International specialized media for agricultural mechanization in Asian developing countries.

AMA

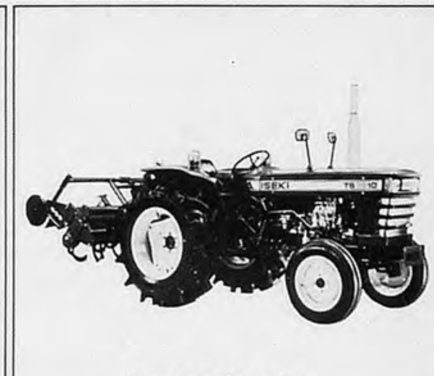
AGRICULTURAL MECHANIZATION IN ASIA

VOL.IX,NO.4,AUTUMN 1978

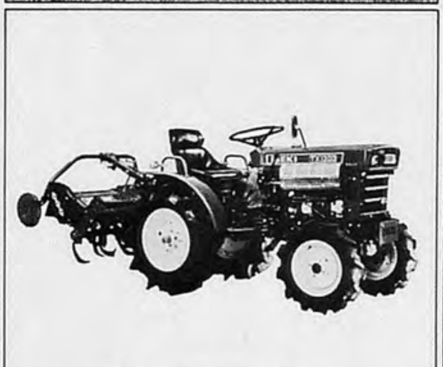
FARM MACHINERY INDUSTRIAL RESEARCH CORP.

Pleasant Working with

Tractor T series

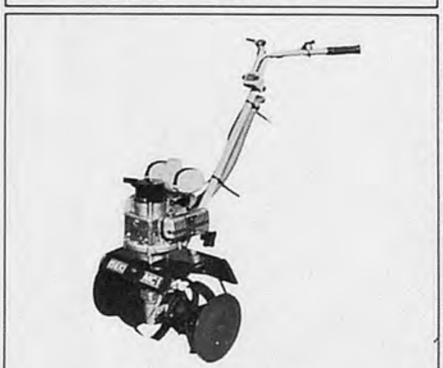


Tractor TS series

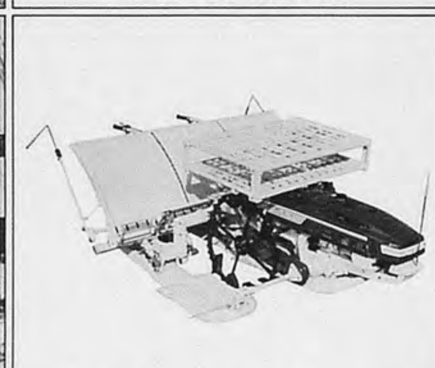


Tractor TX series

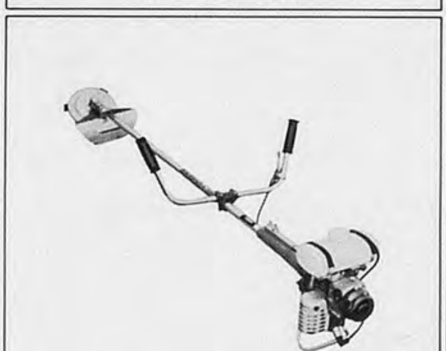
Power Tiller KS series



Mini-Tiller MC



Rice Transplanter PF series



Brush Cutter

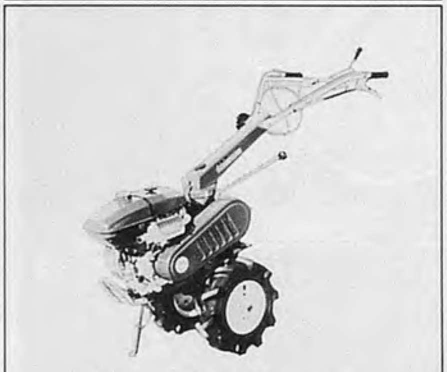
Thresher D series

Rice Huller (all steel type)

Iseki Products

Tractor TS series

Tractor TX series



Power Tiller KC series

Compact Tiller AC series

Combine Harvester HD series

Reaper Binder RX series

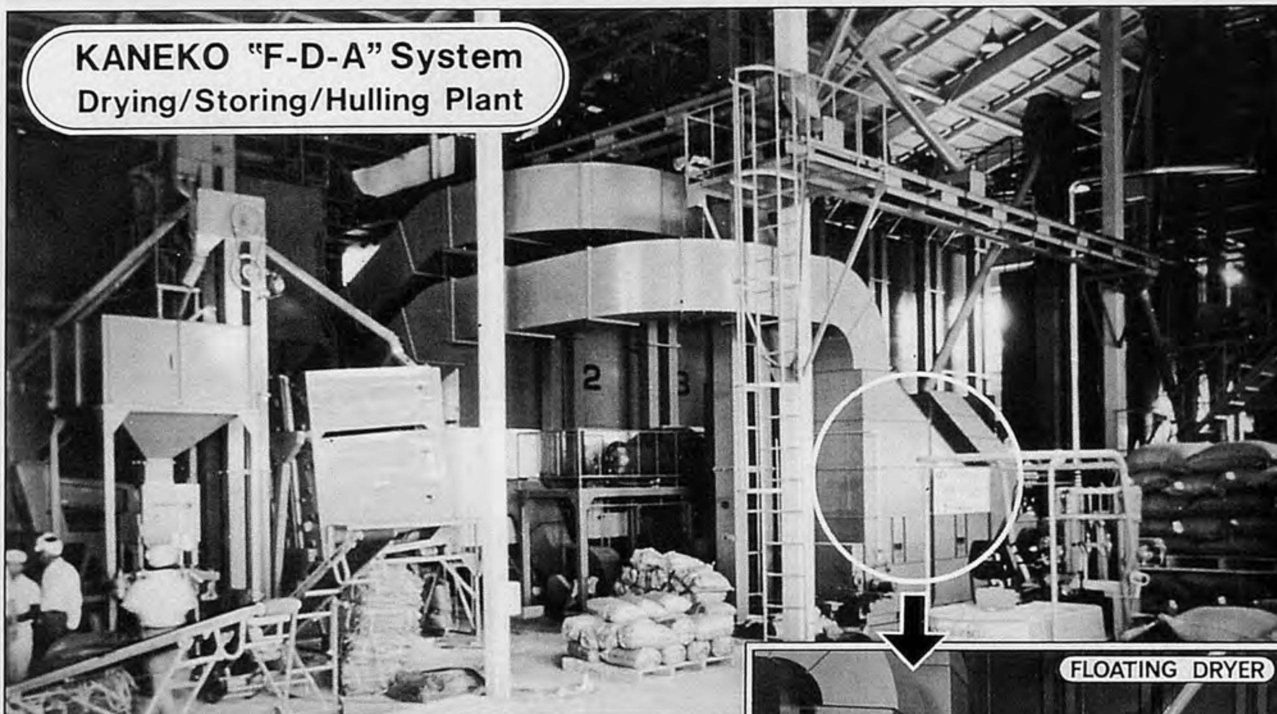
Rice Polisher

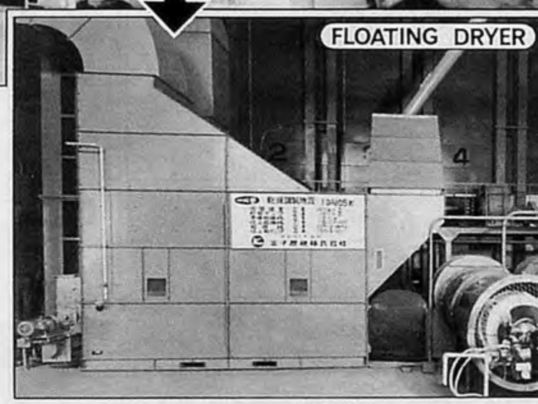
ISEKI

ISEKI & CO., LTD.

Overseas Administrative Division
3, Kioi-cho, Chiyoda-ku, Tokyo, 102 Japan
Cable Address: ISEKIRICE TOKYO
Telex: 232-2752, 232-2753
Phone: (03) 265-9301 ~ 9310/9359

KANEKO'S DRYERS LINEUP LETS





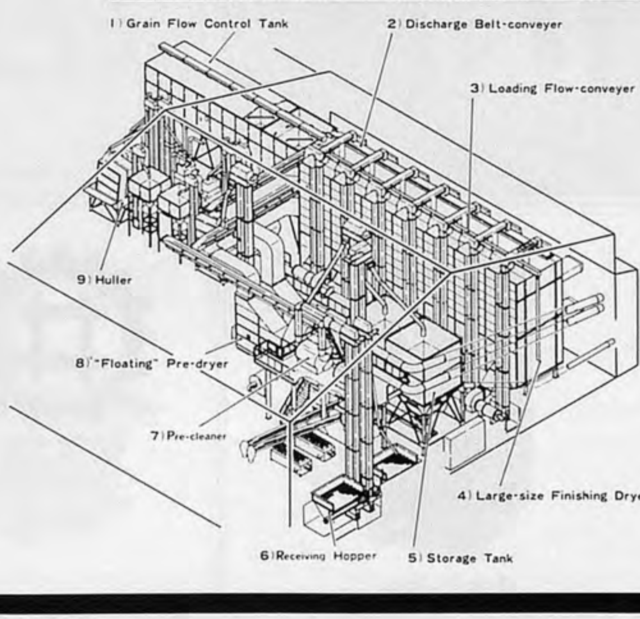
New"F-D-A"system characterized by the FLOATING Dryer, a pre-drying machine, dries paddy and corn of high moisture contents quickly, in large amount, with good quality, and, even more, at low cost.

Firstly, large amount of raw paddy and corn is rapidly pre-dryed in succession by means of the FLOATING Dryer.

Secondly, large amount of paddy and corn pre-dryed by the FLOATING Dryer is given the last finish drying in the large-scale finishing dryer.

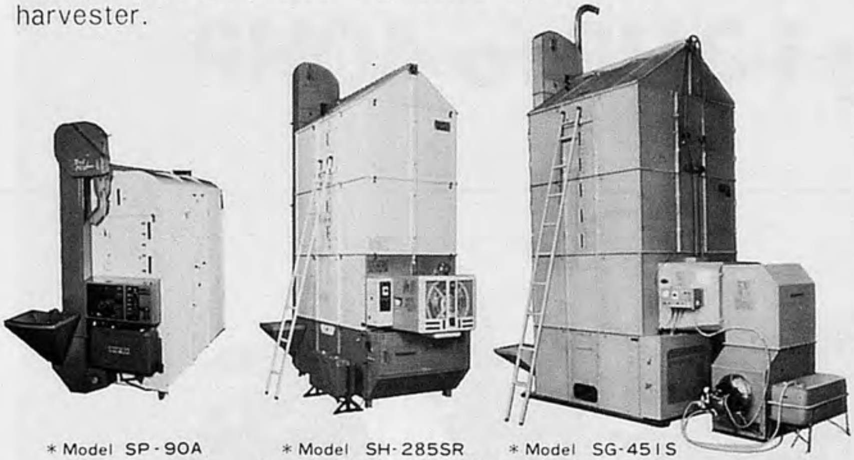
Thus, drying is completed easily and effectively in the"F-D-A" system with the KANEKO originated two-tier drying process empolyed.

*The FLOATING Dryer, both stationary and movable models available now, works efficiently by itself to dry paddy and corn. Movable one can do work at many places on purpose.



YOU HAVE GOT MORE RUNS IN!

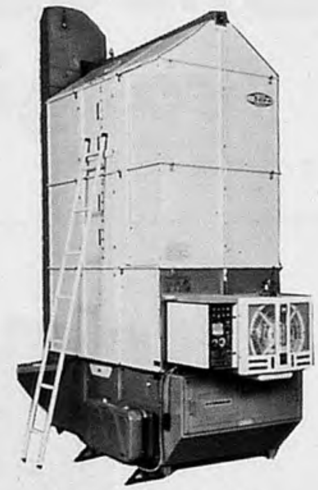
"Supering" Circulating Suction Type Grain Dryer
The circulating type dryer capable of drying raw paddy immediately after harvested by combine harvester.



* Model SP-90A　　* Model SH-285SR　　* Model SG-451S
Grain Holding Capacity — Paddy
0.4—0.9t.　　0.8t—2.8t.　　1.5—4.5t.

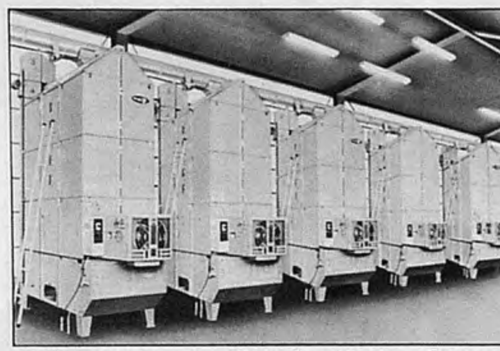
10 Models from 0.9 to 4.5t. Grain Holding Capacity/Paddy

Full-automatic First Developed by Kaneko all over the World, Super-Auto.



2 Models — 2.8t. and 3.3t.
Grain Holding Capacity/Paddy.

COMPACT RICE MILL UNIT
model krm-500
hulling and polishing capacity
650—750kg/h



RICECON System — Rice Conditioning System
is small-size grain drying and conditioning facilities marked by the separate operation of each dryer and a variety of application.

KANEKO, with sixty years of experience to its credit, is a leading manufacturer of a wide variety of drying machines and related equipment and facilities.

Whether the climate is hot or cold, arid or with plenty of rain, whether the land is at high or low attitude, KANEKO farm products, with their applications of new scientific theories, guarantee the optimum in efficiency and work rationalization wherever used.

Sell the Post-harvest System.

KANEKO AGRICULTURAL MACHINERY CO., LTD.

Overseas Division
9-12, Asakusabashi 1-chome, Taito-ku, Tokyo 111 Japan
Phone: (03)862-2459 Cable: AGRIKANEKO Tokyo
Telex: 0265-7165

Headoffice
21-10, Nishi 2-chome, Hanyu, Saitama 348 Japan
Phone: (0485)61-2111 Telex: 2942-462

Catalogue available upon request.

International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL.IX,NO.4,AUTUMN 1978

Edited by

YOSHISUKE KISHIDA

Published quarterly by

The Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

SHIN-NORIN Building
7,2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101 Japan
Printed in Japan

This is the 21th issue since the issue, Spring of 1971.

Preface

The number of research and studies on the agricultural mechanization in the developing countries has been increasing year after year, however, there are still many that people have very few opportunity of knowing the contents. "AMA" has gotten many contributors since 1971, narrowing the subject of papers on the problems of the agricultural mechanization in the developing countries. And for these few years, the number of the contributed papers has increased so largely that we must have a hard time to choose the ones to publish in each issue.

In late September, Dr. Moss, former Director of NIAE in England and now Head of Agricultural Engineering Dept. of IRRI, visited in Japan, and then we talked together about the necessity of development of the simple and cheap machines for the small farms in Asia. But it is indeed very difficult to design and produce such machines.

We talked also about the history of agricultural mechanization in Japan, and on that occasion, I showed him the results of the efficiency test of pedal driven threshers with separator, which had been held in the agricultural experiment station in Niigata-pref. 41 years ago. Although the object of this test was such a simple machinery as the pedal thresher, the report of the test was very excellent, so that we are deeply impressed by the fact that such a excellent study was already made in Japan about 40 years ago.

I think that it is now required an organization which may look back upon the history of agricultural mechanization for the last 100 years in the advanced countries, dig up the research data, patents and publications of manufacturers which are now buried in the history, and put them again to practical use for the developing countries.

In such a sense, I want to introduce in "AMA" something useful of the old materials from time to time. So I would like to ask you to inform us if you have any useful materials.

Chief Editor
Yoshisuke Kishida

October,1978
Tokyo

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA

Vol. IX, No. 4, Autumn, 1978

Agricultural Machinery Service Company

by
W. S. Weil
Agricultural Engineer
Kibbuz Maayan Zwi
D. N. Hoff Hacarmel, Israel

Abstract

The writer participated as adviser (Consulting Engineer) in a very large agricultural development project. The development of agricultural machinery was operated as a government department during the begining of the project. The operation of the machinery was turned into a Service Company (non-profit) as the scope of the project expanded.

The experience, organisation and operation of this Agricultultural Machinery Service Company can be valuable to other developing countries, hence the following report.

Operation of the Service Company

Board of Directors

Composition

The following members comprise the Board of Directors : Director General of the development project who acts as Chairman of the Board ; District Agricultural Officer who represents the Ministry of Agriculture ; District Manager of the Agricultural Development Bank ; Six elected farmer representatives from different parts of the project ; and General Manager of the Company who acts as Secretary of the Board.

Functions

The Board of Directors lays down the policy of the Company, approves the budget proposal of the Company, approves the balance sheets of the Company, and appoints the general Manager of the Company.

General Manager

It is the responsibility of the General Manager to implement the policy as laid down by the Board of Directors ; carry out his tasks in cooperation with the project Management, the Agricultural Development Bank and the different ministries ; administer the Company ; draw up the annual budgt proposal with the assistance of the Chief Accountant ; appoint the personnel of the Company and lay down the employment policy ; coordinate the activities of the different department of the Company ; implement the acquisition and sales programme of the Company.

Board of Management

The Board of Management does not perform a line function but has been created to assist the General Manager in executing his tasks. It consists of all five heads of the department, including the General Manager, who acts as Chairman. It meets weekly to discuss the problem and current business of the Company.

Accounts Department

The Accounts Department is charged with the responsibility of keeping the accounts of the Company, assists the General Manager in the preparation of the annual bugget, and draws up the yearly balance sheets to preparing statical data which assists the General Manager and heads of departments.

Development Operation Department

An engineer is in charge of this department. It implements the whole physical field development programme of the project as well as contract earthmoving and snow clearing during winter.

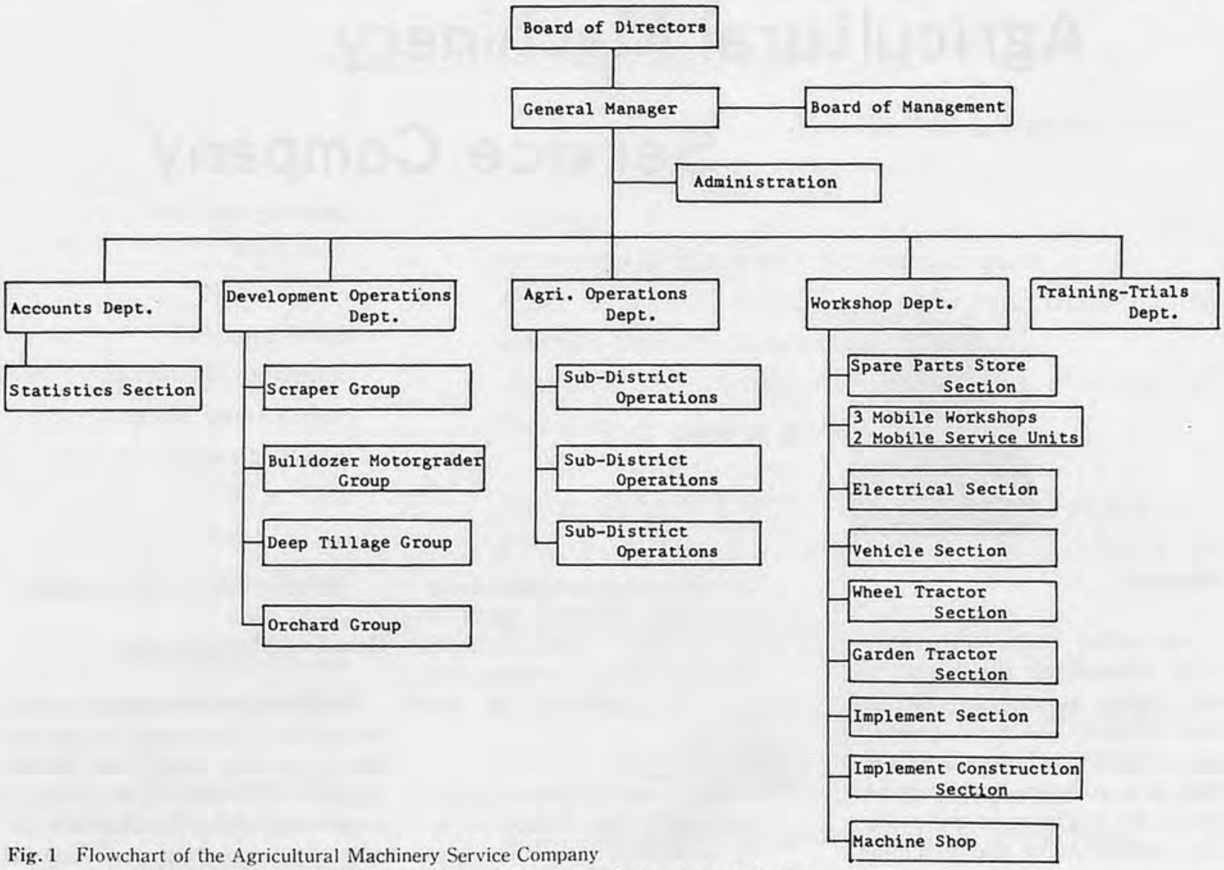


Fig. 1 Flowchart of the Agricultural Machinery Service Company

The development programme consists of preparing large tracts of land for cropping and surface irrigation. This is accomplished by levelling and grading, deep culttivation, construction of water carriers and grading, deep cultivation, construction of water carriers and reservoirs, preparing orchards for planting, etc.

The department looks after the areas until they are handed over to the village and farmers.

The annual programme is handed down by the project management through the General Manager to the head of the department who prepares the detailed operational plan.

The equipment team work in groups of five to eight tractors and a senior tractor driver is in charge of the group.

With the head of the department is a clerk who serves as his assistant. He receives daily reports from each group about the operation of each tractor and the work accomlished. He could thereby follow-up the implementation of the plan of operation. The head of the department knows each day, through these details, the reation between plan and implementation and, if necessary, could re-assign and move equipment. A detailed report is handed over to the General Manager periodically.

As the clerk receives daily reports from each tractor in each group, he knows exactly how many hours each tractor had worked and servicing required. He then provides instructions to the mobile service units to service repairs needed for each tractor.

Also, work reports are provided to the Accounts Dept. for billing. Each group maintains a tank trailer which receives fuel at regular intervals from the fuel tank truck. Small repairs are undertaken by the District Mobile Workshop.

Agricultural Operations Department

An engineer is in charge of this department which carrieds out all the agricultural machinery work after development and after the fields have been relinquished to the villages and farmers.

The whole project area is divided into three districts each covering an area of approximately 1,000 sqkm. The entire area, however, is not cultivated, nor covered by the project. In charge of operations in each is the district machinery supervisor who is usually an experienced tractor driver and specially trained for the job. Each district has a district center with fuel tank, machinery parking area sheds, etc.

The supervisor receives the cropping plan from each village and requests for special operations. These are indorsed to the department. Based on this information and after having received all the details from all the three districts, the operational plan for the comming year is drawn up.

A clerk works as assistant to the head of the department. He receives daily reports from each district about the operation of each tractor and the work accomplished. He could thereby follow up the implementation of the plan of operation. The head of the department knows the details daily, hence each day, with the help of these details the relation between plan and implementation he could reassign and move equipment, if neccessary. A detailed report is handed over to the general manager periodically.

Workshop Department

An engineer is in charge of the workshop department. A foreman supervises each of the sections. Both the district mobil workshops and the mobil service units are under the professional supervision of the workshop management. The vehicle section services the vehicles of the Company as well as those of vehicles of the whole development project. The two tractor sections service all the tractors of the Company and prepare them once a year for next year's operations. The implement section services all the implements of the Company and prepares them annually for the following operations. The implement construction section fabricates and assembles new equipment and implements of the Company's own design. The machine shop section repairs and make parts.

The workshop also faburicates, repairs and services the equipment of the different departments of the development project (research stations, grain drying, seed cleaning and dressing, daily, etc.)

Training and Trial Department

An engineer is in charge of this department. His assistants are four technicians, a secretary and translator from English to the local language.

A training programme is drawn up once a year, which consists of courses and in-field training of all personnel. The training programme is organized and implemented by the department. Training and operating manuals are written, translated and published.

The department undertakes field trials for all new equipment to find out their suitability to special local conditions. Standard equipment undergo trials and if necessary. recommendations are made on how to adapt equipment to local conditions. Recommendations and plans are indorsed to the implement construction section for alterations and construction of implements.

Organization of the Service Company

Introduction

A short description of the organizational net-up, composition and tasks of the Company was given in the previous chapter. A detailed description is provided in this chapter in order to fully understand the operation of the Company.

The whole organization used to receive advise for the first two years of operation from four consulting engineers (management, workshop-training-trials, development operations, and agricultural operations). This number was gradually reduced when the department was converted into a service company.

Equipment

Before giving a detailed description of the operation of the Company, it is thought best to give an idea of the scope on its operation.

There are about 35 medium-sized wheel tractors (60 hp) with all the necessary implements and 10 crawler tractors (120 hp) during the first two years of operation. The number of the equipment was gradually increeased. After five years, when the organization had operated for two years as a service company the following equipment become available at its disposal :

10 light wheel tractors (45hp) : 135 medium wheel tractors (60 hp) ; 35 heavy wheel tractors (120 hp) ; 36 crawler tractors (120 hp) ; 2 motograders ; 26 self-propelled combine harvesters ; 15 light vehicles (2 fuel tank trucks ; a large selection of pulled earth moving equipment ; tractor-mounted and pulled implements and trailers. Each group of tractors is essentially of one make and model.

The Company also dealt (in the workshop) with approximately 100 light vehicles and 4 trucks, belonging to the development project. Also, a large number of stationary and mobile equipment of the different departments of the development project, are fabricated, serviced and repaired by the Company.

Accounts Department

This department is a large enterprise that keeps the accounts of the Company. The operation is mechanized (accounting machine) but not computerized.

After operating for a short time as an independent Company, the management found that it required a very large amount of details to arrive at proper decisions. Therefore, a statistics section (cost accounting) was organized in the department. This section uses the information available from the accounts for policy decisions of the management.

This procedure may be discerned through the following the examples: In cost accounting, e.g., the annual operating costs of one type equipment or a single machine are recoded. If for instance the fuel or oil consumption of a certain tractor went above a fixed average, a memorandum would be sent to the manager, who in turn will issue instruction to check the report, which usually meant immediate repairs or, in a few cases, or waste or "side income". Naturally, with such a large number of machinery, a few liters burned and a few wasted there, if without suitable control, can accumulate to very large sums during a year's operation.

Development Operations Department

Land development is carried out in two phases: primary development and secondary development. The purpose of the primary development phase is to plan and implement surface irrigation on land previously classified as "permanent fallow" or "irrigated from intermittent flowing streams (floods)". No earth moving is included at this stage, except possibly an embankment to bring water from the source to the field.

On the other hand, the purpose of the secondary development phase is to complete the development process, i.e., to grade fields within the already developed area which are found unirrigable, surplus water drains, drainage feeder roads, etc. This process is appllied to 20 to 30 percent of the primary development phase.

Primary Development

The planning department of the development project can decide to increase the irrigated area of a certain village, based on economic considerations, availability of water, etc. The location of the additional area is marked on a map of 1:20,000 and indorsed to the Company for first levelling. The area marked on the map is usually by 20 percent larger than the area finally to be allocated to the village. This is done in order to be able to select the most suitable area.

All first-levelling work is executed by crawler tractors with bulldozer heavy land plane with the purpose of smoothing existing bunds and land plane, and otherwise perform cut-and-fill operations in the field.The land planes are built at the implement construction section of the workshop, based on foreign and the Company's own design. Sea and overland freight costs of a foreign product would be very expensive for such large implement. The land planes are 16.5 m long. 3.6 m mide and have a scoop of 2 3/4 to 3 m^3 capacity.

As soon as the first levelling is completed, the irrigation department of the development project surveys the field and draws up a map of 1 : 2,500. On this map the irrigation system is planned and parcellation for individual families of the village is marked. The map is relayed to the Company for deep tillage, final levelling and construction of water carriers, if required.

Deep tillage is done by crawler tractors with sub-soiler or ripper. In both caes fields are worked to an average depth of 50 cm to 70 cm. The whole area is then levelled a second time by crawler tractors (without bulldozer) and heavy land plane. About 50 percent of all fields developed are levelled a third time.

Secondary Development

As stated previously, about 20 to 30 percent of the whole area developed in the first stage requires a second stage levelling. As soon as decision has been made to include to a certain area in this second stage, the irrigation department draws up a map of 1 : 1,000 from its previous survey. On this map the proposed grading plan is indicated. The field then receives a first levelling by crawler tractor and heavy land leveller.

After this, the surveyors of the irrigation department lay out stakes of 10 m × 15 m. Distance for cut-and-fill operations. plastic bands are tied to the stakes 20 cm above the map reading the same distance of the scraper's folding arm from ground level. This arm folds back out (through spring action) after hitting the marked stakes or any other obstructions enabling the operater to see how far to cut or to fill and at a very high level of accuracy. All the grading operations are done by crawler tractors (120 hp) and scrapers (7m^3).

When once the levelling is completed, the stakes are removed from the field. A small strip of original soil remains where the stakes had been laid out. If there was a deep cut, this strip is removed by the scraper and land plane. This is followed by deep tillage in the direction of irrigation and levelling at right angle to the scraper operation.

Embankments for Irrigation Water Conveyance

The irrigation department of the development project surveys and plans the whole operation, on a map of 1 : 1,000 in the field. The embankment is staked out in the field and marked with plastic band. Also, the area from which the soil is to be taken is marked in the field.

This operation is done by heavy wheel tractor and PTO driven self-loading scraper for the following reasons:

a. the soil usually has to be transported over long distances, which is not economical to do by crawler tractors ; and

b. ground pressure of the wheel tractor is very much higher and by spreading very thinly this layer of soil, a very high compaction is attained which is necessary for minimizing high water seepage.

The trench is either opened by a toolbar mounted ditcher or by PTO driven mechanical ditcher.

Bunds for Flood Irrigation (Orchards)

Bund formation for irrigation used to be accomplished with the use of hilling discs. The slope of the field, next to the bund, from where the soil had been removed, had to be very often repaired resulting in so much waste of time and efforts. In order to make the operation efficient motorgrader was developed A water pipe is mounted behind the blade, parallel to the cutting edge. A plastic pipe, standing upright is connected at both ends of the metal pipe. A scale is painted on the rear side of the blade, next to both plastic pipes. The whole pipe is then filled with a coloured liquid. In this way, the operator could see the liquid in the pipe on both scales and could adjust the blade to exact level or to any slope required. In this way, bunds could be formed without altering the level of the adjoining fields.

Agricultural Operations Department

This is the largest and most difficult department to operate. Previously all basic tillage was done by crawler tractors (plough, chisel-plough, disc, leveller). But the operational costs were too expensive for farmers. A number of trials were undertaken to find a cheaper way to do the work, using varying sizes of wheel tractors with different sizes of implements. The outcome was a heavy 4-wheel drive tractor.

The head of this department knows at the beginning of each season, to a reasonale degree of certainty, what operations must be undertaken in each sub-district. Based on this knowledge, the tractors and equipment are distributed to each subdistrict. Due to the daily follow-up and by comparing implementation to planning, the heavy equipment could be moved and re-allocated as the need arises

Tractors never worked anywhere as single units. It would have been impossible to supervise a large number of single units spread over a wide area. They usually work in groups of at least three tractors, depending on the amount of work at hand.

Operators of heavy equipment are hired based on previous experience, and possess at least, a driving license. All operators are then trained in basic and refresher courses during the winter and work seasons in the field. Part of their basic pay is based on seniority. Their path of advance is from assistant driver for a medium wheel tractor, to driver on the same, to heavy wheel tractor, to crawler tractor and the outstanding ones are trained to be supervisors. Operators usually work permanently on one tractor the whole season.

When the Company was still operating as a government department, every operator received a full set of tools for implement adjustment and small repairs. The operators had to pay for any lost tool. Therefore, almost all tools were kept at home, in a safe place with the result that tractors were sometimes found idle in the field for hours for the lack of, say, a spanner. When the department was turned into a Company, each operator received a small amount of "Tool Money", to pay for any tools lost. On the other hand he is fined heavily if found without tools in the fielld.

Drivers receive a basic wage throughout the year and a bonus based on output in the season. This will be explained in detail later. All operators are employed throughout the year. They work in the fields during the season. During off season they assist in the workshop and in between they participate in courses. The average allocation of operators is follows: Medium wheel tractor 11/2 (some tractors work one shift, others two); heavy wheel tractors 2(both work two shifts); combine harvesters 2 (both work two shifts). The latter are drawn from the senior wheel tractor drivers during the season.

Almost all groups of equipment are of standard make for ease of repair and maintenance.

The supervisor allocates a group of tractors, implements and operators to a certain village for certain operation. He checks all the groups every day. In case of breakdown, he contracts the mobil workshop and give instructons accordingly. He reports back to the head office almost every day in the late afternoon.

Any special problem (adjustment of implement, special requirement of a certain field operation, etc.) is transmitted to the training and trial department.

Fuel could either be taken at the sub-district centre, if the tractor works nearby, or was supplied by tractor and trailer.

All equipments are returned to the workshop at the end of its special season for check-up and reconditioning for the next season.

Workshop Department

Spare Parts Store

The store is divided into five section. The first section deals with tools, special tools equipment, etc. The second part deals with universal items such as bolts nuts, washers, splints, bearings, oil seals, etc. and materials for the machine shop. The third part deals with vehicle spares. The fourth part deals with tractor spares. The fifth part deals with implement spares.

Each item is marked on a card of a card index, the quantity stock, quantity to re-order, purchase price, etc. A spare part issued to the workshop is marked on the item-card-index, copied on to the equipment history card and report sheet for the accounts department.

New equipment is usually purchased with a certain amount of manufacturer recommended spare parts. A large quantity of spare parts are purchased through international tender. Other parts are acquired in the open market, from dealers, etc. One man does the acquisition of urgently required materials in the nearby city.

District Mobil Workshop. Mobil Service Units.

As mentioned before, the central workeshop is only responsible for these units from the professional point of view. This means, that instructions are issued when repairs could be undertaken in the field and how, and which repaire have to be referred back to the workship, etc., what lubricants should be used for certain equipment and what should be specially looked into when servicing, etc.

Electrical Section

This section functions as two departments. One deals with the reconditioning of electrical units and the other with electrical repairs on the machinery. Faulty dynamos, alternators, starters, distributors, regulators, lamps etc. are removed from the equipment and replaced by reconditioned units. Therefore, almost all the repairs on the equipment is rectifying wiring faults. The reconditioning of faulty units is charged against the equipment from which they were removed. This working system saves building space and still more important, valuable working time of the equipment.

Vehicle, Wheel and Crawler Tractor Sections

When the enterprise was still working as a government department and in the old workshop (a new one was built just before the department was transformed into a Company), vehicles and tractors were taken into the workshop, dismanteld and repaired.

The new workshop was planned and built for the "unit replacement" system. With this new system the vehicles and tractors do not spend more then two or three days (at the most) in the workshop. Not only is there a large saving of valuable building space, but also, the utillisation of the equipment is considerably enchanced.

When, for instance, a tractor's oil consumption level went above the previously fixed limit, the engine would not be opened nor piston, rings and liners removed and replaced. The whole engine is replaced by a reconditioned, run-in one. In this way the tractor is back at work after 1½ to 2 days.

The reconditioning of run-down units is charged against the equipment from which its was removed. The units are usually made available by dismantling a number of vehicles or tractors, depending on the number of equipment in that group Some units are purchased. The usual practice is that in case the estimated time to repair replace the part would last longer than that more then 1 to 1½ days, the whole unit is promptly placeds.

All equipments are checked and necessary, reconditioned every year, starting with the beginning of the slack season. As field operations slow down and finally came to a complete stop still, the operators come into the workshop, are assigned to the different sections and the guidance of qualified mechanics, and assist in the reconditioning of the equipment.

Implement Section

The work in this section is organized in such a way that seasonal implements are reconditioned as soon as the particular season is over. Implemment that have been used throughout the year are reconditioned during the off-season (winter). Usually all the implements of one make and model are brought in together as a group.

A small part of this section, naturally, works on running repairs.

Implement Construction Section

This section works first of all, on the assembly of new implements. These are usually received dismantled, to save shipping and assembly (abroad) expenses.

Another task of this this section is the of alteration on standard implement in order to adapt them to special local conditions. Plans are supplied by the training and trials department. Complele construction of implements, generally designed by the training and trials department. ,i.e. heavy and light land planes, side dressers, etc. is done by this departments, including the construction of implements for which accessory units are imported, i.e. sprayers, grain drills, fertilizer distributors, etc.

Machine Shop Section

This section works in two spheres, either making or repairing parts not available,or producing parts for the implement construction section

Training and Trials Department

Although this is a small department, it is probably the heart of the whole Company, besides the general management. The success of the Company depends on two major items: skill of the whole staff and suitability of the equipment. The training of the personal is accomplished in three ways: literature, courses, in-the-field training.

Training

Literature

There is a huge amount of professional literature available over the world: periodicals, manufacturer's advertising literature, institutions, universities, books, etc. The department concentrates on a number of basic subjects, collects material on them and translates them into the local language. Each subject is mimeographed in the form of a booklet, i. e. The sprayer, Tillage implements. The combine harvester, sowing and planting implements, etc.

Besides, the department issues a monthly information sheet for the staff in cooperation with the general management. This consists of information about all the departments of the Company and one or two professional articles.

Courses

All training courses take place during the slack season (winter). A programme is usually drawn up in the spring or early summer. Naturally, to find suitable lecturers is the biggest problem. It takes generally months to find suitable people, convince them to come and lecture and everything organised. Some of the dealers cooperate and put local and foreign service staff at the disposal of the Company. Other lecturers come from trade schools, manufacturers, etc.

The length of the course depends on the subject and educational level of the trainees. Some courses are run continuously for a few days, while others in afternoons only as the personnel work in the morning. Courses are organized for different sections of the workshop, tractor and implement operation, foremen, supervisors, managing personnel, etc.

One of the most successful courses was the one organised by two consulting engineers for the entire management staff. It operated for almost two month, five afternoons a week and discussions twice or three times a week in the evenings. It deals with the whole scope of tractors and implements, management and economics.

In-the-Fieled Training

There is one major system to accomplish this subject. Just before the start of any particular season, a few tractors and the special implements are assembled in a field and all the adjustments, servicing and any points requiring attention, are examined by all the operators who would have to work with the implements.

The other method is that of a mobile instructor who moves over the whole area and instructs the operators on the proper use of the equipment.

Trials

The other function, no less important than the others, is to try, check, test and adapt any equipment under peculiar local conditions. It also cooperates with the implement contruction section in the building of prototype models which could be field tested for later mass production.

Grain used to be harvested by hand and thershed on the threshing floor of the village. The harvesting season is short and if not enough manpower was available or the weather was specially dry and hot, grain losses in the field are extensive. Combine harvesters were then introduced. But when they arrived in the field farmers refused to work with them. It took some time to find out the reason. Straw is almost as valuable in price as grain since it was used as animal feed and building material (mixed with clay mud). The farmers noticed that the combine harvester was loosing some chopped straw, chaff, grain shells, etc. And so they refused to work with them. A large tray was constructed under the straw chute at the rear end of the combine harvester. It collected all the straw, chaff, shells, etc. When a pre-determined volume reached, the tray is tipped over and the contents are piled in one heap on the ground and tipped back into horizontal position, assisted by springs. In this way, no material is lost, the straw was deposited in heaps along the field, instead of windrows.

