International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL. XI, NO. 1, WINTER 1980

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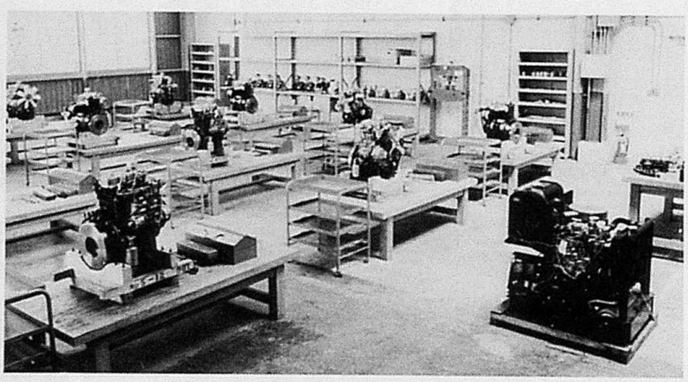

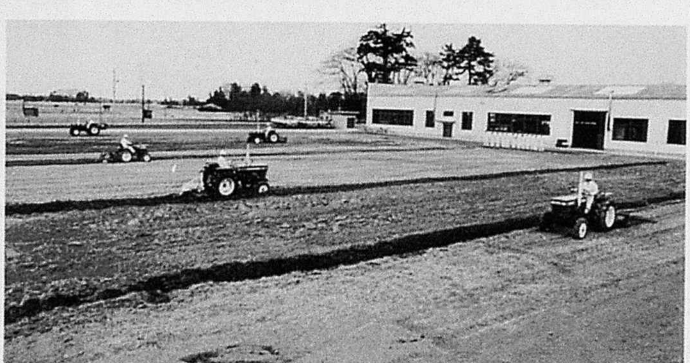

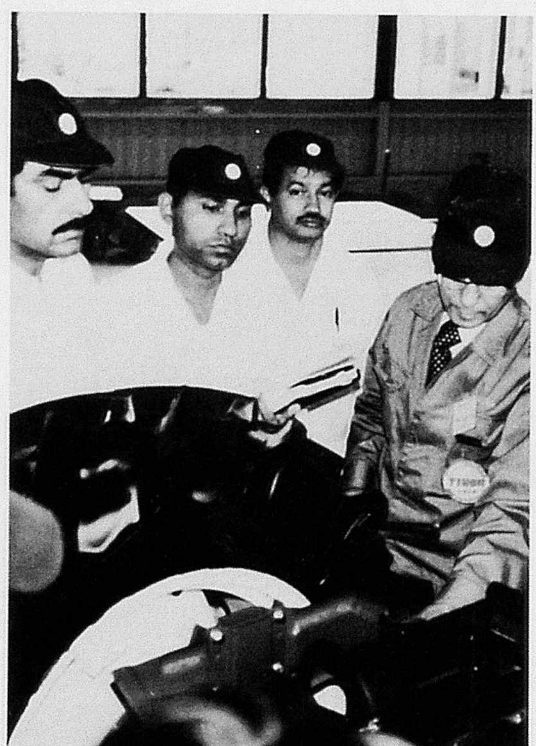

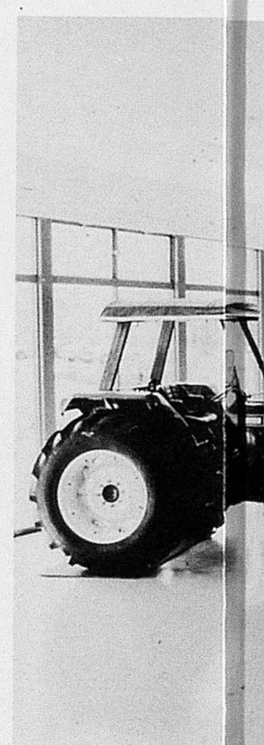

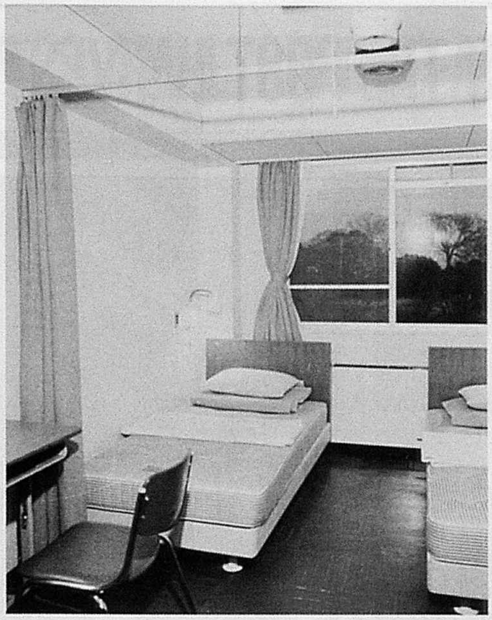

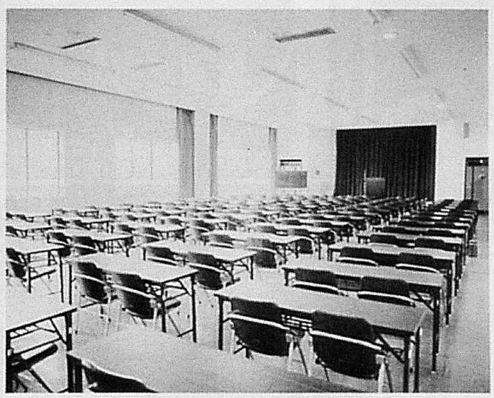

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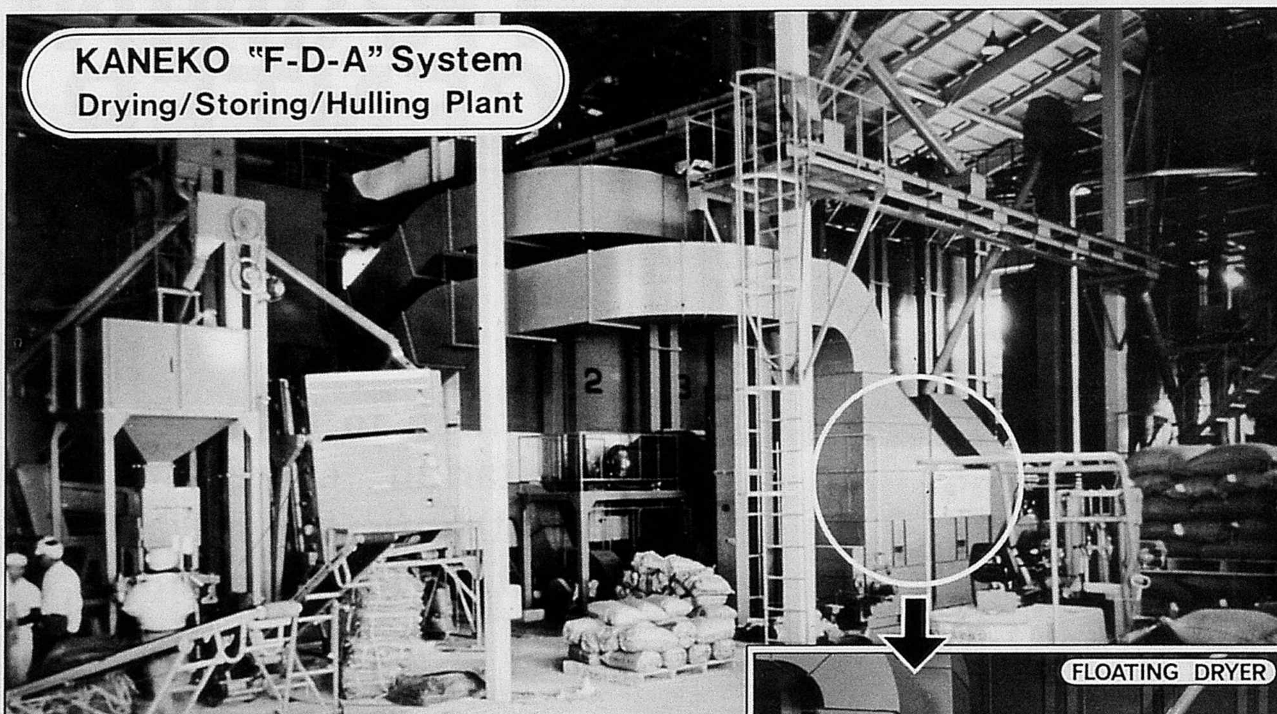

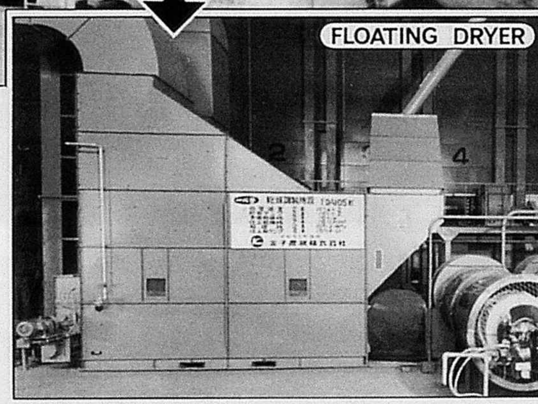

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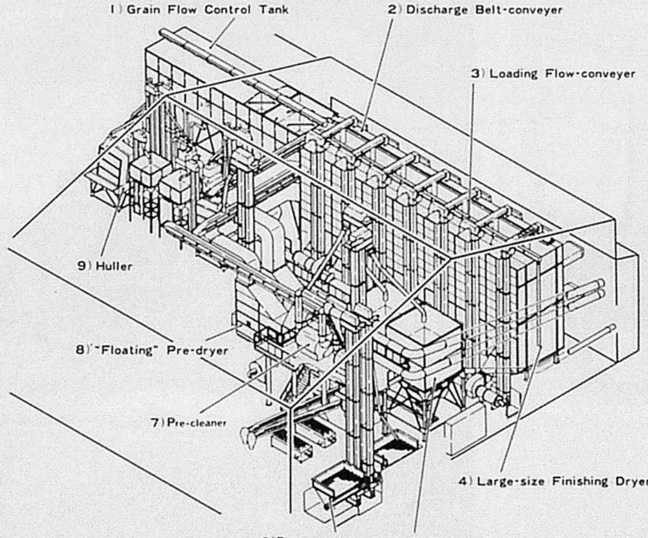

