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*Full Length Research Paper*

# Relationship between management and field performance of draught animals used for land preparation. An example from South Kordofan State, Sudan

**Elsamawal Khalil Makki[1] and Samia Abu-Elgasim Manzool**

School of Rural Extension, Education and Development, Ahfad University for Women, Omdurman, Sudan.

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**This study was conducted to investigate the association between animal work hours, feeding and other aspects of animal management and care on the field capacity and efficiency recorded by these working animals in Adilling, South Kordofan State, Sudan. The study followed the cross-sectional survey design with a sample of 100 farmers from 10 villages in the locality following the systematic random sampling technique based on geographical location. Data were collected using a formal survey questionnaire in a face to face interview, for literacy reasons, combined with direct field measurements during land preparation. The results revealed that field capacity was significantly related to veterinary care of draught animals (p= 0.001), while the effect of daily work hours and type of animal feed was not significant. Farmers' status and financial capacity, as expressed by their production, purpose significantly affected field capacity and efficiency (p = 0.033 and p = 0.021, respectively) with 64% of those producing cash crops working at 0.02 – 0.08 ha/h. The majority of the latter group (78%) recorded field efficiencies between 70 and 90%.**

**Keywords:** animal power; husbandry; performance; smallholders; working practices; harness

## INTRODUCTION

Power inputs constitute a limiting factor for the expansion of agriculture in the developing countries. This is more evident in the traditional farming systems where motorised power is difficult to access and/or is unaffordable for the vast majority of the farmers. In these systems, farming is mostly subsistence-oriented and the returns do not always justify the resources invested. In such cases, animal power remains a valuable alternative to motorised power for raising power inputs and productivity.

Farmers need to know exactly what factors influence the performance of draught animals and to what extent these may influence animal power use on their land. This knowledge enables them to most effectively decide the draught animal technology to use for a profitable farming practice. An understanding of work output and field

*Corresponding Author's Email: sammakki@hotmail.com, Tel: +249 (0)918006915, Fax: +249 187 579111

efficiency are of utmost importance here. However implement and animal performance assessments in the past have often been carried out in "on station" research studies under standard conditions using large experimental animals. This study may not relate to the "field" situation and so may only give a general view.

The failure of some animal power projects can be attributed to failure in investigating the different aspects of animal power in relation to its work output in the different agro-ecological zones to which it was introduced. Pearson (1998) mentioned that *"the main challenges to the researchers and those involved in development are to translate the understanding of systems into a form in which the knowledge can be put to practical use by the farmers. This will enable them to improve the effectiveness with which they use the animal power for crop production and transport"*.

Therefore, the objective of this study was to examine the effect of some animal and management practices on field capacity and efficiency of soil tillage when using animal power. The findings should assist farmers in making effective use of animal power in smallholder agriculture. The work was carried out in Sudan where animal power has been widely promoted in the past and is extensively used today.

## MATERIALS AND METHODS

### Study Area

Adilling locality is one of five localities in South Kordofan State in the Nuba mountains region, of the Sudan. Lying in the semi-arid area of the savannah, it covers an area of about 80.000 square kilometres. The annual amount of rainfall can range from less than 200 mm in the North to 300 mm in the South. The locality is considered to be one of the richest areas in natural resources in Sudan especially in arable land and seasonal streams of surface water. Most of the population in the area are farmers. The soil types in the area are sand (67%), sandy loam (15%) and clay (18%). The main crops grown in the area are sorghum and millet as food crops; and ground nuts, sesame, hibiscus and few vegetables as cash crops. The proportions produced from each type are decided by the resources available and the risks of sacrificing part of the food crops land to the cash ones. Among the farmers who use draught animals 84% owned their land, 11% rented it and only 5% share cropped it. Oxen are the dominant type of draught animals (77%), followed by horses and donkeys (10% each) and camels (3%).

### Sampling

This study was based on the cross-sectional survey design. A sample of 10 farmers was selected equally from each of 10 villages in the locality following the systematic random sampling technique based on geographical location. Along a survey line drawn across each village the first of every four farmers was chosen until 10 farmers had been selected. The study resorted to this procedure of farmer selection as it was difficult to obtain an accurate list of the farmers in each village and so establish a sampling frame.

