



**Analysis of different tillage implements with respect to reduced fuel consumption, tractor operating speed and its wheel slippage**

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Received 18<sup>th</sup> May 2015 and Revised 24<sup>th</sup> September 2015

**Abstract:** Nowadays the prices of agricultural farm produced products are increasing with ant-speed and the prices of input for raising crops are increasing with rocket-speed. Therefore, there is a dire need to conduct some important studies to innovate the techniques which can lower the costs of crop production. In this context, this study was conducted to evaluate the consumption of fuel at different tillage implements, tractor operating speed and its wheel slippage. In this study the fuel efficiency of disk plow + disk harrow and disk harrow (twice) were tested on a clay loam soil with moisture content 12.5% and bulk density 1.32 g/cm<sup>3</sup>. To find out the more efficient implement with regard to fuel consumption two treatments T1 (disk plow + disk harrow), T2 (disk harrow) were evaluated in three replicated randomized complete block design plots.

Fuel consumption with a set of two treatments disk plow + disk harrow and disk harrow (twice) has been studied and compared for fuel consumption. Time consumed as well as number of tractor trips needed for performing tillage operations were used for comparison. The fuel consumption per hour of T1 (disk plow + disk harrow) was assessed at 6.97 lit/hr and 41.3 lit/hectare, and for T2 (disk harrow twice) was 6.03 lit/hr and 35.73 lit/ hectare. The research study revealed that the fuel consumption was influenced by actual width of cut, plowing speed, efficiency of plowing operation and bulk density and moisture content.

**Keywords:** Fuel, land, plow, tillage, wheel.

1. **INTRODUCTION**

In crop production technology soil tillage is one of the main energy-intensive operations. It is highly expensive, complicated, laborious, fuel consuming and time consuming as well (Zugec *et al*, 2000). Due to high prices of fuel energy the growers have been enforced to apply alternative economic tillage technology. It is obvious that energy saving tillage is preferred to reduce the cultivation costs (Bayhan, 2006). Tillage operations in soil require direct energy for the production of crops (Robertson 2000). However, the tillage of heavy clay soils accounts for 55-65% of the direct field energy consumption (Pelizzi 1988). Average fuel consumption is a dependent variable which varies as the soil texture, tillage system and crop stubbles (winter wheat, barley) and row crops (maize, soybean) vary (Tajnssek, 2002).

The significant amount of energy is required for mechanized crop production. During the course of mechanized farming about 85% of energy is wasted. Therefore, to cope with current energy crises growers can apply techniques to decrease energy costs with increase in energy efficiency (Saghafi, 2003). Nowadays conservation tillage occupies 1.3% of total agriculture land in Portugal, very significant amount of 14% in Spain, 17% in France, 20% in Germany till fascinating 30% of total agricultural land in United Kingdom (European Conservation, 2004).

Speed of operation, area of cut, type of soil and skills of operator on fuel consumption (Bukhari and Baloch, 1982). Energy requirement increased with increasing implement velocity (Al-Jalil, 2001).

The core objectives of this study were to analyze the measurements of fuel consumption of two different soil tillage systems; the second goal was to evaluate the most suitable method for fuel savings, the third aim was to find out the fuel utilization of tillage implements, to study the more effective implement on fuel basis, to determine the best tillage implement for required soil texture and to determine the effect of tillage implements on soil properties.

2. **MATERIAL AND METHOD**

The research study was conducted at Latif farm of Sindh Agriculture University, Tandojam, Pakistan. For this purpose MF-375 tractor, 65 hp with 3-linkage arrangement was used as a prime mover to pull the (3-disk) Disk plow & (mounted double action regular) Disk harrow, fitted with rear wheel with 60 cm diameter of each disk and overall rated width of 150 cm was tested. Tailed type disk harrow having 2-disk gangs, 12 disks of 60 cm (diameter) in front gang and 12 disks of 60cm (diameter) in rear gang and the overall rated width of 175 cm was also tested during the present research work.

