LIVESTOCK PRODUCTION PROGRAMME
& CROP PROTECTION PROGRAMME

Improving production in the Teso Farming System through the development of sustainable draught animal technologies

R7401

FINAL TECHNICAL REPORT

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List of abbreviations

AEATRI	Agricultural Engineering and Appropriate Technology Research Institute
cm	Centimetre
CPP	Crop Protection Programme
DA	Draught Animal
DAP	Draught Animal Power
DFID	Department for International Development
FP	Farmer practice
ha	hectare
hh	household
km	Kilometre
LPP	Livestock Production Programme
m	metre
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organisation (Uganda)
NGOs	Non-government Organisations
NRI	Natural Resources Institute
PRA	Participatory Rapid Appraisal
PTD	Participatory Technology Development
SAARI	Serere Agricultural and Animal Production Research Institute (Uganda)
SAIMMCO	Soroti Agricultural Implement and Machinery Manufacturing Company
SG2000	Saskawa Global 2000 (NGO)
TVC	Technology Verification Centre
Ush	Uganda Shilling

Executive summary

This project worked with farmers in the Teso farming system of Uganda to develop appropriate animal drawn implements, primarily for weeding but also for planting. Research activities included:

- A literature review and baseline survey
- A weed characterisation survey
- PRAs to explore labour constraints and to identify collaborators
- Training of farmers in DAP weeding
- On-farm and on-station trials to test 5 weeding implements and a planter
- Participatory assessments of weeding implements
- Planter design and testing
- Dissemination, training and extension

Project outputs:

- The weed flora of Teso is very diverse with at least 85 species present, of which two thirds are annual broadleaves and one-sixth annual grasses.
- Weed characterisation will allow the performances of weeders to be ascertained over an extended period, aiding decisions on how best to control weeds on farms in Teso.
- All four DAP weeders tested on-farm performed well in terms of reducing the labour and costs required for weeding sorghum and groundnuts.
- Judged solely in terms of weed control, there is little or no difference between the 5 weeders tested on-station and on-farm.
- DAP weeding does not enhance yields when compared with efficient hand weeding.
- There were significant differences in weeding efficiencies, with the AEATRI weeder being least effective.
- DAP weeders are a practical and effective alternative to hand-hoe weeding.
- The capital required for investment in DAP weeding is zero for those farmers (the majority) who have access to oxen and ploughs
- From the farmers perspective the plough, SAARI, SG2000 are the preferred weeders while AEATRI is the least preferred.

Project outputs will contribute to the livelihoods of poor women, men and children in Teso in the following ways (assuming extension and training organisations use project outputs):

- A reduction in the drudgery associated with handweeding arable crops (a task predominately undertaken by women and children)
- Improved school attendance during the weeding seasons (human capital)
- Reduced costs of production, higher returns and higher incomes (financial capital)
- Opportunities for men and particularly for women to re-deploy labour elsewhere in productive or reproductive activities
- The project contributed to the human capital of collaborating farmers (training in weeding, data collection and farm management)
- It is likely that the social capital of the participating farmers was also enhanced as they now have a skills that can be used to train others and may be considered experts within their local communities.

Weeding technology is unlikely to have an immediate impact on the very poorest households. These are often female-headed and have limited access to draught animal power. However, as hire markets develop for DAP weeding it is likely that this will be a cheaper option than hiring manual labour.

There is a commercial opportunity for machinery manufacturers to produce a simplified SAARI design of weeder. This may in the longer term provide employment opportunities in urban and peri-urban locations.

There is a need now for further promotion of project outputs. Teso farmers have limited opportunities to articulate their needs and there is a risk that little progress will be made in the promotion of DAP weeding without some kind of external intervention to co-ordinate and promote activities in this sphere.

Sadly, two members of the DAP Project team died in 2001

Joel Wange, co-leader of the project at SAARI

and

Nelson Olani, agronomist at SAARI

1 Background

1.1 Introduction

This project worked with farmers to develop appropriate animal drawn implements, primarily for weeding but also for planting. The geographical location was the Teso Farming System of Uganda (Katakwi, Kumi, Pallisa and Soroti Districts). The research was jointly managed by the Serere Agricultural and Animal Production Research Institute (SAARI) of the National Agricultural Research Organisation (NARO) of Uganda and the Natural Resource Institute (NRI) of University of Greenwich in the UK. NRI sub-contracted specialist inputs from Silsoe Research Institute and IACR-Long Ashton Research Station. The Project was part of the portfolios of two DFID research programmes, the Livestock Production Programme (LPP) and the Crop Protection Programme (CPP).

The climate of Teso is classified as semi-arid. Annual mean rainfall is in the range of 1,000-1,250 mm over much of the area but can be higher towards the south. This is distributed over two wet seasons, March/April to May and September to November. The priority crops in order of importance in the Teso Farming System are cassava, sorghum, finger millet, groundnuts and sweet potatoes (Okwadi & Akwang, 2000) but other crops grown include cotton, sunflower, cowpea, maize, simsim, soyabean, pigeon pea, vegetables, bananas and rice (Macmillan Uganda, 1998). The project concentrated on two of the priority crops, groundnuts grown mostly in the first wet season and sorghum grown mostly in the second wet season.

The use of draught animals for land preparation (ploughing) was introduced to the Teso Farming System during the colonial era (1920s) and was associated with the commercial production of cotton. The technique is therefore well established but there has been has been a shortage of draught animals following civil disruption during the 1980s and 1990s. This constraint has been addressed by a number of ‘oxenisation’ or ‘restocking’ projects and many households are now able to open up land (plough) with oxen. The benefits of using draught animals however, will not be fully realised until animals are used for tasks other than ploughing (particularly weeding). Expansion of the area cultivated, following the re-introduction of oxen for ploughing often leads to a labour constraint for weeding which is undertaken by hand (mostly by women and children). The range of implements available for weeding and planting is limited and the project addressed this issue by testing and evaluating with farmers, on their fields, a variety of implements likely to be appropriate to their circumstances.

Cereal crop yields (finger millet and sorghum) in the Teso Farming System have stagnated at below 1500 kg/ha, in spite of increasing access by farmers to high yielding varieties. Continuous cropping of land due to power shortages which prevent the opening of new land led to the collapse of the traditional soil productivity management practice of crop rotation which in turn causes declining soil fertility and increasing weed pressure. A heavy build up of mainly annual grass weeds, especially of genera such as *Eleusine* and *Setaria* occurs. Difficult to control perennial weeds such as *Digitaria spp*, and *Imperata cylindrica* occur in some areas. Crop losses due to weeds at the farm level have not been quantified but based on yields from research supervised trials on-farm, these are estimated at between 40% and 80%. The soils in the Teso Farming System are generally light, ranging from sands to sandy loams. These soil types are readily worked by animal draught equipment. However, being light, they also easily lose moisture, creating environments that allow the hardy and adapted weed species to thrive to the disadvantage of crops. The method of broadcasting seed at planting makes weed management extremely laborious and slow. The traditional work groups “Alea”, no longer exist and weeding becomes prolonged with associated yield loss.

Few farmers can afford to purchase labour for weeding as prices rise during periods of peak labour demand.

1.2 Demand for the research

As early as 1975 Uchendu and Anthony commented that: "Teso economy lost the cumulative impact of the ox-plough technology because of the lateness of the introduction of other associated equipment. It was only during the 1960s, 40 years after the introduction of the plough that attempts were made to alleviate the labour bottlenecks it had created" (p39).

A *'Needs Assessment for Agricultural Research in the Teso Farming System'* (Akwang, et al, 1998) was undertaken by NARO with support from DFID in February 1998 which confirmed the views of Uchendu and Anthony. This rapid rural appraisal described the researchable constraints to increased production from farms in the Teso system. These included:

- labour constraints at peak periods, in particular for land preparation, weeding and harvesting of broadcast crops (finger millet and sesame)
- a lack of access to draught power for most female headed households and for women in general as men control access
- high labour requirements for planting groundnuts (in lines)

These findings were confirmed during a DFID-funded Stakeholder workshop held at SAARI in February 1998 to formulate a proposal for this research.

2 Project purpose

2.1 LPP Purpose

LPP Purpose was "*Develop and promote strategies for the allocation and management of on-farm and locally available resources in order to optimise livestock production and improve their contribution to the crop/livestock farming system"*

In this context the project purpose was to test and evaluate draught animal technologies (weeding and planting[1]) on farmer's fields in the Teso Farming System to improve the contribution draught animals make to the crop/livestock farming system. The primary objective was to test weeding equipment to address the weed management difficulties faced by farmers, the negative yield effects of poor weed management and the labour constraints and drudgery associated with hand weeding.

2.2 CPP Purpose

CPP purpose was *"Benefits for poor people generated by application of new knowledge of crop protection in cereal-based, semi-arid cropping systems"*, with the indicators of achievement being, *"stabilising yields, sustaining the resource base and reducing drudgery through improved and sustainable management of weeds"*.

The project was to achieve this in Uganda through making weed management less time-consuming and more effective, leading to increased land use and crop yields.

[1] Originally the project planned also to investigate transport constraints and solutions but the time, cost and effort required to manage on-farm trials left insufficient time for the research team to investigate this aspect of draught animal power.

3 Research Activities

3.1 Literature review

The review examined the available literature relating to weed management by the use of human power (hoes) draught animals and herbicides. There is a limited amount of published material relating to weed management with draught animals in sub-Saharan Africa.

3.2 Baseline survey

A baseline survey by questionnaire of 691 households in four Districts of Teso (Kumi, Soroti, Katakwi and Pallisa) was undertaken at the outset of the project in late 1999. The objective of the survey was to provide information about:

- Cropping patterns
- Crop yields
- Resource endowments (land, labour, and draught animals)
- Areas cultivated
- Area of land left fallow
- Labour bottlenecks and shortages

The questionnaire can be found in Appendix 1 and survey results in section 4.2.

3.3 Weed characterisation survey

The weeds of East Africa have been reported and described by several authors (e.g. Ivens, 1989; Terry & Michieka 1987), and Tiley (1970) published a checklist of Uganda weeds. However, they are not specific enough to describe the weed flora of Teso. Hence, a weed survey was undertaken at 9 sites where the project planned to carry out on-farm research in order to:

- characterise each sampling location by determining the species of weeds present and prioritising them
- assist farmers and researchers in the identification of weeds
- provide plant material for a reference weed herbarium at SAARI
- provide a benchmark against which changes could be measured (for example, farmers using a particular weeder or plough over several seasons could induce a change in the weed flora)
- identify appropriate methods of controlling weeds

Surveys were carried out on two occasions, in October 1999 at the end of the long rains and in November 1999 at the beginning of the short rains. Three zones were surveyed, Kumi/Pallisa, Soroti, and Katakwi. Three sites were selected from each zone to make a total of nine sites. At each site, weeds were surveyed on ten farms, making a total of 90 different farms.

Categories used to characterise the sites were:

- soil type
- field history
- current crop
- number of weedings in the season
- crop plant populations

- methods of field preparation
- weed species

This information was obtained by interviewing farmers and by direct observation of conditions at each site. Weed species were identified by their vernacular and/or scientific names and the numbers present in each of five randomly placed quadrats per site were measured. This made it possible to determine the frequency of occurrence of every species of weed at each farm. By aggregating the data, it was possible to determine how the occurrence of weeds was related to characteristics such as zone, site and soil type.

Weed frequencies were calculated by taking simple means of either (a) the number of quadrats in which each weed appeared, or (b) the number of farms on which each species occurred. Due to high variation between quadrats in the numbers of weeds present, actual densities were not used. Statistical analyses were undertaken to seek associations between weeds and farms using cluster analysis and principal component analysis.

The results of the weed characterisation survey are presented in section 4.3.

3.4 Participatory rapid appraisals

Participatory rapid appraisals (PRAs) were undertaken with communities at 9 sites throughout Teso. The objectives of the PRAs was to:

- examine or re-examine the labour constraints experienced by farmers
- investigate how male and female farmers manage their labour
- develop an understanding of the crops and tasks that are most labour demanding
- agree a *modus operandi* for the conduct of on-farm trials.

Communities were requested to elect a chairperson at each site and 7 individual farmers who would be trained in the use of draught animal weeders and assist the team with the collection of data from their on-farm plots.

3.5 Farmer training

Towards the end of 1999 a total of 63 farmers at nine sites were trained how to use draught animals for weeding operations. Training involved:

- Uses of draught animals
- Weeder adjustments
- Yoke making
- Harnessing of animals and training oxen
- Simple weed identification
- Data collection and record keeping

3.6 On-station and on-farm trials

Trials were designed to compare the use of animal drawn weeders in line-sown crops with traditional practice (broadcasting and hand-hoe weeding). Trials were conducted at Bukedea and Kaberamaido Technology Verification Centres (TVCs) used by SAARI for locational testing of new varieties and on-farm (9 sites, 7 farmers at each site). Table 1 summarises the trials that took place during 2000 and 2001.

Table 1. On-station and on-farm trials 2000-2001

Date	Location	Crop	Treatments	Parameters measured
1st rains 2000	Bukedea TVC Kaberamaido TVC	Groundnuts	Farmer practice SAARI Weeder AEATRI Weeder Cossul Weeder	Weed population Weeding efficiency Crop yields Weeder performance
1st rains 2000	On-farm	Groundnuts	Farmer practice SAARI Weeder	Weed population Weeding efficiency Crop yields Weeder performance
2nd rains 2000	Bukedea TVC Kaberamaido TVC	Sorghum	Farmer practice SAARI Weeder AEATRI Weeder Plough	Weed population Weeding efficiency Crop yields Weeder performance
2nd rains 2000	On-farm	Sorghum	Farmer practice SAARI Weeder AEATRI Weeder	Labour use Gross margins Weed population Weeding efficiency Crop yields Weeder performance
1st rains 2001	Kaberamaido TVC SAARI	Groundnuts	Farmer practice SAARI Weeder AEATRI Weeder SG2000 Weeder Plough	Weed population Weeding efficiency Crop yields Weeder performance
1st rains 2001	On-farm	Groundnuts	Farmer practice SAARI Weeder AEATRI Weeder SG2000 Weeder Plough	Labour use Gross margins Weed population Weeding efficiency Crop yields Weeder performance

The SAARI and AEATRI weeders were designed and made by the NARO Institutes Serere Agricultural and Animal Production Research Institute and the Agricultural Engineering and Appropriate Technology Research Institute respectively (Figs. 1 and 2). The SG2000 weeder is imported into Uganda from Kenya (Fig. 3). These three types of weeder were provided by the project and delivered to the 9 project sites. The use of the plough without the mouldboard (Fig. 4) was tested as a possible cheaper solution and was known to be used in Zimbabwe (Riches et al, 1997). The Cossul weeder was imported from India and was only used on-station (Fig. 5).

3.6.1 On-station trials

Bukedea TVC and the SAARI research station represented the light sandy soils while Kaberamaido TVC represented the heavy clay loam soils of the Teso Farming System. A complete randomised block design was used and each plot measured 15 x 8 m. Five different designs of weeders were tested between 2000 and 2001 (see Table 1). The whole crop was harvested and taken to SAARI where it was dried and weighed.


Figure 1 SAARI weeder


Figure 2 AEATRI weeder


Figure 3 SG2000 weeder


Fig 4 Plough (minus mouldboard)


Figure 5 Cossul weeder

3.6.2 On-farm trials

On-farm trials were conducted at nine sites; Abalang, Kachede, Kaler, Kibale, Koritok, Obule, Obur, Orungo, and Pingire. Groundnuts and sorghum were sown during the first and second seasons respectively in 2000 and groundnuts in the first season 2001. The SAARI, AEATRI, SG2000 weeders and a plough with mouldboard removed were compared with farmers' practice (see Table 1).

The same field lay out (plan) was used in all farmers' fields, however, the orientation depended on the shape and size of the field and the slope. A general lay out is shown below (Figs. 6 and 7).