Standard 3-point mounted drills with shovel openers are used. Not more then 3m wide drills (3-point mounted) are available in the market. The soil is very heavy and constant breakages occur. A wider and more economical (to the farmer) drill of heavier construction was required. A 3-point mounted parallel beam cultivator chassis was used. Cultivator legs with shovels are mounted in W-formation. Two seedboxes of 2.70 m width are fixed on the chasis. The seedboxes are dismantled from old broken-down drills. The boxes are driven by chains from two depth wheels. Plastic pipes are used as seed spouts. This drill was so successful that later on, this prototype was accepted as the standard drill of the Company. A large quantity was manufactured with seedboxes of 5.40 m width, purchased from a foreign manufacturer. The chasis is used as a cultivator and only in the autumn is it converted into a drill, just before the farm operations.

These are only a few samples of how some operational problems are solved. The field of activaty of this deparment is very wide and there is hardly a corner in the whole Company where its influence is not felt.

Financing the Company

Introduction

After describing the tasks and activities of all the departments and the operation of the Company as a whole, there remains only the subject of the financial operation. This is really the most difficult problem when transforming a Government department into a service company. All the responsible people in the Company seemed apprehensive as to whether this could be accomplished successfully.

At the time the company was managed as a government department all the operations were based on government regulations, covering the whole country, which were unable to take the special conditions of this project into consideration, i. e., annual budget changes, a top-heavy administrative staff, un-realistic employment policy, difficult purchasing and investment policy, etc. When the government department became a service company, a committee of the managing staff was formed to analyze the whole operation and to come up with recommendations of how to run the Company with a balanced budget. This took some time and as a result, almost all its recommendations were accepted.

Following is a short description of how these recommendations were realized and put into operation.

Personnel

This is the largest item of expense but under existing government regulations it almost impossible to reduce it. It was impossible to transfer employees from work ; every vehicle had to have its own driver, even the person sitting next to him has a driving license ; no bonuses could be paid to entice the personnel to increase their output ; salaries were tied to positions regardless of experience, seniority ; etc.

The administrative staff was cut down to a bare minimum and although they were attached to certain departments, they were moved to different departments when the need arose. For instance, there was hardly any work for clerks during the winter months in all the field departments, whereas there were plenty of activities in the workshop and accounts department. All clerks and secretaries of these offices' staff were paid bonus (one or two months extra pay), when all the business could be successful completed in time.

The whole management staff received salaries, comparative to those in the open market but, which were above those offered by government departments. This condition discoraged officials from gaining further professional experience as government employees and then moving on to private enterprises. The training and gaining of experience cost considerable sums and could be counted as a valuable investment. This investment would however be completely lost whenever such a person leaves. The only remedy was a realistic employment and remuneration.

The regulation of a permanent driver was discontinued. The drivers were given the choise of either their profession (tractor driver) or moving on to another government department. The personnel whose jobs were tied permanently to vehicles (engineers, supervisors, mobile service unit, mobile workshop, etc.) had to perform their work and still drive, but received a small monthly bonus.

The largest revolution took place with the operating staff. All calculations, up to then, were based on work norms, which was the average work output over the whole area. This was not very high as no special remunerations could be paid. Based on these norms, the income and expenses were calculated, as well as the number of machines required to accomplish the work plan. The following system was introduced. All the work norms were received by a production committee consisting of five tractor drivers, one supervisor three engineers. All the operators were guaranteed a fixed basic wage for the whole year, including the slack season (winter) when they did not work in the field. They received bonus for any work accomplished above the work norm. The result was amazing. The output rose considirably, less machinery was required to accomplish the annually rising work plan, the frequency of breakdowns and field repairs was reduced, operators looked after the equipment better, being afraid of loosing bonuses,

Although the operators received considerably larger salaries labour expenses per ha worked was smaller then under the previous system and the overall saving was quite considerable. Within this system the "Tool Money" was also included, as mentioned previously.

In the workshop, too, bonuses were paid according to output, based on work records from previous years. This system was very much more difficult to operate since not every operation is exactly the same as the previous one. Its proper function depended a lot on the skill and understanding of the supervising staff.

It was agreed upon, between the Government and the Company, that all expenses, including salaries, of the training and trials department were to be paid by the Government. The agreement was based on the assumption that activities were usually covered by the extension and research departments of the ministry of agriculture, in most countries.

It would probaly be possible to caluculate the savings accomplished by the different systems described in this chapter. However, it is sufficient to state that this was probably the major contribution in being able to run the Company on a balanced budget.

Communications

Vehicles were previously used as means of communication. Besides the high expense of vehicle upkeep, much valuable time was lost in getting impertinent messages to their destination. This problem was solved with the installation of wireless communication.

The central station was located at the head office and three substations were installed in every subdistrict. All vehicles were fitted with wireless transiever sets.

The number of vehicles was reduced from 24 to 15 and all vehicles were kept in a motor pool. The supervisors, mobile workshops, and mobile service units had permanent vehicles. The other seven were allocated according to the importance of the job at hand.

Continuous communication was established and a lot of valuable time and a large amount of money was saved.

Purchasing Equipment and Spare Parts

The fixed and variable expenses are the major items in determining the economic operation of an enterprise, besides the income.

The largest part of the first item, fixed expenses, is the size of the investment and the conditions under which these investments are made such as credit and interest.

The largest part of the second item, variable expenses, is the cost of maintenance and within that, the cost of spare parts.

Therefore, both investments and investment conditions, as well as spare parts expenditure have a major influence on the economic operation of an enterprise.

When the company operated as a small department, purchasing was done in the local market and no special conditions could be obtained, as the scope was too small. When analyzing the economic operation of the department, it was clear that ways had to be found to reduce the cost of investment and spare parts, to make it a balanced enterprise. The following methods were adopted.

Equipment

Based on the experience already accumulated, a detailed list of eqipment and specifications was drawn up. An aproximate work plan for the coming year was drawn up, based on the running year's development operation and anticipated increase of the area. Based on this approximate work plan, the additional equipment could easily be estimated.

An international tender was then published, stating the detailed specifications of the equipment, its quantity, delivery time, etc. The bidders were asked to state the price, delivered at side and which conditions under which they would sell, i. e., cash or credit and terms. These tenders were published in the local press and distributed to the trade attaches of the foreign embassies. The bidders were also asked to state their conditions for follow-up orders. Bids were received from local dealers, manufacturers, international equipment dealers, etc.

Spare Parts

A certain amount of manufacturer-recommended spare parts was included in almost every new equipment order.

The movement of spare parts was known from the card index of spare parts store. It was therefore possible to anticipate the spare parts turn-over. Those who have some experience with tractors and agricultural machinery know that the firms selling such equipment do not manufacture all the parts but buy a large quantity from smaller specialized manufacturers, jobbers, sub-contrartors, etc. For instance:

> bolts, nuts, washers, splints, bearings, oil seals, all electrical equipment, tires, rims, radiators water pums, valves and seats, springs, sleeves, pistons, rings, crankshaft bearings clutches, break linings, tracks, pins and bushes, track rollers, plough shares, discs, cultivator chassis, leg shovels, 3-point linkages, roller and agricultural chains, V-belts, pulleys, idlers, etc.

The competition in this field is even larger then in the equipment busines. An international tender for spare parts was published once year, under similar conditions as the equipment tender.

Both these systems made it possible to save large amounts of money and still obtain special favourable conditions.

Income

The previous chapters dealt with savings on the expense side of the budget. It is now intended to show the aspects of the income side.

It is of course possible to calculate the cost of operating each and every equipment. However, it is impossible to base all calculations for hiring charges on these figures for reasons that follow.

As already explained, the

Company was primarity established to serve the farmers in the area. Therefore, their needs and economic conditions, first of all, have to be taken into consideration. Hiring charges, therefore, have to be based on prices the farmers could reasonably afford. This was the guiding principle in fixings hiring charges for equipment in the agricultural operations department. The actual price charged in this department covered aproximately 90 percent of all the expenses, including overhead, capital recovery and all other fixed and variable expenses.

On the other hand, it must be understood that farmers were unable to pay charges immediately after completion of work. They were generally only able to pay their debts after harvest. This meant that credit arrangements had to be found and for a period of several months. Arrangements were worked out with the Agricultural Bank and the Supply and Marketing Company.

In other words, under the special conditions of this department, a considerable deficit was accumulated. Therefore, in order to balance the budget of the whole Company, prices for service rendered by the other departmens had to be fixed accordingly.

The next in size, in terms of income, is the development department. Here, considerations are different. Development operations of the whole project are financed by the government, through a loan of very favourable conditions from an international institution. The loan was repayable over a very long period and amounted to small annual sums, which were included in the land rent. It was therefore possible to charge hiring remunerations as in the open market, which were 15 to 20 percent above self-cost (contractor's profit).

The prices charged in the workshop were divided into two parts. One was charged against all the equipment of the Company which covers all the expenses incurred. The other price charged is for manufacture, maintenance and repair of all the other equipment belonging to the development project (other than the Company or any other customers). Here, the price charged was cost-plus, with was about 15 to 20 percent above self-cost, roughly equivalent to charges in the open market.

the income of the Training and trial departments was the payment by the government of all its expenses as described previously.

There was a certain amount of additional income through custom work, outside the project, such as combine harvesting, earth moving, snow clearing, etc. All these operations were charged according to market prices.

Financing Investments

When turning the Government department into a company, all its property had to be assesed. Stock was taken, both of the fixed and mobile property. The purchase price was looked up in the books and the years of service deducted (depreciation) the rest was debited to the Company. The total sum was turned into a loan, which the Company undertook to repay within a number of years. All the mobile assets were to be repaid within a short period and the fixed assets over a very much longer period.

Additional investments were financed in a number of ways. First from the sum of money set a side in the budget under "Depreciation". The second method was negotiating special terms from the suppliers (in the tenders), which were in most cases "short term" conditions. The last was a yearly development loan from the Agricultural Bank which had to be repaid within three to seven years.

These methods made possible to make careful and reasonable additional investments. ■■

Field Study of Agricultural Mechanization in the Comilla District, Bangladesh

by
N. N. Sarker
Lecturer in Farm Power and Machinery
Bangladesh Agricultural University
Mymensingh, Bangladesh

Gajendra Singh
Associate Professor of Agricultural Engineering
Asian Institute of Technology
Bangkok, Thailand

Introduction

Most of the efforts made so far to raise agricultural production in Bangladesh have been concentrated on the inputs of high yielding crop varieties, fertilizers, pest control and irrigation water. Most of the planning efforts in agricultural mechanization have been focussed on irrigation in order to provide farmers with water that they need for growing additional crops during the dry season.

Very little attention has been given to farm power and implement innovations. Bangladesh Agricultural Development Corporation (BADC) and other institutions as well as government agencies have experimented with the use of tractors, power tillers and improved bullock drawn implements.

However, these are scattered efforts and cannot, as of yet, form the basis for major policy decisions on mechanization. The possible role of mechanized cultivation in Bangladesh is yet to be evaluated in a comprehen-sive manner.

This study[1] was based on information for crop year 1976-77, collected during September 1977 to December 1977 from 40 farmers of 6 different villages in Comilla District, Bangladesh. The objectives were to compare the yields, labor use and cropping intensity on rainfed and irrigated fields and also to determine the effect of tractor tillage on yields, labor use and cropping intensity on both rainfed and irrigated fields.

Scope and Limitations of the Study

The major crop in the district is paddy. There is a wide variation in cropping practices from one area of the district to another. However, two major cropping seasons can be identified: "Aman" cropping season, (transplanting time July to September and harvest from October to December) and "Aus" (broadcasting time in March to May and is rainfed). But where irrigation facilities are available transplanting is done from of January or as when irrigation water is available. The latter case is very often called as the "Boro" season. Harvesting of Aus paddy in the "Aus" season continues through August.

The Bangladesh Academy for Rural Development (BARD) initiated the tractor mechanization movement with two 35 hp tractors in 1960[2]. For the expansion of the experiment to cover the entire Comilla Thana, a 5-year-scheme, entitled, "Mechanized Farming on Co-operative Basis in Comilla" was approved in 1962 and made possible the development of Kotwali Thana Central Co-operative Association (KTCCA)[3,4].

From then onward the tractor station has been providing custom services to farmers in Kotwali and also others whenever possible.

It could be claimed that Comilla is the leading district for mechanized cultivation in Bangladesh. BADC initiated the mechanized cultivation (MC) program in 1973 and allocated 50 tractors to Comilla district alone from a total of 300 for the whole country for custom services.

More than 50 percent of the holdings are less than 1 ha and over 95 percent are less than 5 ha in size in Bangladesh[5]. The small holdings are fragmented and scattered in different locations. No farmer in the area owns a tractor to plow his field. The distribution of tractors and implements for the whole district is 1976-77 is given in

Table 1.

A famer can use tractor to plow his plot only when some other nearby plot holders are in agreement to make tilling area of about 2 ha. This is the minimum area for which a tractor could be rented from the KTCCA tractor station or BADB (MC). Therefore, usually a farmer cannot plow all his plots with tractor and may not even use a tractor in a single plot for all the crops is a year. The same is true with the use of irrigation facilities by individual farmers.

The farm plots of individual farmers were classified first according to the water management in the following categories:

Category 1: Farm plots unirrigated and depending only on rain water,

Category 2: Farm plots manually irrigated (with the use of swinging basket from ponds or ditches), and

Category 3: Farm plots irrigated low-lift pumps and shallow or deep tube wells.

In each category a farm plot was further classified as whether it was a) tilled with country plow alone, or b) tilled with both country plow and tractor (Farmers always use country plow for final land preparation even after tractor tillage). These were the two mecahnization levels.

These classifcations were considered separately for both Aman and Aus cropping seasons. Specific considerations were also given to high yielding (HY), medium yielding (MY) and low yielding (LY) paddy varieties. The other crops like pulses, oil seeds, legumes, vegetables, wheat, etc. grown generally in between the two cropping seasons, were considered for determining the cropping intensity. There was no farm plot under Category 3 in the Aman cropping season because pump irrigation was provided in the dry season mainly.

From each farmer multiple responses were obtained as a farmer used different farm practices and different paddy varieties in different plots.

Table 1. Distribution of Tractors and Implements in Comilla District in 1976–77

Item	KTCCA	BADC(MC)	Total
1. Tractor	10	22	32
2. Disc plow	1	1	2
3. Moldboard plow	1	–	1
4. Harrow	8	14	22
5. Rotavator	2	27	29
6. Combined polydisc	3	–	3
Total area tilled(ha)	1330	1339	2669

Source: 1. Personal communication, KTCCA Tractor Station, Comilla.
2. Personal communication, Mr. Zinnat Ali, Assistant Engineer, BADC (MC), Comilla.

Results and Discussions

Yield—Mean yields of Aman and Aus paddy are given in **Tables 2** and 3, respectively. The yields of Aman and Aus paddy in the irrigated fields were higher than the yields of fields as the availability of water to the crops was higher. There differences were significant for both tractor-tilled HY Aman and Aus paddy fields. The yields from pump-irrigated Aus paddy fields were higher than manually irrigated fields as the availability and quantity of water when needed was assured for pump irrigation, which was not always possible with swinging-basket irrigation.

In both rainfed and irrigated fields, and for both Aman and Aus cropping seasons, the tractor-tilled fields had higher yields than the yields of country plow-tilled fields. This difference was significant for the manually irrigated HY Aman paddy fields.

There was apparently no difference in yields between tractor-tilled and country plow-tilled unirrigated HY Aus paddy fields but there was evidence of comparatively higher yields in the tractor-tilled unirrigated HY Aman paddy fields. This was because farms in the latter case had adequate water from rains.

Table 2. Mean yield of Aman paddy (kg/ha)

Category	High yielding varieties (HY)		Medium yielding varieties (MY)		Low yields varieties (LY)	
	A	B	A	B	A	B
1 Rainfed	3647 (1224)*	4419 (1157)	2384 (583)	2783 (609)	2028 (537)	2035 (360)
2 Irrigated with swinging basket	4344 (876)	5764 (934)	2987 (882)	3035 (246)	– –	– –

Note: A—Country plow tilled farm plots (fields)
B—Country plow & tractor tiled farm plots (fields)
*—Standard deviation.

Difference of yields between:
i) 1HB and 2HB Significant at 90% confidence level
ii) 2HA and 2HB Significant at 90% confidence level

Table 3. Mean yield of Aus paddy (kg/ha)

Category	HY		MY		LY	
	A	B	A	B	A	B
1 Rainfed	2606 (846)	2680 (1029)	2164 (779)	– –	1456 (523)	2028 (591)
2 Irrigated with swinging basket	3193 (1220)	4058 (1055)	2929 (669)	– –	– –	– –
3 Irrigated with pump	4536 (1424)	5097 (1495)	3202 (216)	– –	– –	– –

Difference of yields between:
i) 1HB and 2HB Significant at 95% confidence level
ii) 1HB and 3HB Significant at 99% confidence level

Labor use—Labor use in the production of Aman and Aus paddy varieties are given in **Tables 4** and 5, respectively. Labor utilization was higher for irrigated fields compared to rainfed fields. The manually irrigated fields required the most labor. The quantity of irrigation water and labor utilization depended on the availability of water and its source.

In most of cases, tractor-tilled fields utilized less labor. Weeding in tractor-tilled fields required less labor because these fields had less weed compared to country plow-tilled fields. Another reason was that farmers who could use tractors could most often afford the use of pedal threshers to thresh their harvest. Only 3.4 man-days were required to thresh 1,000 kg paddy with pedal thresher while threshing by animals required 9.1 man-days for the same quantity.

In many cases, the tractor-tilled fields utilized less family labor but more hired labor. This difference was significant for the production of MY rainfed Aman paddy but the total labor utilization remained unchanged.

Costs of production and gross margins—The mean costs of production and gross margins for Aman and Aus paddy variaties are shown in **Tables 6** and 7, respectively. The cost of production included the custom rate of each farm operation, costs of seed, manures and fertilizers, water charges and pesticides.

The price per 100 kg of high yielding paddy varieties was Tk* 200 to Tk 215 and that of medium and low yielding paddy varieties was Tk 225 to Tk 255 in 1976-77.

The gross margins were higher for the tractor-tilled fields compared to country plow-tilled fields. This was because of higher yields and lower costs of production in tillage, weeding and threshing for the former. The gross margins for rainfed and manually irrigated

*1US$=15.18 Takas(Tk)

Table 4. Mean labor use for the production of Aman paddy varieties

Category	HY				MY				LY			
	A		B		A		B		A		B	
	F	H	F	H	F	H	F	H	F	H	F	H
Rainfed	88.3	95.1	66.2	88.3	89.1	66.0	61.7*	96.8**	86.1	72.9	43.7	100.1
Total	183.4		154.5		155.1		158.5		159.0		143.8	
Manually irrigated	156.1	162.6	74.6	127.4	125.9	91.5	85.7	91.1	–		–	
Total	318.7***		202.0		217.4		176.8		–		–	

Note: F—Family labor
H—Hired labor
*—Difference of family labor Significant at 95% Confidence level.
**— 〃 〃 hired 〃 〃 〃 95% 〃 〃
***— 〃 〃 total 〃 〃 〃 95% 〃 〃

Table 5. Mean labor use for the production of Aus paddy varieties (Man-days/ha)

Category	HY				MY				LY			
	A		B		A		B		A		B	
	F	H	F	H	F	H	F	H	F	H	F	H
Rainfed	106.6	98.3	92.6	67.8	95.7	73.5	–	–	87.3	63.3	98.8	67.0
Total	204.9		160.4		169.2		–		150.6		165.8	
Manually irrigated	145.6	150.5	130.0	158.5	84.6	188.2	–	–	–	–	–	–
Total	296.1		288.5		272.8		–		–		–	
Irrigated with pump	83.5	110.9	70.6	115.1	78.6	150.0	–	–	–	–	–	–
Total	194.4		185.7		228.6		–		–		–	

Table 6. Mean cost of production and gross margin for Aman paddy varieties (Tk*/ha)

Category	Item	HY		MY		LY	
		A	B	A	B	A	B
Rainfed	Production cost	2472	2626	2279	2258	2260	1452
	Value of produce	7363	7519	5096	6210	4210	4242
	Gross margin	4891	4893	2817	3952	1950	2790
Manually irrigated	Production cost	4476	3188	2921	2679	–	–
	Value of produce	7335	9168	6391	6636		
	Gross margin	2859	5980	3670	3957		

*1 US$=15.18 Takas (Tk)

Table 7. Mean cost of production and gross margin for Aus paddy varieties (Tk/ha)

Category	Item	HY		MY		LY	
		A	B	A	B	A	B
Rainfed	Production cost	2529	2261	2230	–	2088	2467
	Value of produce	5535	5625	4917	–	2984	3512
	Gross margin	3006	3364	2687	–	896	1045
Manually irrigated	Production cost	4125	3607	3944	–	–	–
	Value of produce	6591	7571	7649	–	–	–
	Gross margin	2466	3864	3705	–	–	–
Irrigated with Pump	Production cost	3608	3533	2862	–	–	–
	Value of produce	10373	10304	8054	–	–	–
	Gross margin	6765	6771	5192	–	–	–

fields were more or less the same because of additional labor requirements in the latter method of irrigation. Pump irrigated Aus paddy fields had higher margins for higher yields and cheaper water.

Cropping intensity—The mean cropping intensities of country plow-tilled fields and tractor-tilled fields under varying categories are shown in **Table** 8.

Cropping intensity was more or less the same for rainfed and irrigated fields. But for both rainfed and irrigated fields the cropping intensities were slightly higher for tractor-tilled fields than for country plow-tilled fields. The tractor tillage facilities were not adequate in the area to raise the cropping intensity significantly.

Table 8. Cropping intensity (Percent)

Category	Country plow-tilled fields (A)	Tractor-tilled fields (B)
Rainfed	214	236
Manually irrigated with swinging basket	223	240
Irrigated with pump	225	231

Conclusions

The yields of Aman and Aus paddy were higher in the irrigated field than in the rainfed fields. The yields of pump irrigated Aus paddy fields were higher than that of the manually irrigated fields.

In both rainfed and irrigated fields, for both Aman and Aus cropping seasons, the tractor-tilled fields had higher yields than the country plow-tilled fields. This was reflected more in the fields with adequate water supply with high yielding paddy varieties.

Labor utilization was higher for irrigated fields compared to rainfed fields. The manually irrigated fields required the most labor.

In most of the cases, tractor-tilled fields utilized less total labor and in many cases, these fields utilized less family labor compared to country plow!tilled fields.

For both rainfed and irrigated fieelds the cropping intensities were slightly higher on tractor-tilled fields compared to country plow-tilled fields.

Gross margins for rainfed and the manually irrigated fields were more less the same. Pump irrigated Aus paddy fields had higher margins for higher yields and cheaper water. Gross margins were higher in tractor-tilled fields than plow-tilled fields for both rainfed and irrigated fields.

REFERENCES

1. SARKER, N. N. (1978), Field Study of Agricultural Mechanization in the Comilla District, Bangladesh. Unpublished Master's Thesis, AIT, Bangkok.
2. ESMAY, M. L. & L. W. Faidley (1973), Ownership Pattern for Tractors and Machinery, Agricultural Mechanization in Developing Countries, Shin-Norinsha Co. Ltd., PP. 104-134.
3. ANNUAL REPORT (1963-69), Rural Co-operative Pilot Experiment, Ninth Annual Report, Bangladesh Academy for Rural Development, Comilla, Bangladesh, p. 1.
4. ANNUAL REPORT (1071-72), Rural Co-operative Pilot Experiment, Twelfth Annual Report, Bangladesh Academy for Rural Development, Corilla, Bangladesh, p. 5.
5. BUREAU OF STATISTICS (1972), Master Survey of Agriculture in Bangladesh (Seventh round, Second phase), M. S. A. Series No. 9. Bangladesh Bureau of Statistics. p. 48. ■■

Appraisal of Mechanization in Sind Province of Pakistan ——A Research Approach

by

Bherulal T. Devrajani
Principal Investigator
Sind Agriculture University
Tandojam, Pakistan

Abdul Qadir Ansari
Vice Chancellor
Sind Agriculture University
Tandojam, Pakistan

James L. Butler
Research Leader
USDA-ARS, Hyattsville, Maryland, USA

Introduction

Almost every nation has been endeavouring to achieve economic prosperity through the exploitation of resources to optimum use. Agriculture is the basic industry of Pakistan, and national policies aim to achieve increased agricultural production for self-sufficiency in food, and to generate more foreign exchange resources and to improve the standard of living of the farming community. The development of production technology for crops has been necessary. It demands great efforts to economize on work through modern tools and efficient machines. The farmers of Sind are more or less ready to adopt modern technology, but the management and selection of the technology is delaying the adoption. The evtremely low productivity of farm labour using ineffective, primitive methods of cultivation and inadequate and un-economic capital investment on farms compel the introduction of technology improvements.

Farm mechanization has been considered as the most important improvement, but it is yet to be decided whether the economy of the country would permit the technical advances with all its socio-economic dimensions. There is a substantive gap between need and practice in farm mechanization. This problem needs consideration in its review and appraisal. The developed nations have demonstrated that machine use increases production and decreases labour requirement, but the economic scope of machine use in Sind agriculture is still a confused, un-analysed and controversial issue owing to the absence of specific and uniform importance attributed to it. All the provinces of Pakistan have recently introduced farm mechanization as a means to increase benefits from improved agricultural production. However, there are many problems yet to be tackled, such as adopting the right kind of machine and using it at the right time and at the proper place aiming at yield increase per unit area. With the increase in industrialization and education facilities, farm labour is shifting from farms to towns reducing farm workers day by day. Moreover, when labour has scarcity value and land is relatively abundant, farm rechanization is considered as an engine of growth.

Pakistan agriculture is passing through a transttional stage where land has scarcity value and shortage of agricultural labour occurs during certain periods, for certain operations, or, in certain areas. Since the cultivated land area is not increasing so much, the first step to be taken for agricultural development is to raise the yields. For the yield take-off, improved varieties, fertilizers, better management, and farm mechanization are necessary. Thus, the use of farm machines supplemented by bio-hydro-chemical technologies enhances agricultural production and replaces man-animal labour and overcomes periodic labour problems. Scientific research appraising the work quality, efficiency, cost of mechanization, potential pay-off, effects on employment, and social infra-structure are necessary.

This paper is based on a 3-year study determining the contribution of farm machinery in the production function on progressive farms using farm machines against traditional farms using indigenous implements. Efforts have been made to evaluate timing efficiences, field and economies of machine use in the production of

Table 1. Cropping Pattern and Intensity of Cropping Followed on Selected Progressive and Traditional Farms in Sind During 1974–76

Year	Total holding	Cropping Pattern and Intensity							
		Wheat	Cotton	Fodder	Other crops	Annual Crops		Total	Intensity
						Sugar-cane	garden		
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Percent.
Progressive									
1974–75	49014	14574	16064	4859	6736	3782	4031	50046	102.11
1975–76	48149	19295	16100	5394	6984	4902	4353	57028	118.44
Average	48581.5	16943.50	16082	5126.5	6860	4342	4192	53537	110.20
Percent	–	34.86	33.10	10.55	14.12	8.94	8.63	110.20	–
Traditional									
1974–75	2594	1014	766	230	147	87	65	2309	89.01
1975–76	4101	1324	1057	280	152	268	80	3161	77.08
Average	3347.50	1169	911.50	255	149.50	177.50	72.50	2735	81.70
Percent	–	34.92	27.23	7.62	4.47	5.30	2.17	81.70	–

crops.

The study sought the suitability of farm machinery for important crops under under different types and conditions of soil and aimed at defermining the effective use, functions and efficiency of machines on pre-sowing, sowing, post-sowing and harvesting operations, including the effects of size and make of a paticular machine. It appraised the economic efficiency of various machines competing in the production of wheat, cotton and sugarcane crops in Sind.

Sind is the second largeest agricultural province of Pakistan. Over the years, its agriculture has been dependent upon bullock power and indigenous implements. The agriculture of Sind has remaine up to subsistence level until the recent advent of commercial agricultural products. Rice, wheat, cotton and sugarcane are the major crops in Sind. More than 70 percent of the population lives in rural areas and depends largely on agriculture. Though there are a few farm machines on progressive farms bullock power is still in use in those farms. Share cropping system is common. There is specialized farming as to soil type, irrigation system and climatic conditions,. The use of seed, fertilizers and pesticides is almost common on both progressive as well as traditional farms. There is a difference in cultural practices between tractor farms and traditional famms and so in yield.

Table 1 indicates that 34 percent of the cropped area is planted to wheat, 23 percent to cotton and only 5 percent to sugurcane. In addition the table compares the cropping intensity on progressive and traditional farms.

Implications

Influenced with the efficiency of machines, Sind farmers now tend to mechanize their farms. But machinery related expenditures are thought to be the greatest single item in production cost. The lack of local machine manufacturing industries, insufficient spare parts, absence of adequate repair and service facilities, lack of sufficient capital inadequate technical services, high prices of machines, lack of research in the field of machinery management and other related disciplines, and traditional-oriented customs and habits of farming community are the major problems in the way of popularization of machine use in agriculture. Tractor use is still confined to difficult jobs like pre-sowing operations.

Methodology

The study considered all mechanized and semi-mechanized farms of Sind growing selected crops on commercial scale. A sample of 50 progressive and 25 traditional farms were selected by purposive sampling method representing the universe in almost all respects from five districts where wheat, cotton and sugarcane crops dominate the cropping pattern. (Tharparkar, Sangher, Hyderabad, Nawabshah and Sukkur) The sample was drawn from three sub-districts of selected districts on the basis of variations in machines and tractor available on different farms and types of soils coupled with the ability of operator to respond and cooperate in providing data. The traditional farms represented traditional methods of cultivation with a similar type of soil, irrigation facilities and other common resources.

Frequent visits were made to the selected farms to collect desired information. Farmers were interviewed to record data on pretested questionnaire prepared for the purpose. The reliability of data was tested from time to time through multiple question series. Experimental methods of investigation were adopted to collect data for computing field and performance efficiencies of machines. The time, number of operations and work quality measurements were determined to estimate various aspects of machine use efficiency. The farms under study were stratified into small, medium and large according to the land acreages devoted to the cultivation of wheat, cotton and sugarcane. For analysing production function of wheat and cotton crops, the farms were grouped as follows:

small farms, below 200 acres ; medium farms, 201 to 500 acres ; and large farms, above 500 acres.

Since sugarcane is a resource

corpetitive crop, growers do not devote more land for its cultivation. Therefore, the sugarcane farms were stratified as follows ;

Small Farms : Growing below 100 acres ;

Medium Farms : Growing 101 to 200 acres ; and

Large Farms : Growing above 200 acres.

The Variables

Sind its considered a labour surplus province. The farming class being tradition-oriented, adopted tractor use in the 50 s. There are many types of tractors imported from outside Pakistan since no tractors are manufactured in the country. The number of tractors purchased by the selected progressive growers is shown in **Table 2, Fig. 1.**

Tractors used on farms range in size from 45 hp to 65 hp with a majority in the 55 group . The per acre horse power is not uniform. A grower may possess a varying number of tractors with similar or different horse power rating.

Table 2. Types and Number of Tractors Purchased by Selected Progressive Farmers of Sind Upto 1975–76

Type of Tractors	Purchased During										Total	Per-cent
	Upto 1966	1967	1968	1969	1970	1971	1972	1973	74–75	75–76		
International Harvester	4	9	8	15	10	2	6	–	–	3	57	36.31
Byelarus	3	–	10	10	8	5	6	2	7	–	51	32.49
Massey Fergusen	3	3	6	–	3	1	4	1	–	1	20	12.74
Ford	1	–	4	–	2	5	2	1	1	1	19	12.18
Deutz	–	–	–	2	1	1	1	–	–	–	5	3.19
Ursus	–	–	–	–	1	–	–	–	1	–	2	1.27
Fiat	–	–	–	–	–	–	–	–	–	3	3	1.91
Total	11	12	28	27	25	14	19	4	9	8	157	100
Percent	7.01	7.64	17.83	17.20	15.92	8.9	12.10	2.55	5.73	5.10	100	–

Table 3. Utilization of Various Tractors for the Cultivation of Wheat, Cotton and Sugarcane Crops on Selected Progressive Farms in Sind Province During 1974–76

Operation	Contribution of Tractors					
	1974–75		1975–76		2 years average	
	Actual	Percent	Actual	Percent	Actual	Percent
	Hours		Hours		Hours	
Plowing	112349	52.92	184781	52.78	–148565	52.83
Clod Crushing	2867	1.35	566	0.16	1716.50	0.61
Levelling	68077	32.06	137179	39.18	102628	36.50
Bund Making	1496	0.70	2666	0.76	2081	0.74
Channel preparation	1002	0.74	987	0.28	994.50	0.35
Sowing	3980	1.87	5319	1.52	4649.50	1.65
Spraying	170	0.08	–	–	85	0.03
Harvesting	4838	2.29	7176	2.05	6007	2.14
Threshing	17539	8.26	11407	3.27	14473	5.15
Total	212318	100.00	350081	100.00	281199.50	100.00

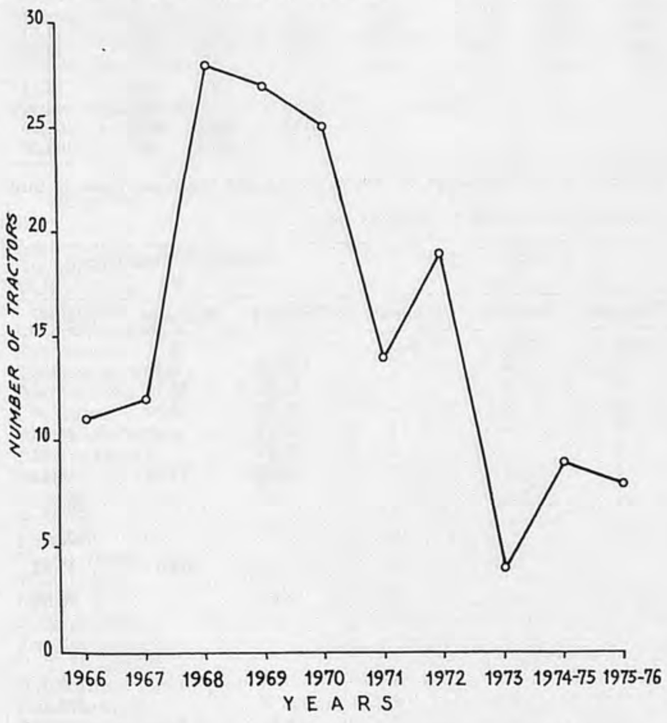


Fig. 1 Number of tractors purchased by selected progressive farms in Sind up to 1975-76

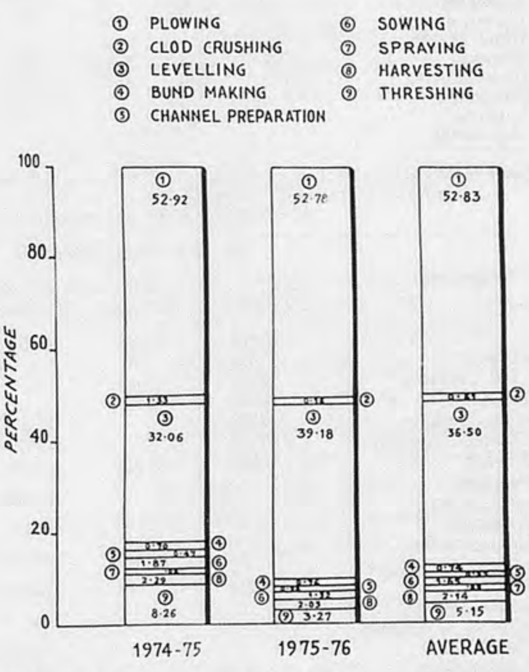


Fig. 2 Utilization of tractors for cultivation of wheat, cotton and sugarcane crops on selected progressive farms in Sind during 1974-76

There is no consideration of size of tractor with the size of farm. The average tractor horse power calculated on progressive farms was 0. 17 per acre supplemented by an average bullock power of 0. 05 horse power per acre, considering 3 bullocks to a horse power, whereas, on traditional farms the only bullock horse power available averaged 0. 07 per acre.

