REPORT TO INVIERNO
BY JOHN BALIS
FOR ASSIGNMENT OF FEBRUARY 1-8, 1978

Recommendations on Appropriate Technology

Preface

This report is in response to the Plan of Work prepared by the Invierno Staff and supplemented during the assignment (Appendix A).

The Assignment of February 1978 was requested to develop detailed information on selected concepts for farm development introduced during the course of an assignment in August 1977. The recommendations and earlier analysis are not repeated in this report. However, these two reports are integrally related.

This report has been drafted from recall. Detailed references were not at hand for verification of specifications, etc., or for annotation of the report.

And lastly, because of the limited time available to cover this extensive Plan of Work, an outline form has been used for presentation of the material. Elaboration can be developed as might be required for most sections.
Introduction

After due considerations, Invierno has accepted the recommendations of the initial study and identified various tools and facilities for detailed consideration with respect to development for the project area. This report provides a detailed analysis of these selected items and includes some descriptions of prototypes that offer potential. The last two sections outline the research and development process which can utilize these prototypes and evolve them into suitable technology for extensive application in the project area.

The research and development process for any technology is an iterative process which feeds back into the process the local experience in technology use as an input to improve the design of the items and the supporting facilities. This feedback capability is in place in the form of the Agromoc's and institutional structure of Invierno. It is assumed that this staff can readily incorporate technology research and development operations and expeditiously move the prototypes suggested to effective tools and facilities of utility to project farmers. Not that Invierno will undertake all of the necessary R&D work, for there are several specialized institutions and enterprises that can contribute. With its broad mandate and strong capability, the Invierno structure provides the coordinating capability as well as the technology transfer resources and feedback linkages that will be crucial to accelerated change of technology.

As a basic principle, the author expects that Invierno can supplement the information that is provided from the accumulated staff experience and select prototypes and development plans. In some cases additional
reference material and appendices to this report will be mailed to provide supplementary details of design and construction. Of course, it is quite likely that some problems will be encountered in field experimentation that might be more expeditiously resolved by further consultation rather than by an additional, local research program. In other words, some means of technical assistance may be useful to Invierno in an accelerated program of technology development, but such inputs are anticipated to be modest in amount and specialized in subject matter.
I. Animal-Drawn Implements

A. Traditional Plows

It is a good principle to understand the function and economy of conventional practices before attempting to present improved methods. The traditional plow is very low cost and quite simple in adjustment and maintenance. While this plow does not till the soil effectively or kill weeds well, it does conserve moisture and can be used for plowing, planting and cultivating. It is impossible to design a machine, or machines, that do these several jobs better at close to the cost of the traditional plow. At the same time, it is impossible to use the traditional plow and achieve the soil conditions that agronomists specify as required for high productivity of the major field crops. Steel points and a few other variations have been introduced for traditional plows which have improved their durability, but these innovations have not improved the functions. Thus, it is necessary to abandon the traditional plow in order to raise agricultural productivity.

B. Soil Turning Plow

1. Long-Beam Type (Shabash Plow)

The soil turning plow uses a steel share and mouldboard assembly to cut and invert a slice of soil. This process opens the soil and buries surface trash, thus quickly preparing a better seedbed. Small animal-drawn plows do not perform as well as large tractor plows, yet the steel plow is much better than the traditional plow on the soils with sufficient rainfall. It is generally possible to cut plowing time by 50 - 75 percent and also have a better quality of tillage, better coverage of
surface trash and better weed control. These conditions may contribute 20 to 50 percent to crop yields depending upon variety grown and other management practices. It is this extra production that can readily offset the purchase and maintenance costs.

The operating adjustments of the long-beam plow are similar to those of the traditional plow, therefore readily understood by farmers.

Assembly and servicing of the soil turning plow could be done by village blacksmiths with a few hours of training. It is necessary to produce the share, moldboard and base frame (log) in a factory to get good performance and repair part interchangeability. A large cutting and forming press, plus an assembly jig for welding are the major tooling, thus manufacturing is quite simple. Raw material requirements are also minimal with all parts except the share produced from mild steel. The share should be in the 0.80 - 1.00 percent carbon category.

