Animal-drawn implements for improved cultivation in Ethiopia: participatory development and testing

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Abstract

Ethiopian farmers have been using an ox-drawn ard plough known as 'Maresha' for thousands of years. Although simple and cheap this implement is inefficient and several researchers and organisations have been trying to introduce new implements from other countries as early as 1939. Farmers have however rejected the new implements despite their superior field performance. The main reason for the rejection has been the fact that little attention was given to the nature of the traditional implements and to the farmers. Recently, however, studies were made on the farming systems of farmers and their indigenous knowledge was used in developing a package of improved pre-harvest implements for tillage, row planting, tie-ridging and weeding. Farmers were involved in the process of development and testing of implements. They conducted simple experiments comparing the new animal-drawn implements with the traditional ones. Results showed reduction in labour and time requirements for land preparation, row planting and weeding. Improvements in soil moisture conservation using simple techniques like tie-ridging, improved tillage and fertilizer incorporation when planting tef, and inter-row weeding, resulted in higher yields. An animal-drawn ripper has recently been developed to undertake minimum tillage and to break the plough pan.

Introduction

Ethiopian farmers have been using the *Maresha*, an ox-drawn ard plough for thousands of years. Most of the components of the plough are wooden except two pieces: the plough share and a tying unit. It is cheap and simple, but inefficient compared to mouldboard ploughs. In the past several researchers and organizations have made repeated attempts to replace the Maresha with the mouldboard plough. The animal drawn mouldboard plough was for the first time introduced to Ethiopia by Italians in 1939 (Goe, 1987). However, farmers rejected the plough for its heavy weight, high draft power requirement and complicated adjustment and attachment systems.

The Italians concluded that the Ethiopian farmers were conservative and did not want to take new technologies. This was probably one of the major causes for failures to improve farm implements in Ethiopia. Farmers' ideas were not taken seriously. Their traditional plough (Maresha) was not studied well. Its simplicity, light-weight and low cost nature were not considered.

Several attempts made after the second world war followed similar trends. FAO conducted several trials on small farm implements in the 1950s. The Jimma and Alemaya Agricultural Colleges, also conducted trials on implements between 1955 and 1965. The Chilalo Agricultural Development Unit (CADU) started research on farm implements in 1968 and had some success stories but could not go far.

In 1976 the Institute of Agricultural Research (IAR) began testing and modification of farm implements. However, the methods followed were more or less similar to the previous ones and hence development of acceptable implements proved to be difficult. In 1985 the Agricultural Implements Research and Improvement Centre (AIRIC) was established to coordinate research nationally. A national survey was conducted to identify implements related production constraints and research priority was set up (Pathak, 1986). Extensive testing and modification of implements were made. However, because farmers' indigenous technology knowledge (ITK) was not considered seriously, the implements developed were not accepted.

Recently, the approach was somewhat changed and working with farmers, some of the design features of the Maresha were incorporated into the new implements. This proved to be the best way to develop acceptable implements. The results were extremely encouraging. Previously, farmers were not even willing to use the implements, but now they not only have adopted, but are ready to buy them.

The research centre could not meet the demand of farmers and hence passed the design to a factory that has started manufacturing and selling the new implements. This paper describes how farmers were involved in implement development and the achievements.

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Farmer participation

Two sites namely Bofa and Wulinchity were selected for the study. Bofa is a dry area with sand and gravel soils. Wulinchity is relatively wet with black (clay) soils. Twenty farmers were selected from Bofa and 10 farmers from Wulinchity for the study. Through Participatory Rural Appraisal (PRA) sessions the farmers at each site met and discussed agricultural production constraints and put the problems in their order of importance. They pointed out their own strategies for solving these problems while the researchers suggested new techniques involving improved small farm implements.

Problem identification

Farmers considered soil moisture stress to be the most important production constraint. The following are definitions of some of the farmers' strategies in combating moisture stress problems in the two areas.

'Nish Kebera'

This means prevention of evaporation losses. Traditionally farmers reduced surface area and kept dry soil on top as mulch to minimise evaporation losses. Weeds emerging after the first tillage deplete soil moisture through evapo-transpiration. However, since the lower moisture-soil would be exposed to the sun, farmers refrained from ploughing the land that would control weeds. Some farmers ploughed the land in the night under moonlight.