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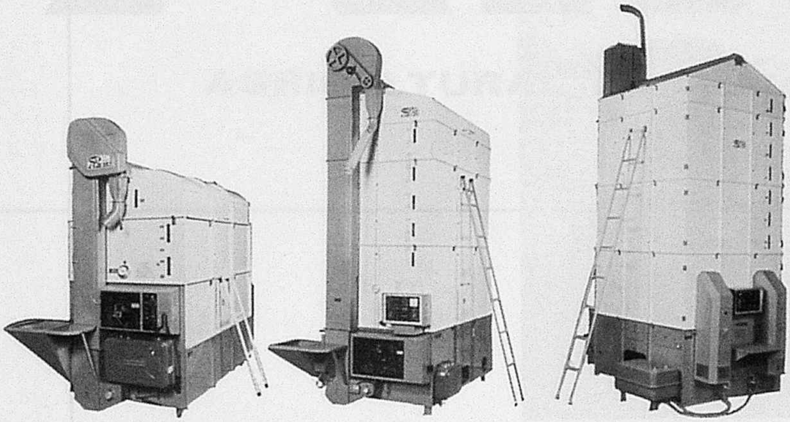

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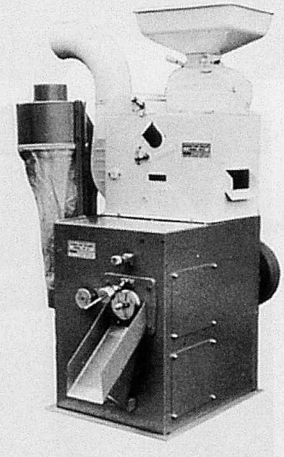

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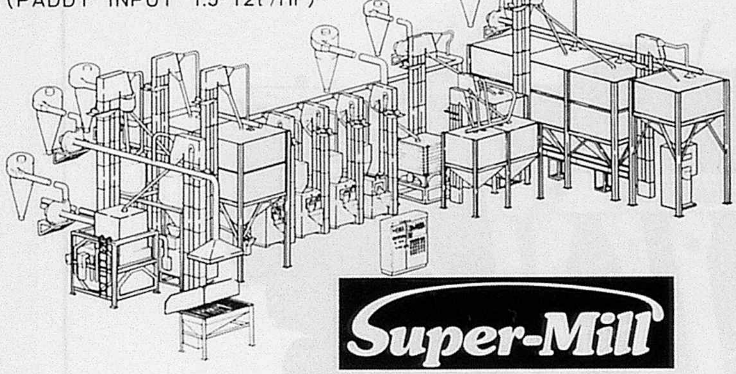

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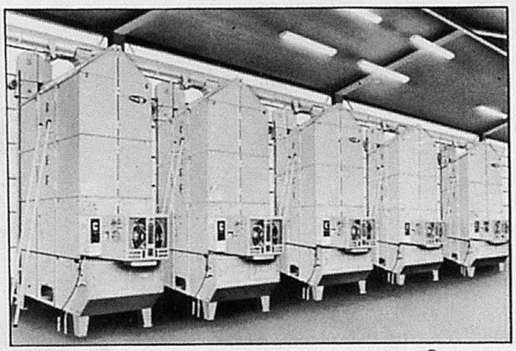

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YOSHISUKE KISHIDA

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TOKYO

This is the 26th issue since the issue, Spring of 1971.

Editorial

The 80s Beckon with Challenges

A HAPPY NEW YEAR to all of you from all of us at AMA!

As 1980 goes off to a start, it has suddenly become easy to figure out that the year 2,000 is only 20 years away! And as we move closer to the advent of another century, we can only look back and see that the past few decades have witnessed many global happenings – many of them for the good of mankind and a few others meant misfortune to some. But we also want to look foreward to with hope and wish that more good than bad await mankind in the 80s. However, the realities are that the 80s beckon with challenges to mankind in many ways: food production and availability, energy problems, population boom, disease and poverty, strained international relations among some countries, and more.

The food situation is, of course, the AMA's main concern about which it has since been doing its share in accelerating agricultural productivity and food production through farm mechanization. And the AMA intends to keep up with its commitment to help meet some of the challenges in the decade ahead. Alone, the AMA cannot do very much for which reason, we reiterate the clarion call to all institutions and individuals to close ranks in increasing food availability, particularly for the least less developed countries (LLDC) which stand to suffer the most. That farm mechanization must be promoted further in order to contribute to the total effort of raising agricultural productivity levels is less debatable than drumming up interest among the developed countries to share with the less developed ones their continued support in transferring technology of farm mechanization to the latter countries.

However, in developed, industrialized countries like Japan, agricultural product are imported in large quantities and seems that even through this means, food supply through the 80s is not going to be stable nor reliable. What this means is that countries that depend on imported food supply – developed or developing – must make every effort to be self-sufficient in food production. In particular, developed countries that continue importing agricultural products will likewise continue to push up international prices of these commodities at the expense of developing countries, as a consequence. This cause-and-effect implication in the international food trade can be cushioned through efforts of developed countries to increase their food production, hence reduce their dependency on imports.

The agricultural machinery engineers in developing countries have greatly increased in numbers during the 70s. However, effective communication among them has yet to be satisfactorily established. Working independently of each other, these new crops of engineers are less likely to be effective in their efforts insofar as technology transfer is concerned. It is basically for this reason that the AMA, through the publication of research results or technical papers on agricultural engineering, including addresses of experts, continues to provide the media on a world-wide basis. The AMA is committed to keep on providing this vehicle of information in its humble way of helping meet the challenges of the 80s and beyond.

This editorial winds up with a happy note that, after all, the agricultural way of meeting much of the challenge of the 80s is a peaceful, constructive way through which everyone can contribute sans violence. That is why the AMA reiterates the pressing need to promote farm mechanization through mutual cooperation more than ever before.

Chief Editor

Yoshisuke Kishida

January, 1980

Tokyo

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AGRICULTURAL MECHANIZATION IN ASIA

Vol. XI, No. 1 Winter, 1980

The Challenge of Asian Farming to the Engineer

by
Charles J. Moss
Head
Agricultural Engineering Department
The International Rice Research Institute
Los Baños, Laguna, Philippines

Introduction

The importance of increasing food production in Asia is well known to all of us and the work of plant breeders, agronomists, entomologists, etc. is usually well understood. Frequently, however, that of the engineer is less well understood or even controversial. For example, in the short time that I have been in the Philippines I have been told that the introduction of engineering products to the farms of Asia will cause unemployment, and that so far there is no evidence of a discernible gain in food output from providing farmers with tractors and other engineering products.

Perhaps this state of affairs comes about in part at least because the engineer has done so much for Western farming that he has taken a little too much for granted that he can do the same for Asian farming. For example, the Royal Commission for Farm Machinery, Canada, 1970, stated that in the first 20 post war years engineering had contributed as much to Canadian farming as all the other sciences together! That may well have been true in Europe and N. America but it is not likely to be true in Asia. Nonetheless there is a probability that the engineer, working closely with his biological and agricultural colleagues can make a marked contribution to food production in Asia.

We need a sense of perspective and we need to think of priorities. Clearly no responsible man wants to add thoughtlessly to urban or rural unemployment and yet we must all work to increase food output. One of the potentially valuable ways of increasing food output is to increase the number of crops grown per annum on the greatest possible area of land in the region. What are the limiting factors in doing that?

Indian Experience

According to a report[1] from P. Datt and G. T. Kurup of the Central Rice Research Institute, Cuttack, India, there are frequently not enough men, women, and bullocks in a rice growing village to do all the work of land preparation, transplanting, harvesting and threshing, on the land of the village for the kharif season crop. I should like to quote three of the conclusions of that report:

"In eight villages of the Operational Reserach Project even if the total labour and bullock population is used eight hours per day, 55 percent of the crop area will be puddled and transplanted late.

"Even if the puddling of the whole area is completed in time by machines, unless transplanting is mechanized 33 percent of the total area will be late transplanted.

"A mechanical appliance such as a tractor may displace labour directly in the operation for which it is employed but its total impact on employment depended on its induced effects both on the farm and off-farm. Among the induced effect was a rise in land productivity through increased yields and diversification. Even without considering the multiplier effect it was revealed that mechanization in agriculture does create unemployment."

Thus there is a simple logic that in such circumstances we can increase food production by increasing the power in the hands of the villagers. This has already happened on many farms in the Punjab, and the increase in food output has been striking but one of the most interesting features of this development is the migration of labour from neighboring states to the Punjab every year. C. Mohan, in a recent paper,[2] has given some figures for rural employment based on government statistics. The cultivated area in hectares per agricultural worker decreased from 2–23 in 1965–66 to 1–75 in 1971 while the number of draft animals increased 10 percent and tractors more than six-fold. Many factors have contributed to the increased output of food in the Punjab and not least the increasing availability of irrigation water and fertilizers but the increase in production appears to draw a large number of men to the farms of the Punjab each year and to actually increase employment.

