Conservation farming with animal traction in smallholder farming systems: Palabana experiences

by

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Abstract

Minimum tillage, conservation farming among other words being used have, in recent times become attractive and popular concepts in sustainable farming. Concerns about sustainable use of the land resource base have been noted and expressed by many, including farmers. Through a participatory on-farm trial process, the Palabana Farm Power and Mechanisation centre has taken up the challenge to develop and provide mechanisation inputs in the application of minimum tillage and conservation farming particularly in animal power based farming systems. The Centre has successfully adapted a ripper, a sub-soiler and ripper-planter. These technologies are getting popular in Zambia and are facilitating farmers' efforts into conservation farming. This paper shares Palabana's experiences in the process of developing and promoting the conservation tillage technologies.

1. Introduction

Minimum tillage, conservation tillage, zero tillage, conservation farming, are terms which are gaining popularity in natural resource management and farming. The meaning and interpretation for these terms vary from one situation to another. It is, therefore, important to begin the discussion by presenting the definitions of the above terms as has been used by Palabana.

1.1 Minimum tillage

This refers to those tillage practices where by minimum or no disturbance is effected on the soil for purposes of crop production. It involves the making of furrows or holes where seed is planted. The rest of the field remains undisturbed and crop residue is left on the surface. This practice reduces soil erosion, causes build up of organic matter in the soil, hence better chemical and physical soil fertility. Minimum tillage also implies reduced labour, energy, and reduced time demand in land preparation. Hence, cropping can be done in time at less cost. In most commercial farming, the weeding in minimum tillage systems would be done using herbicides.

1.2 Conservation tillage

This moves further on the definition of minimum tillage to bring in aspects related to sustained environmental care for the natural resource – SOIL. While minimum tillage focuses on the level of soil disturbance and energy level required, conservation tillage includes the WHEN and HOW this tillage is done. The "when" basically refers to the moisture-state of the soil. Conservation tillage takes into account both environmental and tillage factors.

- Environmental factors: slope, vegetation, soil type, rain pattern and intended crops.
- Tillage factors: type of implement/s, timing of operations, depth of the tillage and soil condition.

1.3 Conservation Farming

This concept embraces everything as practised in minimum and conservation tillage. It goes further to include all socio-cultural and traditional practices and decisions relating to sustained chemical and physical fertility of the soil. This is about all those land use practices, which go to allow nature, regenerate and sustain soil fertility as the soil is being used. These include practices such as crop rotation, inter-

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cropping, tillage patterns (gathering and casting) use of organic and inorganic fertilisers, fallowing, etc.

As both large and small farmers pursue farming practices which are not only cheaper, but guarantee sustained fertility of the land resource, several questions arise such as:

- Why is conservation farming a major concern now?
- What are previous and current farming practices and what is their impact on the environment?
- What is the way forward if we have to increase agricultural output and at the same time sustain the soil resource base?

2. Background

Zambia has an area of 75 million hectares with about 9 million noted as suitable for arable farming with good potential for crop production. 25 million hectares are reported as suitable for agricultural production. Much of the agricultural land, about 80%, (MAFF-World Bank report, 1995) is actually held in traditional smallholder-subsistence farming systems. A typical farming household would have in excess of 20 hectares under its direct control. However, only about 10 – 20% of this land is cropped in any one season. The farming practices in these communities reflect this fact and the following can be noted:

> "… soil and water, the primary natural resource inputs in crop production have a way to regenerate themselves (naturally) with TIME being one of the main critical factors."

This fact and also that land was vast and readily available, influenced farming practices. In Zambia's smallholder traditional systems, most common practices include:

i. *Chitemene System* involves the cutting of tree branches in a field to be used for crop production. The cut branches are collected and heaped around the same field. Once dry, the branches are burnt; the remaining ash providing fertile portions of the field. Such a field will be used for a few seasons (3-4). Once its fertility is exhausted, yields reduced critically and the field is abandoned and the tree tracks which had been left standing in the field are allowed to re-grow. This field can be used again after 5-10 years.

ii. In *Fallowing System*: completely cleared and destamped fields are left unused for a few seasons. This allows natural regeneration of the soil fertility.

As from the mid 1960s, Zambia started to experience increased pressures for higher agricultural output. The government, then, came in to facilitate and support those interventions aimed at increasing agricultural output in the country. Some of such interventions with environmental implications was the use of inorganic fertilisers. Just after the country attained political independence, the government aggressively and extensively promoted use of inorganic fertilisers even in smallholder-subsistence systems. In 1980 the Nitrogen Chemicals of Zambia was opened to manufacture and supply of fertilisers. This situation continued into the 1990s with farmers forgetting the use of inorganic fertilisers (like inorganic manure), with which they could use same fields for longer.