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The instruments and other material used in the research study were disk plow, disk harrow, ranging poles, measuring tape (100 meter), steel tape (16 meter), stop watch, meter scale, half meter square frame, soil sampler, sample container, graduate cylinder (1000ml), camera, chalks and permanent ink markers, polythene bags, physical balance, field book, vernier caliper, infiltrometer, sieves and lime powder. The study was carried out in randomized complete block design with three replications and two treatments; treatment<sub>1</sub> (T<sub>1</sub>) disk plow + disk harrow and treatment<sub>2</sub> (T<sub>2</sub>) only disk harrow twice. Before applying the treatments the field was properly leveled with leveler. Then, the field was divided in two different main plots for application of each treatment in an each plot separately; one plot for T<sub>1</sub> and other plot for T<sub>2</sub>. Distance from one plot to another plot was maintained at two meters to ensure the fair turning of the tractor in both plots without disturbing the main field which was marked with lime-powder.

For achieving the results with high precision basic soil parameters were also recorded, such as soil texture was clay loam, soil moisture content (12.5%), soil bulk density (1.32 g/cm<sup>3</sup>) and infiltration rate (25%). However, for fuel consumption in respect of time period, the related parameters were recorded, these were tractor operating speed, wheel slippage and fuel consumption.

**Fuel Consumption Measurement**

To determine the fuel consumption, the fuel tank of MF-375 Tractor was filled up to full capacity before testing the proposed implement in the test plot. After land preparation, the fuel tank of the tractor was refilled up to the same fuel capacity with 1000 ml graduated cylinder marked with milliliters and liters. The total quantity of fuel needed to refill the tractor tank up to the same mark was recorded. The fuel consumption was measured for each replication and means were calculated for each treatment in hectares. The fuel consumption per hour and per hectare was calculated from the observed data.

**Tractor operating speed**

The speed of tractor was determined by time required by tractor to cover a distance of 25 meters between the marked lines. The stop watch was used to record the time taken by tractor to cover required distance. The operating speed of tractor was also been considered by the number of rotations made by rear wheel of tractor to travel measured distance.

On the basis of following formulae, fuel consumption (Liters per hectare and liters per hour), tractor operating speed, and wheel slippage have been determined:

**1. Fuel consumption l**

$$\text{liters/hectare} = \frac{\text{Fuel consumption (lit)}}{\text{Area of plot (m}^2\text{)}} \times 10000$$

$$\text{2. Fuel consumption liters/hour} = \frac{\text{Fuel Consumption (lit)}}{\text{Time of operation}} \times 3600$$

3. For tractor operating speed, has been considered by the number of rotations made by rear wheel of the tractor to travel measured distance.

$$\text{4. Wheel slippage \%} = \frac{A - B}{A} \times 100$$

Where,

A = Distance travelled with no load

B = Distance travelled with load

**3. RESULTS**

**Fuel consumption**

The results highlighted regarding the determination of actual fuel consumption on combination of tillage implements, (disk plow + disk harrow & disk harrow twice). To access fuel consumption the effect of soil properties, tractor implement parameter and plowing operation variables were combined and incorporated. In case of treatment 1 (disk plow + disk harrow) tractor plowed total area (372 m<sup>2</sup>) in 800 seconds for which 6.97 liters/hour of fuel and 41.3 liters of fuel/hectare were consumed. While for treatment 2 (Disk harrow twice) the same area (372 m<sup>2</sup>) was plowed in 800 seconds for which 6.03 liters/hour and 35.73 liters of fuel/hectare of fuel were consumed. In this way, treatment 2 consumed 13.49% less fuel/hour and per hectare as well.

**Table1. Fuel consumption liter/hour as well as fuel consumption liters/hectare with respect to area plowed and time consumed**

Source of variation	Area plowed (m <sup>2</sup> )	Average time consumed (sec.)	Fuel consumption (liters/hour)	Fuel consumption (liters/hectare)
Disk plow + disk harrow (T <sub>1</sub> )	375	800	6.97	41.3
Disk plow twice (T <sub>2</sub> )	375	800	6.03	35.73

**Tractor operating speed**

The speed of the tractor was determined by the “time required by tractor to cover a distance of 25 meters between the assumed lines”. The stop watch was used to record the time taken by tractor to cover required distance.

The operating speed of tractor has also been considered by the number of rotations made by rear wheel of tractor to travel measured distance. The results

showed that maintained speed with the number of rotations of tractor rear wheel were constant. In case of treatment 1 (disk plow + disk harrow) furrow with the length of 25 meters was plowed in 31.3 seconds at the speed of 0.798 m/sec. However, in terms of disk harrow twice, furrow with the same length of 25 meters was prepared in 22 seconds (44 seconds consumed for twice) at the plowing speed of 0.56 m/sec. in this way, treatment 1 took 28.86% more time while it was used twice and it also decreased the plowing speed at 29.82%.