Some farmers practice water harvesting techniques in which they collect and divert runoff from other fields into their own by forming ditches. Farmers grow different types of crops and varieties depending on the rainfall pattern of the season. If rain comes early in March they grow long maturing maize or sorghum varieties. If these happen to fail then they resort to early maturing maize varieties such as Katumani and plant them in June. If both early and late maturing maize varieties fail farmers grow other crops such as tef. Haricot bean is another early maturing crop and is widely grown in the two areas.

Development of implements

The following factors or features were considered.

- ***Functional performance:*** The implement had to perform satisfactorily in the job it was intended for. The advantage that it gave the farmers had to be in line with the identified problems.
- ***Simplicity:*** The implement had to be simple enough for farmers to attach, adjust and operate it easily.
- ***Adaptability:*** The implement had to be adapted to a wider range of field conditions. There needed to be little or no pre-requisite for its use. It had to solve problems instead of creating many others for the farmer.
- ***Minimum deviation:*** The new implement needed to resemble the traditional implement as much as possible. The idea was to study the traditional implement and identify the weak points while leaving the rest of its parts as they were and trying to add whatever was necessary or remove whatever was contributing to the inefficiency of the implement.
- ***Economics:*** Whatever cost was to be incurred due to the new implement it needed to be recovered immediately in terms of the advantages that farmers got through the use of the new implement. These may have been in terms of labour and time saving, seed or fertiliser saving or yield increment.

Based on the above factors and features several implements were developed. These included a mouldboard plough, winged plough weeder, tie-ridger and row planter (see Figures 1 to 4). The row planter was developed such that it did not depend on ground wheels for metering of seeds and fertilizer. This is because ground wheels fail to rotate in stony, muddy, loose or cloddy soils. Moreover, metering of fertilizer became difficult because the rather small diameter wheels and lightweight planter failed to produce the necessary torque for metering fertilizer. The small particles of fertiliser got in-between a rotating and a fixed part causing a jam.

A new type of semi-automatic metering mechanism was developed. With this the operator oscillated his hand corresponding to his footsteps while the mechanism metered seeds and fertilizer at the desired rate.

Field testing

Training was given to farmers on the attachment, adjustment and operation of the new implements. Testing methods were developed in a simplified form so that farmers would not find the trials to be time consuming. They were advised to lay their plots along the slope and insert a narrow strip of the treatment which they thought would give them a lower yield in the middle of the field while the other treatments, usually one or two, were laid above and below. During harvesting narrow strips from both sides and having the same width as the middle one were harvested for comparisons.

Table 1: Implements tested by farmers 1996-1998

Name of implements tested	Number of implements tested			Number of farmers involved		
	1996	1997	1998	1996	1997	1998
1. Row planter	1	4	11	1	13	47
2. Mouldboard plough	1	12	39	1	12	61
3. Winged plough	1	15	43	1	15	140
4. Animal drawn weeder	1	3	15	1	3	26
5. Tie-ridger	-	-	11	-	-	15
6. Single ox-tillage	-	-	2	-	-	2
Total	4	34	121	4	43	291

Figure 1: Mouldboard plough

Figure 2: Winged plough

Figure 3: Tie-ridger

Figure 4: Row planter

Extensive testing of implements by farmers was then conducted. Table 1 shows the types and number of implements tested by farmers over three seasons. A series of testing and modification had lasted more than ten years to come up with the new implements and test them. The implements were tested by farmers who ploughed different types of soils with the implements. Further modifications of the implements were made based on the farmers comments. Farmers were also encouraged to discover additional functions of the implements.

The improved implements tested by farmers were:

Mouldboard plough

Farmers tested the mouldboard plough which had been developed by combining their own indigenous implement (Maresha) parts such as the wooden beam, handle, deger and merget. with that of the mouldboard plough bottom (see Figure 1). This reduced the weight of the mouldboard plough from about 26 kg to 15 kg (the Maresha weighs 14 kg). In some cases the original steel mouldboard plough weighs up to 35 kg. The reduction in weight has avoided the problem of soil compaction and hard pan formation.

Farmers were able to compare the new plough with that of the traditional (Maresha). They reported a 20 to 100% increase in yield resulting from the new plough, the highest advantages having been obtained in seasons of severe moisture stress. Most of the farmers who tested the new plough reported the following advantages:

- It cuts deeper and more water could be retained
- The roots could grow deeper in search of moisture and nutrients.
- The mouldboard plough increased grain yield as it inverted soil and hence weeds were better controlled. Also trash and crop residues were incorporated into the soil, thereby improving soil fertility.
- More weed seeds were brought to the surface and could be destroyed during the next ploughing season, thereby producing a weed-free field after planting.

