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APPROPRIATE MECHANIZATION

FOR THE CLIENTS OF THE

INVIERNO PROJECT

(PART II)

TDY Trip Report to

Nicaragua

by

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

Recommendations on Appropriate Technology

Preface

This report is Phase Two of an analysis and recommendations for improvement of the crop production tools and equipment for the Invierno Project of Nicaragua. Phase One was undertaken in August 1977. The Plan of Work for Phase Two was drawn up by Invierno to develop selected concepts from the Phase One recommendations. The Plan of Work is attached as Appendix A.

Introduction

The research and development process for any technology is an iterative process which feeds back into the process the local experience with technology use in stepwise improvement of the design of the items and the supporting facilities. For the project area this feedback capability is in place in the form of the Agromoc's and institutional structure of Invierno. It is expected that this staff can readily undertake technology research and development operations and thereby expeditiously develop the prototypes suggested in this paper. Not that Invierno will undertake all of the necessary R&D work, for there are several specialized institutions and enterprises in Nicaragua that can contribute to this process. 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.

The author expects that Invierno can supplement the information that is provided in this report in developing the operational programs for research and development. In some cases additional reference material and appendices to this report will be mailed to provide certain 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.

The next phase in this research and development program is probably the undertaking of field trials for selected prototypes. Such programs have been outlined in terms of objectives and approaches. The Invierno staff, from their familiarity with the conditions of the region, should be in a better position than the author to work out the operational procedures for these stages.

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 introducted 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) (Appendix B)

The soil turning plow uses a steel share and moldboard 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 soil turning plow is much better than the traditional plow on the soils with good 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(frog) 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 time 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. 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 to

3-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 to 450 kg.

2. Short-Beam Type Plow (Care Plow) (Appendix C)

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 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.

The short-beam plow 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.

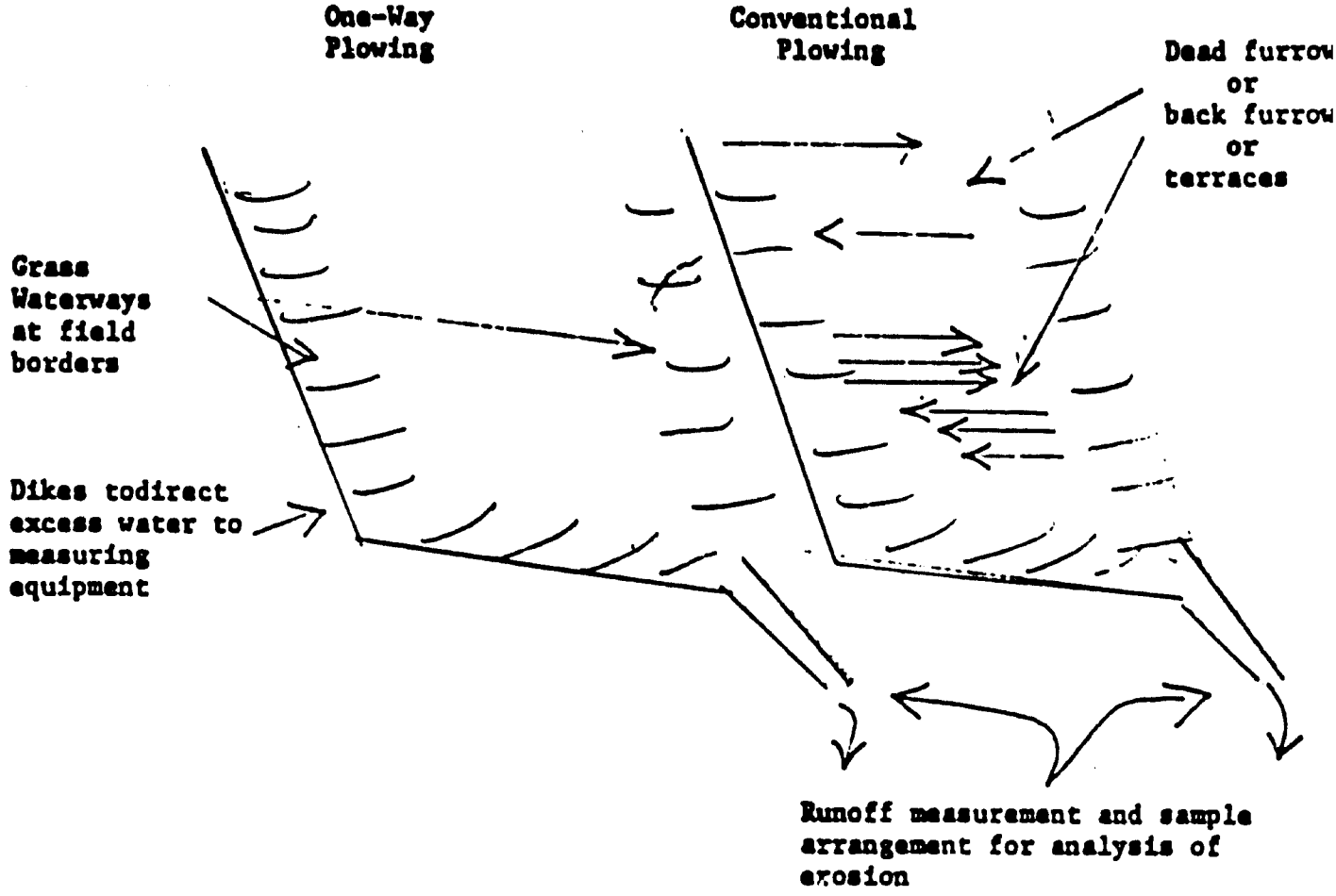
C. Reversible Plows

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 reversible plow will cost more than two times the Shabash or short-beam types. In general, the animal-drawn sizes of reversible plows 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 runoff 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:



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 contou
- 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 in preparation for planting or for cultivating and shaping land during the growing season to control weeds and irrigation water. Furrowers do not make good plowing tools because they do not bury the trash well nor do they produce good soil surface. Also, furrowers 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 after planting. Furrower cultivation 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 dry soil in the plant row. The seeds are then planted in the bottom of the furrow in a conventional manner. 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 (Appendix D)

A 3 or 5-shovel cultivator can be used to finish a seedbed once it has been plowed in 1/3 to 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 (Appendix E)

A 6-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 or three 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 several 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. 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 above 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 cultivator is used alone for tillage. For this reason farmers may deisre to have two cultivators, one fitted with flat shovels at regular spacing over its full width 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 (Appendix F)

Some basic principles of crop planting merit repetition before stating the recommendations of planting equipment. The main crops of the project area--corn, beans, etc.--are classed as row crops and are commonly grown with some intercultivation. Seed planting is not an onerous task, but traditional practices do not result in uniform, good stands of the crops. For many farmers it will be many years before they can afford to purchase seeds, rather than raise their own seed material, which is a serious complication for machine design. From these and related facts, there are three principles of significance in formulating the recommendation for improved seeding of a row marker to be used with hand seed selection and placement.