Other factors have been such as the LIMA recommendations, which effectively discouraged inter-cropping, promoted the maize based mono-culture and, hence, limited possibilities for crop rotations. This led to continuous degeneration of the country's land resource.

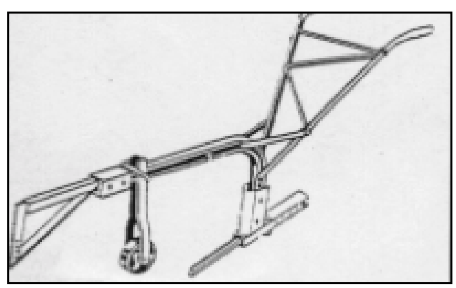

Figure 1: The Palabana subsoiler

In the advent of the new political and economic era coming with the introduction of multi-party politics in 1991, smallholder farmers have been having increasing difficulty in obtaining fertilisers. The price has gone up and there no more government fertiliser loans and the many subsidies. As a result farmers have noted progressive decline in yields.

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The need to facilitate soil regeneration is now paramount. With this realization the Palabana Farm Power and Mechanisation Centre has taken up to develop and promote animal power based technologies which offer farmers opportunities for improved, but cheaper soil conservation practices.

3. Palabana interventions and experiences on conservation farming

3.1 Objectives of the interventions

To fully appreciate Palabana's experiences with conservation farming it is in order to highlight the initial aims and objectives of the Palabana interventions.

Three factors in the circumstance at the turn of the 1990s provided the motivation and hence a basis for the aims and objectives of Palabana's conservation tillage work. These were:

- Three out of every five years in the last 15 years have essentially been drought years. This has had obvious implications for crop production. Among the ideas and practices to mitigate against this problem were planting early, "harvesting" the little rain within the field and tillage practices which prevented excessive water losses from the soil.

- A study of Zambia's agricultural performance noted an apparent surplus in farm land in the country. In smallholder farming systems, an average household was reported to using about 10-20% of the agricultural land under their control.

- A multiple regression analysis of crop production and productivity in smallholder farming systems conducted in the same study identified shortage of active labour and the number of draft animals as the two most important determinants of area cultivated.

Labour saving technologies were noted as the way forward (de Graaf, 1993) in enabling farmers cultivate larger areas. This was to be attained by minimum tillage technology.

The three factors formed the basis of Palabana's initial work in development of minimum tillage technologies. The main objectives of this work were to develop and make available technologies that would enable farmers to:

- Prepare their fields and plant in time for optimal benefits from the now shorter rain period.

    - "harvest" the little rain into within the crop field by ripping through the plough pan to allow for more water infiltration.

    - prepare and plant larger areas within the available time and farm power.

The focus of this work was, hence, development of the ripper and sub-soiler. The ripper was worked on the basis of the ard plough commonly used for centuries in mostly temperate parts of the world.

3.2 Development methodology

This is the process that developed over the years. It is based on in-situ on-farm trial concept, where selected farmers apply the trial technology in their own natural, socio-economic circumstances. The farmers involved were provided with only the prototype and information which empowered them to make objective observations on the technical and socio-economic performance of the prototype. The methodology was interactive and essentially driven by farmer needs and input.

In the ripper and sub-soiler trails, the main parameters under investigation were:

- draft power requirement,

- technical performance of the prototypes, their effectiveness in opening up planting lines (ripper) and ripping through the hard pan (sub-soiler).

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- ease of operation (handling, adjusting, etc.)

- level for repair and maintenance within rural circumstances.

- other factors related to socio-cultural, gender, financial factors in rural farming communities.

The development of both the ripper and sub-soiler was pre-conceived as an attachment on the conventional beam-handler. This attachment concept was justified by the fact that:

- It was going to make use of the largely abandoned and widely available plough and ridger beam-handle units.

- Manufacturing requirements are simpler and scrap steel could be used for some parts, and

- It was going to be cheaper and hence financially within the reach of the targeted farmers.

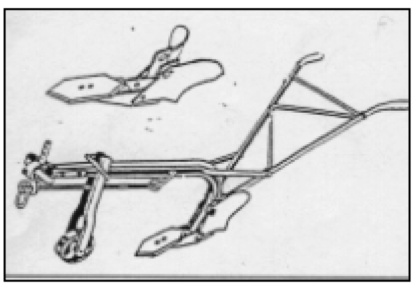

Figure 2: The Magoye Ripper

3.3 The ripper and sub-soiler attachments

3.3.1 Design aspects to meet draft requirement

Both ripping and sub-soiling were carried out in relatively dry soil. This allowed early planting. Sub-soiling allowed the desired breaking up of the soil. Draft requirements would increased.