- It reduces surface area thus minimizing loss of moisture through evaporation.
- It left a dead furrow that could be laid along the contour and be used to check run-off, thus conserving soil and water.
- It achieved complete ploughing in one pass thereby reducing tillage passes by 50%, hence farmers could get free time to do other activities.
- Draught oxen could get rest and use the extra time available for grazing which helped them maintain their body weight and remain powerful during planting time when draught power shortage was particularly critical. The plough needed the use of proper techniques to achieve this.
- Cross ploughing is not required and, therefore farmers could plough their fields only along the contour and avoid run-off.

Usually when farmers used the Maresha they were forced to orient the line of ploughing along or nearly along the slope in one of any two consecutive operations. This exposed the soil to erosion by run-off and the soil water was also lost. When ploughing along terraces with the mouldboard plough, farmers followed only one direction, parallel to the terraces. However, with the Maresha, cross ploughing took more time because the width of terraced fields was small, and it took a long time to go back and forth along them. Ploughing along one direction alone, along the contour was very inefficient with the Maresha owing to the design feature of the implement.

The mouldboard plough cuts thick stemmed weeds that can not be cut by the Maresha. Owing to the nature of the Maresha such weeds are missed during ploughing and farmers have to pull them by hand, which takes time.

For the mouldboard plough, width adjustment is possible without reducing the depth and the weight acting on the soil. When ploughing with the Maresha farmers have to lift the implement in order to reduce its draft force. With the mouldboard plough this can be done by reducing the width of furrow slice cut. Thus depth of operation is maintained and draft force is reduced for weaker animals or hard soils.

Furrow slices are cut from one side and thrown to the ploughed area (furrow). This reduces the draft force because the soil being moved faces little resistance. But when ploughing with the Maresha the soil pushed to the left and right slides by "Deger" faces resistance to its movement from the undisturbed soil. Therefore, the draft force required by the mouldboard plough for a given area of cross section is smaller than that of the Maresha. Hence, the draft force can be reduced to a level less than that of the Maresha.

Winged plough

Farmers tested the original plough and commented that it was too heavy and complicated. It was, therefore, modified in such a way that its weight was reduced from 11 kg to 3 kg (see Figure 2). This weight did not include the weight of the components of the Maresha that would be attached to the new implement. The new implement was tested in comparison with the Maresha. Farmers reported the following advantages of the winged plough:

- The draught power requirements were only 60% of that of the Maresha and hence it could be pulled by a single ox or by a pair of donkeys. One farmer, upon observing the low draught power requirement of the implement decided to use a pair of donkeys instead of oxen. He modified the traditional yoke in such a way that it suited donkeys.
- The winged plough did not invert the soil. It left the top dry soil where it was during secondary tillage thus preventing evaporation by creating soil mulch. Farmers in dry areas found this implement useful for moisture conservation through "Nish Kebera". Its shallow operation allowed farmers to used it to incorporate di-ammonium phosphate and urea fertilizer into the soil when planting tef. A substantial amount of fertilizer was otherwise lost through evaporation when farmers broadcast it on the surface and left it uncovered during tef planting. The Maresha would place the fertilizer too deep.
- The winged plough leveled the field and made it firm. Many farmers used the implement during planting of tef because of the desirable seedbed it produced.
- Some farmers have reported up to 100% increase in yield from the use of this implement.
- The winged plough, when used as a covering device, for crops that required narrow row spacing such as beans resulted in a row planted field.
- The winged plough covers 2-3 times as much area per day as the Maresha.
- Farmers found it useful because it saved their time and the energy spent by oxen. Farmers who owned weak oxen or did not have sufficient feed benefited a lot from using this implement.
- In broadcast crops that suffered from soil crusting problems the winged plough was useful as a crust breaker.

The tie-ridger

The tie ridger (see Figure 3) is meant for reducing run-off by creating a series of basins in the field. Tie ridging is recommended by agronomists for dry areas. However, since the farmer does not have any special equipment for making tied ridges we developed an animal-drawn tie ridger which was found to be four times more efficient than manual tie ridging. The implement was popularised among farmers throughout the dryland areas of the country. However, farmers complained that the implement was inconvenient. The tie ridger was, therefore, modified such that it could be operated using one hand. The implement was tested in 1998 by 15 farmers who found it convenient and easy for their oxen to pull. This year, an additional 60 tie-ridgers were distributed but the number of farmers who used them have not yet been followed up.