Effective weed control is important and requires equally spaced, parallel plant rows. U.S. data have shown yields reduced by 20 percent by

light weed gorwth—that produced within 15 days. Weed removal for a crop season may be as time and power consuming as tillage of the seedbed. That investment in power and labor can be made more effective if the rows are uniform so that the full width can be cultivated out.

Secondly, 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 to reduce field shatter losses.

Thirdly, the mechanical devices for getting the right amount or number of seeds are all very complicated and expensive.

Therefore, the planting technique is based upon a device that marks parallel rows, uniform planting spacings and covers the seed. The functions of selecting seeds and dropping them is recommended 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 to 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. It is recommended that equipment, both tractors and implements, be purchased for the immediate

needs and capability be expanded incrementally as additional needs develop. Tractors, plow and trailer for agricultural use would be the basic equipment. 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. 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 justified the effort required.

It is recommended that 13 Hp tractors not be considered for a rental program. The small sized tractors' potential is less sure and it 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 of field preparation 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 Invierno draft handbook procedures need some revision to get both better information regarding the farmer's plan and better reporting to the farmer of probable availability of the equipment. A suggested procedure is to have the schedules of tractor use made up on Friday from Agromoc's request submitted on Wednesday. Weekly schedules are then distributed to all Agromocs on Monday. If the farmer finds he is not on the week's schedule, he can resubmit 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 by the farmer or tractor operator. Nor does it provide for last minute farmer changes of plan, such as that resulting from excessive rain or continuing dry weather. Consequently it is further recommended that schedules be made up for 5-1/2 8-hr. 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. There should also be an imposition of a strict practice that farmers must pay for at least 60 percent of scheduled work unless the operator finds alternate work, and that a farmer cannot increase unscheduled work without payment of an overtime charge.

The record system also 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 and suggest when machines should be replaced.

Road grading and land improvement was proposed to increase the hours of tractor use. Agricultural seasons are quite short and additional use of the tractors greatly improves the economic performance of the 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 the best tractor size for agriculture is quite limited in other uses, but the reverse is also true. To make it possible to use the tractors for roads and land development, it will be necessary to provide some engineering and other management to plan and supervise the 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 for the treatment to 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 to take grain out either for use or sale. 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. 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 difference 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 conomic 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

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

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

Bin Size Kg	Bins/Farmer*	Farmers/Bin*	Transport & Management Cost Cordobas/Kg	Storage Cost Cordobas/Kg	Cost of Use Cordobas/Kg
100	20	-	-	.35	.35
500	4	-	-	.33	.33
1,000	2	-	10	.30	.30
5,000	-	2½	.20	.14	.28
10,000	-	5	.30	.125	.325
50,000	-	25		.112	.412

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

Farm Size Ha	Major Crop	Secondary Crop	Minor Crop
0.5	250	125	60
1.0	500	250	125
2.0	1,000	500	250
5.0	2,500	1,250	625
10.0	5,000	2,500	1,250

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 ty typical farm cultivating 2 minor crops.

PART B - Calculation of Bin Numbers

Farm Size Ha	Numbers	Bin Size (Kg)					
		60	125	250	500	1,000	2,500
0.5	2,000	4,000	2,000	2,000	-	-	-
1.0	2,500	-	5,000	2,500	2,500	-	-
2.0	2,500	-	-	5,000	2,500	2,500	
5.0	2,000	-	4,000	2,000	4,000	2,000	2,000
10.0	1,000	-	-	2,000	-	2,000	3,000
		4,000	11,000	13,500	9,000	6,500	5,000

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

Time After Harvest Days	Selling Price Cordobas	Storage Losses %	Effective Selling Price Cordobas
0	1.00	0	1.00
45	1.05	1	1.04
90	1.20	3	1.16
180	1.40	5	1.33
270	1.60	7	1.48

- 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

Time After Harvest	Buying Price	Service Cost
0	1.00	-
45	1.10	.10
90	1.30	.30
180	1.60	.60
270	1.80	.80

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 complete 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 num ber 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 ponds

   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 process 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 station may buy a few machines to get the manufacturers started; then 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 techpology?

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 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 this early production. The first production 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.

Appendix A

PLAN DE TRABAJO

TECNOLOGIA APROPIADA

(Asesor John Balis)

Periodo 10 - 7 de Febrero de 1978

I. IMPLEMENTOS De TIRO ANIMAL

1. Arados

- Arado Tradicional (Tipo Egipcio)
- Arado de Vertedera Sencilla
- Arado de Vertedera Reversible
- Arado de Doble Vertedera

Análisis de cada tipo, para diferentes labores agricolas y de conservación de suelos. Diseño de varios prototipos para ser usados en diferentes tipos de suelos y diferentes tareas. Aspectos de fabricación: Procedimientos, materiales, herramientas, entrenamiento, etc.

2. Escarificadores de Discos y de Dientes

Análisis de los dos tipos, ventajas y desventajas en diferentes tipos de suelos. Aspectos de Diseño y Fabricación.

3. Cultivadoras de Surcos

- Análisis de diferentes tipos de acuerdo al tipo de suelo.
- Diseño y aspectos de fabricación de las alternativas mas adecuadas.

