Threshing and Seedbed Preparations

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BOX-3376 A.A.
A.R.D.P’s Experience
And Recommendations
On
Threshing
Including Results Of 1979 Performance Tests

Progrès Report V
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October, 1979

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**threshing**

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1.0 A.R.D.P's Experience and Recommendations on Threshing

1.1 Back-Ground

Arssi has a total area of 1,000,000 hectares (1) out of which 411892 hectares are arable (2). Considering the crop distribution pattern in chilalo Awraja, \( \frac{1}{3} \) of the total cropped area is under wheat, another \( \frac{1}{3} \) under barely and the rest are maize 15%, field peas 5.4%, horse beans 3.5% and haricot beans 2.3% (3).

1.2 The above figures do imply that of all the cropped area, in the Awrajas \( \frac{2}{3} \) is devoted to wheat and barely. If the area occupied by teff is added, the total area of cropped land under wheat, barely and teff will be 71% of the total cropped area.

1.3 This suggests that, if new agricultural implements are to be introduced into the area, they must be geared in such a way that they do aid farmers in bettering the production and handling of the major-crops especially wheat and barely.

1.4 An other study conducted at Chilalo Awraja shows that the short rainy season starts before threshing is finished and therefore much grain is destroyed every year. The estimate has this to say, "it is estimated that up to 15% of the grain produced in chilalo is lost due to the short rains" (4).

1.5 Considering the annual cycle of farming operations of the areas growing wheat and barely as major crops (5), at least four months are devoted for ploughing (including sowing), one month for major weeding (the first weeding), and two and a half months for harvesting, threshing, cleaning and collecting (6).

1.6 According to Gills, who considered labour hire as an indicator of bottlenecks in the annual cycle of farming operations, of all the farmers who were interviewed, 89% have hired labour for harvesting, 33% for weeding, 28% for threshing, 17% for ploughing, 15% for 13% for sowing and 9% for transportation of crops. (7)
2.0 The Previous Threshers

2.1 The crops harvested must be threshed, cleaned and stored as soon as the conditions allow. This process is very important both in terms of qualitative and quantitative preservation of the crops produced.

2.2 The duration between the recommended harvesting date and the short rains, which do usually come in the middle of the month of December, is the time within which all harvesting, threshing, cleaning and storing operations have to be completed if all the damage to be brought due to the short rains is to be avoided.

2.3 There are various ways of separating the seed from the straw but the experience of the project is limited to that of the traditional and small threshers. The traditional threshing system is by trampling animals on the harvested crop spread on the threshing floor. Threshing by small threshers include both animal driven and powered threshers. According to a final summary on the cost of threshing a quintal of grain by using the various systems of threshing, the following figures have been obtained.

<table>
<thead>
<tr>
<th>Threshing System</th>
<th>Man-hour per quintal</th>
<th>Ox-hour per Quintal</th>
<th>Estimated cost/quintal (Birr)</th>
<th>Capacity per day (quintals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tramping</td>
<td>11</td>
<td>12</td>
<td>2.40</td>
<td>2(8)</td>
</tr>
<tr>
<td>Animal Powered thresher</td>
<td>3</td>
<td>2</td>
<td>1.10</td>
<td>8(9)</td>
</tr>
<tr>
<td>Motor powered ARDP thresher</td>
<td>2</td>
<td></td>
<td>1.50</td>
<td>40(10)</td>
</tr>
</tbody>
</table>

2.4 As can be seen above, the cost per quintal is the highest in the traditional system and least in the case of animal-powered threshers. The animals driving the thresher via the tread-mill must be fed well (better breeds may help) if long and continuous operations are to be expected.
2.5 Considering the thresher driven by the tread-mill for short operation, two oxen are made to replace about 10 oxen. (11)

2.6 As has already been stated above, the short rains that do come in December is reported to damage up to 15% of the crops produced and hence a fast threshing system is preferred to the others.

2.7 The project has made a full cleaning wooden-threshers which were later replaced by non-cleaning metal threshers the main reasons being the changing dimensions of the wooden parts which created the problem of un-fitting spare-parts.

2.8 An other problem associated with the wooden thresher was that, there were many moving parts among which are included the straw-walker & air-blower which use belt for power transmission. This implies that there is a lot of energy lost in just driving the parts of the machine. It is also reported that the thresher was kept out of production because it fails to cover cost.

3.0 The Non-Cleaning Metal Thresher

3.1 This is a thresher powered by one 8-hp diesel engine whose fuel consumption rate is 5.2 liters of gasoline per 8 hrs. of operation. Its weight, excluding the motor, is 300 kgs. Its threshing capacity is about 5 quintals per hour and requires at least three people for constant operation. According to the tests made in 1979, of all the grain it threshers, at 16% moisture content, there is 2.15 breakage in barley and 5.8% breakage on wheat at R.P.M. of 1100.

3.2 The non-cleaning metal thresher is designed in such a way that it can be transported by the carts already produced by the project, and distributed to the farmers. Since the development of other activities such as growing horticultural crops, honey production and other cottage level industries have not yet been developed in most of the cereal growing areas of the Region, and since farmers are hence not yet occupied throughout the year, it is assumed that the farmers will have enough time to do the cleaning of the threshed grain.
The average farmer whose arable land is about 2.54 hectares, gets a total yield of nearly 50.8 quintals and this is the amount that could be threshed by a simple non-cleaning thresher in some 10 hrs. This implies that within a threshing period of some 75 days, about 59 families can thresh their crops with a thresher.

Results of 1979 Threshing

According to another threshing result of 1979, the rate of breakage varied considerably with the RPM of the beater as can be seen in the following table.