Need for Farm Power in Indonesia

The engineer can, therefore, face the challenge of how best to contribute to food production with some confidence. Clearly the areas in which he works, both geographically and technically, must be chosen with great care. I have not yet been to Indonesia but from all that experienced men tell me there is a substantial problem of cultivating the land available to the men in the transmigration areas. Is this not then a good part of Asia for an increased effort to provide mechanical aids to farmers? Far from getting two crops a year from all the land provided to them, they are unable to cultivate all of it with the limited power available to them. Surely these men should be helped with 4-wheel or 2-wheel tractors in their heavy work of land cultivation, with improved means of transplanting, harvesting and threshing. It seems highly probable that some of the imports of rice to Indonesia could in the future be replaced by growing more in the transmigration areas.

A Philippines Case

This is an example of a favorable geographical area for introducing farm machines but, by implication, I have also mentioned some of the important technical areas. One study in Iloilo has shown that "with this - wet-seeded rice pattern there was a .7 ton/hectare yield loss for each 10 day delay in planting the second rice crop."[3] It is clear, therefore, that the land should be prepared at the optimum time if maximum outputs are to be obtained, but how is the farmer to attain this goal, desirable no less for him than for his country, if he has very limited power available for his work? Even a small 2-wheel tractor will make available to him 10 times more power for more hours a day than the water buffalo and although the small tractor requires spare parts and fuel, it will not compete for land for its food with that required for men and women and it will not suffer from a host of diseases including some which are very harmful to man. The land cultivation can be speeded up and perhaps where one crop is now grown two can be grown; perhaps where two are grown then we can help to get three grown in future. Of course, there is more to growing a crop than land cultivation; we need cheap seed drills for uplands and either improved direct seeders or transplanters for rice, and this equipment has to be available at prices which the farmer can afford to pay. When the crop is grown he needs to clear the land in the shortest possible time and to thresh his grain and get it into safe storage without delay. Then cultivation can start again with the land lying fallow for a minimum time.

Three Basic Considerations for the Engineer

There are at least two other aspects to this issue. When the land is lying fallow it is drying and becoming harder. Then when cultivation is required, sometimes after as long as six weeks, the field must be flooded to soften the soil and the amount of precious irrigation water needed for this is sometimes greater than the amount needed for the growing of the crops.[4] Thus the water that could be used for growing crops in other fields is used merely to soften land which has been baked hard in the sun. Why not reduce this drying, economize on precious irrigation water, and get more food output by providing the farmer with equipment to help him in his work? This is an approach which seems to me rational for engineers. Let us give a high priority in our work to any steps which will reduce the "turn-around" time for crops and which will reduce the demand for irrigation water. The justification for introducing a transplanter or a harvester into our fields may well be more securely based on increasing cropping intensity than on saving labor although men and women are often scarce enough at the times of the year when the are most badly needed.

The other basic consideration that pertains to the area of work for the engineer is to help the farmer when labor demand is at maximum and when family or casual labor is inadequate. This is so well known that it hardly deserves a long discussion but it is worth observing that reports of labor shortage at harvesting and transplanting time are common enough from many countries. No doubt there are unemployed men and women in the cities and towns but how are they to be attracted back to the country? Will it be by hard work up to the knees in the mud and water of rice transplanting? That scarcely seems likely to me but we may retain some of the most intelligent and enterprising boys in a village when we succeed in making farm work less arduous and less dirty and when it is better paid. For the present there seems every likelihood that migration from country to town will continue and the engineer must provide farmers with good locally designed and manufactured machines which suit the crops and fields of Asia if food production is to be increased, as it most certainly must be.

Then there is a third area of interest to the engineer which frequently depends on his developing a good cooperation with scientists from other disciplines. A good example here is fertilizer application. Here, for example, engineers at IRRI have been working with agronomists for some years and it seems likely that this cooperation will lead to more efficient ways of using fertilizer in the growing or rice. Experiments to date suggest that by metering the fertilizer into the bottom of the furrow behind a mouldboard plough then, for the same quantity of nutrients, a better output of rice may be obtained. It is still early and much remains to be done but the results to date have been very encouraging. The equipment needed is simple and can be made in local workshops. No doubt when the fertilizer work has gone a little further then attention must be paid to granular insecticides and herbicides. There are two problems with them: smaller quantities of active ingredients must be used than with fertilizers and they are probably used most efficiently when placed at a depth of 10 cm rather than 20 cm, and this is rather more difficult to achieve behind a plough. Perhaps another technique will have to be found for these pesticides but the need for a good cooperation between engineer, agronomist, and entomologist is clear beyond argument.

Some Headway Done

Perhaps, however, we may be justified at this stage at looking at a few examples of farm machines already produced in small factories in Asia. When the 2-wheel tractor was being made in the Asian countries it usually costs a little more than $1,000 with a gasoline engine (but this price varies from country to country). That would be hard to justify on a two-hectare farm but of course it is used on other farms in the village. From some data gathered in Luzon (Philippines) it seemed probable that in an area where rice is being double cropped the income from working on a few neighboring farms at about $30/hectare could pay for the tiller in a period of the order of 4 years.

To my mind the portable thresher developed by my colleagues at IRRI is a good example. It can be fitted with a cheap mass-produced gasoline engine and threshes about 500 kg of rice an hour. If a farmer has two hectares and grows 4,000 kg per hectare then he will only need little more than 2 days to thresh his entire crop and then he can get on with cultivating his fields and planting a second crop. The same engine can be used for the thresher and the 2-wheel tractor, or alternatively, if the engine is left on the thresher it can be hired out to neighbors in the village. The thresher can be used, with small modifications, for wheat, soya beans and sorghum but its full potential is yet to be explored. The cleaner is a simple machine with a 1/2-1 hp motor which can clean up to a 1,000 kg of grain per hour, and the dryer, which is largely of wooden construction to economize on imported materials, will dry 2,000 kg of paddy in about 5 hours. At this stage there are no reliable data on the losses which occur in the sun-drying of grains in the tropics or on the extent and importance of any contamination which may occur. It is known, however, that when the rate of drying is not controlled properly there may be an increase in grain breakage on milling.

A quite different example is a windmill which with winds averaging about 15 mph for 12 hours a day will lift sufficient water about 10 ft. to irrigate a hectare of rice.

A further example to illustrate what is already being done in Asia is the Thai 4-wheel tractor which uses an imported single cylinder diesel engines of about 15 hp to power a simple but robust machine for which there seems to be a considerable demand from the farmers in the Central Plain of Thailand. It is understood that the cost is in the region of $2,500 which is a remarkable achievement.

A much more difficult problem is the development of a simple, reliable hand operated rice seedling transplanter. Much effort is being devoted to this problem and it is interesting to note that the Regional Network of Agricultural Machinery (RNAM) of ESCAP is supplying prototypes and organizing trials of two designs of transplanter in seven of the eight participating countries. The RNAM is similarly providing prototypes and organizing tests in seven of the network countries for two designs of harvesting machines for grain crops. Although there have been delays in launching this work it will, in the long run, foster the development of practical machines for Asian farmers and it will also help to build up cooperation between the various countries involved. Furthermore, the policies of the RNAM include the development of cooperation with the manufacturing in dustries in the countries concerned and I have no doubt that the other international bodies such as FAO and UNIDO, as well as ESCAP and IRRI, appre-

Plate 1. The power tiller is designed to suit the needs of paddy production in developing countries which completes land preparation about three times faster than the use of the traditional animal-drawn plow.

Plate 2. A 5-h.p. portable thresher that can efficiently thresh 500 kg/hr of dry paddy of the short straw variety.

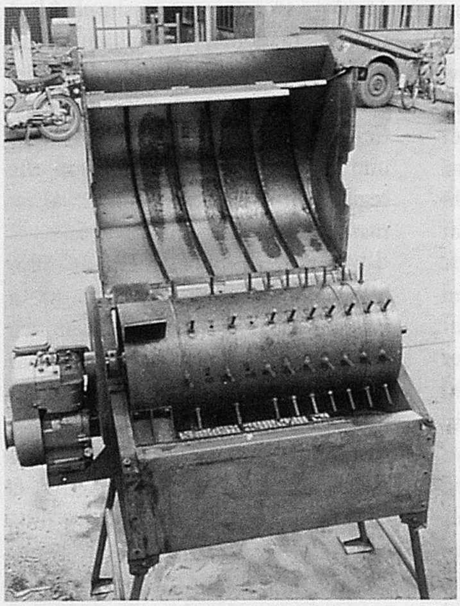

Plate 3. The exposed drum of the paddy thresher shows the curved partitions in the inside back cover that permits an axial movement of grains. This model can be conveniently carried by two men from one threshing floor to the other.

Plate 4. A simple grain cleaner for cleaning paddy from a thresher at the rate of about 0.5 to 1.0 mt/hr.

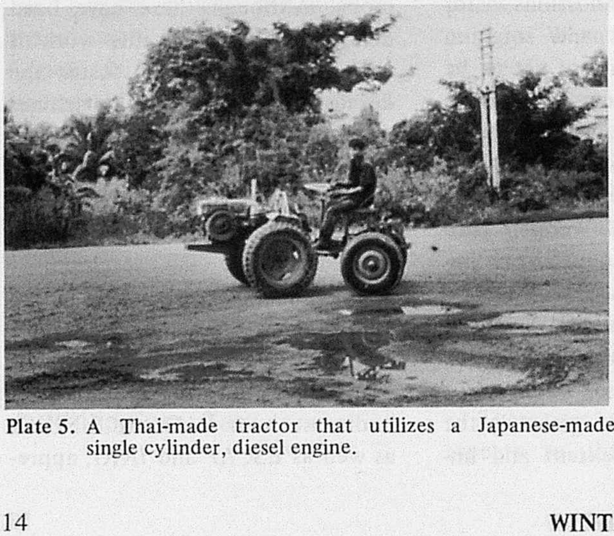

Plate 5. A Thai-made tractor that utilizes a Japanese-made single cylinder, diesel engine.