II. DISCUSION SOBRE SEMBRADORA DE GRANOS PROPUESTA POR JOHN BALIS.

III. ASPECTOS DE DISEÑO Y FABRICACIÓN DE SILOS PARA ALMACENAMIENTO DE GRANOS.

Secadora de granos:

- a nivel familiar
- a nivel comunal

IV. PLAN DE IMPLEMENTACION PARA TECNOLOGIA APROPIADA (Programa de extension - demostración).

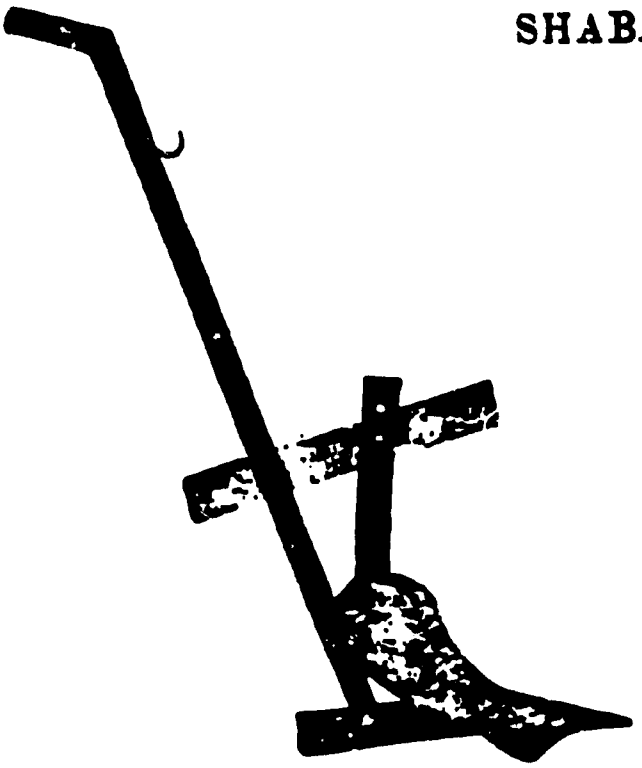
V. TRACTORES

1. Recomendaciones sobre: Tipo, tamano y marcas de Tractores a ser adquiridos para alquiler de los mismos.
2. Revisar Manual de Procedimientos para alquiler de Tractores (información tecnica que podria generarse para futuras investigaciones).

VI. RECOMENDACIONES SOBRE MANUAL PARA SELECCION DE BOMBAS DE RIEGO.

Appendix B

SHABASH PLOUGH



India's most popular and largest selling, SHABASH plough is a small, cheap and single purpose mould-board plough. Easily operated by a pair of medium size bullocks, it makes a 6" furrow to the depth of 4" to 5."

It can plough 3/4 of an acre in a 10-hour working day and thus can easily manage annually about 10 to 12 acres. It gives an excellent performance on wet land and light soils. It also turns under weeds, trash and stubble and is used for ploughing fallow land to keep weeds under control.

Among its inimitable qualities are.:

- Sturdy all-steel body
- Light weight
- Hard-wearing, high carbon steel share
- Generous throat clearance
- Light draft
- Conveniently placed handle

It is accompanied by a free spanner.

SHABASH plough is also available with left hand mould board, at no extra cost.

INDIAN FARM EQUIPMENTS

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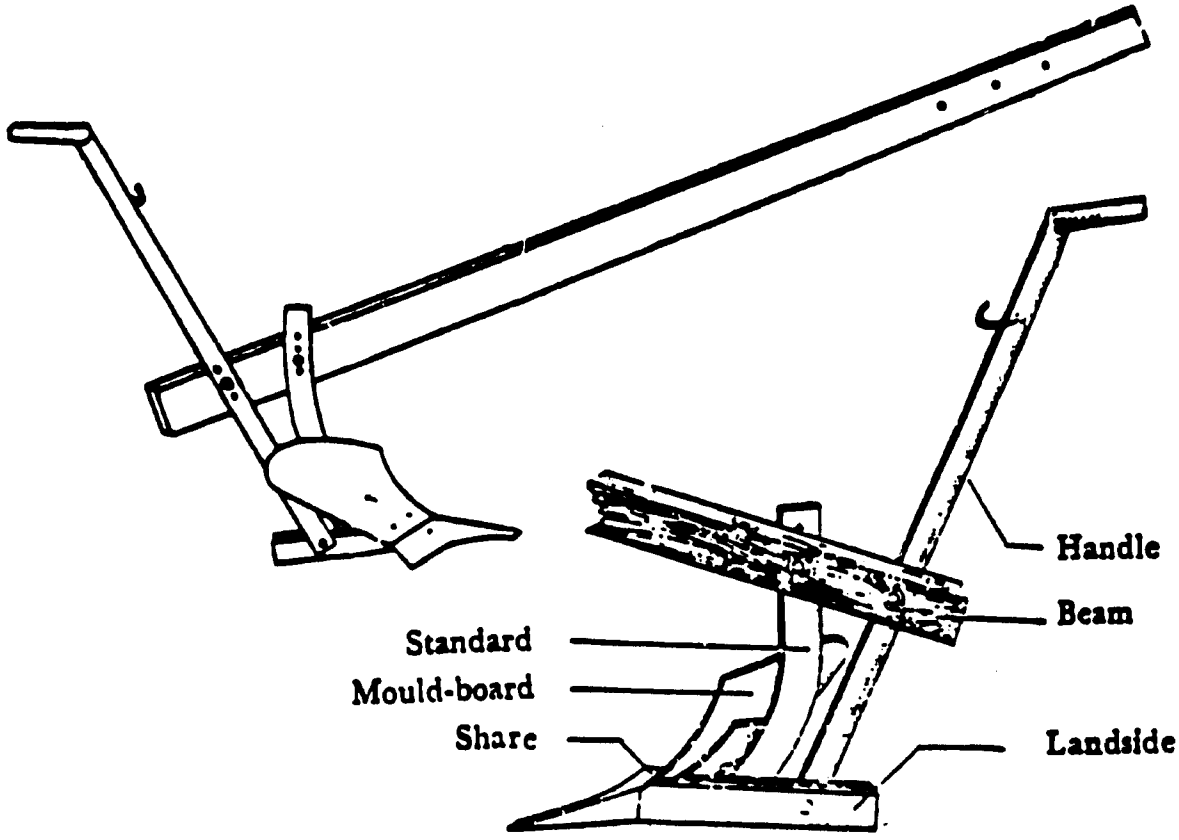


PARTS OF SHABASH PLOUGH

.....Strict utilitarian logic

Appendix C — CARE-Type Plow

THE VICTORY PLOW

A deep, well-pulverized seedbed is the basis for high yielding crop production. The moldboard plow is used throughout the world as the basic primary tillage implement because of its ability to invert and pulverize the soil. Through this action, soil is loosened to allow free root development and penetration; weeds, grasses, and crop residues are buried; rainfall is absorbed and retained; and certain insects and disease organisms are destroyed.

