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A Comparison of Conventional and Conservation Tillage Implements Used for Crop Production in Omusati Region of Northern Namibia

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Abstract. Experiments were conducted to test and compare the performance of four tillage implements (two for Conventional Tillage (CV) and two for Conservation tillage (CT) used by farmers in Omusati conditions of Namibia. The two CV implements are the animal drawn plough and the tractor drawn disc harrow whilst the two CT implements are the animal drawn and the tractor drawn ripper furrowers. The parameters evaluated were draught force, draught power, effective field capacity, field efficiency, average depth and width of cut during the various operations. The research design was a randomised complete block design. Results showed that there are significant differences (p = <0.001) in mean depth, draught and effective field capacity among the tillage methods. They show that draught requirements vary with implement type, speed of operation and depth of operation.

Keywords: Comparison, Tillage, Performance, Draught Force, Draught Power, Effective Field Capacity

1. Introduction

Traditional soil cultivation systems, with intensive soil tillage, will generally lead to soil degradation and loss of crop productivity. (Derpsch, 2009, FAO 2009). World-wide the focus has shifted to conservation agriculture, and sound tillage systems are an integral part of it. Conservation tillage embraces all practices that minimise soil disturbance thereby embracing one of the principles of Conservation Agriculture (CA) to minimise soil movement. Conservation tillage is generally defined as any tillage sequence whose objective is to minimize or reduce the loss of soil and water. It is operationally defined as any tillage or tillage and planting combination which leaves 30% or more mulch or crop cover on the surface (ACT, 2005). Conservation tillage practices simultaneously conserve soil and water resources, reduce farm energy and increase or stabilise crop production (Mpangwa *et al* 2008). This is crucial for Namibia with a climate that can be described as semi-arid to arid. CA enhances water infiltration, improves soil water use efficiency, and provides increased insurance against drought. (Dumanski *et al,* 2006.) Soil physical properties that are influenced by conservation tillage include bulk density, infiltration and water retention (Osunbitan et al 2004 cited in Mpangwa *et al* 2008). Andrade-Sanchez et al 2007 mentioned that studies had shown that increased level of soil compaction leads to a reduction in infiltration characteristics of soil, which in turn leads to low soil moisture.

Energy plays a key role in the various tillage systems Implement width, operating depth and speed are factors that affect draught of a tillage implement. Also depends on soil conditions and geometry of the tillage implements (Upadhyaya et al., 1984). (Grisso et al., 1994). Farmers mostly depend on past experience for selecting tractors and implements for various farming operations. This previous experience may not be sufficient in selecting newly available implements. Therefore performance data under different soil conditions is important for animals, tractor selection and implements matching as these are important parameters for measuring and evaluating performance of tillage implements

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2. Objective of the Study

The objective of this study was to test and compare the performance (working depth, draught power and work rates) of four tillage implements (two for CT and two for CV) used by farmers in Omusati.

Research hypotheses

- Animal and tractor drawn CA implements used in this study exhibit significantly different performance characteristic in terms of depth, compared to Conventional Tillage implements.
- Animal and tractor drawn CA implements used in this study exhibit significantly different performance characteristic in terms of draught power requirements compared to Conventional Tillage implements.
- Animal and tractor drawn CA implements used in this study exhibit significantly different performance characteristic in terms of work rates compared to Conventional Tillage implements.

3. Methodology

3.1. Experimental Site Characteristics

The experiment was carried out at Ogongo Campus in the north of Namibia during 2010 and 2011 cropping season. The station lies in a semi-arid region and receives a mean annual rainfall between 300 and 500 mm of rain annually (Kuvare, et al 2008). However the total rainfall recorded at Ogongo from 21st December 2010 to 1st May 2011 was 621.6 mm. The soils at the site are predominantly sands Moisture content at the time of implement tests was ranging from 2.1 to 3.2 %.