Shares will need sharpening and repair about two times per season. Share replacement may be necessary every third year, moldboards may need replacement after the fourth year on stony and coarse soil or at longer intervals on lighter soils, while repair and replacement of the landslide heel will be required about every second season. Repairs can be done by blacksmiths if they stock necessary replacement parts.

Farmers would not require much more than a short training period to understand operation and care. It may be necessary to follow up after a few days to verify that adjustments were understood, and a month thereafter to see that share sharpening and other maintenance was also understood. Blacksmith training in fabrication and service may require a 3-5
day program as well as assistance in the early procurement of parts, raw materials and additional tools and in the business management of this new enterprise.

Variations in moldboard are not required for this plow to accommodate different soil conditions. Furrow width of 15 cm can be handled by a pair of draft animals each weighing 350 - 450 kg.

2. Short-Beam Type Plow (Care Plow)

Large draft animals (more than 500 kg. per animal) can readily pull soil turning plows of 20 cm width. However, such plows in the long-beam design are excessively heavy and difficult to handle. The short-beam design is, however, more complicated to hitch and adjust properly. Farmers will require more training in use and manufacturers may require more help in getting started so that they the right customer training program is set up.

Production and service can be established in the same way as for the long-beam plow. It might be desirable to offer two or more moldboards to improve the performance on different soils.

This should be a second generation of plow technology offered only after the long-beam type is well established. Because the number of large draft animals are few, this plow is not now important. The long-term importance of this type of plow depends upon the development of larger draft animals.

C. Reversible Plows

Reversible plows (or one-way plows) have been developed to be used in situations where it is desirable to keep the field surface very level
such as in intensive irrigated farming. Reversible plows have also been used on hillsides to throw the soil uphill, thereby compensating somewhat for erosion effects. Intensive irrigation under carefully leveled soil is not practiced in the project area; therefore, that need for the reversible plow does not exist. The use in maintaining hillside soil contours may apply, but the advantage of better erosion control, etc., has not been established through a program of soil and water management research.

The reversible plow will cost on the order of 2 times the Shabash or short-beam types. In general, the smaller sizes such as animal drawn sizes do not turn uniform furrows and are probably not worth the cost. Also, proper use requires more training of farmers. Proper manufacture also is more complex and will require an additional investment in tools and training in production and servicing techniques.

Before this plow is considered for commercial development, a research program involving comparative plowing treatments and soil erosion measurements should be set up. Comparisons should be made with the diversion of excess run off to grassed waterways by the back furrows or dead furrows of the standard plow. The program could be expanded to include alternative terrace designs. Experimental layouts are illustrated in the following sketches:
Runoff measurement and sample arrangement for analysis of erosion

Alternative Experimental Comparisons:
- traditional plowing
- soil turning with terraces or furrows on contour
- soil turning with furrows in direction of slope
- one-way plowing on contour
- comparison of several spacings and sizes of contour terraces
- comparison of grass waterways in construction and in kind of grass
- comparison of various treatment and with various crops such as maize, potato, beans or pasture
D. Furrowers

Furrowers are shaped like two plows back to back and throw two narrow furrows in opposite directions. This tool is used for shaping tilled land or for cultivating and shaping land during the growing season. Furrowers do not make good plowing tools because they do not bury the trash well nor do they produce good soil surface and generally cannot plow as deep for the same amount of power input.

This tool appears to be a good one for use in Nicaragua for cultivating corn and potatoes. It would build the hills and eliminate weeds in a series of treatments through the row during the early growing season -- perhaps three treatments at 7 to 10-day intervals. This may be especially beneficial in growing maize in areas of high rainfall.

The furrower might be used for harvesting potatoes by plowing out the mature rows.

In very dry land, the furrow may be used just prior to planting for removal of the deep layer of any soil in the plant row. The seeds are then planted in the bottom of the furrow in a manner similar to that now practiced with the traditional plow. The furrower can later be used to hill the soil around the growing plants and shape the soil for removal of excess water in poorly drained soils.