The design challenge was therefore to manipulate a combination of tine shape, tine size and angle of attack so that the draft required was within the draft ability of a pair or two of oxen.

Through the on-farm trials with back-up on-station trials, a 35^0 attacking angle was determined and shape and size of the tine was decided. With this angle of attack, working in dry average sandy-loam soils a draft force of 100 Newton (N) was required. This was within the pulling capacity for a pair of oxen.

The tine was made from hardened steel and was reversible when worn. The subsoiler was most popular in Southern Province during the drought years. Palabana noted a lot of farmer innovations in the use of this implement. The implement was used in land preparations. Often before ploughing or ripping the sub-soiler was passed through the field. This was to break the plough pan. However, the most common use was to rip through a field between rows of crops. This was done when rain was expected. It increased infiltration and, harvesting of water within the field.

On-station trials were conducted at Magoye Technology Assessment Site (Simuyemba, 1998) and they indicated insignificant difference in yield between a field ploughed and later sub-soiled and one ploughed normally. However, the effect of the sub-soiling was significant and encouraging in critical drought seasons.

One major remarkable issue brought out in the use of the sub-soiler was the amount of draft power required. This operation to be meaningful, had to be done in dry soil, and had to be deeper than ripping. This meant higher draft demand. In normal operation two pairs of cattle were required. However, this could not go on well as the province was at the same time suffering from epidemic level, cattle deaths.

To meet the power demand required, one farmer group in Kalomo area developed the idea of a three-unit yoke (see Figure 3).

Farmer interest in the sub-soiler has lately regained interest due to the effects of hard pans which farmers are increasing noting in their fields.

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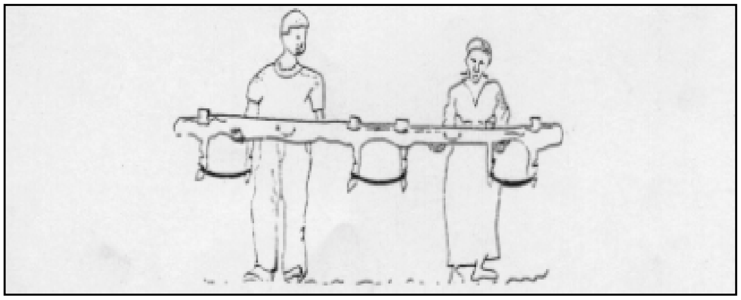

Figure 3: Three unit yoke: farmer innovation (Source: Zambia ADP Newsletter; Palabana FPMC)

3.3.2 Weeding

The weed problem was the immediate outcome of using a ripper for minimum tillage – making planting lines and leaving the rest of the field undisturbed. Even with the advantage of ease of preparing the land for planting and possibilities for expanding area and planting early, the weeding issue was more of a deciding factor for farmers. It is noteworthy that in most cases the mulch left on the surface was minimal. Also compounding this problem was that with ripping, the household would increase the area planted, but still it depended on hand based weeding systems.

So, with limitations in the use of chemical weed killers, a feasible option for large-scale commercial farmers, some mechanical weeding technology had to be integrated into the system. This compelled the incorporation of an animal drawn weeder in the use of a ripper in minimum tillage. A cultivator was promoted with two weeding sessions recommended; one just after germination and the other when the crop is about knee-high.

3.3.3 Planting

In ripped fields planting was by, manually placing the seed in the furrow and covering it with the foot. This planting system, which was the most common way of planting, regardless of how the field was prepared had problems, especially in relation to its extensive labour demand.

With the ripper gaining popularity, the idea of a combined ripping-planting operation developed. A ripper planter was put under trial from 1992 to 1997.

3.3.4 Yields and ripping

Ripping was viewed as an integral part of a cropping system. Therefore, its application has to ultimately affect cost of production and indeed the profits from cropping. This was in three ways:

- Reduced production cost (land preparation costs per unit area),
- Increased area cultivated and
- Increased crop yields.

Trials done at Magoye TSA (Simuyemba, 1998) during the 1995/96 and 1996/96 seasons indicated insignificant yield difference between ploughed and ripped fields (Table 1). The yield difference between 1995/96 and 1996/97 could be due to the fact that 1996/97 was a better season with a good rainfall.