3.2. Experimental Procedure and Treatments

On station trials to compare the equipment were conducted at Ogongo. The research involved testing the draught performance of four tillage equipment namely. (1) Animal drawn mouldboard plough (AMP), (2) Animal drawn ripper furrow (ARF), (3) tractor disc harrow (TDH), (4) tractor ripper furrower (TRF). The research was set up in a randomised complete block design with 4 tillage treatments by 4 replications totalling 16 plots. The plots were 10m x 10m, with 5m borders between blocks and 2m between plots to allow proper turning and movement of tractors and animals. An animal drawn mouldboard plough and a tractor disc plough were used to conventionally till the land whilst an animal drawn Baufis ripper furrower and tractor ripper furrower were used for ripping and making furrows

A dynamometer Novatech F 256 Axial Compensated Load cell together with a TR150 portable load meter was used to measure draught. Two tractors A and B were made available. For the tractor drawn implements, draught was measured using a digital dynamometer attached to the front of the tractor on which the implement was mounted. Another auxiliary tractor was used to pull the implement mounted tractor through the dynamometer. Tractor A pulled the implement-mounted tractor B with the latter in neutral gear but with the implement in the operating position. The draught was recorded within the measured distance of 10m as well as the time taken to reverse it. On the same field, the implement was lifted out the ground and the rear tractor was pulled to record the idle draught force. The difference between the two readings, gives the draught of the implement. This procedure was repeated for each of the implements evaluated.

Depth was measured as the vertical distance from the top of the undisturbed soil surface to the implements deepest penetration. During the field operations for each tillage implement, the tractor was operated at the same forward speeds. A moisture meter was used to measure moisture content at the time of testing the implements. The gravimetric method of determining moisture content was also used as a backup.

4. Data Analysis

GenStat (DE3) was used to analyse the data. Analysis of variance was used to test for any significant differences among means of all tillage technologies. Levels of 0.05 were used to determine the level of significance between means.

5. Results and Discussions

It is important to mention that whilst the graphs and tables in this document show all four tillage treatments in one graph or table, the authors understand that tractors and animals cannot be compared one to another. However in cases where tractors and animals can complement each other this will be clarified in the text.

Table 1: Implement specifications and performance

Implement Type	**Function**	**Model**	**Dimensions**	**Working Depth (cm)**	**Working Width (m)**	**Draught Force (kN)**	**Speed (km/ hr.).**	**Effective field capacity (ha/hr.) SWE/ 10**	**Efficiency (%)**	Draught Power **Pull(kn)x speed (m/s)** **3.6**
Standard Animal Drawn single furrow plough (AMP)	Conventional tillage	Standard V8 Mouldboard plough	20mm	Mean 8.31 Range 7.5 - 9.75	0.20	0.650	2.4	0.03	67	0.44
Animal drawn ripper furrower (ARF)	Conservation tillage	Baufis ripper furrower	10mm	Mean 13.7 Range 13.3 -14.8	0.10	0.933	2.4	0.16	65	0.62
Tractor drawn offset Disc Harrow (TDH)	Conventional tillage NB Whilst this implement is generally a secondary tillage implement, in Namibia it is used as a primary tillage implement.	Offset -20 discs	2.2 x 2.2m	Mean 14.9 Range 14.5 -15.3	2.2	1.774	6.7	097-1.18	52	3.30
Tractor Drawn ripper Furrower (TRF)	Conservation tillage	Baufis 2 tine	185cm x 166 Height - 60 - 100cm	Mean 29.4 Range 26.3 – 31.3	167-2.0	2.797	6.7	0.70-0.88	65	5.21

5.1. Draught Performance

It was possible to achieve depths of 31 cm with the tractor ripper furrower as compared to the 14.9cm with the tractor disc harrow. It was also possible to achieve 13.7 cm with the animal drawn ripper furrower as compared to the 8.31cm with the animal drawn plough. The speed for both animal drawn implements was 2.4 km/hr. whilst for both the tractor equipment was 6.7km/hr. (Table 2) Table 2 shows the summaries of depth for each implement. There are significant differences ($p = <0.001$) in mean depth among the tillage methods. Figure 1 below shows the depths for various tillage implements.