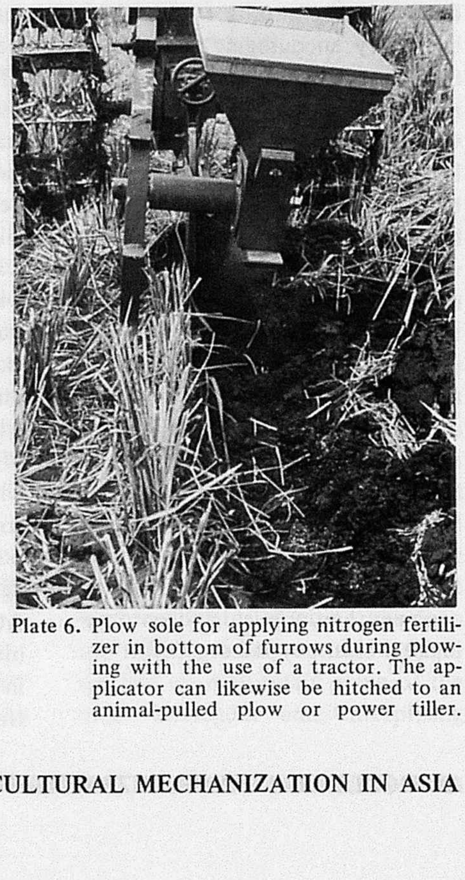

Plate 6. Plow sole for applying nitrogen fertilizer in bottom of furrows during plowing with the use of a tractor. The applicator can likewise be hitched to an animal-pulled plow or power tiller.

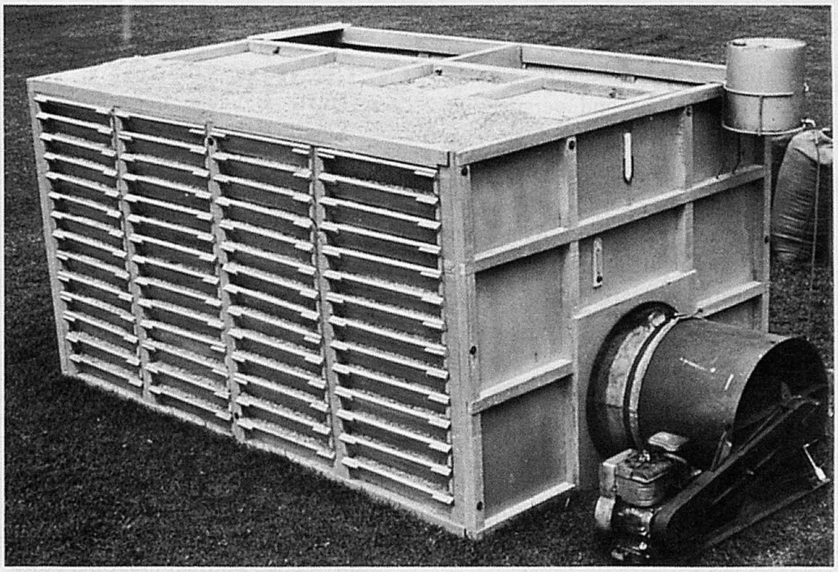

Plate 7. A 2-ton vertical bin dryer capable of drying 2 mt paddy in 6 – 8 hours that operates on kerosene burner and uses a fan driven by a small gasoline engine or electric motor.

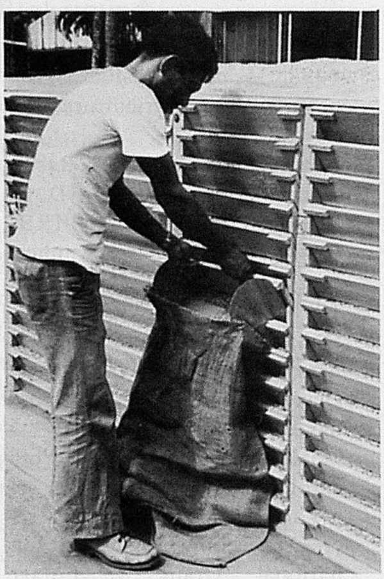

Plate 8. One side of the vertical bin dryer showing a chute and the wooden materials that it is made of indicating its ease of construction from locally available materials in all developing Asian countries.

Plate 9. An axial flow water pump in operation that is capable of lifting water up to 2 – 3 meters. It can be driven by the engine of a power tiller or thresher.

ciate the need to avoid increases in the importing of farm machinery and the encouragement of local manufacturing and employment. It is an important responsibility of the engineers in design and development institutions in many countires of Asia to work with manufacturers to ensure that machines which can help the farmer to get to work in the fields and do not languish merely as interesting technical exercises.

Wanted: Workable Designs

I hope, therefore, that in this paper, with the photographs and references included, I have said enough to show how the challenge to the engineer comes from Asian farming and how, to my mind, we should meet this challenge. So far, however, I have not said much about some other aspects of these problems. First, I believe that Asia has a great need for design and development, and I am less inclined to believe that the need is for research.[5] My reason for this is that the needs of the farmers are urgent and fundamental research, as distinct from design and development, is a luxury which limited resources make less attractive in Asia than elsewhere. Next I believe that many of the practical problems of Asian farming must be solved where the crops are grown and freely available. This is, for example, particularly true of rice grown in small bunded fields which are so different from the conditions in which wheat and barley, potatoes and sugar beet are grown in N. America and in Europe. Sometimes equipment from those countries can help Asian farmers but this will more often be the exception than the rule. A vitally important point which cannot be emphasized too strongly is that the design and development engineer must do all that he can to help to establish local manufacturing industries for farm machines. It is unthinkable that the increasing quantities of such farm machines should be a burden on the relatively small sums of foreign exchange available to developing countries and this can be avoided if locally designed and developed machines are made in local workshops. Initially some imports may be needed, e.g., small gasoline engines and diesel engines, ball bearings, etc. but they are products which cost much less than complete machines and which, as experience and skill develops, can be made in at least some of the Asian countries.

Finally we need a sense of perspective, not least in discussing our problems with economists. Machines to suit the special conditions of Asia are not developped in a year but often require several years to bring them to a state of reliability and durability. They must then be demonstrated widely to farmers so that a demand for them develops and, sometimes at the same time and sometimes a little later, manufacturers must be encouraged to invest their money in factories to produce the machines and to organize both sales and servicing organizations. All of these are vitally important steps because the best design of farm machine in the world is useless until it gets into the fields and actually works efficiently, reliably and durably to produce more food and better quality food.

The many aspects of engineering require many years for fulfillment and so we need all the help we can get to increase our rate of work. On the other hand, there is little likelihood of farms being provided with machines at such a rate that there is a sudden and catastrophic release of men from the farms to the cities. Considerable progress has already been made but the number of problems to be faced is formidable and, as I have said, success must be measured by the employment of locally made machines in the fields. One example may help to illustrate the progress and the challenge; we were delighted to find at the end of 1977 that 2,000 threshers to IRRI designs had been made in that year in the Philippines alone. That represents splendid progress but it is a sobering thought to realize that there are 2,000,000 farmers in the Philippines. Thus, I conclude this paper by reiterating that engineers have immense challenges to face, that they need a well developed sense of priorities and perspective but feeling confident that we can do much in the coming decades to play our part in feeding the ever-increasing populations of Asia even though there is little new land to be brought into cultivation.

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Acceleration of Farm Mechanization Through More Adequate Financing Taiwan

by
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Background

Up until 1965, rural manpower – about 45% of the country's total population – was still ample. Owing to the successes in land reform, some 100,000 more head of draft cattle for intensive cultivation became necessary. It was very difficult to get so great a number of draft animals in a short period. On the other hand, the implementation of three successive four-year economic development plans brought about a rapid industrialization. It was then that the country's agriculture began a new phase which marked an end of labor slack. This situation called for an acceleration of the farm mechanization drive that had been carried out in the 1950s but with emphasis merely on encouraging the replacement of draft animals by power tillers for land preparation. Accelerative efforts were then directed at extending the use of such labor-saving machines as rice transplanters, combines and grain dryers.

Since 1970, government agencies and banks had provided low-interest loans to farmers in addition to subsidies for the purchase of farm machines – a total of NT$3.6 billion in a period of seven years. Inspite of such support, there remained a need for a fixed fund. For one thing, farm mechanization is a long-term, continuous drive; for another, the purchasing power of small farmers is low.

In September 1977, Premier Chiang Ching-kuo announced at the 60th Session of the Legislative Yuan that a special found would be established for an overall agricultural mechanization scheme with the government to provide a yearly amount of NT$1 billion in 1978–81 and the banks and farmers' associations to contribute a yearly counterpart loan of NT$1 billion.

Work Plan

Based on the decreasing rate of farm labor and on the working capacity of farm machinery, it is planned to increase 150,000 units of various kinds of farm machines during the period of FY1979-82. By the end of June 1982, there will be 350,000 units of farm machines in use and the input rate of power tillers and tractors per hectare will be 1 horsepower. Farming operations will then be mostly mechanized as far as rice production is concerned.