Table 2

<table>
<thead>
<tr>
<th>RPM</th>
<th>Type of grain</th>
<th>% breakage</th>
<th>Moisture %</th>
</tr>
</thead>
<tbody>
<tr>
<td>619</td>
<td>Wheat</td>
<td>2.5</td>
<td>17%</td>
</tr>
<tr>
<td>1666</td>
<td>&quot;</td>
<td>4.6</td>
<td>17%</td>
</tr>
<tr>
<td>2712</td>
<td>&quot;</td>
<td>19.4</td>
<td>17%</td>
</tr>
</tbody>
</table>

Farmers' Reactions to the non-cleaning metal thresher during the threshing period of 1979.

Of those who were asked, which threshing system leaves more grain on the straw, all of them said that the one threshed by the non-cleaning thresher leaves more grain on the straw.

While responding to whether there is any qualitative difference between the grain threshed using the traditional trampling system and the non-cleaning thresher, 57.14% of the respondents said that threshing by oxen is preferable against 42.86% who preferred the thresher. The reasons given by those who preferred threshing by oxen to the thresher is that the thresher does more breakage of the grain.

When asked which system would they like to use in threshing their grain in the future, all of them said that they would like to use the thresher. The reasons given were the threshers do help them in threshing soon and avoid the risk of grain damage due to the short rains; and the thresher does not eat the grain and it does not partly damage the grain by urine like the animals.
While responding to which straw would be of better help to them, all of them said that the one collected from the animal threshing floor is of better help to them. The reasons given were the straw from the threshers have got to be rethreshed both to be stored and to be easily palatable by animals.

When asked to compare the amount of damage brought about due to breakage of the thresher and the urine dung of the animals, all of them said that there is more damage in the breakage done by the thresher than that made by the animals.

When asked what improvements do they suggest on the future design of the thresher, they all suggested that:

1. The thresher must have wheels so that transporting it from place to place is made possible easily.
2. The rate of grain breakage must be decreased.
3. The number of human requirements must be decreased.

Human and Animal Labour inputs in Traditional Threshing

Basic data

a) Population per family is 4.1 people.
b) Ownership of arable land per family is 2.54 hectares.
c) Ownership of livestock per family is 4.1 animals.

The traditional system of threshing is by trampling. In this system, the preparation of the threshing floor, threshing, winnowing and collecting are the major human and animal inputs.

Man-hour requirements in preparing the threshing floors.

Table 3

<table>
<thead>
<tr>
<th>Types of crops</th>
<th>Man-hour requirements *1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teff</td>
<td>50</td>
</tr>
<tr>
<td>barley</td>
<td>28</td>
</tr>
<tr>
<td>Wheat</td>
<td>28</td>
</tr>
</tbody>
</table>

*1 one day = 6 working hours.

According to the study made at Shorina in 1979
6.4 Man-ox day requirements to thresh various grains.

Table 4

<table>
<thead>
<tr>
<th>Type of crops</th>
<th>Man days</th>
<th>ox-days</th>
<th>Quantity threshed (in quintals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barely</td>
<td>4</td>
<td>14</td>
<td>12.3</td>
</tr>
<tr>
<td>Wheat</td>
<td>4</td>
<td>14</td>
<td>12.3</td>
</tr>
</tbody>
</table>

6.5 Man-hours required to winnow and collect a quintal of wheat and barely:

Table 5

<table>
<thead>
<tr>
<th>Operations</th>
<th>Time taken (man hrs/quintal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winnowing—remove the major straws</td>
<td>1.235</td>
</tr>
<tr>
<td>Winnowing remove the seed from small straws</td>
<td>1.235</td>
</tr>
<tr>
<td>Collecting into sacks</td>
<td>1.765</td>
</tr>
<tr>
<td>Total</td>
<td>4.625</td>
</tr>
</tbody>
</table>

7.0 How long will it take an average farmer to thresh all of his crops?
7.1 a) Arable area is 2.54 hectares
     b) Yield is 20 quintals/hectare
     c) Total agricultural product = 2.54 x 20 = 50.8 quintals

7.2 As can be seen on table 2.28 man-hours are required to prepare a wheat/barely threshing floor. Which means 2.3 days will be required if 2 people make the threshing floor.

7.3 As can be seen on table 4, 4 man-days and 14 ox-days are required to thresh 12.3 quintals.
7.4 This implies that to thresh 50.8 quintals, 16.39 man-days and 57.82 ox-days are required. With all the animals and human resources available in the house of each average family, it is possible to thresh all of his crops within \((57.82 \div 4.1)\) 14.1 days. If all conditions (of wind) favour, all the grain will be winnowed and collected (at the rate of 4.625 hrs/qt. by two people. Within 50.80 x 4.625 \(-2\) 19.6 days. This shows that \((14.1 + 19.6)\) 33.7 continuous working days are required to thresh, clean, and collect all the grains each family has. Including the time taken to prepare the threshing floor, 2.3 more days will be included which will rise the total operation days from 33.7 to 36 continuous working days.

7.5 The average threshing floor has, on the average, a capacity of threshing 10 quintals of grain. This means there will at least be 5 threshings to be made. Though it is common in the area to be without enough wind for 3 days to winnow the grains traditionally, lets consider only two days of wind shortage per threshing time. This will make the farmers ideal for a total of \((5 \times 2)\) 10 days during the threshing season.

7.6 Assuming a gap of at least two days between each threshing, for cleaning the floor and spreading the sheaves on the floor, there will be a total of 8 additional days thus required.