Fig. 6. Field lay-out of on-farm trials, first rains, 2000 and 2001

SAARI weeder (recommended spacing, seed rate and weeded with DAs) 2000 Choice of weeder (SAARI, AEATRI, SG2000, Plough) (recommended spacing, seed rate and weeded with DAs) 2001	Farmer's plot (planted and sown according to the farmer's practice) Broadcasting and hand hoeing

Fig. 7. Field lay-out of on-farm trials, second rains, 2000

Farmer's practice
SAARI weeder
AEATRI weeder

Crops were weeded twice where necessary. On arrival at the site, the DAP team would call at the chairperson's home and the participating farmers were asked to have their oxen ready. The weeder was then attached and adjusted. Before carrying out weeding, weed data were collected by the group (DAP team and farmers).

Data were collected from each farm on weeds, crop yields and weeder performance, labour use and time spent weeding with draught animals. A quadrat measuring 33 x 33 cm (0.11 m^2) was used for weed data collection. The quadrat was randomly thrown ten times in each plot and the weeds inside the quadrat were counted. Weeds from on-farm trials were categorised as perennial grasses, annual grasses, sedges and broad-leafed annuals, while each individual species was recorded on the TVCs. Data on weeds were collected at the times of: (a) first weeding, (b) second weeding, and (c) at maturity (i.e. at harvest time). Efficiencies of the different methods of weeding were calculated using the formula:

$$\textit{Weeding efficiency (\%)} = 100 - \{[(W_0 - W_1)/W_0] \times 100\}$$

Where W_0 = weed density immediately before weeding and W_1 = weed density immediately after weeding.

The whole plot was harvested and farmers dried and threshed the crop and retained the harvest for their own use. Results of on-station and on-farm trials are presented in section 4.4.

3.7 Participatory assessment of weeders

Following on-farm field trials male and female farmers were invited to share their experience of the use of DAP weeders with the research team. A PRA methodology (matrix scoring) was used in 9 locations with a total of 56 male and female farmers. The efficiency of each weeder was assessed against a range of technical and ergonomic parameters (the matrix is shown in Appendix 2). Participants assigned scores ranging from 1 to 10 to each weeder for each parameter with maximum of 10 points for very good and 1 for very poor. This gave an indication of the relative merits of each type of weeding implement. Semi-structured interviews followed the completion of the matrix to discuss and follow-up on issues raised by farmers. The results are presented in section 4.3.

3.8 Planter design and testing

As line-planted crops are a prerequisite for the adoption and use of animal-drawn weeding implements, the project activities included the design and initial development of a simple planter specifically for Teso farmers. The emphasis was on simplicity due to both fabrication and cost constraints and because the initial need was for the planting of groundnuts only. It was felt that design developments for other crops could be developed according to demand and through farmer participation. Results are presented in Section 4.11.

3.9 Dissemination/training and extension

The results of the research were presented at 2 stakeholder workshops in 2001 and 2002[2]. Both government and non-government organisations were represented at these workshops. In addition 2 papers and a poster were presented at an international workshop “Modernising Agriculture: Visions and Technologies for Animal Traction and Conservation Tillage 19-25 May 2002, Jinja, Uganda”. A poster was presented at the BCPC Conference -“ Weeds 2001, Brighton, 12-15 November 2001”.

[2] These were both published as proceedings:
Wange, J and Barton D. (eds) 2001 Weed management using draught animals in the Teso Farming System. Proceedings of a stakeholder workshop held at Eneku village, Soroti 19-20 April 2001. NRI, Chatham
Barton D. (ed) 2002 Weed management using draught animals in the Teso Farming System. Proceedings of a stakeholder workshop held at Eneku village, Soroti 7-8th February 2002. NRI, Chatham

An extension leaflet has been drafted for reproduction in Uganda by SAARI. This describes with simple diagrams, how to weed with a plough (minus mouldboard).

Following final field trials and participatory assessments, a programme of extension and training was initiated to assist participating farmers to begin their own training programmes for their neighbours. This involved the organisation of demonstration plots at each of the 9 sites where on-farm trials took place. Participating farmers then demonstrated the use of weeders and trained their neighbours in the techniques of line sowing and weeding with oxen. A brief survey followed this activity to assess the number of farmers trained and adopting the technology (see section 4.5).

4 Outputs

4.1 Logframe outputs

The project logframe had 5 outputs (Appendix 5):

1. Characterisation of the relationship between labour and power availability and area cultivated, yields, cropping patterns and returns to labour inputs
2. Characterisation of weeds and weed management problems in the Teso area
3. Analyses of the efficacy of draught animal equipment for weed management, planting or sowing and transport[3].
4. Specific advice on the use of draught animal equipment for weed management and planting
5. Information for stakeholders (farmers, manufacturers, extension services, NGOs) produced and delivered to appropriate uptake pathways

4.2 Labour and power availability and returns to labour use (output 1)

4.2.1 Background

A review of the literature (Barton et al, 2000 and Wange, 1999) established that the labour demand for weeding annual crops in smallholder farming systems in sub-Saharan Africa represents one of the major bottlenecks to increased production. This is also the case in the Teso Farming System of Uganda. Poor or inadequate weeding has a major impact on yield and new planting technologies (higher yielding varieties) often require higher labour inputs than traditional or local varieties. The use of DAs for land preparation only exacerbates labour demand for weeding (larger cultivated areas). The benefits of fertiliser applications will not be fully realised unless timely weeding is carried out.

It has been demonstrated that animal drawn weeders can reduce labour requirements for weeding by up to 80% (Tanzania) (Shetto, 1993). However, many smallholder farmers are unable to invest in weeding equipment. The plough has been demonstrated (in Zimbabwe) to be a tool that can be used effectively for both land preparation and weeding (Riches et al 1997).

Much of the labour for hand weeding in sub-Saharan Africa is provided by women and any investment in animal powered weeding may have its greatest impact on their lives by reducing the time they devote to this activity. However, men often control access to draught animals and may be reluctant to invest in technologies that benefit women rather than men.

There is little recorded data on the technical and financial impact of the adoption of DAP weeding in smallholder farming systems in sub-Sahara Africa, although there is a general acceptance that the technology increases labour productivity.

The limited amount of published literature suggests that animal powered weeding provides the best or most appropriate solution, in many cases, to the problems associated with labour shortages for weeding annual crops (as opposed to herbicides or improved hand tools). However, adoption and uptake of animal powered weeding technology has been poor even in those locations where the use of draught animals for land preparation is widespread. The major reasons for this are:

- Poorly trained extension staff and consequently poorly trained farmers

[3] It proved impossible in the time available to investigate transport constraints and solutions.

- Inappropriate weeding tools both in terms of their technical performance and their cost
- Gender issues
- The need for row planting (broadcasting is quicker and cheaper)
- Narrow row spacing or inter-cropping which restrict the passage of draught animals (Farrell and Kibata, 1999)

To ensure success it has been demonstrated that:

- Farmers should have expressed the need for weeding technology (i.e. there should be demand for the technology)
- Tools should be tested and farmers be involved in the evaluation of different designs (participation)
- Extension workers require training

4.2.2 Baseline survey

A baseline survey of 691 (559 male-headed and 132 female-headed) households in four Districts of Teso (Kumi, Soroti, Katakwi and Pallisa) was undertaken at the outset of the project in late 1999. The objective of this survey was to ascertain the extent of draught animal ownership and its relationship with land ownership and gender of the head of household. The results would give some indication of the availability of draught power and the types of households who have access to this power.

Land is not owned in the formal sense in Teso and few if any households have title to the land they cultivate, use or consider to be their own. However, it is clear that most households have a clear idea about land which they have rights to use and this land is passed from one generation to another. Land ownership varies by District with the more densely populated Pallisa having the lowest land ownership per household and the least land left as fallow (although only marginally less than Kumi households) (Table 2). On average a little less than half the land available to households is left fallow indicating that if labour and power were available there is scope to expand the area of land cultivated and increase production.

Table 2. Land ownership (ha) (acres in brackets)

	Land owned	Land Cultivated	% cultivated	n
Kumi	3.65 (9.03)	2.26 (5.59)	61.87	147
Soroti	3.63 (8.97)	1.89 (4.67)	52.02	217
Katakwi	4.77 (11.79)	2.71 (6.68)	56.69	246
Pallisa	3.17 (7.84)	1.99 (4.92)	62.76	81
Mean	3.81 (9.41)	2.21 (5.46)	58.33	

Family labour availability is crucial for crop production in the Teso Farming System where planting, weeding and harvesting operations are undertaken by hand. Data in Table 3 are presented as adult equivalents with children between the ages of 12 and 16 assumed to contribute about 50% of the work of an adult male or female. Soroti District has the highest family labour availability per hectare cultivated (there is less land cultivated/available and household sizes are larger than elsewhere). Katakwi District has the lowest family labour per hectare of cultivated land and the highest cultivated acreage per household. The overall correlation between cultivated land and labour availability is positive (+0.311) and between cultivated land and draught animal ownership (+0.386). Neither correlation is high but suggests that there is a relationship between availability of labour and draught animal ownership and the area cultivated by a household.

Table 3. Availability of family labour per ha of cultivated land (acres in brackets)

	Family labour (adult equivalents/hh)	Cultivated hectares/hh (acres)	Family labour/ha (acre)	n
Kumi	4.41	2.26 (5.59)	1.95 (0.79)	147
Soroti	4.22	1.89 (4.67)	2.23 (0.90)	217
Katakwi	3.35	2.71 (6.68)	1.24 (0.50)	246
Pallisa	3.36	1.99 (4.92)	1.69 (0.68)	81
Mean	3.83	2.21 (5.46)	1.78 (0.72)	

Male-headed households appear to have a higher cultivated acreage and better access to draught power than female headed households. There are no differences between total available family labour (Table 4).

Table 4. Land and labour availability by gender of household head

	Male	Female
Average age of head of household	41.41	48.89
Family labour	3.86	3.76
Total land (ha)	4.24	2.19
Cult land (ha)	2.42	1.58
No. of DAs	2.28	1.23

A shortage of draught power, principally to open up land (ploughing), has been considered a major constraint to agricultural production in Teso for a number of years. Following civil disruption and insurgency during the 1980s and 1990s most households lost their cattle. A major effort has been made by government and non-government organisations (NGOs) over the past 6-7 years to rectify this problem. The data in Table 5 suggests that around half the farmers in Teso now have access to their own draught animals. Farmers in Kumi and Pallisa own on average less than 2 animals per household. The highest level of ownership was observed in Katakwi District (2.68 per household).

Table 5. Draught animal ownership

	No of DA/hh	Land cultivated ha (acre)	DAs/cult ha (acre)	n	No of hh with no DAs	%
Kumi	1.54	2.26 (5.59)	0.68 (0.28)	147	85	57.82
Soroti	2.11	1.89 (4.67)	1.12 (0.45)	217	104	47.93
Katakwi	2.68	2.71 (6.68)	0.99 (0.40)	246	91	36.99
Pallisa	1.07	1.99 (4.92)	0.54 (0.22)	81	50	61.73
Mean	1.85	2.21 (5.46)	0.83 (0.34)	691	330	47.76

Overall 47% of households are still without their own animals (Table 5). However many (57% of the sample) are able to hire draught power (Table 6). Male-headed households are more likely to own oxen than female headed households (Table 7). Some female-headed households power their agricultural activities entirely by hand, as only 90% of this category of households own or hire oxen.

Table 6. Use and hiring of DAs

	hh using own DAs	hh hiring in	hh hiring out	n
Kumi	58	95	30	147
Soroti	93	114	56	217
Katakwi	148	115	55	246
Pallisa	28	69	17	81
Total	327	393	158	691

Table 7. Use of DAs by male and female headed households

	Male	%	Female	%	n
Own oxen	285	50.98	42	31.82	327
Hire in	317	56.71	76	57.58	393
Hire out	136	24.33	22	16.67	158
hh with no DAs	249	44.54	81	61.36	330

Approximately 18% of the sample reported that they are often late weeding their crops. Major reasons for late weeding include (in order of importance):

- Shortages of family labour
- No cash to hire labour
- Drought
- Illness
- No oxen or implements

Only one household reported the use of herbicides and only 4 households used oxen for weeding.

4.2.3 The Impact of Ox-weeding on Labour Use, Labour Costs and Returns

This section reports the impact of the use of 4 weeders on labour use, labour costs, returns to labour and gross margins based on data collected on-farm for the second season 2000 and the first season 2001(abbreviated data can be found in Appendix 3). The 4 weeders tested on-farm are shown in figures 1-4 (above).

Second Season 2000

Full data was collected from 66 farmer plots (43 hand weeded and 23 weeded with draught animals) Planting of sorghum on-farm was timely and reasonable yields resulted (Table 8). Only one weeding was undertaken by the majority of farmers as crop growth was rapid following the first weeding and a second weeding was not necessary. The differences in yields between DAP and handweeding treatments were not large or statistically significant. Given the variation between sites and plots in planting dates, rainfall (which was not recorded) and other factors such as soils, cultural practices etc. it is not possible to attribute yield effects from this data to a particular weeding technique. If weeding is undertaken effectively by both implement and by hand, a yield effect would not be anticipated.

The use of ox-drawn weeders reduces the hand labour required for weeding from 157 hours/ha to 34 hr/ha. Hand weeding costs (at the prevailing market rate) are significantly reduced to around Ush 10,000/ha compared with Ush 47,000/ha[4] for farmer practice.

[4] One GBP =Uganda Shilling 2,500 (approx)

Table 8. Labour use, costs and margins on-farm, season 2, 2000 (sorghum) (DAP weeding versus farmer practice)

	DAP weeding	Farmer practice (hand hoe)	Statistics[5]
Yield (kg/ha^{-1})	894.1	833.7	ns
Hand weeding (hr/ha^{-1})	34.7	157.8	p<0.001
Cost of hand weeding (Ush/ha^{-1})	10,401	47,343	p<0.001
Gross Margin (Ush/ha^{-1})	14,359	771	ns
Returns to hand weeding (Ush/day)	19,388	3,735	p<0.001
Hand weeding costs as % of total	13.2	51.3	p<0.001
Number of observations	43	23	

Hand weeding costs as a percentage of total costs are reduced from more than 50% to 13%. All costs and returns were monitored (including draught animal costs) and gross margins were higher for DAP weeded plots but there were large variations within the sample and the difference was not statistically significant. Returns per day of hand weeding labour are significantly increased with the use of ox-drawn weeders.

The relative performance of the 2 weeders is shown in Table 9. Although the SAARI weeder appears to perform better than AEATRI in terms of yield and margins neither of these differences was statistically significant. In terms of reducing the time required for hand weeding and labour costs there is little to choose between the 2 designs.

Table 9. Comparative performance of 2 weeders (sorghum, season 2, 2000)

	SAARI	AEATRI	Statistics[6]
Yield (kg/ha^{-1})	1,016.6	776.8	ns
Hand weeding (hr/ha^{-1})	32.2	37.0	ns
Cost of hand weeding (Ush/ha^{-1})	9,656	11,114	ns
Gross Margin (Ush/ha^{-1})	25,004	4,176	ns
Returns to hand weeding (Ush/day)	21,978	16,911	ns
Hand weeding costs % of total costs/ha^{-1}	12.4	13.9	ns
Number of observations	21	22	

First season 2001

Full data was collected from 92 farmer plots including 45 weeded by hand (traditional practice) and 47 weeded by draught animals. Planting of groundnuts on-farm was timely, rains were good and in general good yields resulted (Table 10). DAP weeding produced higher yields (1823kg/ha) than hoe (hand) weeding (1397kg/ha) but these differences were not significant reflecting the high variability in yields between farms. The yield differences may be partly explained by an optimum plant population associated with precise row planting to facilitate DAP weeding.

[5] Direct variance ratio test F probability
[6] Direct variance ratio test F probability

Table 10. Labour use, costs and margins on-farm, season 1, 2001 (groundnuts) (DAP weeding versus farmer practice)

	DAP Weeding	Farmer practice (hand hoe)	Statistics[4]
Yield (t/ha^{-1})	1,823	1,397	ns
Hand Weeding (hr/ha^{-1})	31.8	73.2	p<0.001
Cost of hand weeding (Ush/ha^{-1})	13,717	30,727	p<0.001
Gross Margin (Ush/ha^{-1})	1,117,444	852,547	ns
Return/day of hand weeding labour (Ush)	230,835	31,315	p<0.001
Hand weeding as % of total costs/ha^{-1}	7.7	21.5	p<0.001
Number of observations	47	45	

Most farmers weeded their crop twice. The use of ox-drawn weeders reduces the hand labour required for weeding from 73hr/ha to 32hr/ha. The difference is statistically significant demonstrating that DAP weeding provides important benefits in terms of reducing the time and drudgery associated with hand weeding a groundnut crop.