Furrowers have somewhat different shapes from moldboard plows because they are used in well tilled soil. However, the principles of construction and use are quite similar. We don't have hard data to prove the benefits of use. Under the soil types, climatic conditions and with
the crops grown in the Invierno project area, the furrower should have some utility for up to one-half the farmers. However, it is recommended that firm data be developed before promoting this tool. In addition, its use should be encouraged only on farms that have adopted improved plows and are regularly preparing good seedbeds.

E. Secondary Tillage Tools

1. Shovel-Type Cultivators

A 3 or 5-shovel cultivation can be used to finish a seedbed once it has been plowed in 1/3 or 1/5 the time that might be taken to work the ground down by successive treatments with the soil turning plow or traditional plow. In some dry land areas this tool alone may be adequate for preparing the seedbed. The cultivator can be fitted with flat shovels or sweeps according to depth and soil treatment desired. Flat shovels are used when depth is desired, while sweeps are used for shallow treatment such as weed control. Cultivators can be made with adjustable shovel spacing; to accommodate row cultivation of crops.

Shovel cultivators can be fabricated by blacksmiths. Good quality shovels can be made from medium carbon steel and should have smooth surfaces such as those formed by a large press. Pieces other than the shovel can be fabricated from mild steel and could be produced by blacksmiths in a variety of shapes and designs. Shovels may require repair and sharpening on a seasonal basis and replacement every third season or more. Other repairs are a minimum. Training requirements for farmers and blacksmiths are about the same difficulty as for the soil turning plow.
Introducing the shovel cultivator as an alternate to the traditional plow is a possibility in certain light, dry soil areas. In heavier and more moist soils, it is advisable to introduce the soil turning plow and the shovel cultivator as companion tools. Together these two tools would increase the soil preparation capacity of a pair of draft animals from 50 - 75 percent.

2. Disk-Type Cultivator

A six-disk cultivator can till a strip of land approximately 75 cm wide and approximately 8-10 cm deep when pulled by a pair of animals. The quality of tillage is generally superior to that produced by two treatments with the shovel cultivator. However, the machine costs perhaps four times that of the shovel cultivator. The disk cultivator handles irregular soil surface conditions and occasional partially covered trash much better than the shovel cultivator.

Manufacturing of disk harrows is considerably more complicated than for other tools. A large press is required to form the disks from a steel of approximately 1.00 percent carbon. Heat treatment of the disks is also desirable. The disk harrow also uses bearings which can be made from wood for animal-drawn disk harrows. In addition, there are more pieces and somewhat more care is required in production and assembly. From these characteristics it is obvious that training of manufacturers and organization of production for disk harrows require some two to three times as much effort as for plows.
Training of farmers, however, is not significantly more complicated than training them to use plows. The only adjustment in both cases is that of depth. Operation, care, and servicing are also similar in terms of daily care, while disk harrows may require replacement of bearings and sharpening on an annual basis. This service might best be provided by the blacksmith rather than being undertaken by the farmer. Nevertheless, it would be possible to develop a farmer training course for this annual servicing if replacement bearings were readily available.

The advantages of the disk harrow in accommodating very irregular surface conditions and partially buried trash adapt this tool very well to secondary tillage after plowing by tractors. For almost all other tillage situations, it is more often a matter of farmer opinion rather than evidence of any research that leads to the choice of disk or shovel harrows. Research on the comparative merits of these two implements is not recommended. It is recommended, however, that disk harrow promotion be delayed until some experience in production and servicing is built up for plows and shovel cultivators.

F. Row Cultivators

Removal of weeds between rows of maize, potatoes, beans and other crops can add 20 percent or more to the yield of the crop by conservation of both water and fertilizer. In the situation where reshaping of the land is done with the furrower, weed control is generally accomplished well at the same time. It is also possible to readjust the shovel cultivator to make it fit between rows or straddle rows and cultivate out the
weeds. Obviously all of these treatments require straight, parallel rows at equal spacing across the field to get good weed control.

Some farmer training on machine adjustment and operation will be required but there are no special manufacturing requirements for row cultivators that have not been addressed in the discussion of shovel cultivators and furrowers.

As a general practice farmers find sweeps are better for weed control and good moisture conservation. However, sweeps are less effective as a secondary tillage tool or for locations where the cultivation is used alone for tillage. For this reason farmers may desire to have two cultivators, one fitted with flat shovels at regular spacing over its full width of tillage and for use in working the land,; the other machine fitted with sweeps spaced to cultivate between rows. This kind of decision is largely a matter of the farmer's choice and his ability to pay the price.