Table 1 also shows the summaries of draught performances of each implement.There are significant differences ($p = <0.001$) in mean draught among the tillage methods. Figure 2 below shows the mean draught or pull in kN for various tillage implements.

From the two graphs above, this shows that draught requirements vary with implement type, speed of operation and depth of operation. This means that in cases where there in soil compaction and reduced root penetration, the tractor ripper furrower can be used to achieve greater depths and thereafter an animal drawn ripper furrow or ripper can be used.

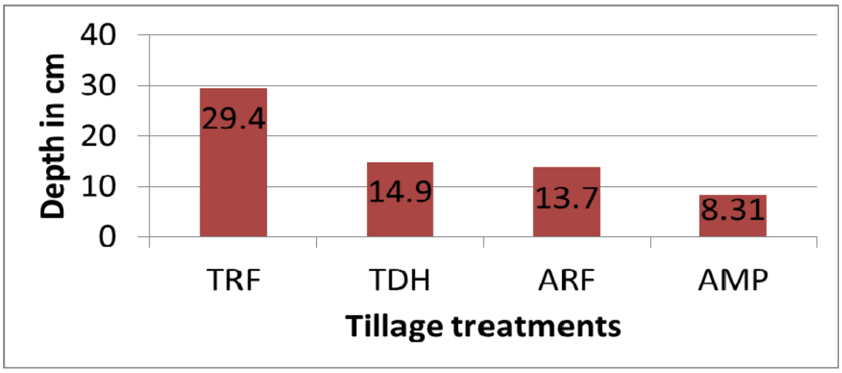

Fig. 1: Mean depths for 4 tillage implements

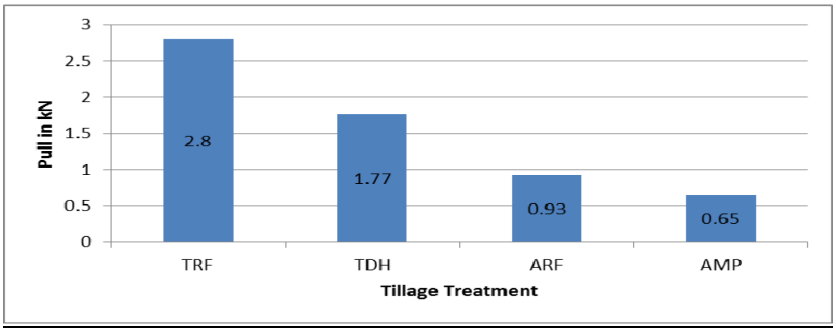

Fig. 2: Mean draught (kN) for four tillage implements

5.2. Draught Capabilities for the Donkeys

A team of 3 donkeys was used for pulling the animal drawn equipment. The weight of the animal drawn plough is approximately 300N (30kg) and the animal drawn ripper furrower is approximately 340N (34 kg). From the results shown in figure 2 above (AMP, 0,93kN) (ARF, 0.63kN) and table 1 above we can deduce that the 3 donkeys 218.6kg, 242kg and 212.6kg are capable of pulling the two implements as donkeys can pulls 17 – 25 % of body weight, 15 % for horses and 12.5% for oxen while ploughing (Starkey, 1985).

5.3. Efficiency

Table 1 also shows the efficiencies for various tillage implements. The tractor disc harrow was least efficient. This was mainly because the plot distances were small so more time was taken during turning. With bigger plots the efficiency is bound to improve. However the disc harrow is one of the methods that is being increasingly used by farmers but causing the most disturbance and pulverisation to the soil.