Hand weeding costs (at the prevailing market rate) are reduced by at least 50% (from Ush 25,290 to 11,580 per hectare) when DAP weeders are used. The difference is statistically significant providing strong evidence of the cost savings associated with the adoption of DAP weeding. Gross margins were higher for DAP weeded plots (Table 10) although not significantly so. Returns per day of hand weeding labour are increased with the use of ox-drawn weeders. The difference was statistically significant.

The comparative performance of the four ox-drawn weeders is shown in Table 11. Although some differences can be discerned from the data none of these were significant statistically, reflecting again the high degree of variance between farms. Individually only the SAARI weeder gave significantly higher yields (p<0.01) than farmer practice. This can be attributed to the action of the SAARI weeder which digs deeper than other designs, burying weeds and allowing greater infiltration of rainwater. It may also have a ridging effect, which may provide positive benefits for a groundnut crop. Given the variation between sites and plots in planting dates, rainfall (which was not recorded) and other factors such as soils, cultural practices, weed densities and species etc. it is not possible to attribute, with confidence, yield effects to a particular implement. In terms of time required for weeding there were differences between individual weeders with the SG2000 model performing relatively poorly but these differences were not statistically significant.

Table 11. Comparative performance of 4 weeders (groundnuts, season 1, 2001)

Implement	SAARI	AEATRI	SG2000	PLOUGH
Yield (t/ha)	2,162	1,897	1,457	1,577
Hand Weeding hr/ha	28.7	22.0	45.2	25.6
Cost of hand weeding (Ush/ha)	12,050	9,250	19,000	10,750
Gross Margin (Ush/ha)	1,348,926	1,173,561	844,691	953,910
Return/day of hand weeding labour (Ush)	191,000	233,300	81,600	162,800
Hand weeding as % of total costs/ha	8.0	6.1	11.4	7.4
Number of observations	15	11	6	15

4.2.4 Conclusions

Although the situation is much improved in Teso, compared with 6-7 years ago, in terms of the availability of oxen for land preparation, many households still rely on their neighbours for the hire of oxen. This almost certainly compromises the timing of their land preparation and planting activities as the owners of oxen will wish to prepare their own fields before hiring their animals to others. However, most households, with the exception of some poor female-headed households have access to oxen for land preparation.

The baseline survey confirmed that:

- There is a positive correlation between area cultivated and access to labour and draught animals
- Labour shortages for weeding harvesting and planting are major constraints faced by poor households in the Teso Farming System
- Almost half the land available for cultivation (owned land) is fallow indicating that there is scope for area expansion.
- Area expansion will be dependent upon access to power and labour for ploughing, weeding and harvesting
- Female headed households are less likely then male-headed households to have access to oxen for land preparation and some may have no access at all (ownership or the means to hire)
- There are differences between the Districts in access to land, labour and oxen partly caused by differences in population densities and land availability

The results from on-farm trials of weeder technology suggest that all four DAP weeders tested performed well in terms of reducing the labour and costs required for weeding sorghum and groundnuts. However, there is little evidence to suggest that DAP weeding enhances yields when compared with efficient hand weeding. Its major impact is therefore on labour use and deployment. It requires more than twice as much labour to weed a groundnut crop by hand compared with the use of DAP weeders (despite the fact that hand labour is still required to weed within the rows) and between 4 and 5 times as much labour to weed sorghum. DAP weeding therefore reduces the costs of hand weeding and increases the returns to weeding labour. Gross margins may increase also (having taken into account the cost of DAP weeding and the extra costs associated with labour use for line planting). Returns per day of family labour may of greater interest to farmers than gross margins as family labour is rarely paid and has a low opportunity cost (i.e. there are limited opportunities for alternative employment, other than working on other farms).

Most farmers will not need to make additional investments in oxen or weeders to undertake mechanised weeding. Access to oxen and ploughs (which can be adapted to perform the weeding operation) is widespread and therefore represents a cheap and appropriate solution to weed management in the Teso farming system.

The SAARI weeder may provide some yield advantages for groundnuts and further work is required in collaboration with blacksmiths or manufacturers to simplify the design and cost of this equipment.

4.3 Weed characterisation in Teso (output 2)

4.3.1 Introduction

It is widely accepted by farmers and researchers that weeds are a problem in smallholder agriculture. This is certainly true for the Teso region of Uganda. Although the weeds of East Africa have been reported and described by several authors (e.g. Ivens 1989; Terry & Michieka 1987) and Tiley (1970) published a checklist of Uganda weeds, they are not specific enough to describe the weed flora of Teso.

4.3.2 Methods

Surveys were done twice, in October 1999 at the end of the long rains season, and in November 1999 at the beginning of the short rains season. Three zones were surveyed, (a) Kumi/Pallisa District, (b) Soroti District, and (c) Katakwi District. Three sites were selected from each zone to make a total of nine sites (Table 12). At each site, weeds were surveyed at ten farms, making a total of 90 different farms.

Table 12. Zones and sites of Teso characterised in weed surveys

Zone	Site
Kumi/Pallisa	Kibale Kacede Kaler
Soroti	Abalang Pingire Obule
Katakwi	Orungo Okoritok Obur

Weed species were identified by their vernacular and/or scientific names and the numbers present in each of five randomly placed 0.11m^2 quadrats per site were determined. This made it possible to determine the frequency of occurrence of every species of weed at each farm. By aggregating the data, it was possible to determine how the occurrence of weeds was related to characteristics such as zone, site and soil type.

Weed frequencies were calculated by taking simple means of either (a) the number of quadrats in which each weed appeared, or (b) the number of farms on which each species occurred. Due to high variation between quadrats in the numbers of weeds present, actual densities were not used. Statistical analyses were done to seek associations between weeds and farms using cluster analysis and principal component analysis. Data were analysed by (a) the presence or absence of weeds on individual farms and (b) by the number of quadrats in which they were present on individual farms.

Two methods were used to determine between farm similarity matrices:

- Jacard coefficient: a/(a + b + c)
  where: a = no. of weeds present in both farms
  b, c = no. of weeds present at one farm but not another

- Ecological coefficient: 1 - [(Xi - Xj)/5]
  where: Xi = no. of quadrats in which the weed appears on one farm
  Xj = no. of quadrats in which the same weed appears on another farm

These were then subjected to cluster analyses, which are illustrated as dendrograms to reveal relationships between farms.

Principal co-ordinates analyses were also done which give orthogonal co-ordinate axes that account for the maximum variability and are illustrated by scatter plots.

4.3.3 Results

Eighty-five species of weeds were found at the sites that were sampled (4). The most comon group over all sites in October 1999 was annual broadleaved weeds (68% of the total number of species), followed by annual grasses (12%), perennial grasses (11%) and perennial sedges (7%) (Fig. 8).

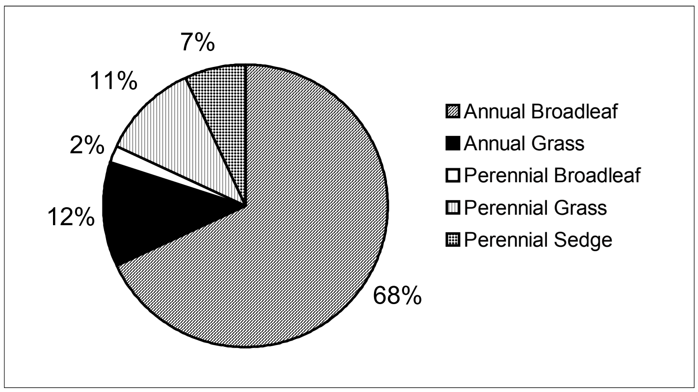


Figure 8. Relative frequency of weeds in three zones of Teso – October 1999

A similar pattern was found at the beginning of the short rains season in November 1999. Annual broadleaved weeds were the most common (61%), followed by annual grasses (23%) and perennial grasses (10%) (Fig.9).

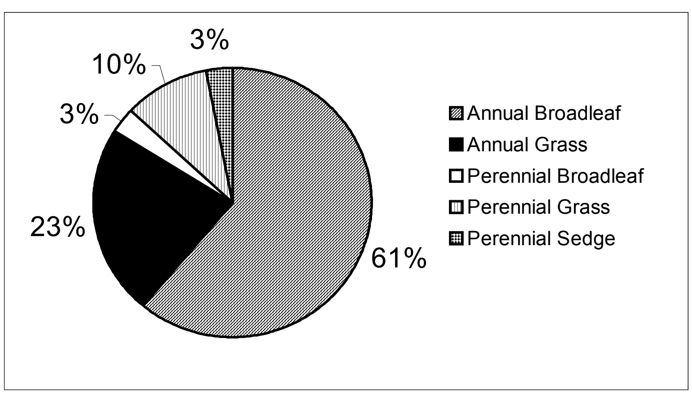


Figure 9. Relative frequency of weeds in three zones of Teso – November 1999

There was little or no difference in weed populations between zones (Figs. 10 and 11). There was an indication that perennial sedges might be more common in Kumi/Pallisa than in Katakwi but this is not statistically significant.

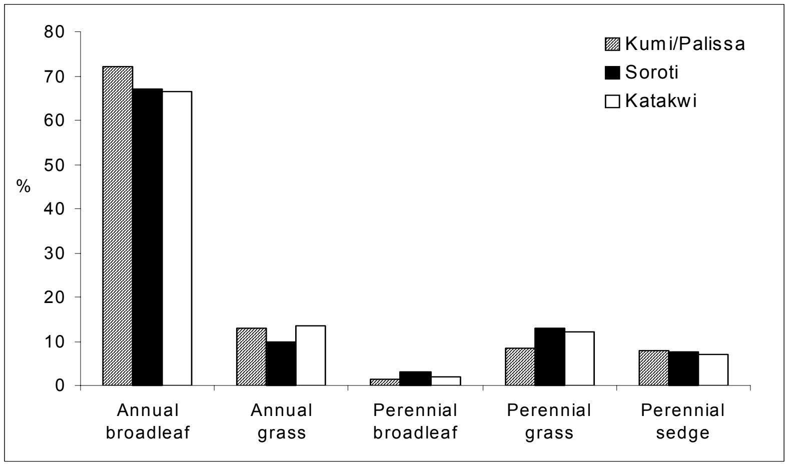


Figure 10. Relative weed distributions in three zones in October 1999

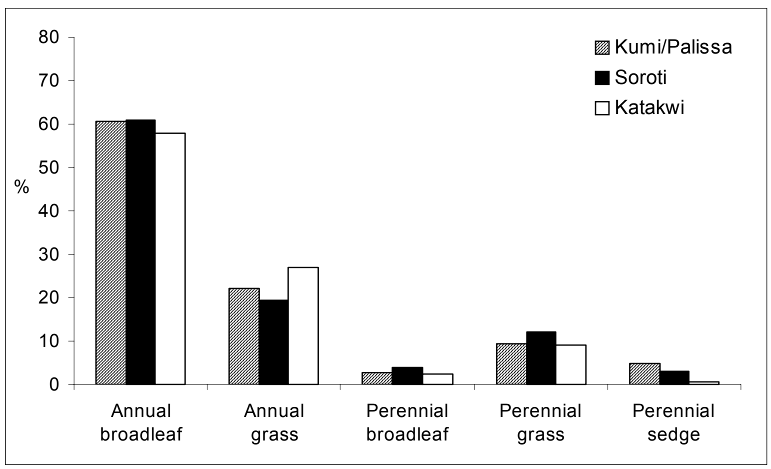


Figure 11. Relative weed distributions in three zones in November 1999

Relating weed groups to soil types, there is an indication that annual grasses might be more common on sandy soils than on loam or clay and that perennial grasses might be more common on clay soils (Fig. 12). These results were more or less as expected but they are not statistically significant.

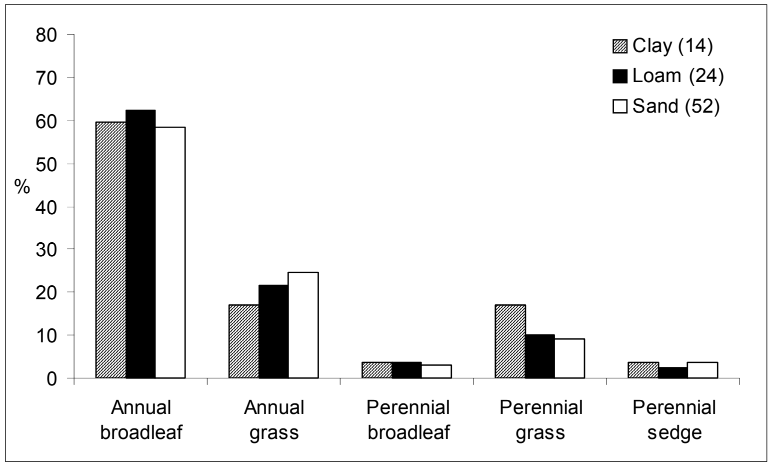


Figure 12. Relative weed distributions (%) on three soil types
(Figures in brackets = no. of sites with this soil type)

The most frequently observed weed over all sites was *Boerhavia*, occurring in 34.7% of all quadrats. *Tridax procumbens* was the commonest weed in Kumi/Pallisa Zone (60.7% of all quadrats) but *Commelina* (45.3%) was commonest in Soroti Zone and *Rottboellia cochinchinensis* (56.7%) was commonest in Katakwi Zone. The ten commonest species in each zone are given in Table 13.

Neither the cluster analysis shown in the dendrograms (Fig. 13) nor the principal co-ordinates analyses shown in the scatter plots (Fig. 14) reveal any significant differences between the weed floras at the 90 farms that were sampled. Farm no. 13 (listed at the top in figure 13a), on clay in Kibale, appears to be slightly different from other farms but little or no significance can be attached to this.