The use of tractors varied from farm to farm, used mainly for tillage operations and road transport without proper work schedule for jobs, but used as and when required. The tractor utilization for the cultivation of selected crops is shown in **Table 3 and Fig. 2.** The amount of tractor work needed on a particular farm depends on the mechanized operations, area operated and pressure of work, and nature of operations considering cropping intensity and availability of tractors. The pattern of mechanized operations on farms under investigation is shown in **Table 4.** Complete mechanization is seldom seen in Sind even on farms where facilities are available. The degree of mechanization was worked out

Table 4. Percentage of Operations Mechanized for the Cultivation of Wheat, Cotton and Sugarcane crops on Selected Progressive Farms in Sind During 1974－76

Operations	Bullock Drawn Implements				Tractor Drawn Machines				Manual (Hand Tool)			
	Area Operated				Area Operated				Area Operated			
	1974－75	1975－76	Average	Percent	1974－75	1975－76	Average	Percent	1974－75	1975－76	Average	Percent
	Acres	Acres	Acres		Acres	Acres	Acres		Acres	Acres	Acres	
						Wheat Crop						
Plowing	578	–	289	1.71	13996	19295	16645.5	98.29	–	–	–	–
Clod crushing	9628	3576	6602	38.99	4946	2921	3933.5	23.23	–	–	–	–
Levelling	600	600	600	3.54	13974	18695	16334.5	96.46	–	–	–	–
Bund Making	–	–	–	–	4694	7910	6302	37.21	9880	11385	10632.50	62.79
Channel Dressing	–	–	–	–	3554	3450	3502	20.68	11020	15845	13432.50	79.32
Sowing	5813	13242	9527.5	56.26	4094	5351	4722.5	27.89	4667	702	2684.5	15.85
Harvesting	–	–	–	–	2444	4150	3297	19.47	12130	15145	13637.5	80.53
Winnowing	–	–	–	–	–	–	–	–	4432	8746	6589	38.91
						Cotton Crop						
Plowing	–	–	–	–	16064	16100	16082	100.00	–	–	–	–
Clod crushing	2895	3055	2975	18.50	2294	1390	1842	11.45	–	–	–	–
Levelling	–	400	200	1.24	16064	15700	15882	98.76	–	–	–	–
Channel Dressing	–	–	–	–	1860	3090	2475	15.39	14204	13010	13607	84.61
Bund making	–	–	–	–	3550	6025	4787.50	29.77	12514	10075	1129.50	70.23
Sowing	12139	13070	12604.5	78.38	3925	2830	3377.5	21.00	–	200	100	0.62
Interculturing	16064	16100	16082	100.00	–	–	–	–	16064	16100	16082	100.00
Spraying	–	–	—	–	1248	–	624	3.88	14816	16100	15458	96.12
Picking	–	–	—	–	–	–	–	–	16064	16100	16082	100.00
						Sugarcane Crop						
Plowing	–	–	–	–	3782	4902	4342	100.00	–	–	–	–
Clod crushing	–	942	471	10.85	72	178	125	2.88	–	–	–	–
Levelling	–	150	75	1.73	3782	4752	4267	98.27	–	–	–	–
Channel dressing	–	–	–	–	635	1830	1232.5	28.39	3147	3072	3109	71.61
Bund Making	–	–	–	–	1326	3152	2239	51.57	2456	1750	2103	48.43
Planting	2712	2465	2588.5	59.62	1070	2437	1753.5	40.38	–	–	–	–
Interculturing	3782	4902	4342	100.00	–	–	–	–	–	4902	2451	56.45
Earthing	–	–	–	–	–	–	–	–	3782	–	1891	43.55
Spraying	–	–	–	–	–	–	–	–	3782	4902	4342	100.00
Harvesting	–	–	–	–	–	–	–	–	3782	4902	4342	100.00

Table 5. Degree of Mechanization Achieved on Selected Progressive Farms for the Cultivation of Wheat, Cotton and Sugarcane Crops in Sind Province of Pakistan During 1974－76

Wheat 16935 Acres, Cotton 16082 Acres, Sugarcane 4342 Acres Total 37359 Acres

Operations	Area completely operated By			Passess By			Percent of Operations By		
	Tractors	Bullocks	Labour	Tractors	Bullocks	Labour	Tractors	Bullocks	Labour
	Acres	Acres	Acres	Nos.	Nos.	Nos.	%	%	%
Plowing	47070	289	–	3	4	–	100.00	0.78	–
Clod Crushing	5900	11548	–	1	1	–	33.82	66.18	–
Levelling	36484	875	–	1	1	–	77.66	2.34	–
Bund Making	12758	–	24600	1	–	1	34.15	–	65.85
Channel Dressing	7780	–	29579	1	–	1	20.83	–	79.17
Sowing	9553	24720	2790	1	1	1	27.86	72.10	8.14
Fertilizer application	–	–	37359	–	–	2	–	–	100.0
Irrigation	–	–	37359	–	–	10	–	–	100.0
Interculturing (Cotton & S.Cane)	–	20424	18533	–	2	1	–	100.0	47.85
Pesticides application (Cotton & S.Cane)	624	–	19800	1	–	2	3.05	–	96.95
Harvesting			4342						
Sugarcane	–	–	16082	–	–	1	–	–	100.0
Cotton	–	–	13638	–	–	2	–	–	100.0
Wheat	3297	–	13638	1	–	1	19.47	–	80.53
Threshing	8270	6589	–	1	1	–	55.66	44.34	–
Winnowing	–	–	6589	–	–	1	–	–	100.0

considering the accomplishment of a particular field operation partially by bullock power and partially by tractor. The degree of mechanization for selected crops was worked out as in **Table 5.** The investigation regarding the rate of mechanization and management problems was carried out to make troubleshooting in the popularization of machines. The interviews recorded are listed in **Table 6.** The machine resources available on selected farms were recorded and tabulated as shown in **Table 7.** The agronomical efficiency in performing jobs of seed bed preparation was observed. The ultimate aim of using these equipment was measured in terms of depth of work and clod size on both progressive as well as traditional farms as given in **Table 8, Fig. 3.** The average per acre investment on farm power and machinery was also worked out on various farm hoidings as in **Fig. 4.**

Machine capacity and efficiency was calculated on different farms for every machine under operation and averaged for each kind of machine as shown in **Table 9.** The use of man-power is an important aspect from view point of planning for agricultural mechanization considering the problem of unemployment and displacement of labour. There is difference between calculated and actual labour, causing expected displacement, but in practice there was no displacement rather shortage of labour at certain peak periods. The average labour efficiency index was worked out as shown in **Table 10.** Also the analysis of farm level cost-benefit budget was made for 50 progressive farms under study considering all crops grown in the year as shown in **Table 11.**

Table 6. Rate of Mechanization and Management Problems Observed on 50 Progressive Farms in Sind During 1974 – 76

Reasons Advanced	Years 1974 – 75	Years 1975 – 76	Average	Percent
Lack of knowledge	27	25	26	52
High initial costs	46	46	46	92
No money to buy	30	28	29	58
Delay in credit facilities	40	36	36	72
High rate of interest	44	40	42	84
High cost of maintenance	49	45	47	94
Costly repairs and service facilities	48	50	49	98
High cost of fuel and oil	50	50	50	100
Complicated nature of machinery	42	40	41	82
Does not know the use	32	30	31	62
Lack of spare parts	44	48	45	90
Improved implements not multipurpose	32	44	38	76
Indigenous implements efficient	29	25	27	54
Lack of nearest repair and service centre	50	50	50	100
Holding being small	14	16	15	30
Displacement of family labour	32	30	31	62
Labour being cheaper	37	45	41	82

Table 7. Agricultural Machines Available on Selected Progressive Farms in Sind Province During 1974 – 76

Machines	Farms Surveyed	Farms using Machines: Number	Farms using Machines: Percent	Machines in Use: 74 – 75	Machines in Use: 75 – 76	Machines in Use: Average
Disc plows	50	46	91	74	74	74
M. B. Plows	50	21	42	38	25	32
Chisel plows	50	3	5	3	4	4
Reversible plows	50	1	2	1	1	1
Rotavators	50	21	41	28	30	29
Tandem harrows	50	39	77	47	66	57
Disc harrows	50	20	40	37	19	28
Cultivators	50	45	89	66	67	67
Trenchers/ditchers	50	9	17	8	10	9
Bund makers	50	11	22	17	19	18
Ridgers	50	13	25	15	14	15
Rollers	50	12	24	8	18	13
Scrapers	50	7	13	8	9	9
Levellers	50	14	28	18	17	18
Tracer rlades	50	44	87	61	59	60
Wheat drills	50	15	30	21	25	23
Cotton drills	50	22	43	19	59	39
Cane planters	50	3	6	3	3	3
Fertilizer spreaders	50	2	3	1	2	2
P. T. O. sprayers	50	13	26	16	12	14
Hand operated power sprayers	50	29	58	54	80	67
Hand sprayers	50	17	34	67	83	75
Self propelled combines	50	1	2	1	1	1
P. T. O. combines	50	14	28	13	17	15
Threshers	50	26	52	33	30	32

Analyses

The objectives of farm mechanization are tied up with the performance of farm power, farm machinery and farm labour derived out of machine use. In order to determine the efficiency of various machines in the production of wheat, cotton and sugarcane, nurerous standards were used to test field efficiency, tillage efficiency, work quality, labour efficiency index, field machine index, economic implement width and time-cost analysis, energy requirements and farm level cost-benefit ratio.

Capacity and Efficiency of Machines.

New machines need to be used effectively and efficiently to make their maximum contribution to agricultural production. Efficicent use means deriving maximum machine capacity at minimum per unit cost. Timely operations are necessary for effective machine use which, in tunr,is influenced by many factors such as soil and seed-bed conditions and ability of operator. Machine capacity varies with the nature of field and row arrangement. Row arrangement is a function of field size, field shape, soil conditions and soil conservation practices. Eliminating short

Table 8. Average Depth of Plowing and Crumbling Effect of Various Sets of Machines Used for the Cultivation of Wheat, Cotton and Sugarcane crops in Sind During 1975–76

Set of Machines Used.	Average Depth of work (feet.)	Average Crumbling Friability Percent					
		25–00 Cms.	25–15 Cms.	15–10 Cms.	10–5 Cms.	5–1 Cms.	1.0–0.50 Cms.
Progressive Farms							
Disc plow+Cultivator+Roller+Blade	0.75	–	10	30	19	13	28
Disc plow+Tandem harrow+Cultivator+Roller+Blade	0.67	–	1	3	8	28	60
Tandem+harrow+Cultivator+Roller+Blade	0.58	–	2	3	7	26	62
M.B.plow+Tandem harrow+Cultivator+Roller+Blade	0.74	–	2	8	10	30	50
Disc plow+Tandem harrow+Cultivator+Disc harrow+Leveller	0.65	–	1	4	12	25	58
Disc plow+Tandem harrow+Cultivator+Leveller	0.75	2	3	5	20	30	40
M.B.plow+Disc plow+Cultivator+Blade	0.75	4	8	12	26	20	30
Tandem harrow+Cultivator+Blade	0.50	1	8	15	15	25	36
M.B.plow+Tandem harrow+Cultivator+Disc harrow+Leveller	0.75	–	2	20	25	25	28
Disc plow+Cultivator+Disc harrow+Leveller	0.67	1	4	10	21	33	31
Disc plow+Tandem harrow+Cultivator+Roller+Leveller	0.67	–	1	12	19	25	43
Tandem harrow+Cultivator+Roller+Leveller	0.62	–	2	15	20	25	38
Disc plow+Tandem harrow+Cultivator+Blade	0.67	–	2	6	25	25	42
Disc plow+Cultivator+Roller+Leveller	0.67	2	1	12	15	16	54
Disc plow+Disc harrow+Cultivator+Blade	0.67	–	5	10	15	25	45
Tandem harrow+Cultivator+Leveller	0.50	1	5	10	16	25	43
Disc plow+Cultivator+Blade	0.67	3	6	13	20	23	35
Disc plow+Disc harrow+Cultivator+Roller	0.68	–	3	8	16	33	40
Sub-soiler+Tandem harrow+Cultivator+Blade	0.80	3	5	12	20	25	35
Disc plow+Tandem harrow+Rotavator+Cultivator+Blade	0.68	–	–	8	10	22	60
Disc plow+Tandem Harrow+Leveller	0.69	–	3	8	15	34	40
M.B.plow+Disc plow+Disc harrow+Cultivator+Blade	0.76	–	1	10	12	23	54
Average	0.68	0.77	3.41	10.64	16.64	25.27	43.2
Traditional Farms							
Local Meston plow+Sindhi plow+Sohaga+Patio	0.47	6	12	20	21	24	17
Egyptian plow+Sindhi plow+Sohaga+Patio	0.44	6	13	18	20	23	20
Average	0.46	6	12.5	19	20.50	23.5	18.5

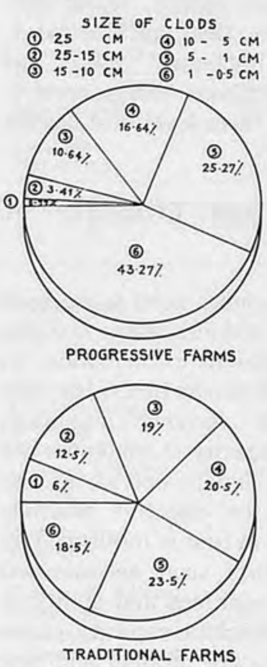


Fig. 3 Crumbling effect observed on the selected progressive and traditional farms in Sind during 1975-76

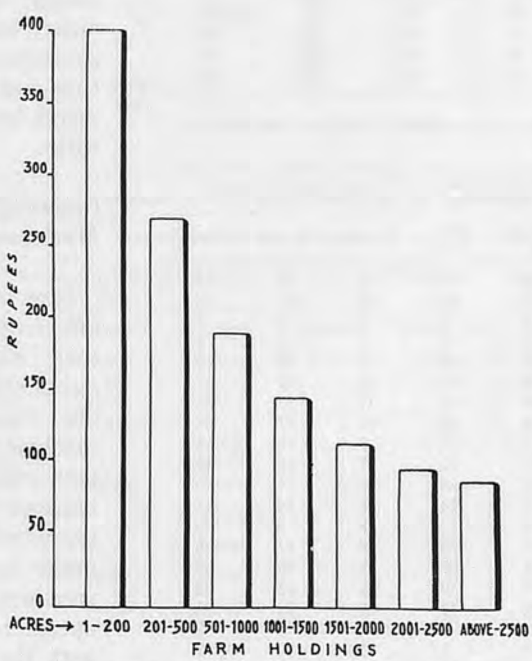


Fig. 4 Per acre machinery investment on selected progressive farms in Sind 1974-76 (50 farms)

rows increases machine capacity.

1. Machine Efficiency

In the use of agricultural machinery performance efficiency and field efficiency are required where performance efficiency refers to the degree of effectiveness in performing field jobs. Field efficiency is somewhat similar to time efficiency and is examined through operational analysis of effects of many activities performed by man-machine combinations working in specific situations. Field efficiency is the ratio of effective field capacity to the theoretical field capacity expressed in percentage. Thus—

a) Field efficiency=

$$\frac{\text{Effective field Capacity}}{\text{Theoretical field capacity}} \times 100$$

In other words, the actual average rate of work of an implement is dependent on productive activities in acres per hour as obtained by the following formula:

b) $C = C_{te} = \frac{S_{we}}{8.25}$

Where:

C = Effective field capacity,

Table 9. Field Efficiency Computed on the Sample of Progressive Farms in Sind During 1974−76

Implements	Normal working speed (MPH)	Theoretical: Average rate of work per ft. width per hour.	Theoretical: Average width.	Theoretical: Capacity	Effective: Average rate of work per ft. width per hour.	Effective: Average Effective width.	Effective: Capacity	Field Efficiency
		Acres	Feet	Acres	Acres	Feet	Acres	Percent
Disc plows	2.5	0.18	3.50	0,63	0.18	3.00	0.53	84
Mould board plow.	2.5	0.18	4.50	0.81	0.17	4.00	0.68	84
Tomdem harrows	3	0.25	7.25	1.81	0.23	7.00	1.60	88
Disc harrows	3	0.25	8.00	2.00	0.22	7.50	1.65	83
Cultivators	3	0.25	7.25	1.81	0.24	7.00	1.70	94
Rotavators	2	0.15	5.50	0.83	0.14	5.00	0.69	83
Rollers	3	0.30	8.50	2.55	0.22	8.00	1.75	69
Levellers	3	0.25	9.50	2.38	0.26	9.00	1.55	65
Wheat Drills	3	0.18	6.00	1.08	0.18	5.75	1.04	96
Cotton drills	3	0.18	8.00	1.44	0.17	7.50	1.30	90
Cane planters	3	0.26	5.00	1.31	0.24	5.00	1.20	92
Tractor drawn combines.	2.5	0.14	8.25	1.16	0.13	8.00	1.00	86
Self propelled combines.	2.5	0.14	8.25	1.20	0.13	8.00	1.00	83

Table 10. Average Labour Efficiency Index Obtained on the Sample of Selected Progressive and Traditional Farms in Sind During 1974−76

Farms/Crops	Average Days	Average Area Sown	Estimated Labour Requirement: Permanent Labour	Casual Labour	Family Labour	Occasional Labour	Total	Labour Available: Permanent Labour	Casual Labour	Family Labour	Occasional Labour	Total	Labour Efficiency Index
	Nos.	Acres	Nos.	Nos.	Nos.	Nos.	Nos.	Nos.	Nos.	Nos.	Nos.	Nos.	%
						Wheat Crop							
Progressive													
Large Farms	11456.5	832.35	16	32	–	65	113	138	–	276	138	252	20
Medium Farms	4686.0	334.17	7	13	–	22	42	56	–	112	112	290	15
Small Farms	1570.0	93.83	2	3	–	6	11	15	–	30	30	75	15
Total	17712.5	1260.35	25	48	–	93	166	209	–	418	280	907	–
Average	5904.17	420.12	8.3	16	–	31	55	70	–	139	93	302	18
Traditional Farms	1159.5	46.76	4	4	4	–	12	11	–	22	4	37	32
						Cotton Crop							
Progressive													
Large Farms	25503.5	957.75	19	38	–	198	255	160	–	320	160	640	40
Medium Farms	9534.5	330.60	7	13	–	143	163	55	–	110	55	220	74
Small Farms	3676.5	122.57	2	4	–	52	58	20	–	40	20	80	73
Total	38714.5	1410.92	28	55	–	393	476	235	–	470	235	940	–
Average	85404.5	470.31	9.33	18.33	–	131	159	78	–	157	78	313	51
Traditional Farms	1409.5	44.47	4	4	4	10	22	11	–	22	11	44	50
						Sugarcane Crop							
Progressive													
Large Farms	17434.0	404.80	8	80	–	100	188	67	–	134	100	301	62
Medium Farms	8930.0	177.17	4	35	–	43	82	30	–	60	45	135	61
Small Farms	2256.5	36.55	2	7	–	8	17	6	–	12	10	28	61
Total	28720.5	618.52	18	122	–	151	287	103	–	206	155	464	–
Average	9573.5	206.17	6	40.67	–	50	96	43	–	69	152	155	61
Traditional Farms	1104.5	35.27	6	6	6	35	53	9	–	18	18	45	78

acres per horur

C_t = Theoretical field capacity, acres per hour

W = Machinne size (rated width)

S = Field speed, miles per hour and

e = Field efficiency, in decimal

Non-productive activities are combined and considered as time lost per acre. This relationship is:

c) $C = C_t / (1 + C_{tH})$

Where:

H = time loss, hour per acre.

Sine field efficiency is related to non-productive activitois, this relation may be exyressed as—

d) $C = \frac{K_{tp}}{T_p + T_h + T_a}$

Where:

T_p = Theoretical time for operation (primary activity):

T_h = Time loss proportion to T_p

T_a = Time loss proportion to area and

K = Important width utilization, in decimal.

2. Tillage Efficiency

In evaluating machine use, basic information about power requirements for desired quality of work is necessary. The soil-loosening effects, soil crumbling and friability effects, soil forming and grading effects, soil turning effects, soil dragging and transporting effects of various machines are factors that determine tillage efficiency. Furtheomore, tillage efficieney is influenced by characteristics of fields, of work work quality, depth of work, and sur-

Table 11. The Analysis of Farm Level Cost-Benefit Budget on The Sample of 50 Progressive Farms in Sind During 1975−76

Losses		Gains	
Custom Work of Bullocks		Yield Increase Benefits	
Wheat	Rs. 442048.45	Wheat	Rs. 8436738.75
Cotton	Rs. 205114.00	Cotton	Rs. 3999240.00
Sugarcane	Rs. 130638.30	Sugarcane	Rs. 4271700.84
Other Crops	Rs. 287480.40		
Total :	Rs. 1065281.15	Total :	Rs. 16707679.59
Operational Cost of Machines		Crop Intensity Rise Benefits	
Wheat	Rs. 1697077.96	Wheat	Rs. 1813841.63
Cotton	Rs. 1933862.00	Cotton	Rs. 2162397.60
Sugarcane	Rs. 537214.70	Sugarcane	Rs. 1645867.38
Other Crops	Rs. 669909.24	Other Crops	Rs. 4233870.38
Total :	Rs. 4838063.90	Total :	Rs. 9855976.97
Hired Labour Gost		Average Increase Benefits	
Wheat	Rs. 134883.13	Wheat	Rs. 583258.50
Cotton	Rs. 214117.86	Cotton	Rs. 833454.00
Sugarcane	Rs. 191718.26	Sugarcane	Rs. 2083161.96
Other Crops	Rs. 100386.79		
Total :	Rs. 646506.04	Total :	Rs. 3499874.46
		Benefits out of Alternate Use of Bullock Land.	Rs. 13019623.66
		Saving from Bullock Concentrated Feed.	Rs. 2668150.00
		Saving From Maintenance of Bullock Equipment.	Rs. 21911.60
Y_1 =	Rs. 6549851.09	Y_2 =	Rs. 61773216.28
C = Rs. 10502259.88		$Y_2 - Y_1 - C = O$ = Rs. 1064.42 Per Acre.	

face conditions of soil in terms of crumbling and friability percentage. For this purpose the depth of work and clod sizes were measured.

3. Labour Efficiency

Labour requirement under normal farm conditions for an acre of cotton crop was calculated. The number of man-days required was related to the number of days actually provided by the present farm workers. The following formula was used for estimating labour requirement.

e) $L_{el} = \frac{E_{lr}}{L_a} \times 100$

Where :

L_{el} = Labour efficiency index

E_{lr} = Estimated labour reouirament and

L_a = Labour available

An index figure of 95 percent or more was considered satisfactory and less than 80 percent was considered insufficient.

Cost-Benefit Ratio

The shift in source of farm power from bullock to machinery brought out certain socio-economic changes. Where the most important economic change concerns possible increases in acreage cultivated, increased timeliness and higher yields, change in cropping pattern, cost of machinery and fuel, savings in labour and land previously used for bullock fodder the social gains include increase in standard of living. And social losses include unemployment and a widening of income differences. Internal rate of return is calculated from the following equation :

f. $\frac{Y_2 - Y_1}{R} - C = O$

Where :

Y_1 = Loss of cash income

Y_2 = Gain in cash income

C_2 = Capital cost of the farm and

R = Internal rate of raturns

Size of farm influences economic efficiency of mechanization. It is much easier to achieve economy of scale on large farms as compared to small holdings. Most farm machines are used only over short seasons of the year. Machines and tractors can not be scaled down much due operational requirements in the per acre investment on equipment which becomes high on small farms. The size of farms in Sind is sufficiently large from the stand-point of its management. In the development of mechanization, the ownership units should not be considered. Instead the operational units must be taken into account because due to land reforms the holdings have been divided among the family members and are being cultivated in large units under sole management. Thus, farm mechanization in Sind suits farm size. ■■

Energy Requirements for High Intensity Cropping Pattern in Rice Growing Regions and Its Effect on Employment Pattern

by

T. P. Ojha — Head
Dipankar De — Ex-Graduate Student
D. S. Rajput — Agricultural Engineer

Rice Process Engineering Centre, Indian Institute of Technology
Kharagpur 721302, India

This paper reports on a case study of one of the comprehensive area development projects in India. A model to properly organize the agriculture production has been discussed with the objective of defining areas where different power sources can be used keeping in view that (i) total labour demand approaches the labour availability and (ii) monthly labour fluctuation is minimum. The use of only one power source such as bullocks is not justified and quite practicable also to achieve 300 percent cropping istensity. It would be more realistic to employ existing bullock power in conjunction with either tractors or power tillers or both . Under this situation there can be labour shortage during some parts of the year and surplus during other parts, which may be overcome by the steps suggested in the paper.

Introduction

Only recently has India been able to produce sufficient quantity of food such that her food imports have been stopped. It may not remain so if the agriculture production lags behind the population growth. Among the important inputs, farm power is one which should be made available at required time and in adequate reassure for increased production. When a cropping intensity of more than 200 percent has to be achieved, the existing bullock and human power available in rural India has to be supplemented with mechanical and electrical power. The use of tractors and power tillers with matching implements and machines has to be ensured for efficient farm operation. It is universally accepted that the minimum power requirement for efficient and proper farm practices is about 3 hp/ha (4), whereas currently 0. 3 hp/ha is available in India . As there is hardly any scope for increasing the horse power availability through human and animal source, the only alternative is that mechanical/electrical power be introduced at an accelerated rate.

Most of developing countries that experience food shortage are generally faced with the problem of unemployment among the rural labour force. The problem can be ameliorated by increasing the cropping intensity approaching to 300%. In achieving this objective a serious labour shortage may develop and that can be overcome by judicious use of mechanical power.

This case study, therefore, seeks to define areas where different power sources(human, bullock, power tiller, tractor) can be used assuming that (i) total labour demand approaches the labour availability and (ii) monthly labour fluctuation is minimum.

The Study Area

The CADP area in Debra, West Bengal State consists of 126 small villages. The soils of the area vary from clay loam to heavy clay. According to the 1971 Census, the total population of the area was 28,538 persons out of which 14,902

Table 1. Land Holding Pattern of the Farmers (2)

Category of farmers	Holding size (ha)	No. of families	Percentage	Cumulative percentage	Total land area (ha)
Marginal	Less than 0.8	1761	48.4	48.4	2238
Small	0.8−2.0	1587	43.6	92.0	2038
Big	Above 2.0	290	8.0	100.0	355

were males and 13,636 females. The average number of families per village was 38 and the average family size was 6 members (2).

Pattern of land ownership — of the total families studied 1,121 families may be classified as landless labourers. The remaining 3,638 families can be classified according to their land holding pattern as shown in **Table 1.**

Collection of data — Each farmer was interviewed personally with the help of the village officers and the use of questionnaires. Repeated interviews were mostly done for proper assessment and verification whenever necessary. The information collected was classified into farmers' family background;

farm inventory, including irrigation facilities; cropping pattern and area under each crop; detailed information about each farm opeation; man-hr/bullock-hr/machine-hr. required for each farm operation by crop; and farm output for each crop.

Since the farmers had no recorded information the data gathered were based on their past experiences or from memories. For this reason, inconsistencies were observed in the data collected which was minimized through verification and repeated interviews.

The average size of plot by category of farmers was observed to conform to the following areas and overall dimensions.

Marginal farmer: 0. 07 ha
=38 X 18 m
Small (poor) farmer : 0.16 ha
=58 X 28.5 m
Big (rich) farmer: 0. 24 ha
=70 X 35 m

Of the many operations performed for crop production, data on some of the operations, e.g., threshing by means of tractor and power tillers could not be collected from the CADP area. Hence, the same was obtained from the IIT, Kharagpur experimental farm records.

Cropping Pattern and Water Resources

Against the background of low cropping intensity (114%), CADP has a plan to cover the entire cultivable area under uniform, assured irrigation system of shallow and deep tubewells and canal system. The existing canal work is being supplemented by shallow and deep wells in such a planned manner that by the end of 1977, nearly the entire area can be given supplemental irrigation. By the end of December, 1976, more then 40 deep and 200 shallow tubes were energised. As per plan, all agricultural inputs (fertilizers seeds, plant protection chemicals) will be made available through a series of strategically located agro-services centres. Tractors and power tillers with matching implements shall be available from CADP at reasonable hiring rates to most of the willing farmers any time of the year.

Of the total area of the project, 91 percent is medium land 4% being lowland and only 5 percent being upland. Thus the area is suitable for the following crop rotations with the assured irrigation facilities: i) raddy — paddy —jute and ii) paddy — wheat — moong bean.

The survey data reveal that all farmers cultivated paddy in rainy season. The marginal and small farmers attempted to plant additional paddy crop in the winter season. However, practically there was no third crop in the summer due to lack of irrigation and other agricultural inputs. winter paddy (Boro paddy) demands large quantity of water due to excessive evaporation demands. Hence, the rich prefer not to grow it in preference to wheat crop . Keeping the above facts in view the following crop rotations have been assumed to determine the necessary energy inputs.

Category of farmers	Crop Rotation
Marginal	Paddy-Paddy- Jute
Small and large	Paddy-Wheat-Moong

Energy inputs for the production and post production operations with regard to the crops like jute and moong bean were not available from the CADP area. Hence, the same was acquired from the neighbouring areas-including those from the I. I. T., Kharagpur farm (1). All the farm operations for the different crop rotations have been plotted on a time scale of 52 weeks as shown in **Fig. 1.**

Availability of Energy for Agriculture

As indicated earlier, the main sources of power for agriculture in the project area are human and animals. The use of mechanical and electrical energy so for was at a very low level. In order to achieve the desired level of cropping intensity, additional energy input has to be supplied in the from of tractors, power tillers and electric motors or diesel engines.

It was assumed that 1 man-hour equals 0. 1 hp-hr and 1 bullock pair-hour equals 0. 75 hp-hr. Based on tee population growth rate of 3.4 percent in that area the population is expected to reach 34, 600 by 1978, i. e., 18, 064 males and 16, 536 famales (corresponding to 1971 population) . It was furthar assumed that the working labour force falls in the age group of 15 and 59 years.

Assuming that 52 percent of male population and 30 percent of

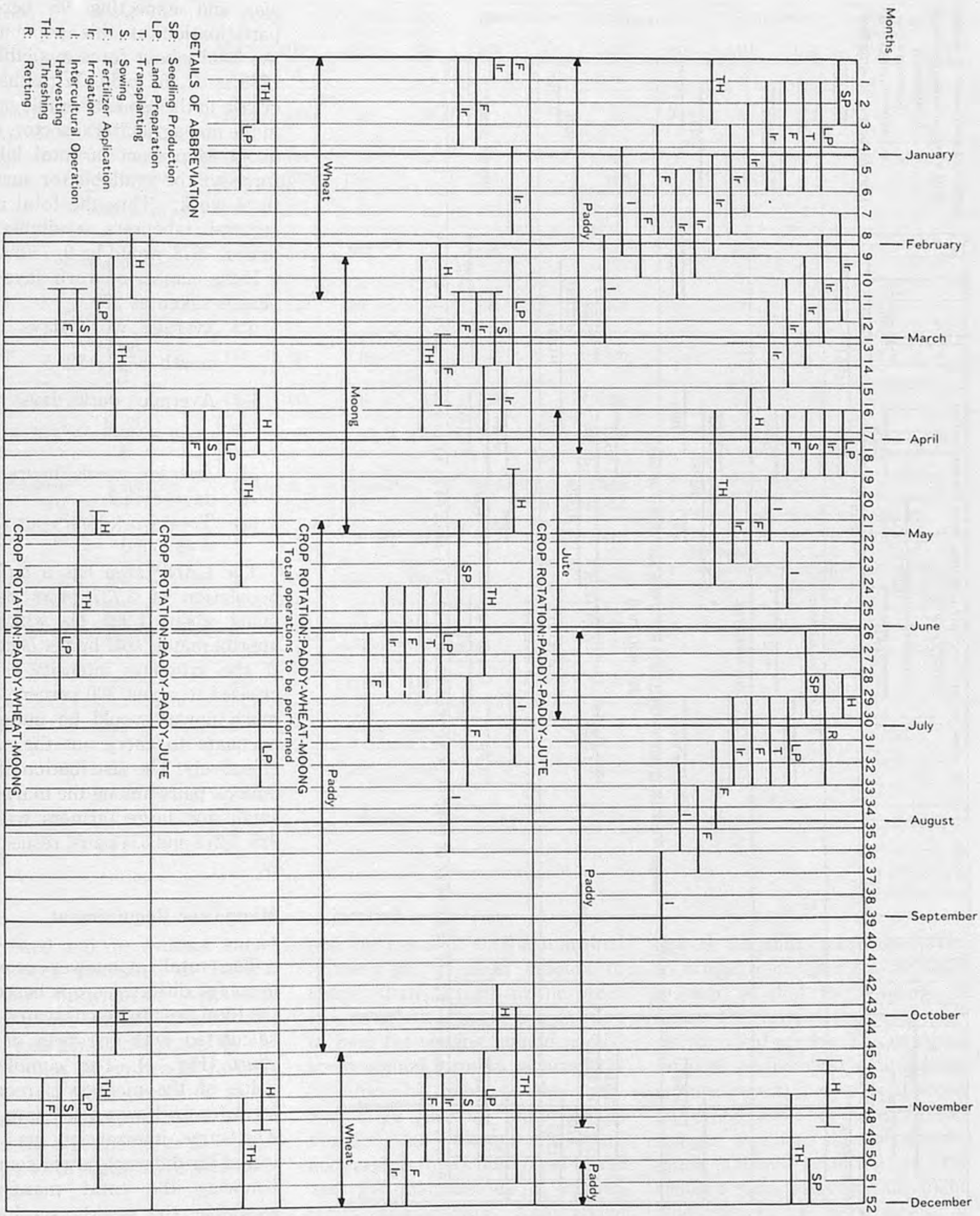


Fig. 1 (a)Operation chart for different crop rotations

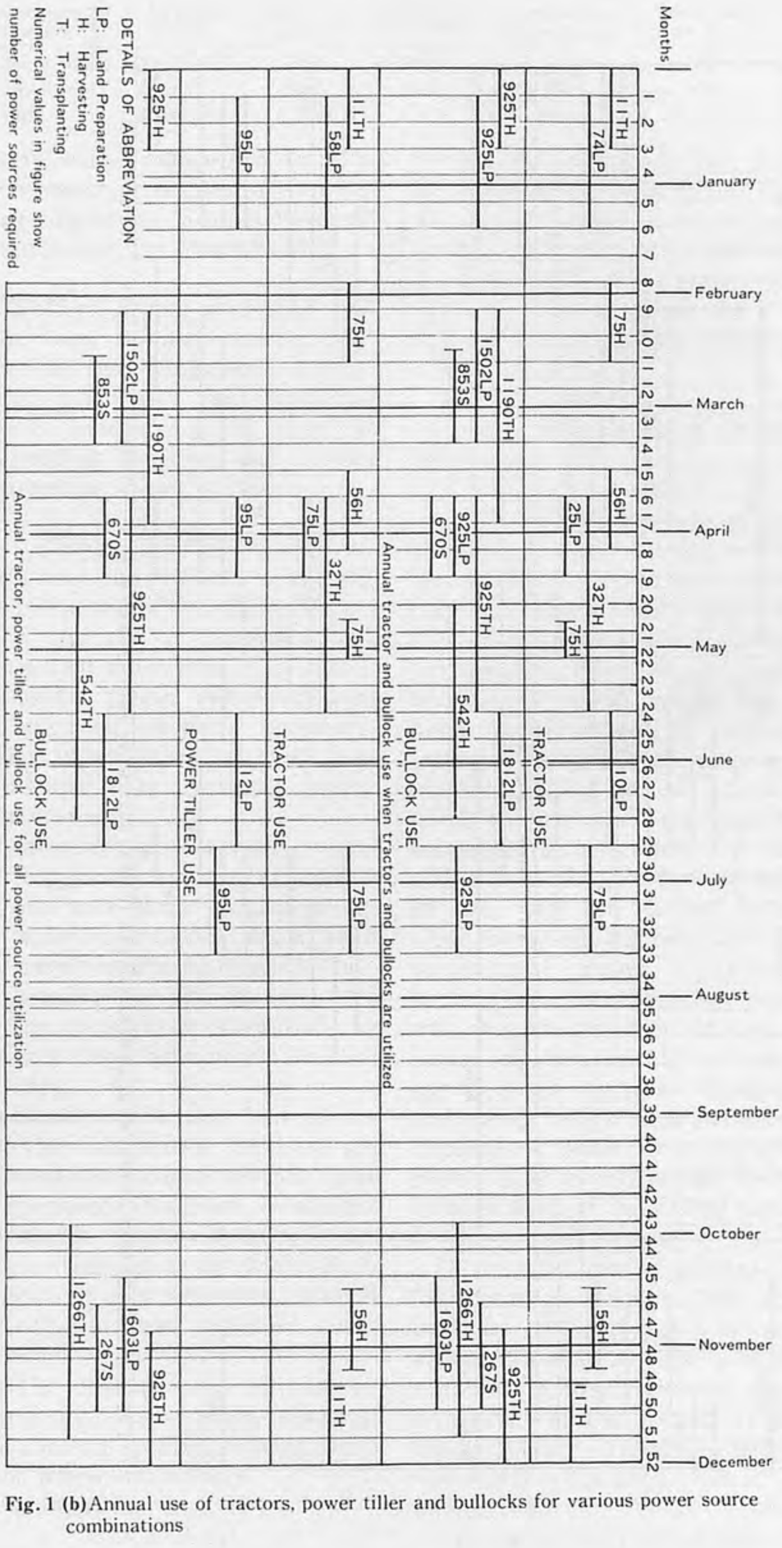


Fig. 1 (b) Annual use of tractors, power tiller and bullocks for various power source combinations

female population belong to this age and expecting 95 percent participation of this population, the total labour force available in 1978 is 11,568 only. With the increase in the scope of employment in the non-agricultural sector, only about 84 percent of total labour force will be available for agricultural work. Thus the total agricultural labourers available by mid of 1978 would be 9, 750.

If the number of work days in a year is taken as 270,

i) Average work days in a month $=\frac{270}{12}=22.5$

ii) Average work days in a week $=\frac{22.4}{4}=5.6$

iii) Average work hours per day $=8=8.0$

iv) Total work hours per week $=45=45.0$

The CADP area has a bullock population of 2,737 pairs developing about 1,908 hp which is approximately 0.41 hp per hectare. If the cropping intensity is increased to about 300 percent, this much power would be quite inadequate to carry out the work effectively. The distribution of the bullock pairs among the marginal, small and large farmers was as 925, 1,278 and 534 pairs, respectively.

Manpower Requirement

The total manpower requirement for different crops based on the total area to be cultivated was calculated with the help of the chart **(Fig. 1)**. The cumulative value of the manpower requirement for each was also computed. The same information was collected for different power sources. Knowing the total manpower available, the weekly surplus or deficit could be determined.

Results and Discussion

The survey data collected through various sources were

Table 2. Energy Consumption in Various Operations by Farmers Using Different Sources of Power per Hectare

Category of farmers	Crop	Tillage MH[a]	Tillage BH[b]	Sowing/Transplantation MH	Sowing/Transplantation BH	Interculture MH	Interculture BH	Irrigation MH	Irrigation BH	Fertilization MH	Fertilization BH	Plant protection MH	Plant protection BH
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Marginal	Aman Paddy (sown)	123.4	123.4	36	30.87	327	—	34	—	94	26	—	—
Small	Paddy sown (Transplantation)	136 (174)	136 (174)	26 (274)	25	395 (308)	—	27 (43)	—	82 (55)	—	—	—
Big	Paddy sown	154	154	31	31	453	—	36	—	82	14	—	—
Marginal	Boro (Transplantation)	244	244	855	—	342	—	389	—	195	—	—	—
Small	Boro (Transplantation)	215	215	905	—	298	—	262	—	128	—	90	—
Small	Wheat (sown)	144	144	19	—	—	—	170	—	172	—	—	—
Small & Big	Moong bean	135	135	46	32	100	—	100	—	125	—	—	—
Small & Big	Jute	81	81	44	29	618	—	38	—	129	—	—	—

Category of farmers	Crop	Harvesting MH	Harvesting BH	Collection MH	Collection BH	Transport MH	Transport BH	Threshing MH	Threshing BH	Marketing MH	Marketing BH	Yield Qtl/ha.
1	2	15	16	17	18	19	20	21	22	23	24	25
Marginal	Aman Paddy (sown)	173	—	106	—	104	—	180	180	46	—	21.72
Small	Paddy sown (Transplantation)	198 (200)	—	98 (95)	—	93 (101)	—	171 (182)	171 (182)	49 (36)	—	25.52 (25.97)
Big	Paddy sown	183	—	71	—	69	—	138	138	—	—	26.76
Marginal	Boro (Transplantation)	287	—	155	—	285	—	225	225	50	—	44.43
Small	Boro (Transplantation)	526	—	141	—	227	—	237	237	—	—	55.70
Small	Wheat (sown)	184	—	94	—	56	—	171	171	—	—	14.01
Small & Big	Moong bean	553[c]	—	—	—	—	—	78	—	—	—	10.00
Small & Big	Jute	234	—	—	—	—	—	680[d]	—	—	—	21.50

a MH=Man Hour
b BH=Bullock Hour
c Moong bean crop is harvested by picking the ripe pods 3−4 times in the season.
d Jute is retted in water for removing the fibre. Collection of harvest is included in retting.

processed and the average values have been presented in **Table 2**. Similar information regarding other crops, namely jute, moong, bean and wheat cultivated by the three main categories of farmers could have been presented in the paper. However, in order to restrict the size the paper to what it is, some of data have not been included.

