Conservation tillage for soil and water conservation using draft animal power in Zambia

Kenneth Chelemu and Peter Nindi

Farm Power and Mechanisation Group, Palabana Animal Draught Power Development Programme
Private Bag 173, Woodlands, Lusaka, Zambia

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Abstract

Southern Africa is currently experiencing drought conditions characterised by late and scattered rains and insufficient total rainfall. Conventional plowing needs to be carried out after the onset of the rainy season. As a result, planting is often delayed. With the current short rainy season this often leads to partial crop failure. In these conditions, conventional plowing can also result in large losses of soil moisture due to inversion of the topsoil, in reduced infiltration in the furrows and in increased soil erosion. As a result farmers are ready to consider alternative 'conservation' tillage practices that maximise use of available water and reduce erosion. The Palabana Animal Draught Power Development Programme in Zambia has been promoting rippng and subsoiling as conservation tillage practices that are appropriate under certain conditions. Mechanical planting has also been promoted as a quicker method of seeding that can improve timeliness and make the best use of the short rains.

Ripping can be carried out before the begining of the rains, facilitating dry planting and improved timeliness. It reduces soil disturbance and can channel soil moisture to the ripped areas. However, it can lead to serious weed problems if timely weeding is not carried out. Palabana has developed a ripper attachment for conventional I-beam plows that has been popular with farmers in demonstrations.

Whilst conventional animal-drawn mechanical planters are effective, they have not been widely accepted by farmers due to high initial costs, high maintenance costs and complicated operation. The Palabana programme has developed a new planter attachment for conventional plow frames that should be cheaper, easier to use and more reliable.

Subsoiling is only effective in a limited set of situations and it requires at least four strong oxen. Trials of a subsoiler developed at Palabana are being carried out and the response from farmers requiring this specialised tillage method have so far been positive.

Introduction

Depletion of soil moisture is influenced by many factors which can be categorised in two broad groups: climatic, and soil physical conditions. Most factors are natural and can only be controlled indirectly. The most critical factor is the amount of moisture received to be conserved. During the recent past most countries in the southern part of Africa and particularly Zambia have experienced serious drought seasons for the past 5 years. As a result some agricultural research projects have focused on improving the catchment, conservation and efficient use of available water.

One human factor influencing the rate of water loss is the method and extent of soil manipulation. The most common tillage method is conventional plowing using mouldboard plows. This tillage technique completely disturbs and inverts the soil. Since this buries weeds and leaves the loose surface bare, sheet erosion becomes more probable. The compaction and smearing effect at the base of furrows creates a compact pan which retards water infiltration. This reduces depressional storage and encourages runoff and consequently increases soil degradation due to erosion. Moreover, conventional plowing can only be performed when soils are substantially wet. As a result plowing is often delayed due to the late and scattered rainfall currently being experienced. Consequently subsequent activities, especially planting, are delayed; this frequently leads to partial crop failure.

Many farmers, especially in the drier most southern part of Zambia, have realised these problems and are ready to try promising new techniques aimed at maximising use of the available precipitation. A number of tillage systems aimed at increasing depressional storage and reducing soil loss, collectively referred to as 'conservation tillage', are being promoted but not all are feasible in all situations. The concepts

behind these techniques are well understood but most of them have a problem with weed infestation since weeds are not buried during primary tillage.

In some instances the conservation tillage techniques do not fit easily into the existing farming system. In the recent past the Palabana Animal Draught Power Development Programme has introduced ripping and subsoiling. These are conservation tillage operations that farmers, particularly those using animal draft power, have perceived as promising to address the problem of timeliness of field operations and efficient moisture utilisation during prevailing drought periods. The limitations of these methods are generally accepted, for example farmers in the sandy Western province of the country are unlikely to appreciate operations such as subsoiling. Similarly ripping would give farmers of the high-rainfall northern part of the country a massive weed problem if care is not taken to include a good preventative weed control measure.

This paper describes the conservation tillage methods of ripping, planting and subsoiling being promoted by the Palabana programme and its experiences with them.

Ripping

Ripping is the breaking-up or loosening/disturbing of soil in the arable layer at regular intervals, in principle without inversion. Planting is done in the ripped strips. Because of the low infiltration in the undisturbed areas, these strips act as catchment areas for the ripped areas and increases the amount of water available within the ripped confines. Ripping is carried out with a simple narrow tined point to a desired depth that depends on the crop being planted. The quality of ripped lines is determined by the design and setting of the ripper. Ripping becomes beneficial if it can be carried out sufficiently before the rains to facilitate dry planting. The recommended time is before (dry ripping) or upon the onset of the rainy season. Experience indicates that serious weed problems result if ripping is carried out long after the onset of the rainy season.