The victory plow is a short-beam (chain hitch) moldboard plow which cuts a furrow slice about nine inches wide and from four to seven inches deep, depending on adjustments made. It is patterned after the "Ransom" plow from England.

Fig. 1. The moldboard plow cuts, lifts, inverts, and pulverizes the soil.

Parts of the Victory Plow

The victory plow consists of three major units:

The handles

Handles are bolted to the beam and are used to guide the plow.

The bottom

The bottom is made up of the *plowshare* which acts as a wedge to cut through the soil; the *moldboard*, which turns, inverts, and pulverizes the soil; and the *landside*, which transmits side pressures, caused by the action of the share and moldboard, to the furrow wall. These three parts are bolted to the *frog*, which, in turn, bolts to the beam.

The beam

The beam transmits the pull from the bullocks to the plow bottom. The *hake*, *regulating bar and clamp*, and *draft rod and ring* are attached to the beam to allow vertical and horizontal hitch adjustments. The *gage wheel* also attaches to the beam when used.

Fig. 2. Parts of the victory plow: 1. handles 2. frog 3. landside 4. moldboard 5. plowshare 6. gage wheel 7. hake 8. clamp 9. regulating bar 10. draft rod and ring 11. beam.

Plow Adjustments

To allow the victory plow to penetrate to the desired depth and take the proper width of cut, two adjustments are provided on the plow hitch. Both adjustments are made by shifting the position of the regulating bar in the hake.

Vertical hitch adjustment

Regardless of the position of the regulating bar, the line of draft on a moldboard plow is always in a straight line from a point about two inches in from the landside where the moldboard and share meet (known as the *center of pull*), through the hitch and chain, to the bullock yoke (Fig. 3).

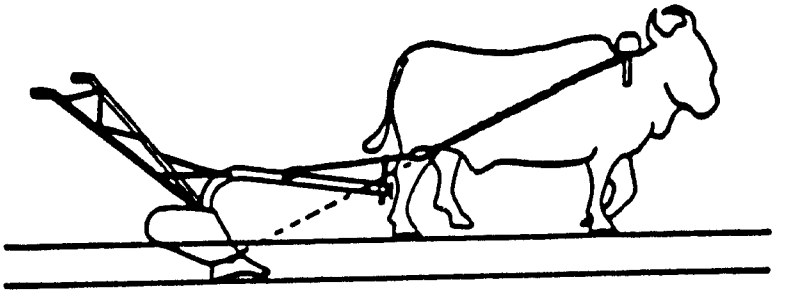


Fig. 3. The line of draft is always in a straight line from the center of pull, through the hitch, to the bullock yoke. The regulating bar is raised or lowered to obtain the correct vertical hitch.

Therefore, if the regulating bar is set too high in the hake the front of the plow beam will be forced down, which causes the share point to be "nosed down", draft will be high, and soil will not slide off the moldboard.

If the regulating bar is adjusted too low (raising the front of the beam), the plow may not enter the soil or very shallow plowing will result.

To properly adjust the vertical hitch, set the plow at operating depth, then raise or lower the regulating bar in the hake so the heel of the landside clears the bottom of the furrow by about 1½ inches.

After this initial adjustment, the chain can be shortened slightly (which raises the front of the beam) to reduce depth of plowing, or lengthened slightly to increase plowing depth.

In practice, vertical hitch adjustment is generally made on a trial and error basis. The plow can be operated without the regulating bar and draft rod by attaching the hitch chain directly to the hake. However, the chain will be rather long, which may cause the operator some difficulty in controlling the bullocks.

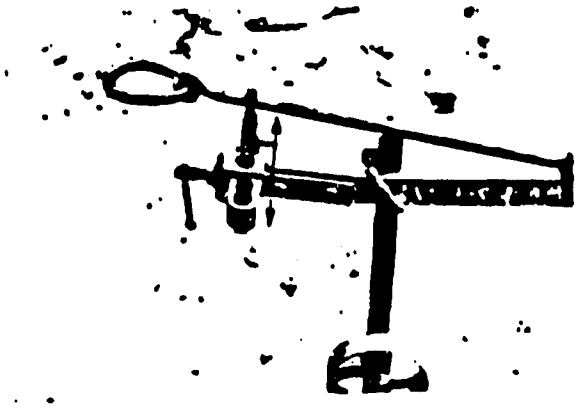


Fig. 4. The regulating bar is raised or lowered for proper vertical hitch adjustment.

Since the pull from the bullock yoke is transmitted to the plow by means of a chain or rope, a slight push forward (not down) on the handles will cause the plow to increase its depth. This is helpful when soil or moisture conditions of the field varies.

Horizontal hitch adjustment

By adjusting the regulating bar horizontally, the proper width of cut can be maintained with little effort on the part of the operator.

Fig. 5. The regulating bar is shifted to the left or the right in the hake to decrease or increase the width of cut.

The regulating bar is moved to the left in the hake to decrease the width of cut, and to the right to increase the width of cut.

Field Operation

Ordinarily, only one plowing with a victory plow, followed by harrowing, is required for seedbed preparation, as compared to four to eight plowings with the desi plow. This provides a considerable savings in time and labor, which is especially impor-

tant in multiple-cropping systems. One acre can be plowed in about ten hours with the victory plow.

The victory plow can be drawn by an average pair of bullocks on light or medium soils : on heavy soils large bullocks will be required.

To eliminate a number of dead furrows and to save time, the plow should travel completely around the field finishing the job in the center (gathering method), rather than making many narrow strips ("kondras") as is commonly done with the desi plow.

Although two handles are provided on the plow, the operator generally uses his left hand (on the right plow handle) to guide the plow and his right hand for driving the bullocks.

The victory plow is sufficiently heavy to penetrate easily in most soils when moisture conditions are satisfactory. However, weight can be added if necessary when plowing sod or very heavy soils. To add weight, a rock or a bag of sand can be tied between the handles and the beam (weight should be directly over the plow bottom).