Energy for Aman Paddy Production

The average energy consumption for the operations performed by different groups of farmers as shown in the **Table 2** shows a definite trend, i. e., the marginal farmers put in lesser amount of energy than farmers in the other two categories. In the preparation of land for sowing upland paddy, the marginal farmers required 123 man-has/ha, whereas the small and large farmers required 123 man-hrs/ha, whereas the small and large farmers had to put in 136 and 154 man-hrs/ha of human labor, respectively. The above difference is due to hired labour and inefficient supervison put in by the small and marginal farmes. Marginal farmers depend on the hired bullock which they use with considerable restraint. Wherever their own family labour was required, the marginal farmers tried to utilize it in the most judicious manner so that the shortage of inputs like fertilizers may not off set the yield per ha. The marginal farmers performed the first interculture (weeding) operation timely and effectively and, therefore, subsequent weedings did not demand much labour resulting in the reduced total man-hr requirement. The farmers are very careful in the post-production operations such that minimum losses occur due to shattering, spillage, and threshing. The small and large farmers require more energy for harvesting than the marginal farmers. This is justified by the fact that the yield/ha for these farmers is higher. Marginal farmers have to put in more energy for transporting the farm produceas their fields are generally located away from the threshing yards.

The poorer yield received by the marginal farmers is mainly due to poor soil and inadequate inputs.

Energy for Boro Paddy Production

Due to the abundance of solar energy, high yielding variety (HYV) planted in winter gives yields better than those planted during the rainy season. Invariably, the Boro crop is produced by the marginal and small farmes only. But the rich farmers own tube wells and pumping sets even sell irrigation water to other categories of farmers.

The marginal farmers require more energy/ha than the small farmers for all operation except for transplanting, harvesting and threshing. As indicated earlier, the small farmers employed hired labour whose poor efficiency results in increased labour requirement for these operations. Besides, increased paddy also demands extra labour for harvesting and threshing.

Additional energy required by the marginal farmers for irrigation is necessary for drawing irrigation water from tanks. The other group makes use of mechanical/electrical energy for part or full irrigation water requirements.

Energy for Jute, Moong bean and Wheat

The survey also reveals that the farmers were picking up the cultivation of wheat in place of Boro paddy in most part of the W. B. State. This changed situation is due to low water requirement and fairly high yield per ha of wheat. With proper water management and adequate supply of other inputs, much higher yield (24 Qtl/ha) was obtained in the same area by few farmers compared with the States level of 21 Qtl/ha.Thus with the same quantity of water three times more area can be brought under wheat yielding 1½ times more wheat than paddy. Both jute and Moong bean are short duration crops which have been successfully grown to raise the crop intensity to 300 percent. The Moong bean crop demands highly labour — intensive, particularly havesting (picking the pods) which can be mechanized. However, the jute crop demand hand-weeding, hand-harvesting and retting of plants for fibre extraction by hand as shown in **Table 2.** It is very interesting to note that successful attempts have been made to mechanize all of these operations by developing bullock and mechanically operated machines at the Jute Research Institute, Barrackpur (W.B.).

Operational Time Requirement for Various Machines

The time required by any power machine combination to complete an operation depends on the field dimension, operating speed and percentage overlap of the machine during operation, when other factors such as field condition, machine condition, operator's efficiency, etc. remain constant. The results of the experiments conducted are presented in **Table 3.**

Effect of Various Uses of Power Sources on Labour Requirement

The two cropping patterns (paddy-paddy-jute and paddy-wheat-moong bean) selected for the CADP area demand power source of different types. The use of human power is exentsively

Table 3. Operational Time Required for Various Machines

Power Source	Operation	Plot Size, ha 0.07 ha	0.16 ha	0.24 ha
		Time required		
		Hr/ha	Hr/ha	Hr/ha
Tractor	Cultivating (4 times with 9 tyne cultivator 2.25 m width)	7.62	5.42	5.36
	Levelling (Twice with a 2.5 m wide leveler)	1.92	1.36	1.32
	Seeding (1.9 m wideseed drill)	2.38	1.66	1.56
	Harvesting (1.9 m wide reaper)	–	–	3.36
	Puddling	–	–	11.79
Power Tiller	Tilling (Twice with 0.54 m wide rotary tiller)	25.00	17.98	20.02
	Sowing (with a seed drill of width 0.52 m)	9.73	7.84	7.85
	Puddling	–	15.48	–

Table 4. Use of Power Scurce for Different Operations

Operation	Power Source: Human	Bullock	Power tiller	Tractor
Land preparation	Yes	Yes	Yes	Yes
Sowing	Yes	Yes	Yes	Yes
Broadcasting	Yes	No	No	No
Transplanting	Yes	No	No	No
Interculture	Yes	No	No	No
Irrigation (by pump) (for distributing water)	Yes	No	No	No
Fertilizer application (for the first application only with sowing)	Yes	Yes	Yes	Yes
Plant protection	Yes	No	No	No
Harvest	Yes	No	No	Yes
Collection	Yes	No	No	No
Transport	Yes	Yes	Yes	Yes
Threshing	Yes	Yes	Yes	Yes

made in all the production and post production operations. But the labour availability in the area is limited to 9, 750 only. It is a very known fact that the existing human power with the present animal source available in the area is in no way adequate to achieve a 300 percent cropping intensity as desired with the above cropping pattern. Hence, the use of power tillers, tractors in combination with bullock has to be thought of. In order to determine the exact mix of animal and machanical power for achieving the objectives, the following assumption as presented in the **Table** 4 are baing made.

As seen from **Table** 4 different sources of can be used for land preparation, sowing, fertillzer application, harvesting, threshing and transport. For all the other oparations, for the time being human power can used. Thus, for any particular work the labour requirement for these operations assumes a value and the same has been stated as 'constant' weekly labour requirement.

On the hasis of the above assumptions **Table** 5 and **Fig.** 2 have been prepared. They present the labour requirements of 52 weeks with different combinations of power sources for various operations involving the cropping pattern accepted for the area.

Labour Requirement with Bullock Power

The results (**Fig.** 2) reveal that labour shortage exists in about 25 weeks out of 52 weeks in a year. The shortage in 9th to 11th weeks is due to the overlapping of the harvesting operation of wheat and land preparation for and sowing of Moong bean. Similarly, harvesting creates a shortage in the 16th week. In the 17t week, the shortage of labour is further coupled by

Table 5. Weekly Labour Requirement* for Different Operations Performed by Various Power Source Combinations

Power Source	Number of Weeks								
	1	2	3	4	5	6			52
Constant human labour	2152	10578	10800	11670	12799	13669	···	···	1076
Only bullocks	3289	14150	14372	14105	15204	16104	···	···	2213
Surplus**	+6461	−4400	−4622	−4355	−5484	−6354	···	···	+7537
Only tractors	2206	10750	10972	11788	12917	13787	···	···	1130
Surplus	+7544	−1000	−1222	−2038	−3167	−4037	···	···	+8620
Only power tillers	2314	10895	11117	11825	12954	13824	···	···	1238
Surplus	+7436	−1145	−1367	−2075	−3204	−4074	···	···	+8512
Tractors and bullocks	3088	12513	12735	12787	13916	14668	···	···	2012
Surplus	+6662	−2763	−2985	−3037	−4166	−4918	···	···	+7738

**Surplus over the available labour force of 9750.
*Man-weeks. One man-week = 45 man-hrs.

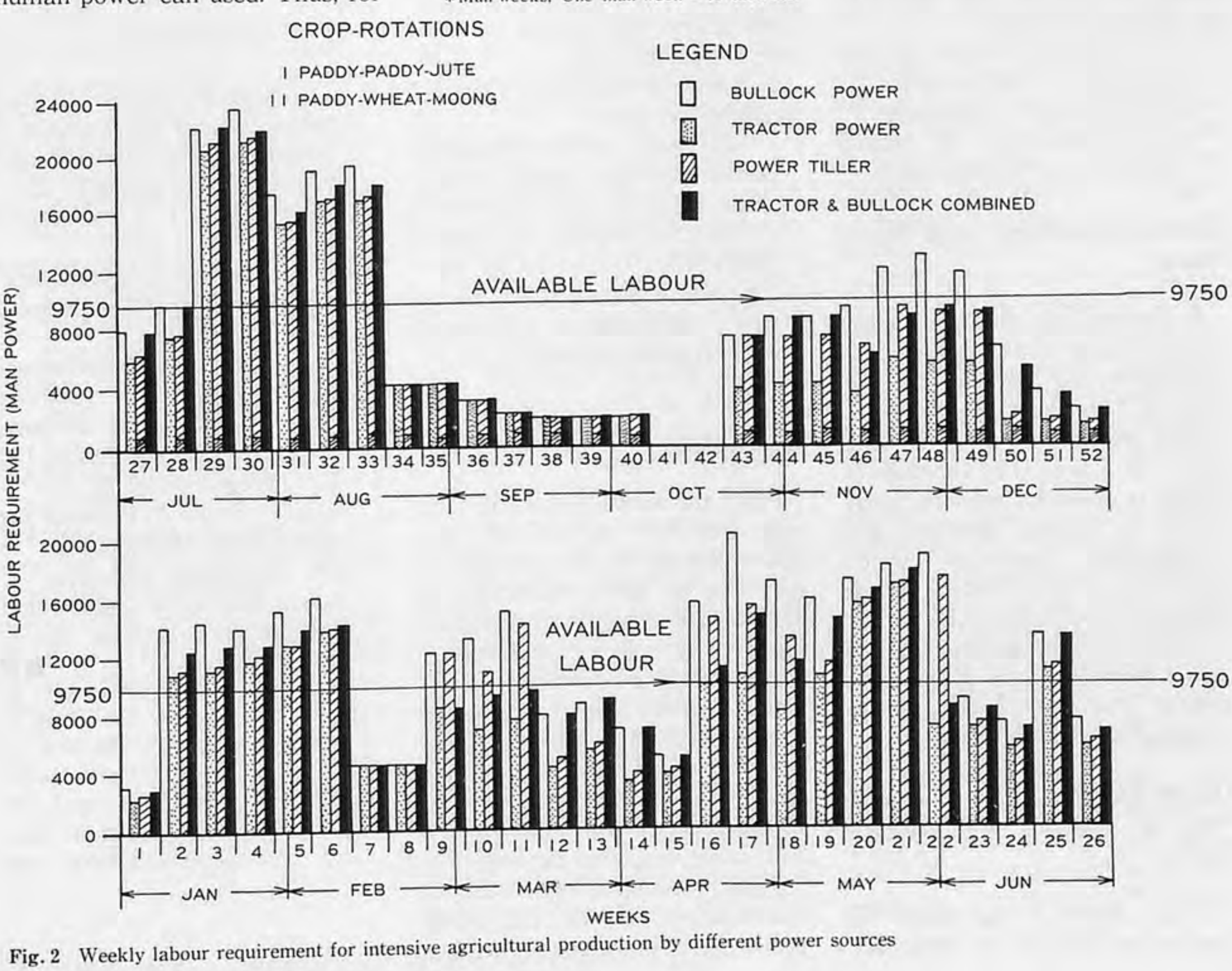


Fig. 2 Weekly labour requirement for intensive agricultural production by different power sources

the harvesting of paddy and land preparation and sowing of jute crop. The shortage from the 4th to the 6th week are due to the overlapping of harvesting and threshing of Aman paddy and land preparation and sowing of wheat.

Labor Requirement with Tractor Power

The results pressented in **Fig. 2** indicate that the labour shortage exists for about 15 weeks in a year. But, on the other hand, the use of tractors displaces labour out of employment considerably in a few weeks. This has happened due to replacing the bullock power by tractors as well as by mechanizing operations like harvesting and threshing which demanded large number of human labour otherwise.

The use of tractor as the only power source is not justified due to the following reasons:

i) What will happen to the bullocks already available ?

ii) Heavy capital investment:

iii) Displacement of human labour out of employment.

Labour Requirement with Power Tillers

It appears that the introduction of power tiller results in the labour shortage during 21 weeks in a year **(Fig. 2)**. This has happened due to partial mechanization of agriculture in that area. The shortage of labour is observed predominantly in the harvesting, threshing and transplanting operations which were not at all affected by the introduction of power tillers.

It would not be advisable to use power tillers in place of bullocks. Instead they should be used to complement bullock power.

Labour Requirement in Combination of Tractor and Bullock Power

It is estimated that about 75 tractors of 25 to 35 hp range are required to supplement the existing bullock power (2,737 pairs) for the timely operations throughout the year. Even for such a combination, there exists a shortage of labour in about 18 weeks during the year. The unemployment of the labour force exists only in few weeks having a very small margin below the existing labour force. The use of tractors during the year would be as follows:

i) Entire fleet of 75 tractors can be fully employed for 18 weeks.

ii) The fleet will need to do over-time work for about 5 weeks.

iii) Only a part of the fleet is employed for 14 weeks.

iv) Other jobs (transport, repairs, etc.) are to be done in 15 weeks to employ the tractors gainfully.

Thus the estimated use of tractor per year will be approximately 1,200 hours. The number of tractors is thus justified.

For such a combination the hp available per ha =

〔Bullock powar + tractor power + human power〕/total area = 〔(2737x75) + (75x30) + (9750x0.1)〕/4631 ha = 〔1908 + 2250 + 975〕/4631 = 1.1 hp/ha

The above figure seems to be more reasonable for a 300 percent cropping pattern.

Conclusions

From the above discussion, it is seen that the use of only one power source is not justified. It may not be quite practicable to achieve 300 percent of cropping intensity by employing bullocks as main source of farm power. It would be more realistic to employ existing bullock power in conjunction with either tractors or power tiller or both. A combination of 75 tractors and the existing bullock force seems to be the most justified combination. Such a combination enables the fuller utilization of machines resulting in reduced unit cost of operation. However, the labour shortage in this situation can be overcome by reducing the cropping intensity through restricted area under jute and moong bean and improving the degree of mechanization with the introduction of machines such as paddy transplanter, jute fibre scutching machines, etc.

The surplus labour during a few weeks in a year can be employed in agricultural and cottage industries with a view to utilizing the by-products of the agro-industry.

ACKNOWLEDGEMENT

The authors are grateful to the officers of CADP, Debra for their assistance in furnishing some of the data and also in assisting in the collection of most of the data.

REFERENCES

1. ICAR Research Scheme (Annual Report), Energy Requirements in Intensive Agricultural Production, April '74 to March '75, April. Engg. Dept., I. I. T., Kharagpur-721302.
2. Personal Contact, Director, Comprehensive Area Development Project, Debra.
3. De, Dipankar, Energy Requirement for Different Land Holdings Under High Cropping Intensity, M. Tech. Thesis Agri. Dept., I. I. T., Kharagpur-June, '76.
4. McColly, H. P. A Proposal for Agricultural Mechanization in the Developing Countries of South East Asia. Agricultural Mechanization in Asia, Spring, 1971, 21-25. ■■

Low-Cost Linings for Irrigation Canal

by
Abul Khair
Assistant Professor
Department of Irrigation
and Water Management
Bangladesh Agricultural University
Mymensingh, Bangladesh

Md. Daulat Hussain
Assistant Professor
Department of Farm Power
and Machinery
Bangladesh Agricultural University
Mymensingh, Bangladesh

Abstract

A study was conducted with a view to finding out low-cost lining materials for irrigation canals. Different types of natural indigeneous materials were used for this purpose. Seepage losses through the different types of linings were measured by ponding method. Studies showed that the following as listed below in their suitability may be used for lining purpose.

1. Earth materials and rice-husk with cow-dung as binding material.
2. Earth materials and saw-dust with cow-dung as binding materials.
3. Sand with clay as binding material.

The last type, with clay, may be used for small irrigation ditches especially where velocity of flow is low. When cow-dung with earth materials, the seepage losses through the lining decreases to a great extent and addition of rice-husk or saw-dust with it increases resistance to erosion considerably. The findings of the studies may be used to improve irrigation efficiency especially at the farm level.

Introduction

The command area of existing irrigation unit in Bangladesh as reported by different surveyors is as low as 18 acres which indicates poor water distribution efficiency, On the other hand, Government of Basgladesh has also taken a comprehensive programme to bring large portion of cultivable land under irrigation through the implementation of irrigation projects with a view to meeting the present chronic food deficit of the country. In order to make these irrigation projects successful, attention must be given to improving the distribution efficiency of the irrigation systems.

Seepage losses in an unlined channel due to absorption and percolation may cause much loss of valuable irrigation water. Studies at various areas show that about one-fourth to one -third of all the water diverted for irrigation purposes is lost in conveyance. Information collected by U. S. Bureau of Reclamation from 46 different irrigation projects show that losses range from 3% to 86%. Kanwar (1972) reported that losses in unlined irrigation channel in India have been about 47% of the amount diverted. Besides such a heavy losses of irrigation water, excess canal seepage also contributes to water logging to farm lands, silt and alkali concentration in the soils, costly maintenance of road and drainage system. Therefore, in most cases, linings may be economically feasible in irrigation channel in order to increase channel's resistance to scour and to prevent seepage losses or, at least, to reduce it.

Canal linings may be constructed with a large number of materials, such as concrete, masonry, brick, bentonite earth mixtures, natural clays of low permeability, and different rubber, plastic and asphalt compounds. The selection of a lining material largely depends on cost and availability of materials, soil conditions, cross section and length of the canal and comparative annual costs. Concrete more or less meets all of the requirements for a lining than any other matemials. But its high initial cost lead to the use of low cost lining material for a channel. For economic return from crop fields the use of standard types of costly lining for irrigation channels may not be feasible under the economic condition of Bangladesh.

Young (1947) states that "the high initial cost of standard types of lining is, at present, prohibitive for many projects. The need is great, therefore, for reducing the cost of canal lining or for discovering a satisfactory type of lining which at lower cost will still provide durability and serviceability".

Low-cost lining already under consideration fall into three general groups(1) hydraulic cement mixtures, (2) asphaltic materials, (3) earth materials. Hydraulic cement mixtures include concrete and mortar of portland cement and hydraulic lime with or without various additives. Asphaltic materials include asphalt macadam, asphalt concrete, asphalt sand, spary applied asphaltic membranes, and prefabricated bituminous surfacing. The earth materials include lossely placed, and compacted untreated earth soil cement, bentonit lining, soil resin and silt treated earth.

Asbestos cement, plastic materials like polyvinylchloride (PVC) and polyethylene, either as slabs or as mats are being used especially for laterals and farm ditches in which they prevent seepage losses.

At present, low cost materials are becoming more widely used for linings in canal and much research is being done with various materials at various places of the world. Biswas (1975) showed that cow dung-cum-clay lining 3 in. thick when laid careaully reduces seepage losses noticeably. Kinori (1970) states that sand with clay as binding material, (50-70% sand, 30-40% clay, 0-10% silt) can reduce seepage losses but cannot resist scour caused by water satisfactorily. Therefore, the present study was undertaken to find out low cost lining materials for canal lining and for efficient and effective water distribution of irrigation water.

Experimetal Investigation

The following materials were selected in order to prepare suitable mixtures to be used as lining for canals.

(a) earth materials (sand, silt and clay)
(b) cow-dung
(c) saw-dust and
(d) rice-husk.

Three types of mixtures were prepared with the materials in the following way, (i) only earth materials (sand, silt and clay), (ii) earth materials and cow-dung with saw-dust and (iii) earth materrals and cow-dung with rice-husk.

The materials were mixed at different proportions with required amount of water to make suitable paste. The pastes were exposed to sunshine with a view to observing their plasticity and bonding characteristics. After a large number of trials the combinations as shown in **Table 1** were found satisfactory.

Test ditches of trapezoidal shape were excavated randomly

Table 1.

Expt. No.	Materials	Ratios	Remarks
1	Clay : sand (negligible amount of silt)	1 : 1	Plastic in character and no cracking observed when exposed to sunshine.
2	Sand : clay : cow-dung : rice-husk	6 : 4 : 2 : 1	
3	Sand : clay : cow-dung : saw-dust	6 : 4 : 2 : 1	

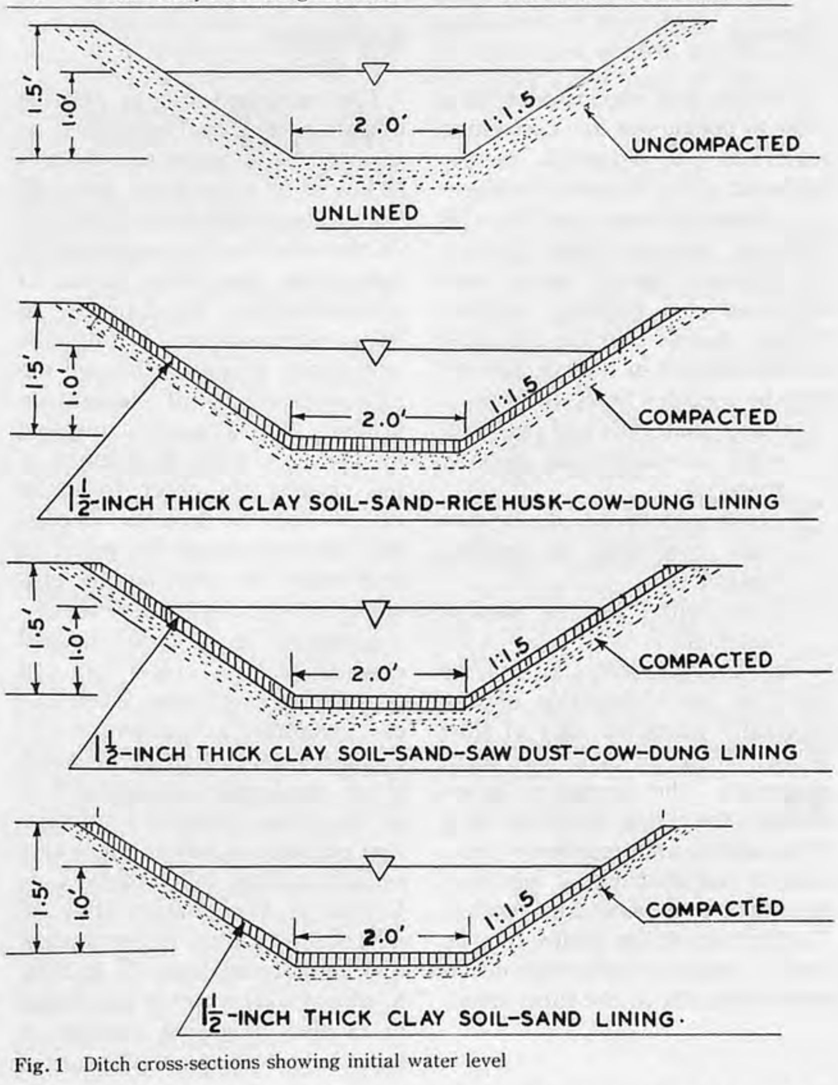


Fig. 1 Ditch cross-sections showing initial water level

with the following dimension :

- bed width : 2.0 ft.
- side slope : 1 1.5
- length of the ditch : 8.0 ft.
- top width : 6.5 ft.
- depth of ditch : 1.5 ft.
- cross sectional area : 6.38 sq. ft.

The plot where the ditches were excavated was selected on a elevated land so that groundwater table cannot contribute any moisture to the ditches by capillary action. The land was completely dry and the soil was homogeneous sandy in character.

The ditches shown in **Fig. 1** were lined with the materials as described in **Table 1** initially having 1.5 inches of thickness. The seepage rate through sides and bottom of a channel was calculated by ponding method. The following relationship was used for the calculation.

$$S=\frac{W(^{d}1-^{d}2)xLxL24}{PxLxt}$$

Where,

S = Seepage rate, $ft^3/ft^2/day$

W = Average width of water surface in ft.

d^1 = Actual depth of water at the begining of measurement in ft.

d^2 = Actual depth of water after 't' hours in ft.

L = Length of ditch in ft.

p = Average wetted perimeter in ft.

t = Time interval between d_1 and d_2 in hours.

The ditches were filled with water to certain level as shown in **Fig. 1**. The initial depth (d_1) and final depth (d_2) after certain period were recorded. The depths of water in the test ditches were

Table 2. Conveyance loss in Cubic Feet Per Square Foot of Wetted Perimeter for lined and Unlined Canals not Affected by the Rise of Groundwater.

Time in days	Character of Lining			
	Expt. No. 1 clay and sand with a negligible amount of silt	Expt. No. 2 sand, clay, cow-dung & rice-husk	Expt. No. 3 sand, clay, cow-dung & saw-dust	Unlined ditch having bed of loose sandy soil
1st day	0.569	0.136	0.125	3.48
2nd 〃	0.601	0.112	0.099	2.88
3rd 〃	0.551	0.092	0.087	2.71
4th 〃	0.501	0.0841	0.080	2.50
5th 〃	0.415	0.0781	0.074	2.35
6th 〃	0.365	0.0729	0.071	2.18
7th 〃	0.317	0.0683	0.066	2.04
8th 〃	0.283	0.0661	0.0644	1.97
9th 〃	0.275	0.0658	0.0635	1.86
10th 〃	0.268	0.0651	0.0630	1.81
11th 〃	0.260	0.0648	0.0628	1.76
12th 〃	0.257	0.0647	0.0625	1.74
13th 〃	0.255	0.0645	0.0621	1.72
14th 〃	0.253	0.0644	0.0620	1.71
15th 〃	0.251	0.0642	0.0619	1.70

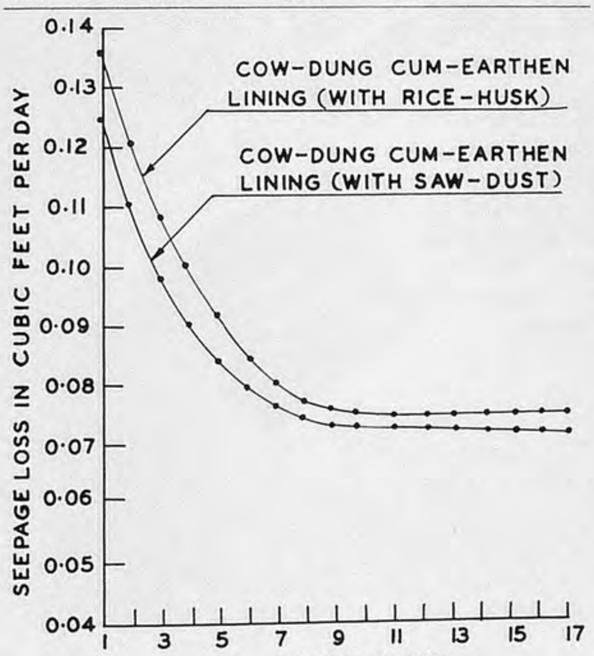


Fig. 2 Curve showing the relationship between seepage rate and time

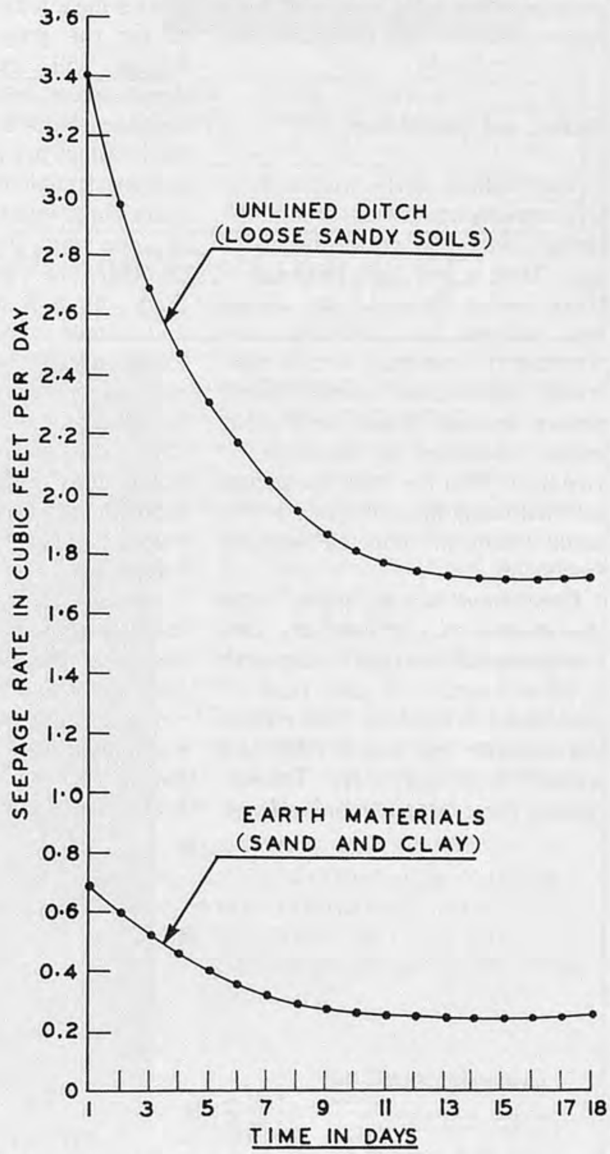


Fig. 3 Curve showing the relationship between seepage rate and time

measured for a period of consecutive 15 days at regular interval of 24 hours. The fall of water depths were mainly due to seepage through the bottom and sides of the ditches and evaporation from the free water surface.

The apparent seepage rates were adjusted with evaporation rates in order to obtain actual seepage rates through the linings. The measurement of seepage rates were continued until a more or less constant rate was observed. The results thus obtained have been presented in **Table 2, Fig. 2** and **Fig. 3** show the variation of seepage rate with time and ultimate reduction to a constant rate.

Result and Discussion

The findings of the studies show that the seepage losses through the linings decrease noticeably with age. After a few days the rate of these losses through the linings was reduced to a constant rate. The use of cow-dung with a relatively impervious earth lining reduce seepage losses to a great extent. Addition of saw-dust or rice-husk with the cow-dung-cum earthen lining has more or less the same effect in reducing seepage losses.

Conclusion can be made from the studies that a carefully laid cow-dung-cum-earthen lining with a little amount of saw dust or rice-husk 1.5 in. thick may reduce the seepage loss about 0.006 per square foot per day, Thinner linings have proportional effects. Low-cost lining made of earth materials (sand and clay) as stated above appreciably reduces seepage losses. For an earthen lining of sand and clay 1.5 in. thick carefully laid, a loss of 0.25 cu. ft. may be safely used. Such linings are inexpensive but not permanent. Unless velocities are low, the lining is subject to erosion and may require protection by a layer of more stable material. In irrigation canals or farm ditches. where velocity of flow will not increase 3 fps. linings made of sand clay may be used.

Addition of cow-dung, saw-dust or rice-husk with the earth material for the preparation of canal linings will undoubtly increase resistance to erosion and reduces seepage losses to a great extent. Such linings are also more durable and serviceable than simple impervious earth linings and are capable of carrying higher discharges through the same crossection. Such linings if properly prepared and placed may reduce seepage losses to 0.06 fps. /ft^2/day whereas seepage losses through concrete linings are about 0.604 ft^3/ft^2/day. Thus the cow-dung-cum-earthen lining may safely be used for laterals and farm ditches, where velocity of flow does not increase 3 fps-4 fps.

Lining made of indigeneous materials may reduce seepage losses considerably but in less permanent and less effective than concrete linings. But the need for economy must lead to the utilization of natural indigeneous materials as canal linings.

ACKNOWLEDGEMENT

Authors are indebted to Bangladesh Agricultural University for financial support during the course of this study and to Sunil Chandra Dutta, lecturer, Dept. of Irrigation & Water Management for his kind help.

REFERENCES

1 Biswas, M. R & A. F. M. I. Islam, 1975. Seepage reduction in the irrigation ditches with clay soil and cow-dung presented at the seminar on Integrated Rural Development. Organized by the Institution of Engineers, Bangladesh.

2. Kanwar S. 1972. Canal lining in India. Third Congress of the International Commission of Irrigation & Drainage.

3. Kinori, B. Z. 1970. Manual of Surface Drainage Engineering, Vol. 1. Publishing Company, Amsterdam.London, New York.

4. Young, W. R. 1947. Low-cost lining for irrigation canals, Engg. News-Record, Feb. 6, 1974, P. 64.

NewsLetter

INTERNATIONAL FARM MECHANIZATION RESEARCH SERVICE
c/o SHINNORIN-SHA 2-7 KANDA NISHIKI-CHO CHIYODA-KU,
TOKYO, JAPAN., TEL. 03-291-5718, 3674

Dear friends

International Farm Mechanization Research Service was established in 1968 with the pourpose of promoting efective communications and researches on agricultural mechanization especially in developing countries.

We will gladly welcome everybody to join us who want to promote free and vital communications on agricultural mechanization over many barriers like sectionalism.

Our body is really independent one supported by every member's free and active mind to make better world.

Whenever you need more informations, please write me.!

Yours Sincerely
Yoshikuni Kishida
Head of Directors

ADVERTISED PRODUCTS INQUIRY

Product	Advertiser	Vol., No., Page

EDITORIAL REQUEST TO AMA

Your Name :

Address :

Occupation :

SUBSCRIPTION/ORDER FORM

AGRICULTURAL MECHANIZATION IN ASIA (AMA)

Issued Quarterly

Subscription Rate(includes surface mail postage)

Annual(4 issues) ------------ ¥.5,000
Single copy ------------ ¥.1,500

Back Issues (1971—75, ¥.2,000 per copy)
(1976—77, ¥,1,200 per copy)

☐Spring, 1971	☐Vol.5 No.1, Summer, 1974	☐Vol.7 No.4, Autumn, 1976
☐Autumn, 1971	☐Vol.6 No.1, Spring, 1975	☐Vol.8 No.1, Winter, 1977
☐Vol.3 No.1, 1972	☐Vol.6 No.2, Autumn, 1975	☐Vol.8 No.2, Spring, 1977
☐Vol.3 No.2, Summer, 1972	☐Vol.7 No.1, Winter, 1976	☐Vol.8 No.3, Summer, 1977
☐Vol.4 No.1, Spring, 1973	☐Vol.7 No.2, Spring, 1976	☐Vol.8 No.4, Autumn, 1977
☐Vol.4 No.2, Autumn, 1973	☐Vol.7 No.3, Summer, 1976	

(Check issues and number of copies you wish to order)

Back Issues from 1978, ¥.1,500 per copy

Vol._____ No._____, _____ 197_____, _____ copy/copies

(check one)

☐ Please invoice me/us

☐ I/We enclose remittance for ¥__________

****

Name: ____________________

Firm: ____________________

Position: ____________________

Address: ____________________

(block letters)

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7, 2-chome, Kanda Nishikicho, Chiyoda-ku,

Tokyo 101 Japan

Tel. (03)–291–3671–4, 5718

STAMP

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7, 2-CHOME, KANDA NISHIKICHO, CHIYODA-KU
TOKYO, 101 JAPAN

1st FOLD HERE

2nd FOLD HERE

Some Technical and Social Problems in the Irrigation Projects of Sri Lanka

by
Arumugam Kandiah
Head
Department of Agricultural Engineering
Faculty of Agriculture
University of Sri Lanka
Peradeniya, Sri Lanka

Abstract

Increasing food production is one of the major objectives of the Government of Sri Lanka. Moving towards this goal, the Government in recent years invested large amounts in agricultural development projects, and more specifically, on irrigation schemes in order to supply water for crop production. However, the production response from most irrigation schemes thus far has not been encouraging, the average production being far below the potential level. One of the major bottlenecks is poor water management at the farm level.

Solution to the problems of water management at farm level in Sri Lanka could be worked out along the following guidelines :a) Measures to increase benefits from irrigation projects must be centeed around the farmers' fields ; b) Attention should be given to on-farm irrigation system design and ; c) Incentives and economic benefits should be planned along with the introduction of new water management practices.

Sri Lanka is an agricultural country where the overall growth of the economy is closely related to the increases in agricultural production. In 1975 the agricultural sector contributed 32.4 percent of the Gross Domestic Product. Agriculture also presents the greatest scope for the expansion of output and employment in relation to investment outlay.

The domestic agriculture, which is directly concerned with meeting the food requirements of sri Lankans plays a crucial role in the economy of the country. This is realised from the fact that in 1975, out of the total foreign exchange earnings of 3,913 million rupees, 2,257 mdillion rupees were spent on imported food items. Domestic agriculture also provides direct employment to more than 60 percent of the rural population.

In the domestic agricultural sector, production of paddy plays a dominant role in terms of acreage cultivated, employment and value of production. It is estimated that about 50 percent of the total employment in domestic agriculture is related to paddy cultivation. Some 1.7 million acres are planted to paddy.

Irrigation Development in Sri Lanka

In order to meet the food requirements, the Government of Sri Lanka over the years has brought under cultivation vast areas of land and has implemented a number of irrigation projects, especially those possess the greatest potential for agricultural production.

Table 1 presents the extent of land under various irrigation schemes in Sri Lanka.

Table 1. Extent of land under irrigated agriculture in Sri Lanka.

Scheme	Area in acres
Major irrigation scheme (Excluding Mahaweli)	580,000
Minor irrigation scheme	400,000
Lift irrigation scheme	60,000
Mahaweli irrigation Project	132,000

Thje primary tbjectives of the major irrigation schemes, for which 30 to 40 percent of the budget allocated to the agricultural sector is used, are to increase rice production and to settle people in the new irrigated areas of the dry zone so as to provide employment and alleviate population pressure in the wet zone. For this purpose, irrigation schemes coupled with land settlement receives high priority. Under these schemes, each settler is allocated 3 to 5 acres of irrigable lowland for the cultivation of paddy and 1 to 3 acres of upland for the cultivation of subsidiary food crops.

Production Levels and Water Use Efficiency

Increased production per unit land area is one of the major goals of irrigated agriculture. It is assumed that the provision of water and land (two primary factors of production) which involves heavy capital investment for development and hence beyond the reach of individual farmers, is bound to increase production levels. However in reality, the production levels in most irrigation projects have been rather low and in certain cases have even been below the national average values.

Table 2 shows the production levels in selected major irrigation schemes of the dry zone.

Farmer et al (1970) in an analysis of the Gal Oya Development Project, one of the oldest irrigation projects of Sri Lanka, reported that the low benefit cost ratio of the project is not merely due to high cost of project development but also due to low productivity of paddy fields. In 1966, the average paddy field from this project area was 38 bushels compared with the national average of 42 bushels per acre. Jogaratmam (1974) reported that in most dry zone irrigation schemes, yields per acre of paddy in Yala were lower than those obtained in Maha. These differences can be attributed to deficiencies in water supply.

The efficiency of water use in most irrigation projects has been very low, about 30 to 40 percent. Perera (1970) attributes this low water use efficiency to 1) farmers continuing traditional methods of rice cultivation, using constantly flowing water and uneven timing of plowing and 2) lack of water measurement and control in the distribution system.

Water requirement of a 4-month paddy crop in the dry zone was found to be 60.6 inches in the Maha and Yala seasons, respectively, **Table 3.**

It has been reported that in most irrigation projects water use has been very much in excess of the above figures. In those irrigation projects where the storage tanks have large catchment areas and also augmented from perennial rivers of the wet zone, water use has been about 12 to 20 acre feet per acre. Water is consided an unlimited resource in these project areas. In project areas where storage tanks fed by smaller catchment areas and supplied with limited quantities of water from other reservoirs and rivers, water use tend to be in excess during the Maha season covering almost the entire project area. In comparison during the Yala season the supply is limited to only a portion of the project area with somewhat less liberal water use compared with the Maha season's use. Amerasinghe (1975) reported that farmers in irrigation projects used water as much as 28 to 12 acre feet depending on the farm group based on land-labour ratio. Very often the farmers closer to the distributory channels use more water than required resulting in inadequate supply to farmers at the far end of the distributory channel. Jogatnam and Schickele (1969) reported the following with regard to water supply in the Rajangana irrigation project:

"There is much complaint about inadequate irrigation facilities for the lowland; 30 percent of the farmers report part of their low land allotment as non-irrigable ; 9 percent of the farmers have no irrigation water for any of their lowland due to breached channels or channels too low to serve their allotments". **Table 4** shows the farmers'appraisal of water distribution and overall irrigation facilities in nine irrigation projects of Sri Lanka.