7.7 This on the whole will rise the total length of the threshing operation to \((36 + 10 + 8) = 54\) days. *2

7.8 According to an oral report available from the farmers around Kulumsa, it requires 12 men-days to harvest a hectare of wheat or barley. This suggests that a farmer needs \((8 \times 12 \times 2.54)\) 30.54 solid-days to harvest all of his crops. If all the continuous operations of harvesting and threshing are added, a total of 84.5 days of continuous working are required.

7.9 According to the data available from the Meterology Unit, the short rains begin in the month of December. This is before threshing is over *3 and hence crop damage due to the short rains may be inevitable.

*2 Note that no allowance has been included for holidays and other social gatherings.

*3 There are 75 available days where-as at least 84.5 days are required for the harvesting threshing and cleaning are required.
8.0. Improvements to be made on the Non-Cleaning Metal Thresher

8.1 The non-cleaning threshers seem to be appropriate for the small rural house-holds because they are relatively simple and could be operated by members of the rural house-holds. The other justification for their appropriateness is they are relatively cheap. The following proposal on the threshers must be made before releasing it for mass production.

8.2 1. The thresher has a high percent breakage and is mainly due to the nature of the concave which is corrugated sheet metal. The grain already separated from the straw is beaten over and over again, as the result of which percent breakage is raised. It is hence recommended that the concave of the thresher is made porous to allow grain to pass through.

8.3 2. The other recommendation is that the width of the threshing drum be made wider in order to allow more straws to be fed into the threshing unit. This, I think, is very essential to decrease the % of unthreshed heads which is due to too much feeding of straw into the narrow threshing unit, as the result of which some straws pass through without enough threshing.

8.4 3. The other proposal is increasing the threshing surface of the concave, for better threshing of the straws, ie to tear the straw into small pieces. This is very essential since it decreases the amount of crop left in the straws and makes better straws for storage (it will be similar like the one available after trampling) for future animal consumption.

8.5 4. In-order to increase efficiency and improve the working conditions in winnowing the crop threshed by the non-cleaning thresher, it is necessary to make bar-meshes that may be used as a dumping floor for the threshing straw and grain.
Schematic diagram showing how the mesh will be used in combination with the non-cleaning thresher.

A) Threshed-straw and grain
B) Large straw being pushed across the mesh to the collection of straws.
C) Grain and small straws to be cleaned by wind or seed cleaners.
5. If one rolls the dumped straw away from the thresher, it is expected that the crop separated from the straw will be dropping to the bottom of the floor pushed further away but the crop collected under the mesh can be cleaned by making use of either wind in the same way (as the traditional system) or manually operating cleaners.

9.0 Imported Indian Thresher

9.1 In the same year, the threshing capacity and the cleaning quality of the imported Indian thresher has also been tested. According to the data available:

   a) Threshing capacity = 125kgs/hr
   b) Cleaning quality = 100%
   c) % breakage = 0%

9.2 In this thresher the straw is broken into various pieces so that it can easily be carried (lifted) by the draught of air coming in and in so doing, it separates the clean seed from the straws. The thresher loses more energy in breaking the straw into pieces rather than threshing and it is why the threshing capacity has been reduced to only 1.25 quintals/hr. Its cleaning quality is excellent and does not cause any significant breakage of the grains. There is an inverse relationship between the threshing capacity and the cleaning quality of the thresher in that if more straw is fed into the threshing unit, the rpm of the beater and the blower (since they are attached to the same shaft) will also be slowed there by resulting in poor cleaning quality.

10.0 The Cleaning Principle used in the Imported Indian Thresher.

10.1 Unlike the previous full-cleaning wooden threshers the Section has already produced (but now out of production), this thresher does not clean by forcing (pushing) a draught of air against the straw and seed, but instead a low pressure area is created in the cleaning unit through which air can be allowed to come to the low pressure area from one direction and in so doing a draught of air is created. Against this draught of air is allowed to fall the uncleaned seed and as the result the straw is separated from the seed. This can be schematically shown with the help of the following diagram.
11.0. Recommendations and the new full cleaning Thresher

11.1 The section has so far an experience on three threshers namely the full-cleaning wooden thresher, the non-cleaning metal thresher and the full cleaning imported Indian thresher.

11.2 Considering the merits and demerits of all the three threshers, and considering farmers reactions, the section has decided to make one full-cleaning thresher whose both the threshing and cleaning qualities and all other desirable qualities of all the three threshers are cross-bred in one.

11.3 The desirable qualities that have been taken from the full-cleaning wooden thresher is the beater and concave while the clearance adjustment is that of the non-cleaning metal thresher. The cleaning system is that of the imported Indian thresher.

11.4 The undesirable qualities of the three threshers, that have disqualified their appropriateness is, too much seed breakage and lack of cleaning unit in the case of the non-cleaning thresher; low threshing capacity, in the case of imported Indian thresher. The full cleaning wooden thresher has withdrawn from production because it was reported not to be covering costs. (IDR-CADU by Gills, pp70)

12.0 The Threshing and Cleaning Units of the new thresher

12.1 The same threshing system that has been used in the full cleaning Indian thresher has been used. A straw walker is used to separate the large straws from the rest. There is an other sieve to separate the unthreshed heads, from the seed and chaff, so that the unthreshed heads will be rethreshed. After the unthreshed heads and large straws have been separated, the rest is allowed to pass through a draught of air running to occupy the low pressure area in the cleaning system and in so doing the clean seed will be separated from the chaff and hence can be collected at the bottom.
(THE FIRST Prototype)

THE PERSPECTIVE DRAWING OF FULL-CLEANING THRESHER

DRAWN BY MELAKU TEKA    DATE 16.2.80.
DESIGNED BY BEYENE MEGERSA    NOT TO SCALE
13.0 What is the use of the straw walker?

