COMPARATIVE STUDY ON FIELD CAPACITY AND SPECIFIC FUEL CONSUMPTION OF THREE DIFFERENT MODELS OF TRACTORS

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ABSTRACT

A field experiment was conducted during June to July 2015 at Kibungo, Ngoma District, Eastern Province of Rwanda to evaluate the fuel consumption and work performance of three different models of tractors of different Brake Horse Power (bhp) with Rotary plough and cultivator in sandy loam soil. Three soil cover conditions viz. unploughed soil; stubble soil and tilled irrigated soil surface were taken to determine the better performance of tractor-implement system and fuel economy. Mahindra 55 bhp, MF 35 bhp and TYM 30 bhp tractors were used at three speed control setting of the tractors, viz. 1/3\textsuperscript{rd}, 2/3\textsuperscript{rd} and full throttle positions. The cultivator and rotary plough combination were found most economical to be operated at 2/3\textsuperscript{rd} speed control position. Maximum fuel consumed 4.1 l/h in tilled irrigated soil with cultivator and rotary plough 3.6 l/h at 2/3\textsuperscript{rd} throttle position because of increased depth of operation. Almost in all soil cover conditions, rotary plough gave maximum field capacity. Fuel consumption for cultivator was higher than rotary plough due to higher depth of ploughing.

\textit{Key words:} Tillage implements, tractor, specific fuel consumption, brake horse power, soil conditions

INTRODUCTION

Tractor is the elementary requirement for the agricultural sector of any country. Growth of tractor population from 2009 to 2016 in Rwanda is an indicator of need, importance and use of it in Rwandan agriculture. During last seven years the
demand and use of tractor dawn machinery have increased substantially due to increased awareness about usefulness of tractor machinery among potential farmers, NGOs and cooperatives. Majority of tractor owners are mostly using two implements namely disc plough and rotary plough. Even in case of tillage, tractor implement system is used in varying field conditions at different levels of load. It is desirable to have a tractor implement system which is both fuel and work efficient. However, both these tractor performance indicators are dependent on various factors like type of soil, type of operation, soil cover condition, and age of tractor, technical knowledge and skill of the tractor operator. It has been observed that due to lack of awareness on these accounts a numbers of tractors become diesel guzzlers in several districts of Rwanda. Keeping above views, a study was conducted during June to July 2015 at Kibungo of Ngoma District, Eastern Province of Rwanda on work performance of tractor-implement-system, fuel economy in different type of soil, different tractor models and recommended proper method of use of tractor-implement-system for better performance and fuel economy.

**MATERIALS AND METHODS**

The study was conducted in sandy-loam soil plots of Kibungo, Ngoma District, Eastern Province of Rwanda. Three different soil cover conditions selected for the experiments were unploughed soil, stubble soil with maize root residues and tilled irrigated soil. Three different models of tractors (Mahindra 55bhp, MF 35 bhp and TYM 30 bhp) were used in the study with three setting of throttle i.e. 1/3rd , 2/3rd and full in high first gear. However, 1/3rd speed control operation was not accepted to the farmers due to slow speed (1.51 km/h) and field capacity (0.24.9 ha/h). Before starting the operation, the fuel tank of the tractor was filled with fuel up to brim. Tractors were operated with disc plough and rotary plough in unploughed soil, stubble soil with maize root residues and tilled irrigated soil with different throttle position. At each throttle position in every soil under operation, fuel was filled again in tank after 15 minutes of operation. The additional fuel which was filled at this time was measured. Thus, fuel consumption was computed in litre per hour. Fuel consumption was measured in the field simultaneously with the measurement of speed, time, field capacity, depth and width of cut of implements used. For an overall comparison of fuel efficiency, the specific fuel consumption, i.e. fuel consumed
(g/bhp-h) was evaluated. Specific fuel consumption is a most useful parameter of the tractor - implement - system, because it includes the actual work output to fuel ratio.

\[
SFC = \frac{\text{Fuel consumption (cc)} \times \text{Specific gravity of HSD}}{\text{Rated BHP of tractor}}
\]