The following are the major measures for the promotion of overall agri-mechanization:

a. <u>Development of local farm machinery industry</u>:
   1) Assist local manufacturers in devising procedures for the quality control of their products;
   2) Draw up testing standards for major farm machines and conduct field tests; and
   3) Encourage manufacturers to expand their operations and increase their products so as to reduce production costs.

b. <u>Speeding-up of the proliferation of farm machines</u>:
   1) Extend loans to farmers through local banks and township FAs at an annual interest rate of 8.5%;
   2) Provide subsidies for farmers to purchase combines, grain dryers and other farm machines;
   3) Subsidize well-trained farmers in setting up rice nursery centers each capable of providing rice seedlings for about 200 ha of paddy fields so as

to speed up the mechanization of rice transplanting; and

4) Strengthen farm mechanization promotion centers at the township level, making them capable of repairing farm machines, training farmers and arranging custom work.

c. Training of farmers and technicians:

1) Train farmers in the use of less complicated machines by both agricultural vocational schools and township farm mechanization promotion centers; for complicated machines, the training is conducted by the MOEA Agricultural Vocational Training Center;

2) Train agri-school graduates majoring in farm machinery to become extension workers or after-sale servers; and

3) Give the FA personnel of some 300 townships an intensive training course on how to handle the farm machinery loan project.

d. Strengthening of custom work:

In order to ensure an effective and efficient utilization of farm machines, government agencies and FAs assist machine owners in doing custom work for farmers who cannot afford to buy and sometimes for those who live outside their townships.

e. Strengthening of research and experimentation:

Efforts are being continued to provide various research institutions with better equipment and more well-trained technical personnel. Meantime, the bigger farm machinery manufacturers are encouraged to set up their own research units for conducting specialized studies and tests in order to produce high-quality machines for farmers.

Financial Source

An Agricultural Mechanization Fund has been set up with the Central Government to provide a yearly amount of NT$1 billion in 1978-81; by FY1982, the fund will reach a total of NT$4 billion. An equal amount of counterpart fund is contributed by the loaning banks and FAs. Part of the fund's loan interest is used for supporting projects that pertain to research, training and extension of farm machinery.

Benefit

a. To agriculture sector:

Use of the existing farm machines may help save about 9,270,000 man-days which, if calculated on the basis of NT$200 per man-day, are worth NT$1.85 billion. By the end of June 1982, when the number of farm machines will have increased to 350,000 units, 24,250,000 man-days or NT$4.85 billion may be saved. In other words, the project for an overall agri-mechanization will save a labor cost of NT$3 billion or more per year. Besides, it may increase the yield of various crops and reduce the loss of farm products. For instance, it may increase the output of paddy by 90,000 tons which are worth about NT$1 billion. All in all, farmers will get a total benefit of NT$4 billion every year upon completion of the project.

b. To other sectors:

The rapid development of industries needs more labor for their continuous growth. About 23,000 workers, 1.5% of rural labor, tend to shift from the agricultural sector every year. This relies on farm mechanization which not only can make up for the decrease of rural labor but also help keep a stable growth of agriculture. Besides, it may stimulate the development of local farm machinery industry. Under the overall agri-mechanization project, five big farm machinery manufacturers are to be either newly established or reorganized from the existing ones. In the near future, all major farm machines will be totally made locally for domestic use and export.

In recent years, many rural youths have been drawn away from the country-side to cities and factories. Consequently, most of the remaining farming population are the elderly people, women, and children. This also necessitates the use of farm machines to reduce the drudgery of field work and thus allow farmers to have more leisure time to improve their life quality. And with this, young farmers could be always available to join the army in wartime.

c. To future development:

The promotion of overall agri-mechanization is a long-term work. Its pace depends on farmers' demand and national manpower planning. Farmers' demand for mechanization varies with rural labor productivity, i.e., the total rural labor force multiplied by the unit labor productivity. Unit labor productivity can be raised with the use of machines to conduct farming operations. Therefore, farm mechanization could make up for the ever-decreasing rural labor, on the one hand, and promote an effective utilization of national manpower to allow a shift of the labor force from agricultural to other sectors, on the other. This will definitely serve to reduce the soaring cost of labor, thus decreasing the cost of industrial production and increasing our competitive potential in international markets. As the case stands, the overall agri-mechanization is good to both economic and social developments. ■■

Research and Development Process of Designing Agricultural Machinery

—Tractor as Example—

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Introduction

Machine is the product of modern industry, hence there ought to be an engineer who decides the shape and quality of each part of the machine. Such an engineer is called a designer. The group of designers that create the machine is a design team. The engineer who leads the team and organizes a machine with many parts designed by them is called a chief designer.

If we can only define and realize the importance of modern mechanical industry to human beings through products, then we will be determined to believe that research and development activities ought to exist in order to create a better machine through the blue prints drafted by the designers.

Agricultural mechanization can and should be developed fully with the farm machinery and equipments to suit local farming conditions that are acceptable by farmers. In order to develop such farm machinery as quick as possible, design technology as well as testing technology have to be mastered. It is also important that an efficient development process should be applied by design and test engineers.

The modern machinery in the market is usually developed by the engineers in companies. Each company has its own technique. Therefore, the existing technical process of developing machinery is scarcely reported in detail to the public. However, the engineers in developing countries need to know this process. The author investigated the conceptional process of several companies in Japan. The process differs somewhat with companies and sorts of products. The author feels that even if a few designers develop a machine, he or they are advised to efficiently produce all the items which are done by a big group of engineers for both the design and tests.

This paper introduces the efficient research and development process of a new agricultural machinery, especially a design process of developing a power tiller and/or tractor.

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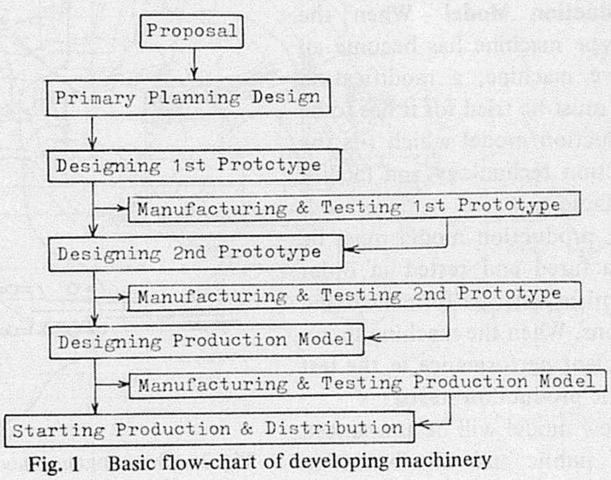


Fig. 1 Basic flow-chart of developing machinery

Concept of Effective R & D Process

The general principle of the development process is shown with the flow-chart of **Fig. 1**. The process starts from the primary planning as a proposal, not a design, with a presumption of the social needs in the future farming. As a rule, it is an efficient method that the development design is done through four designing stages of the primary planning, the 1st prototype, the 2nd prototype and the production model.

Primary Planning Design – The original plan should be accepted by the design engineer who can be a chief designer to create the machinery with design technology. When the original plan is reasonable, he can draft the whole view of the machine in 1/5 to 1/10 scale, as a planning design, after the additional investigation and calculation by himself.

1st Prototype – This is the machine to be realized from the primary planning design and the abstract idea at the previous stage without an existing machine. A chief designer and his design team create and draft all the parts to make a machine. The 1st one is manufactured and tested.

2nd Prototype – This is developed from the 1st one with the useful test data. This must be also manufactured and tested.

Production Model – When the prototype machine has become an effective machine, a modification design must be tried for it has to be a production model which fits the production technology and facility in the factory.

The production model must be manufactured and tested in order to confirm the performance and functions. When the machine shows a sufficient performance in the test data, the production starts.