A gage wheel is supplied with the victory plow. It is seldom useful in the field and should be removed for best results.

Fig. 6. When plowing under adverse soil conditions, weight may be added to improve penetration.

Plowing more than six inches deep is generally not beneficial unless it shatters a hardpan, a thin impervious layer of fine soil particles at plow sole depth.

To do a good job of plowing, soil moisture must be adequate, the plowshare must be kept sharp, the polish must be maintained on the moldboard, and the plow must be adjusted properly.

Soil Moisture Requirements

Soil moisture condition at plowing time is an extremely important factor with regard to draft as well as quality of work.

If the soil is too dry, the plow may not penetrate or will turn up large clods of earth. A dry soil causes excessive draft and accelerates wear of plowshare edges.

When soil is too wet, there may again be difficulty in penetration, the plow will probably not scour (soil will not slide off the moldboard), and if the soil contains clay it will not crumble when inverted, but will turn up large slabs of earth.

If a soil containing clay is saturated with water and allowed to dry, it passes through the following conditions: sticky, plastic, crumbly, and hard (cemented). The crumbly stage is the ideal condition for plowing, and all other tillage operations as well. Lighter soils may come to the crumbly condition within a few days after rain or irrigation, whereas heavy clay soils may require 7 to 10 days or more.

Plowshare

The plowshare slices through the soil and thus receives more wear than any other part of the plow. When one acre is plowed to a depth of six inches, nearly 650 tons (650,000 kg.) of soil is sliced, lifted and inverted in about 10 miles of travel.

Fig. 7 Hardsurfacing materials are applied to the plowshare point on the top side.

Fig. 8 The entire length of the cutting edge of the plowshare is hardsurfaced on the bottom side

Shares on bullock drawn plows are generally worn out completely and discarded rather than being sharpened, even though a dull share increases draft.

Several shares should be kept on hand for replacements. Shares can be made by local blacksmiths if a new factory-made share is provided for a pattern. The original shape must be maintained or the plow will not operate properly in the field.

Life of plowshares can be greatly increased at little expense by having a welder apply a thin layer of very hard metal on the cutting edge and point of the share with an arc welder (Figs. 7 and 8). This treatment is known as "hardsurfacing" or "hardfacing". A special electrode, such as Advani-Oerlicon Superesist or Cemarc Hardweld 550, is used in this process.

Fig. 9. The face and bottom edge of the landside should be hardsurfaced as shown.

The face and bottom edge of the landside can also be hardsurfaced to prevent wear.

Hardsurfacing applied on the moldboard is generally not recommended as it often causes scouring difficulties.

Maintenance

The major expense of using a victory plow is in replacing plowshares. This expense is easily justified, as it is a waste of time and energy to attempt to use dull or worn out shares.

A worn out landside can be rebuilt to the original condition with an arc welder, fabricated by a local blacksmith, or purchased from the manufacturer. Moldboards should be replaced from factory stocks when worn out as exact curvatures must be maintained.

Fig. 10. Checking alignment of the bottom. The share point should extend about two inches to the left of the beam.

Although the plow is strongly built, if the point hits a stone or stump the beam can become bent so that the entire bottom is out of alignment. Alignment can be checked by placing a straight-edge vertically on the left side of the beam down to the share point. The share point should extend about two inches to the left of the beam (Fig. 10) when alignment is correct. If the beam has been bent, a blacksmith can heat and bend the beam to its original position.

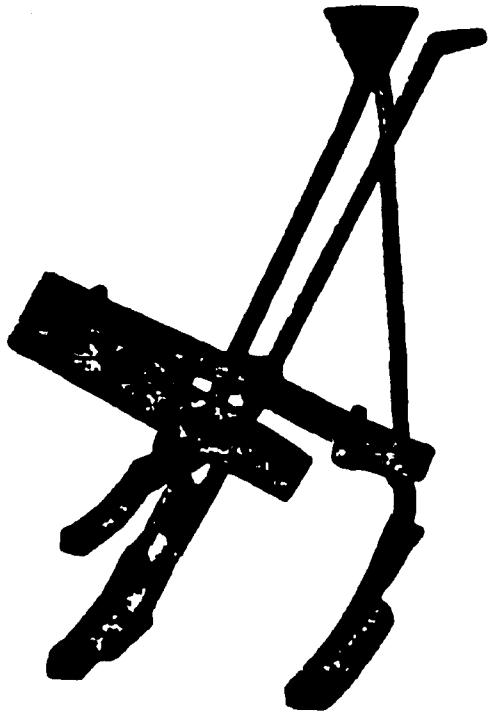
Storage

When storing the plow, the moldboard, landside, and share should be coated with grease or waste oil to prevent rusting. With this protection, soil will not stick to these parts when plowing is resumed, and life of the implement will be increased.

With proper care and maintenance, and occasional replacement of worn out parts, a victory plow will give satisfactory service for many years.

Appendix D

WAH-WAH JUNIOR CULTIVATOR



This Cultivator is a highly efficient, light weight and multi-purpose implement. It can be used for shallow ploughing, seed bed preparation of all crops, interculture, and with the seeding attachment, for 1, 2 and 3-row seeding. The seeds are dropped by hand into the funnel.

The Wah-Wah Junior Cultivator equipment is available in three combinations :

COMPLETE SET, consisting of:

1. Wah-Wah three tyne Cultivator
2. Mould board plough bottom
3. Three row seeding attachment
4. Wooden beem

COMPLETE CULTIVATOR, consisting of :

1. Three tyne cultivator attachment
2. Three shovels, fitted to the tynes

CULTIVATOP PARTS, consisting of :

1. A tool bar, two tynes with shovels
2. A shovel with frog, designed to convert the WAH-WAH plough into a WAH-WAH Junior cultivator.
3. Three row seeding attachment.

WAH-WAH Junior Cultivatior set provides the farmer with the maximum range of implements at a very low cost.

To attain greater efficiency in seed bed preparation and interculture, 6" sweeps can be fitted instead of shovels. For seed bed preparation it is thrice as efficient as the *desi* plough.