II. Row Marker for Seeding

Effective weed control is important and requires equally spaced, parallel plant rows for many crops. U.S. data have shown yields reduced by 20 percent by light weed growth--that produced within 15 days. Weed removal may be as time and power consuming as tillage of the seedbed, and that investment can be made more effective if the rows are uniform so that the full width can be cultivated out.

Second, uniform crop growth and harvest maturity require uniform plant spacing in the row and in depth of planting. This fact is more important for high yielding varieties and for early harvesting.
Third, the mechanical devices for getting the right amount or number of seeds are all very complicated and expensive.

Therefore, the initial report only recommended a device that marked parallel rows, uniform planting spacings and covered the seed. The functions of selecting seeds and dropping them was proposed as a manual task.

This simple device could be readily fabricated by blacksmiths, although factory made wheels and other parts might be more easily adjusted.

Farmers may require some training in getting the unit set up for optimum seeding of the crops and varieties for the soil and climate of their farms. This training might require 1-3 hours for each farmer for each crop the first year and may necessitate some follow-up the second year. Once a few farmers have this device, new purchasers can learn from their neighbors.

III. Tractor Hiring

The present fields and farms are quite small and probably most effectively tilled by tractors in the 50-70 Hp range. Would recommend buying equipment, both tractors and implements, for the immediate needs and add additional capability only as needs develop. Recommend tractors, plow and trailer for agricultural use. To increase annual hours of use, a road grader and small earth scraper could be added for light construction and maintenance. However, buying heavier tractors for better construction performance would seriously limit tractor ability to till small fields.

Tractor brands vary more with respect to the dealer service provided than in terms of the built-in quality and engineering factors. All tractors are subject to operating breakage and require service or repair parts in
the range of 3-7 percent of the initial cost per year. However, the cost of time lost in waiting for a part can be more serious than the cost of the part. When the working season is only 20 days, a wait of 30 days for a part is a serious matter. It is possible to compensate for a poor dealer service organization by stocking parts and providing service facilities, but this is only practical for a large fleet operation. Evaluating service in tractor selection is more difficult than comparing prices but justifies the effort required.

Recommend that 13 hp tractors be taken out of the rental program. Its potential is less sure and will require quite different management. The potential of the smaller tractors should be studied in a research program before setting up any rental arrangement.

Time scheduling is very important to the farmer. Generally he cannot anticipate the best day to start tillage more than a week in advance, and the farmer will become very unhappy with a service that cannot be provided within three days of his desired time. The handbook procedures need some revision to get both better information regarding the farmer's plan and better reporting to the farmer of probably availability. Suggest that schedules of tractor use be made up on Friday from Agromoc's request submitted on Wednesday. Weekly schedules are distributed to all Agromocs on Monday. If the farmer finds he is not on the week's schedule, he can re-submit or make alternate arrangements. It appears that there would be difficulty to have closer scheduling with the existing communications.

The handbook does not indicate how bad weather or breakdown is to be allowed for. Nor does it provide for last minute farmer changes of plan,
such as that resulting from excessive rain or continuing dry weather. Suggest that schedule be made up for 5-1/2 hour days per week, but with the operator given authority to work 12-hour days if necessary to meet requests or catch up with lost time due to equipment failure or weather. Also suggest imposition of strict limitation that farmers must pay for at least 60 percent of scheduled work unless operator finds alternate work, and that a farmer cannot increase unscheduled work without payment of an overtime charge.

The record system needs a running record of tractor use and servicing, repairs and performance. This information will verify that operators are following good maintenance and operating practices as well as confirm machine performance levels.

Road grading and land improvement was proposed to increase the hours of tractor use. Agricultural seasons are quite short and additional use greatly improves the economic performance of a tractor fleet. It is possible to use the tractors more hours per year for other work; however, buying tractors for this other work may further limit the value to agricultural operations. It is likely that best tractor size for agriculture is quite limited in other uses, but the reverse is also true. To make possible to use tractors for roads and land development, it will be necessary to provide some engineering and other management to plan and supervise work. It will also be necessary to work out payment for hiring equipment.
IV. Grain Storage

Tropical storage requires, among other things, that grain moisture be under 12 percent and provision is made for control of insects. Drying of grain by traditional methods can produce the desired drying, but can probably be done with less quality and material losses (discussed in next section).