### Data collection and analysis

Data were collected using a formal survey questionnaire in a face to face interview for literacy reasons combined with direct field measurements during farm operations.

Direct field measurements were concerned with determining field capacity and field efficiency. Two stop watches and a tape measure were used to record the total and net times of operations and the land dimensions, respectively. Land in Sudan is usually measured in feddan which are equivalent to 0.42 ha. In this paper these values were reported in hectares.

The effective field capacity (ha/h) was taken as the product of dividing the area worked (ha) by the total time (h) as follows:

Effective field capacity (F.C) = Area (ha)/ Total time (h)

And the field efficiency = Net productive time/ Total time of operation

Survey data were entered into an SPSS computer programme (SPSS 14.0) and analysed to produce frequency tables and the different parameters were assessed using the *chi* square test (SPSS.14).

## RESULTS AND DISCUSSION

### Farm characteristics

A farmer's status within their community is decided by the size of the land they cultivate and whether or not they grow cash crops. Those who produce cash crops tend to be more established and can potentially manage their animals well. This extends to cover the decisions on the type of animal they use, veterinary care and the type and amount of feed they are given along with the daily working hours of the animals, as they reflect the intensity and size of the farming land. All these factors relate to varying extents to the field capacity and efficiency of operations.

Table 1 shows the different management characteristics on those farms growing only food crops (60 farmers), those farms growing only cash crops (33 farmers) and those growing both (7 farmers). Within the three groups there was a general tendency of working for 5 – 6 hours/day. Farmers producing cash crops only or in combination with

**Table 1.** Management characteristics of farmers groups

| Categories | Farmers groups | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | food crops/subsistence (60 farmers) | | cash crops (33 farmers) | | food and cash crops (7 farmers) | | |
| | F | % | F | % | F | % | |
| | Daily work hours | | | | | | |
| 2 - 4 hours | 16.00 | 57.1 | 9.00 | 32.1 | 3.00 | 10.7 | 28 |
| 5 - 6 hours | 37.00 | 59.7 | 21.00 | 33.9 | 4.00 | 6.5 | 62 |
| 7 - 8 hours | 7.00 | 70.0 | 3.00 | 30.0 | 0.00 | 0.0 | 10 |
| | type of feed | | | | | | |
| forage | 29 | 67.4 | 11 | 25.6 | 3 | 7.0 | 43 |
| concentrate | 11 | 61.1 | 7 | 38.9 | 0 | 0.0 | 18 |
| both | 20 | 51.3 | 15 | 38.5 | 4 | 10.3 | 39 |
| | veterinary care of drought animals | | | | | | |
| yes | 13 | 37.1 | 19 | 54.3 | 3 | 8.6 | 35 |
| no | 47 | 72.3 | 14 | 21.5 | 4 | 6.2 | 65 |
| | type of Animal used in farm | | | | | | |
| Donkeys | 4 | 40.0 | 6 | 60.0 | 0 | 0.0 | 10 |
| oxen | 51 | 66.2 | 19 | 24.7 | 7 | 9.1 | 77 |
| camels | 1 | 33.3 | 2 | 66.7 | 0 | 0.0 | 3 |
| Horses | 4 | 40.0 | 6 | 60.0 | 0 | 0.0 | 10 |

food crops worked their animals for comparatively more hours/day. This can possibly be justified by the farm size and the need for maximising the returns. However, the difference between the three farming cropping systems was not significant ($p > 0.05$).

The highest percentage of market oriented farmers fed their animals forages and concentrates (38.9%), while those producing only for subsistence relied mainly on forages to feed their animals. This is evident based on their financial condition as they are not expected to have enough resources to spend on additional feed. This can lead to remarkable differences in the body weight and the general condition of the animals and consequently their ability to work or their power output. The difference between the three groups in feed type was not statistically significant ($p > 0.05$). Differences among farmers in the amount of feed offered to the animals are normal in the study area even in the same farmers' group.