Figure 13. Cluster analysis of between farm similarity matrices using Jacard and ecological coefficients in October and November 1999

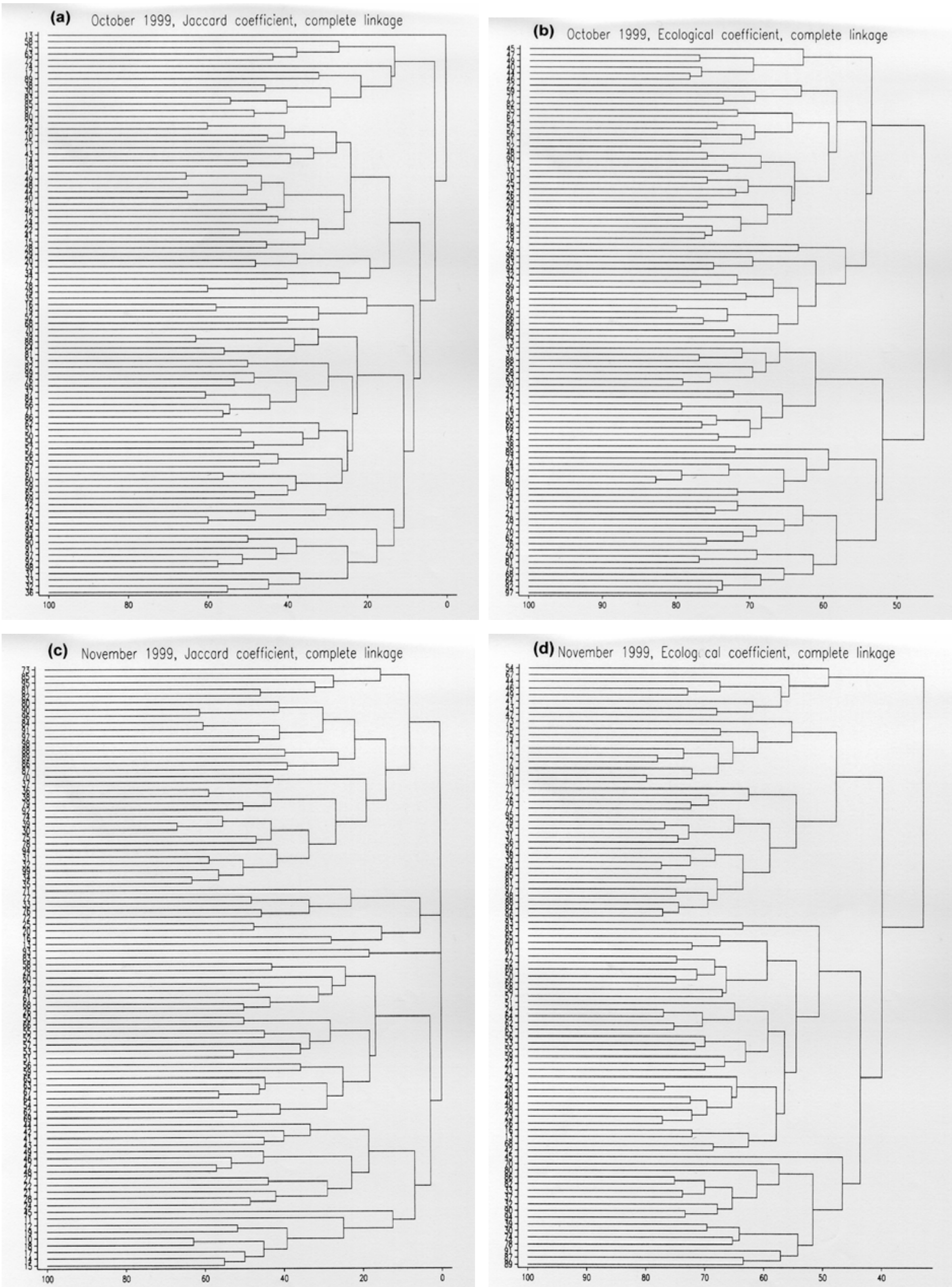


Figure 14. Principal co-ordinates analysis of between farm similarity matrices using Jacard and ecological coefficients in October and November 1999

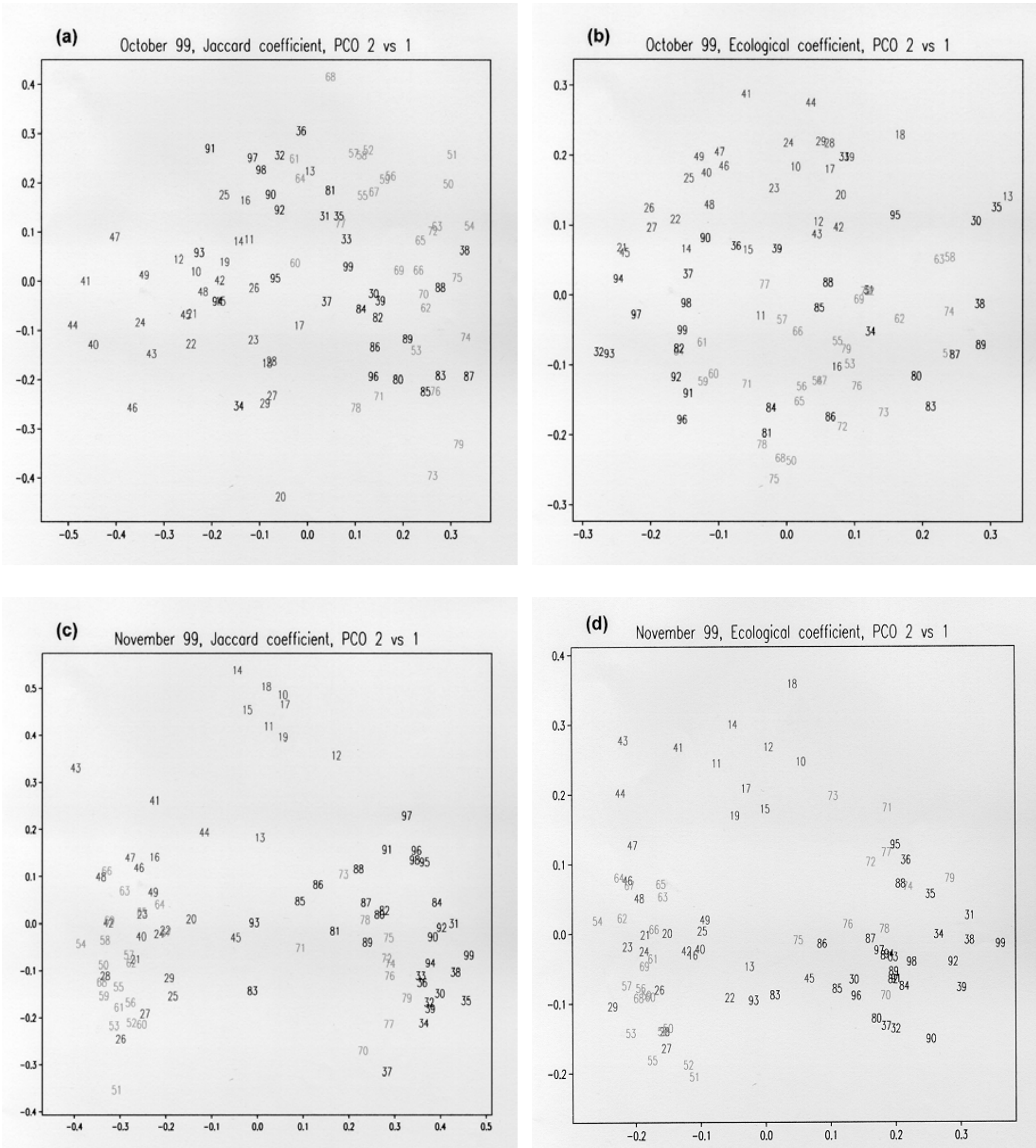


Table 13. Commonest weeds in three zones

Rank	Kumi/Pallisa	Soroti	Katakwi
1	*Tridax procumbens* (60.7)	*Commelina* spp. (45.3)	*Rottboellia cochinchinessis* (56.7)
2	*Bidens pilosa* (44.7)	*Bidens pilosa* (40.7)	*Euphorbia* spp. (46.7)
3	*Cyperus* spp. (40.0)	*Ageratum conyzoides* (37.3)	*Boerhavia* spp. (46.0)
4	*Commelina* spp. (34.7)	*Sida acuta* (35.3)	*Setaria* spp. (44.0)
5	*Cynodon dactylon* (32.0)	*Euphorbia heterophylla* (30.7)	*Dactyloctenium aegyptium* (43.3)
6	*Rhynchelytrum repens* (30.7)	*Polygonum convolvulus* (30.0)	*Trichodesma zeylanicum* (42.0)
7	*Boerhavia* spp. (30.0)	*Dactyloctenium aegyptium* (28.7)	*Cynodon dactylon* (40.7)
8	*Digitaria* spp. (26.7)	*Boerhavia* spp. (28.0)	*Oxygonum sinuatum* (40.7)
9	*Sida acuta* (26.0)	*Euphorbia hirta* (26.7)	*Ocimum* sp. (32.0)
10	'Orwa etom' (23.3)	*Digitaria* spp. (25.3)	'Otunboi' (28.7)

(Figures in brackets = % of quadrats with weed)

4.3.4 Discussion

The weed flora of Teso is very diverse with at least 85 species present, of which two thirds are annual broadleaves and one-sixth annual grasses. Perennial grasses and sedges, which are usually considered to be the most difficult weeds to control, represented about a sixth of the total species present. The weed populations found in Teso are typical of the undifferentiated floras that can be expected in smallholder farming systems. This is because there has been no selection pressures caused by agronomic practices such as repeated use of one herbicide or the growing of the same crop repeatedly on the same land over several seasons. Cluster analyses and principal component analyses do not reveal any significant differences between the weed floras of farms despite the fact that some farms are situated on clay whilst the majority are found on lighter sands and sandy loams.

Ugen & Wortmann (2001) found links between the distributions of 14 weed species and soil properties in four districts of Uganda, including Pallisa district. They noted that relative densities of some weeds were associated with soil nutrient status. For example*, Digitaria abyssinica* and *Euphorbia hirta* were associated with low soil nutrient levels, *whilst Eleusine indica* and *Oxalis latifolia* were associated with higher nutrient levels.

It would be reasonable to anticipate that differences exist between hand weeders and animal draught weeders in their abilities to control weeds. For example, draught animal equipment may fragment and disperse the rhizomes of perennial grasses (such as *Digitaria abyssinica*) and sedges (such as *Cyperus rotundus*) to a greater extent than hand weeding with a hoe, where intact rhizome systems can be removed from the field and destroyed. It is probable that some weeding equipment would be better than others at removing different types of weeds. If so, this could dictate which equipment is most appropriate for use at a particular site.

By characterising sites, the performances of weeders can be ascertained over an extended period, aiding decisions on how best to control the weeds on farms in Teso.

4.4 The technical efficiency of hand and DAP weeding (output 3)

4.4.1 On-farm trials

On-farm trials were conducted to test the technical efficiency of 4 different weeders in terms of weed densities (before and after weeding), crop yield, weeder performance and weeding efficiency.

4.4.2 Methods

The trials were conducted on seven farms at each of nine sites: Abalang, Kachede, Kaler, Kibale, Koritok, Obule, Obur, Orungo, and Pingire. Groundnuts and sorghum were sown during the second and first seasons, respectively, in 2000 and 2001. The SAARI weeder was compared with farmers' practice of hand weeding in the second season of 2000; SAARI, AEATRI and SG2000 weeders were compared with ploughs (with the mouldboard removed) and the farmers' practice of hand weeding in the first season of 2001.

Each participating farmer had two experimental plots; one plot received traditional hand weeding, the other was weeded by one of the DAP weeders. Plots were oriented to fit the size of the field and had an average area of 600 m^2. Weeders were distributed to farmers throughout the trial areas, thereby ensuring that each model of weeder was exposed to a range of soils and weeds. In 2001, this allowed each weeder to be evaluated on between nine and 16 farms.

The crops were weeded twice. Data were collected from each farm on weeds, crop yields and weeder performance. A quadrat measuring 33cm x 33cm (0.11 m^2) was used for weed data collection. The quadrat was randomly thrown ten times in each plot and the weeds inside the quadrat were counted. Weeds were categorised as perennial grasses, annual grasses, sedges and broad-leafed annuals. Aerial parts of weeds in each quadrat were collected, bulked for each plot and dry weights were determined. Efficiencies of the different methods of weeding were calculated using the formula:

$$\textit{Weeding efficiency (\%)} = [(W_0 - W_1)/W_0] \times 100$$

Where: W_0 = weed density immediately before weeding
W_1 = weed density immediately after weeding

The whole plot was harvested and farmers retained the harvest after drying and threshing. All data were subjected to statistical analysis using ANOVA.

4.4.3 Results

In 2000, throughout the nine sites, the category of weeds with the highest population was the annual broadleafed species (Fig. 15).

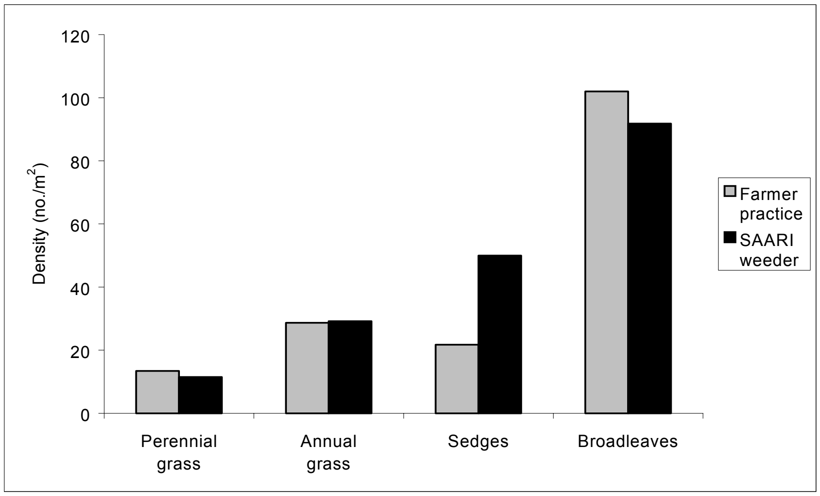


Figure 15. Weed densities on farms at 2nd weeding in 1st season 2000

The SAARI weeder was very effective in controlling annual weeds. By contrast, the farmers' practice of hand-weeding was better for controlling perennial grasses and sedges because of the reproductive parts were pulled out of the soil by hand. The mean weeding efficiency of the SAARI weeder determined from 17 farms was 74.2% (SD ± 17.3).

In 2001, weed densities and dry weights were collected from 47 of the 63 farms. As there were different numbers of farms for each weeder type, different SEDs applied, depending on which comparison was made. In Tables 14, 15 and 16 below, the standard deviation (SD) is given, along with minimum and maximum SEDs: these have been calculated for comparing the two means with the highest number of farms and those with the lowest number of farms, respectively. For example, in Table 14, the minimum SED is for comparing Plough (11 farms) and SAARI weeder (14 farms), and the maximum SED is for comparing the AEATRI and SG2000 weeders (both on 9 farms). The overall between DAP variance ratio F-prob is also given.

1st weed assessment on farms in 2001

There is no evidence of any difference in the weed density and dry weight (compared to farmer practice) between weeders, neither is any difference from farm practice significantly different from zero (Table 14). No differences of statistical significance were found for weeding efficiency.

Table 14. Mean weed density, dry weight and weeding efficiency on farms at the time of the first weeding

DAP weeder	No. of farms	Weed density (no./m^2)			Weed dry weight (g/m^2)			Weeding efficiency (%)
		Farmer practice (FP)	DAP weeder	Difference (FP-DAP)	Farmer practice (FP)	DAP weeder	Difference (FP-DAP)	
AEATRI	9	204.6	185.6	19.0	37.2	49.0	-11.8	77.3
Plough	11	179.7	173.5	6.2	37.1	33.9	3.2	74.7
SAARI	14	303.2	299.9	3.3	47.5	38.7	8.8	84.5
SG2000	9	267.5	291.5	-24.0	61.4	53.1	8.4	77.4
s.d. (39 df)				80.0			27.1	15.4
Min SED				32.2			10.9	6.2
Max SED				37.7			12.8	7.3
F-prob				0.710			0.311	0.426

2nd weed assessment on farms in 2001

Again, there is no evidence of any difference in the weed density and dry weight (compared to farmer practice) between weeders, neither is any difference from farm practice significantly different from zero at the time of the second assessment (Table 15). However, the weeding efficiency of the AEATRI weeder was significantly lower than the other three weeders. When the means for all weeders and the plough are combined (Fig. 16), they do not differ significantly from farm practice and there is no evidence of hand weeding being better against sedges as shown in 2000 (Fig. 15).

Table 15. Mean weed density, dry weight and weeding efficiency on farms at the time of the second weeding

DAP weeder	No. of farms	Weed density (no./m^2)			Weed dry weight (g/m^2)			Weeding efficiency (%)
		Farmer practice (FP)	DAP weeder	Difference (FP-DAP)	Farmer practice (FP)	DAP weeder	Difference (FP-DAP)	
AEATRI	11	125.7	142.3	-16.6	41.6	52.8	-11.2	66.0
Plough	11	164.5	178.1	-13.6	32.4	39.3	-7.1	88.3
SAARI	15	205.8	171.7	34.1	42.4	40.2	2.2	88.8
SG2000	9	190.5	196.7	-6.2	43.8	61.1	-17.3	85.9
s.d. (42 df)				81.6			50.2	14.5
Min SED				32.4			19.9	5.8
Max SED				36.7			22.6	6.5
F-prob				0.349			0.813	0.001

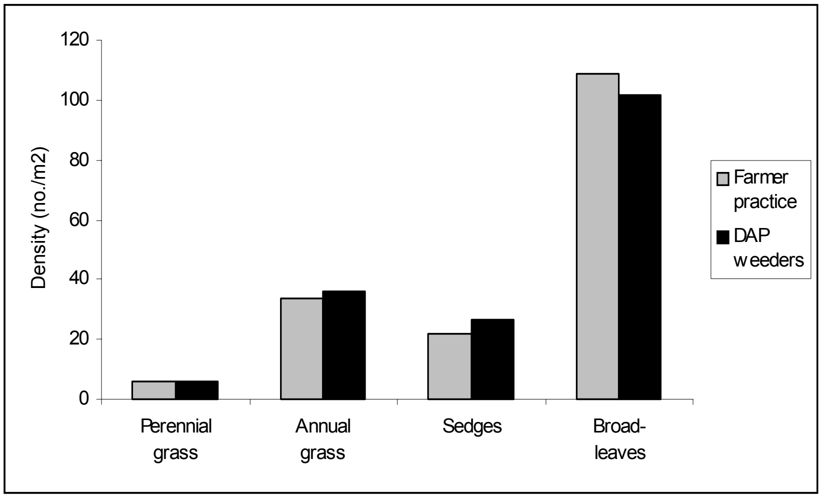


Figure 16. Weed densities on farms at 2nd weeding in 1st season 2001

Weed assessment at harvest on farms in 2001

There is no evidence of any difference in effect for weed density but there is a slight indication that the SAARI weeder gave a lower weed dry weight than the farmer practice (Table 16).