Insect control can be achieved by the use of airtight storage structures. Grain respiration uses up oxygen and quickly limits insect development. However, the seals and construction features of airtight structures frequently fail, leading to disastrous and often unknown losses. Fumigants, such as ethylene dibromide, appear to be more practical. This material and others are cheap and safe to humans. A solid, nearly airtight structure is required and the treatment will have an effective life of six months. The fumigant can be prepared in glass vials measured for standard sizes of bins.

Bin, silo or other structures should be designed and installed so as to be both convenient to fill and from which to take grain. Storage may be used to hold a large quantity for delayed marketing or for storage of the grains consumed by the family. One case requires comparatively rapid emptying and the other requires daily removal of a small quantity. Many prototype bins have been severely criticized by farmers because either filling or unloading did not fit readily into the farmer's system of grain handling. Also, many bin prototypes have not fit within or among the existing farm or community structures. Many farmers would prefer to hide
their grain and some proposed bins are very conspicuous, leading to their unpopularity with farmers.

Farmers need storage for several commodities and may need to handle quite significant differences in amount from season to season as weather and rotation plans affect harvest. Provision of this flexibility has often been neglected in proposed improved grain storage systems.

Plastic bags and barrels would meet the requirements of being easily cleaned, easily closed, fabricated in various sizes, etc. Unfortunately, plastic is readily damaged by birds and rodents. Some experiments are continuing to mix a repellent in the plastic.

At the present time metal bins are the best thing, although expensive and not durable unless specially coated and occasionally cleaned and repainted. Brick structures are hard to clean and sometimes crack, but have some popularity. It is possible that an enterprising manufacturer could develop a number of cost saving techniques for small bins, but so far there has not been sufficient intensive research and development work done on small bins to develop low-cost designs that can be easily fabricated and widely distributed to small farmers.

The principles of grain storage economics are illustrated in the following tables. These calculations indicate approximate orders of importance. The various factors need to be analyzed in some detail to improve the accuracy with which they represent conditions in Nicaragua. Table I illustrates the comparative costs for use of small and large bins. Table II illustrates the cost for use of large bins in communal storage. Table III
indicates the number of various sizes of bins that would be required in small-farm diversified agriculture. Using these economic performance factors, the break-even point for economic grain storage can be readily analyzed for market trends as shown in Table IV.

This analysis illustrates the economic effect of low-cost small bins as well as the comparative importance of good management in realizing cost savings for on-farm storage.
TABLE I

COST OF STORAGE FOR VARIOUS BIN SIZES

<table>
<thead>
<tr>
<th>Bin Size Kg</th>
<th>Cost of Capacity</th>
<th>Cost/Kg</th>
<th>Estimated Life</th>
<th>Cost/Kg/Yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>350</td>
<td>3.50</td>
<td>10</td>
<td>.35</td>
</tr>
<tr>
<td>500</td>
<td>1,650</td>
<td>3.30</td>
<td>10</td>
<td>.33</td>
</tr>
<tr>
<td>1,000</td>
<td>3,000</td>
<td>3.00</td>
<td>10</td>
<td>.30</td>
</tr>
<tr>
<td>5,000</td>
<td>14,000</td>
<td>2.80</td>
<td>20</td>
<td>.14</td>
</tr>
<tr>
<td>10,000</td>
<td>25,000</td>
<td>2.50</td>
<td>20</td>
<td>.125</td>
</tr>
<tr>
<td>50,000</td>
<td>115,000</td>
<td>2.23</td>
<td>20</td>
<td>.112</td>
</tr>
</tbody>
</table>

Calculations:

Bin size and Cost come from manufacturer's tables and literature.

Life is estimated based upon performance of similar structures.