13.1 As has already been stated, we want the threshing capacity to be around 5 quintals an hour like the non-cleaning-thresher. Here rasp-drum (rearing) drums, and they, very often, do not thresh the straw. These behave like the spike-drums of the imported thresher. It means the straws will be large and hence it can not be easily lifted by the draught of air. Even if the large straws are lifted, there is a fear that they will be clogged at the inlet. Hence it is found out that straw walkers be used to cut out large straws from the seed and chaff. It is thought that the draught of air would lift the remaining straws besides cleaning the seed.

14.0 Certain Design Features Considered

a) Revolutions of the straw walker 55 at 225 rpm. (Rural Development
   # 1, P17)

b) Area of the straw walker is calculated on the basis of
   0.175 m² for every quintal per hour. (Rural Devel. # 1, P17)
   The width is that of the width (half of the straw walker.

c) Revolutions of the thrasher main while threshing 1200 rpm.
   (Letter to the Project Director 10/26/1976)

d) Sieve sizes for wheat are 5.5 mm and 6.5 mm respectively.
References

1. "Attitudes of Chilalo Farmers To Farm Equipment Innovation" 
   International Rural Development Division. The Agricultural 
   College of Sweden - 1975 (pp.?)

2. AIDP - Planning. Evaluation and Budget Section

3. "Farm Technology Pilot Survey", Gills, Research Report no 23, 
   Institute of Development Research, Addis Ababa University, 
   July 1976, (pp. 115)

4. Rural Development Studies: - # 1, (pp. 8)

5. Zone B (Gonde) and C(Egu) are considered.

6. Gills, (pp.45 and 47)

7. Gills, (pp. 126)

8. "On Evaluation of Innovation dissemination strategy and process 
   in CADU Project Area, Michael Beyene, CADU Planning & Evaluation 
   Section Asella, Dec. 1973. (pp. 9)

9. Deduced from, Rural Development Studies, no.1 (page 7), under 
   the condition that $\frac{2}{3}$ of the whole straw is grain and $\frac{1}{3}$ is 
   the straw. Daily labour cost is assumed to be 2 birr/day/ man 
   and hire cost of a pair of oxen is taken to be 3 birr/day

10. Michael Beyene, (pp.9)

11. This has been deduced from the assumption that 12 ox-hours 
    are required to thresh traditionally and 2 ox-hours are required 
    to thresh a quintal of cereals crops, by making use of tread- 
    mill driven threshers.
A Summary Of A.R.D.E.P.'s Experience
And Recommendations On Ploughs and Harrows

(Including Results Of 1979 Field Tests)

Beyene Mesersa
ARDP Engineering Department
Agricultural Engineering Section
October, 1979
1.1. There is no doubt that in order to develop a country, its level of technology must be raised. When talking of advancing technology, one must note that it will give sense if, and only, if space and time is considered as well because what is appropriate to a country today may no longer hold true for the same country, say after a decade; and similarly what is advanced technology for one country may be of primitive nature to another country.

1.2. In developing a country, both the new ones and indigenous technologies must be made to combine in order to suit the realities in the country.

1.3. In Ethiopia the traditional farming technology is at its lowest level whereas, both in the Eastern and Western Worlds, it is at a high level.

1.4. To develop the country, improved and manageable systems must be introduced and practised without delay.

1.5. According to the studies made previously, it was recommended that "intermediate technology for Ethiopia must be one which is labour intensive as traditional methods but, more efficient one". (1). This suggests that research activities must be conducted in this field. The "nationalisation of rural land has made the search for intermediate technology even more urgent since labour hire even at "bottle neck" periods are not allowed". (2).

2.0. Objectives of the Project and Activities on farm implements.

2.1. Arsi Rural Development project (A.R.D.P.) is a Comprehensive Rural Development Project whose main objective is "to bring about economic and social development in Arsi Region". (3).

2.2. In its strategy to bring about economic development in the Region, it has a research center where new innovations are first tested (sorted out) and an extension service where those innovations proven successful are made to reach the farmers.
2.3 The then Implement and today Agricultural Engineering Section, whose objective includes conducting research on implements at the intermediate technology level, has hence designed, made and tested prototypes of various implements among which animal-drawn mould-board plough and harrows are nothing but only two turo of them.

2.4 The Project is in its third phase plan includes that "Agricultural Research and Experimentation work already started in the first and second phase..... will continue to develop innovations which will maintain and advance the economic status of the peasant farmers. (4).

3.0 Objective of the Paper

3.2 The objective of this paper is not to present a detailed plough design but summarizes the sections experience on ploughs and identifies problems related to it so as to give the next plough designer the grounds on which to base his design. It also includes a summary of data collected from ARDU plough conducted in 1979.

4.0 Some facts about the Mould-Board Plough

4.1 The mould board plough which was originally of "VITA" version has been tested and according to the data available from the reports made then, its pull-power requirement was 126 kg-mts/sec (5), while that of local plough was 118 kgs-mts/sec (6) on heavy soils.

4.2 More information may be got from the following table (7).

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Mould Board plough</th>
<th>Local plough 1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plough-power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kgs-mts/sec</td>
<td>126</td>
<td>156</td>
<td>135</td>
<td>108</td>
<td>73(8)</td>
</tr>
<tr>
<td>Working depth</td>
<td></td>
<td></td>
<td>11.4</td>
<td>11.3</td>
<td></td>
</tr>
</tbody>
</table>

4.3 From the above table, which was conducted on heavy soil, it is necessary to note that the pull power required by the local plough was 156 kgs and 135 kgs for the first and second ploughings respectively (9).
This implies that its pull-power requirement for those two operations, is much more than that of the mould board plough which was only 126 kgs mts/sec. The working depths for both plows is satisfactory because the bacteria that assist the growth of crops are within the top four inches of the soil (10).