Weeding efficiencies of DAP weeders

The weeding efficiencies of the plough and three weeders ranged from 74.7 to 84.5% at the first weeding (Table 14) but were not significantly different from each other. At 66.0%, the weeding efficiency of the AEATRI weeder was significantly lower than the others, which ranged from 85.9 to 88.8% at the second time of weeding (Table 15).

Table 16. Mean weed density and dry weight on farms at the time of harvest

DAP weeder	No. of farms	Weed density (no./m^2)			Weed dry weight (g/m^2)		
		Farmer practice (FP)	DAP weeder	Difference (FP-DAP)	Farmer practice (FP)	DAP weeder	Difference (FP-DAP)
AEATRI	12	73.0	75.4	-2.4	31.2	35.3	-4.1
Plough	13	67.7	72.2	-4.6	31.7	38.2	-6.5
SAARI	16	81.7	76.0	5.8	53.7	30.4	23.3
SG2000	9	126.0	136.3	-10.3	64.3	68.6	-4.3
s.d. (42 df)				42.2			39.4
Min SED				15.8			14.7
Max SED				18.6			17.4
F-prob				0.349			0.145

4.4.4 Discussion and conclusions

On farms, there were few statistically significant differences in total densities and dry weights of weeds between DAP weeders and hand weeding. This suggests that overall there is little or no practical difference between hand weeding and DAP weeders. The weeding efficiency of the AEATRI weeder was significantly lower than the other weeders at the time of the second weeding but this was not evident at the first weeding and must, therefore, cast some doubt as to whether there is any real difference. The SAARI weeder appeared to give the highest weeding efficiency at both times but this was not statistically significant. In conclusion:

- DAP weeders are a practical and effective alternative to hand weeding for controlling weeds.
- Judged solely in terms of weed control, there is little or no difference between the weeders.
- Farmers could use a plough (with the mouldboard removed) to control weeds as it performs just as well as the AEATRI, SAARI and SG2000 weeders. This being so, it is questionable as to whether farmers need to invest in specialised weeders when they can obtain satisfactory results from simply modifying ploughs.
- Weed control is not the only parameter by which to judge the performance of DAP weeders; labour inputs, crop yields and cost/benefits are important considerations for farmers (see section 4.2.3).

4.4.5 On-station trials

In addition to trials on farmers' fields, complementary evaluations of weeders were undertaken at technology verification centres (TVCs) at Kaberamaido and Bukedea and on the research station at SAARI. Bukedea TVC represented the light sandy soils while Kaberamaido TVC represented the heavy clay loam soils of the Teso Farming System. By working on the TVCs it was possible to compare several weeders at the same site using replicated plots and make more detailed assessments than were possible on farms.

4.4.6 Methods

Groundnuts var. '*Igola 1*' and sorghum were sown in the first and second seasons of 2000, respectively, at Kaberamaido and Bukedea TVCs. Groundnuts were sown in the first season of 2001 at Kaberamaido TVC and SAARI research station. A completely randomized block design was used and each plot measured 15m x 8m, except for SAARI research station where the plots measured 6m x 4m.

In the first season of 2000, SAARI and Cossul weeders and ploughs without mouldboards were tested and compared with the typical farmer practice of hand weeding. In the second season, the AEATRI weeder was used instead of the plough. Weeding was done once or twice with each DAP weeder. In the first season of 2001, the AEATRI, SAARI and SG2000 weeders were tested in the same way.

Weed densities were assessed by counting the weeds present in ten randomly placed, 33cm x 33cm (0.11 m^2) quadrats three times: immediately before the first and second weedings and just before harvest. Every species of weed was counted, unlike the on-farm trials where weeds were grouped into categories (annual grasses, broadleaves, etc.). Aerial parts of the weeds were removed, dried and weighed to determine the biomass present. Immediately after weeding had taken place, a single 100 x 100cm (1 m^2) quadrat was placed on the plot to record the total number of weeds remaining, i.e. with viable parts visible on the soil surface. Using weed densities pre- and post weeding, it was possible to determine the weeding efficiency of each weeder using the formula:

$$\textit{Weeding efficiency (\%)} = [(W_0 - W_1)/W_0] \times 100$$

Where W_0 = weed density immediately before weeding
and W_1 = weed density immediately after weeding

Data from the TVCs and SAARI research station were statistically analysed separately for each site using ANOVA.

4.4.7 Results

First season 2000 at Kaberamaido and Bukedea TVCs
Weed densities and dry weights recorded immediately before the first weeding do not indicate treatment effects, except for determining weeding efficiencies of the DAP weeders. Weed densities and dry weights immediately before the second weeding and at harvest are shown in Tables 17 and 18. No significant differences were found between any of the weeding treatments. There was an indication that weed densities at harvest were lower with two weedings than with one at Bukedea (Table 17) but this was not evident at Kaberamaido, nor was it statistically significant.

Table 17. Weed densities and dry weights before second weeding and weed density before harvest at Bukedea TVC in the first season of 2000

Weeder	No. of Weedings	Density at 2^{nd} weeding (no./m^2)	Dry wt at 2^{nd} weeding (g/m^2)	Density at Harvest (no./m^2)
Cossul	1	3.56	1.71	4.43
Cossul	2	-	-	2.53
Plough	1	2.98	1.42	8.17
Plough	2	-	-	4.00
SAARI	1	7.41	1.64	6.03
SAARI	2	-	-	3.63
Hand	1	6.22	0.72	-
Hand	2	-	-	3.83
SED		3.343	1.066	1.919
LSD		NS	NS	NS

Table 18. Weed densities and dry weights before second weeding and weed density before harvest at Kaberamaido TVC in the first season of 2000

Weeder	No. of Weedings	Density at 2nd weeding (no./m^2)	Dry wt at 2nd weeding (g/m^2)	Density at harvest (no./m^2)
Cossul	1	5.08	2.01	8.07
Cossul	2	-	-	6.87
Plough	1	5.75	1.42	8.63
Plough	2	-	-	8.83
SAARI	1	5.61	1.64	8.57
SAARI	2	-	-	8.83
Hand	1	9.58	0.98	-
Hand	2	-	-	7.40
SED		1.429	1.105	3.322
LSD		NS	NS	NS

Weeding efficiencies of the Cossul and SAARI weeders and the plough (with mouldboard removed) varied from 72% to 87% during the 1st and 2nd weedings at Bukedea and Kaberamaido but no significant differences between the DAP weeding equipment could be seen (Table 19).

Table 19. Weeding efficiencies (%) for control of all weeds by Cossul and SAARI weeders and by plough (without mouldboard) at Bukedea and Kaberamaido TVCs in the 1st season of 2000

Weeder	Bukedea		Kaberamaido	
	1st weeding	2nd weeding	1st weeding	2nd weeding
Cossul	78.8	80.8	83.6	76.2
Plough	72.0	83.0	87.3	82.8
SAARI	85.2	80.0	77.9	80.0
SED	5.63	11.09	9.19	3.33
LSD	NS	NS	NS	NS

Second season 2000 at Kaberamaido and Bukedea TVCs

Weed densities and dry weights immediately before the second weeding and at harvest are shown in Tables 20 and 21. As in the first season of 2000, no significant differences were observed between any of the weeding treatments.

Table 20. Weed densities before second weeding and weed densities and dry weights before harvest at Bukedea TVC in the second season of 2000

Weeder	No. of Weedings	Density at 2^{nd} weeding (no./m^2)	Dry wt at 2^{nd} weeding (g/m^2)	Density at harvest (no./m^2)	Dry wt at harvest (g/m^2)
AEATRI	1	26.70	No data	26.40	88.80
AEATRI	2	-	-	18.70	81.20
Cossul	1	17.00	No data	27.00	128.80
Cossul	2	-	-	22.20	97.70
SAARI	1	16.70	No data	19.90	55.70
SAARI	2	-	-	17.90	33.70
Hand	1	14.20	No data	-	-
Hand	2	-	-	16.70	35.60
SED		6.780		6.170	41.70
LSD		NS		NS	NS

Table 21. Weed densities and dry weights before second weeding and harvest at Kaberamaido TVC in the second season of 2000

Weeder	No. of Weedings	Density at 2^{nd} weeding (no./m^2)	Dry wt at 2^{nd} weeding (g/m^2)	Density at harvest (no./m^2)	Dry wt at harvest (g/m^2)
AEATRI	1	10.73	16.90	12.30	67.30
AEATRI	2	-	-	15.80	39.30
Cossul	1	12.60	24.40	16.50	57.30
Cossul	2	-	-	20.30	38.80
SAARI	1	11.47	31.20	13.80	73.60
SAARI	2	-	-	11.30	53.30
Hand	1	6.80	9.00	-	-
Hand	2	-	-	9.90	78.60
SED		5.150	15.420	7.060	30.350
LSD		NS	NS	NS	NS

No individual weed species were present in sufficient density to determine differences between weeders. Aggregating weeds into annuals and perennials was done but no significant differences between weeders were found (data not presented).

The efficiencies of weeding annual and perennial weeds were determined at the first and second times of weeding at Bukedea and Kaberamaido TVCs (Tables 22 and 23). For perennial weeds, hand weeding was more efficient than the AEATRI weeder at three times, the SAARI weeder was more efficient than the AEATRI weeder twice and the Cossul weeder was more efficient once. The only significant difference for annual weeds was at the first weeding in Bukedea when hand weeding was better than the AEATRI weeder (Table 22).

The efficiencies of all weeders over the first and second seasons of 2000 are graphically summarised in Figure 17. The trend indicates that the AEATRI weeder gives the least efficient weed control but there is little or no difference between the Cossul and SAARI weeders, the plough (without mouldboard) and hand weeding.

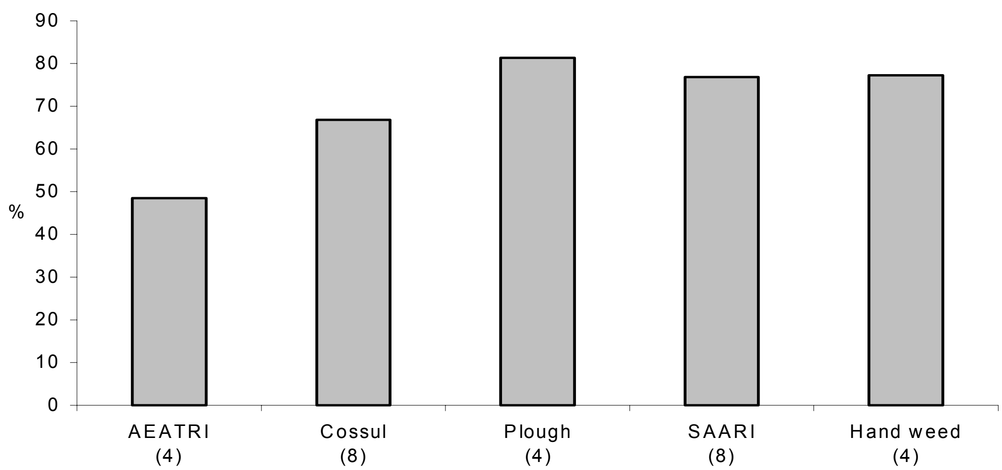
Table 22. Weeding efficiencies (%) for control of annual, perennial and all weeds by AEATRI, Cossul and SAARI weeders at Bukedea TVC in the 2nd season of 2000

Weeder	1st weeding			2nd weeding		
	Ann	Per	All	Ann	Per	All
AEATRI	46.7	36.5	31.5	63.4	37.0	44.7
Cossul	68.3	69.8	64.9	50.1	38.2	43.7
SAARI	71.5	74.6	55.6	93.6	59.0	90.7
Hand weed	90.1	88.4	85.8	73.6	86.0	74.1
SED	15.37	11.68	23.9	15.45	9.65	16.6
LSD	33.48	25.44	NS	NS	23.62	NS

Table 23. Weeding efficiencies (%) for control of annual, perennial and all weeds by AEATRI, Cossul and SAARI weeders at Kaberamaido TVC in the 2nd season of 2000

Weeder	1st weeding			2nd weeding		
	Ann	Per	All	Ann	Per	All
AEATRI	78.9	59.8	65.8	88.6	27.2	51.9
Cossul	94.8	28.8	50.3	67.5	43.0	56.3
SAARI	92.7	62.5	72.7	64.4	64.8	72.2
Hand weed	77.9	69.1	72.2	85.3	72.4	76.7
SED	16.46	22.7	12.47	18.97	9.10	7.77
LSD	NS	NS	NS	NS	22.26	19.01

Figure 17. Weeding efficiencies of DAP weeders and hand weeding averaged



over the number of times they were evaluated in the 1st and 2nd seasons of 2000 at Bukedea and Kaberamaido TVCs
(Figures in brackets = no. of assessments)

First season 2001 at Kaberamaido TVC and SAARI research station
The overall trend was for hand weeding to give lower weed densities and dry weights than the DAP weeders (Tables 24 and 25). However, differences were generally not significant except for harvest at SAARI research station when hand weeding produced significantly

lower weed densities than one or two weedings by the Cossul, one weeding by the SAARI and two weedings by the SG2000 weeders (Table 25).

Table 24. Weed densities and dry weights before second weeding and harvest at Kaberamaido TVC in the first season of 2001

Weeder	No. of Weedings	Density at 2^{nd} weeding (no./m^2)	Dry wt at 2^{nd} weeding (g/m^2)	Density at harvest (no./m^2)	Dry wt at harvest (g/m^2)
AEATRI	1	17.00	36.00	43.30	0.205
AEATRI	2	-	-	31.10	0.227
SAARI	1	15.10	21.00	44.60	0.177
SAARI	2	-	-	34.20	0.205
SG2000	1	17.70	12.70	29.60	0.154
SG2000	2	-	-	25.20	0.149
Hand	1	8.70	10.30	-	-
Hand	2	-	-	17.60	0.109
SED		4.52	7.460	10.60	0.0634
LSD		NS	NS	NS	NS

Table 25. Weed densities and dry weights before second weeding and harvest at SAARI in the first season of 2001

Weeder	No. of Weedings	Density at 2^{nd} weeding (no./m^2)	Dry wt at 2^{nd} weeding (g/m^2)	Density at harvest (no./m^2)	Dry wt at harvest (g/m^2)
AEATRI	1	37.30	68.00	25.80	0.237
AEATRI	2	-	-	23.50	0.105
SAARI	1	46.30	89.20	28.20	0.148
SAARI	2	-	-	21.90	0.131
SG2000	1	61.20	126.40	15.50	0.130
SG2000	2	-	-	23.10	0.141
Hand	1	38.00	61.50	-	-
Hand	2	-	-	13.50	0.139
SED		10.640	44.500	3.970	0.0436
LSD		NS	NS	8.660	NS

4.4.8 Discussion and conclusions

In terms of weed densities and dry weights, the overall impression from tests in three seasons is that there are no significant differences between hand weeding, a plough without the mouldboard and four different DAP weeders. There are, however, significant differences in weeding efficiencies, with the AEATRI weeder being least effective. In the second weeding, first season 2001, all the weeding methods (AEATRI weeder, SAARI weeder, SG 2000 and hand hoe) investigated returned higher efficiencies at the Kaberamaido TVC than at the SAARI TVC. The AEATRI weeder was the least efficient (n.s.) at both TVC sites and the difference between the sites was more marked for the AEATRI weeder. The poorer performance of the AEATRI weeder may be attributable to its relatively low penetration into the soil (see section 4.4.9) and to the shape of its tines. Several users have observed that the narrow tines on the AEATRI weeder leave some weeds untouched (Barton, 2002). A number of small deficiencies in the AEATRI weeder, which may not be individually significant, seem to have combined to give a significantly poorer overall performance.