Cost/Kg/yr. is the cost of use. A maintenance cost may be necessary for various bins which might require an additional series of calculations.
TABLE II

COSTS OF COMMUNAL STORAGE FOR VARIOUS BINS

<table>
<thead>
<tr>
<th>Bin Size Kg</th>
<th>Bins/Farmer*</th>
<th>Farmers/Bin*</th>
<th>Transport &amp; Management Cost Cordobas/Kg</th>
<th>Storage Cost Cordobas/Kg</th>
<th>Cost of Use Cordobas/Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>.35</td>
<td>.35</td>
</tr>
<tr>
<td>500</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>.33</td>
<td>.33</td>
</tr>
<tr>
<td>1,000</td>
<td>2</td>
<td>-</td>
<td>.10</td>
<td>.30</td>
<td>.30</td>
</tr>
<tr>
<td>5,000</td>
<td>-</td>
<td>24</td>
<td>.20</td>
<td>.14</td>
<td>.28</td>
</tr>
<tr>
<td>10,000</td>
<td>-</td>
<td>5</td>
<td>.30</td>
<td>.125</td>
<td>.325</td>
</tr>
<tr>
<td>50,000</td>
<td>-</td>
<td>25</td>
<td>.112</td>
<td>.412</td>
<td></td>
</tr>
</tbody>
</table>

Bins/Farmer is calculated on basis of farmer production of 1,000 Kg/Ha from 2 Ha or storage of 2,000 Kg.

Farmers/Bin is calculated based upon same production level.

Transport and Management Cost is the cost of using a communal facility.

Storage Cost is taken from Table I.

Cost of Use is the total of Transport and Storage Costs.
TABLE III
CALCULATION OF STORAGE BIN REQUIREMENTS FOR SMALL FARMS

PART A - Farm Production

<table>
<thead>
<tr>
<th>Farm Size (Ha)</th>
<th>Major Crop</th>
<th>Secondary Crop</th>
<th>Minor Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>250</td>
<td>125</td>
<td>60</td>
</tr>
<tr>
<td>1.0</td>
<td>500</td>
<td>250</td>
<td>125</td>
</tr>
<tr>
<td>2.0</td>
<td>1,000</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>5.0</td>
<td>2,500</td>
<td>1,250</td>
<td>625</td>
</tr>
<tr>
<td>10.0</td>
<td>5,000</td>
<td>2,500</td>
<td>1,250</td>
</tr>
</tbody>
</table>

Crop Production estimated at 1,000 Kg/ha for all crops.
Major Crop estimated at 50% of land area under cultivation.
Secondary Crop estimated at 25% of land area under cultivation.
Minor Crops estimated at 12-1/2% of land area under cultivation with typical farm cultivating 2 minor crops.

PART B - Calculation of Bin Numbers

<table>
<thead>
<tr>
<th>Farm Size (Ha)</th>
<th>Numbers</th>
<th>Bin Size (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>60  125 250 500 1,000 2,500</td>
</tr>
<tr>
<td>0.5</td>
<td>2,000</td>
<td>4,000 2,000 2,000 - - -</td>
</tr>
<tr>
<td>1.0</td>
<td>2,500</td>
<td>- 5,000 2,500 2,500 - - -</td>
</tr>
<tr>
<td>2.0</td>
<td>2,500</td>
<td>- - 5,000 2,500 2,500 2,500</td>
</tr>
<tr>
<td>5.0</td>
<td>2,000</td>
<td>- 4,000 2,000 4,000 2,000 2,000</td>
</tr>
<tr>
<td>10.0</td>
<td>1,000</td>
<td>- - 2,000 - 2,000 3,000</td>
</tr>
</tbody>
</table>

Numbers can be determined from census data.
Bin Numbers are calculated from production and farm numbers.
TABLE IV
BREAK-EVEN CALCULATIONS

CASE A - Delayed Sale to Market

<table>
<thead>
<tr>
<th>Time After Harvest Days</th>
<th>Selling Price Cordobas</th>
<th>Storage Losses %</th>
<th>Effective Selling Price Cordobas</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>0</td>
<td>1.00</td>
</tr>
<tr>
<td>45</td>
<td>1.05</td>
<td>1</td>
<td>1.04</td>
</tr>
<tr>
<td>90</td>
<td>1.20</td>
<td>3</td>
<td>1.16</td>
</tr>
<tr>
<td>180</td>
<td>1.40</td>
<td>5</td>
<td>1.33</td>
</tr>
<tr>
<td>270</td>
<td>1.60</td>
<td>7</td>
<td>1.48</td>
</tr>
</tbody>
</table>

- Selling Price can be taken from market records.
- Storage Losses must be measured and include shrinkage due to bin drying.
- Effective Selling Price = Selling Price x (100 - % Loss).