The problems of water management at the field level in Sri Lanka are numerous and very complex. They are interdependent and link-

Table 2. Production levels in selected irrigation projects of the dry zone, Sri Lanka, 1972–73

Project Area	(1) Average yield (Bushel/acre)	(2) Varieties Cultivated (Bushel/acre)	(3) Production in Govt. Farms (Bushel/acre)	(4) Experimenal Yield petential (Bushel/acre)
Nachaduwa	42.4	NIV *	95–105	120–150
Giritala	53.5	NIV	〃	〃
Kaudalla	42.6	NIV	〃	〃
Kantalai	45.4	NIV	〃	〃
Usgala Siyambaln Gamuwa	43.4	OIV@	75–100	115–140
Kandalama	39.2	OIV	〃	〃

* NIV–New Improved Varieties comprising B. G. 11, B. G. 34–6, B. G. 34–8 & L. D. 66
@OIV–Old Improved Varieties comprising H4, H8 and IR8.
Source–(1) Jogaratmam(1974) : (2) Jogaratmam(1974) ; (3) and (4) Peiris (1973).

Table 3. Water requirement for paddy cultivation in the dry zone of Sri Lanka. (4-month crop)

Item	Values Expressed in inches Yala Season (May-Aug.)	Maha Seasen (Nov.-Feb.)
Land preperatien	6.7	6.7
ET* from plamting to harvest	30.0	20.3
Percolation lesses	33.6	33.6
Total	70.3	60.6
	App.=6.0 feet	App.=5.0 feet

* Evaporation

Table 4. Farmers appraisal of water distribution and overall irrigation facilities in 9 irrigation projects Sri Lanka.

Project Area	Percentage of total Complaints Not Satisfied with the Services	
	Water distribution (Cultivation comm.)	Overall irrigation (Irrigation Dept.)
Minipe	52	8
Hakwatuna Oya	36	19
Mahavilachchiya	28	12
Iranamadu	24	20
Minneriya	26	24
Gal Oya	28	18
Padawiya	31	19
Rajangana	35	8
Allai	31	10

Source : Jegaratnam and Schickele (1969).

ed with one another. These problems are technical, economic and social in nature. Hence, improvements in water management cannot be limited to engineering aspects alone, but must be integrated to cover technical, economic and social aspects in order to achieve optimum benefit. Effective water management at the field level should be the focal point in any irrigation project as the effectiveness of all investments depends ultimately on the proper use of water.

Improvements in Engineering Design

Schickele (1970) stated that an intensive and detailed examination of irrigation systems in the major colonization schemes appears to be urgently needed for the purpose of determining improvements or adjustments in the irrigation and drainage facilities, e. g., preventing seepage losses, realigning of canals, providing for drainage, and placing sluices and control gates and water measurement devices at strategic locations. These measures ensure a most efficient use of water, especially in the Yala season.

The successful operation of an irrigation project depends a great deal on proper planning, design and construction of its conveyance and contrtol structures and on-farm irrigation system. Generally speaking, proper functioning of these hydraulic network can be achieved if the flow capacities are designed in accordance with the overall project irrigation requirements. This would necessitate, in addition to sound engineering designs, a thorough knowledge of soil moisture, crop growth and the climatical factors of the irrigation project area. In many of Sri Lanka's irrigation schemes the engineering design was limited to the head works and canal network, the rest of work being left to the farmers themselves. It is important that the project is planned and executed down to the level of the farmer's fields and land development measures such as levelling, terracing, bunding and drainage be included in the engineering design.

The importance of proper maintenance of the irrigation structures cannot be over-emphasized. Investments in irrigation schemes are rapidly devalued when lack of proper maintenance prevents the farmer from deriving full benefits from the use of water. Poor maintenance of distributory canals and irrigation control structures have caused in many of irrigation projects a high rate of depreciation and has rendered the schemes obsolete within a short peried.

Improvements in Agricultural Practices

It is generally agreed that changes in agricultural practices are needed when irrigation is introduced into existing agricultural practices. Crop selection and cultural practices that increase crop yields will raise water use efficiency. To achieve maximum production per unit of water used, other factors controlling plant growth must be optimal.

For example, it is wasteful from the standpoint of water use efficiency to supply water to a field where crop growth is seriously restricted by nutrient deficiencies, lack of pesticides, or use of a crop variety which cannot make best use of the environment and physical inputs.

Or, when both water and nitrogen are limiting factors it is wasteful to apply water without nitrogen. Recent surveys show that in most of the country's irrigation schemes a great majority of the farmers plant high-yielding (HYV) paddy varieties. Amerasinghe (1974) reported that in the Minipe irrigation scheme more than 80 percent of the area under under paddy was planted to high yielding varieties while Jogaratnam (19749 reported that the percentage adoption in dry zone irrigation projects varied from 23 to 75. Despite an increase in the adoption of HYV the concommittant increase in the use of complementary inputs has not been given due attention. In a study of the irrigated farming in the dry zone of Sri Lanka, Jogaratnam (1974) remarked. "the percentage of farmers who report having followed fertilizer recommendations varied from 5 to 60. The data do not indicate any close association between variety of paddy planted, levels of fertilizer application and yieds per acre of paddy".

In order to obtain optimum benefits from water development for agriculture a better knowledge and understanding of water management at the farm level will be necessary. The farmer must know how to use water, i. e., when and how much to apply in ovder to obtain high crop returns ; he must also know how to combine water with other agricultural inputs ; he must know to prepare his fields for the application of water and removal of excess water and how to conserve water and soil-his most valuable resources.

Socio-Economic Considerations

The major objective of investments in agricuture for farmer-users should be to obtain economic benefits. This is achievevable only when the value of water and its costs are recognised by the farmers for, like any other farm input, e. g. fertilizer, water should also be treated as an economic input. Cultural practices should, theufore, be geared to obtaining maximum efficiency of the input use.

The economics of irrigation are determined not only by its costs, but also from its potential benefits. Even if irrigation construction is at the lowest possible costs, the project could be uneconomical if water is not used properly. Hence, the success of an irrigation project depends to a very great extent on the motivation of farmers to increase production and the availability of means at hand to do so. Socio-economie incentives which motivate the farmers to transplant the production potential provided by physical facilities into actual gains of agricultural productivity play a key role in irrigated agriculture. Several incentive schemes such as guranteed price for paddy, subsidised seed materials, fertilizers and agro-chemicals have already been introduced in Sri Lanka, but for some reasons or other these seem not to be working properly. It has been found in a number of surveys that in general, most of the irrigation projects are not well utilized due to the lack of proper socio-econmic incentives.

In implementing subsidy schemes, the kind of input subsidised and the level of subsidy should be carefully studied. In Sri Lanka, irrigation water is provided free of charge, which means that it is fully subsidised. Although this has been to be justified to increase farmers profits by cutting down cost, its has been taken by the farmers as a social welfare and political favour and has not, therefore, any incentive effect. In fact, this has lead to even increased consumption of water with little increased benefits.

On the other hand, if water were priced at an economic rate, the increased cost would have motivated the farmers to use it more judiciously.

Recent experience in some lift irrigation schemes in the northern and northwestern Provinces where water is pumped from wells for the cultivation of subsidiary food crops has shown that farmers are willing to pay for water as long as it can assure them an extra, more secure or more lucrative crop.

Training and Extension Service

To change successfully a cropping pattern from a rain-fed agriculture to an irrigated agriculture requires extensive preparation. The lack of farmers' experience with irrigation is found to be a serious limitation in achieving production under many irrigation schemes. Although some efforts have been made in the recent past to educate farmers about modern irrigation practices, in general the effort is insufficient.

It has been estimated (Hagan, 1963) that about four to five years are required before the farmer learns good management of irrigated lands, including the proper use of water and fertilizer. One of the frequent causes of failures of irrigation projects is the slow adoption by farmers of rational practices in the use of irrigation water. This could be overcome by commencing educational programmes simultaneously with the start of the project planning, by the time construction starts. Pilot farms in the project area can be developed with the use of existing water resources in order to test local trials and venue for the training of extension personnel. Demonstrations of sound irrigation practices on farmer's fields are recognized as the most effective teaching methods. It is important that training should be an integral part of water development projects and the extension personnel must receive as part of their training adequate understanding of irrigation and drainage skills so that they can properly advise the farmer.

Conclusion

Most irrigation schemes in Sri Lanka are characterized by low level of production, low water use efficiency, and low farm income. The problems are many, but one of the basic problems is the lack of effective water management at the field level. In most schemes much effort and money has been spent on the head works and hydraulics of the system with little or no attention paid to improving on-farm irrigation methods and socio-economic conditions of the farmers. It should be realised that irrigation is actually a part of agriculture and should, therefore, be directed towards obtaining the objectives of increased food production, increased farm income and accelerated growth of national economy.

Considerable changes are required to transform subsistence agriculture to a productive and self-supporting agriculture. Changes are required is engineering, agricultural, institutional and socio-economic approaches in the irrigation project planning, implementation and management. Modern agriculture calls for revolutionary changes in farm operations such as multiple cropping, application of new technologies and new farming practices.

Such changes affect the way of life of the traditional farmer and are seldom readily accepted. Support incentives and guidance by institutions and services such as extension services, schemes and training facilities are needed and should be considered as part and parcel of an irrigation project.

REFERENCES

Amerasinghe, N. (1974) The impact of high yielding varieties of rice on a settlement scheme in Sri Lanka., Trop. Agriculturint, Vol. cxxx.

Amerasinghe, N. (1975) Increasing farm incomes and efficiency of resource use under peasant farming conditions in Sri Lanka. J. Nao. Sci. Coun. Sri Lanka 3, (2).

Central Bank of Ceylon (1975) Review of the Economy, Central Bank, Sri Lanka.

Farmer, B. H. (1970) Report of the Galoya Project Evaluation Committee, Sessional paper 1, Govt. Printers, Sri Lanka.

Hagan R. M. (1963) Water Management-A major requirement for increased agricultural production. Seminar Study on Agricultural Productivity, M. I. T.,

Jogaratnam, T. and Schickele, R, (1969) Socio-economic survey of 9 colonization schemes, Agric. Econ. Res. Unit, University of Sri Lanka.

Jogaratnam, T, (1974) Irrigated Farming in the Dry Zone of Sri Lanka. Agric. Econ. Res. Unit, University of Sri Lanka.

Perera, P. H. (1970) Country Statement-Ceylon., Farm Water Management Seminar, FAO, Rome.

Peiris, J. W. L. (1973) Recent advances in the development of high yielding rice varieties JAO/Sri Lanka Water Management Seminar.

Schickele, R. (1970) Colonization schemes as special projects for dry zone development. Seminar on special Projects, Land Commissioners Department, Sri Lanka. ■■

Post Harvest Losses of Paddy in Bangladesh

by
Bilash Kanti Bala
Associate Professor
Department of Farm Power & Machinery
Bangladesh Agricultural University
Mimensingh, Bangladesh

Abstract

This paper gives an account of production, import, price, threshing, drying, distribution pattern and storage of paddy in Bangladesh. An account of estimates of probable quantitative/of losses of paddy at each stage from harvesting to retailing is also given.

These estimates are crude and suggests for scientific assessment of post harvest losses. Finally, it concludes that the quantitative and qualitative losses can be reduced by improved threshing, drying and storage facilities at the farm level.

Introduction

Bangladesh is an agricultural country with a popuqation of 82.7 million and the total cropped area is 31,135,000 acres with a cropping intensity of 1.48 (Monthly Statistical Bulletin of Bangladesh, January, 1977). The acreage, production and yield rate of paddy is shown in **Table 1.**

The country is a food deficit one and imports rice and wheat to fulfill this requirement. In addition, people of Bangladesh prefer rice to wheat. The production, import and price of paddy are shown in **Table 2.**

This commodity is now showing

Table 1. Acreage, Production and Yield rate of Paddy

Crops	1975−76			1976−77		
	Area (1000acres)	Production (1000tons)	Peracre yield (maunds)	Area (1000acres)	Production (1000tons)	Peracre yield (maunds)
Aus	8,452	3,230	10.40	7,952	3,011	10.31
Aman	14,236	7,045	13.47	14,355	6,906	13.10
Boro	2,837	2,286	21.93	2,112	1,650	21.27

One maund is equal to 82.286 pounds.
Source : Monthly Statistical Bulletin of Bangladesh, September, 1977, Dacca.

Table 2. Production, Import and Price of Paddy

Year	Production (1000tons)	Import (1000tons)	Average Retail Price (Dacca) Rice-boiled medium (Taka/seer)
1973−74	11,720	86	−
1974−75	11,109	264	6.79
1975−76	12,561	396	4.06
1976−77	11,600	196	3.51

One seer is equal to 2.0572 pounds and one Taka is equal to 0.065 dollar (U. S.)
Source : Monthly Statistical Bulletin of Bangladesh, January and September, 1977.

Table 3. Estimates of All Probable Quantitative Losses

Sources of loss for all rice crops	Conservative estimates of Agri. Marketing study group of 1970	High ranges of estimates from 1974 interviews by T. F. in Dacca Division
Shattering loss during and after harvesting	1.06%	1.5%
Carrying loss, field to Premises	0.63	−
Threshing losses on different methods	1.65	2
Drying losses due to inadequate drying	1.56	5
Storage losses due to rottage, insects and rodents	3.05	7.5
Total handling and transportation losses	−	6.0
Total	7.95% (approx. 8%)	22%

Source : Farouk, S. M. 1975.

Table 4. Post harvest losses of paddy of some asian countries

Country	Situation	Types of loss	Amount	Period	Cause	Comments
Bangladesh	All levels	Weight	8% to 22%	–	Various	Published in proceeding of the Workshop on Appropriate Tecnology Feb. 6–8, 1975, Dacca
India	Farm Trader	Weight Germination	15% 8%	Continuing study from 1961–1971	Insects, Vertebrates & fungi	Samples removed from stores for examination
Indonesia (West Java)	Farm	Weight	10%	–	Insects, rodents & fungi	Various farm surveys in collaboration with different agencies
Japan	All Levels	Weight	5%	–	Various	Published in Agricultural Mechanization in Asia, Vol. VII. No. 3

fluctuation in production and price with shortages to meet the requirement of Bangladesh. To cope with this crisis high yielding varieties have been developed by Bangladesh Rice Research Institute (BRRI). During rainy season some high yielding varieties ripen. Once grown whatever season it may be, it must be harvested, processed, stored, transported and marketed with minimum loss and the quality of paddy must be improved for best econmic returns.

Post Harvest Losses

Post harvest loss of paddy in Bangladesh is estimated to be about 8% to as high as 22% counting all the processes between the harvest and retailing. An account estimates the quantitative losses at each stage as follows (**Table 3**).

The actual loss perhaps lies between 8% and 22%. The important stages of losses are threshing, drying, distribution, and storage losses. Post harvest losses of paddy of some Asian countries, including Bangladesh are shown in **Table 4.**

The post harvest loss of Bangladesh is very high while Japan has the lowest. Total loss is proportional to the total production and increases with the development of high yielding varieties.

This loss is quite significant and must be reduced.

Distribution Pattern

The distribution pattern of paddy from the farmer to consumer is shown in **Fig. 1.** Middlemen and wholesalers stock the paddy in gunny bags in covered areas and only a few wholesalers store paddy in godowns.

The Government storage capacity is 1,200,000 tons and the capacity is not sufficient to meet the requirement. Farmers store the paddy in traditional farm structures and the major portion of the total paddy is stored in these structures in rural areas.

Threshing

Threshing in most cases is done by bullock. Sometimes it is done by beating and treading. Mechanical threshing reduces labour requirement, but it improves the grain yield. Pedal thresher is now being practised in Comilla and some places of Bangladesh. These reduces labour requirement slightly but improves the grain yields.

Drying

Drying is mostly done by sun shine and depends on Nature's whims. Drying is performed on beaten earth and sometimes on metallic roads in Bangladesh. There is no control on the rate of drying. This increases losses by birds and decreases quality by addition of foreign materials. This method of drying is now practised all over the country. Even during rainy season (main rainy season, July-November), sun drying is practised intermittently. Mechanical drier suitable for socio-economic conditions of Bangladesh should be develoved. This will decrease the losses and slightly decrease labour requirement. In addition, it will improve the quality.

Storage

Farm level storage in Bangladesh is a function of cropping pattern, consumption requirement, price and labour payments.

Grops Aus, Aman and Boro contribute roughly ¼, ½ and ¾ of

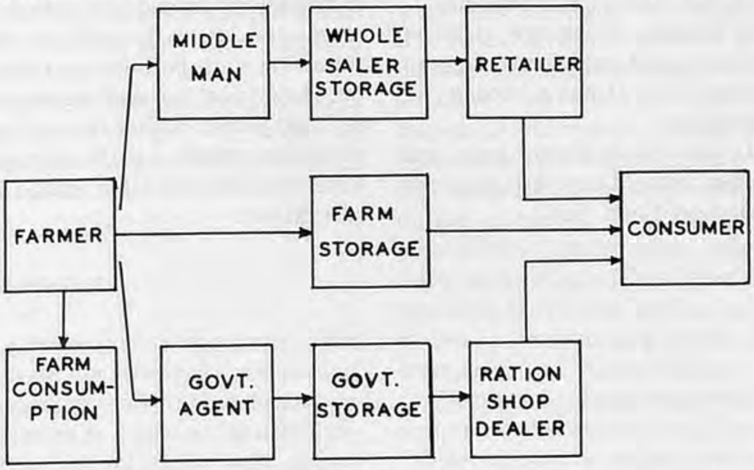


Fig. 1 Flow diagram of paddy distribution patterns

the total production respectively and majority of the farmers have an optimum storage period of 3-4 months. Storage period will determine the loss level. Most of farms are below 5 acres and a large portion of the production is consumed at the farm level. This necessiates the improverent of storage capacity at the farm level. Most of the paddy consumed is parboiled and this facilitates the farmers to keep the wet paddy in water up to 10 days during rainy season. But this parboiled paddy is poor in quality and cheaper in price. Rainfall during season increases the difficulty of sun drying and storage. In addition, relative humidity is high over the large part of the year. It is about 75% during winter and about 85% during rainy season. This high relative humidity affects the storage of paddy.

Storage Structure

The storage structures in rural-Bangladesh with variations are as follows:

(1) Duli type—This type of structure is circular or barrel type in shape and made of woven bamboo. This duli is placed on a raised platform and is widely used. The capacity is up to 25 maunds.

(2) Dhan gola—These are made of thick bamboo splits and placed on wooden or bambooo support. Generally it has large capacity.

(3) Motka—These are made of fired clay and used for storage of seed and rice. It has a capacity of 6 maunds.

(4) Oil drums, gunny bags and wooden box—These are used for storing seed and rice.

(5) Mosa—These structures are found in Sylhet and made of paddy straw enclosing the loose paddy and held together by thin bamboo splits. Its maximum capacity is 2 maunds.

(6) Corrogated metal bin—An outdoor structure found in Rangunia of Chittagong district of in Bangladesh. Its capacity is 250 maunds.

(7) Outdoor gola—It is found in the district of Mymensingh and it is a bamboo building on raised platform with thatched roof.

Infestation of Stored Paddy

Seeds are kept in Motka, Oil drums, etc., and scaled to limit the insect infestation if they are full and dry. Dulis and golas are not rodent proof and completely open to insect infestation.

They are also less amenable for fumigation. Few farmers are conscious of insect damage and some farmers use locally available plant leaves to limit the insect damage. Only very few farmers are using modern techniques.

Conclusions

Post harvest loss of paddy in Bangladesh has been estimatjd by crude methods and none of them gives the actual result. This suggests that a suitable research methodology should be applied to assess the losses. In addition, the following steps be taken to reduce the major post harvest losses and to improve the quality for the best economic returns for the farmers. Research and extension should be carried out.

a) to popularise and improve the existing pedal thresher,
b) to develop low cost rice drier for Bangqadesh Conditions and
c) to design and develop low cost farm structure.

Research work is going on for development of low cost rice drier for Bangladesh conditions under the department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh.

REFERENCES

1. Adams, Jm. 1977. Post-harvest losses in cereals and pulses—the results of a questionnaire survey, June 1976. Tropical Stored Products Infomation 34, 23-48.
2. Boxall, Robin. Greeley, Martin. and Neelakanta, J. 1976.Review of IDS/IGSI Storage Project and Observation on farm level storage in Bangladesh. AATC Monograph No.2, BARC, Dacca, Bangladesh.
3. Farouk, S. M. 1975. Probable losses in post harvest period: How to minimize them. Proceedings of the Workshop on Appropriate Agricultural Technology. Feb. 6-8, 1975, Page 153-159, BARC, Dacca.
4. Koga, Y. 1977. Rice Post-Harvest Process in Japan. Agricultural Mechanization in Asiaa, 6(3): 57-60, Tokyo, Japan.
5. 1977. Monthly Statistical Bulletin of Bangladesh Vol. VI, No. 1 Bangladesh Bureau of Statistics, Ministry of Planning, Dacca.
6. 1977. Monthly Statistical Bulletin of Bangladesh Vol. VI, No. 9, Bangladesh Bureau of Statistics, Ministry of Planning, Dacca.

■■

Comparative Performance of Tillage Implements



by Ghulam Sarwar Sheikh
Professor
Faculty of Agricultural Engineering
University of Agriculture
Faisalabad, Pakistan

Syed Iqbal Ahmed
Research Fellow
Agricultural Engineering Department
University of Illinois
Urbana, Illinois 61801, USA

A. D. Chaudhry
Chairman
Department of Farm Machinery & Power
University of Agriculture
Faisalabad, Pakistan

Abstract

A comparative study of tillage implements like subsoiler, disk harrow, disc plow, mold-board plow and field cultivator was carried out with a view to assessing their performance for a given soil and crop. The crop and soil parameters considered were emergence, yield of wheat, moisture content, bulk density, penetration resistance, strength of soil and emergence force exerted by seedlings. The results on sandy loam soil indicated that different tillage implements had different effects on the emergence and yield of wheat. Further, different tillage operations had different effects on soil physical properties such an density, moisture content and penetration resistance. However, such properties of soil could not clearly explain the difference in emergencce and yield resulting from different tillage operations. In the last analysis, shear strength of soil and emergence force exerted by seedlings were considered proper parameters in understanding the effects of different tillage implements on the emergence and yield of wheat.

The last two parameters established the superiority of operations with disk harrow under the conditions specified in this study. Operations with such an implement resulted in highest yield and lowest emergence force and shear strength of soil, It is noted with interest that the emergence force exerted by wheat seedling varied from a minimum of 13 grams for disk harrowing to a maximum of about 80 grams for operations by subsoiler and mold-board plow.

Since many combinations of tillage implements used in this sttudy are possible, disk harrow alone may not be guaranted as optimum type tillage tool. However, the combinations used in this study are appropriate for field operations.

Further, there is a need to assess the performance of such an implement with respect to cost of operation.

Introduction

A variety of tillage implements is usde for seedbed preparation. Excessive soil manipulation by implements, however, is detrimental to soil structure with serious conquences on the emergence and yield of crop. It is thus important that proper types of implements are selected for different soil and crop conditions, so that suitable seedbed invironment is achieved.

The physical environment of soil resulting from the application of different implements may be of such a nature that the processes of plant germination and growth could seriously be hampered.

The use of improper and heavy implements, for example, may produce soil compaction that could greatly upset the balance between air, soil and water components of soil. The reduction in the aeration of soil may obstruct the metabolic activities of the roots. The compaction may increase the shear strength of soil so that root growth could be impeded. However, compacting operations are needed to gain good contact between the seeds and soil during planting. The degree of compaction, penetration resistance, shear strength, moisture etc. needs to be determined so as to evolve a relationship with the emergence and yield of crops.

The purpose of this study was to determine the effects of different tillage operations on the physical and engineering properties of soil and yield of crop with the ultimate objective of selecting proper types of implements for a given soil type and crop.

Materials and Methods

Tillage Operations

The following sets of tractor-mounted tillage implements were used on sandy loam soil:

Treatment A : Subsoiler, cultivator, cultivator.

Treatmest B : Disk harrow, cultivator, cultivator.

Treatment C : Disk plow, disk harrow, cultivator.

Treatment D : M. B. Plow, disk harrow, cultivator.

Treatment E : Disk harrow, disk harrow, disk harrow.

Each of the above treatments was applied on three plots of equal sizes with a total area of 1.62 ha.

After tillage operations, wheat seeds (SF-42) were planted by a carefully caliberated grain drill (operated with tractor). However, the central portion of each plot was planted by a hand drill so as to avoid high seed density which could result from the tractor operated grain drill. Three rows spaced at 20 cm were selected in the central portion of each plot and 16 seeds per row were planted by hand to a depth of 5 cm and 20 cm distance between seeds. The emergemce of hand planted seeds was noted after 4 weeks of planting.

Measurement of Soil Density and Moisture

After tillage operations, three samples of soil were collected from a depth of 15 cm with the help of a soil sampler from each experimental plot. The wet and dry densities of soil as well as its moisture content were determined from the following formula:

Wet density of soil

$$= \frac{\text{Weight of wet soil}}{\text{Volume of wet soil}}$$

Dry density of soil

$$= \frac{\text{Dry weight of soil}}{\text{Total volume of wet soil}}$$

Moisture contest of soil in percent

$$= \frac{\text{Weight of wet soil} - \text{Weight of dried soil at } 105^{\circ}}{\text{Weight of dried soil}} \times 100$$

Measurement of Penetration Resistance

The penetration resistance of soil was determined after tillage operations at a depth of 15 cm with the help of a cone penetrometer having an area of 7.314cm^2. (dia = 2.845cm). At least 5 readings of the penetrometer were taken from each plot.

Measurement of Shear Strength

The shear strength of soil was determined with the help of Cohron Shear graph. Three levels of normal stress were selected at each location and the corresponding values of shear stress were obtained with the apparatus. The process was repeated three times over each experimental plot. The linear regression analysis of the values of normal and shear stresses provided the values for cohesion and angle of internal friction of soil corresponding to the intercept and slope of the regression line.

Emergence

The percentage emergence of wheat seedlings was recorded after four weeks of planting. The seedlings were hand counted from the central portion of planted plot.

Yield

Samples of harvested wheat were collected from the central area planted by hand in each plot and weighed after threshing.

Results and Discussion

Effect on Emergence

The data on emergence was analysed to determine the effect of different tillage operations. The analysis of variance (ANOV) on the mean values of emergence obtained from different plots gave the calculated value of F for treatment means divided by individuals as 0.84. The tabulated value of F for 4 and 10 degree of freedom wan 5.64 at 99 percent level and 3.48 at 95 percent level of significance. It was, therefore, concluded that different tillage operations had different effects on the emergence of wheat seedlings. The analysis, however, could not determine the superiority of a particular treatment over the others with respect to emergence.

Effect on Yield

The data on yield was analysed to determine the effect of different tillage treatments. The calculated value of F was determined as 16.1 against the tabulated value of 5.64 at 99 percent and 3.48 at 95 percent level. This clearly indicates that different tillage treatments had different effects on the yield of wheat. The analysis, however, failed to establish the superiority of different operations with respect to the yield of crop.

The difference in yield may possibly be attributed to the change in the physical and engineering properties of soil brought about by the tillage treatments. It was, therefore, decided to study later the effect of tillage operations on the properties of soil (soil moisture, bulk density and shear strength) in order to determine the particular properties of soil which contributed most to the yield of wheat.

Effect of Soil Moisture

The data on soil moisture was analysed to determine the difference in soil moisture content resulting from the application of different tillage treatments. The ANOV on the data revealed that there was a significant difference between the levels of soil moisture at a specified depth of 15 cm for different tillage operations. The calculated value of F was 7.75 against the tabulated values of 3.48 and 5.64 at 95 percent and 99 percent levels of significance. The analysis, however, could not pin-point a particular treatment which contributed most towards the optimum level of soil moisture and, thereby, affecting the yield.

Effect of Density

The ANOV reveals that there were possibly no significaant differences in the dry density of soil for different tillage treatments. The calculated value of F was found to be 3.756 against the tabulated values of 3.48 and 5.64 at 95 percent and 99 percent levels of significance. The mean value of soil dry density was higher for treatments C and D and lower for treatments B and E. On the other hand, the mean value of yield was higher for treatments D and E than for treatment B. Logically, the emergence should decrease with the density of soil but property has not been able to dinsinguish the effect of different tillage operations on yield.

Effect of Penetration Resistance

The data on penetration resistance was analysed to determine the effect of different treatments on the penetration resistance of soil. The ANOV indicates that the differences between the resistances resulting from different tillage treatments were highly significant. The analysis, however, could not distinguish between the treatments affecting such a resistance.

Effect of Shear Strength

The linear regression analysis of the data on shear strength using Computer program, gave the following regression equations on the pattern of Coulomb's law, $S = c + N \tan \phi$:

Treatment	Shear Strength
A	$S = 43.0 + 0.383$ N
B	$S = 22.14 + 0.310$ N
C	$S = 36.5 + 0.327$ N
D	$S = 48.19 + 0.288$ N
E	$S = 7.88 + 0.294$ N

Where:

S = Shear strength of soil (gms/cm^2)

N = Normal stress of soil (gms/cm^2)

C = Cohesion of soil (gms/cm^2)

ϕ = Angle of internal friction of soil (degrees)

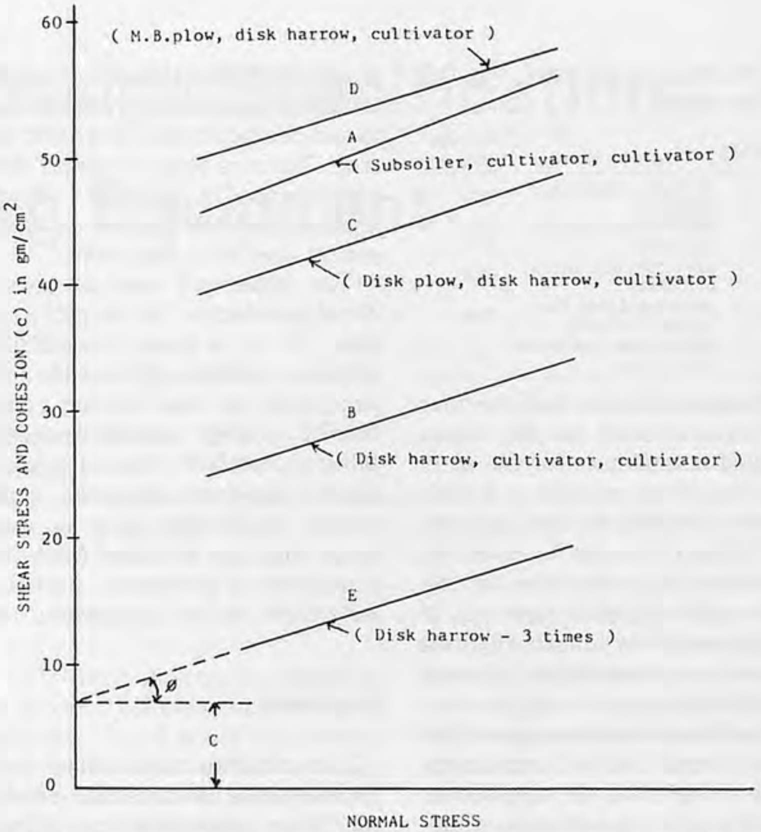


Fig. 1 Shear stress for different tillage treatment (values of cohesion and angle of internal friction)

The above Coulomb's type equations are illustrated in **Fig. 1.** It appears that the shear strength of soil for the treatments B and E is lower than for treatments D and A. Further, the mean value of yield was found higher for treatments D and E. However, the treatment E (disk harrow operation) may be considered better, as it gave the lowest value of shear strength and highest mean value of the yield.

Emergence Force

An attempt was made to determine the effect of tillage treatments on the force exerted by wheat seedlings during emergence with a view to establishing the comparative merits of the treatments. The force exerted by the seedlings was calculated from the following formula developed by Sheikh (1964):

$$F = u'' D \left[2\, cL \tan(45^\circ + \phi 2) + \frac{wL}{2} - \tan^2 (45^\circ + \phi 2) \right]$$

Where:

- F = Force exerted by the seedling (gms)
- u = Coefficient of friction between the seedling and soil = 0.25 (assumed)
- D = Mean stem diameter of the seedling (cm) = 0.1524
- L = Depth of planting (cm) = 5.08
- c = Cohesion of soil (gms/cm^2)
- ϕ = Angle of internal friction of soil (degrees)
- W = Wet density of soil (gms/cm^3)

The values of c'ϕ and w were different for different treatments and are as follows:

Treatment	o (gms/cm^2)	ϕ Degrees	w (gms/cm^3)
A	43.00	20.92	0.2329
B	22.14	17.22	0.2149
C	36.50	18.10	0.2192
D	48.19	16.00	0.2217
E	7.88	16.40	0.2131

Substitution of these values in

the above formula gave the following results:

Treatment		Force exerted (gms)
A	(Subsoiler, Cultivator, Cultivator)	76.4
B	(Disk harrow, Cultivator, Cultivator)	37.1
C	(Disk plow, Disk harrow, Cultivator)	61.8
D	(Mold-board plow, Disk harrow, Cultivator)	78.4
E	(Disk harrow, Disk harrow, Disk harrow)	13.4

The above results indicate that the force exerted by the wheat seedling is minimum for the plots which received treatments E (disk harrow followed by disk harrow) and B (disk harrow followed by cultivator) and maximum for the plots subjected to treatments D (mold-board plow followed by disk harrow) and A (subsoiler followed by cultivator).

The above results suggest that shear strength of soil and emergence force may be considered proper parameters in understanding the effects of different tillage implements on crop yield. Such parameters indicate the superiority of tillage operations with disk harrow followed by disk harrow under the conditions specified in this study.

Since, mathematically, many combinations of tillage implements used in this study are possible, disk harrow alone may not be guaranted as an optimum type tillage implement. However, the combinations used in this study are appropriate from the standpoint of field operations.

Further, the present study was directed to assess the performance of tillage implements with respect to soil characteristics and yield of crop. There is need to assess the performance of different tillage implements with respect to their cost of operation and yield.

The implement may be considered satisfactory in its performance, if it is found technically suitable, economically feasible and acceptable by the farming community. The suitability-feasibility-acceptability type of assessment, therefore, demands that tillage implements used in this study must also be tested from the standpoint of economics, particularly their cost of operation.

Conclusion

The experimental results and their analysis indicate that different tillage implements had different effects on the emergenece and yield of wheat. Further, different tillage operations had different effects on soil physical properties such as density, moisture content, and penetration resistance. Such properties of soil, however, could not clearly explain the difference in emergence. The shear stength of soil and emergence force exerted by seedlings were considered proper parameters in establishing the superiority of a tillage treatment over the others. With respect to soil characteristics and yield of crop, disk harrow was considered as a suitable type of implement under the conditions used in this study. It is, however, suggested that a relationship between the cost of operation of different sets of tillage implements and their respective yields be further studied before making final recommendations about the performance of tillage implements.

REFERENCES

1. Sheikh, Ghulam Sarwar. 1964. Soil mechanics and emergence of seedlings. M.S. thesis. Iowa State University, Ames, Iowa, U.S.A.
2. Gill, W.R. and Vanden Borg, C.E. 1967. Soil dynamics in tillage and traction. U.S. Department of Agriculture, Agriculture Handbook 316.
3. Lambe, T.W. and Whitman, R.V. 1969. Soil mechanics. New York, N.Y., John Wiley and Sons, Inc.
4. Sheikh, Ghulam Sarwar. 1972. Soil cutting equipment and emergence of seedlings. Ph. D. thesis. Ames, Iowa, Library Iowa State University.
5. Sheikh, Ghulam Sarwar. 1976. Effects of different tillage practices on soil characteristics and emergence of wheat seedlings under irrigated conditions. FAO Agricultural Sciences Bulletin 28. (Mechanization of irrigation crop production. Proceedings of an expert consultation held in Adana, Turkey, April, 1976. ■■

Optimum Design Specifications for Planting Equipment

by
Ghulam Sarwar Sheikh
Professor
Faculty of Agricultural Engineering & Technology
University of Agriculture
Faisalabad, Pakistan

Abstract

Farm equipment used for planting seeds do not have effective provision for affecting proper depth of planting and soil compaction pressure. There is a need for ascertaining relevant research information such as optimum depth of planting and soil impedance for different soils and crops so that such information could be used for incorporating suitable design features in the planting equipment with a view to optimizing soil-seed contact environment. In this study, research experiments were conducted for determining the optimum depth of planting and soil impedance for a particular soil and wheat crop. The relevant values for the optimum depth of planting wheat seeds and soil impedance, determined with the help of a computer program, were found to be 5.504 cm and 2.2 kg/cm^2. The method outlined in this study could be used for determining the relevant optimum values for different soils and crops. Such information may then be used for incorporating adjustable type furrow openers in the planting equipment for placing seeds and developing proper press wheels for affecting suitable compaction pressure in order to ensure the emergence of seedlings.

Introduction

The basic objective of designing a modern planting machine is to produce a tool which will create soil environment conducive to rapid germination and emergence of seedlings. The equipment should be so designed as to fulfill the biological requirements of crops while operating on the soil prepared by tillage implements. The important factors governing the design of planters include the depth of planting, soil-seed contact, and compaction pressure of soil experienced by the seedlings during emergence. The present planting equipment have no effective provision for adjusting the press wheel pressure (for obtaining proper soil-seed contact as well as maintaining low compaction pressure) and affecting proper depth of planting with the help of furrow openers.

Adequate moisture in soil can usually be found if the planting depth is reasonable, but hazards from soil impedance or compaction pressure increase with the depth of planting. Thus to optimize the situation, the operator must plant deep enough to ensure moisture and shallow enough to avoid excessive penetration resistance or impedance of soil experienced by the emerging seedlings.

The objective of this study was to develop important planter design specifications such as optimum depth of planting and compaction pressure of soil so as to be regulated respectively by the furrow openers and press wheels of planters.