**Specific fuel consumption**

Fuel consumed in gram per unit of rated power per hour was calculated as expected as this tractor had higher horse power. In case of unploughed soil at 2/3rd load setting the fuel consumption by MF 35 and TYM 30bhp were 3.2 l/h and 2.9 l/h for rotary plough and 3.2 l/h and 2.7 l/h for cultivator respectively (Table1and 2). At the same time corresponding specific fuel consumption for rotary plough was 88.53, 68.77g/bhp-hand for cultivator was 88.53, 64.03g/bhp-h, respectively. At the same load setting data showed that specific fuel consumption decreased with increased in tractors horse power. Similarly, in stubble soil at full load condition the fuel consumption for hourly basis for Mahindra 55, MF 35 and TYM 30bhp were 4.3, 3.8 and 4.0l/h for rotary plough and 3.5, 3.4 and 3.8l/h for cultivator, respectively. Specific fuel consumption in unploughed condition was 55.84, 90.17 and 11.067g/bhp-h, for cultivator and 72.44, 101.97 and 127.27 g/bhp-h for rotary plough, respectively. For tilled irrigated condition at full load, the fuel consumption for Mahindra 55, MF 35 and TYM 30 bhp

**Field Efficiency**

The field efficiency of the implements used in the study was computed by operating disc plough and rotary plough on large area which was observed about 73 percent. Thus, 73 percent field efficiency was used in computing all the field capacities.

**Field capacity**

Field capacity was calculated with the help of standard method given by as:

\[
C = \frac{SW \times EF}{10 \times 100}
\]

Where,

- \( C \) = effective field capacity (ha/h)
- \( S \) = speed of travel (km/h)
- \( W \) = rated width of implement (cm)
- \( EF \) = field efficiency (%)
was 5.0, 4.6 and 4.9 l/h for rotary plough. These were 4.0, 4.0 and 4.1 l/h for cultivator, respectively. Fuel consumption was minimum at 1/3rd part load for all the three tractor-implement systems. The same increased with increase in load. Although, tractor gave the best work performance at full load but, the field capacity at 2/3rd and full load setting was not commensurate with increase in fuel consumption at these loads setting. At 2/3rd part load setting the tractors gave optimum work performance and efficient fuel consumption (Fig. 1.)

Fuel consumption pattern for different soil cover condition

The fuel consumption pattern for different soil cover conditions are shown in Table 1 and 2. Stubble soil permitted average depth of cut of 6.00 cm for disk harrow and 8.17 cm for rotary plough. In case of rotary plough the fuel consumption by the tractor of Mahindra 55 bhp at 2/3rd load were 3.9, 3.9 and 4.1 l/h for unploughed, stubble and tilled irrigated soil, respectively. Tilled irrigated soil showed higher fuel consumption for both rotary plough and cultivator in all tractor implement systems. The average depths of cut with the rotary plough and cultivator in tilled irrigated soil were 18.17 cm and 14.50 cm, respectively. Thus, the tilled irrigated soil consumed maximum fuel due to higher depth of ploughing.

Field capacity versus part load operation

Almost in all the soils, rotary plough gave the maximum field capacity at all the three speed controls followed by cultivator. At 1/3rd throttle position in stubble soil field capacities of cultivator and rotary plough with Mahindra 55 bhp, MF 35 bhp and TYM 30 bhp tractors were 0.29 and 0.32,
0.28 and 0.30, 0.26 and 0.30 ha/h, respectively. The corresponding values were 0.84 and 0.93, 0.76 and 0.72, 0.80 and 0.77 ha/h at full speed. In unploughed soil the corresponding field capacities at 2/3rd throttle speed control of Rotary plough and disc-harrow were 0.57 and 0.58, 0.56 and 0.45, 0.56 and 0.48 ha/h, respectively. Generally, field capacities were slightly higher in stubble soil. The field capacity was the maximum at the maximum speed. Increased in field capacity due to increase in load setting from 2/3rd to full, was not appreciable as increased in fuel consumption due to same change in setting (Table 3). In case of tilled irrigated soil for rotary plough with 30bhp tractor the increase in field capacity from 2/3rd to full load setting was observed as 13.2% whereas, with same change fuel consumption was enhanced by 22%.

Similar trends were observed for other tractor models with these implements under various soil conditions.