CASE B - Immediate Sale and Later Procurement for Consumption

<table>
<thead>
<tr>
<th>Time After Harvest Days</th>
<th>Buying Price</th>
<th>Service Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>45</td>
<td>1.10</td>
<td>.10</td>
</tr>
<tr>
<td>90</td>
<td>1.30</td>
<td>.30</td>
</tr>
<tr>
<td>180</td>
<td>1.60</td>
<td>.60</td>
</tr>
<tr>
<td>270</td>
<td>1.80</td>
<td>.80</td>
</tr>
</tbody>
</table>

Service Cost is the cost per Kg paid to the market place for supply of clean grain at the later time—notice that for half the year this is more than the cost per Kg to store in the small bins.
V. Dryers for Grain

Grain drying can be improved in a number of ways, although some of the techniques require complex equipment and special training. Most mechanical dryers require expensive fuels; however, a few designs are being developed to utilize agricultural waste as the source of heat. These types are generally more difficult to use and also require moisture measuring instruments to insure safe operation.

For many agricultural wastes such as crop straw and stalks, a large furnace is required to accommodate the fuel and hold it long enough to get full burning. Fire regulation is not difficult but cannot be kept entirely uniform. Simple flatbed dryers with manual grain stirring is workable.

The International Rice Research Institute has been experimenting with rice hull furnaces and various crop dryers. These reports might be reviewed as a good source for prototypes for Nicaraguan trials.

Solar heat collectors are also under study in many places. Air temperatures are generally lower for solar collectors. Most research is using large volumes of forced airflow.

Grain drying design should start from the data on common harvest moisture levels and safe storage requirements. Reliable drying also requires clean grain; therefore, improved harvesting and threshing is probably a prerequisite to the extensive use of improved drying. Potential improvement in storage and market price is generally very high when compared with traditional methods. However, the technology is not simple.
VI. Research and Development

Many questions are noted in the above sections which are researchable items. Priorities among these various questions and a strategy for a research and development program are necessary to coordinate technology development with the total Invierno program. In this section a number of high priority research problems are described in their order of priority. Also, a technology transfer process is described for taking the information from the research program to the state of common farm use. These recommendations are prepared in the briefest of outline form because of the limitations of time.

A. Research Programs

1. Comparative Performance of Plows and Seedbed Preparation
   a. Plows to be included
      - Traditional
      - Shabash Plow
      - Tractor Plows
   b. Measurements
      - Depth
      - Time required
      - Yield
      - Soil and water erosion
      - Cost
   c. Locations
      - In major soil types
      - In major rainfall patterns
      - On several slopes and crops
2. Weed Control
   a. Treatments
      - Traditional plow and machete
      - Furrowing cultivator
      - Shovel cultivator
   b. Measurements
      - Time required
      - Yield
      - Soil and water losses
      - Cost
   c. Locations
      - Similar to those used in plowing research program

3. Field, Harvesting and Storage Losses
   a. Treatments
      - Traditional harvesting
      - Threshers
      - Dryers
      - Improved storage bins
   b. Measurements
      - Rate or capacity
      - Losses
      - Cost
   c. Locations
      - For major crops
      - In several climatic zones
4. Cost of Keeping Draft Animals
   a. Comparisons
      - Size of animals
      - Use of range for grazing as part of feed supply
   b. Measurements
      - Cost of feed supply
      - Marginal utility of land, labor and other support
   c. Locations
      - Representative of common maintenance practices

5. Small Tractor Evaluation
   This research is described in detail in an earlier report

6. Soil and Water Management
   a. Treatments
      - Terraces and water control practices
      - Contour plowing and planting
      - Small roads
   b. Measurements
      - Cost of installation
      - Soil and water losses
      - Crop yields and other benefits
   c. Locations
      - Major soil areas and rainfall zones
      - On several slopes
      - For major crops
B. Technology Transfer

Once tools and facilities are proven by a research program to be improvements over traditional practices, a technology transfer (extension) program is needed. It will be necessary to concurrently transfer this technology to farmers, thereby stimulating their demand and to industry, thereby stimulating a supply. Good coordination between transfer to farm and to industry is difficult, with the industrial extension of agricultural technology being comparatively less well understood. The several stages in the technology transfer proven for an improved plow are illustrative of this facet of development.