The type of soil may also be a contributory factor to the different levels of performance at the TVCs (and, indeed, on-farm) but no data are available to examine this possibility in greater detail.

DAP weeders are a practical and effective alternative to hand weeding for controlling weeds. Judged solely in terms of weed control, there is little or no difference between the weeders. However, weed control is not the only parameter by which to judge the performance of DAP weeders; labour inputs, crop yields and cost/benefits are important issues that have been addressed by the project.

4.4.9 Technical assessment of weeder performance

The technical performance of weeders were assessed using a variety of parameters. For the weeder itself, the key parameters are depth and width of work and weeding efficiency. For the animal-implement system, additional key parameters are draught requirement, speed of work and field capacity. Draught requirement is mainly influenced by tine design but can also be affected by the hitching arrangement so, strictly speaking, should be considered as a system parameter. System parameters in different soil types and different types of weed infestation should also be considered before general recommendations on weeder design can be made.

Taking as an example the combined results of the first and second weedings of the first season in 2001, the technical performance of the four main weeding implements tested on-farm has been compared. Only five of the six parameters listed above have been compared as there were insufficient draught force data.

Depth of work
The average depths of working during the first and second weedings are given in Fig. 18. The SAARI and ox-plough results are almost identical. This is attributed to the rigidity of the tines for SAARI weeder and the non-flexing bottom of the ox-plough. In contrast, the AEATRI and SG2000 weeders work slightly more shallowly. This may be because of the flexible nature of the tine supporting elements, which allow the tines to yield when encountering deeper, and usually less penetrable soil. The AEATRI and SG2000 weeders perform adequately in light sandy soils, but the SAARI weeder and ox-plough may be better suited to the heavier, more clayey soils.

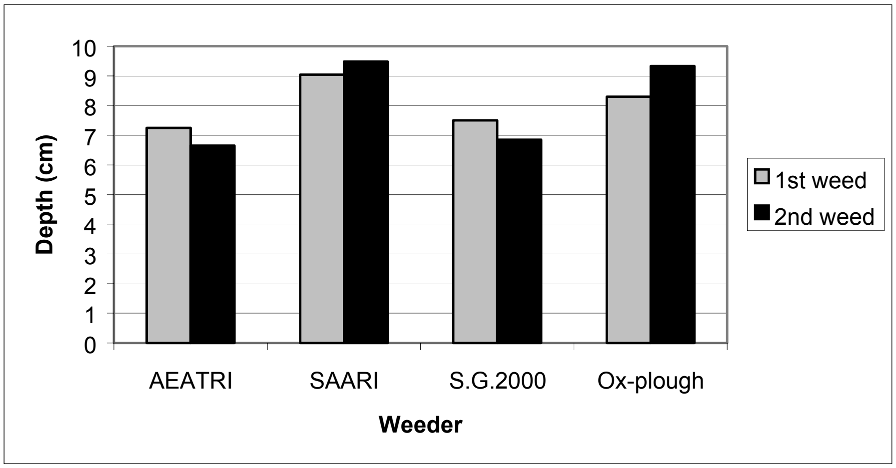


Figure 18. Average depth of work (cm)

Width of work
The average widths of working during the first and second weedings are given in Fig. 19. The greatest working width was achieved by the SG2000 weeder, although the differences between weeders were very small and unlikely to be statistically significant. The slightly narrower result for the ox-plough is attributed to the fact that the share is fixed and there is no scope for adjustment.

The SAARI and AEATRI weeders give very similar results as they can both be adjusted for rows not more than 60cm apart, enabling effective performance. The SG2000 weeder has a wider range of adjustment, making it more suitable for crops such as sunflower, cassava, maize, cotton etc.

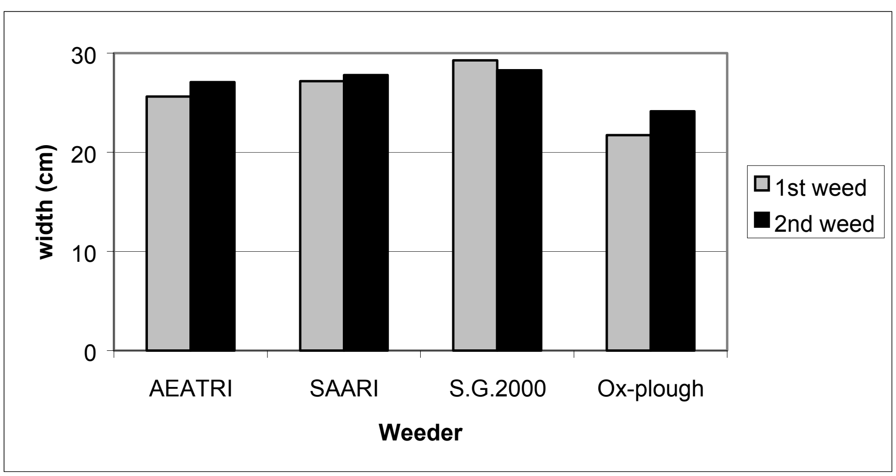


Figure 19. Average width of work (cm)

Speed of work
The average speeds of working during the first and second weedings are given in Fig. 20. Considering both weedings, the SAARI weeder works slightly faster than the other weeders. This may be attributable to its rigidity and stability during work. The lower working speed of the AEATRI weeder may be due to the stoppages that occurred when attending to the maintenance and adjustment needs of this weeder.

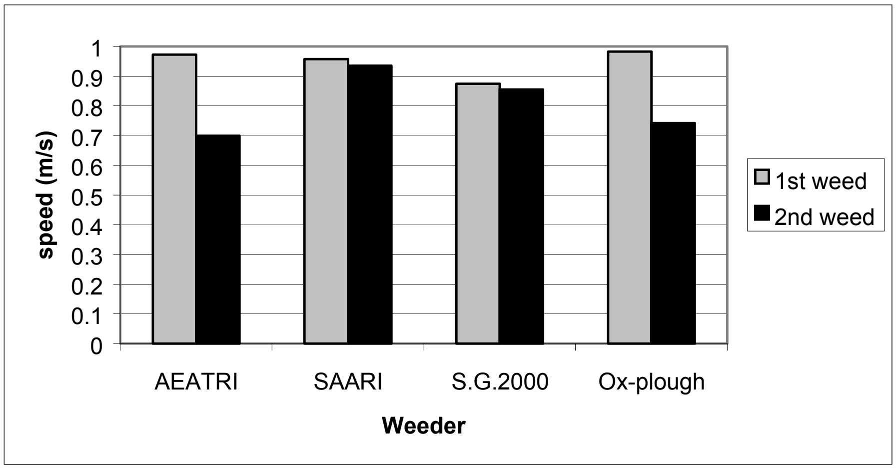


Figure 20. Average speed of work (m/s)

Field capacity
The average field capacities during the first and second weedings are given in Fig. 21. The higher field capacity of the SAARI weeder is attributed to its greater stability and rigidity that the other weeders. The relatively low field capacity of the SG 2000 may be due to its heavy weight and the stoppages caused by problems of slackening and failing of the spring tine supports.

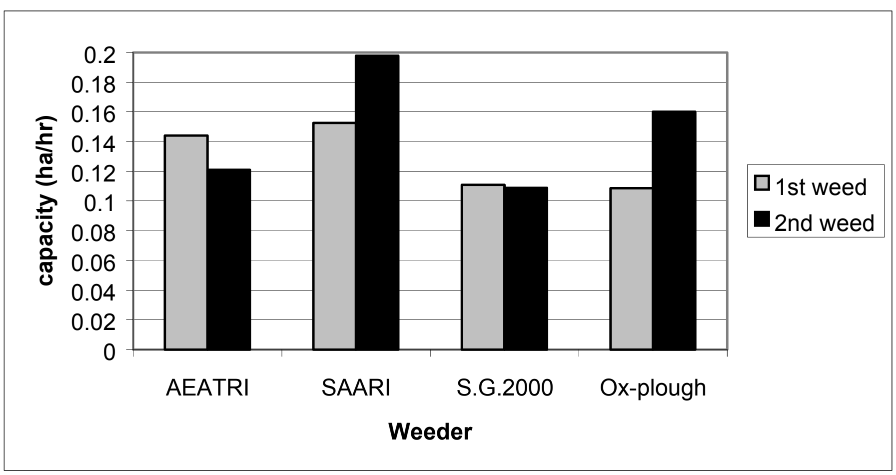


Figure 21. Field capacity (ha/hr)

Discussion

The relative performance of the weeders for each of these parameters for the two seasons is summarised in the Fig. 22. In all but two cases, the AEATRI weeder was out-performed by the other implements, and consistently so by the SAARI weeder.

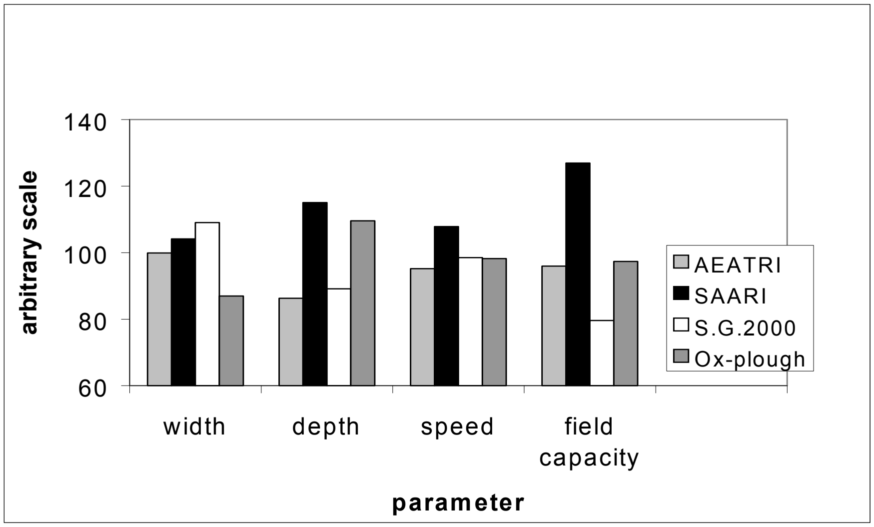


Figure 22. Relative performance of weeders (4 parameters)

4.4.10 Farmers' assessment of technology

Following on-farm field trials male and female farmers were invited to share their experience of the use of DAP weeders with the research team. A PRA methodology (matrix scoring) was used in 9 locations (on-farm trial sites) with a total of 56 male and female farmers. The efficiency of each weeder was assessed against the attributes in the first column in Table 26[7]. Participants assigned scores ranging from 1 to 10 to each weeder for each attribute with maximum of 10 points for very good and 1 for very poor. This gave an indication of the relative merits of each type of weeding implement. When measuring the damage done to the crop by weeders those machines which did most damage scored less points and vice-versa. The results from the 9 sites are summarised in Table 26.

[7] These parameters were developed and adopted during a participatory exercise with the farmers at one of the sites.

Table 26. Average scores for each weeder

	SAARI	AEATRI	SG2000	Plough	F-prob
1 – Removal of grass weeds	7.67	4.44	7.22	5.56	<0.001
2 – Removal of broadleaved weeds	7.00	4.56	7.67	6.11	0.042
3 – Comfort	6.89	7.00	7.22	6.56	0.924
4 – Damage to crops	6.22	2.44	4.67	5.11	0.008
4 – Speed of work	7.67	4.67	7.22	5.89	0.009
4 – Ease of adjustment	6.11	5.00	7.89	6.78	0.018
7 – Ease of transport	6.44	3.44	6.33	8.67	<0.001
8 – Durability and strength	8.11	3.78	7.67	8.67	<0.001
9 – Ease of cleaning	6.89	4.00	7.00	8.89	<0.001
10 – Availability of spare parts	7.89	2.44	4.56	9.78	<0.001

An analysis of variance was carried out on each of the 10 scored attributes. The residual variability is similar for all attributes except no. 9 (ease of cleaning), where it seems rather lower than for other attributes – probably indicating greater agreement amongst farmers. The differences between weeders is highly significant, with the Plough rated higher than SAARI & SG2000, and AEATRI much lower than the rest. AEATRI has the lowest rating for all attributes except no. 3 (comfort), where there is no evidence of any differences between all four weeders. SAARI and SG2000 are rated significantly higher than the Plough for just one attribute - no. 1 (removal of grass weeds) and significantly lower than Plough for attributes 7 (ease of transport), 9 (ease of cleaning) and 10 (availability of spare parts). The only attributes for which there are significant differences between SAARI and SG2000 are no. 6 (ease of adjustment), where there is slight evidence of SG2000 scoring more highly, and no. 10 (availability of spare parts), where SAARI gets a much higher rating.

Conclusions

From the farmers perspective it is clear that:

- The plough, SAARI, SG2000 are the preferred weeders while AEATRI is the least preferred
- SAARI and SG2000 are the best at removing grasses and broad-leaved weeds
- SG2000 is the most comfortable tool to work with and the easiest to adjust
- AEATRI does the most damage to crop plants and has the slowest work rate
- SAARI and SG2000 have the fastest work rates
- The plough is the easiest to clean and maintain and the most durable implement
- Spare parts are available for the ox-plough and to a lesser extent the SAARI weeder but are scarce for the SG2000 and AEATRI weeders.

4.4.11 Planter design

The main criteria for design arrived at by relevant members of the project team are summarised in Table 27. The involvement of SAIMMCO (Soroti Agricultural Implement and Machinery Manufacturing Company), a local manufacturer, was anticipated in the project proposal and the design criteria were also agreed with a SAIMMCO (production) engineer.

The resulting implement is shown in figure 23. It was tested at SAARI (following recommendations by Smith *et al*, 1994) and its performance compared to that of an Italian made planter (double row), which was tested in an adjacent plot. The Italian planter, which is shown in fig 24, was available at SAARI but was deemed unsuitable (too complicated, not reliable enough) for use by the Teso farmers.

Table 27. Criteria for prototype planter design

Feature	Reason

As an attachment to SAIMMCO plough	$ no need for completely separate implement
	$ most farmers have SAIMMCO ploughs
	$ easier for SAIMMCO to fabricate

Single-row planter	$ simplicity
	$ low cost
	$ introduce basic idea to farmers for them to develop, if they wish (PTD)

Design for groundnuts only	$ farmers will be planting this crop next (April)
	$ seed size easily manageable
	$ avoids immediate complication of accommodating different seed sizes (this can be the subject for further development, if design has potential)

Seeds metered via ground contact	$ speed of seed deposition too high for human application (one seed every 15 cm at 0.9 m/s is 6 seeds per second) $ accommodates variable speed of draught animals
Use rolling drum	$ direct ground contact, so need for drive mechanism avoided $ SAIMMCO can easily fabricate
Use narrow tine as coulter (to open furrow)	$ simple, well-established technology
Use drag chain to close furrow	$ simple, well-established technology

Figure 23. Prototype planter designed by the project

Figure 24. Italian planter (double row)

In the short time available, only very limited testing was possible. The project planter was tested over 6 rows of 41 m length and the Italian planter was tested over 7 rows 69.1 m in length. The comparative results, based on ten operating parameters, are summarised in Table 28.

Table 28. Planter performance for selected operating parameters

Parameter	**Project Planter**	**Italian Planter**
Average inter-plant spacing (cm)	12.1	12
Average inter-row spacing (cm)	45	44.7
Time taken to plant plot (min)	18	20
Area per hour (m^2/h)	304	560
Overall planting efficiency[81] (%)	91	55
Evidence of crushed seed	nil	nil
Ease of operating	easy and stable	easy
Ease of turning	slightly heavy	quite difficult
Ease of adjusting	simple	easy
Weight	slightly heavy	light

These results indicate that the project planter operated effectively and that further testing and development would be warranted.