Materials and Methods

Description of Soil

Samples of soil were taken at depths of 6, 9 and 12 inches and from different locations in the experimental area of the Faculty of Agricultural Engineering and Technology, University of Agriculture, Lyallpur, Pakistan. Six samples were made after thoroughly mixing the soil collected from such depths and locations. Mechanical analysis of samples yielded the following average values of different constituents of soil : -

Sand	56.6%	(0.50 to 2.00 mm)
Silt	21.0%	(0.002 to 0.50 mm)
Clay	22.4%	(0.002 mm)

Operations

The experimental area covering about 4 acres of land was prepared by tillage implemants like disk harrow, cultivator and land leveller. The central portion of the area was selected for study. It was converted into 12 equal sized plots, with 3 plots considered for each of the 4 depths of planting used in this study. Each of the plots on which observations were made was 10 in x 10 in (305 cm x 305 cm) in size. Wheat variety AU-26 with 95 percent germination, developed at the University was used for planting. The seeds were planted at different depths by means of furrow openers an follows: -

Seed to seed distance: 6 in. (15.24 cm)

Row to row distance: 9 in. (22.86 cm)

Seeds studied in a row: 15

Rows studied in a plot: 3

Depth of planting: 4 (1, 2, 3 and 4 inches)

Plots or replications: 3

Total plots for 4 depths of planting: 12

Emergence

Water was uniformly distributed over the observation area after 10 days of planting. The emergence of wheat seedings was recorded after 20 days of planting. The percentage emergence is shown in **Table 1** for different plots used for different depths of planting.

Impedance

Soil impedance (pressure) was determined after 20 days of planting (at the time of counting of emergence) at different depths by means of a cone penetro-meter with cone area of 6.45 cm^2.

Results and Discussion

Effect of planting depth on emergence

The following equation showing the relationship between the emergence and depth of planting was obtained with the help of a Computer Programme, using the mean values of the data recorded in **Table 1.**

$$E = 47.825 + 8.253\,L - 0.747\,L^2 \qquad \text{(i)}$$

Where

E = Emergence (%) of wheat seedling recorded after 20 days of planting.

L = Depth of planting (cm)

Equation (1) is graphically

Table 1. Penetration resistance and emergence at different depth.

Depth (cm)	Plot No.	Cone index dial reading	Penetration load (kg)	Penetration resistance (kg/cm^2)	Emergence	Emergence Percent
1	2	3	4	5	6	7
2.54	1	18	8.0	1.240	10	66.67
		17	7.5	1.163	11	73.34
		17	7.5	1.163	10	56.67
		15	6.5	1.008		
		mean =	7.375	1.143		68.89
	2	18	8.0	1.248	8	53.34
		19	8.5	1.318	6	40.00
		20	10.0	1.550	9	60.00
		20	10.0	1.550		
		mean =	9.125	1.414		51.11
	3	22	11.0	1.705	10	66.67
		19	8.5	1.318	10	66.67
		24	11.8	1.829	8	53.34
		17	7.5	1.163		
		mean =	9.700	1.504		62.36
5.08	1	35	18.0	2.791	10	66.67
		25	12.0	1.860	12	80.00
		29	16.5	2.558	10	66.67
		30	17.0	2.636		
		mean =	15.875	2.461		71.11
	2	35	18.0	2.791	14	93.34
		30	17.0	2.636	14	93.34
		25	14.0	2.171	12	80.00
		40	20.0	3.101		
		mean =	17.25	2.675		88.89
	3	35	18.0	2.791	14	93.34
		44	21.5	3.333	10	66.67
		44	21.5	3.333	12	80.00
		28	16.0	2.481		
		mean =	19.25	2.985		80.00
7.62	1	80	42.0	6.512	8	53.34
		80	42.0	6.512	10	66.67
		60	30.0	4.651	9	60.00
		68	35.5	5.504		
		mean =	39.375	5.795		60.00
	2	92	44.5	6.889	9	60.00
		92	44.5	6.889	9	60.00
		80	42.00	6.512	7	46.67
		60	30.0	4.651		
		mean =	40.5	6.240		55.56
	3	80	42.0	6.512	7	46.67
		90	44.0	6.822	12	80.00
		70	36.0	5.681	7	46.67
		70	36.0	5.581		
		mean =	39.5	6.124		57.78
10.16	1	145	76.0	11.783	7	46.67
		145	76.0	11.783	10	66.67
		115	60.0	9.302	7	46.67
		120	62.0	9.612		
		mean =	68.5	10.62		55.34
	2	142	72.5	11.248	5	33.34
		115	60.0	9.302	10	66.67
		100	50.0	7.152	11	73.34
		120	62.0	9.612		
		mean =	61.12	9.481		57.78
	3	150	77.0	11.938	9	60.00
		140	72.0	11.163	8	53.34
		120	62.0	9.612	10	66.67
		115	60.0	9.309		
		mean =	67.75	10.50		60.00

represented by **Fig. 1.** It indicates that the emergence increases with initial depths and then decreases.

Optimum depth of planting

To determine the optimum depth of planting for emegence, Equation (1)-and **Fig. 1** were studied for the type of function involved. The graph and its equation was found to represent a unimodal function.

Computer Subroutine Gold, written by Mischke (1967) was employed to determine the optimum depth of planting for the emergence of wheat seedlings. With tbe help of this Computer Subroutine, the following results were obtained. :

Optimum depth of planting= 5.504 cm

Corresponding emergence= 70.62%

The optimum depth and the corresponding percent emergence are indicated in **Fig. 1.**

The optimum depth as mentioned above has been determined as 5.504 cm for the type of soil and seed conditions used in this study. The planting epuipment may thus be equipped with an adjustable type furrow opener so as to place the seed at an optimum level to be determined by the method outlined above for different soil and crop conditions.

Effcct of planting depth on soil impedance

The following equation showing the relationships between the soil impedance and planting depth was obtained with the help of a Computer Programme using the data of **Table 1.**

$P = 1.10 - 0.198L + 0.108L^2$ ···(2i)

$F = 8.763 - 1.99L + 0.75L^2$ ···(2ii)

Where

P = Soil impedance or pressure (Kg/cm^2)

F = Force exerted by soil (Kg)

L = Depth of planting (cm)

The equations are depicted graphically in **Fig. 1.** A non-linear effect of depth on force and pressure exerted by soil can be observed from the figure. It will be seen that a vertical line showing the optimum conditions has been erected from absissa corresponding to the optimum depth of 5.504 cm. The vertical line hits the three graphs at 2.2 kg/cm^2 (pressure), 20 kg (force) and 70,62% (emergence).

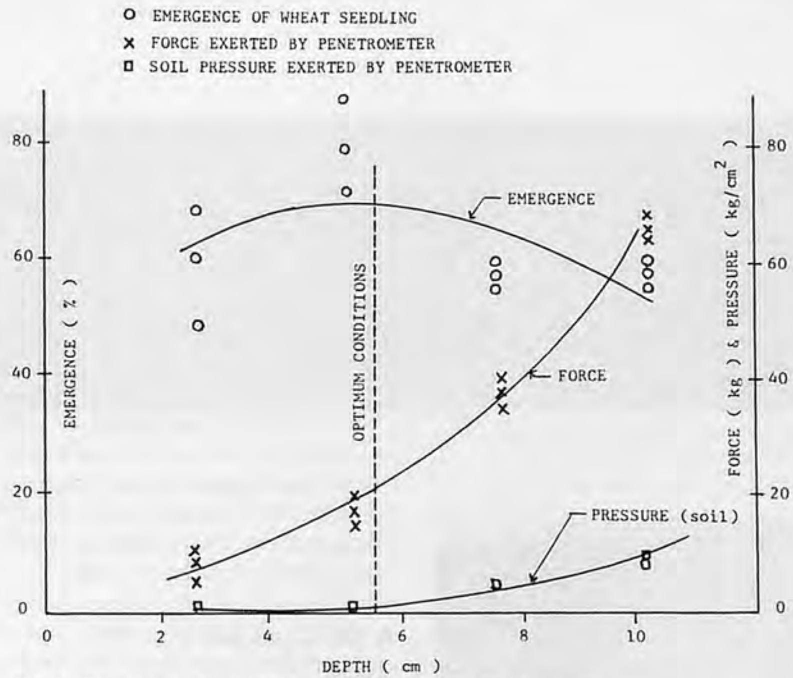


Fig. 1 Effect of planting depth on emergence, force and pressure

Experiments may be conducted with a view to determining the optimum values of depth of planting and soil pressure for different soils and crops. The planting equipment may then be designed so as to incorporate adjustable type furrow openers and press wheels for producing optimum conditions of depth and pressure for different soils and crops.

Conclusion

The optimum values of depth of planting and soil impedance have been determined in this study for a given soil and crop condition. The values will differ for different crops and soils. The present study may have established general trends which the emergence and soil impedance are expected to follow with the change of depth of planting. A range of optimum values of planting depths and soil impedance may be determined for important grain crops and soils, using the approach outlined in this study. These values may then be used for incorporating the necessary features in the planting equipment, particularly the adjustment needed for manipulating the furrow openers and press wheels with a view to optimizing soil-seed contact environment.

LITERATURE CITED

Bowen, H. D. 1960. Measurement of edaphic factors for determining planter specifications. American Society of Agricultural Engineers Transactions. 9 : 725-735.

Gill, C. H. 1968 Influence of compaction hardening of soil on penetration resistance. American Society of Agricultural Engineers Transactions. 11 : 741-745.

Kollman, G. E. 1968. Influence of soil compaction on weed seedling emergence. Unpublished M. S. thesis. Iowa State University, Ames, Iowa.

Mischke, C. R. 1967. (Golden Section Search). Unpublished computer program. Mechanical Engineering Subroutine Gold. Iowa State University, Ames, Iowa.

Sheikh, G. S. 1972. The mechanics of soil cutting equipment and emergence of seedlings. Ph. D. thesis, Iowa State University, Ames, Iowa.

Design and Development of Self-Propelled Multicrop Reaper

by
A. D. Chaudhry
Chairman
Department of Farm Machinery & Power
University of Agriculture
Faisalabad, Pakistan

Abstract

The conventional method of wheat harvesting with sickle is a most labor intensive operation. The socio-economic and agro-climatic conditions of Pakistan have prevented the adoption of Western-type mowers and combines for harvesting grain crops. Careful investigations of grain crop harvesting with special reference to farm size in Pakistan led to development of a simple, self-propelled and multicrop reaper at the University of Agriculture. The machine can harvest wheat, rice and other small grain and forage crops in 2.5 hours/ha with a cost of only US $ 7.5 per hectare. The major components and parts of this machine, except the prime mover, have been fabricated from locally available materials.

Present Situation

Wheat and rice are the staple crops in Pakistan. Straw and chaff are fed to cattle. These crops are grown on an area of 8.3 million ha representing 67 percent of the total/cropped area. The traditional practice of harvesting these crops uses a sickle with serrated blade and a wooden handle. It is a one-handed tool permitting one hand to grasp the stalks and sirulltaneous cutting is the serrated blade held in the other hand of the harvester. It is very slow and laborious process. Pakistan's changing weather and unpredictable rains chalcenge the search for timely harvest operations. During last two years, there has been considerable damage to standing crops due to unfavourable weather. Available labor has not been sufficient to harvest the entire wheat crop. Consequently, substancial grain quantities are left in the fields as loss and waste. The Agriculture Department officials refer to this loss as a significant problem.

At the peak of harvest the scarcity and unavailability of labor increases labor costs with the result that farmers now to pay an exorbitant amount of US $ 25 equivalent per hectare for harvest.

Mechanizing labour-intensive activities, howeve, must be so designed as to minimize the impact of labor displacement that is likely to come about. The labour whose employment will be replaced by machine is temporary or seasonal labour that gains its normal income from other sources. Approximately 50 percent of the harvest labour is not normally otccupied in agriculture so that if the harvest labouris reduced to 50 percent, it need not affect the income of those who are normally farm laborers. The present labour force used in harvesting is insufficient for the size of the crop and therefore, the general economy as well as the farmers lose the value of that portion of the crop not harvested.

The counter-balancing factors of total harvest : lower cost, and multiple cropping, in this case, appear to outweigh any temporary labour displacement which may occur for mechanization. For this reason it is not considered that technological unemployment is a valid reason for continuing hand harvesting of grain in Pakistan. Therefore, if a machine could be dveloped that could reduce the amount of time and labour required to harvest grain would be of immediate benefit to the society of the country.

Choice of Technology

Two possible ways of overcoming the problem of labour shortage during harvest and attaing timely operation to facilitate a multiple cropping sequence are the use of a combine harvester and development of improved simple harvesting machines. Certain factors that have prevented the adoption of western-type mowers and combines for harvesting grain crops in Pakistan are the small sizes of farms and the presence of numerous bunds that serve as paths around wet fields and as irrigstion water control. These bunds prevent access of large equipment to the fields. Even farmers owning two hectares of farm land have holdings usually split into several smaller fields. This is due to land parcelization through inheritance, the requirement of irrigation practices, and steep terrain. Village lanes are usually 2.5 to 3 m wide that limit the width of farm machines.

Both the initial high cost of the machine and facilities of repair and servicing by the machinery dealers are equally important problems. The dealers are not likely to establish repair/service shops when only a few umits of machinery are available in a given area. Government also restricts imports and levies taxes on farm machinery. Hence the need to introduce a machine that requires minimum maintenance and service parts which are available or preferably locally manufactured.

Wheat harvest season lasts only for 10-15 days and a machine designed only for wheat harvesting will not be attractive to a traditional farmer. What he needs is a multicrop harvesting equipment which could cut wheat, rice and forage crops which he can use practically year round.

Development of Appropriate Machine

Careful inrestigations on the techno-economic, agroclimatic and other requirements enumerated above led to the development of a simple, low cost and multipurpose reaper. The few imported reapers, both self-propelled and tractor-drawn and tried at different places were not accepted the farmere due to operational problems, high cost ,difficulty in bundling and poor maneuverability. These machines were also found unsuitable in uneven and small fields borded by narrow bunds. The machines designed for harvest were too heavy for a pair of average size bullocks and were inefficient to harvest when the crop stand was thick.

A multipurpose, multicrop, self-propelled reaperto overcome the above mentioned problems was designed and developed at the University of Agriculture, Faisalabad. The Pakistan Science Foundation sponsored this project and final design of this machine was purchased by the Malbro International, a local counterpart of an Australian firm M/S Toft Brothers, for large scale production.

The main frame of the machine is supported on two front driving wheels and one rear supporting wheel with pneumatic tires (**Fig. 1**). The power for cutting operation and for forward travel of the machine are provided by a 6-8 h. p. light-weight gasoline engine fixed to the read of the machine . A V-belt drive and bevel gear mechanism provide the necessary reduction of the engine speed from 25.. r. p. m. to 350 r. p. m. at the crank wheel to which the pitman shaft's head is fixed (**Fig. 2**). This produces 700 strokes per minute of the cutter bar. A roller chain and spur gear reduction mechanism has been provided to avoid slippage losses and to run the front driving wheel ft 30 r. p. m. (**Fig. 3**).

The conventional mower cutter

Fig. 1 A view of final version of reaper(1. Supporting wheel for cutting blade, 2. Cutting blade assembly, 3. Front pneumatic tyres, 4. Prime mover)

Fig. 2 Bevel gear and power transmission to pitman shaft(1. Bevel gear, 2. Power transmission to pitman shaft)

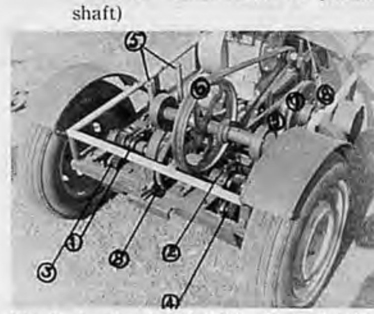


Fig. 3 Inside details(1&2. Dog clutches for forward travel control, 3&4. Final speed reduction gears for forward travel, 5. Cutting blade height adjusting screws, 6. First speed reduction, 7. Second speed reduction, 8. Dog clutches to control cutting blade operation, 9. Rollor chain)

Fig. 4 A practical demonstration of the first prototype unit(Dr. Amir Mohammad Vice Chancellor, University of Agriculture, is operating the machine at a wheat crop field of the University's farm)

bar has been adopted to form the cutting unit. Two dog clutches are provided on each of the front wheels (**Fig. 3**). These dog clutches work simultaneously to engage or disengage engine power for forward travel and work independent of each other. The expensive differential gear mechanism has been replaced by this simple arrargement. One dog clutch is provided to engage and disengage engine power from cutter bar (**Fig. 3**). The cutter bar is mounted at a distance of 5 cm. at the back front wheel (**Fig. 1**).

To avoid swinging of the cutter bar a supporting wheel of 20 cm. dia is provided at the right hand side of the cutter bar (**Fig. 1**). This arrangement helps in easy running of the machine in uneven fields. Four adjustable screws are used for raising and lowering the cutter bar to cut the crop at desired height (**Fig. 3**). For transportation purposes the cutter bar can be lifted up at an angle of 80 degrees and tied on the frame of the machine Thus the machine occupies only one meter space while travelling on a road.

The major components and parts of the machine , except the prime mover, were fabricated from the local available materials. The life of the machine has been estimated from 6 to 8 years with proper care and maintenance. The unit is quite cheaper than imported machines and can be fabricated and marketed by local manufacturers for US $ 800 only.

Operation, Function and Performance

Only one operator is required to control and operate this machine. Two control levers accessible to the operator, one for cutter bar control and the other for forward travel control, are provided (**Fig. 4**). The operator can walk or sit on the seat provided for this purpose. Two additional workers are necessary for tying bundles of the cut crop or removing it from the field and taking it to a threshing yard.

With the adjustable cutter bar the crop can be cut at a desired height with a maximum of up to 33 cm and by detaching the cutter bar from the main assembly the machine can be used as small power tiller or hitched to a seed and fertilizer drill. The prime mover of this machine can be independently used to power small grain thresher designed by IRRI in Pakistan and also to power irrigation pumps.

One hectare of wheat, rice and forage crops can be harvested in 2.5 hours with an estimated harvesting cost of US $ 7.5 per hectare. This cost includes fuel, labor and depreciation of the machine where as the harvesting cost of wheat crop by conventional method is US $ 25 per ha. ■■

ERRATA

A. Vol. IX, No. 2, Spring, 1978

Solar Pond and Storage of Solar Energy, by Md. Daulat Hussain, p.54, p.55

a. Page 54 column 3, line 10 should read : $Q_1 = M_w C_h (T_f(X) - T_o(X))$
b. Page 54 column 3, line 39 should read : $Q_1 C = h(T_p - T_a) + E_p \sigma (T_p^4 - T_a^4)$
c. Page 55 column 1, line 1 should read : σ=Stefan Boltzman Constant
d. Page 55 column 1, line 9 should read : $\phi_m = \phi_c + \phi_r = K_c(T_s - T_a) + E_s \sigma (T_s^4 - T_a^4)$
e. Page 55 column 1, line 34 should read : $Q_g = \Delta T \ 4K_s \rho_s C_{ps} / \pi \times t$
f. Page 55 column 1, last line formula should read : N_p=Total rate of energy in coming to the pond-all energy losses from the pond over that period /Total rate of energy in coming over the pond
g. Page 55 column 2, line 4 should read : $N_p = \Delta E / \Delta S$
h. Page 55 column 2, line 5 should read : Where N_p=efficiency of

B. Vol. IX, No. 3, Summer, 1978

New Co-operting Editors' column, P.89

The nationality of Amala Prasad Sharma should read : India instead of Fiji

Utilization and Energy Conversion Furnaces of Rice Husk

by
Ritsuya Yamashita — Professor
Nguyen Hao — Research Student
Faculty of Agriculture, Kyoto University
Kyoto Japan.

Introduction

Research on the new sources of energy has become an essential theme over the world and has generated a great interest in many fields of study. Although agriculture is a vast industry that can produce and converse energy there still have been many resources in agriculture which have not been effectively utilized. Rice husk is one of these valuable resources which is abundant and usable as energy source.

In Japan, about three million tons of rice husk are produced annually as by-product of rice milling. A large quantity of this by-product was once used widely in many aspects, especially in agriculture. Nowadays, with the advance of industry, the utilization of rice husk has been partially limited because of the introduction of many kinds of synthetic materials.

Therefore, the renewable and extensive utilization of rice husk, especially as energy source, should be pursued.

The fundamental properties of rice husk, its utilization and some typical kinds of energy conversion furnace of rice husk are introoduced in the pages that follow.

Properties of Rice Husk

Rice husk is 18–20% of rough rice by weight, and its heating value is about 3,500 kcal/kg. **Table 1.** shows the calorie value and cost of equipment of some heat sources. Handling of rice husk is difficult because husk is bulky and dusty, its angle of repose is about 42° and this angle varies with paddy variety, type of rice husker, ratio of foreign matters and moisture content. The apparent density of rice husk is about 0.09–0.10, and this density is about 0.16 in case of treading. For these reasons, considerable space is needed for rice husk storage and sizable labor cost is required for handling and transporting it. The composition of rice husk and ash is shown in **Table 2.** From this table, the high SiO_2 content is especially noticed because of which rice husk is difficult to decompose and is effectively utilized as a material in underdrainage.

Table 1. Calorie value of some heat sources

Kind	Calorie	Cost of Equipment
	(Kcal/Kg)	
Coal	6,500	high
Coke	6,800	low-medium
Rice Husk	3,500	highest
Kerosene	10,300	low-medium
Heavy oil	9,900	medium-high
LPG	12,000	lowest
	(Kcal/Kw-hr)	
Electricity	860	lowest

Table 2. Composition of husk and ash

Husk		Ash	
Lignin	33.83%	K_2O	12.30%
Pentosan	22.58	Na_2O	0.40
Cellulose	24.16	Mg_2O	0.60
Mannan	6.00	CaO	0.60
Fat matter	2.06	P_2O	3.50
Ash	11.37	SiO_2	82.60
Total	100.00	Total	100.00

Utilization of Rice Husk

Rice husk is both dusty and bulky. Hence transportating it is rendered difficult. Since rice husk is difficult to decompose, but generally abandoned elsewhere, its huge piles in open space have become a great public annoyance. **Table 3** and **Fig. 1** show the present utilization and treatment of rice husk. The quantity of incinerated rice husk is large but that

Table 3. Present utilization and treatment of husk

Item	Percent
Incineration	32.9
Carbonated husk	8.7
Compost	15.9
Process compost	4.5
Process feed	0.4
Soil amendment	1.7
Floor material of livestock	9.9
Horticulture	6.6
Underdrainage material	2.7
Grinding	0.7
Fuel	1.3
Abandonment	7.3
Processing (board etc.)	0.3
Others	7.1

which is utilized in energy conversion is low. Difficulty in handling rice husk is one of the main reasons of incineration, and this treatment could be considered as an irrational solution because most of the energy produced during incineration of rice husk is lost to tte atmosphere.

Matsuyama found that rice husk keeps materials warm in the iron industry. Pig-iron is usually cooled after each process of iron manufacture. In order to prevent this heat loss, pig-iron can be covered with a layer of rice husk. In the Eapanese shochu industry, a kind of alcohol, rice husk is a raw material of this product. A composition of the same quantity of rice husk and "sake" draft is boiled and fermented to produce this kind of alcohol. Rice husk is a feed stuff produced by ammonia treatment. In Japan, the mixing ratio of rice husk in feed staff up to 20% is allowable. Crushed rice husk can be mixed in feces and urines of cattle as a moisture-regulator material for compost making. Rice husk is effectively used as material in underdrainage and soil amendment. In the nursery, rice husk is a good material for seedbed. Moreover rice husk is also an oil absorbent material.

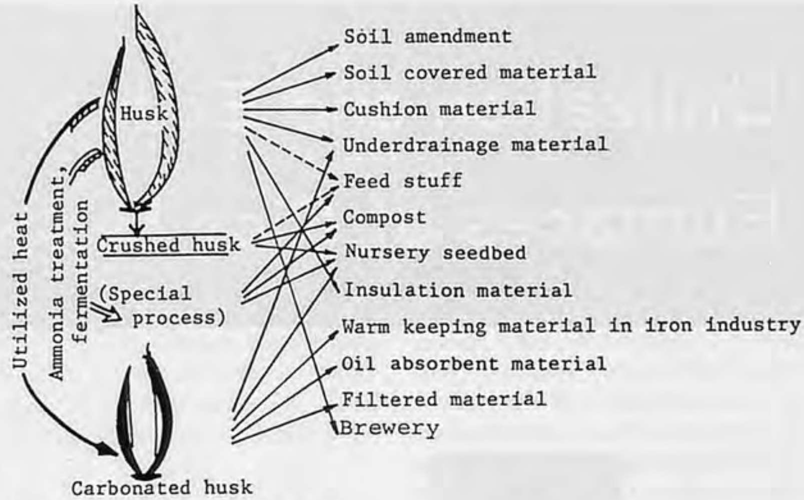


Fig. 1 Some utilization of rice husk

Energy Conversion Furnace of Rice Husk

Rice husk furnaces have been in use for many years now in Japan. All of these equipments have the function to incinerate, or to produce carbonated rice husk, or to produce heated air from rice husk combustion. This energy is used in heating greenhouses or drying grains.

Important Points of Rice Husk Furnace

Handling of rice husk – In handling rice husk, a pneumatic coveyor and cyclone have been developed. But the wear and tear of contact parts and dust density are still a problem which should be considered.

Need for a uniform combustion – In mantaining a uniform combustion, rice husk must be supplied continuously into the combustion chamber in a fixed quantity. Carbonated rice husk and ash are discharged continuously, and air is supplied with an optimum flow. In order to supply and discharge rice husk and ash in fixed quantity, devices which adopt forced air, rotating rooster, drum and cyclone have been also developed. In regard to combustion, the method in which combustible gas, after the first combustion, is completely burnt with the intake of secondary air is effective, and in fact, many types of rice husk furnace adopt this principle.

Durability of rooster – Since the temperature of the layer of red heated combustion reaches about 13000C, the wear of rooster should be regarded. For this reason, the rooster of the chain conveyor type or rotating type have been adapted, and there are also other devices in which excess temperature is prevented, or the outer part of the furnace is cooled by water. If the screen of the rooster is clogged, the combustion will be discontinuous, and in avoiding this case, the injected air or the device which prevents clogging by means of the impact caused by up and downward moving have been adapted.

Prevention of scattering of dust and ash – Because the quantity of fine particles generated by the cyclone device is small, the scattering of dust and ash is a public annoyance. Dust which is dispersed in gas can be filtered if it

Table 4. Types of husk furnace

Rooster	Fixing	Flat grate			
		Inclined grate			
		Forced air			
	Rotating	Spreader			(Fig. 2)
		Lattice cylinder			(Fig. 3)
		Chain conveyor			(Fig. 4)
Flowing type	Drum	Vertical	Straight flow		(Fig. 5)
			Circulating flow		(Fig. 6)
		Horizontal	Circulating flow		(Fig. 7)
	Cyclone				
Special type		Gas combustor			(Fig. 8)

passes through a layer of red heated combustion or it can be taken out by a cross (dust collecting device) installed separately.

Smoke emission—Emitting of smoke occurs because the temperature of the furnace is low in the first stage of operation, hence combustion is not complete. This problem diminishes when indirect heated air is used. In order to prevent smoke emission during the first period of operation, an oil burner is usually attached to the furnace. Since the carbonated rice husk can be used as cover material for nursery seedbeds or restored in soil as a fertilizer, there are several types of furnace which produce carbonated rice husk and heat than those that provide only complete combustion.

Classification of rice husk furnace – Classification of rice

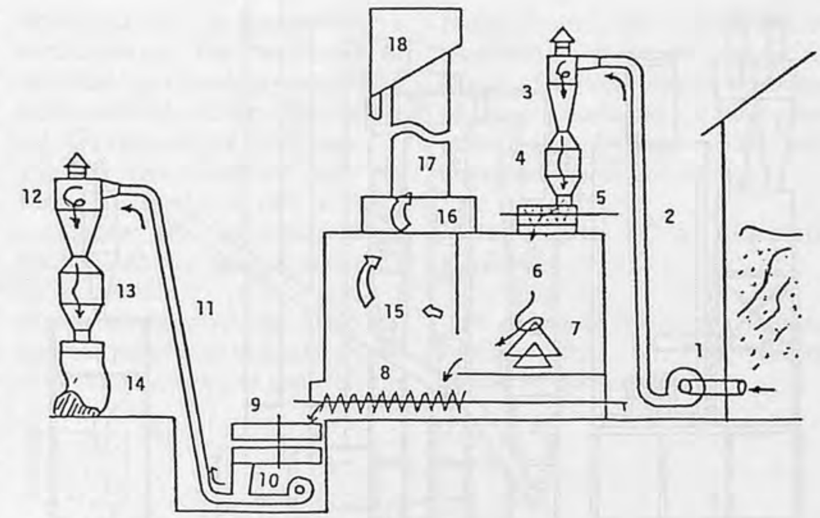


Fig. 2 Husk-furnace of rotating spreader type
1 : Husk conveyor blower, 2 : Husk conveyor pipe, 3 : Cyclone, 4 : Hopper, 5 : Feeding screw, 6 : First burning chamber, 7 : Rotating spreader, 8 : Screw conveyor, 9 : Carbonated husk extinguisher, 10 : Carbonated husk conveyor blower, 11 : Carbonated husk conveyor pipe, 12 : Cyclone, 13 : Carbonated husk hopper, 14 : Carbonated husk container, 15 : Secondary burning chamber, 16 : Third burning chamber, 17 : Chimney, 18 : Showering tower,
(Kojima)

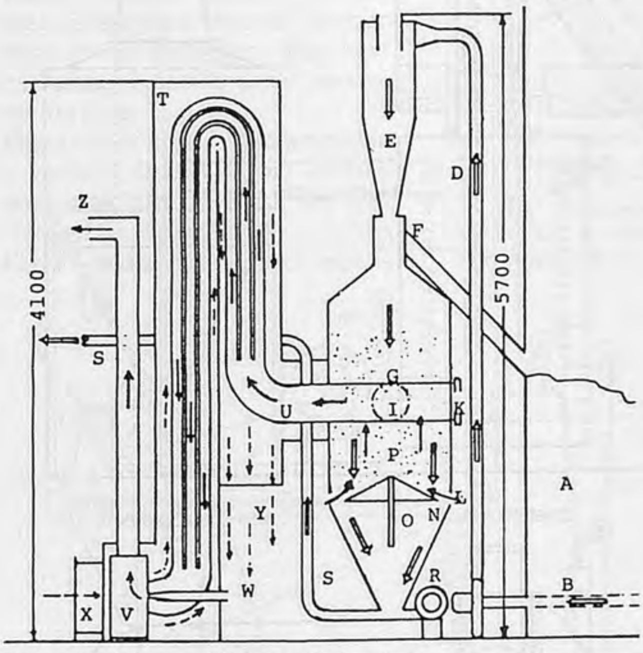


Fig. 3 Husk-furnace of lattice cylinder type
A : Husk chamber, B : Husk inlet pipe, C : Husk fan, D : Husk outlet pipe, E : Cyclone, F : Husk return pipe, G : Husk oven, H : Checking door, I : Rotating furnace bed, J : Driving pulley, K : First inlet air, L : Secondary inlet air, N : Ash dropping outlet, O : Ash hopper, P : Ash dropping device, R : Adjusting jack of ash dropping device, S : Ash conveyor pipe, T : Heat exchanging chamber, U : Combustion air pipe, V : Combustion air fan, W : Cooling air pipe, X : Blast fan, Y : Blast outlet, Z : Chimney
⇐Husk
←Combustion air
←---Blast
(Takano)

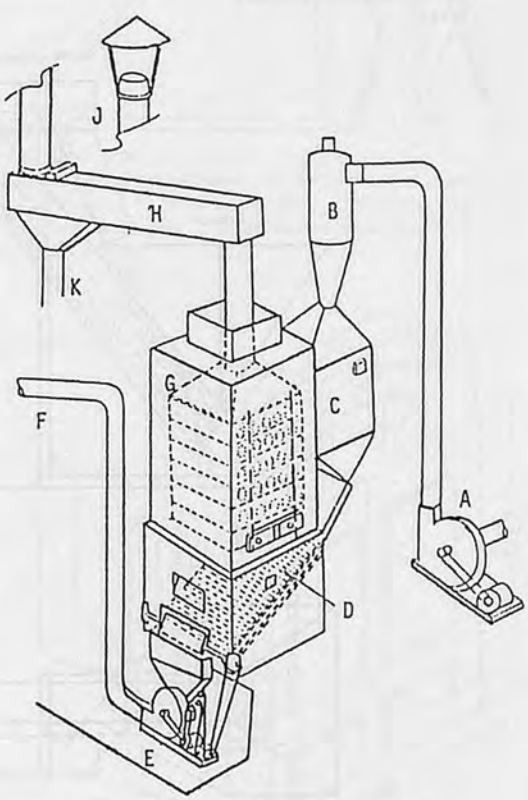


Fig. 4 Husk-furnace of chain conveyor type
A : Husk conveyor, B : Cyclone, C : Tank, D : Rotating rooster, E : Carbonated husk conveyor, F : Carbonated husk pipe, G : Heat exchanging device, H : Smoke path, J : Chimney, K : Dust collected gate
(Kanaoka 2)

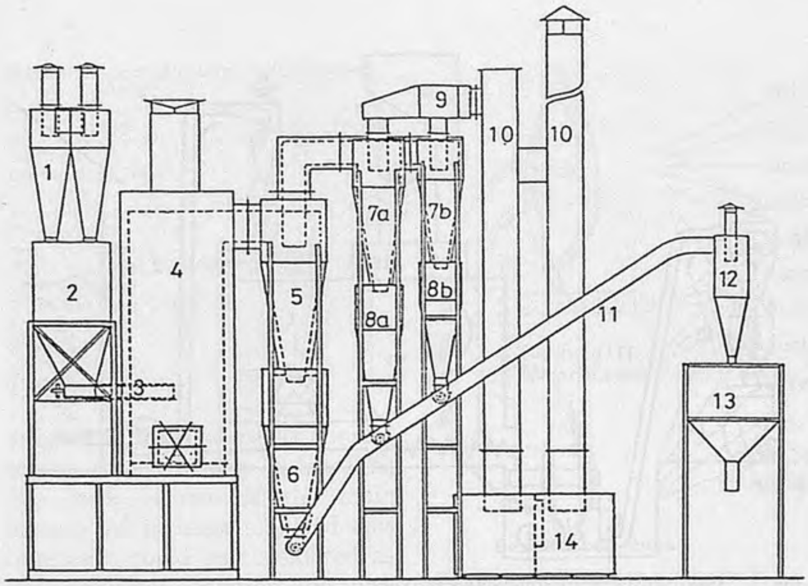


Fig. 5 Husk-furnace of vertical drum type
1 : Feeding cyclone, 2 : Hopper, 3 : Burner feeding gate, 4 : First burning chamber, 5 : Secondary burning chamber, 6 : Carbonated husk collector, 7 : Dust collected cyclone, 8 : Dust collector, 9 : Smoke path, 10 : Chimney, 11 : Carbonated husk conveyor pipe, 12 : Carbonated husk cyclone, 13 : Carbonated husk hopper, 14 : Precipitation chamber
(Arai)

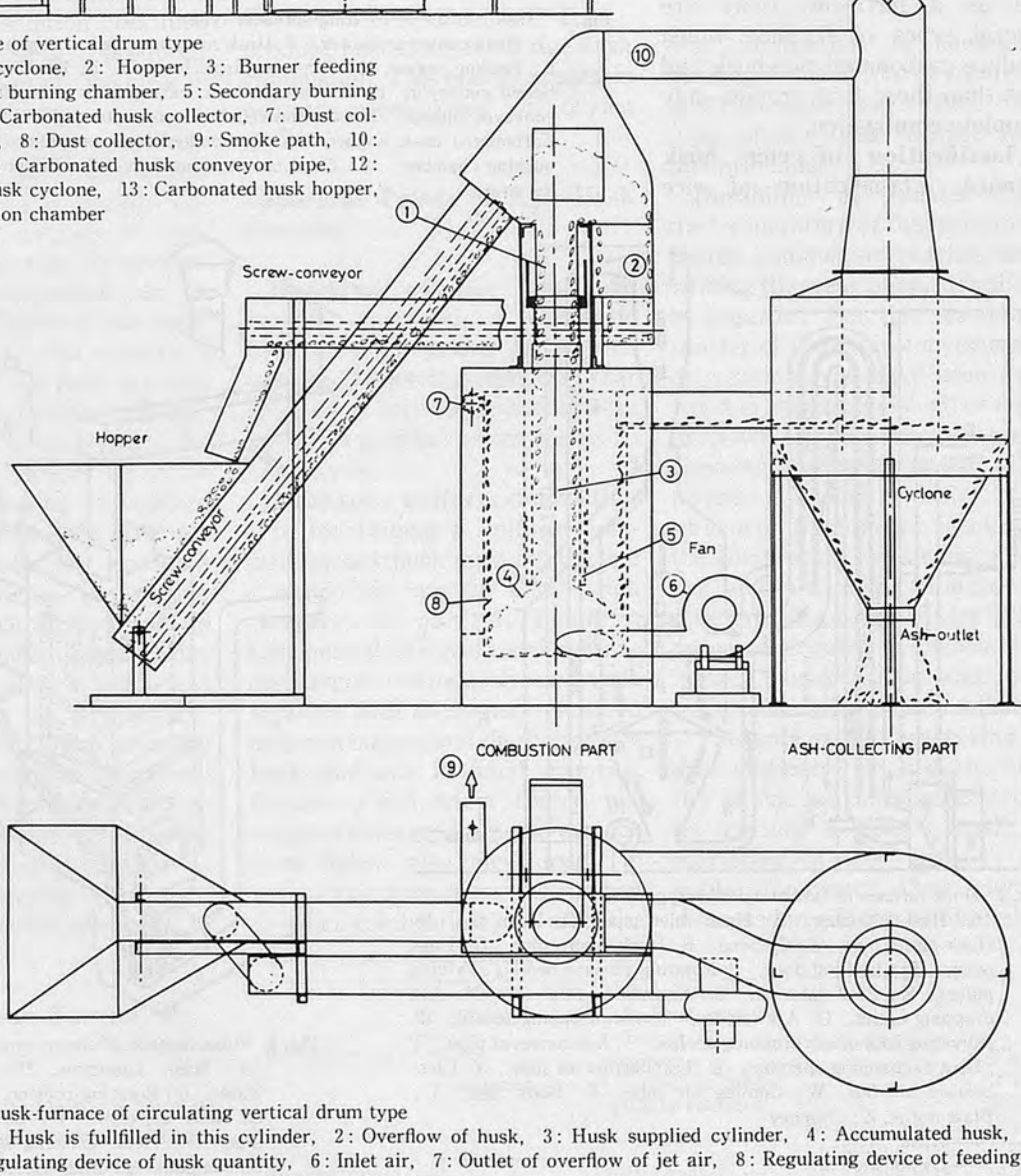


Fig. 6 Husk-furnace of circulating vertical drum type
1 : Husk is fullfilled in this cylinder, 2 : Overflow of husk, 3 : Husk supplied cylinder, 4 : Accumulated husk, 5 : Regulating device of husk quantity, 6 : Inlet air, 7 : Outlet of overflow of jet air, 8 : Regulating device ot feeding of husk, 9 : Discharge of clean heated air, 10 : Chimney
(Shizuki 2)

husk furnace is based on the structure of rooster. **Table 4** shows the classification of rice husk furnace. The principal structures of other types of rice husk furnace are shown in **Figs. 2–8.** These types of rice husk furnace are now in the market. Other types are being studied.

Fig. 2 : A type of furnace developed about 10 years ago is shown. Many drying storage facility complexes have adopted this kind of furnace to produce carbonated rice husk.