A new model will be announced to the public and distributed to

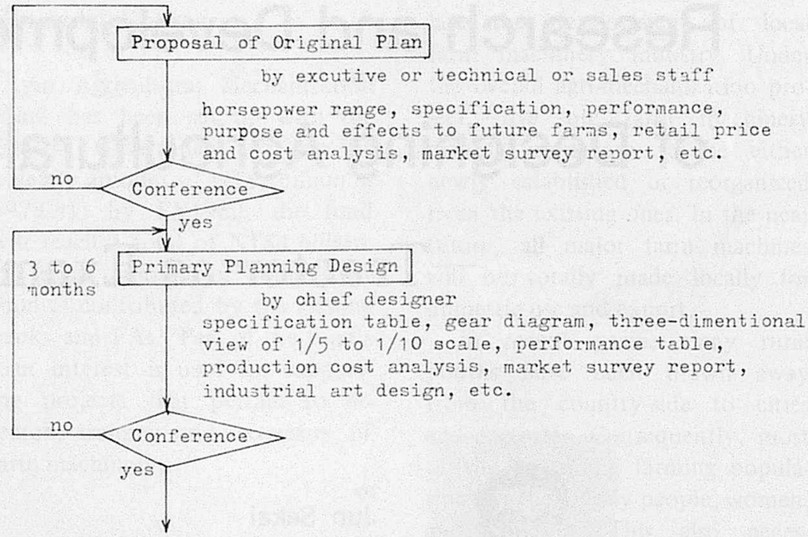


Fig. 2 Proposal and primary planning design

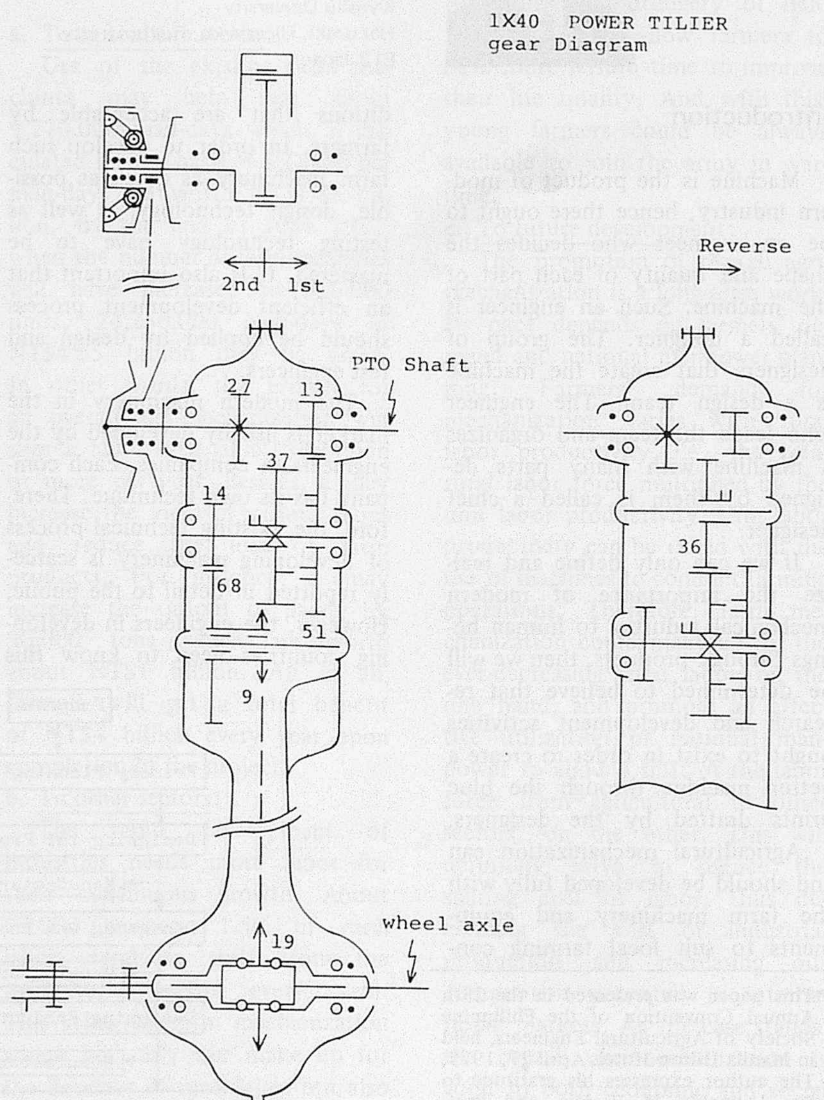


Fig. 3 Gear diagram (modified from Service Manual, Honda, by the author)

the farm areas.

Detail Process of Primary Planning Design

Fig. 2 shows the process of the proposal of an original plan and the primary planning design. The proposal can be made by any person who is interested in agricultural machinery. However, as shown in **Fig. 1**, it takes at least two to three years to develop a new machine, such as a tractor. It is also necessary for the new model to be produced continuously and successfully for five years or more.

This means that the excellent planner and/or designer should precisely understand the trend of farming expected to be realized for five years or more after the proposal time. Therefore, the proposal should be formulated after a special market survey and research on the past, present and future farming had been done including the structural current of a country. Moreover, the proposal should include the possible specifications and performance for the new machine or mechanism, with the information of production cost which is acceptable by the farmers or farm society in the future. Only a practicable proposal will be accepted by the designer.

After the approval of the proposal, the planning designer, as the chief, starts to calculate the performance of the machine, and to select the main mechanical elements and structure to organize the whole machine. He also calculates the strength of the main parts of every element in order to know their approximate sizes. When the approximate size of the whole machine has been decided, he starts to make the primary planning in engineering expression. Namely, he will express these in a gear diagram as shown in **Fig. 3**, and also in the drawing of a three-dimensional view reduced to a scale of 1/5 to 1/10 of the actual size, as shown in **Fig. 4**. These are called a "lay-out design" also. The lay-out design is sometimes done for two or three models at the primary stage.

(A bird's-eye view is useful for only a simple machine or to non-professional people, but not to a real engineering design group.)

(Production-cost analysis means to express an ideal production-cost of the factory, related to an optimum retail price to the farm after passing the necessary marketing channels that need sale and post-sale services and so forth.)

Designing the 1st Prototype Machine

Fig. 5 shows the process of designing the 1st prototype machine. When a model is selected to be developed from the primary planning design, developing design starts after the design team has been organized, if there are many designers. A simple power tiller can be designed by one to three de-

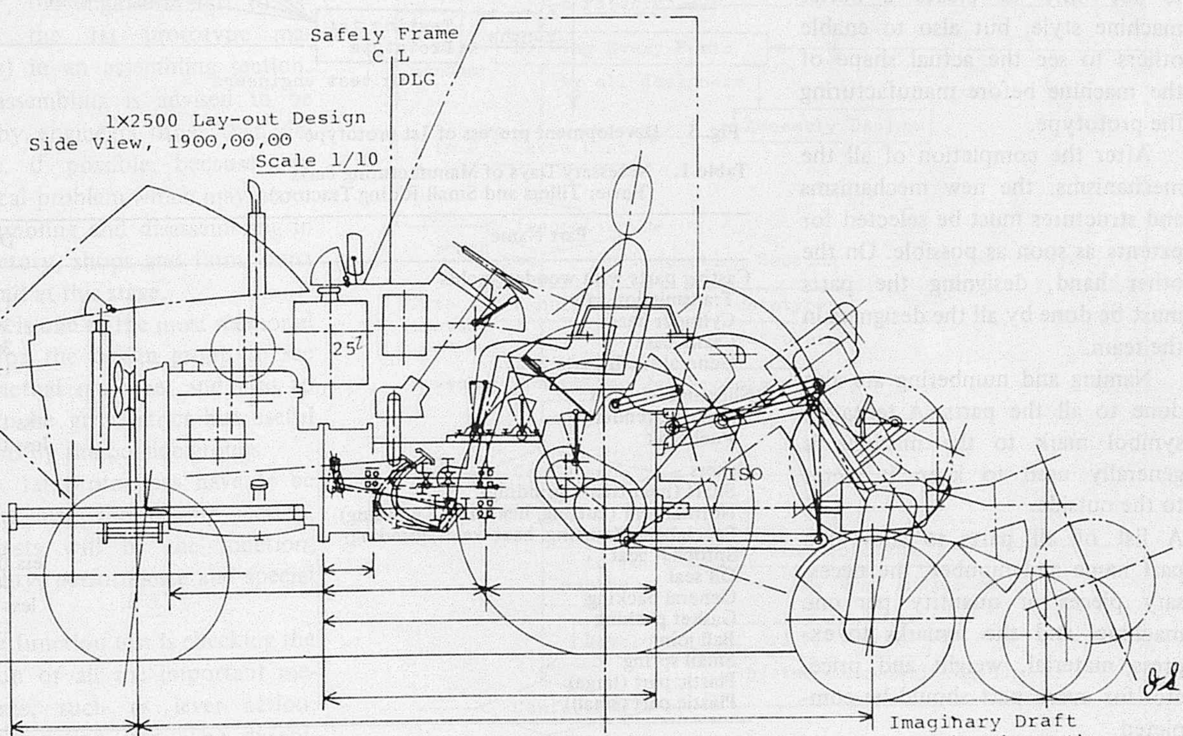


Fig. 4 Lay-out design in primary planning (side view)

signers, while a big one or a small riding tractor with no engine but a rotary tiller on it, by two to six designers in general.

The planning design of the whole view (1/1 to 1/2 scale) is produced by one designer, usually the chief designer. When the whole planning design is being drafted, the machine is separated into such components as an engine, transmission, frame and chassis or handle portion, attachments and so forth, and each component is distributed to each designer for the start of the detailed planning design.

When the outside shape and relative location of every component are decided through the whole and detailed planning design, which is called a "lay-out design", the special drafting for a mock-up is done as shown in Fig. 5. Materials for this model are wood, plastic and/or clay, etc. A better and reasonable appearance of the machine is freely created by a group of industrial art designers. The purpose of making a mock-up is not only to create a better machine style, but also to enable others to see the actual shape of the machine before manufacturing the prototype.

After the completion of all the mechanisms, the new mechanisms and structures must be selected for patents as soon as possible. On the other hand, designing the parts must be done by all the designers in the team.

Naming and numbering are also done to all the parts. A tentative symbol mark to the machine is generally used to keep it secret to the outside.

A list of all parts to show the part name and number, the necessary pieces or quantity per one machine, and the remarks to express material, weight and price, etc. for every part should be completed.