An attempt to compare the cost benefit analysis of the farming operations with the mould board plough combined with harrow and local plough has also been made.

The comparison was made in 1971 and hence what will be referred to as "new method" is the then new method and does not refer to the trials of 1979.

Comparison between new method and local method (of cost) on 3 hectares during one ploughing season have been made in 1971 (7), and the data are listed below.

The cost of first ploughing is about the same for the local and the new methods.

Local method on heavy soils.

| 1st ploughing | 8 days at $3/6hrs/day | $24.00 |
| 2nd ploughing | 6 days at $3/" " | 18.00 |
| 3rd " | 4 days at $3/" " | 12.00 |
| Covering | $10.00 |
| Total cost for 1 hectare | 64.00 |

New method on heavy soils.

| 1st ploughing | 8 days at $3/6hrs/day | 24.00 |
| 1st harrowing | 1/3 " " " | 1.50 |
| 2nd " | 1/3 " " " | 1.50 |
| Seed covering | 1/3 " " " | 1.50 |
| Total cost for 1 hectare | 28.50 |

4.10 The comparison was made in 1971 and hence what will be referred to as "new method" is the then new method and does not refer to the trials of 1979.

4.7 Comparison between new method and local method (of cost) on 3 hectares during one ploughing season have been made in 1971 (7), and the data are listed below.

The cost of first ploughing is about the same for the local and the new methods.

| 1st ploughing | 8 days at $3/6hrs/day | $24.00 |
| 2nd ploughing | 6 days at $3/" " | 18.00 |
| 3rd " | 4 days at $3/" " | 12.00 |
| Covering | $10.00 |
| Total cost for 1 hectare | 64.00 |

New method on heavy soils.

| 1st ploughing | 8 days at $3/6hrs/day | 24.00 |
| 1st harrowing | 1/3 " " " | 1.50 |
| 2nd " | 1/3 " " " | 1.50 |
| Seed covering | 1/3 " " " | 1.50 |
| Total cost for 1 hectare | 28.50 |

4.10 The comparison was made in 1971 and hence what will be referred to as "new method" is the then new method and does not refer to the trials of 1979.
4.11 Difference for 3 hectares on heavy soils

<table>
<thead>
<tr>
<th></th>
<th>Local method</th>
<th>New method</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$192.00</td>
<td>$85.50</td>
</tr>
</tbody>
</table>

4.12 Local method on light soils.

<table>
<thead>
<tr>
<th></th>
<th>1st ploughing 3 days</th>
<th>2nd ploughing 2 days</th>
<th>3rd ploughing 2 days</th>
<th>Total cost for 1 hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$3/6hrs/day</td>
<td>$3/6hrs/day</td>
<td>$3/6hrs/day</td>
<td>$33.00</td>
</tr>
<tr>
<td></td>
<td>3 days at $3/6hrs/day</td>
<td>2 1/2 days at $3/6hrs/day</td>
<td>2 1/2 days at $3/6hrs/day</td>
<td>$99.00</td>
</tr>
</tbody>
</table>

Total cost for 3 hectares = 3 x $33.00 = $99.00

4.13 New method on light soils

<table>
<thead>
<tr>
<th></th>
<th>1st ploughing 3 days</th>
<th>1st harrowing 1/4 day</th>
<th>2nd harrowing 1/4 day</th>
<th>Seed covering 3/7 day</th>
<th>Total cost for 1 hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$3/6hrs/day</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>$13.50</td>
</tr>
</tbody>
</table>

Total cost for 3 hectares 3 x $13.50 = $40.50

4.14 Difference for 3 hectares on light soils

<table>
<thead>
<tr>
<th></th>
<th>Local method</th>
<th>New method</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$99.00</td>
<td>$40.50</td>
</tr>
</tbody>
</table>

4.15 When seed covering is done by harrowing rather than local plough, there is an increase in yield from 2-3 quintals per hectare. Assuming the price of wheat to be $20.00 per quintal the average profit from the increased yield will be $50.00.

4.16 To sum up the difference in gain from using the new rather than the local method;

4.17 On heavy soils

gain from using the new method (50 x 3 hec.) = $106.50

gain from selling of increased yield = $256.50
4.18 Cost of harrow
Cost of M.B plough
Total cost
Total saving on 3 hectares of heavy soils
Total cost of implements
Net profit on heavy soils

4.19 - On light soil
   gain from using the new method
   gain from selling of increased yield
   Total saving from 3 hectares

4.20 Total saving on 3 hectares (on light soils)
Total cost of implements
Net profit on light soils

4.21 So one can cover the cost of harrow and M.B plough within one season of cultivation with additional profit of
   - on heavy soils
   on light soils

4.22 Contrary to what the figures tell us, farmers reactions to the plough was much less than the sections experts, in fact, according to the study made in Chilale in 1975, only 0.041% of the farmers dealing with the project used mould board plough (10).

4.23 What then is the problem? Has the section used wrong calibers in evaluating the plough to approve its appropriateness? or is it because the advantage brought about by the plough is not significant enough to be observed by the farmers? or is it because it did not widen any bottle-neck the farmers had in their farming operations?
5.0 Farmers comments on the mould board plough

5.1 The farmers and extension agents were dissatisfied with the stubble bottomed mould-board plough "the roots of their dissatisfaction lies in its heavy weight, bad firmness and short durability of the plough in comparison with the high price. Only very few farmers are convinced that it is more durable than the local plough" (11) the share of the local plough lasts for two years but that of the mould board plough lasts for four years. (12).