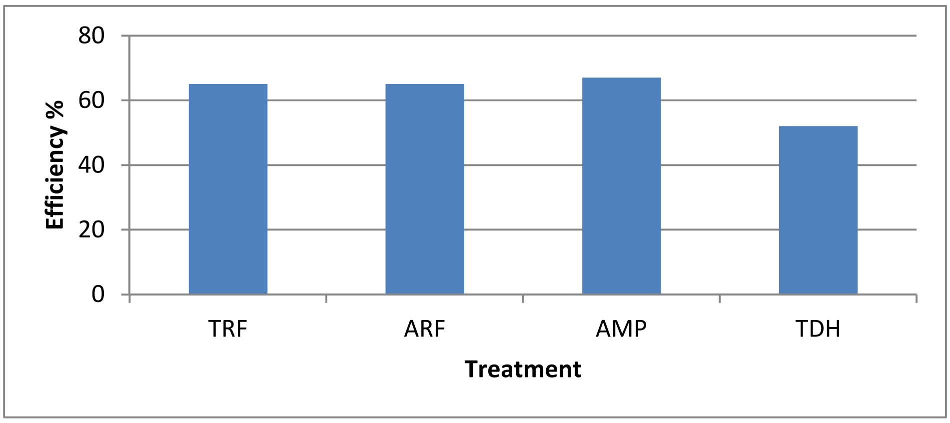

Fig. 3: Percent Efficiency of various tillage methods

5.4. Effective Field Capacity

Summaries of effective field capacity for each implement are also shown in table 1.There are significant differences (p= <0.001) in mean effective field capacity in ha/hr among the tillage methods. Figure 4 below shows the effective field capacity for various tillage implements.

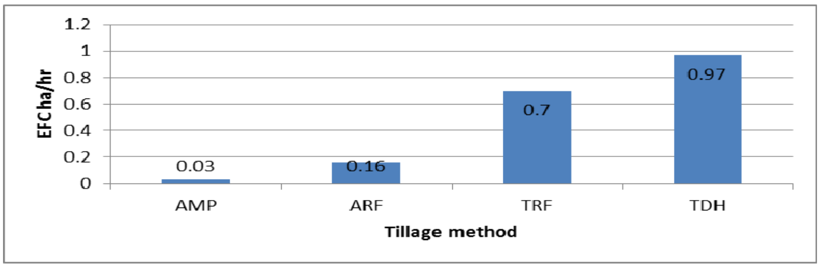

Fig. 4: Mean EFC in ha/hr. for four tillage implements

Figure 5 below shows the draught power in kilowatts needed for the various implements.

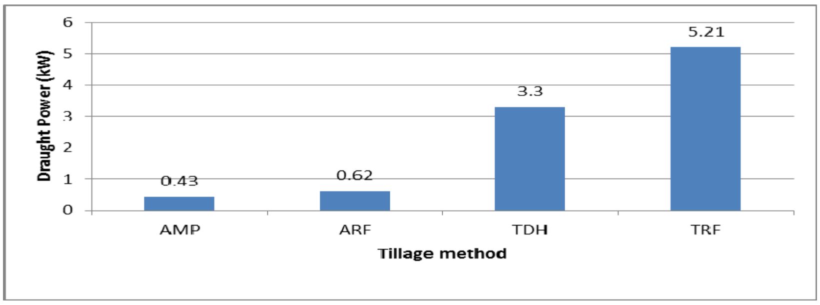

Fig. 5: Draught power (kW) for four tillage treatments

6. Conclusions and Recomendations

Four tillage implements (two for Conventional Tillage (CV) and two for Conservation tillage (CT) used by farmers in Omusati were tested. There are significant differences (p = <0.001) in mean depth, draught and effective field capacity among the tillage methods. The TRF managed to achieve greater mean depth of 29.4cm. Both CT methods can be used for breaking the plough pans and to enable root penetration and water infiltration. Tractors and animals can actually complement each other. The Tractor Ripper Furrower can be used in the first year to break the plough pan and thereafter an animal drawn ripper furrower can be used in subsequent years. The animal drawn ripper furrower method has shown that it can achieve equally comparable results in terms of effective field capacity and draught requirements are less. It can also achieve minimum soil disturbance much better than the Tractor ripper furrower method. Since tractor drawn equipment is expensive and most smallholder farmers use draught animals, it might be important to explore options that address the utilization of animal-drawn CA equipment.

7. Acknowledgements

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