When these design and preparation are finished, each drawing

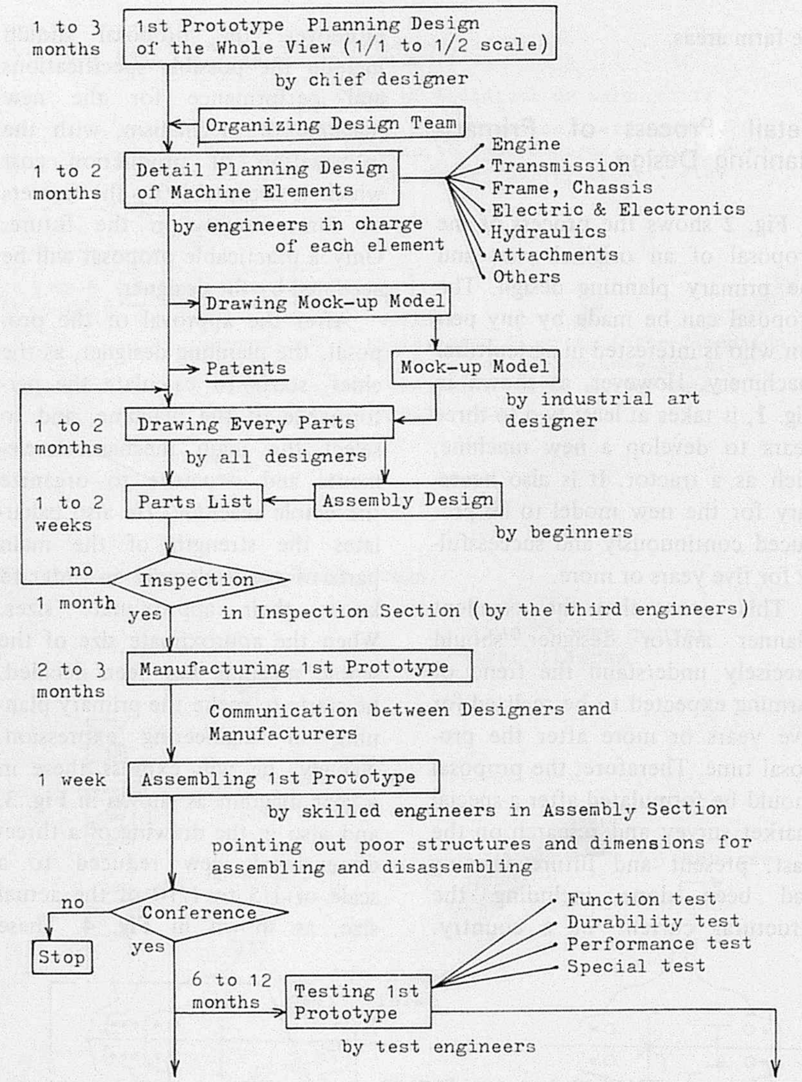


Fig. 5 Development process of 1st prototype

Table 1. Necessary Days of Manufacturing Parts (Power Tillers and Small Riding Tractors)

Part Name	Days
Casting parts with wooden molds	
Transmission case	15 – 30
Cylinder head	30 – 60
Crank case	30 – 40
General small parts	15 – 25
Sheet-metal parts	
Muffler, fender	less than 20
Fuel tank	less than 30
Others	
Shaft (heat-treat., grinding)	5 – 15
Normal gear (cutting, heat-treat., grinding)	2 – 10
Special gear (cutting, heat-treat., grinding)	15–20
Sprocket gear	less than 15
Oil seal	10 – 25
General packing	less than 7
Gasket packing	15 – 20
Ball joint	30
Small spring	7 – 15
Plastic part (large)	20
Plastic part (small)	10

Notice: 1) Investigated by the author on individual manufacturers in Japan.
2) About 50 to 100% days should be added in the case of schedule management, because there are poor parts that can not pass the inspection.

must be checked by the engineer who should be a third person other than its designer. The purpose of this is to inspect if the drawing has any mistake or insufficient information in it for the engineers who manufacture the parts.

Manufacturing and Testing the 1st Prototype

When all the drafting processes are finished, the blue prints of all the parts will be distributed to the parts manufacturers, and the designers must have technical communication with them. Some engineers in the manufacturers will give the useful questions or technical suggestions to make better parts to the designer. The necessary days of trial manufacturing the parts in Japan are shown in **Table 1** as an example.

When all the parts are perfectly collected in a part-storing section, after passing the inspection for the accuracy of their dimensions and quality, the engineers start to assemble the 1st prototype machine(s) in an assembling section. This assembling is advised to be done by engineers other than designers, if possible, because any technical problem which may occur in assembling and disassembling in the factory, shops and farms must be found at this stage.

This is one of the most memorial days for the design group to see their actual machine, and also to start to be given strict but useful opinions by the outside groups.

The 1st prototypes have to be brought into the testing section. The tests will be the function, durability, performance and special ones.

The function test is checking the function of all the important mechanisms, such as lever action, clutch function, etc. The durability test is separated into the field and simulation ones. Some reasonable loading conditions have to be decided carefully by both the designer and the test engineer. The total driving hours by the durability test under Japanese farming conditions are usually more than several hundred hours as to a power tiller and greater hours than it as to a riding tractor, under various loading conditions. This means the field test requires heavy work of the driver. In order to save manual labour, specialized devices to simulate the actual loading condition on the farm are prepared and used for the indoor durability test through the year. Because the machine is allowed to be driven 8 hours a day, as a rule, and it has to be disassembled for checking every fifty to one hundred working hours.

The performance test is to estimate the working capacity of the machine for every work expected on the farm throughout the year. Many attachments have to be tested with the tractor, and the best one is selected as the standard attachment.

The special test means, for example, the test under a special temperature or air pressure, etc. The machine has possibilities to be used under irregular conditions, such as driving in a mountainous district or in foreign countries. Optional parts are selected for such special driving conditions.

The test engineers are expected to find the remaking ideas to promote machine functions, durability and performance as well as to find all insufficient structures, functions, materials, performance, etc.

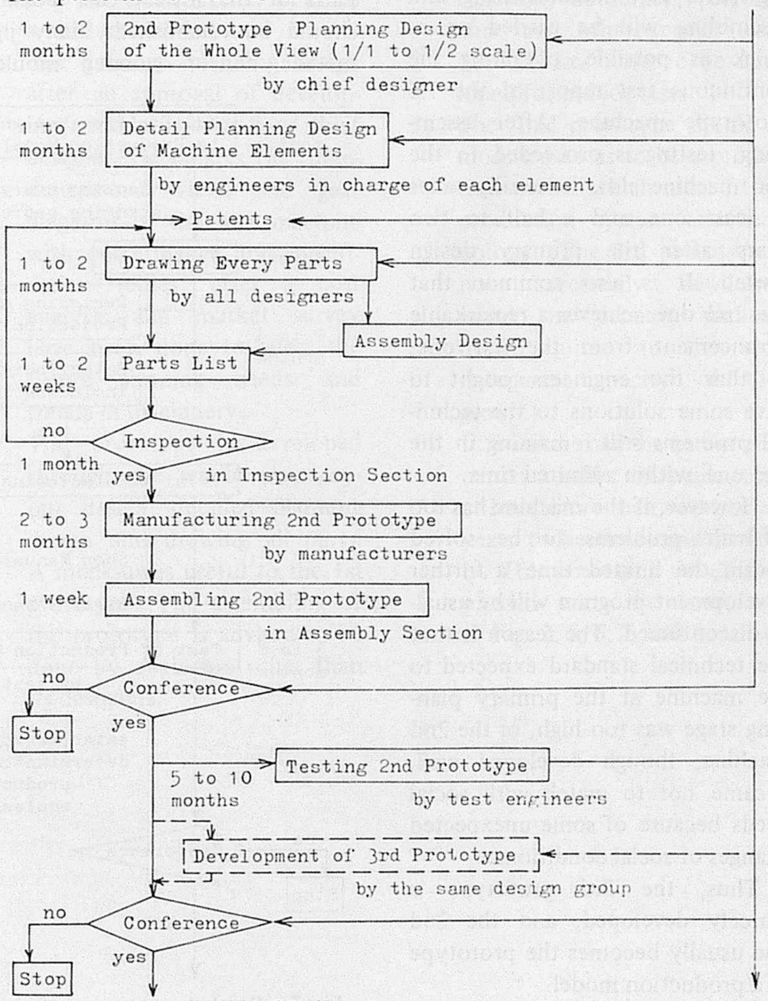


Fig. 6 Development process of 2nd prototype

Developing the 2nd Prototype Machine

As shown in **Fig. 6**, the 2nd prototype has to be developed from the 1st one. This process starts also from the lay-out design of remaking the 1st model. All the data obtained from the test reports is applied to remake it. The process of this machine is almost the same as that of the 1st one. However, there is a great difference in meaning between them, because the 1st one was the product from the ideas of brains, while the 2nd one is the product remade from the existing machine with the abundant test reports and suggestions.

The planning design of the whole view, detail planning design, part design, assembly design, making parts list, manufacturing and assembling will be carried on as quick as possible, obtaining the continuous test report of the 1st prototype machine. After assembling, testing is proceeded to the 2nd machine also. It usually takes at least one and a half to two years after the primary design started. It is also common that the 2nd one achieves a remarkable advancement from the 1st one, so that the engineers ought to have some solutions to the technical problems still remaining in the 2nd one, within a limited time.

However, if the machine has too difficult problems to be solved within the limited time, a further development program will be usually discontinued. The reason is that the technical standard expected to the machine at the primary planning stage was too high, or the 2nd machine, though developed well, became not to match with social needs because of some unexpected changes of social conditions.

Thus, the 3rd prototype is scarcely developed, and the 2nd one usually becomes the prototype of a production model.

Modification Process for the Production Model

When the prototype machine shows an acceptable performance and function, all the parts must be reviewed and modified to suit the production facility and technology applied in the factory. The angles and dimensions of some parts, especially casted, pressed, forged and welded ones, are different so delicately depending upon their production methods that the function and strength also differ from each other. **Fig. 7** shows the modification process.

The secret model-name of all the drawings should be different from a public one. While the modification is being made, the real production facilities to produce the optimum parts at the lowest cost possible should be established. Many jigs, metalic and/or wooden moulds, machine tools, devices, etc. are designed and/or prepared. These are done by production engineers.

The specifications of the new model are informed to the attachment manufacturers.

The trial manufacturing of the production model with real production devices and lines is conducted, and the production model is tested again on all the items of specifications, performance, functions, durability and so forth. Remaking and revising some designs are usually added to the drawings.