The outstanding features of this Cultivator are :

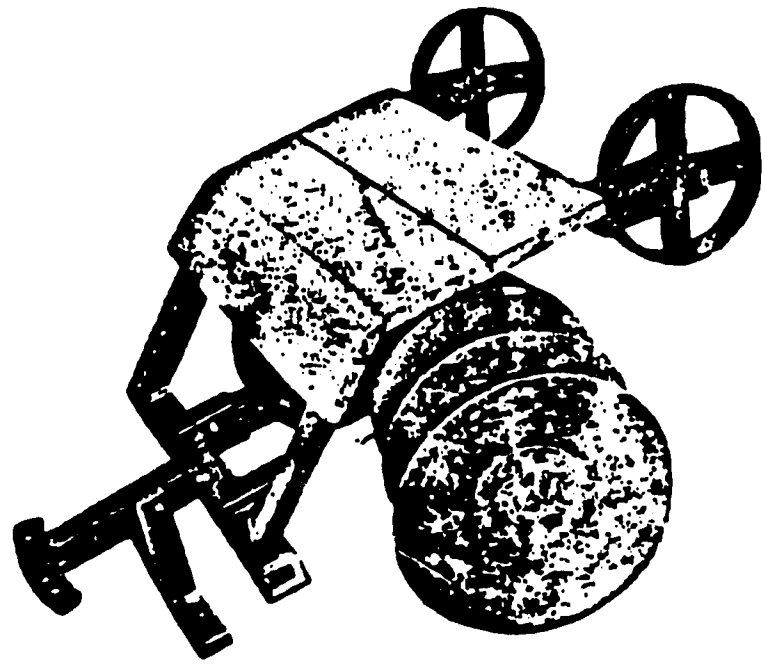
- ▷ Simplicity in design
- ▷ Three medium carbon steel shovels, which can make furrows 3"–4" deep
- ▷ Very low draft
- ▷ All steel construction
- ▷ Multiple use as a cultivator, plough and for inter-culture and seeding.
- ▷ 6" high carbon sweeps are interchangeable with the shovels for greater efficiency.

INDIAN FARM EQUIPMENTS

P. O. NAINI ALLAHABAD

Appendix E—

"BIJLI" DISC HARROW



This new disc harrow is rugged in construction, simple in operation and utilitarian in design, with easy adjustments and minimum wear and tear. ---- A pair of medium size bullocks can easily pull it. It levels the ground evenly and makes a deep seed bed at a fast rate. In a 10-hour working day it harrows about 3-4 acres of land with 2"-4" depth by double discing, depending upon the type of soil conditions.

It has six steel discs, each 16" in diameter and 5 mm. thick, arranged in two bumper type gangs mounted on a tool bar by just two bolts.

It has a wooden, platform-type seat which is placed very low to prevent overturning. Its transport wheels are fixed at the back of the platform. For transportation, it is turned over.

Its special features are:

▷ Light draft, uniform harrowing and even depth, ensured by deliberately eliminating the shovels between gangs.

Two big oil impregnated, dust protected, enclosed wooden bearings with oil holes. When worn out, these wooden bearings are cheaply replaceable.

▷ Depth adjustments for shallow, medium and deep settings.

▷ Adjustable wooden beam to fit to all sizes of bullocks.

▷ Shims provided in the bearings to adjust periodically, the wear in the bearing by taking out one or two strips at a time.

INDIAN FARM EQUIPMENTS

P. O. NAINI ALLAHABAD

THE DISK HARROW

There are few farmers who would not profit by owning and using a disk harrow. It is used to good advantage before plowing to pulverize the soil surface and mix crop residues (or green manure) with the topsoil. Its major use, however, comes after plowing to pulverize clods, firm the seedbed, and prevent or destroy weeds.

One of the most satisfactory methods of preparing a seedbed is to disk, then plow, then disk again. In sandy soils, farmers sometimes prepare land for planting by disking alone.

The disk harrow discussed in this publication was developed at Allahabad Agricultural Institute, and is popular in parts of northern India.

Fig. 1. The disk harrow in operation. The operator can ride when extra depth and cutting action is required.

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Parts of the Disk Harrow

Two basic units make up the disk harrow.

The gangs

There are two gangs of disks which throw soil in opposite directions. Each gang consists of three *disks* held six inches apart by *spacers* (spools). Cast iron *bumpers* counteract the opposing side-draft of the two gangs when the disk harrow is in operation. The entire gang is held together by a *gang bolt*. The *gang fork*, which attaches the gang to the tool bar, contains the wooden *bearing* and disk *scrapers*.

The frame

The frame, as a whole, includes the *transport wheels, operator's seat, tool bar, and quadrant* (for vertical hitch adjustment). The *foot rest* and *beam* attaches to the quadrant. Holes are provided in the tool bar for disk angle adjustment.