5.2 The mould board plough is not only heavy to be carried while transporting but its draught requirement on the average is also greater than that of the local plough.

5.3 The other problem with the mould-board plough is that its mode of operation needs a continuous draft which implies that the oxen do not get rest at intervals like the traditional one. This is assumed to exhaust the oxen earlier than the local plough.

6.0 Indicators of bottle-necks in farming operations

6.1 The whole objective of conducting research activities is to widen bottle-necks that have been created earlier. In order to discover the bottle-necks, the indicators have been identified and a survey has been made.

6.2 According to the studies made in 1976, hiring of labour and operational calender for various farming operations have been used as indicators of bottle-necks. In the study, it is reported that farmers have previously hired labour on temporary basis, and considering each farming operations, 89% of all the farmers have hired labour for harvesting, 33% for weeding, 28 for threshing, 17% for ploughing, 15% for winnowing, 13% for sowing and 9% for transproting crops (14).

6.3 As far as the calender of farming operations for wheat and barley which constitute 67% of all the crops in Chilalo (15) is concerned it is spread over a period of, at least, four months.
7.0 How long will it take a farmer to complete ploughing his farms?

7.1 With the assumption that:
   a) each farm is ploughed 4 times (16)
   b) each family, on the average owns 3.5 hectares (17)
   c) the rate of performance of the local plough is 4 days/hec
tare (18)

7.2 Total ploughing days required by traditional system to complete seed-
bed preparations for a farm owned per family with a pair of oxen will
be (4 days x 3.5 x 4 ) 56 days. (This is a rough estimate; the third
and fourth ploughings do require less than 4 days to complete farming
a hectare of land).

7.3 As has already been cited above, there are, at least, four months for
seed-bed preparation including sowing, ie a total of (4 x 30 days)
120 days.

7.4 From the above figures, one can conclude that farmers are using only
46.7% (56 / 120) of the time allocated for ploughing in the operat-
ional calendar. This indicates that since ploughing period is long
enough to allow the farmers to till their farms with the local plough
within the allowable range of time, the introduction of the mould-
board plough does not seem that urgent.

8.0 Mould Board ploughs increased yield of water-
logged areas

8.1 A good percentage of potential arable land in the project area is
having drainage problem and hence results in very low yield.

8.2 The ox-driven mould-board plough helps the farmers in increasing yield
on areas where there is drainage problem. According to recent
studies made by the project on areas with drainage problems, various
oxen-camber beds have been made and the following results have been

got.
As can be seen from the above figures, there is a big difference in yield, between the check and the various camber-beds. The differences are in the range of 2175 kgs/hectare and 835 kgs/hectare. This implies that the increase in yield, by using improved implement is roughly 1505/kgs/hectare.

9.0 What then should be done?

9.1 The mould-board plough helps the farmers in saving time, increase yield and reducing the density of weeds, which means that additional costs to be incurred to purchase herbicides or, for labour to weed, is as well reduced. Hence (although ploughing ranks fourth in terms of priorities of bottle-necks created in the farming operations), the plough must be designed in such a way that its pull-power requirements are within the range of the local oxen.

9.2 The success of the mould-board plough may also, to a greater extent, be affected by the delay of the rural community in other fields of development (other than growing crops) such as cottage industries, irrigation activities, honey production, poultry production etc which would mean that the farmers will then be more occupied than today and hence give more importance to the saving of time in ploughing.

9.3 Though the objective of this section is not to make ploughs of various shapes to suit various soil conditions, especially today when the farmers taste is not that encouraging, it is necessary to measure the soil resistance of the various soil types for future recommendations.

9.4 A comparative study must be made on the reversible mould-board plough, the local plough, the mould-board ploughs in order to find out the one which is more appropriate to the specific soil conditions and yet the draught power requirement is within the range of the local oxen.

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
<th>Spacings and yields (kg/ha)</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 mts</td>
<td>1.5 mts</td>
</tr>
<tr>
<td>Sagare</td>
<td>76/77</td>
<td>4100</td>
<td>3302</td>
</tr>
<tr>
<td>Sagare</td>
<td>77/78</td>
<td>3444</td>
<td>3081</td>
</tr>
</tbody>
</table>
9.5 Design defects of the previous plough have also contributed to the increased draught power requirement of the mould-board plough. The defect is the drop structure at the end of the share and at the beginning of the mould-board. The drop being uneven keeps some soil at the joint while ploughing. Since soil over soil resistance is much more than the soil over metal resistance, the presence of the accumulation of the soil at the drop structure increases the resistance to motion there by increasing the total draught power requirement of the whole plough.

9.6 The section, after collecting the farmers reactions to the previous plough, has again made an other mould-board plough with the general purpose bottoms. The new plough does not have the drop structure like the previous ploughs and its handle is very similar to that of the local one. The handle of the present ploughs is very similar to that of the local plough. The handle of the previous mould board ploughs rises suddenly and makes of nearly $90^\circ$ with the beam and this created inconvenience to the bare footed farmer due to frequent hammering of his toes. The handle of the present plough does not cause any harm with this regard.

10.0 Performances of the New Plough

10.1 According to the study made on clay-soils of Kulumsa during the seed-bed preparation season of 1979, the following results from the performances of the plows have been recorded.