The cultivator and rotary plough combination were the most economical to be operated at 2/3rd speed control. The tilled irrigated soil required maximum fuel consumption for all tractor-implement systems because of increased depth of operation. Tillage equipment used in field operations consumed fuel differently. Almost in all the soil cover conditions, rotary plough gave maximum field capacity. In un-ploughed soil field capacity at 2/3rd throttle setting of 55, 35 and 30bhp test tractors were 0.57 and 0.58, 0.56 and 0.45, 0.56 and 0.48 ha/h for both tractor-implement systems. Fuel consumption for rotary plough was higher than cultivator due to higher depth of ploughing.
Table 1: Fuel consumption at 2/3rd throttle position of three tractors at different soil conditions

<table>
<thead>
<tr>
<th>Implement</th>
<th>Unploughed soil</th>
<th>Stubble soil</th>
<th>Tilled irrigated soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>55bhp</td>
<td>35bhp</td>
<td>30 bhp</td>
</tr>
<tr>
<td>Cultivator</td>
<td>3.9</td>
<td>2.9</td>
<td>3.2</td>
</tr>
<tr>
<td>Rotary plough</td>
<td>3.2</td>
<td>2.7</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Table 2: Field capacity (ha/h) of three tractors for different tractor – implement system

<table>
<thead>
<tr>
<th>Tractor</th>
<th>Implement</th>
<th>Tilled irrigated soil</th>
<th>Stubble soil</th>
<th>Unploughed soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>55 bhp</td>
<td>Cultivator</td>
<td>0.596</td>
<td>0.660</td>
<td>0.574</td>
</tr>
<tr>
<td></td>
<td>Rotary plough</td>
<td>0.600</td>
<td>0.608</td>
<td>0.580</td>
</tr>
<tr>
<td>35 bhp</td>
<td>Cultivator</td>
<td>0.570</td>
<td>0.570</td>
<td>0.560</td>
</tr>
<tr>
<td></td>
<td>Rotary plough</td>
<td>0.490</td>
<td>0.420</td>
<td>0.450</td>
</tr>
<tr>
<td>30 bhp</td>
<td>Cultivator</td>
<td>0.570</td>
<td>0.630</td>
<td>0.560</td>
</tr>
<tr>
<td></td>
<td>Rotary plough</td>
<td>0.510</td>
<td>0.430</td>
<td>0.480</td>
</tr>
</tbody>
</table>

Table 3: Field capacity (ha/h) of three tractors at 2/3rd throttle position with implements

<table>
<thead>
<tr>
<th>Tractor</th>
<th>Implement</th>
<th>Tilled irrigated soil</th>
<th>Stubble soil</th>
<th>Unploughed soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1/3rd</td>
<td>2/3rd</td>
<td>Full</td>
</tr>
<tr>
<td>55 bhp</td>
<td>Cultivator</td>
<td>0.296</td>
<td>0.596</td>
<td>0.700</td>
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<tr>
<td></td>
<td>Rotary plough</td>
<td>0.268</td>
<td>0.600</td>
<td>0.720</td>
</tr>
<tr>
<td>35 bhp</td>
<td>Cultivator</td>
<td>0.290</td>
<td>0.570</td>
<td>0.610</td>
</tr>
<tr>
<td></td>
<td>Rotary plough</td>
<td>0.260</td>
<td>0.490</td>
<td>0.620</td>
</tr>
<tr>
<td>30 bhp</td>
<td>Cultivator</td>
<td>0.290</td>
<td>0.570</td>
<td>0.650</td>
</tr>
<tr>
<td></td>
<td>Rotary plough</td>
<td>0.260</td>
<td>0.510</td>
<td>0.640</td>
</tr>
</tbody>
</table>
CONCLUSION

The main objective of the experiment was to evaluate the fuel consumption and work performance of three different Models of tractors of different Brake Horse Power with Rotary plough and cultivator. Three soil cover conditions viz. unploughed soil; stubble soil and tilled irrigated soil surface were taken to determine the better performance of tractor-implement system and fuel economy. Mahindra 55 bhp, MF 35 bhp and TYM 30 bhp tractors were used at three speed control setting of the tractors, viz. 1/3rd, 2/3rd and full throttle positions. The cultivator and rotary plough combination were found most economical to be operated at 2/3rd speed control position. Maximum fuel consumed 4.1 l/h in tilled Irrigated soil with cultivator and rotary plough 3.6l/h at 2/3rd throttle position because of increased depth of operation. Almost in all soil cover conditions, rotary plough gave maximum field capacity. Fuel consumption for cultivator was higher than rotary plough due to higher depth of ploughing.

ACKNOWLEDGEMENT

Authors are thankful to Ngoma district Agronomist for permitting to conduct the experiment and other logistical support provided during the period of investigation.

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