Row planter

A simple animal drawn semi automatic row planter (Figure 4) was developed at AIRIC. The metering of the row planter was made independent of ground wheels because ground wheel driven animal drawn row planters failed to work effectively in the rather rough and cloddy fields of the small-scale farmers. In contrast, the new planter worked effectively wherever the Maresha worked.

Farmers conducted trials on the operation techniques of the row planter. The decision was left for them as to whether the planter should be used with open or closed furrow planting. Farmers have reported that if they do not expect any rain seven days after planting, the closed furrow planting is advantageous. In contrast, when it rains in the first few days after planting crust formation can hinder seedling emergence for closed furrow planting. Many farmers have been able to demonstrate this phenomenon using replicated trials in which they compared closed and open furrow planting.

Farmers were also able to practice tie-ridging on the open furrow planted fields. Some farmers did this by cross ploughing while others lifted the row planter at 4-6m intervals along the furrow. During the current season they were able to use the new tie-ridger.

Farmers who tested the row planter by comparing it with manual row planting and broadcasting of seeds and fertiliser came up with the following results. First and foremost the row planter saves time and labour. When operated with the open-furrow system one person can finish a given area of land in three hours while three persons will take nine hours to do the same manually.

When the closed furrow system is used the time required is doubled. With the open-furrow planting system, the row planter facilitates moisture conservation through tie-ridging. In crust-forming soils the use of an open furrow system with the row planter improves crop emergence, moreover, hand operated crust breakers can be used efficiently.

With the open furrow system, weeding is more efficient and helps in earthing up the crop. Some farmers have demonstrated this phenomenon by planting the same crop with the two systems side by side. Heavy run-off that occurred 30 days after planting washed all the crop planted using conventional techniques while those planted using the row planter and weeded by the cultivator survived because of the strong support the crop got from earthing up.

The planter was also found exceptionally useful for inter cropping. A farmer can do four operations in one. These are:

- Inter cropping of beans or forage between maize or sorghum rows.
- Incorporation of urea fertiliser
- Inter-row weeding
- Tie-ridging

The row planter places seed and fertiliser in a more desirable way. According to field experiments conducted by agronomists over two seasons, the row planter gave 30% more grain yield compared to manual placement of two seeds and 4 g of DAP fertiliser.

Inter row weeder

The animal-drawn inter row weeder is the same as the winged plough but with a reduced width of cut (20-40 cm depending on the type of crop and row spacing). The winged plough with 55 cm cutting width can also be used on widely spaced crops (75-80 cm). It can be pulled by a single ox or a pair of donkeys.

According to field tests by farmers the weeder reduced the time and labour required for manual weeding, up to 18 fold. It also earthened up row-planted crops with the open furrow system and killed weeds between rows and buried those in the row. An exceptional advantage is that it cuts shallow and moves little soil, such that the young seedlings are not buried unlike the Maresha.

Minimum tillage trials using a ripper (sub-soiler)

The sub-soiler was found to operate deeper than Maresha by up to 5 cm. There are several ways of using the ripper. One can use the ripper after having ploughed the land with the traditional plough or the mouldboard plough, the latter giving a much better result. The sub-soiler can also be used to undertake minimum tillage especially in combination with the weeder. Several experiments are now being conducted comparing conventional ploughing with that of strip ploughing and different ways of reducing tillage. A substantial reduction in ploughing time and

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energy has been observed with increased retention in the root zone. The trials are sponsored by the Regional Land Management Unit (RELMA).

Production and sale of improved implements

Because of demand created in one area for the new mouldboard plough the research center made agreements with a factory to hand over the design of the plough. The factory produced and sold a total of 360 ploughs in 1999.

Conclusion and recommendation

It has been found that involving farmers in implement development and testing is a very effective approach. Utilizing indigenous knowledge and incorporating design features of traditional implements in the development process is important. What has been learnt in colleges in which the curriculum is based on European and other experience needs to be combined with the rather undocumented local knowledge. Farmer to farmer learning and dissemination of implements was found to be effective. It developed confidence in researchers, extensionists, higher officials and above all encouraged manufacturers to enter into the commercial production of the improved implements. Future research and extension of on-farm implements should follow this trend.

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