Table 1: Yield comparisons in ploughed and ripped fields

Tillage type	**Yield – 1995/96 (tonnes/ha)**	**Yield – 1996/96 (tonnes/ha)**
Ploughed	3.695	4.067
Ripped	3.618	4.333

The effect of ripping on physical soil fertility normally takes a few years to manifest. It is therefore difficult to see yield improvement within the first few years.

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3.3.5 Soil degeneration – refocusing of trial objectives

During the years of the ripper, sub-soiler trails, other critical developments with implication for agricultural productivity were taking place. With the withdrawal of subsidies among other agricultural input and the collapse of the smallholder farming credit schemes, use of inorganic fertilisers drastically dropped, with more than expected effect on the yields. This brought the awareness that most fields could not produce any thing unless fertiliser was used.

It became apparent that these soils had been damaged. The land use patterns for these lands allowed very little replacement of organic matter into the soil. Crop residue was either feed to cattle or burnt. An urgent need to reclaim such lands and develop land use patterns, which will ensure no or little damage to the soil structure, was identified. At this point, focus started to shift from timely planting technologies to soil conservation technologies.

4. Discussion and conclusions

4.1 The minimum tillage technologies

The ripper technology, has steadily gained in popularity and adoption rates in Centre, Southern and Western provinces and to an extent in Eastern Province. These are areas, which are relatively dry with shorter rain seasons. The soils are generally light sandy to sandy-loam, getting more sandy to the South. The areas are intense farming (crop and livestock) locations. Due to less rainfall and other natural factors these areas have little plant matter especially, for feeding the livestock. Little organic matter gets back into the soil.

Ripping has obvious and almost immediate effects on timeliness in planting, labour and energy demand, however, its effect on yield may not be significant in the initial years. Effect of ripping on yield is affected by various factors including the soil type. Ripping works well on sandy soils with concerns for conservation of soil and water. On dense clay and self-compacting soils, ripping could easily have negative effects on yield, unless combined with other practices, such as deeper sub-soiling and mulching.

Ripping can also not be taken in isolation, especially in the longer term. Alternative combination of ripping and conventional ploughing after a few years would be ideal in maintaining the soil fertility.

4.2 The ripper-planter technology

The ripper-planter, because of its considerable time and labour saving possibilities has made it a widely accepted technology among Zambian farmers. Also "difficulties" on conventional planters (expensive and complicated; require a relative smooth and fine seedbed) goes to make the ripper-planter popular.

This technology may provide the desire break through in easing planting problem for smallholder farmers. The ripper planter can effectively be used in both ploughed fields or fields not ploughed (direct dry planting), become desirable.

4.3 Conservation farming

Considering current and future agricultural demand on land, need for integration of conservation farming techniques cannot be over-emphasised. Whatever, conservation farming technologies are developed, the cardinal factor is their adoptability. It is, therefore, important to realise that mechanisation inputs do not easily and immediately translate in higher yields, as would be the case with fertiliser. Therefore important factors to influence farmers' adoption of the technologies will mostly relate to:

- Increase in area cropped,
- Reduction in drudgery, energy and time.

Adoption will also be influenced by:

- Cost of new technologies and practices.
- Compatibility of new technologies and practices with existing socio-cultural practices.
- Information support services in addition to farmer training.

Conservation farming will affect the entire cropping and farming practices in a community. Therefore, any attempts at such should consider a broad based and multi-disciplinary approach.

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References

Dryland Farming research Scheme (DLFRS), Botswana. 1985. Final report; Volume 4: Tillage and Water Conservation. Agricultural research Station, Sebele, Botswana.

de Graaf, P J. 1993. Challenges of animal traction development in a changing economy in Zambia.

MAFF-World Bank *et al*. 1995. Assessment of potential land for expending agricultural production in Zambia.

Palabana FPMC. 1996. On-farm trial programme report – 1990-1996. Palabana Farm Power and Mechanisation Centre.

Palabana FPMC. 1997. Annual Report – 1996. Palabana Farm Power and Mechanisation Centre.

Palabana FPMC. 1998. Annual Report – 1997. Palabana Farm Power and Mechanisation Centre.

Simuyemba, J. 1998. Minimum tillage comparative trial results. A study report.

 This paper is published in: Kaumbutho P G and Simalenga T E (eds), 1999. *Conservation tillage with animal traction.* A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Harare. Zimbabwe. 173p. A publication supported by French Cooperation, Namibia. For details of ATNESA and its resource publications, see **http://www.atnesa.org**