Ripping as a primary tillage field operation has many advantages including:

it is quite a light operation for oxen, ie requires a low draft force compared to plowing

it results in minimal disturbance to the soils of the field worked

since it enhances field preparation time, planting can be done early/timely

the planting depth can be regulated, unlike planting behind the plow

using well trained draft animals and the right harnessing (eg a long double-neck yoke), crop rows can be made very straight and well-spaced for easy weeding using animal draft power

the sturdy chisel tine is reversible

there is no need for a complete new implement since the attachment is cheap and suits all I-beam type plow frames.

The major disadvantage of ripping is the possibility of serious weed problems if it is carried out too late. Post-planting operations may therefore be more intensive. To minimise the problems timely weeding is essential.

The Magoye *ripper*

During the past few seasons the Palabana programme has developed a ripper, called the *magoye* ripper (Figure 1) in close liaison with farmers (through the local extension staff) on one hand and manufacturers on the other. It looks very much like the traditional ard plow. It was introduced in Niger with promising results (Kruit, 1994) and further developed into a simple and sturdy attachment in Zambia by the Palabana programme. In over 25 districts where it has been demonstrated it has been well appreciated by farmers. Major positive points for its acceptance are its ability to facilitate dry planting (prior to the rains) and the fast and light nature of the operation.

The special features of the *Magoye* ripper include a sturdy tine and two small wings to make a wide clear furrow most suitable for large seeds especially for a staple crop maize. This attachment fits on the I-shaped plow beams in common use in the region. Since many of these beams are left unused by farmers because of lack of spares for the original implement, there is a readily available

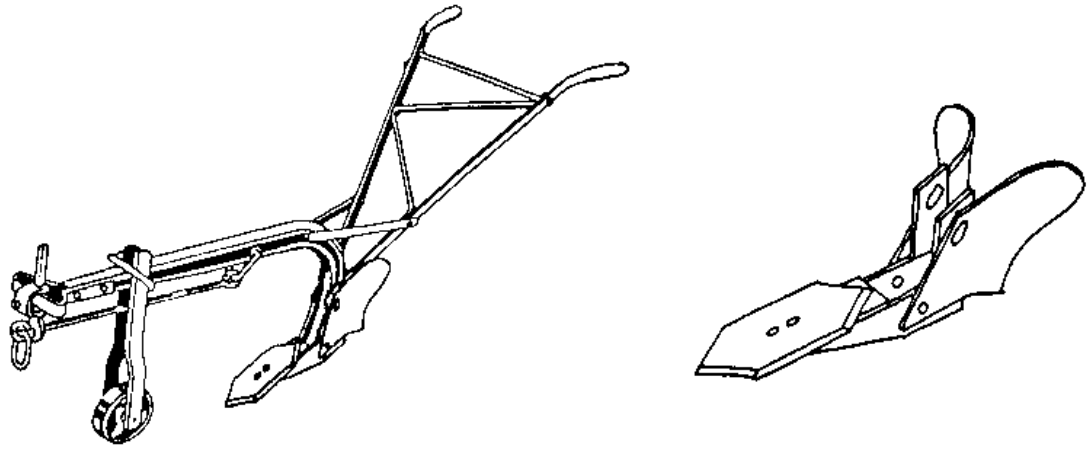


Figure 1: The Magoye *ripper*

supply.The working depth is easily influenced by soil conditions (whether wet/light or dry/heavy). This necessitates a good depth regulator. The distance between ripped lines is regulated by sequence of operation and the most practical way is to allow one draft animal to work in a previously ripped line. In this case the same yoke should be used for weeding. Figure 1 shows the major components of the ripper. The Palabana Animal Draught Power Development Programme has received encouraging reactions from soil and water conservation experts in Zambia, Zimbabwe and Tanzania who recognise the appropriateness of this tool to help farmers improve their tillage practices. For instance, a land management project in Tanzania recently ordered some *Magoye* ripper and subsoiler attachments to try under varying conditions.

The major components of the *Magoye* ripper attachment are:

- a reversible chisel tine for opening the furrows
- a subframe which attaches all components together and to the main beam
- left and right wings to keep the loosened soil from falling back into the furrow opened by the chisel tine

Harnessing for ripping

A harnessing system for ripping must space the draft animals at twice the desired inter-row spacing (Figure 2) unless a single animal is being used. The same harnessing system should be used for weeding ripped fields using animal draft power.

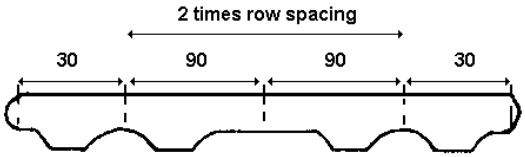
Subsequent operations after ripping

Seed dropped into the furrow by hand may be covered by passing a cultivator between the planted furrows. This also serves as a preventative weed control measure (pre-emergence weeding). A harrow can be used instead. Conventional weeding can be carried out with either a cultivator or a ridger.