Fig. 3 : Carbonated rice husk produced in this type of furnace is discharged continuously and automatically by an ash drop outlet (N). Moreover, rice husk is supplied in a fixed quantity by a rotating bed (I). The indirect heated air is available by means of a heat exchanger.

Fig. 4 : A fixed quantity of rice husk is supplied into the furnace by a chain conveyor. The heat exchanger is in the upper part of the furnace.

Fig. 5 : Rice husk is incinerated in a vertical drum (4), and carbonated rice husk and ash are discharged by a cyclone.

Fig. 6 : In this furnace, rice husk is circulated and incinerated in a vertical drum. The combustion of rice husk is complete and heated air is available. After incinerating, ash is taken out by a cyclone.

Fig. 7 : The structure of this furnace is similar to that in **Fig. 6** except for the horizontal drum. Carbonated rice husk is taken out by a cyclone.

Fig. 8 : Carbonated rice husk and gas are separated in a gas generated chamber (e), and gas which is produced in this chamber is available.

Fig. 9 : This dust collector device is usually installed to filter fine particles and dust which are dispersed in gas and smoke.

Main Points of a Complete Furnace

In order to design a complete furnace, the following points should be considered :

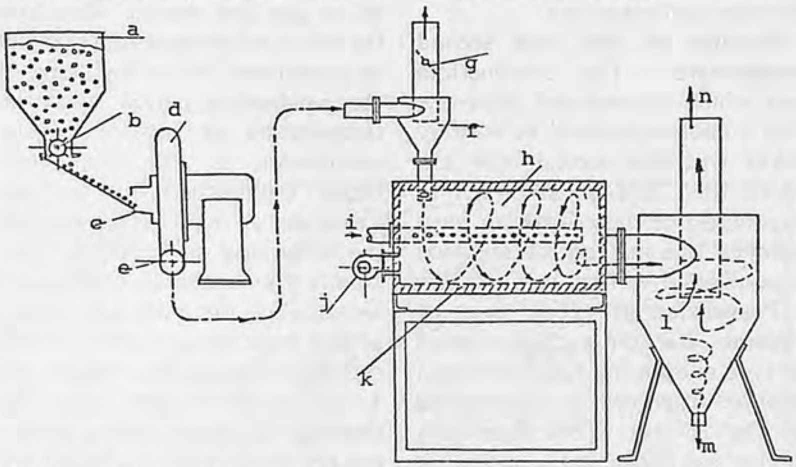


Fig. 7 Husk-furnace of horizontal drum type
a : Husk tank, b : Feeding roll, c : First air inlet, d : Air blower, e : Conveyor gate, f : Cyclone, g : Damper, h : Burning chamber, i : Secondary air inlet, j : Oil burner, k : Insulating material, l : Carbonated husk separating cyclone, m : Carbonated husk, n : Gas
(Nokiken 2)

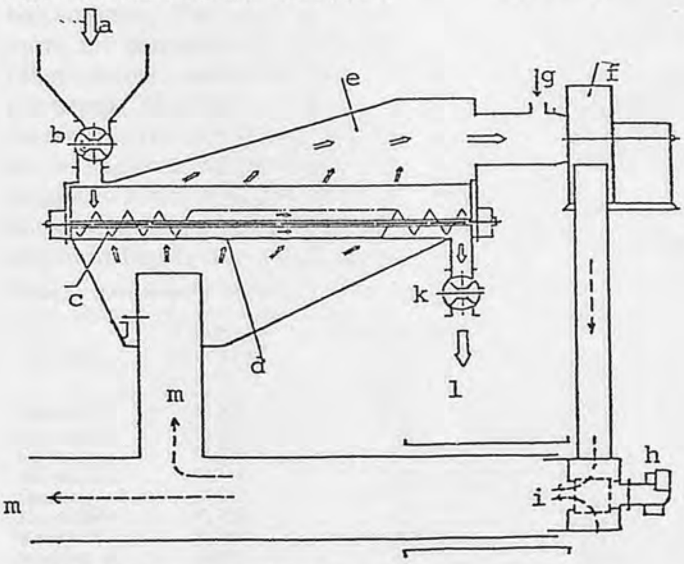


Fig. 8 Husk-furnace of gasified type
a : Husk, b : Feeding valve, c : Slit plate, e : Gas generated chamber, f : Suction blower, g : First air suction gate, h : Preheated burner, i : Burning chamber, j : Heated air inlet, k : Outlet valve, l : Carbonated husk, m : Usable heated source
(Kaneko)

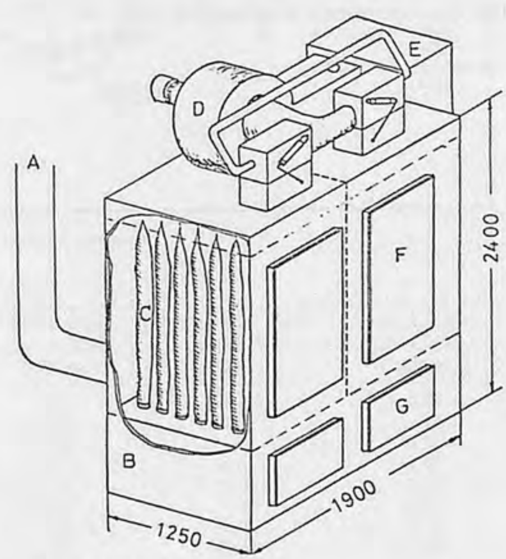


Fig. 9 Dust collecting device
A : Smoke path, B : Cross divided chamber, C : Cross, D : Blower, E : Silencer, F : Checking door, G : Door of dust collecting chamber
(Kanaoka 3)

Transportation of rice husk—In order to handle rice husk with ease and to save labor in transportation, air pneumatic conveyor has been developed. In this case, the wear and tear of pipes and fans and the incidence of dust should be given due consideration.

Fixed quantity of supplied husk—Screw conveyor or chain conveyor can supply rice husk to the furnace in a fixed quantity. Incinerated husk and ash are freely dropped and taken out.

Sorting of first and second combustions — The combustible gas which is produced after the first combustion could be entirely burnt with the second inlet air. More than half of all types of Japanese rice husk furnaces have adopted this method. Combustion is completed without smoke.

Prevention of excess heat of rooster—Rooster of chain conveyor type or rotating type have been adopted to prevent excess heating of the rooster. This regulating device has since been in use in Japan. The outer part of furnace is otherwise cooled by water to insure an extended use of rooster.

Prevention of clogging of rooster—Jet air is used to prevent the discontinuous combustion due to the clogging of screen of rooster.

Prevention of the scattering of dust and ash—Dust and ash can be filtered by a cyclone and a dust collector device.

Heat Exchange

Direct combustion is available for drying grain if smoke and soot are not emitted. In fact, smoke and soot are considerably dispersed in gas and smoke. Therefore the use of a heat exchanger should be considered. In the beginning of the combustion period when the temperature of furnace is low combustion is still incomplete, hence combustion air is not available. A heat exchanger has the advantage of supplying constantly the available combustion air. Already there are some types of rice husk furnace which install this device as shown in **Figs. 3** and **4.** At the present time when the shortage of energy source threatens the research of renewable use of rice husk has been highly evaluated. The extension of utilization of this resource, especially in view of energy conversion calls for further investigations.

REFERENCES

1 : Pimentel, D. et al , Food production and the energy crisis, Science, Vol. 182, pp. 443-449 (1978)

2 : Amir U. Khan , Rice drying and processing equipment for South East Asia, Trans. ASAE, Vol. 16, pp. 1131-1135 (1973)

3 : Eldon C. Beagle , Equipment and machinery to convert rice husk to energy and for other related functions, FAO, pp. 96-143

4 : Ritsuya Yamashita , Rice husk furnace, J. of the Soc. of Agri. Machinery, Japan, Vol. 39. No. 1, pp. 75-79 (1977)

5 : Ritsuya Yamashita , Energy consumption in drying of farm products, Symposium on energy utilization in agriculture, Japan, pp. B3-B5 (1975)

6 : Farm Machinery News, Japan, February (1978)

7 : Zennozuke Ratsuyama , Utilization of husk in agriculture and industry, unused resources in agriculture, The Soc. of Agri. Machinery, Japan, September (1977) ■■

Potential of Bullock Cart Transport in Orissa—A Case Study

It's problems and possible solutions

by **B. G. Yadav**
Reader
College of Agicultural Engineering and Technology
O.U.A.T. Bhubaneswar-751003, India

Introduction

Bullock carts are the main source of transport in rural areas of Orissa (1, 4). It is estimated that 587,206 bullock carts are in use in Orissa (2). The distribution of available bullock carts for cultivable and forest area per cart are given in **Table 1.** It is seen from the table that highest number of bullock carts are used in Puri and Sambalpur districts for transport of agricultural produce keeping the use at 4.01 and 8.83 ha per cart, respectively. The use of these carts for transport of wood and other forest materials are at minimum. The highest share of forest area per cart comes to 50.05 ha in Phulbani district being the largest in forest area amongst the various districts of Orissa as shown in **Fig. 1.** The larger share

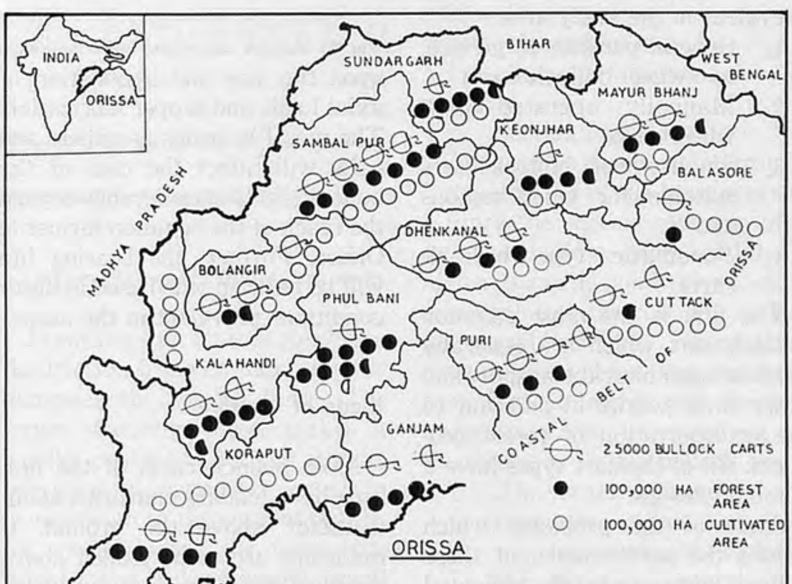


Fig. 1 Bullock cart distribution pattern in Orissa

Table 1. Distridution of Bullock Carts for Cultivable and Forest Land by District Farm.

Districts	Number of Carts**	Net Cultivated Area (1000ha)	Forest Area (1000ha)	Total Geographical Area (1000ha)	Cultivable Area per Cart (1000ha)	Forest Area per Cart (1000ha)
Balasore	27,206	449	100	647	16.49	3.68
Bolangir	73,085	487	163	883	13.12	4.40
Cuttack	36,408	626	84	1,089	17.18	2.31
Dhenkanal	67,144	404	297	1,092	6.02	4.42
Ganjam	45,380	254	401	1,220	5.59	8.84
Kalahandi	43,359	407	541	1,158	9.40	12.48
Keonjhar	10,448	195	350	831	18.61	33.50
Koraput	28,885	881	462	2,702	30.50	16.00
Mayurbhanj	48,302	349	347	1,042	7.22	7.18
Phulbani	15,225	151	762	1,104	9.85	50.05
Puri	88,883	374	292	1,046	4.01	3.29
Sambalpur	90,101	796	712	1,749	8.83	7.90
Sundargarh	12,780	318	464	979	24.91	36.31

Source : Agricultural Census of Orissa, 1970−71
*Calculated, **Data Collected from the statistical abstract of orissa 1973.

per cart of forest area in Phulbani, Sundergarh and Keonjhar districts indicates the tremendous potential of carts for use of transport of forest materials.

Carts are generally pulled by a pair or single bullock, some times with buffaloes, and have limited haulage capacity. Further, the narrow width of large diameter wheel sinks in country roads increasing the draft beyond the capacity of bullocks and damage other public roads during haulage. In addition, there are certain other constraints, too, which reduce the performance of various types of Orissa bullock carts.

Four types bullock carts are prevalent in the study area.

1. General purpose, large size, two-wheel bullock carts.
2. Manually operated two-wheel carts.
3. Small wheels bullock carts suitable for Ghat regions and
4. Pneumatic type bullock carts.

The first is the most common bullock cart which are generally used for agricultural transport and other farm works in addition to the transportation of forest products. All of the cart types have a common design.

Some of the problems which reduce the performance of these bullock carts are briefly indicated as follows.

Wheel Hub and Axle Friction

The size and shape of a typical bullock cart popularly used is shown in **Fig. 2.** The width of the hub is generally 30 cms. Wooden axles are used on bullock carts used in rural area. However, are also popular in bullock carts used in urban areas. The frictional contact on the both types of axles are large, and a good amount of energy is lost in overcoming the friction. The frictional contacts could be improved by putting a hard metal 2 to 3 hulls depending

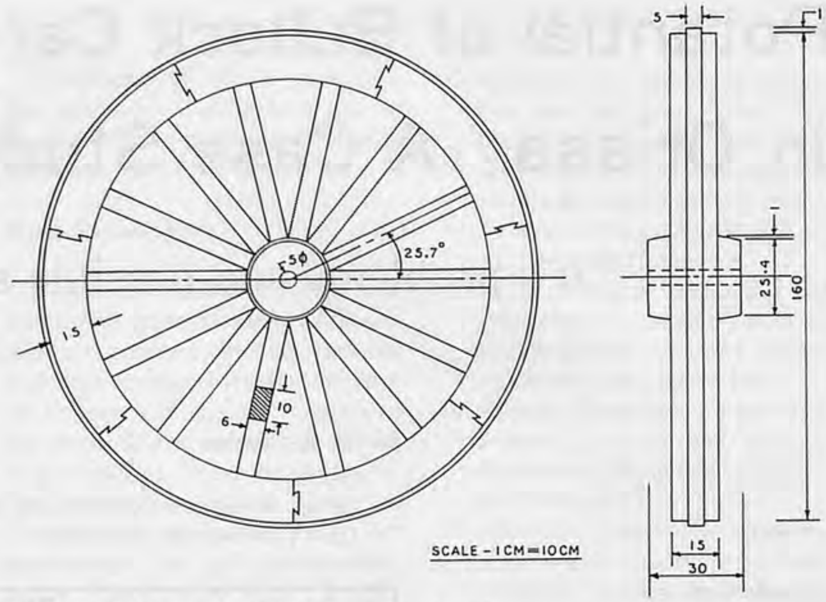


Fig. 2 Bullock cart wheel (all dimensons are in cm)

upon the size and application of axial loads and proper lubrication. The metal bearings as rollers and balls will affect the cost of the bullock carts considerably beyond the reach of the common farmer in Orissa. Further, the bearing life will be reduced when used in dusty conditions prevalent in the areas.

Mode of Loading

Most bullock carts of the first type have loading platforms about a meter above the ground. If materials are to be loaded above the platform it involves considerable amount of work. However, this clearance helps in loading considerably when load is to be carried beneath the loading platform specially when loading heavy (**Fig. 3**). Two labours can load ttem

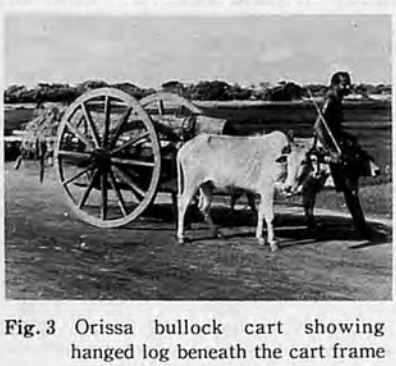


Fig. 3 Orissa bullock cart showing hanged log beneath the cart frame and load on top

easily. The bending moments developed on the beam at the wheel axle due to repeated shock affects the life of the bullock carts considerably. There is specific need to give the design compromise in respect of height of platform, mode of loading, cost and life of the bullock carts.

Rim Width and Diameter of Wheel

The diameter of the wheel and the rim width are very important in assessing the road damage and energy loss during the transportation. The ground contact area which is the product of rim width and a portion of wheel section determines wheel sinkage on the various types of roads depending on the load. A compromise design is the only solution to this problem.

Cart Balance

During the operation of cart under load, as the cart's frame is hanged in centre as a double cantilever, transfer of certain load on the shoulder of the bullock over undulating terrains causes sore neck resulting in cancerous diseases and unwillingness of bullocks to neck and pull the yoke. Further, during the halting position the weight is supported on the neck of bullocks. A third wheel in rear will support the weight of the cart reducing the weight on the yoke and shoulder of bullock and keep the cart in dynamic balance.

Manually Operated Cart

The second category of bullock carts are used for transporting smaller loads for much shorter distance as transportation of wood, forage crops grain bags, etc. Since these carts are towed/pushed instead by animals, (**Fig. 4**) they are useful for transporting smaller materials frequently. They need due consideration for design improvement, hence afficiency.

Fig. 4 Hand pushed cart for transporting wood and grain bags

Design of Bullock Cart Wheel

The towing force (F) required by a pair of bullock under any particular loading (W) depends on wheel diameter (D) rim width (b) and friction between axle and hub (μ).

It can be written as:

$$F = f\,(W, D, b, \mu) \quad \cdots\cdots(1)$$

By rearranging the terms and using the principles of dimensional analysis.

$$F\frac{d}{b} = K\,(\frac{W_n}{b}), \mu \quad \cdots\cdots(2)$$

Based on the experiments it is established that the value of

n = 3/2 (Gill and Waden Berg 5)

Further

$$F\frac{d}{b} = K\,(\frac{W}{b})^{3/2} + C \quad \cdots\cdots(3)$$

Where K is the slope of the curve when plotted on ordinary graph paper and C is the constant.

Rearranging the terms eqn. (3) yields

$$F = \frac{K}{d}\frac{W}{b} + \frac{b}{d}C \quad \cdots\cdots(4)$$

From eqn (4) it is clear that the towing force is directly proportional to $W^{3/2}$ whereas inversely proportional to wheel diameter. The effect of width b is not clear from equation (4).

Under a particular loading W, for a minimum towing force

$$\frac{dF}{db} = O \quad \cdots\cdots(5)$$

Differentaiting eqn. (4) and equating to zero

$$\frac{dF}{db} = \frac{K}{b}W^{3/2}(-\frac{1}{2})b^{-3/2} + \frac{C}{d} = O$$

$$b = (\frac{K}{2c})^{2/3}W \quad \cdots\cdots(7)$$

The actual value of $(\frac{K}{2c})$ can be determined experimentally.

Friction Between Wheel and Axle

From the eqn, (2) it is clear that the friction between hub and axle increases the towing force. The larger diameter wheel makes a smaller contact in the hub at axle, operating at particular speed, in comparision to the smaller diameter wheel. Hence the total frictional force is considerably small resulting in lower towing force.

Considering the above design criterion the following should be the dimensions of the cart wheel.

1. Diameter of wheel 150 to 180 cms
   (a compromise dimension for loose sand and hard clay or other soils)
2. Rim width 7 to 10 cm
   (suitable for country roads and farm terrains)
3. Load: Higher possible load depending upon the pulling capacity of a pair of bullock should be considered on loose sand (Ojha & Pandya 3.)

Design of Axle

The load on cart wheels act through axle. As mentioned earlier, two types of cart axles are commonly used, wooden and circular steel.

The wooden axles are poor in performing the task and wear off frequently, but steel axles are costly. The replacement of solid circular axle with a hollw circular shaft will reduce the cost.

The design equation

$$\frac{M}{I} = \frac{f}{y} \quad \cdots\cdots(8)$$

Can be re written as;

$$M = \frac{I}{y}f \quad \text{or}$$

$$M = fz$$

Where M bending moment

f allowable stress of the material

z Section modulous

The section modulus determines the strength of the cross section.

Since the section modulus of a circular hallow cross-section is higher than the solid for an equal sectional area the cost will be less for equal strength when same material is used for their construction. The following are the few suggestions for improvement of the exhisting Orissa bullock carts.

1. The larger diameter of the cart wheel offers least rolling resistance and increases the ground contact. The wider width causes high rolling resistance but narrow wheels sink frequently. A compromise solution yields better result. The ratio of rim width and wheel diameter $(\frac{b}{D})$ should be optimized for minimum rolling resistance for average and above average loads to utilize the fuller capacity of the cart.
2. A third rear trailed wheel should be fitted in the horizontal slot made on the frame to support the cart weight and slide the wheel on a side in line of axis of

either of the wheels for the period when logs are to be hanged and transported beneath the cart.

3. The extension of cart frame should be adjustable in width to accommodate the bulk of materials and when its' position is reversed should form a hood. A canvas or cloth cover make a good protection for the farmer during transport.
4. The cart axle should be made of hollow circular pipe for higher sectional modulous excepting the bearing points in the hubs for higher axial loads. The hub axle should be solid and circular with moderate width and of hard materials as bronze etc.
5. The hitch of the yoke on the cart should be flexible. Provisions should be available to made it rigid instantaneously when required.
6. Provisions should be available to break the motion of the cart during down slopes at the control of the cart operator.
7. The yoke should be circular, but free to rotate slightly on it's axis with the variation in direction of force. The yoke should be made of a light and soft wood.

The above suggestions are for carts used in rural and semi-urban areas when cart owners possibly cannot afford to own more than one cart or pneumatic wheel assemblies as spare. Further, the use of local materials and cost oaf the cart are the greatest limiting factors along with the availability of village artisans for it's manufacture.

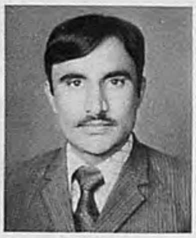
ACKNOWLEDGEMENT

Author is thanful to the Dean, College of Agricultural Engineering and Technology Bhubaneswar for providing the facilities for this work.

REFERENCES

1. Anon, Agricultural census of Orissa, 1970-71.
2. Anon, Statistical abstract of Orissa, 1973. Burea of Statistics and Economics Orissa, Bhubaneswar.
3. Ojha, T. P. and Pandya, A. C. Optimum size of bullock cart wheel, J. Agric. Engg Res. 13 (2), 134-140. 1968.
4. Vagh, B.V. A design for bullock cart wheel. J. Indian Road Congress 9 (1), 1944.
5. Gill, W. R. and Waden Berg, G. E. Soil dynamics in tillage and traction 381-391, 168. ■■

Design and Testing of Groundnut Decorticator



by

Rajvir Singh
Research Engineer
Rice Process Engineering Centre
I.I.T., Kharagpur, India

R. Shrivastava
Scientist SI
I.A.R.I., New Delhi
India

Bhagwan Singh
Associate Professor
C.B. Pant University of Agriculture
& Technology, Pantnagar, India

Abstract

The paper describes the design and fabrication of different components of groundnut decorticator. The various parameters such as blower speed, airflow rate, eccentric speed, cylinder speed and feed rate have been studied during the experiments. The highest decorticating efficiency (98 percent) was obtained at 100 rpm cylinder speed, 150 kg/hr feed rate and 15 percent moisture content at a clearance of 1.5 cm.

Introduction

The groundnut is a cultivated annual herb grown in many tropical and temperate countries for its seeds which contain 50 per cent non-drying oil and about 35 per cent protein. Groundnut production in India is about 6,000,000 tonnes annually.

The groundnut pods after harvest are marketed as such or as kernels after decortication. Though decortication helps to reduce volume and transport charges, it is disadvantageous in that the kernels are easily attacked by insects and deteriorate much more rapidly than pods.

Two methods of decortication are prevalent in India ; hand-shelling and power decorticating. In the process of hand shelling the pods are previously moistened with water and spread in thick layers over a threshing floor and beaten with sticks and stirred frequently till all the kernels break. On the other hand the power decorticators come in two types : grate and beater type.

The grate type is preferred to the beater type as the percentage of breakage of kernels is comparatively small.

Since the aim of the owner of the machine is to maximize output per hour they run the machine at high speed, unmindful of the quality of the kernels turned out. Very little attention is being paid to the efficiency of machines in order to produce quality kernels. This is due to the lack of technical knowledge on the part of operators. The producer, on the other hand, is indifferent to the percentage of brokens since he is not aware of any appreciable premium for better quality ground nut.

To be sure, there is need for further studies in order to evolve different parameters for efficiency of the groundnut decorticating machine.

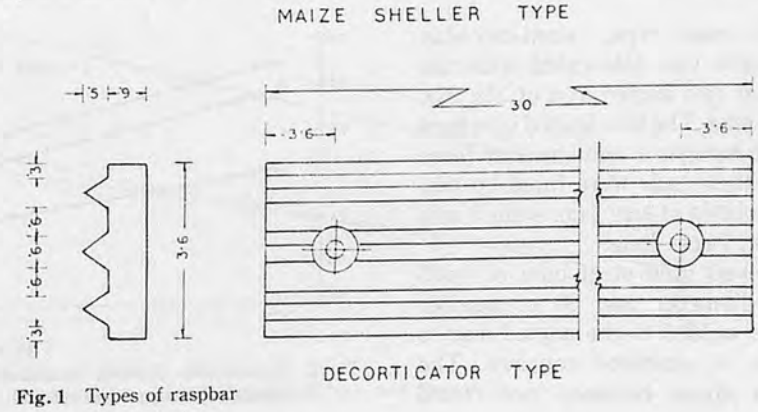


Fig. 1 Types of raspbar

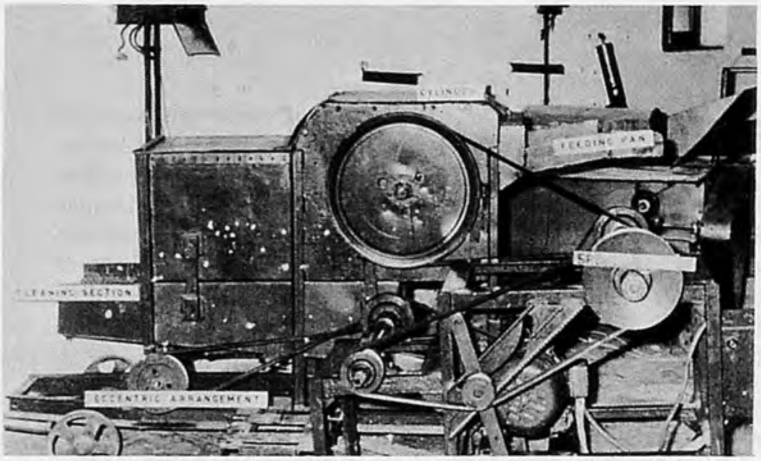


Fig. 2 Isometric of groundnut decorticator

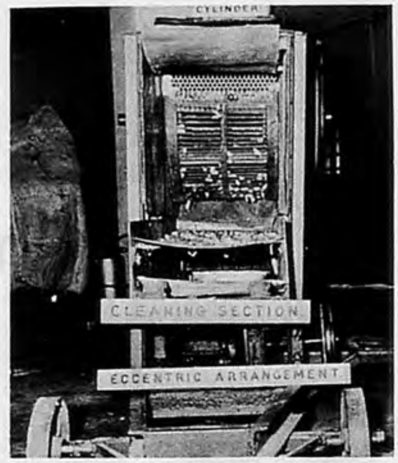


Fig. 3 Concave and cleaning section

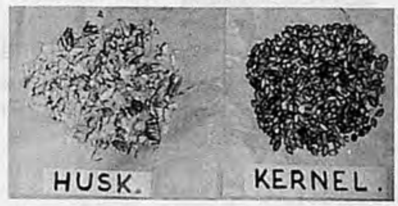


Fig. 4 Husk and shelled kernels

Materials and Methods

The diameter and length of the experimental cylinder were 45 cm and 30 cm, respectively. No. 8 rasp bars were provided on the periphery of the cylinder for giving the shearing action on groundnut pods. Maize sheller type and decorticator type rasp bars were used for experiments as shown in **Fig. 1.** On the basis of some initial trials the cylinder speeds between 48 mpm ad 100mpm (59 mpm ad 142 mpm) were selected for further extensive trials to test the performance.

A replaceable concave assembly of the open type was designed according to the size of the pods and seeds. Average thickness of pods and seeds were found to be 1.21 cm and 0.80 cm, respectively. The average length of pods and seeds were found to be 2.68 and 1.39 cm, respectively. The clearance between cylinder and concave at inlet was 4.00 cm and clearance at outlet was 0.75 to 1.5 cm.

A case type, semi-circular concave was fabricated with the use of two angled iron of 35x 35x 5cm size. The two angled iron bars were bent in a semi-circular form and their ends were fixed by two flat plates of size 2 cm wide, 3 mm thick, 74 cm long.

Round mild steel bars of 0.635 cm diameter and 80 in number were welded to the angled iron to form a complete concave. The clear space between two round bars was kept at 1.1 cm.

On the basis of the aerodynamic properties of groundnut shells and a few preliminary trials on the machine indicated the necessity of more intense velocity of the air with a particular directional concentration. Therefore, a blow-

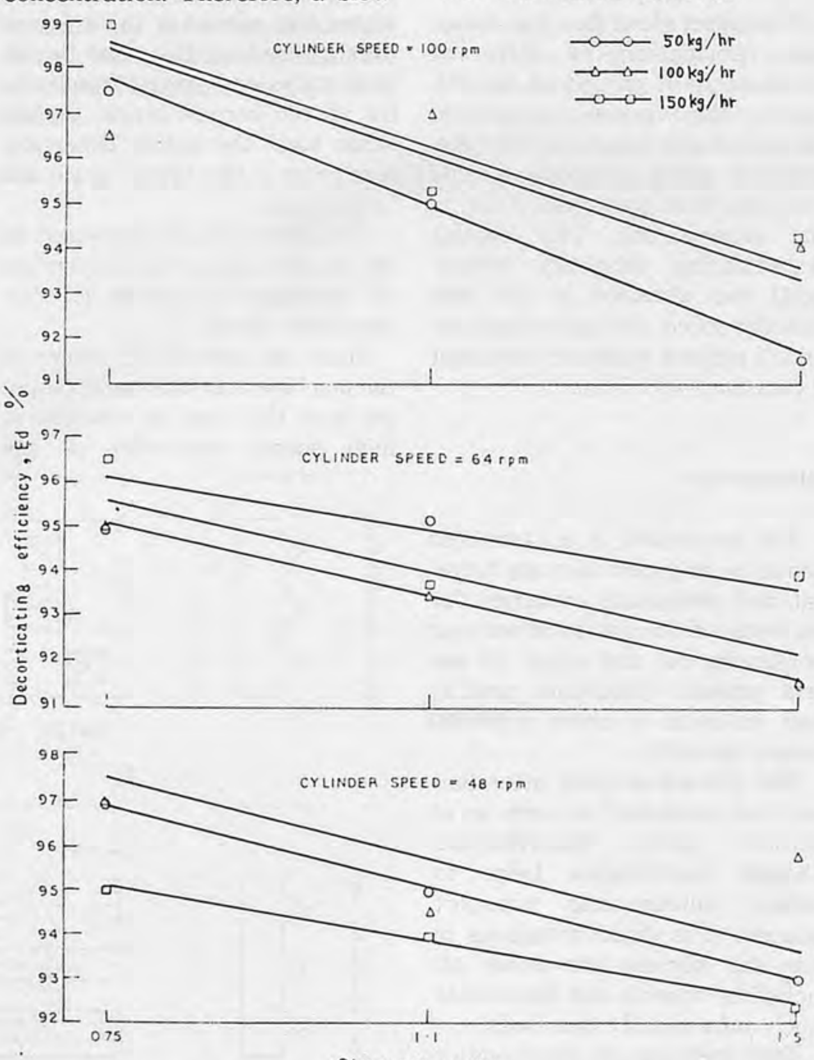


Fig. 5 Relationship between decorticating efficiency and clearance at different cylinder speed and feed rates

er of 1700 rpm (460 mpm) was selected for cleaning the kernels.

A complete isometric view of the machine is shown in **Fig. 2. Fig. 3** shows the open type concave and cleaning section.

The operational procedure of the machine is outlined as follows:

The groundnut pods were fed to the cylinder concave assembly at a rate of 50, 100, 150 kg/hs. The materials were collected at the two outlets, one delivery chute sloping below the pan towards the ground, containing decorticated kernels and other product, containing husk and shells at the rear of the machice. The decorted kernels were taken by hand and whole grains were separated. Then the rest was passed through 480 mesh number sieve.

The finer broken particles were separated from the other broken grains. All the three components were weighed separately. Undecorticated pods were separated from husk and weighed. A photograph of shelled kernels and husk is given in **Fig. 4**.

The following variables were taken into consideration during the tests.

i) Cylinder speed: 48, 64, 100 rpm in sequence of 59, 91, 142 meter per minute.

ii) Clearance: at inlet 4 cm (constant) and at outlet 0.75 cm, 1.10 cm, and 1.50 cm.

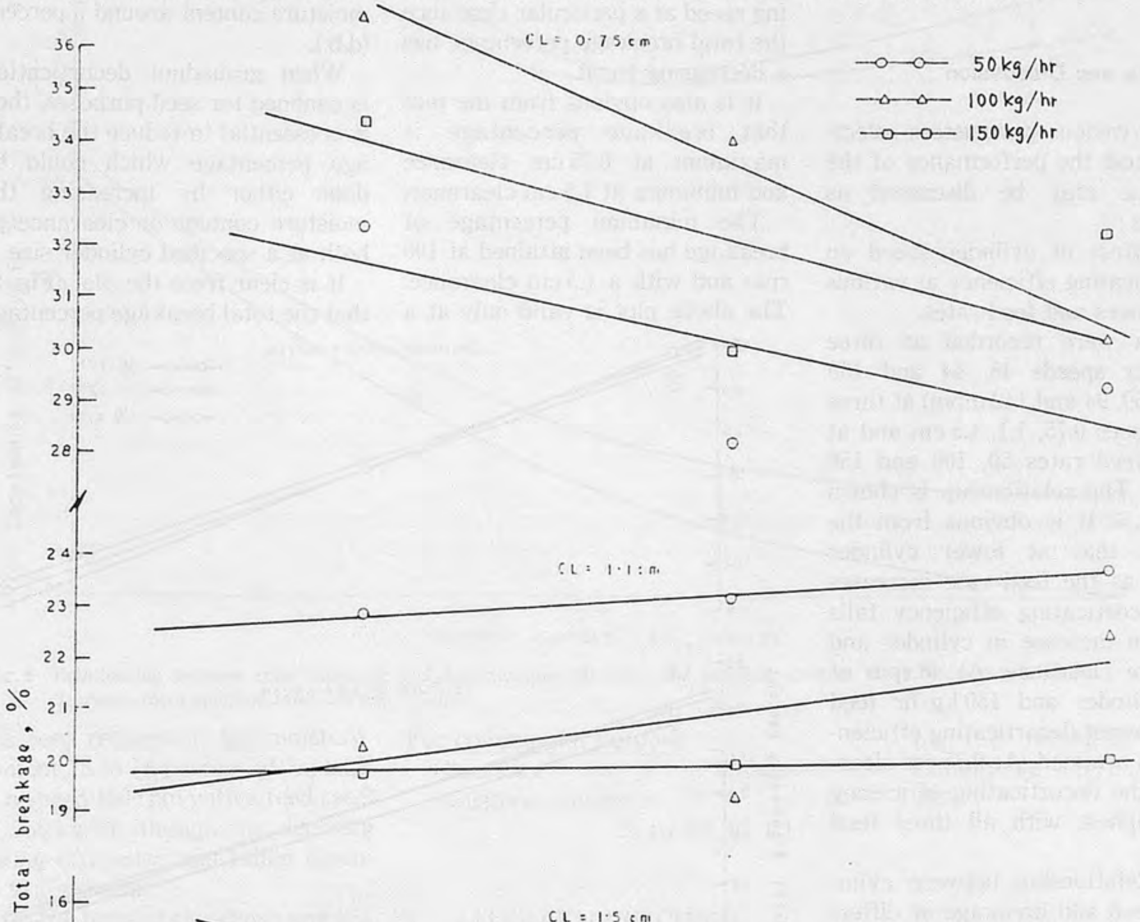


Fig. 6 Relationship between total breakage and cylinder speed at different feed rates and clearances

iii) Feed ratio : 50, 100, and 150 kg per hour.

iv) Moisture content : (dry basis) 5, 15 and 25 percent.

Keeping the clearance constant, the revolutions of cylinder was changed for three rates and were recorded for three sets of clearance, three sets of cylinder speed, three sets of feed rate and moisture content.

A 3.5hp motor was used to run the machine at full load.

Results and Discussion

The various parameters selected to test the performance of the machine may be discussed as follows :

i) Effect of cylinder speed on decorticating efficiency at various clearances and feed rates.

Data were recorded at three cylinder speeds 48, 64 and 100 rpm, (59, 94 and 142 mpm) at three clearances 0.75, 1.1, 1.5 cm and at three feed rates 50, 100 and 150 kg/hr. The relationship is shown in **Fig. 5**. It is obvious from the graphs that at lower cylinder speed, as the feed rate increases the decorticating efficiency falls with an increase in cylinder and concave clearance. At 48 rpm of the cylinder and 150 kg/hr feed rate, lowest decorticating efficiency was attained. At 0.75 cm clearance, the decorticating efficiency was highest with all three feed rates.

ii) Relationship between cylinder speed and breakage at different clearances and feed rates.

It is evident from the plot (**Fig. 6**) that as the cylinder speed increases, the breakage percentage, half and full both decreases at a fixed rate. At 0.75 cm clearance breakage percentage have been found to be higher for all the cylinder speeds and feed rates in general.

Minimum breakage was found at 100 rpm of cylinder and feed rate of 150 kg/hr with 1.5 cm clearance. So a speed of 100 rpm with a clearance of 1.5 cm may be fixed as optimum operating parameters from minimum breakage point of view.

iii) Relationship between clearance and total breakage at various speeds of cylinder and feed rates.

The plot shown in **Fig. 7** predicts the nature of this relationship as follows :

The total percentage of the breakage is a linear function of speed and feed rate. With increasing speed at a particular clearance the total breakage percentage has a decreasing trend.

It is also obvious from the plot that breakage percentage is maximum at 0.75 cm clearance and minimum at 1.5 cm clearance.

The minimum percentage of breakage has been attained at 100 rpm and with a 1.5 cm clearance. The above plot is valid only at a fixed moisture content.

iv) Relationship between moisture content and decorticating efficiency and breakage.

For commercial decortication where breakage has little effect on the market value of this product, a clearance of 0.75 cm and speed of 100 rpm may be proposed. The decorticating efficiency of 98.5 percent was attained with 150 kg/hr feed rate and 0.75 cm clearance with 100 rpm of cylinder taking moisture content around 5 percent (d.b.).

When groundnut decortication is confined for seed purposes, then it is essential to reduce the breakage percentage which could be done either by increasing the moisture content or clearance or both at a specified cylinder size.