[8] Plant population after germination/expected plant population x100

4.5 Specific advice on the use of draught animal equipment for weed management (output 4 and 5)

4.5.1 Major findings

This research has established that:

- Labour shortages for weeding harvesting and planting are major constraints faced by poor households in the Teso Farming System
- There is scope for area expansion in Teso but this will be dependent upon access to power and labour for ploughing, weeding and harvesting
- Female headed households are less likely then male-headed households to have access to oxen for land preparation
- The weed flora of Teso is diverse
- Weed characterisation of sites will allow the performances of different designs of weeders to be ascertained over an extended period
- All four DAP weeders tested performed well in terms of reducing the labour and costs required for weeding sorghum and groundnuts.
- DAP weeding reduces the costs of hand weeding and increases the returns to weeding labour.
- Gross margins may increase with DAP weeding
- Returns per day of family labour increase with DAP weeding
- DAP weeding is a technically efficient means of managing weeds for sorghum and groundnuts in the Teso Farming System
- Judged solely in terms of weed control (weeding efficiency), there is little or no difference between the 5 weeders tested
- The SAARI weeder performed best for weeding of groundnuts both in terms of yields and removal of problematic perennial grass weeds
- The plough with its mouldboard removed works reasonably well as a weeder and provides an alternative to handweeding for all farmers who have access to this implement (i.e. the majority)
- The capital costs required to adopt DAP weeding are zero for most farmers who have access to oxen and ploughs
- Generally, farmers disliked the AEATRI weeder.
- There is a need for further work to investigate the practical and economic aspects of mechanised planting

These conclusions were presented to an audience of farmers, extension workers (District and NGO) and machinery manufacturers at 2 stakeholder workshops and form the basis of extension material published by SAARI.

4.5.2 Demonstrations of DAP weeding and farmer training

Following the success of on-farm trials for research and as a form of training and extension, the project set up demonstration plots in the nine locations where trials took place as a means of promoting DAP weeding to the wider community. Plots were chosen on the basis of their accessibility to the local population and were mainly located close to main roads.

Participating farmers planned their own plots supported by project scientists if assistance was required. They demonstrated all four types of weeding equipment on these plots (SAARI, AEATRI, SG2000 and Plough) often comparing them with a broadcast and hand weeded plot. Open days were organised and farmers who expressed interest in demonstrated techniques were trained by farmers who had participated in the project. By February 2002 302 farmers had been trained in DAP weeding.

A brief questionnaire (Appendix 6) was designed to assess to what extent weeding technologies and associated practices (line planting) had been adopted by farmers who had received training from their neighbours.

Survey results
A total of 105 farmers were interviewed (88 male and 17 female). Their average area cultivated during the first season, 2001 was 4.2 acres (1.7ha) and in the second season, 2001 2.1 acres (0.85ha).

Seventy five out of 105 (71%) had weeded their crops with draught animals during the second season, 2001. Average area weeded with draught animals was 1.7 acres (0.69 ha) (81% of total area planted).

Crops weeded using draught animals included:
- Cowpeas
- Greengrams
- Groundnuts
- Beans
- Sorghum
- Maize
- Cassava
- Soya

One hundred and two farmers (97%) intended to use DAP weeders during season 1 2002. The average area to be weeded (planned) with draught animals was 2.8 acres (1.13 ha) (66.6% of total area planted during 2001).
Crops to be weeded included:
- Beans
- Soya
- Sunflower
- Groundnuts
- Cassava
- Maize
- Cowpeas
- Sorghum
- Cotton

Major benefits of using DAP weeders (described by farmers) include:
- Faster than hand weeding
- Cheaper than hand weeding
- Harvesting is easier (crops sown in lines)
- Yields are higher
- Weeding is easier
- Uses less seed than broadcasting
- Crops grow faster
- Saves time and money
- Reduces drudgery
- Larger areas can be cultivated
- Good water infiltration

- Reduces labour costs
- Ridges groundnuts (higher yields)
- Easy to spray (between lines)

Problems associated with the use of DAP weeders include:
- Too few weeders (to share)
- Shortage of weeders
- No credit to buy equipment
- Transport shortages (harvesting)

Conclusions
It is clear that DAP weeding has the potential to reduce both the drudgery suffered by poor farming households and the costs of production in the Teso Farming System. Although this research tested weeders on only two crops (sorghum and groundnuts), in practice farmers have used the equipment on a wider range of crops. This is a significant departure from traditional practice. Many of these crops would have previously been broadcast and farmers appear willing to invest additional labour in line sowing (which is recommended practice) to facilitate DAP weeding and reduce the labour requirements for this task. Farmers also claim that line sowing had additional benefits in the form of higher yields (possibly associated with optimum plant populations). There is potential for the widespread adoption of DAP weeding subject to the following preconditions:
- information is delivered to those institutions involved in agricultural extension
- manufacturers are prepared to invest in production of affordable weeding tools
- farmers are prepared (in the short-term) to compromise and use a plough (without its mouldboard) for weeding.

5 Contribution of outputs

5.1 Beneficiaries of this research

If those agencies responsible for the promotion of agricultural and rural development in eastern Uganda are willing and able to promote the outputs of this research project this should lead to the widespread adoption of animal drawn weeding in Teso.

The major impacts on the livelihoods of poor women, men and children in Teso, Eastern Uganda are likely to be in the following areas:

- A reduction in the drudgery associated with handweeding crops in the Teso Farming System. This will benefit women and children mostly as traditionally they have been responsible for weeding
- Improved school attendance during the weeding seasons (May/June and October November) as families do not need to withdraw children to weed crops (human capital)
- Reduced costs of production, higher returns and higher incomes, although this will be dependent upon growth in demand for the major crops produced in Teso either in Uganda, the wider region or internationally[9] (financial capital)
- Opportunities for men and particularly for women to re-deploy labour elsewhere in productive or reproductive activities

Characterisation of the weed flora in 1999 has provided a benchmark for determining changes that arise as a result of changes in farming systems and climate. It was not possible during the three-year time frame of the project to identify changes in the weed flora that could be associated with DAP weeders but, over a longer time scale, these will probably arise, alerting researchers and advisers that remedial action may be required. The creation of a reference weed herbarium at SAARI is a resource that can be used by researchers and others concerned with the identification of weeds in Teso.

5.1.1 Impact on livelihoods

The project contributed to the human capital of collaborating farmers (training in weeding, data collection and farm management) as well as those that were subsequently trained by these farmers. It is likely that the social capital of the participating farmers was also enhanced as they now have a skill that can be used to train others and may be considered experts within their local communities. There are also likely to be gains in terms of financial capital for those farmers employing DAP weeding as returns to crop production improve.

Weeding technology is unlikely to have an immediate impact on the very poorest households. These tend to be female-headed households and often have limited access to draught animal power (either owned or hired). However, as hire markets develop for DAP weeding it is likely that this will be a cheaper option than hiring manual labour.

There is a commercial opportunity for machinery manufacturers to produce a simplified SAARI design of weeder. As this tool attaches to the existing plough beam it is cheaper than other designs. Farmers prefer this tool as it is effective against perennial grass weeds and is well suited to the production of groundnuts and may provide yield advantages for this crop.

[9] This is by no means guaranteed and will be dependent to a degree upon diversification as well as developing access to new markets.

This may in the longer term provide employment opportunities in urban and peri-urban locations.

5.1.2 Promotion pathways

As district agricultural extension services in Uganda shift towards private sector provision under the NAADS programme[10] it will be important that information is delivered to a range of likely providers of extension services. In the Teso context these will include NGOs, farmer associations as well as input suppliers (including machinery manufacturers and distributors) and agricultural researchers. Some of this information has already been delivered to stakeholders at workshops and extension material has been produced. Local NGOs have also been involved in the farmer managed demonstration plots at the nine on-farm trial locations.

There is a need now for further promotion:

- From researcher to extension worker
- From extension worker to farmers
- From farmer-to-farmer and the development of links between farmers in different locations
- The development of links between farmers and machinery manufacturers

Teso farmers have limited opportunities to articulate their needs and there is a risk that little progress will be made in the promotion of DAP without some kind of external intervention to co-ordinate and promote activities in this sphere.

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Appendix 1 Baseline Survey Questionnaire

FARM NUMBER[11] ___________

NAME OF HEAD OF HOUSEHOLD_____________________________________

1. List all family members living in the household

Name (head of household first)	Relationship to head of household	Age	Principle occupation/ source of income[12]	Other occupation	Does family member work on farm (Y/N)	Sex (M/F)

2. List all permanent employees

Name	Age (years)	Sex (M/F)

[11] Enumerator to assign a number
[12] For example: farming, petty trade, artisan, salary, day labour

3. Total land area owned[13] and cultivated members of this household (hectares)

Plot name (or number)	Area (ha)	Crop grown in 1st season (include intercrops)	Crop grown in 2nd season (include intercrops)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

List all cattle owned by members of this household

Cattle	Male/female (M/F)	Draught animal (Y/N)	Age (Years)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

5. Which of the following tools or implements do you own?

Hoes (number)	
Machete (number)	
Wheelbarrow	
Plough	
Weeder	
Seeder	
Ox cart	
Knapsack sprayer	
Other (specify)	

6. Do you regularly hire labour for agricultural tasks?

YES ☐ NO ☐

[13] Although land may not be owned in the formal sense (title) households will cultivate land they consider is theirs

7. Please indicate the number of days of labour hired used in the past season?

Crop (or intercrop)	Area cultivated (ha)	Task	Days of labour hired	Daily rate (USh)	Payment in kind (specify)

Which tasks are most labour demanding?

Task	Crop

Are you able to effectively weed all your crops?

YES ☐ NO ☐

10. In a normal year would you expect to buy food for your family?

YES ☐ NO ☐

Appendix 2. Matrix for participatory assessment of weeders

CRITERIA	SAARI WEEDER	SG 2000 WEEDER	AEATRI WEEDER	OX-PLOUGH
Removal of grass weeds.				
Removal of broad leafed.				
Comfort				
Damage to the plants.				
Speed of work				
Ease of adjustment.				
Ease of transport.				
Durability and strength.				
Ease of cleaning and maintenance.				
Availability of spare parts.				
Total.				

Appendix 3. Farm management (financial and labour) data

The following data was collected from on-farm plots during season 2 2000 and Season 1 2001:

- Dry grain weight (yield) (kg/ha)
- Planting labour (hours/ha)
- Weeding labour (1st and 2nd weeding) (hours/ha)
- Ox-weeding (hours/ha)
- Harvesting labour (hours/ha)

The following constants were used in gross margin calculations:

- Sorghum seed rates 12/kg/ha
- Sorghum seed costs Ush250/ha
- Sorghum farmgate price Ush100/kg
- Groundnut seed costs Ush700/kg
- Grioundnut farmgate price Ush600/kg shelled
- Labour costs Ush1800/day
- Ox-hire costs Ush8000/day (ploughing and weeding)
- Ploughing costs Ush24,000/ha (hire rate)

Abbreviated data Season 2 2000

No.	Treatment	yield (kg/ha)	Gross Margin (Ush/ha)	Hand weedinghr/ ha	Hand Weeding cost/ha (Ush)	hand Weeding cost as% of total costs	Return/day to hand weeding labour (Ush)
1	1	300.00	-56546.33	56.67	17000.00	19.64	2647.06
2	1	110.29	-79307.12	44.12	13235.29	14.65	1250.00
3	1	148.81	-81929.67	41.67	12500.00	12.91	1785.71
4	1	965.07	27779.28	29.87	8961.40	13.04	16153.85
5	1	1018.52	46668.48	29.63	8888.89	16.11	17187.50
6	1	875.00	29697.00	22.92	6875.00	11.89	19090.91
7	1	600.60	439.85	36.04	10810.81	18.13	8333.33
8	1	1264.37	41488.92	34.48	10344.83	12.18	18333.33
9	1	2829.02	193375.04	50.52	15155.47	16.93	28000.00
10	1	1810.70	105698.93	19.20	5761.32	7.64	47142.86
11	1	935.37	19898.56	20.41	6122.45	8.31	22916.67
12	1	1250.00	64402.18	14.88	4464.29	7.37	42000.00
13	1	1000.00	36787.00	23.33	7000.00	11.07	21428.57
14	1	1206.14	49408.05	28.51	8552.63	12.01	21153.85
15	1	1107.69	55925.46	8.97	2692.31	4.91	61714.29
16	1	1916.67	114403.67	25.00	7500.00	9.71	38333.33
17	1	2362.64	156289.20	18.32	5494.51	6.87	64500.00

18	1	1428.57	80471.13	19.84	5952.38	9.54	36000.00
19	1	219.30	-62609.49	35.09	10526.32	12.45	3125.00
20	1	255.64	-75069.39	73.31	21992.48	21.85	1743.59
21	1	222.22	-45290.78	41.67	12500.00	18.51	2666.67
22	1	538.72	-71891.79	33.67	10101.01	8.03	8000.00
23	2	266.67	-83079.67	80.00	24000.00	21.87	1666.67
24	2	55.15	-67873.29	36.76	11029.41	15.03	750.00
25	2	178.57	-71215.38	47.62	14285.71	16.04	1875.00
26	2	501.93	-12236.94	28.96	8687.26	13.92	8666.67
27	2	1041.67	50359.50	29.17	8750.00	16.26	17857.14
28	2	1081.08	38385.80	36.04	10810.81	15.51	15000.00
29	2	205.13	-13885.14	7.98	2393.16	6.96	12857.14
30	2	1377.78	67480.33	33.33	10000.00	14.23	20666.67
31	2	2290.16	116317.89	151.55	45466.41	40.34	7555.56
32	2	600.00	-6579.67	11.67	3500.00	5.26	25714.29
33	2	107.61	-49452.05	21.52	6456.61	10.72	2500.00
34	2	831.70	31368.60	13.59	4076.97	7.87	30600.00
35	2	799.32	-6564.02	18.14	5442.18	6.29	22031.25
36	2	1205.36	45451.29	17.86	5357.14	7.13	33750.00
37	2	1300.00	58687.00	31.67	9500.00	13.32	20526.32
38	2	1030.70	50241.39	21.93	6578.95	12.45	23500.00
39	2	884.62	41294.69	10.26	3076.92	6.52	43125.00
40	2	2719.78	201206.78	16.48	4945.05	6.99	82500.00
41	2	263.16	-72872.65	65.79	19736.84	19.90	2000.00
42	2	443.61	-44712.25	39.47	11842.11	13.29	5619.05
43	2	141.44	-79571.70	59.41	17821.78	19.02	1190.48
44	2	333.33	-36013.00	55.56	16666.67	24.03	3000.00
45	2	208.19	-60688.92	17.35	5204.72	6.39	6000.00
46	3	200.00	-60413.00	86.67	26000.00	32.33	1153.85
47	3	36.76	-140630.65	235.29	70588.24	48.92	78.13
48	3	238.10	-100977.29	111.11	33333.33	26.71	1071.43
49	3	620.40	1860.16	68.93	20680.15	34.36	4500.00
50	3	925.93	50987.00	37.04	11111.11	26.71	12500.00
51	3	750.00	27820.33	51.39	15416.67	32.68	7297.30
52	3	113.96	-22075.68	22.79	6837.61	20.43	2500.00
53	3	2098.77	141542.56	123.46	37037.04	54.20	8500.00
54	3	230.59	-45530.25	145.63	43689.85	63.70	791.67
55	3	695.76	-58927.61	337.34	101201.77	78.75	1031.25
56	3	1394.56	69966.59	136.05	40816.33	58.74	5125.00
57	3	1825.00	4212.00	500.00	150000.00	84.13	1825.00
58	3	1798.25	71622.96	263.16	78947.37	72.96	3416.67
59	3	788.46	13833.15	128.21	38461.54	59.16	3075.00
60	3	1416.67	13153.67	333.33	100000.00	77.81	2125.00
61	3	2101.65	158596.89	73.26	21978.02	42.62	14343.75
62	3	1904.76	125748.90	119.05	35714.29	55.18	8000.00
63	3	1277.78	61394.41	129.63	38888.89	58.58	4928.57
64	3	65.79	-32258.61	29.24	8771.93	22.59	1125.00
65	3	413.53	-30103.23	150.38	45112.78	63.13	1375.00
66	3	113.15	-35554.73	66.01	19801.98	42.25	857.14
67	3	527.78	-5624.11	83.33	25000.00	42.81	3166.67
68	3	138.79	-75470.32	156.14	46842.47	52.43	444.44
69	3	333.33	-114679.67	400.00	120000.00	81.07	416.67