Veterinary care of draught animals was significantly decided by the production purpose ($p = 0.02$). Market oriented farmers paid more attention to the veterinary care of their animals (54%). This is probably due to their financial stability and therefore their ability to afford the cost of veterinary care. Farmers with potentially higher returns will spend more on their animals. This argument is supported by the fact that more farmers within those producing cash crops take their animals to the veterinary care compared to the farmers who produce food crops. The latter group is expected to have comparatively lower returns. Despite their notion that animals which are underfed or sick will not perform well (Joubert, 1999), farmers in the study area do not value the importance of veterinary care of their animals as 65% of the total sample do not take their animals to the veterinary centre. This could be a direct result of the lack of information on working animals available from the extension service they receive and the inaccessibility of the service in some villages. The latter condition is typical of rural Kordofan (Makki and Omer, 2011).

Oxen were the dominant type of draught animals in the three groups of farmers (77% of the total sample use them). This is because the area is well known for cattle rearing and it is easy to purchase a pair of oxen if the farmer does not own any especially for those producing cash crops. Oxen dominance in rural Kordofan was also reported by Makki and Jamaa (2012). Further, the clay soil of the area necessitates having powerful animals that can provide the draught power required for land preparation. This is typical of the fact that cattle are preferred over donkeys and light horses in tillage operations where the draught power required is high (Pearson and Vall, 1998). Horses and donkeys ranked second and they are mostly used on sandy and/or loamy soils as they are light and the plough does not require a high draught force to operate on

**Table 2.** Performance of draught animals in the study area

| Animal types | Work hours/day | Forward speed (km/h) | Work rate (ha/h) | Field efficiency |
|---|---|---|---|---|
| Donkeys | 4.0 – 7.0 | 0.60 – 2.70 | 0.004 - 0.13 | 66.7 – 83.3 |
| Oxen | 2.0 – 8.0 | 0.90 – 2.16 | 0.017 - 0.13 | 37.5 – 85.7 |
| Camels | 5.0 - 6.0 | 1.68 – 1.80 | 0.029 - 0.11 | 75.0 – 80.0 |
| Horses | 4.0 – 6.0 | 0.60 – 2.10 | 0.017 - 0.14 | 50.0 – 80.0 |

**Table 3.** Distribution of the different draught animals used in South Kordofan by forward speed

| | Forward speed | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.6 -0.9 km/h | | 1.2 - 1.8 km/h | | 2.1 - 2.7 km/h | | |
| type of Animal | F | % | F | % | F | % | Total |
| oxen | 6 | 7.8 | 67 | 87.0 | 4 | 5.2 | 77 |
| Donkeys | 3 | 30 | 6 | 60 | 1 | 10 | 10 |
| Horses | 0 | 0.0 | 9 | 90.0 | 1 | 10.0 | 10 |
| camels | 0 | 0.0 | 3 | 100.0 | 0 | 0.0 | 3 |

these soils. Camel use in the study area is remarkable as the area is not known for rearing camels. They are all used by farmers producing cash and food crops (probably migrants from the neighbouring Darfur where camels are used as draught animals in agriculture).

### Field capacity and efficiency

Table 2 presents a summary of the field capacity and efficiency related parameters. All the farmers in the area used the same type and size of the mouldboard plough with all their animals and on all soil types. This limits the implement draught force factors to the difference in soil types only. The ranges of working hours, forward speed, field capacity and efficiency were typical of those reported in similar farming systems in the region with most of the oxen recording comparatively higher values than those in other species. Comparable results for draught oxen and donkeys with a similar plough were reported by Nengomasha (1999).

Forward speed of the different animals is shown in Table 3. Oxen are the only animals that are harnessed in pairs for work here, and are therefore better able to generate the high draught required on the clay soil than single animals. Because of this they are less limited in their forward speed and consequently field capacity compared to the other single harnessed animals is higher. Forward speed appears to be the major factor affecting field capacity in this case. Most of the four animal types worked at 1.2 – 1.8 km/h speed range with oxen outnumbering the other animals in this range. However, the forward speed difference between the four animal types was not significant ($p > 0.05$).