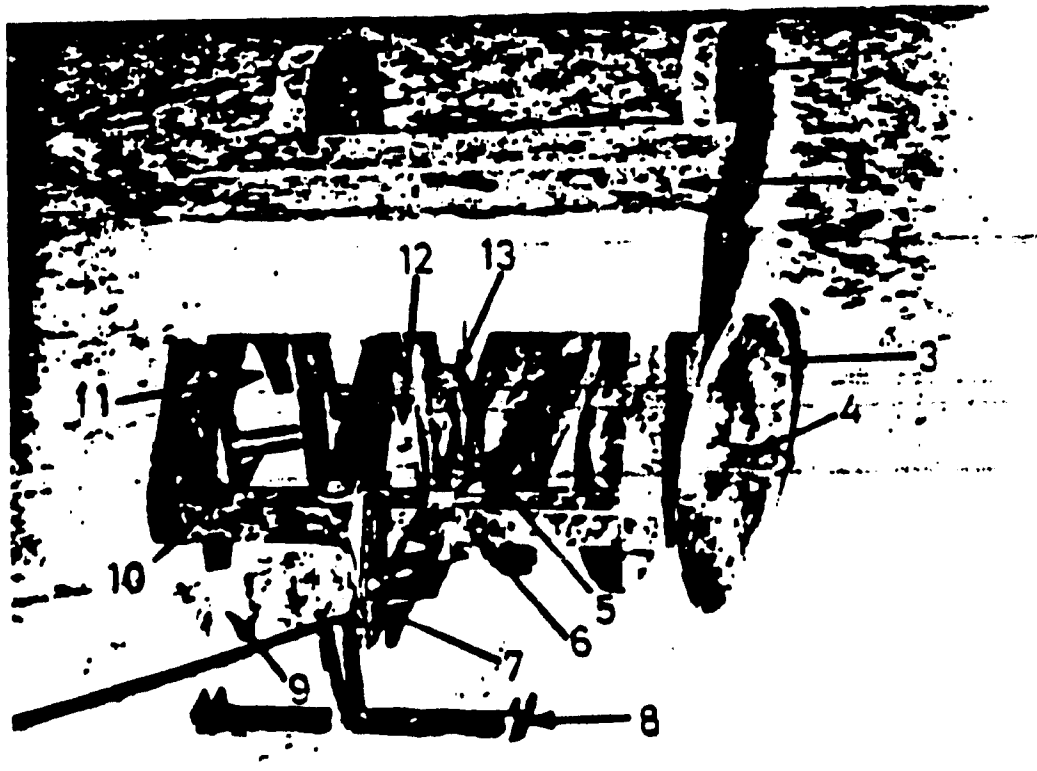

Fig. 2. Parts of the disk harrow 1. transport wheel 2. operator's seat 3. disk 4. gang bolt and nut 5. gang fork 6. tool bar 7. quadrant 8. foot rest 9. beam 10. spacer 11. scraper 12. bearing 13. bumper

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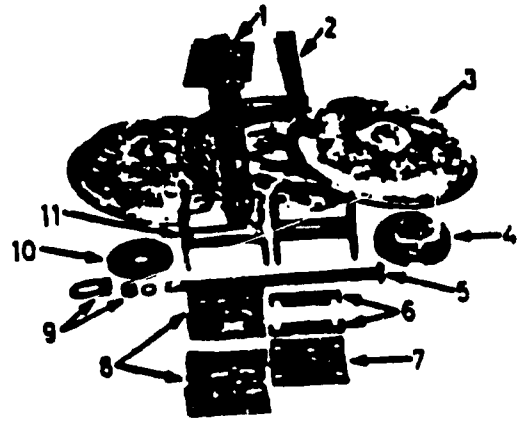

Fig. 3.
Disk gang parts. 1. bearing block & gang fork 2. scraper 3 disk 4. bumper 5. gang bolt 6. shims 7. bearing cover plate 8. wooden bearings 9. gang bolt nuts 10. gang washer 11. spacer (spool)

Disk Harrow Adjustments

Vertical Hitch

To do a good job, the disk harrow must penetrate evenly over its entire width. The hitch is adjustable vertically by changing the position of the wooden beam on the quadrant so that both gangs of the disk harrow are level during operation. As the quadrant bolt and beam are shifted to the upper holes, outer disks will penetrate deeper; in the lower holes, penetration of center disks increases. This adjustment is made with the beam attached to the bullock yoke.

If vertical hitch adjustment is incorrect the outer disks will not penetrate to the same depth as the center disks and it will not be possible to keep the surface of the field level. To some extent, lengthening or shortening the beam at the bullock yoke will change the vertical hitch.

Fig. 4. By changing the position of the beam on the quadrant, all disks can be made to penetrate to the same depth.

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Angle and weight adjustments

The degree of soil pulverization and depth of penetration is determined by the angle of the disk gangs, sharpness of the disks, and total weight applied to the disks.

The angle and weight necessary depends on soil moisture conditions and soil texture, and the amount of surface trash to be cut.

Ordinarily, disk gangs are kept at the maximum angle (23 degrees). However, the angle can be changed by moving each gang fork on the toolbar to any of the three holes provided (Fig. 5).

Both gang forks must be in the same relative position on the toolbar.

In general, the greater the angle of disk gangs, the more thoroughly soil is pulverized and the deeper the disks will penetrate.

Fig. 5. Angle adjustment of the gangs is made by moving the gang forks on the tool bar.

When more depth and cutting action is required, the operator can ride on the disk harrow, as shown in Fig. 1, thus adding weight.

Field Operation

The bullock drawn disk harrow has two gangs of disks placed end to end which throw the soil in opposite directions. Because of this action, a single disking will leave the soil slightly ridged. Soil tilth can be improved and ridges can be eliminated by overlapping half the width of the disk harrow each pass (double disking).

Fig. 6. Disking in land previously plowed with a moldboard plow. In sandy soil the operator need not ride on the disk harrow. Note that the disk farthest to the right is cutting the center strip left during the previous round (overlapping half the disk harrow width), leaving the field level.

The disk harrow should travel the same direction as the moldboard plow, going completely around the field and ending the operation in the center.

Disking should be done soon after plowing before clods become dry and hard, or when clods are in a crumbly condition a few days after a rain.

Puddling with the Disk Harrow

In rice production, the disk harrow can be used soon after flooding the field as a green manure trampler and puddler. No previous plowing is necessary. Disking the length of the field and then crosswise generally completes the puddling operation. Tests

Fig. 7 Puddling with the disk harrow. When small bullocks are used, two pairs will probably be required. If soils are such that bullocks sink deeply, it will not be possible to puddle with the disk harrow.

indicate that puddling can be completed in about one-fourth the time required by the desi plow.

If bullocks are small, two pairs will be required as draft is increased somewhat over disking dry soil. This operation is most successful on lighter types of soils. On heavy soils, draft increases and two pairs of bullocks will probably be necessary. If animals sink deeply into the mud, it will not be possible to use the disk harrow.

The field should be levelled with the local "jumbu" after puddling.

Transport

To transport the disk harrow, turn it over so that it rests on the transport wheels. It is not necessary to unhitch the bullocks to do this. When returning the disk harrow to the working position, it is well to remember that the disks can be damaged by dropping them on a hard surface.

Fig. 6. Disk harrow in transport position.

Maintenance

Disk bearings should be lubricated with motor oil at least twice a day while in operation. The disk harrow must be in the transport position to oil the bearings as the oil hole is found in the bearing cover plate. After considerable use, shims provided in the split wooden bearings can be removed to compensate for wear. Disk bearings can easily be replaced by a carpenter when worn out.

Transport wheels require an occasional oiling.

Bolts must be kept tight. If the nuts on the gang bolts are allowed to become loose, damage to the disks and gang bolts will result.

Although seldom necessary, cutting edges of the disks can be sharpened by grinding them on an emery wheel.