Abbreviated data Season 1 2001

No.	treatment	yield (kg/ha)	Gross Margin (Ush/ha)	Hand weedinghr/ha	Hand Weeding cost (Ush/ha)	Hand Weeding cost as% of total costs	Return/day to hand weeding labour (Ush)
1	1	1841.70	1079393.94	30.10	28772.87	13.71	179275.21
2	1	1942.10	1246622.82	29.71	12478.78	11.06	209788.81
3	1	889.60	472035.89	40.68	17084.04	11.34	58023.47
4	1	4016.70	2641628.10	42.05	17661.76	10.39	314092.05
5	1	2055.60	1284474.43	54.24	22778.72	14.75	118417.37
6	1	6428.60	4271154.42	42.31	17770.23	7.76	504744.35
7	1	2968.80	1941976.97	17.99	7557.83	5.55	539592.85
8	1	1593.80	991534.27	30.51	12813.03	10.32	162508.16
9	1	2375.00	1534445.54	27.09	11379.46	8.89	283171.31
10	1	981.90	516440.14	34.29	14401.49	8.43	75306.41

11	1	1288.90	689300.17	55.34	23240.90	10.91	62283.75
12	1	1700.30	1038673.72	12.29	5162.00	3.41	422551.93
13	1	2330.00	1481393.75	14.81	6219.58	4.16	500182.69
14	1	912.00	487311.73	15.62	6560.27	4.34	155992.72
15	1	1108.00	557502.69	26.33	11057.36	5.07	105880.23
16	2	3046.00	1952795.81	26.61	11174.21	6.23	366994.31
17	2	1791.70	1106441.71	15.77	6623.16	4.48	350818.54
18	2	2366.70	1524240.35	14.01	5882.85	4.44	544107.62
19	2	1083.30	623047.82	23.24	9762.31	7.22	134025.71
20	2	1200.00	672674.59	44.43	18658.74	11.15	75708.03
21	2	1896.90	1193953.83	30.37	12757.32	9.53	196538.36
22	2	942.90	519304.43	43.50	18268.25	12.98	59695.88
24	2	1628.60	1008788.81	25.06	10526.32	8.02	201253.37
25	2	1350.00	819618.12	20.37	8556.88	6.82	201147.95
27	2	4273.50	2787654.70	18.74	7872.24	3.86	743634.77
29	2	1287.00	700646.79	7.64	3207.48	1.60	458727.47
30	3	1807.70	1109003.27	21.69	9111.49	5.83	255601.14
31	3	1388.90	772906.90	56.99	23934.16	12.01	67815.38
32	3	447.40	203880.44	24.65	10352.07	9.47	41358.78
33	3	1968.80	1213425.50	60.53	25421.80	15.43	100236.57
34	3	1200.00	691874.15	48.81	20500.85	13.84	70871.98
35	3	1928.40	1077056.43	95.26	40008.04	14.66	56534.09
36	4	2888.90	1878639.92	13.77	5783.81	4.03	682100.70
37	4	1623.40	954637.09	46.06	19344.55	10.64	103633.22
38	4	1563.60	955761.76	16.44	6903.84	4.98	290722.09
39	4	1243.80	761328.25	20.89	8774.46	8.03	182209.35
40	4	2757.40	1756657.13	35.89	15074.15	8.69	244722.20
41	4	916.70	510828.01	28.96	12161.86	9.29	88205.19
42	4	2775.00	1801353.35	57.19	24021.65	17.02	157476.38
43	4	1546.90	940733.50	48.37	20315.15	14.30	97244.67
44	4	468.80	204729.57	50.80	21336.48	17.29	20150.09
45	4	1369.90	786742.91	41.48	17419.82	10.12	94843.70
46	4	1664.60	1008477.27	22.37	9396.86	6.00	225373.49
47	4	1521.70	908758.32	15.72	6602.53	4.22	289039.67
48	4	1259.40	770103.69	8.59	3608.13	3.24	448215.18
49	4	1012.20	549181.70	26.35	11066.59	6.94	104212.96
50	4	1045.50	520716.14	12.75	5354.96	2.54	204204.04
51	5	2444.00	1571712.89	100.00	42000.00	30.20	78585.64
52	5	748.00	379746.89	135.19	56777.78	39.47	14045.43
53	5	1756.40	1054713.29	132.96	55844.44	31.95	39661.92
54	5	1580.10	971204.15	51.23	21515.15	15.95	94795.00
55	5	2413.00	1547631.91	153.26	64367.82	45.50	50491.49
56	5	1600.00	1005891.67	115.63	48562.50	42.56	43498.02
59	5	627.10	272811.60	183.33	77000.00	46.34	7440.32
60	5	1218.20	756412.65	87.88	36909.09	38.32	43037.27
61	5	666.70	346023.20	142.86	60000.00	49.72	12110.81
62	5	1094.50	681214.79	17.25	7243.78	8.53	197486.79
63	5	1461.10	919814.49	45.37	19055.56	18.51	101367.31
64	5	2242.60	1447805.48	83.95	35257.35	28.90	86234.25
65	5	2783.30	1838121.24	50.00	21000.00	19.06	183812.12
66	5	1444.40	878635.73	46.30	19444.44	14.68	94892.66
67	5	5000.00	3379333.33	71.43	30000.00	24.86	236553.33
68	5	1266.70	691956.53	233.33	98000.00	50.33	14827.64
69	5	1366.70	875889.87	50.00	21000.00	25.99	87588.99
70	5	1412.50	885162.50	52.08	21875.00	21.12	84975.60
71	5	2500.00	1617343.75	57.29	24062.50	18.14	141150.00
72	5	1620.00	1020045.00	65.42	27475.00	24.11	77965.22
73	5	1414.30	886752.80	47.14	19800.00	19.18	94049.54
74	5	947.40	558206.19	56.58	23763.16	22.64	49329.85
76	5	1093.80	644753.55	73.96	31062.50	25.69	43588.97
77	5	1734.40	1099798.65	41.15	17281.25	15.12	133646.42
78	5	890.60	514920.10	93.75	39375.00	36.29	27462.41
79	5	1223.80	725431.47	59.52	25000.00	19.05	60936.24
80	5	1050.00	621575.00	66.67	28000.00	24.69	46618.13
81	5	375.00	186468.75	28.13	11812.50	15.54	33150.00
82	5	2125.00	1381325.00	40.42	16975.00	15.99	170885.57
83	5	1275.00	806350.00	22.92	9625.00	11.17	175930.91
84	5	574.20	258525.59	60.49	25405.12	17.71	21369.85
85	5	1071.60	633658.06	60.95	25599.35	21.98	51981.08
86	5	898.60	473066.05	67.42	28314.61	18.16	35085.73
88	5	888.90	477385.51	125.19	52577.78	36.30	19067.17

89	5	704.00	327569.50	30.84	12954.36	7.84	53101.51
90	5	2564.10	1634673.43	67.66	28418.80	17.74	120793.76
91	5	1785.70	1136555.53	23.03	9672.62	8.53	246754.95
92	5	845.40	471095.81	21.23	8915.24	7.39	110967.43
93	5	863.40	519576.50	39.68	16666.67	19.65	65466.64
94	5	1250.00	755875.00	30.83	12950.00	10.87	122574.32
95	5	1110.20	625801.29	72.64	30508.61	20.16	43075.79
97	5	720.50	376047.55	37.88	15909.09	12.40	49638.28
98	5	877.20	476004.88	14.62	6140.35	4.45	162793.67
99	5	483.00	223474.82	59.66	25056.82	21.86	18729.32
100	5	872.10	408252.92	175.06	73527.13	36.36	11660.06

Appendix 4. Weeds of 90 farms in 4 Districts of Teso

Latin name	Vernacular name	Type*
Acanthospermum hispidum	Esimama	AB
Achyranthes aspera	Eciria	AB
Ageratum conyzoides	Atiraja	AB
Alternanthera pungens		AB
Amaranthus sp.		AB
Asystasia schimperi	Ecototo	AB
Bidens pilosa		AB
Boerhavia sp.	Egolimate, Epetecor, Petecor	AB
Borreria stricta		AB
Brachiaria lata	Ebilameleku	AG
Cassia obtusifolia	Eedo, Elekete	AB
Celosia trigyna	Ekiliton	AB
Celosia trigyna	Otipet	AB
Chloris guyana	Ekodait, Ekodet	PG
Cleome sp.	Ehi-hi	AB
Commelina sp.		AB
Corchorus sp.	Alilot, Etigo	AB
Cynodon sp.	Star grass	PG
Cyperus rotundus		PS
Cyperus sp.		AS
Dactyloctenium aegyptium	Eudu-udu	AG
Digitaria abyssinica (= D. scalarum)		PG
Digitaria sp.	Acipa	AG
Digitaria sp.	Erwerwe	AG
Eleusine indica		AG
Eragrostis parva	Esiriko	AG
Erigeron floribundus	Okwaras	AB
Eurphobia heterophylla	Epetero	AB
Eurphobia hirta		AB
Eurphobia sp.		AB
Fuirena umbellata	Emiria miria	PS
Galinsoga parviflora		AB
Gutenbegia cordifolia		AB
Hyparrhenia rufa	Elagara	PG
Hyparrhenia sp.	Asisimit	PG
Hyptis suaveolens	Emopim lo apolon	AB
Imperata cylindrica	Spear grass	PG
Indigofera spicata		AB
Launaea cornuta		PB
Leonotis mollissima	Ecekai, Ecika	PB
Malva sp.	Atigo	AB
Mimosa sp.		AB
Mitracarpus villosus ?	Otuboi	AB
Nicandra physalodes		AB

Continued …

Ocimum sp.	Emopim, Emoping	AB
Oxygonum sinuatum		AB
Panicum maximum		PG
Paspalum scrobiculatum	Ayac (ayak)	PG
Phyllanthus amarus	Orwa etom	AB
Physalis philadelphica	Aduduma	AB
Polygonum convolvulus		AB
Portulaca oleracea	Elekete, Eleketete	AB
Rhynchelytrum repens	Apero, Apoo, Apuna	AG
Rottboellia cochinchinensis	Ewokiwok	AG
Sacciolepis africana	Alele	PG
Schkurhria pinnata		AB
Setaria sp.	Fox tail	AG
Setaria sp.	Ipunuka, Iswiswit	AG
Setaria verticillata		AG
Sida acuta	Egweret	AB
Sorghum sp.	Etirok	AG or PG
Sorghum sp.	Wild sorghum	AG or PG
Sporobolus pyramidalis	Ejanit, Ekosile	PG
Striga hermonthica		AB
Tagetes minuta	Marigold	AB
Trichodesma zeylanicum	Eileile	AB
Tridax procumbens		AB
Triumfetta rhomboidea	Abubon	AB
Vernonia perrottetti	Etibinet, Otipet (?)	AB
?	Akonye amereke, Aokot, Egougou	AB
?	Akurayele	
?	Akwangapel	AB
?	Alibilib	
?	Apetecor	
?	Apuru	AB
?	Ediriton	AB
?	Elibilib	AB
?	Epungula, Opungula	PB
?	Okwangapel	
?	Otibilok	

Key: AB = annual broadleaf, AG = annual grass, AS = annual sedge
PB = perennial broadleaf, PG = perennial grass, PS = perennial sedge

Appendix5. Project logframe

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Goal			
LPP Performance of livestock (including draught animals) in semi-arid (crop/livestock or livestock production systems improved. Impact of significant pests on production of cereal (particularly sorghum) based systems minimised	To be completed by Programme Manager	To be completed by Programme Manager	To be completed by Programme Manager
Purpose			
LPP develop and promote strategies for the allocation and management of on-farm and locally available resources in order to optimise livestock production and improve their contribution to the crop/livestock farming systems. CPP improved methods developed for the management of weeds in semi-arid cropping systems	To be completed by Programme Manager	To be completed by Programme Manager	To be completed by Programme Manager
Outputs			
1. Characterisation of the relationship between labour and power availability and area cultivated, yields, cropping patterns and returns to labour inputs	1. The relationship between labour and power availability and output described by 2000	1. Survey results, annual reports and publications	Farmers, extension workers and NGOs collaborate in data collection
2. Characterisation of weeds and weed management problems in the Teso area	2. Weed management problems characterised by 2000	2. Survey results, annual reports and publications	Farmers, extension workers and NGOs collaborate in data collection
3. Analyses of the efficacy (practically and economically) of draught animal equipment for planting or sowing, weed management and transport.	3. At least 2 technologies identified and successfully used by farmers by 20001	3. Annual reports and publications	Farmers receive extension messages and adopt transport technology Extension services promote research results
4. Specific advice on the use of draught animal equipment for weed management.	4. At least 3 technologies are proved to provide benefits to farm households and	4. Research programme reports and publications	Local restocking schemes continue to provide access to draught power

	women farmers by 2001		
5. Information for stakeholders (farmers, manufacturers, extension services, NGOs) produced and delivered to appropriate uptake pathways	5. Information materials delivered by end of project	5. Published materials	Research identifies suitable technologies for extension
Activities	**Inputs**	**Means of Verification**	**Important Assumptions**
1.1 Planning workshop 1.2 Literature review 1.3 Baseline survey	Total Budget here	0 Workshop report 1.1 Review of literature 1.2 Survey results	Collaborators and stakeholders agree to co-operate Farmers co-operate
2.1 Weed survey and characterisation of the problems 2.2 Literature review to aid the identification of appropriate technology to manage weeds		2.1 Survey results 2.2 Quarterly reports and annual reports	Collaborators and farmers co-operate
3.1 PRAs to confirm labour contraints and identify collaborating farmers 3.2 Identification of appropriate weeding equipment for testing on farmers' fields 3.3 Design experiments 3.4 Train farmers in use of line-sowing and weeding techniques 3.5 Data collection 3.6 Financial, economic and social impact assessment 3.7 Testing of simple on-farm transport designs		3.1 PRA summaries 3.2 Quarterly reports 3.3 Annual reports	Farmers co-operate
4.1 Stakeholder workshops 4.2 Draft recommendations		4.1 Workshop reports 4.2 Quarterly and annual reports	
5.1 Design information for uptake pathways 5.2 Deliver material to stakeholders and uptake pathways		5.1 Final report 5.2 Published materials	

Appendix 6. IMPACT QUESTIONNAIRE

Date--------------------- ENUMERATORS NAME.-------------------------------------

District---
County---
Sub-county--
Parish---
Village---

1. Name of respondent ---------------------------------

1.1 Age --
1.2 Gender ---
1.3 Education (Highest level attained)---------------------

2. Land under cultivation by household members.

	1st season	**2nd season**
Major crops grown	Area (acres)	Area (acres)

3. Have you received training in DAP weeding? Y/N

3.1 Who provided this training (ie DAP project contact farmer/neighbour/other [specify])

3.2 If yes did this training include (please tick):

	Demonstration only	**Practical (hands on) experience**
Row planting		
Yoke making		
Ox-training		
Inter-row weeding with oxen		

4. How much of the training you received has been put into practice (ie. in 2nd rains 2001)?

	Y/N	Crop	Area (acres)
Row planting			
Ox-training			
Inter-row weeding with oxen			
Yoke making			

5. Which of the following do you intend to practice next season (1st rains 2002)?

	Y/N	Crop	Area (acres)
Row planting			
Ox-training			
Inter-row weeding with oxen			
Yoke making			

6. Please list the reasons (in order of importance) why you prefer ox-drawn weeding to farmer practice (broadcasting and hand weeding)?

1……………………………………………………………..

2……………………………………………………………..

3……………………………………………………………..

4……………………………………………………………..

7. Comments

Thank you for your response.