows to pulverize the soil in the field and their energy utilization efficiency using three forward speeds and three plowing depths Also, to determine the best plow type in soil breaking and energy utilization efficiency.

MATERIALS AND METHODS

A three bottoms moldboard plow was used in the experiments. The bottoms were of a general-purpose type. The working width of the plow was 1.05 m. A disc plow of three discs was also used in the experiments. The diameter of the disc was 68 cm. The disc and tilt angles were 42 and 15 degrees respectively. Both plows were used at plowing depths of 10, 15 and 20cm and forward speeds .26, .46 and .67 m/sec.

The experiments were carried out as follows: The plowing depth of the polw was predetermined (e.g. 10 cm). The engine speed of the tractor was increased to 1500 RPM and then put in gear to give the required forward speed (e.g. 0.26 m/sec). The tractor then left to move forward a distance equivalent to three revolutions of its rear wheels. The draft force, the travelled distance and the time taken to cover the distance were measured. The run was repeated three times. The same treatments were repeated for each plow type, plowing depth and forward speed.

Three samples from the manipulated soil by the plows were collected randomly from each run. The samples were left to dry out then passed through sets of sieves their sizes were >125, 90-125, 75-90, 50-75, 25-50, 16-25, 10-16, 4-10, and < 2 mm. The clod fraction left on each sieve was weighed in order to determine the mean-weight diameter (MWD) for each run using the following equation

$$MWD = (\sum Xi .Mi) / \sum M$$

where Xi= The average of the sieves range (e.g. 90-125 Xi= 107.5mm).

Mi= The weight of soil fraction accumulated on the sieve (kg).

M= The total weight of sieved sample (kg).

Blocks of soil of different sizes were collected from the field of the experiments. The Blocks of soil were dropped a number of times each from a height of 76 cm onto a flat surface. The input energy for each test was calculated as the weight of soil multiplied by the height of drop and the number of drops for each block. Following the dropping of each block, the soil sieved, and the clod size fractions weighed in order to determine the mean-weight clod diameter for each test using the previous equation.

Physical and mechanical properties of the experimental soil were as follows : Sand, silt and clay were 1.3 , 36.5 and 62.2% , respectively ; cohesion 8.4 KN/m^2 ; angle of internal friction 37.0 (degrees) ; Bulk density 1.22 t/m^3 and moisture content 22.14% .

The experimental design used was a randomized complete block. The experimental area was divided into three blocks. Each block was divided into plots. The plot dimensions were 15x5 m. The treatments tested were two plow types (moldboard plow and disc plow); three plowing depths 10, 15 and 20 cm and three forward speeds .26, .46 and .67m/sec. The treatments were randomly assigned to each block. Each treatment was replicated three times. The experiments were carried out in silty clay soil. The analysis of variance of the experimental parameters is shown in table (1). LSD was used to compare the means of the treatments.

Table 1: Analysis of variance of the experimental parameters

Source of variation	d.f	Mean squares		
		MWD	Specific energy	Energy utilization efficiency
Blocks	2	26.12	5.22	0.0016
Plows(A)	1	1193.89**	9600.44**	0.4626**
Plowing Depth (B)	2	352.24**	2765.55**	0.1419**
Forward Speed (c)	2	222.89*	1493.95**	0.0122**
AXB	2	113.20	360.91	0.0219**
AXC	2	29.67	380.75**	0.0044
BXC	4	212.83*	29.96	0.0239**
AXBXC	4	27.13	146.54*	1.0023
Error	34	62.49	33.97	0.0020

* ($p < 0.05$) ; ** ($p<0.01$)

RESULTS AND DISCUSSION

The relationship between the MWD and the specific energy:

Results of MWD obtained by the drop shatter method are plotted versus the logarthim of the energy spent in breaking the soil up when dropped on the hard surface are shown in figure (1). The MWD is inversely related to the energy requirement due to the increase in soil pulverization (low MWD) as the energy input increased. This relationship was used to estimate the equivalent energy which was supposed to be spent in obtaining the same MWD in the field. The method of estimation was by projecting the value of the MWD on the plotted line and the corresponding equivalent energy was determined from the x-axis.