Status of Magoye ripper attachment

Prototype development of this implement started in 1992. The design is now acceptable to farmers and has already been taken up by some manufacturers. Jigs and templates to standardise its manufacture have been developed (and made on request or need) by the Palabana programme as a service to promote manufacture of *Magoye* rippers. These are intended for both centralised and small rural workshops. To mention but a few, MDM Engineering Company on the Copperbelt in the northern part of Zambia, SARO Agri-equipment Limited in Lusaka, and Kaleya Agricultural

Figure 2: A yoke for ripping



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Engineering Company in the southern part of the country are some of the major companies that have taken up the challenge. Other smaller (rural) workshops have also been assisted and encouraged by Palabana to manufacture the attachment and supply their local farming clientele.

Palabana planter attachment

Mechanised planting using animal drawn planters has proved effective and efficient in some farming systems. However, this technique has often not been accepted by farmers. This has been because the available models of planter have been expensive, been complicated to calibrate and use properly and been vulnerable to breakdowns and so have a high maintenance cost. The common models are equipped with a blade-type coulter for furrow opening that requires moist and fine tilth. This delays planting because plowing must be carried out when the soil is moist.

With this background the Palabana Animal Draught Power Development Programme has developed a planter attachment (Figure 3) that makes use of the ripping concept to open up planting furrows. This speeds up planting and can even facilitate dry planting. The planter attachment consists of a seed hopper, a metering unit and two landwheels on either sides. The seed metering mechanism works using a cellwheel fixed on a horizontal shaft with a key and driven by the two wheels. The planter unit pivots in a 3-point linkage system behind the beam and thus follows the undulating surface neatly during planting. When used in combination with a ripper as a leading point the system has the same advantages as discussed for ripping alone.

The major components of the Palabana planter attachment are:

- a ripper subframe attaching the ripping chisel tine to the main beam
- the chisel tine itself acting, as usual, as a furrow opener
- planter side-plates connecting the planter unit to the main beam
- a seed pipe
- an aluminium seed wheel with 4 equidistant seed cells on its surface. This is fitted inside the seed pipe on an axle with drive wheels (100 cm circumference) on both ends

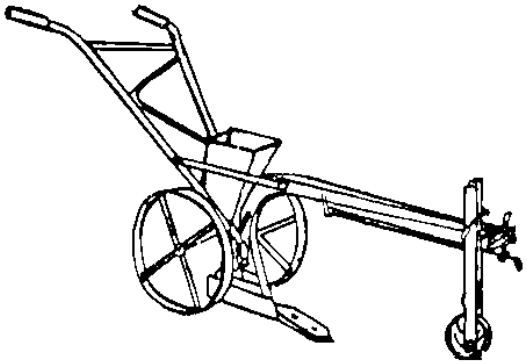


Figure 3: The Palabana planter/ripper attachment

- the axle itself – a 25 mm diameter shaft which drives the seed wheel by means of a key fitting in a key way in the bore of the seed wheel
- a rubber fitted by a bolt and wing nut to the front of the seed pipe to act as a brush preventing multi-drops of the seed
- an adjustable (by screw) metallic flap inside the back of the seed pipe to prevent seed from falling through the seed pipe backwards
- a hopper with a lid
- a stay that connects the seed pipe to the main beam
- a furrow covering assembly is optional.

Status of the Palabana planter attachment

The attachment has reached an advanced development stage. An extensive on-farm test is planned for this season, 1995/96. The design will be tested for technical suitability as well as acceptability by farmers. Most potential manufacturers in Zambia and the region have been informed about this project. It is hoped that the Palabana planter will be appreciated as an appropriate alternative to the regular type of planter. It will be less costly, less susceptible to technical failure, and will function in a wider variety of soil conditions. The possibility of planting without prior plowing and harrowing will be a most attractive advantage. However, weed control measures will need to be intensified. Several companies have already shown interest in its manufacture.

Harnessing for planting

Harnessing for planting depends on the desired inter-row spacing in the same way as harnessing for ripping.

Subsoiling

Subsoiling is the breaking up of the hard underlying pans beneath the plowing depth. The main purposes of subsoiling are to increase water infiltration and storage, and to allow easier penetration of the root system (especially tap roots) beneath the plowing depth (up to 25cm). However, this method is only useful in certain circumstances, and is hence expected to attract only a particular group of users, especially as the subsoiler requires at least two strong pairs of oxen. Subsoiling should be carried out in the dry season, well or just before the onset of the rainy season. The operation cannot be carried out in wet conditions.