**Table2. Tractor operating speed during treatment 1 (disk plow + disk harrow) and treatment (disk harrow twice)**

Source of variation	Length of furrow (m)	time consumed (sec.)	Plowing speed (m/sec)	Plowing speed (km/hour)
Disk plow + disk harrow (T <sub>1</sub> )	25	31.3	0.798	2.87
Disk plow twice (T <sub>2</sub> )	25	44	0.56	2.01

#### Wheel slippage

The data of wheel slippage for T<sub>1</sub> (disk plow + disk harrow), and disk harrow twice was calculated and tabulated in table3. The total numbers of revolutions were 5.

The average wheel slippage for treatments T<sub>1</sub> (disk plow + disk harrow) was recorded at (7.23 %). In case of disk harrow twice (T<sub>2</sub>), the wheel slippage of tractor was noted at (2.94 %). The wheel slippage of tractor is mainly associated with the depth and width of implement. The wheel slippage was highest while operating disk plow with load, and minimum wheel slippage was obtained while operating disk harrow with load.

**Table3. Wheel slippage for disk plow + disk harrow (T<sub>1</sub>) as well as disk harrows twice (T<sub>2</sub>) (With and without load)**

Source of variation	No. of revolutions	Distance covered with no load (A)	Distance covered with load (B)	Wheel slippage
Disk plow + disk harrow (T <sub>1</sub> )	5	24.9	23.07	7.23
Disk plow twice (T <sub>2</sub> )	5	24.9	24.3	2.94

#### 4. DISCUSSION

The present field study was conducted to investigate the field performance of tractor with disk plow and disk harrow for fuel consumption, its operating speed and wheel slippage. The tests were performed in a rectangular piece of land (1 acre). The size of the test plot for each

replication was 25m x 15m. Massey Fergusson (MS-65 Horse power) diesel engine tractor was used to operate the implements in field. The performance parameters studied were operating speed, width and depth of implement cut, wheel slippage, field capacity, and the most importantly the fuel consumption.

The results obtained through this study indicated that the plowing depth has more effect on the fuel consumption of farm tractors than the plowing speed. The fuel consumption of farm tractor varies with changes in plowing speed and depth. These findings are in agreement with those of Stajniko et al., (2009) , they also recorded that highest fuel was consumed when different tillage implements were used for plowing the land. These findings are further supported by Moitz et al., (2014) that fuel consumption increased with increasing area depth. Higher infiltration rate, soil moisture, and effective field capacity were observed by operating disk harrow and lower by disk plow.

While treatment 1 (disk plow + disk harrow) was used the fuel consumption was greater than disk harrow twice. The fuel consumption of disk harrow twice was found lower. The field capacity and rate of fuel consumption are influenced by the width of implement and efficiency of plowing. There is profound effect of moisture content on wheel slippage. These results are in similarity with those of Namdari *et al.*, (2011) , their study also found that increase in fuel consumption is dependent variable, because its consumption depends upon different factors.

The results for tractor operating speed revealed that as the speed of the tractor increased, so, the area under plowing operation plowed sharply. In this context treatment 1 (disk plow + disk harrow) consumed less time to plow the covered area under study. These findings are in similarity with those of Christophe et al., (2013) , because they also recorded that as the speed of the tractor increased, so, the less time was required for plowing the area.

In terms of wheel slippage, the results revealed that as the wheel slippage was directly proportional to the depth and width of the implement as well as the cut in the soil given by the tillage implement. In this regard greater wheel slippage was recorded at treatment 1 (disk plow + disk harrow). These results of this study are strongly supported by the Moitz *et al.*, (2014) , because their findings are as same as the finding of this study for wheel slippage. Therefore, it gave us a clear idea that as the depth and width of cut increases, so, the wheel slippage increase.

#### 5. CONCLUSION

On the basis of results of present study, it could be concluded that disk plow followed by disk harrow was

found superior tillage implement as compared to other tillage treatments for economic fuel consumption and tillage effective operation basis. This treatment improved soil structure necessary for plant growth and development. It is therefore, recommended that farmers should plow their agricultural land with disk plow followed by disk harrow in order to reduce cost of crop cultivation.

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