1. Research Plots
   - 5 - 25 plots to establish full range of utility of technology.
   - Up to 3 years may be necessary to establish performance under common weather patterns.
   - Number of machines, etc., will depend upon available transport and communication.

2. Farmer Trials and Demonstration
   - 25 - 100 cooperators to confirm the performance data of the research plot and to provide better exposure of technology to farmers and to industry.
   - Research machines or sponsored prototypes to be used in this phase, research starter may buy few machines to get manufacturers started, their loan machines to cooperators for putting in plots.
   - Field days to be used to inform public.
3. Set up Farmer and Industry Credit, Technical Assistance and other services

- Credit facility calculated according to performance of research and farm plots.
- Similarly technical assistance planned according to earlier experience in meeting both farmers' and industry needs relative to the use and production of technology.

4. Monitor Farm and Industry Performance in use of technology

- Are they able to meet credit payment terms?
- Are they able to realize benefits, stay within costs and meet production estimates?
- Do problems arise which were not anticipated, and are these serious and correctable?
- Would change of practice by other service institutions benefit the subject technology?

5. Report Farm and Industry Experience with the Technology

- To other institutions and stimulate their supporting service activity.
- To industry and stimulate expanding activity.
- To government to insure favorable policy and regulations.
- To professional societies.

VII. An Entrepreneurs' Program

Small-scale entrepreneurs are important in the supporting infrastructure of small farm enterprise. These entrepreneurs and farmers live in the same communities and share many attitudes and needs. Supervised credit and
coordinated technical assistance are as important to the small entrepreneur as to the farmer and in fact are a prerequisite to the expansion of the inputs and services required to expand small farm productivity.

It would be possible to develop a small business management plan for a blacksmith to produce small plows. This supervised credit program could be coordinated with the needs of the community and supported with the production technology required by the blacksmith. The supervised credit could include monitoring of service provided to farmers and price as well as other business and financial performance factors.

Training in production technology could be organized as a service activity of the credit program or could be sponsored at other institutions. Satisfactory completion of a training program should be considered as an additional resource of the small entrepreneur and should enable him to command more resources.

The International Rice Research Institute found that small entrepreneurs could be stimulated to produce new tools and equipment by purchasing a few units (up to five) of their first production. IRRI provided some assistance in the production. The units were used by IRRI in farmer demonstrations and the performance was reported back to the entrepreneur for his consideration in improving his design.

Small manufacturers, such as village blacksmiths, require raw materials and component parts in small quantities and often find it difficult to find the needed items in the market. Consolidation of their requirements or a common source of supply may be of considerable economic benefit. As in the case of moldboard plows, it may be most economical to set up one
factory to produce shares, moldboards and the base frames for the entire country. It may be necessary to undertake some intermediary role to see that such a facility is provided. It may be possible that a small entrepreneur who would serve as a raw material wholesaler could be provided the working capital to set up a vital business link. Industrial patterns of integration vary considerably and it is important to recognize such links as vital and undertake appropriate action when needed links fail to materialize for essential technology.

Small entrepreneurs, like small farmers, are perhaps most productive when they have a degree of independence to maximize their returns from their own resources. This independence will express itself in variations of the tool or technology and in a variety of terms for sale and service. It will be difficult to force these small entrepreneurs to produce identical items and in fact farmers probably prefer differences to accommodate their own special needs. In many cases it has been the innovation of small entrepreneurs that has contributed significant improvements to tools and technology. Careful attention must be given to the policy of accommodating variations among small entrepreneurs to ensure acceptable variation within reasonable business and technical standards.