Harnessing for subsoiling

Subsoiling is normally carried out on dry land to break hard pans so it requires high draft forces. Therefore a team of animals should be used, for example four draft oxen. The effective distance between two spanned animals moving abreast depends on how much subsoiling the operator wants in a particular field. If subsoiling is to be carried out on permanent crop rows similar harnessing to that described for ripping should be used.

Subsequent operations to subsoiling

Subsequent operations after subsoiling can be any primary tillage field operation. For conservation tillage, ripping or ripping and mechanical planting is recommended.

Like the ripper attachment, the subsoiler attachment fits onto any normal I-beam type plow frame. It consists of the following parts (see figure 4):

a jumper bar which cuts deep into the subsoil layer

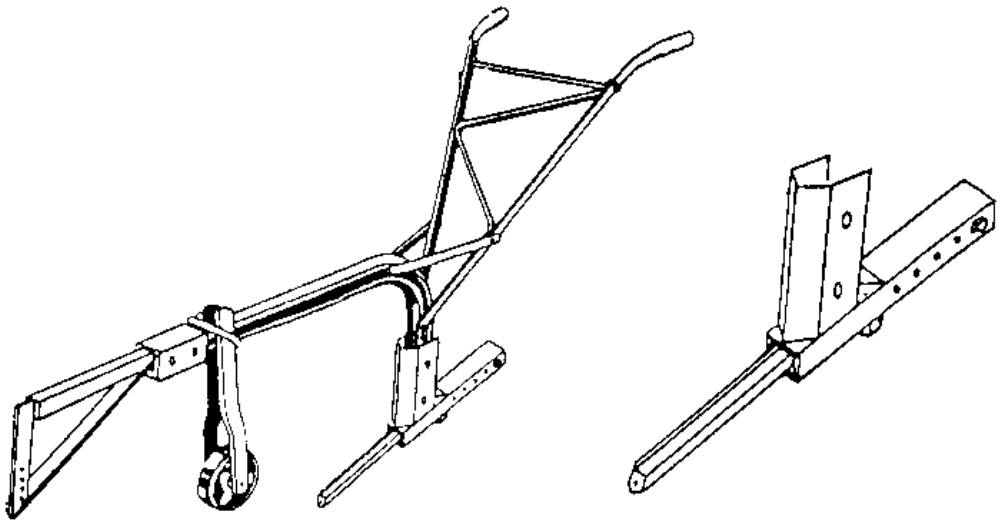
a beam extension which holds the jumper bar and the main beam together and provides for adjustment of the jumper bar for deeper or shallower penetration

a special hitch assembly goes with the attachment. It extends the main beam lengthwise to suit the reaction point geometry of the deep penetrating jumper bar.

Status of the attachment and its manufacture

The attachment is still in the development stage. In readiness for the forthcoming rainy season (1995/96), one engineering company was contracted by Palabana to produce a number of subsoiler attachments which a few selected farmers who requested and have a real need are currently using (November 1995). These farmers are mostly in the midlands and southern part of Zambia. An on-farm trial is being carried out as a follow-up of

Figure 4: Subsoiler attachment



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the subsoiler programme and so far farmers seem to appreciate the performance of the implement.

Discussion

The attachments decribed in this paper are not intended to turn the 'green' plow or ridger beam into a multipurpose toolbar. Multipurpose tool bars exist in French-speaking Africa and have their own shortcomings. However, the advantage seems obvious: only one frame is required to do many different jobs. It is only necessary to swap certain attachments instead of requiring a separate implement for each operation. This is helpful where finances are constraining. The main reason for Palabana to introduce the attachments is to combine the promotion of useful 'new' equipment on durable and well appreciated existing frames. There is simply no need for another frame. Moreover, many farmers using animal traction in Zambia have old 'green' beams. This is a result of the poor supply of spare parts, which has forced farmers to buy complete new plows or ridgers, whenever wear and tear of certain parts made the implement not functional. These unused old plows, currently scrap materia,l often have beams in good condition which could easily be re-used and turned into 'new' implements with these simple attachments.

The current short rainy seasons require timely planting. Conventional plowing delays planting so ripping and and direct planting seem to be realistic alternatives even though additional weeding is called for. An additional advantage of these methods is the efficient use of available soil moisture reducing erosion. As always, meeting the needs of farmers is the most important goal of agricultural projects. Assessing and working towards these needs without creating new problems is extremely difficult and calls for concerted efforts from all parties involved. To achieve this goal the Palabana Animal Draught Power Development Programme has joint the newly formed ‘Minimum Tillage Lobby’ in Zambia. The lobby, set in motion through the Zambia National Farmers Union and funded by the World Bank and European Union is expected to liaise monthly to monitor and analyse trends of the conservation tillage campaign in Zambia. The Palabana Animal Draught Power Development Programme welcomes comments and communications from people seeking more information, with suggestions and with questions about our activities.

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