<table>
<thead>
<tr>
<th>Type of Plough</th>
<th>Force (kgs)</th>
<th>Speed (mts/mns)</th>
<th>X-Sectional area $(cm^2)$</th>
<th>HP Requirement</th>
<th>Unit Force $(kgs/cm^2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>250</td>
<td>35</td>
<td>$0.5 \times 24 \times 14.5 = 174.30$</td>
<td>1.91</td>
<td>1.43</td>
</tr>
<tr>
<td>Old-mould board</td>
<td>275</td>
<td>35</td>
<td>$0.5 \times 36.5 \times 17.5 = 319.4$</td>
<td>2.1</td>
<td>0.86</td>
</tr>
<tr>
<td>New-mould board</td>
<td>325</td>
<td>35</td>
<td>$0.5 \times 37.5 \times 24 = 450$</td>
<td>2.49</td>
<td>0.722</td>
</tr>
</tbody>
</table>

10.2 According to an other study made on Dhera light soils which has been previously under cultivation during the same season, the following results have been recorded.

.../.../10
Table 4

<table>
<thead>
<tr>
<th>Type of plough</th>
<th>Force (kgs)</th>
<th>Speed mts/mns</th>
<th>Cross-sectional area (cm²)</th>
<th>HP requirement</th>
<th>Unit force kgs/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>150</td>
<td>35</td>
<td>0.5x28x15=150</td>
<td>1.15</td>
<td>1</td>
</tr>
<tr>
<td>Old-mould board</td>
<td>215</td>
<td>35</td>
<td>0.5x30.5x26.5=404.13</td>
<td>1.66</td>
<td>0.53</td>
</tr>
<tr>
<td>New-mould board</td>
<td>250</td>
<td>23.33</td>
<td>0.5x40x2=500</td>
<td>1.28</td>
<td>0.5</td>
</tr>
</tbody>
</table>

10.3 Result of the same study conducted on un-ploughed (virgin) land during the same year on Dhera light soil.

Table 5

<table>
<thead>
<tr>
<th>Type of plough</th>
<th>Force (kgs)</th>
<th>Speed mts/mns</th>
<th>Cross-sectional area (cm²)</th>
<th>HP Requirement</th>
<th>Unit Force kgs/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>275</td>
<td>23.33</td>
<td>0.5x12.5x8.5=53.13</td>
<td>1.40</td>
<td>5.18</td>
</tr>
<tr>
<td>Old-mould-board</td>
<td>315</td>
<td>35</td>
<td>0.5x25.5x15.5=197.63</td>
<td>2.41</td>
<td>1.59</td>
</tr>
<tr>
<td>New-mould-board</td>
<td>325</td>
<td>23.33</td>
<td>0.5x39.5x21=362.25</td>
<td>1.66</td>
<td>0.9</td>
</tr>
</tbody>
</table>

11.0 Conclusions and Proposals on Ploughs

11.1 In all the cases the total pull-power requirement of the new-mould-board plough is greater than that of the other two; but in all the cases, the unit force of the new mould-board plough is the smallest whereas that of the local plough is the greatest. This suggests that the efficiency of the unit force of the latest plough is the best, and that of the local plough is the least. This is because most of the vegetational covers of the farm are cut with the share of the mould-board plough, but it is dragged, or rather cut with a dull edge of the local plough.

11.2 Although the efficiency on the unit force of the new-mould-board is best, its total pull-power requirements has been found out to be the greatest and hence two possible alternative solution may be suggested. One possible solution is to have better draft animals that can pull the plough more easily if compared with the local oxen.
but does not seem to be practical within a short period of time and hence the Section is forced to design new-mould board plough whose draught power requirement is within that required by the local plough.

11.3 Results of pull-power requirements by harrows on Kulumsa clay soil

Table 6

<table>
<thead>
<tr>
<th>Type of Harrow</th>
<th>Force (kgs)</th>
<th>Speed mts/mn</th>
<th>Weight of Harrows (kgs)</th>
<th>HP Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trapezoidal</td>
<td>134.2</td>
<td>35</td>
<td>43.1</td>
<td>1.03</td>
</tr>
<tr>
<td>Triangular (Green)</td>
<td>100</td>
<td>35</td>
<td>36.5</td>
<td>0.77</td>
</tr>
<tr>
<td>Triangular</td>
<td>102.5</td>
<td>26.25</td>
<td>38.0</td>
<td>0.59</td>
</tr>
</tbody>
</table>

11.4 Results of horse-power requirements by harrows made by the section Dhera light soils

Table 7

<table>
<thead>
<tr>
<th>Type of Harrow</th>
<th>Force (kgs)</th>
<th>Speed mts/mn</th>
<th>Weight of Harrows (kgs)</th>
<th>HP Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trapezoidal</td>
<td>138.33</td>
<td>35</td>
<td>43.1</td>
<td>1.06</td>
</tr>
<tr>
<td>Triangular (Green)</td>
<td>137.50</td>
<td>35</td>
<td>36.5</td>
<td>1.05</td>
</tr>
<tr>
<td>Triangular (Blue)</td>
<td>137.5</td>
<td>35</td>
<td>38.0</td>
<td>1.05</td>
</tr>
</tbody>
</table>

12.0 Conclusions and Recommendations on Harrows

12.1 As has already been suggested previously, harrows have the advantage of saving time and increasing yield. Their draught requirement, as can be seen on tables 6 and 7 is much less than that required by the local plough; there have not, so far, been any report from the farmers side whether harrows require more draught than local ploughs.
ASSEMBLY OF TRIANGULAR HARROW

T.R.D.P
AGRICULTURAL ENGINEERING SECTION
Units are in cm.
Scale = 1:100
The only comment farmers have so far made on harrows is that they have to pack it on a donkey or horse back to transport from place to place and this is inconvenient since the donkey could be used for other pack activities. The section, considering this suggestion, has made a triangular harrow loaded with sleds that will enable it to be turned-over and dragged by a bullock for transportation purposes.