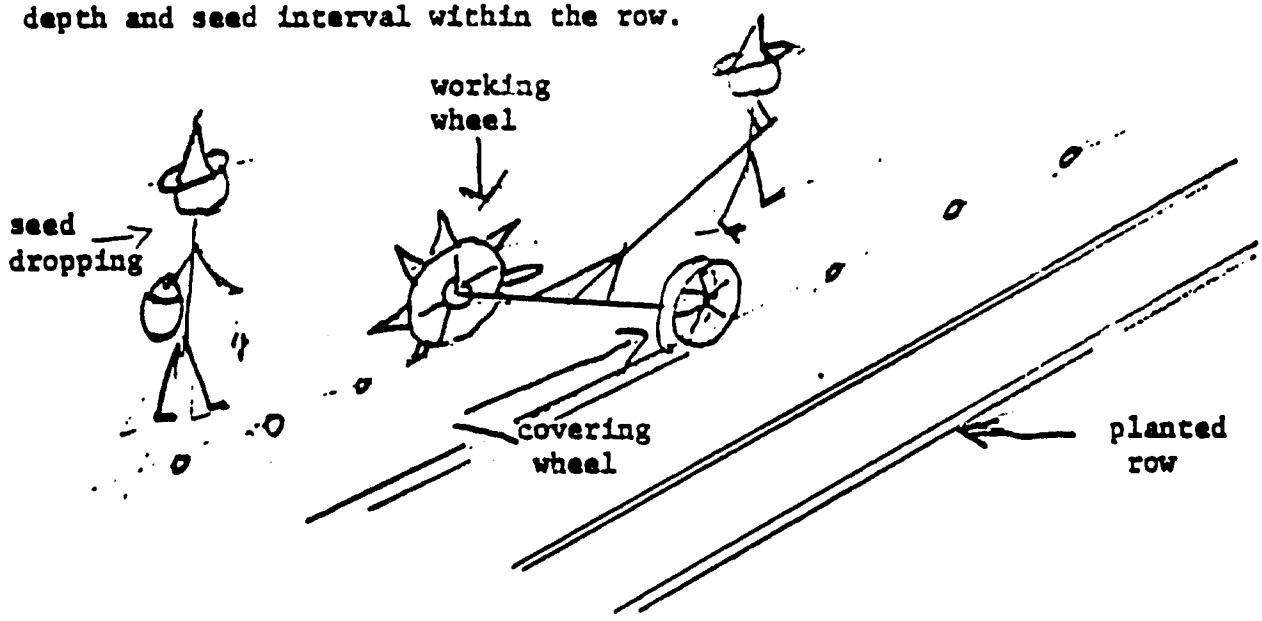
Storage

To prevent rust, apply a coating of grease or waste oil to the disks when the disk harrow is not in use. Thoroughly lubricate the bearings before storage.

Store the disk harrow in a dry place with the machine placed in the transport position.

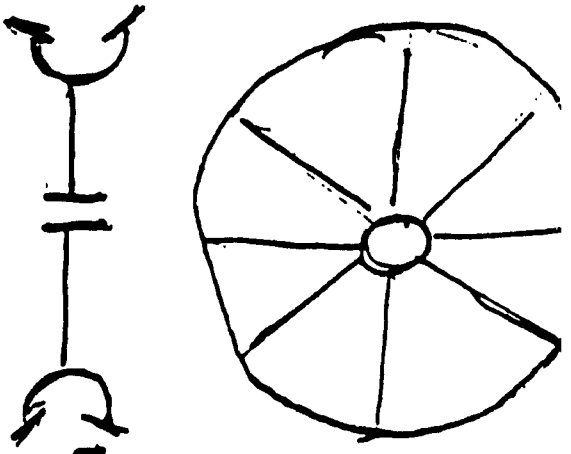
HAND PLANTING TECHNIQUE

The use of the disk harrow for secondary tillage will leave a level, uniform seedbed without furrows for seeding. A simple two-wheel device is suggested which would mark rows of uniform spacing, open the soil for seed placement, and press the soil over the planted seed. Planting with this device would require two persons, one to pull the row marker and the second to drop the seeds. The marker could be made with adjustments for row spacing, planting depth and seed interval within the row.

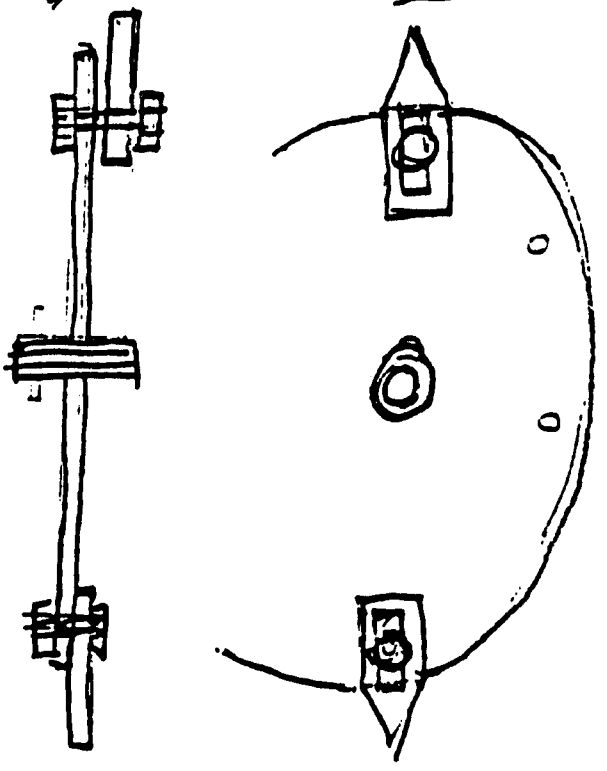


APPENDIX "I"

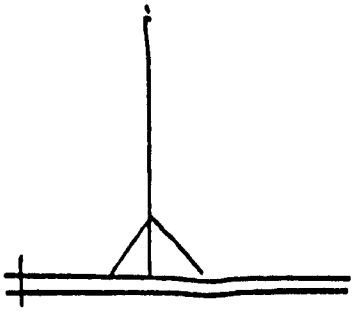
covering wheel



planting wheel



- number of hole farmers farmers and spacing according to requirements of crop
- depth also adjustable to crop
- machine could be made as one piece unit with fixed dimension for particular crop

frame

- axle drilled at intervals for changing of row interval.