Oxen recorded significantly higher forward speed on the clay soil ($p = 0.001$), but this significance was not maintained on the sandy and loamy soils (Table 4). This is a result of the high draught power required on heavy soils which was easily provided by oxen in comparison with donkeys, horses and camels which perform best on light soils. Pearson and Vall (1998) reported that for any animal, as the draught force that they pull increases so the speed of work they work at decreases. Oodally et al. (2000) reported comparable forward speeds for horses, donkeys and camels.

The relationship between field capacity and animal type (Figure 1) shows that the most of the donkeys (80%) worked at 0.05 ha/h or less, while a considerable portion (10%) worked at high rates of 0.13- 0.14 ha/h and low rates of 0.06 – 0.08 ha/h. Different field capacities were recorded by horses as 60% of them worked at 0.05 ha/h or less and 30% worked at 0.06 – 0.08 ha/h. Interestingly horses working at 0.13- 0.14 ha/h were only 10% of them (compared to 10% of the donkeys). For camels the situation is different as they distributed equally between the capacity ranges. Most of the oxen (69%) worked at 0.05 ha/h or less, 20% worked at 0.06 – 0.08 ha/h and only 12% worked at 0.11 - 0.14 ha/h. In this case field capacity

**Table 4.** Distribution of draught animals' forward speed by soil type

| | Forward speed (km/h) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.6 - 0.9 | | 1.2 - 1.8 | | 2.1 - 2.7 | | |
| | F | % | F | % | F | % | |
| Categories | clay soil | | | | | | Total |
| Donkeys | 3 | 100 | 0 | 0 | 0 | 0 | 3 |
| oxen | 0 | 0 | 14 | 100 | 0 | 0 | 14 |
| Horses | 0 | 0 | 1 | 100.0 | 0 | 0 | 1 |
| | sandy soil | | | | | | |
| Donkeys | 0 | 0 | 4 | 100 | 0 | 0 | 4 |
| oxen | 5 | 8.6 | 49 | 84.5 | 4 | 6.9 | 58 |
| camels | 0 | 0 | 1 | 100 | 0 | 0 | 1 |
| Horses | 0 | 0 | 4 | 100 | 0 | 0 | 4 |
| | loamy soil | | | | | | |
| Donkeys | 0 | 0 | 2 | 66.7 | 1 | 33.3 | 3 |
| oxen | 1 | 20 | 4 | 80 | 0 | 0 | 5 |
| camels | 0 | 0 | 2 | 100 | 0 | 0 | 2 |
| Horses | 0 | 0 | 4 | 80 | 1 | 20 | 5 |

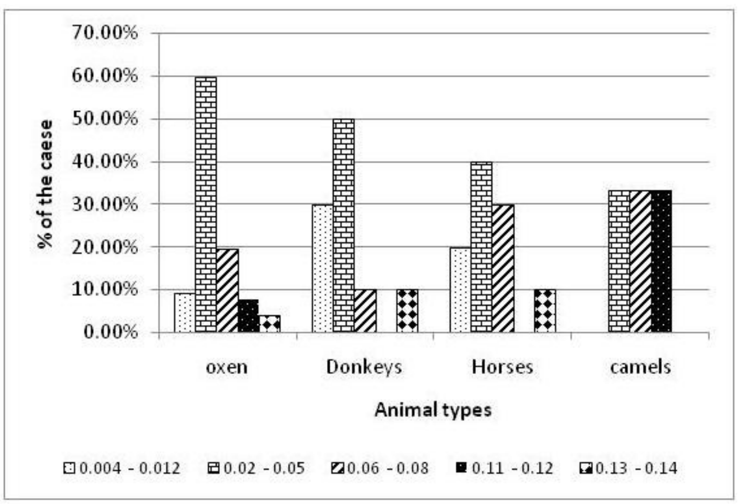


**Figure 1.** Distribution of animals' field capacity (ha/h) by animal types

cannot be viewed in terms of animal type only. Detaching field capacity from both animal and soil types is misleading as the same animal can work at different capacities in different soil types.

Significantly higher field capacities were recorded under sandy soil ($p= 0.02$). In all the field capacity ranges the highest percentage of the farmers was recorded under sandy soils (Table 4).