It is clear from the plot (**Fig. 8**) that the total breakage percentage

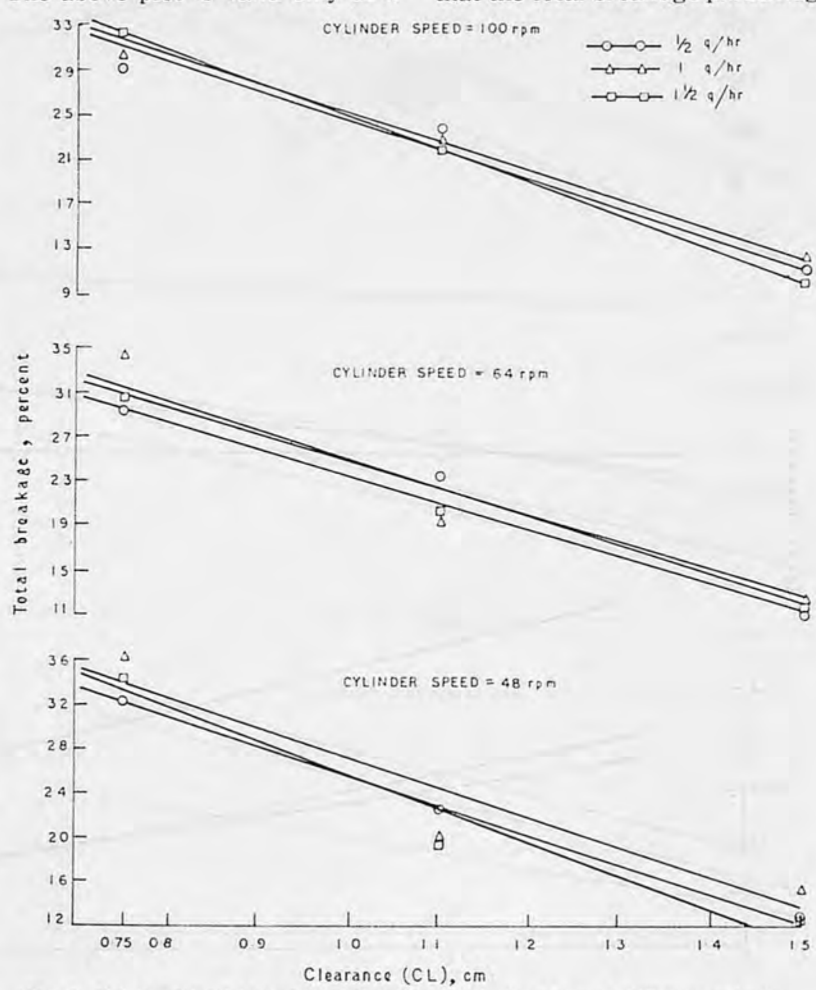


Fig. 7 Relationship between total breakage and clearance at different cylinder speeds and feed rates

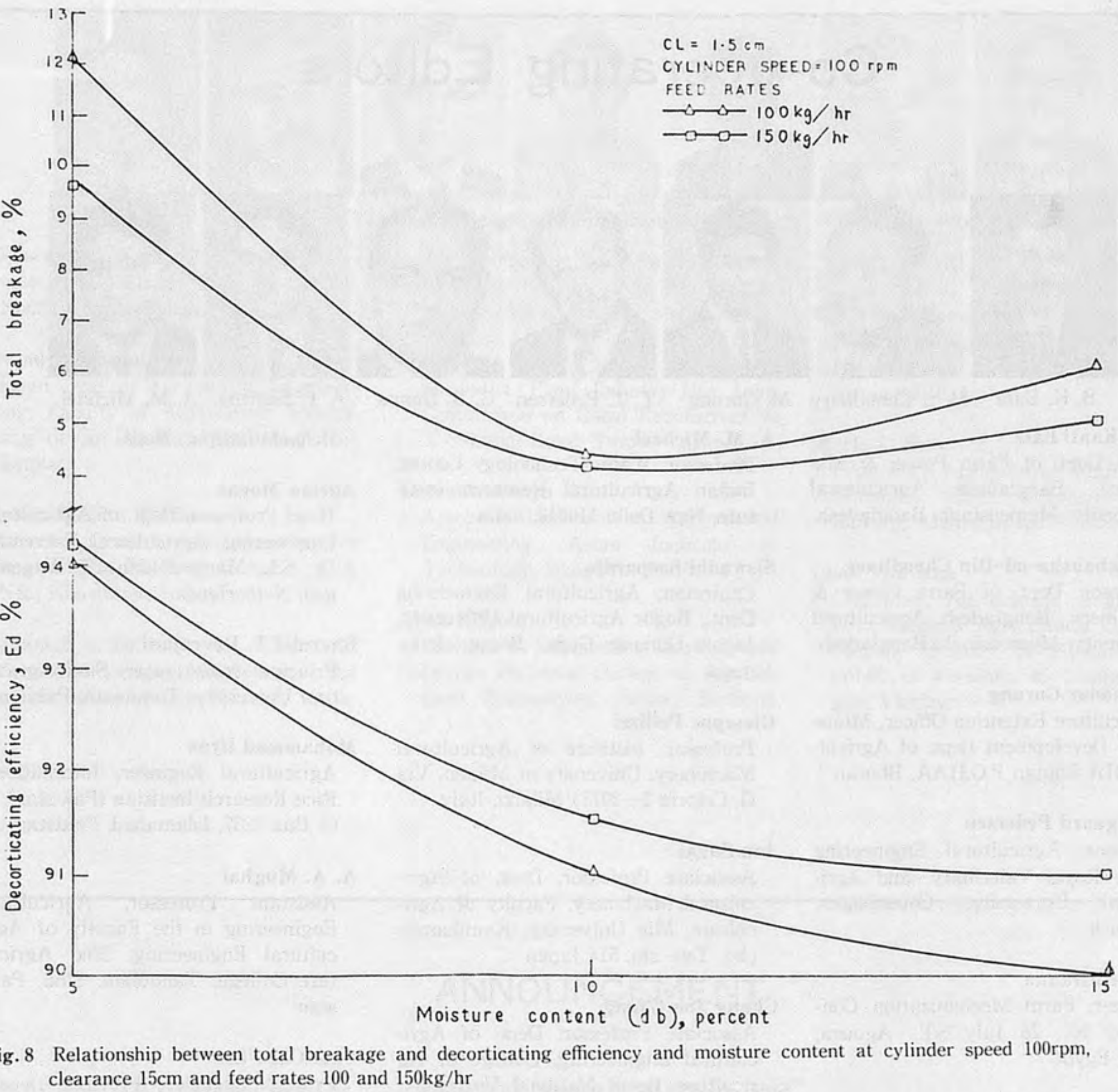


Fig. 8 Relationship between total breakage and decorticating efficiency and moisture content at cylinder speed 100rpm, clearance 15cm and feed rates 100 and 150kg/hr

has been reduced at the moisture content 15 to 18 percent (d. b.) and at a speed 100 rpm with a feed rate of 150 kg/hr, though the decorticating efficiency has fallen down to 91.5 percent.

On the basis of the above studies the proposed parameters were optimized for groundnut decortication.

blower speed = 1,700 rpm (460m/min)
Air flow rate = 12m³/min.
Eccentric speed = 120 rpm
Cylinder speed = 100 rpm (142m/min)
Feed rate = 150kg/hr.

<u>For seed purpose</u> Clearance = 1.5cm
Moisture content = 15 to 18% (d. b.)

<u>For commercial purpose</u>
Clearance = 0.75cm
Moisture content = 5 to 8% (d. b.)

LITERATURES CITED

1. Mittal, J. P., Singh, Bhagwan and Jackson, M. G. (1972). Processing of Mango Guthalies (Stone) by Mango Guthali Decorticator for Evolving Economic Ration for Livestock, paper presented at annual convention of I. S. A. E.

2. Study of Groundnut in India, Prepared by Committee on National resources, Planning Comminnion, Published by the Indian Central Committee, Hyderabad, 1963.

Co-operating Editors

B. K. Bala M. S. Choudhury M. Gurung T. T. Pedersen G. B. Hanna A. P. Sharma A. M. Michael

Siswadhi Soepardjo G. Pellizzi Jun Sakai Chang Joo Chung B. K. Shrestha Adrian Moens

B. T. Devrajani Mohammad Ilyas A. A. Mughal Chul Choo Lee R. P. Venturina Arumugam Kandiah

A. H. Abdoun M. A. Bedri Tien-song Peng Gajendra Singh John Kilgour W. J. Chancellor M. L. Esmay

Research, National Science Development Board, P.O. Box 3596, Rizal, Manila, Philippines

Arumugam Kandiah
Head, Dept. of Agricultural Engineering, Faculty of Agriculture, University of Sri Lanka, Paradeniya, Sri Lanka

Abdien Hassan Abdoun
Director General Administration for Engineering, Ministry of Agric., F & NR., Khartoum, Sudan

Mohamed A. Bedri
General Manager, Democratic Republic of the Sudan Ministry of Industry Project for Manufacture & Assembly of Trucks & Tractors, P. O. Box 1855 Khartoum, Sudan

Tien-song Peng
Specialist, Plant Industry Div. Joint Ccmmission on Rural Reconstruction 37, Nanhai Road, Taipei, Taiwan

Gajendra Singh
Associate Professor of Agricultural Engineering, Asian Institute of Technology, Bangkok, Thailand

John Kilgour
Lecturer in Engineering Drawing and Design, National College of Agricultural Engineering, Silsoe, Bedford. MK45 4DT, U. K.

William J. Chancellor
Professor, Agricultural Engineering, University of California, Davis, California 95616, U.S.A.

Merle L. Esmay
Professor, Agricultural Engineering, Michigan State University, East Lansing, Michigan 48823, U.S.A.

Chau Van Khe
Chairman, Agricultural Engineering Div. National Agricultural Center in Saigon, Ministry of Education Republic of Vietnam, 45 Chungde Saigon, Vietnam

ANNOUNCEMENT

To Contributors for "Agricultural Mechanization in Asia"

We are all pleased to have many excellent articles for our AMA contributed from all over the world.

We would like to ask herewith your cooperation to improve our international journal AMA.

You should send your papers firstly to the Co-operating Editor in your country, and he will send it to Chief Editor after his check and estimation.

In case there is no Co-operating Editor in your country, please send your papers to Chief Editor directly.

We always thank for your contribution and look forward to having the papers on your remarkable activities and useful experience.

Yoshisuke Kishida
Chief Editor

NEWS

The first presentation of "Kishida International Award"

Mr. Ralph C. Hay is receiving the diploma at the ceremony of awarding

The first presentation of ASAE Kishida International Award was taken place in June 30, the last day of the Summer Meeting of American Society of Agricultural Engineers (ASAE) which was being held at Utha State University at Logan, Utha, U.S.A. from June 27, with splendor among over 1,000 ASAE members including the foreigners. The establishment of this Award was formally decided in the last Summer Meeting, and since then its development was being watched with keen interest.

To the first recipient of this Award, they elected Mr. Ralph C. Hay, professor Emeritus of Agricultural Engineering Department of University of Illinois, who has been contributing to the promotion of the agriculture in India. He was presented the engraved diploma and 1,000 dollars for prize from Mr. Yoshikuni Kishida, Chairman of Shin-Norinsha Co., Ltd.

ASAE Kishida International Award was established to reply to the member's voice for retaining the name of Yoshikuni Kishida, Chairman of Shin-Norinsha, in history, in recognition of his great contribution to the development of the international technical exchange for many years. This Award will be presented annually at the Summer Meeting of ASAE from now on.

EIMA-The specialized Farm Mechanization Exhibition

Nov. 9-13, 1978, Bologna/Italy

The 9th Edition of the International Exhibition of Industries for Agricultural Machinery—EIMA—will take place at Bologna, Italy from 9 to 13 November 1978. It is organized by the National Union of Constructors of Agricultural Machinery—UNACOMA—in collaboration with the autonomous administration of the Bologna Fair.

The Show comprises as follows :

Engines ; Equipment for land reclamation ; Tractors ; Equipment for working the soil, sowing and distributing fertilizers ; Equipment for crop protection ; Equipment for irrigation ; Equipment for harvesting ; Equipment for threshing, selection and conditioning ; Equipment for livestock husbandry ; Equipment for the processing of products and for dairy work ; Equipment for handling and transporting ; Components, spares and accessories ; Small powered machinery and hand equipment.

SIMA-PARIS

March 4-11, 1979, Paris/France

International Exhibition of Farm Machinery (SIMA)—one of the greatest agricultural events in the world—is held annually at the Porte de Versailles Exhibition Park in Paris, France. The 1979 Show will take place from March 4th-11th.

The S.I.M.A. is an international show of capital good designed for agricultural applications and associated activities.

From all parts of the world agricultural specialists, agronomists, researchers, industrialists and engineers are coming to visit SIMA, the meeting place of all who are concerned with agricultural equipment and rural life.

The Royal Smithfield Show

Dec. 4-8, 1978, London/U.K.

The 167th Royal Smithfield Show is at Earls Court, London, from Monday December 4 to Friday December 8 inclusive-open daily from 09 00 to 18 00 hours.

Following last year's event which attracted a paid attendance of 73,928 - the best since 1965 - and 5970 overseas trade visitors admitted free of charge-the second best since 1949-demand for over 240,000 sq ft of trade floor space has again been very heavy.

The Show comprises :

1. A fully comprehensive range of farm machinery and associated products.
2. Approximately 1,700 entries of livestock for meat production and carcases are judged and then auctioned for the Christmas market.
3. Comprehensive technical livestock demonstrations and Young Farmers' competitions. ■■

Kubota Tractor M 6000

This tractor with a 69 hp diesel engine is one of the Kubota M series for multipurpose use.

This model has 16 speeds forward and 4 speeds reverse in a transmission so that you can choose a right speed in accordance with working. Especially the ful-synchromesh system adopted in the forward speeds makes its operation easy. You can switch on and off 2 speeds PTO quickly and separately from running speed because of its independent system.

Both position and draft controls are adopted in hydraulic system. Addition to that, it is applied a lowering speed control device, so you can do works very efficiently.

(Kubota, Ltd.: 22-2, Funade-cho, Naniwa-ku, Osaka, Japan)

Hinomoto Tractor Best E18D

This tractor has a 18 hp medium speed engine developed especially for tracter.Special low speed(0.19 km/ha) is possible, and it has 12 forward and 4 reverse in a transmission. So, it suits Both wet-field and dry-field works.

Front wheels driving part designed by Toyosha exceeds in water-proof and mud-proof, steering is easy to handle and extra small turning is realized to the minimum turning radius 1.9 m.

You can put on and off implements with onetouch-docking system and move it lifting and lowering with perfect position control system normally applied.

(Toyosha Co., Ltd.: 55-16 Joshoji-machi, Kadoma-shi, Osaka, Japan)

Yanmar Diesel Tractor YM-2000D

This is a four-wheel driven tractor with 20 hp 2-cylinder diesel engine, designed for efficient works and easy operation.

You can move implements freely with only one hydraulic lever and fix it quickly in any position you like by position control system.

8 forward, 2 reverse and 3 PTO speeds available for any work application.

The special bevel gear drive system of sharp angle is adopted at two front wh eels, so small turning and a drive on the steep slope are possible.

(Yanmar Agricultural Equipment Co., Ltd.: 62, Chayam Kita-ku, Osaka, Japan)

Oshima Combine RD1800

This combine harvester with 3-4 rows has a cutting width of 1,050-1,000 mm, powered by 18 hp diesel engine. This is high efficient type and does the work of 10 are/30 minutes.

Threshing device is lower feeding axial flow drawing type with special solid threshing tooth and extra wide cylinder for threshing in large quantities. You can control threshing depth easily with hydraulic system, and if you set an optional automatic sensor, whole control system will be completly automatic.

With 4 bags and a large hopper of volume for 4 bags, you can continue your job for 8 bags without pause.

(Oshima Agricultural Machinery Mfg. Co., Ltd.: 10-17, 3-chome, Teramachi, Niigata-pref. Japan)

Mitsubishi Combine MC900D

This is a 2 rows combine harvester with a small type 2-cylinder 9 hp diesel engine especially for combine.

With a new upper threshing mechanism, the cutting width is greatly widened and you can do efficient works.

You can move the cutting device up and down easily with only one lever and adjust threshing height freely in one-touch. Cutting device and threshing device are joined in one series, so cut rice is directly conveyed to threshing device in order.

For running part with 6 forward and 2 reverse gears applied endless rubber crawlers of width 300 x 905 mm, so this combine especially suits the work in muddy paddy fields.

(Mitsubishi Kiki Hanbai Ltd.: 3-6-3 Kanda Kajicho, Chiyoda-ku, Tokyo, Japan)

Kubota Diesel Combine NX3000A

4-5 rows combine harvester with a 28 hp 3-cylinder diesel engine.

This model is equiped with automatic system in cutting speed control according to the crops conditions, notice of rice stubble adjustment of rows, threshing depth control according to the length of cut rice, so that you can operate this machine easily only by yourself.

Especially, sensor's response is very quick and accurate, so that threshing ability is highly efficient.

Cutting width : 1,400 mm, Efficiency : 0.27-0.45 h/ 10a

(Kubota, Ltd. : 2-22 Funade-cho, Naniwa-ku, Osaka, Japan)

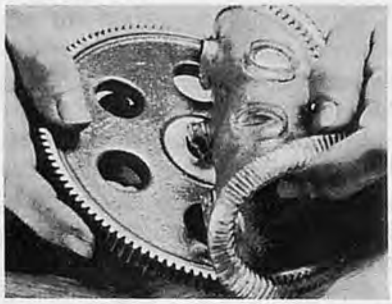
Centuly Portable Heaters

Century oil-fired portable heaters provide clean, dependable, instant heat anywhere you need it. All models run on kerosene or No. 1 fuel oil. Just plug them into any 115 volt outlet. Instantly you have clean, odor-free heat that takes the chill out of you and your work. Simplicity in design means these dependable heaters require minimun maintenance and will give you years of trouble-free service. Large, sturdy handles, free-rolling wheels and light-weight construction make these heaters truly portable.

Century portable heaters are built to give you years of trouble-free operation. However, should your heater ever require service, Century's unique "Power Pack" lets you remove all moving parts and wiring in one package for easy service or low cost replacement.

(Gordon Fennel Company : Cedar Rapids, Iowa 52401, USA)

Thermo-Cote



Thermo-Cote provides an hermetically sealed cushion of protection for all metals. Easily applied, Thermo-Cote protects cutting tools, gages, and highly finished precision tools and parts from the damaging effects of nicks, scratches, rust or corrosion.

Thermo-Cote saves time, space and weight in shipping and storing. No bulky inserts or paper wrapping are required, and because of Thermo-Cote's unique clarity, no duplicate identification is needed—data stamped or printed on the part are clearly legible. Machined parts, tools, and engravings protected by Thermo-Cote in storage can be quickly located for re-use without unwrapping—and there is no possibility of incorrect identification. Thermo-Cote also can be colored (red, green etc.)to aid in tool and part identification programs.

The appearance of expensive tools and parts is greatly enhanced by Thermo-Cote, adding sales appeal at no extra cost. And since Thermo-Cote is chemically inert, and contains no solvents, complete protection of fine surfaces is assured.

Thermo-Cote is quickly and easily applied—just dip—it's on. It requires only noncritical temperature between 300° and 350° F, yet has high fire point of over 410°, making it extremely safe to use.

Thermo-Cote, shipped as an easy to handle solid material, is melted and held at proper temperature for dipping in inexpensive melt tanks.

Once applied, Thermo-Cote cools quickly; the coating sets and can be handled on most parts within a minute. Effective protection is maintained over a temperature range from −40° to +160° F. For thermo-Cote 149A, this range is from −65° F to +100° F.

Thermo-Cote is also easily removed—just slit—it's off. And because of its unique clarity and high stability it can be re-used again and again.

(Grain Equipment Corporation : 14 Lawton Street, New Rochelle, New York, U. S. A.) ■■

UNIDO's New Directory of Financial Resources for Development

(Austria)

Resources wanted for key industries if international targets are to be met by the end of the century are estimated at many billion dollars a year. Much of the information on sources of finance can be found only by complicated research. This is why UNIDO has responded to calls at United Nations and other international gatherings and devised a means of making information freely and easily available to public and private investors and especially to developing countries for the growing volume of projects they are preparing. The method has been to embark on a continual investigation of resources available for industrial projects in the developing countries and to assemble the results in a loose-leaf volume so that data can be kept up-to-date.

As an initial effort, starting in May 1978, details obtained on nearly 200 industrial development finance institutions of about a hundred countries as well as international banking and aid-giving institutions have been compiled for a limited edition of 2000 copies in English. Half of these will go to investment and finance institutions. The directory is compiled from answers to a questionnaire seeking both standard information and other details which will need regular revising. It is hoped that other financial organizations, whether public, private or mixed in constitution, whose activities are relevant to industrial development will also co-operate to make the service complete.

Included in the directory are industrial development finance institutions; national, regional and international organizations, industrial development banks and development bankers' associations ; aid-giving institutions ; and programmes in support of industrial development banking. A few commercial banks which provide a full range of industrial banking services are also represented.

In a final section, new approaches and techniques for industrial development banking are suggested by some individual specialists.

Published by the Investment Co-operative Programe Office, UNIDO, Lerchenfelderstrasse 1, 1070 Vienna, Austria.

Development and Transfer of Technology Series No. 5 Technology for Solar Energy Utilization

(Austria)

This volume deals with the technology of exploitation of solar energy for the benefit of the developing countries. It is hoped that with the further improvements in this technology, solar energy will supply not only the certain needs of industry but also the everyday needs of the population in the rural and remote areas of those countries. The text of the volume is primarily based on the contributions made to the Expert Group Meeting on the Existing Solar Technology and the Possibilities of Manufacturing Solar Equipment in Developing Countries, organized by UNIDO in co-operation with the Austrian Solar and Space Agency (ASSA) and held at Vienna, 14—18 February 1977. In addition it incorporates information obtained by UNIDO as a result of its field contacts in many developing, as well as industrialized, countries.

The first part of this volume contains two papers : a recommended programme for solar utilization in developing countries and a background document on the utilization of solar energy in developing countries. The second part consists of summaries of work being done in some countries and institutions, and the third of 17 technical papers dealing with the conversion of solar energy into mechanical or electrical energy, the design of solar collectors, the utilization of solar energy in heating, cooling, distillation, drying and cooking, and the transfer of technology.

Published by United Nations Industrial Development Organization (UNIDO), Vienna, Austria.

AVRDC International Cooperator's Guide

(Taiwan)

The AVRDC GUIDES are an information filing and retrieval system. As a new and somewhat experimental approach to providing you with information, they are practical, clearly explained and illustrated, and immediately useful.

The AVRDC GUIDES can be kept in a three-ring notebook with seven dividers.These should be labelled : Tomato, Mungbean, Soybean, Sweet Potato, Chinese Cabbage, Other Vegetable Crops, and Scientific Practices and Equipment.

The GUIDE order-number appears in the upper right corner of the first page and shows the year and publication number (AVRDC 78-63, AVRDC 78-64, etc.) The complete number should be used when ordering GUIDES from the Office of Information Services at AVRDC.

Filing instructions appear in

the lower right corner. Instructions such as : "File under MUNGBEAN/B-1, Varieties" indicate that this GUIDE should be filed back of the MUNGBEAN divider according to the number (B-1) indicated.

An index (AVRDC 78-67) is available for ready reference and includes the names of all GUIDES already published. The Index will occasionally be updated by AVRDC. However, until you receive a new Index, new titles can be hand-written in the appropriate part of the Index.

AVRDC's mailing address is : P. O. Box 42, Shanhua, Tainan 741, Taiwan, ROC.

AVRDC Progress Report '77

(Taiwan)

The 1977 Progress Report summarizes research, training, and outreach activities conducted by the Asian Vegetable Research and Development Center (AVRDC). For those interested in more detailed accounts of individual studies, research reports are being published on each crop. These reports and other technical papers may be obtained by writing the Office of Information Services at AVRDC. Please be sure to give your complete mailing address. Scientists in other countries are also urged to correspond with AVRDC's investigators regarding technical points and problems.

The main contents of this report is as follows : Tomato, Chinese Cabbage, White Potato, Sweet Potato, Mungbean, Soybean, Netrition Environment & Management, Outreach Program, Training Communications and Reseach Services, and Appendix.

Size : 17.5×25.0cm, Page : 90 pages.

Published by the Office of Information Services at AVRDC, P.O.Box42, Shanhua, Taiwan741, Taiwan, R.O.C.

Equipment for Rural Workshops

(U. K.)

Workshops in the rural areas of developing countries can range from a wattle and daub shack set up under a tree by the roadside, to a much more sophisticated brick building which may even have electricity laid on. But whatever the standard of the building use, if the workshop is to be of practical use, it has to have suitable tools and equipment.

This book is a guide to anyone who wishes to equip a workshop, from the basic tools required for a one or two man carpentry workshop without power to the more sophisticated establishment requiring power equipment for both wood and metal working. Only well - known and reliable equipment is listed here, and the prices given may soon be out of date, but they give an inexperienced person some idea of the budget required for a particular size of workshop.

The tools specified are all illustrated and workshop layouts are suggested. There are also photographs of varios size of workshop in different countries, as well as some pictures of farming equipment that has been manufactured at some of the workshops. Suppliers' addresses are also given in an appendix.

This publication will be of immense value to any practical field worker involved in the rural areas of developing countries.

94pp. Illus. Price : £2.95 net. £3.39 surface and U.K. postpaid. £3.98 airmail.

Published by Intermediate Technology Publications Ltd., 9 King Street, London WC2E 8HN, U.K.

Ferrocement Water Tanks and Their Construction

(U. K.)

This publication describes in detail methods of constructing water storage tanks from wire-reinforced cement-mortar. These tanks are widely used in many parts of the world to collect and store water for domestic, stock, irrigation and also industrial purposes.

The basic raw materials, water, sand, cement and reinforcing wire, are generally available in most countries. The construction method is simple and easily learnt by the local people, many of whom will already have worked with the basic materials. Wire-reinforced cement-mortar has a variety of uses but the main advantage of using it for water tank construction is its resistance to corrosion. It is also very cheap, compared with other possible construction materials. Water tanks built using the method described in this manual have withstood difficult climatic conditions over many years and tanks with capacities of up to 33,000 gallons can be built with confidence.

For anyone contemplating building a water storage tank, this book is essential reading.

118pp. Illus. Price : £2.95 net. £3.39 surface and U. K. postpaid. £3.98 airmail.

Published by Intermediate Technology Publications Ltd., 9 King Street, London WC2E 8HN, U.K.

Proceedings of the Agricultural Machinery Workshop (Philippines)

This publication is the proceedings of the International Agricultural Machinery Workshop.

The Industrial Extension Workshop was convened at IRRI to discuss the results of an intensified technology transfer effort initiated in 1974 and to suggest means for improving the program. Agricultural engineers, manufacturers, and scientists from 16 countries with a broad range of interest in manufacturing, engineering research and development, and the economic and sociological aspects of farm mechanization participated in the deliberations.

This is introducing the reports about the status of agricultural mechanization in the following areas ; Bangladesh, Philippines India, Southeast and East India, Nepal, Burma, Indonesia, Thailand, Japan, Korea, Malaysia, Colombia, Sri Lanka, Taiwan, Egypt, Pakistan.

Size : 15.0×22.5cm, Page : 203 pages.

Published by The International Rice Research Institute : Los Banos, Laguna, Philippines, P. O. Box 933, Manila Philippines

Final Report on the Development of Rice Trans-Planter and Combine Harvester Suitable for the "Muda Irrigation Scheme", Malaysia (Japan)

This report is a comprehensive summary of the results of joint studies carried out by the Tropical Agriculture Research Center of the Japanese Ministry of Agriculture and Forestry and the Muda Agricultural Development Authority (MADA) in Malaysia from 1973 through 1977.

In the Muda irrigation area, which constitutes Malaysia's principal rice belt, the shift to double cropping brought about changes such as limitation of the working period and supply of manpower, with the consequence that there arose an increased need for the mechanization of rice harvesting and planting and the solution of this issue became an urgent task.

Against this background, studies were initiated with a view to developing rice transplanters and harvesters suitable for use in the Muda irrigation area.

The details of the experiments are outlined in the text of this report. Findings were obtained on the trafficability and durability of the combine, and guidelines for the design of a combine suitable for use in the Muda irrigation area were thus presented.

Published by Institute of Agricultural Machinery, Nisshin, Omiya, Saitama, Japan. ■■

INDEX TO ADVERTIZERS

BACK ISSUES

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 8 no 1. winter, 1977)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (vol. 8 No. 2, Spring, 1977)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 8 no. 3, Summer, 1977)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 8 no. 4 Autumn, 1977)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 9 no. 1, Winter, 1978)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 9 no. 2, Spring, 1978)

◇ ◇ ◇

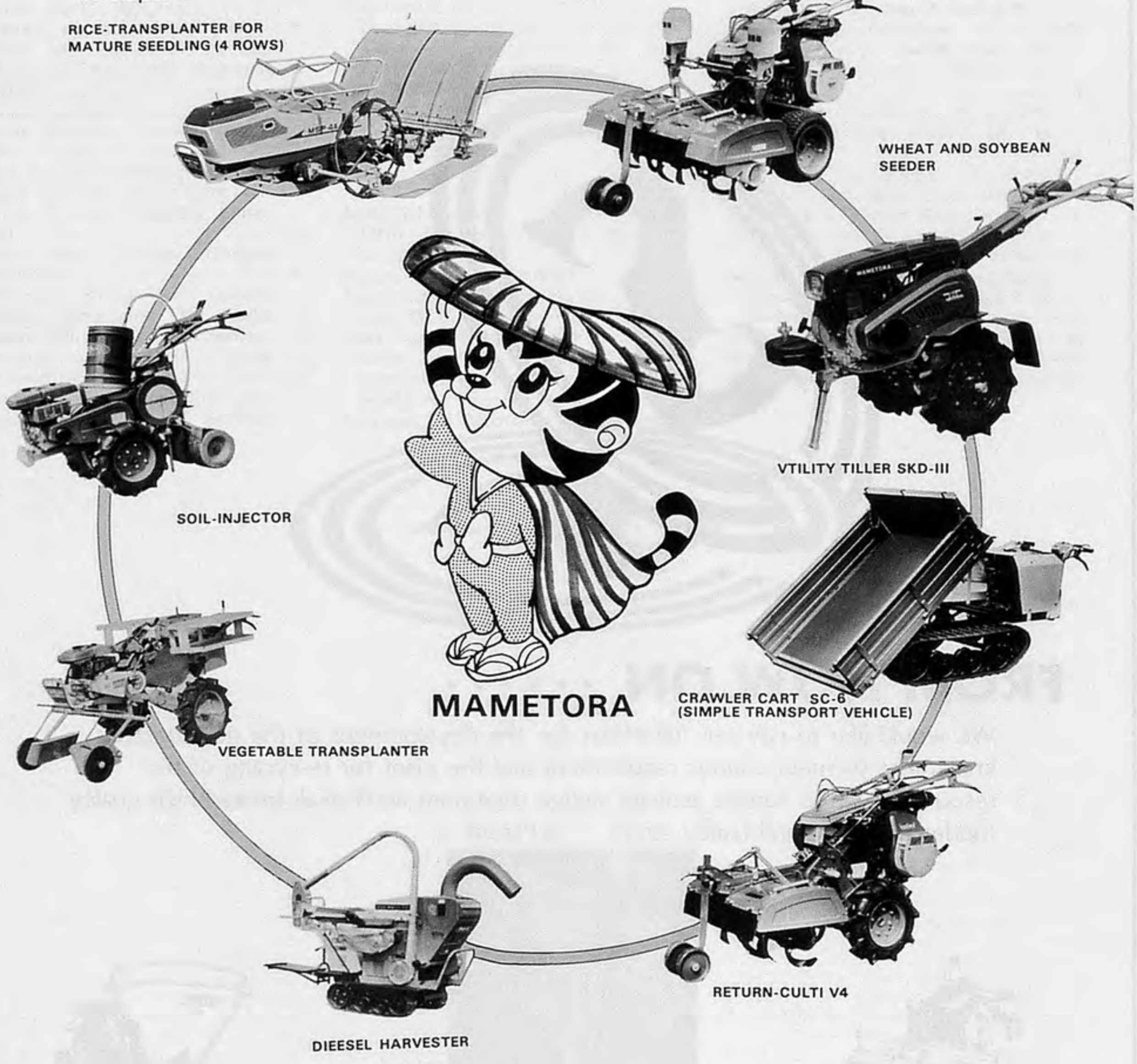
AGRICULTURAL MECHANNIZATION IN ASIA (Vol. 9 no. 3, Summer, 1978)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 9 no. 4, Autumn, 1978)

MAMETORA DEDICATES TO AGRI

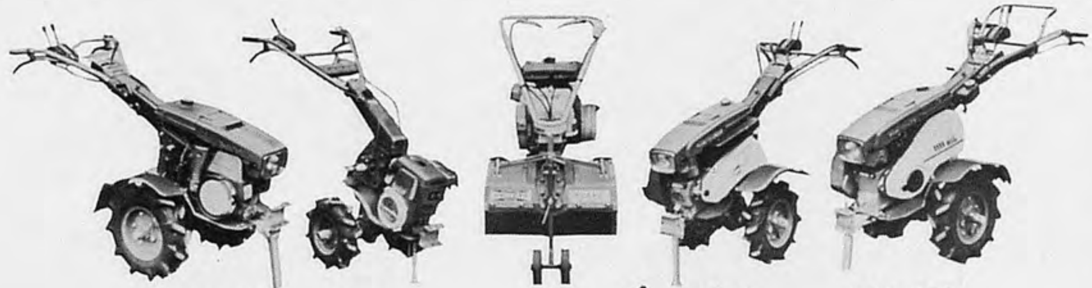
It is the motto of MAMETORA that we manufacture goods in order to meet customer's benefits with originality' trusty and hearty. In addition to the head office in Okegawa' Kisakata Factory has been established. Now that we have formed the much steadier basis as a comprehensive manufacturer. We are always making efforts to manufacture goobs of high quality and are pleased to devote ourselves to the food industry in the world as well as that in Japan.



MAMETORA AGRIC. MACHINERY CO., LTD.

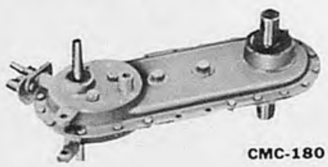
HEAD OFFICE ADD : 9-37, NISHI-2 CHOME, OKEGAWA-SHI, SAITAMA-KEN, JAPAN.
TELEPHONE : 0487-71-1181 TELEX : 2922561 MAMETO-J

CULTURE ALL OVER THE WORLD



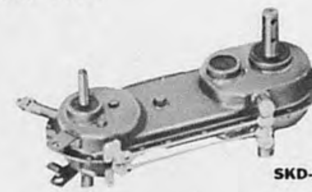
PM-350 DMC-II MRV3 SKD-II HMD-250

We are provided other Japanese manufacturerd with the transmission only.
We believe you can find the satisfaction with MAMETORA AGRICULTURAL MACHINERY.
We have not only the tiller but also the transmission under oder.

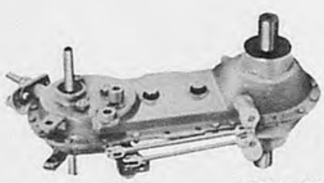


CMC-180

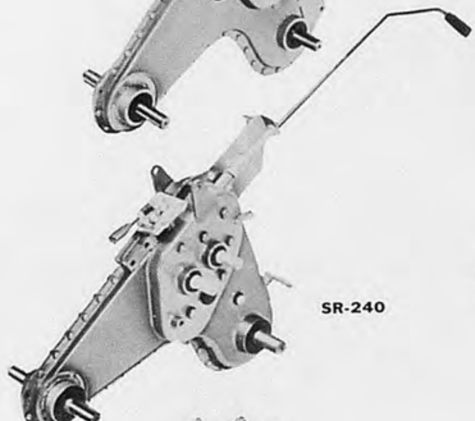
MRV3



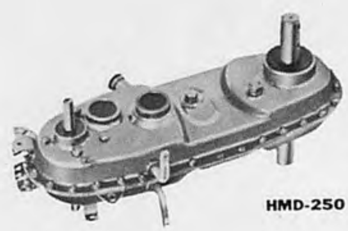
SKD-II



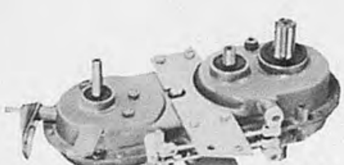
DMC-180



SR-240

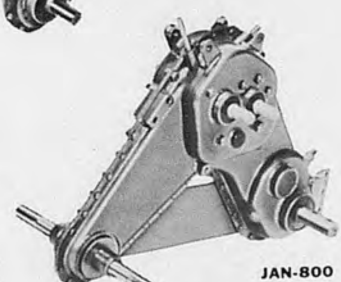


HMD-250



UK-13

PM-350



JAN-800

Model		MC-80	MCF-130K	CMC-180	DMC-180	DMC-II	SKD-18	SKD-II	SKD-III	HMD-250	PM-350	UK-13	MH-750	MT-40
Applications (PS)		1·8~2·5	2·0~3·5	3·0~4·5	3·0~4·5	3·0~4·5	3·0~4·5	4·5~6·0	4·5~6·0	5·0~7·0	6·0~8·0	3·0~4·5	3·0~4·5	3·0~4·5
Shifiting Stages		F1	F1, R1	F2, R1	F2, R1	F3, R1	F2, R1	F2, R1	F3, R1	F4, R2	F6, R2	F2, R1	F1, R2	F1, R2
Sidecluch		—	—	—	—	○	○	○	○	○	○	○	○	○ with Lock
Gear Ratios		F_1=1:21·71	F_1=1:18·16	F_1=1:25·41	F_1=1:25·41	F_1=1:41·31	F_1=1:21·21	F_1=1:31·06	F_1=1:66·07	F_1=1:70·03	F_1=1:53·97	F_1=1:32·13	F_1=1:25·54	F_1=1:37·62
			R_1=1:27·24	F_2=1:15·38	F_2=1:15·38	F_2=1:19·40	F_2=1:10·28	F_2=1:11·34	F_2=1:18·96	F_2=1:38·73	F_2=1:37·41	F_2=1:16·92	R_2=1:29·37	R_1=1:32·83
				R_1=1:35·58	R_1=1:35·58	F_3=1: 9·35	R_1=1:21·33	F_1=1:44·52	F_3=1:11·43	F_3=1:15·81	F_3=1:18·50	R_1=1:32·77	R_1=1:20·22	R_2=1:10·69
						R_1=1:49·91			R_1=1:81·09	F_4=1: 8·74	F_4=1:19·42			
										R_1 1:105·04	F_5=1:13·47			
										R_2 1:23·71	F_6=1: 6·66			
										:	R_1=1:66·67			
											R_2=1:24·0			
Dimensions	A	170	170	170	170	202	192	192	224	234	243·5	192	192	192
	B	434	434	434	435·5	532	492	492	545	578·5	603 3	467	467	467
	C	289·5	289·5	289·5	289·5	344·7	336·75	336·75	336·75	319·7	402·5	409·9	287	287
	D	15	15	15	15	16	16	17	19	19	19	16	16	16
	E	31	31	31	31	31	31	31	31	34·5	34·5	31	31	31