The width of the triangular harrow is greater than that of the previous ones so that more area could be covered at ones. The amount of material it requires is less than others and hence it is cheaper. In case deeper harrowings are needed, weights could be kept on the top of the harrow and the section hence now recommends the triangular harrow to be reproduced and distributed to farmers as the needs come.

REFERENCES AND FOOT NOTES

1. IDR-CADU Farm Technology pilot survey, Gills-page 114.
2. IDR-CADU Gills page 114
3. ARDU publ No. 1 page
4. ARDU publication No. 1, page 40
5. Agr. Engineering Section reports - on 1971 trials
6. This is an average result of all the four ploughings done with the local plough.
7. Agr. Engineering Section reports on 1971 trials
8. The fourth ploughing is for sowing
9. This is due to the various resistances created by the grass grown.
10. IDR-CADU GILLS
11. Minor Research No. 4, Jan Kalisky

Attitudes of Chilalo Farmers to Farm Equipment Innovation

International Rural Development Division - 1975, PP 36
12. CADU - Planning & Eval. Michel Beyene - PP 9
13. As has already been noted on the 1971 report of the section see table 1.
14. Same as the previous trials made on ploughs.
15. IDR - CADU - by Gills PP 115
16. Figure available from planning & Evaluation Section
17. This is the conversion figure used in the project area.
One additional point that is worth mentioning is the reasons given by farmers when asked why they want to hire tractors for ploughing their farms. The farmers said that they want to have their farms ploughed by tractors at intervals of about three years because tractor ploughs disturb the soil to a greater depth than the traditional plough and this will better control weeds and will also make the next ploughing easier with the traditional plough. Even if farmers prefer to use tractors, no evidence is available to show yield difference from farms operated by both traditional (local plough drawn by pair of oxen) system and mechanized system (tractor loaded with its respective implements).
LIST OF CADU/ARDU PUBLICATIONS

A: PROJECT PREPARATION PERIOD


   Part I General Background
   " II Project Outline
   " III Appendices
   (A reprint of the Summary is also available.)


7. Results of Trials and Observation Plots at the Kulumsa Farm in Arssi Province, Crop Production Department, May, 1967.


IMPLEMENTATION PERIOD (CADU Phase I & II)


8. CADU (Pamphlet in English and Amharic).
12. Results of Trials and Observations on Fields, Forage Crops at the Kulumsa Farm and in Asella 1967/68, June, 1968.
15. CADU Statistical Digest, Planning & Evaluation Section, May, 1968.
17. Field Trials and Observations 1968/69, Crop Production Department.
18. Feasibility Study on a Farm for Breeding of Grade Cattle at Gobe, Arssi Province, Planning & Evaluation Section, September, 1968.
34. CADU Annual Report 1968/69.
37. Sanitary Survey in Golja (Ketar Genet), by Gunnar Arhammar, Asella, April 1969.
38. Kap Study of Mothers in Golja (Ketar Genet), by Gunnar Arhammar, Asella, April, 1969.
39. Food Survey of Pre-school Children in Golja (Ketar Genet), by Gunnar Arhammar, Asella, April, 1969.
40. Health Survey of Pre-school Children in Golja (Ketar Genet), by Gunnar Arhammar, Asella, April, 1969.
46. Report on Surveys and experiments, Crop Production Department, Asella, 1969.
47. CADU Work Programme and Budget for the Period 8.7.70 - 31.12.70, Asella, June, 1970.
57. Survey of Health Facilities of Arssi 1969/70, by Stig Lundin M.D.
60. CADU Evaluation Studies: Training of Model Farmers (after measurement of effect) by Goran Bergman, Asella, October, 1970.
68. Health Survey in Sagure Village and Yeloma Farming District, by Gunnar Arhammar and Roland Eksmyr, April, 1968.
70. Survey of the Consumption of Coffee, Tea, Tobacco and Alcohol in a Market Town (Sagure), Especially with Regard to Cost, by Stig Lundin M.D., September, 1971.
75. CADU Annual Reports 1971/72 & 1972/73 - Vol. I & II.
76. Case Study on Farm Households in the Asella Area, April, 1972.
C. PERIOD OF ARSSI REGIONAL DEVELOPMENT


2. Attitudinal Case Study of Farm Families in Robe, Gobessa & Lemu By Hanna Kobe de Asella, May 1976 ARDU Publication No. 2.

3. Economic Characteristics of Peasant Families in the Asassa Area, Chihalo Awraja, By Teruneh Zena (Asella, June 1976 ARDU Publication No. 3)

4. ARDU Work Programme & Budget 1976/77, Asella, November 1976, Publication No. 4


8. Crop Sampling Survey in Arbagugu and Ticho Asella, April 1977 ARDU Publication No. 8


11. ARDU Work Programme and Budget 1977/78 Asella, July 31, 1979, Publication No. 11


MINOR RESEARCH TASKS


3. Credit Situation in Chilalo Awraja (Base-line Study) by Goran Bergman and Hakan Lindquist, July, 1969.


5. An Inventory of Feeding System and Feed Stuff, Chilalo Awraja, Ethiopia, by Oscar Evaldsson.


10. Inventory of Indigenous Ecotypes of Some Species in the Chilalo Awraja Ethiopia, by Joel Carlsson.

11. Inventory of Soils in the Rift Valley Region of Chilalo Awraja, by Carolina Trapp, Asella, April, 1974.


SPECIAL STUDIES