Daily working hours did not have a significant effect on field capacity ($p>0.05$). Nevertheless, animals working for longer daily hours recorded the least percentages in all the field capacity ranges. The 5 – 6 hours daily working range was dominant over the other ranges especially at the higher field capacities.

Differences in the type of feed did not result in a significant difference in the field capacities recorded ($p>0.05$) and the results suggest that the field capacity ranges recorded were related to the amount of feed received rather than on its type.

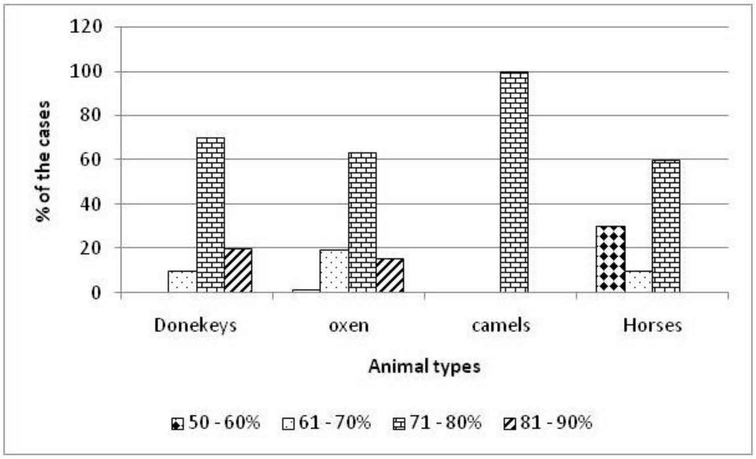


**Figure 2.** Distribution of animals' field efficiency by animal types

**Table 5.** Distribution of draught animals' field capacity by daily working hours, type of feed, veterinary care and soil type

| | Field Capacity (ha/h) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.004 - 0.016 | | 0.02 - 0.05 | | 0.06 - 0.08 | | 0.11 - 0.14 | | |
| | F | % | F | % | F | % | F | % | |
| Categories | daily work hours of drought animal | | | | | | | | Total |
| 2 - 4 hours | 4 | 14.3 | 20 | 71.4 | 1 | 3.6 | 3 | 10.7 | 28 |
| 5 - 6 hours | 8 | 12.9 | 32 | 51.6 | 15 | 24.2 | 7 | 11.3 | 62 |
| 7 - 8 hours | 0 | 0.0 | 4 | 40.0 | 4 | 40.0 | 2 | 20.0 | 10 |
| | type of feed | | | | | | | | |
| forage | 8 | 18.6 | 22 | 51.2 | 9 | 20.9 | 4 | 9.3 | 43 |
| concentrate | 2 | 11.1 | 10 | 55.6 | 6 | 33.3 | 0 | 0.0 | 18 |
| both | 2 | 5.1 | 24 | 61.5 | 5 | 12.8 | 8 | 20.5 | 39 |
| | veterinary care of drought animals | | | | | | | | |
| yes | 4 | 11.4 | 13 | 37.1 | 10 | 28.6 | 8 | 22.9 | 35 |
| no | 8 | 12.3 | 43 | 66.2 | 10 | 15.4 | 4 | 6.2 | 65 |
| | Soil Type | | | | | | | | |
| clay | 4 | 22.2 | 8 | 44.4 | 5 | 27.8 | 1 | 5.6 | 18 |
| sand | 6 | 9.0 | 45 | 67.2 | 10 | 14.9 | 6 | 9.0 | 67 |
| loamy | 2 | 13.3 | 3 | 20.0 | 5 | 33.3 | 5 | 33.3 | 15 |

Animals receiving regular veterinary care recorded significantly higher field capacities (p=0.001). Curran et al. (2005) reported that access to health services improved donkeys' health and households' income in the neighbouring Ethiopia. Our results would seem to support this.

The majority of the horses (60%), oxen (64%) and donkeys (70%) and all the camels recorded high efficiencies between 70 – 80%, while low efficiencies were recorded by 30% of the horses (Fig. 2). Field efficiency relates directly to the time lost in field operations which is decided by the easiness of animal control on one hand; and to the forward speed and the rate at which the animal gets tired on the other, as well as stoppages to adjust/clean the implement. This is supported by the correlation test which revealed an inverse insignificant relationship between the forward speed and field efficiency (r = -0.025 and p>0.05).

The relationship between field efficiency and soil type (Table 6) was statistically significant (p= 0.01). Higher field efficiencies were recorded under sandy soil compared to clay and loam, while comparatively lower efficiencies were

**Table 6.** Distribution of draught animals' field efficiency by daily working hours and soil type

| | Field efficiency | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 51 - 60 | | 61 - 70 | | 71 - 80 | | 81 - 90 | | |
| | daily work hours of drought animal | | | | | | | | Total |
| Categories | F | % | F | % | F | % | F | % | |
| 2 - 4 hours | 0 | 0 | 6 | 21.4 | 4 | 14.3 | 18 | 64.3 | 28 |
| 5 - 6 hours | 4 | 6.5 | 9 | 14.5 | 22 | 35.5 | 27 | 43.5 | 62 |
| 7 - 8 hours | 0 | 0 | 2 | 20.0 | 4 | 40.0 | 4 | 40.0 | 10 |
| | Soil Type | | | | | | | | |
| clay | 0 | 0.0 | 6 | 33.3 | 4 | 22.2 | 8 | 44.4 | 18 |
| sand | 1 | 1.5 | 11 | 16.4 | 21 | 31.3 | 34 | 50.7 | 67 |
| loamy | 3 | 20.0 | 0 | 0.0 | 5 | 33.3 | 7 | 46.7 | 15 |

**Table 7.** The effect of farmers' status on field capacity and efficiency

| | Farmers groups | | | | | | |
|---|---|---|---|---|---|---|---|
| | food crops (subsistence) | | cash crops | | food and cash crops | | |
| Categories | F | % | F | % | F | % | Total |
| | Field capacity (ha/h) | | | | | | |
| 0.004 - 0.02 | 6 | 50 | 6 | 50 | 0 | 0 | 12 |
| 0.021 - 0.05 | 37 | 66 | 14 | 25 | 5 | 9 | 56 |
| 0.06 - 0.08 | 13 | 65 | 7 | 35 | 0 | 0 | 20 |
| 0.11 - 0.14 | 4 | 33 | 6 | 50 | 2 | 17 | 12 |
| | Field efficiency (%) | | | | | | |
| 50 - 60 | 1 | 25 | 3 | 75 | 0 | 0 | 4 |
| 61 - 70 | 11 | 65 | 4 | 24 | 2 | 12 | 17 |
| 71 - 80 | 17 | 56.7 | 11 | 36.7 | 2 | 6.7 | 30 |
| 81 - 90 | 31 | 63 | 15 | 31 | 3 | 6 | 49 |

recorded under the clay soil. This can be successfully explained by the relationship between soil type, animal type, forward speed and the unit draught of each soil type.

Daily working hours did not have a significant effect on field efficiency but higher efficiencies were associated with moderate to low daily working hours.

Field capacity was significantly (p= 0.033) affected by farmers' status (Table 7). Farmers producing for subsistence (food crops) were dominant in the low field capacity ranges, while those producing for marketing were dominant in the high field capacity ranges. Effects of farm size, animal type, and daily working hours that were selected by the farmers' groups are evident here. Further, the results confirm the assumption that field capacity is affected by farmers' status which determines the general condition of draught animals suggesting a result of the resources invested in them. On the other hand, field efficiency was also significantly (p = 0.021) affected by farmers' status (Table 7). Farmers producing for subsistence outnumbered those market-oriented ones in the moderate- to high-efficiency range suggesting that unlike field capacity, field efficiency is determined by farm size and working hours. The effect of operator's experience is marginal in this case as all the farmers received the same training and were introduced to the technology in the same period.

## CONCLUSION

Field capacity and efficiency were closely associated with veterinary care of draught animals and to a less extent with animal feeding and work hours. Management practices were decided by farmers' status and farmers with a better status recorded significantly higher field capacities and efficiencies with all animal types.

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