Test engineers are especially busy in confirming the machine performance in many kinds of farm work with various attachments. To select reasonable standard attachments is one of the important items to develop a better tractor.

Designers and service engineers will also get busy preparing the manuals for owners and shops,

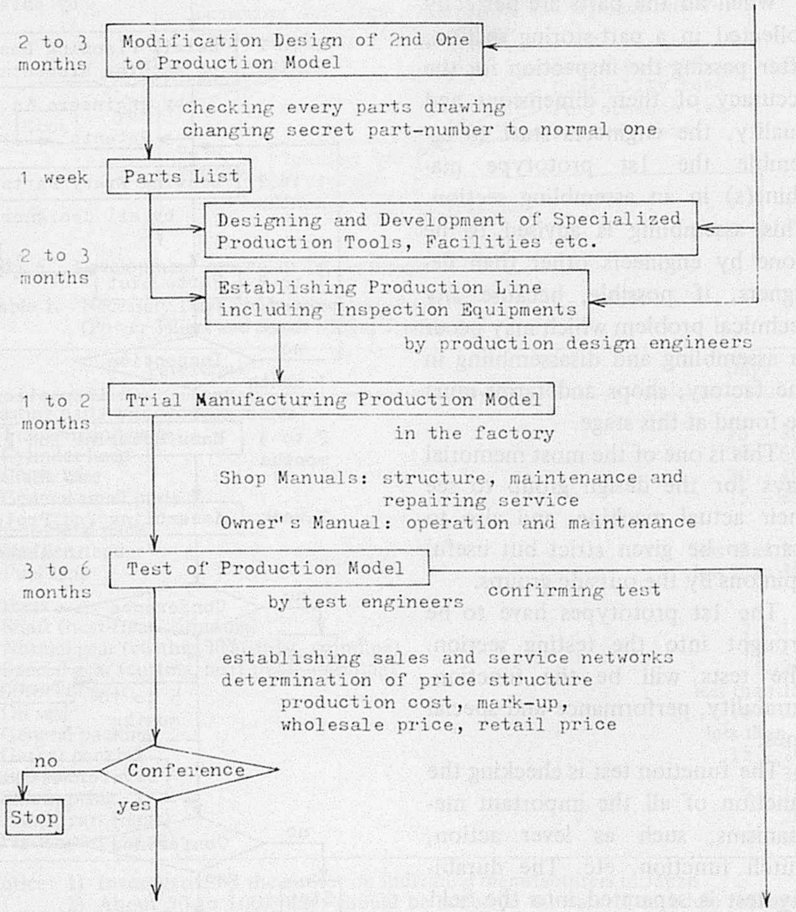


Fig. 7 Development process of production model

expecting their better maintenance and utilization of the machine on the farm.

At the last stage, the effective packing methods for a safe delivery to local dealers should be tested. Usually this is attained after at least two to three years since the primary planning design started.

Production Starting and Distribution

When all the development designs and tests are over, the production starts. The designers and test engineers have to attend the exhibition and display shows.

Then, as shown in Fig. 8, the design team of the model will be dissolved as soon as possible. However, one or two designers who are called a "continuous designer" must take care of the model to continue the remaking design according to the trouble shooting from farmers and marketing channels. The other designers start to design another new model. The machine will become a discontinuity model within several years after starting its production in general.

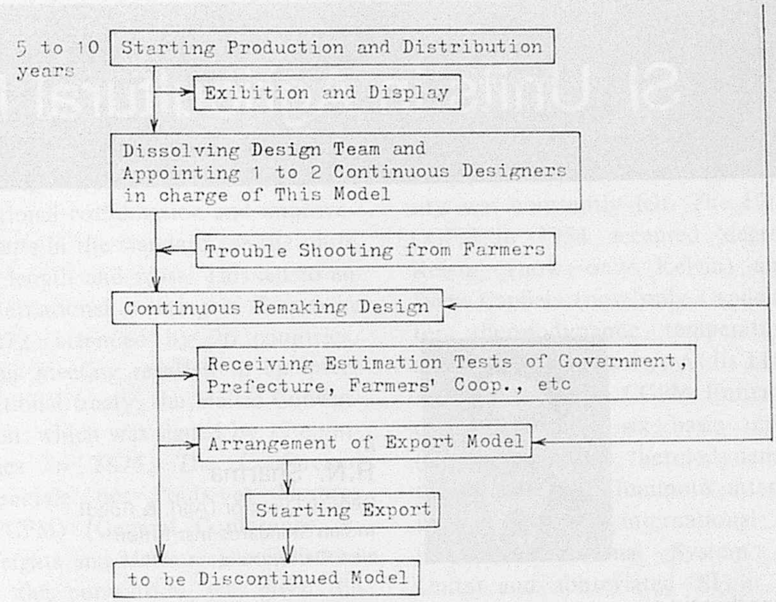


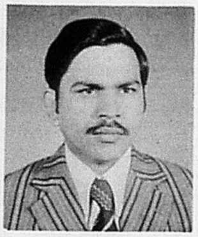
Fig. 8 Starting production and continuous design

Summary

A modern R & D process of designing new machinery, a power tiller or tractor-like machine as an example, is explained as follows:

1) The actual design process in modern industry is usually divided into four stages: primary planning, developing of the 1st and 2nd prototypes and the modification of it to a production model.
2) The primary planning design after an approval of developing a model is done by a chief designer. He creates the three-dimensional views and gear diagrams of the new machine with performance and specification tables, after a cost analysis and market survey have been done to guess the future farming needs and trends in machinery.
3) The prototype is developed through the whole view layout design, detailed planning design and drawing all parts. A mock-up is useful to the 1st prototype. The assembling of the prototype is advised to be done by engineers other than its designers.
4) The developing test consists of function, durability, performance and other special tests. Test devices have to be developed for indoor tests.
5) The final prototype should be modified so as to be a production model which must fit the production system and technology. (The 3rd prototype is not necessarily developed, when the primary planning design suited to the technological capacity of their group.)
6) It is usual that the power tiller or tractor-like machine takes at least more than two or three years to be developed perfectly. This process in detail is expressed with the flow-charts of Fig. 2, 5, 6, 7, and 8. ■■

SI Units in Agricultural Engineering



by
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Introduction

1. A few years ago the whole world was divided between two major systems of measurement – The FPS (Foot-Pound-Second) system and the metric system. New SI system has been accepted by almost every country and most of the countries have already switched over to this system and a few one are on the process of change over.

2. In our country too, SI units are only legal form of units. A lot of literature has been published for the use of educational institution, trade and industry, and other branches of engineering have almost adopted this system. But the field of agricultural engineering (application of engineering principles for the development of agriculture), it appears has not fully geared up itself to adopt this system. This article is intended to help the agricultural engineers in all walks of life to know the system in detail for adoption in their profession.

Historical Background

1. The FPS system, popularly known as British or Imperial system, is a collection of incoherent units which originally had no connection among themselves, because they originated in the periods when one type of measurement rarely had to be connected to an other, e.g. the foot derived its name from the King's foot and was used for measuring short length. It had no correlation with the mile which was used for measuring long distances. The unit of land measurement was the acre which had nothing to do with either foot or miles since it was originally considered to be the area which a single man could cultivate. Therefore, it is not at all surprising that as civilization developed, it became necessary to correlate these units. Hence, such awkward factors like 3, 8, 12, 220, 1760 arose, apart from one acre = 4840 yd^2 = 43560 ft^2; 1 sq mile = 640 acres, and so on. Similarly the power of an engine was designated as horsepower, because the buyers wanted to know how many horses the engine would be able to displace. Likewise, other units bore no particular relationship. No uniformity of weights and measures existed and there were differences from country to country and even from town to town and from one trade to other.

2. The non-uniformity and non-coherency of FPS system led the National Assembly of France on 8 May 1790 to enact a decree, sanctioned by Louis XVI, which called upon the French Academy of Sciences in concert with the Royal Academy of London to "deduce an invariable standard for all the measures and weights". The English were not interested in this project, so the French proceeded with their endeavor alone. The report submitted by the French Academy to the French Assembly in 1791 envisaged the measurement system to the base ten; that is, the units of the system, their multiples and submultiples should be related to each other by simple factors of ten, the system which seems to have been first proposed by Gabriel Monton, a vicar of Lyons, French, in the late 17th century. This system was adopted in France by law in April 1795. The progress of actual use was slow initially whence it was made obligatory in July 1837.

a) Original metric system was based on the metre, gram and second as the units of length, mass and time respectively. The word 'metre' derived its name from Greek Word 'Metron', meaning 'to measure' and which was intended to be one ten millionth part of the distance from the north pole to the equator, along the meridian running near Dunkirk in France to Montjuich near Borcelona in Spain. The 'gram' was intended to be the mass of one cubic centimetre of water at 0°C. Although there was some discussion at the time of decimalizing the calendar and the time of day, the system did not include any new unit for time and adopted 'second' of FPS system.

b) In 'MGS' system the unit of length, metre, represented comparatively higher value than the unit of mass, gram. This system was in use for industry and commerce but scientists were finding some difficulty in the use. So around 1873 they changed metre to centimetre (C) and the system was designated as CGS system. Since the units in CGS system were quite small they could not be accepted by engineers and technologist, so around 1900, practical measurements in metric units began to be based on the metre, the kilogram and the second (MKS) system. During this period, both the CGS system and MKS system were in vogue.

c) In the year 1901, Professor Giovanni Giorgi (Prof. of Electrical Engineering, University of Rome) suggested that the MKS system of units of mechanics should be linked with the electromagnetic units used in electrical engineering by the adoption of any one unit as fourth unit. After a long deliberations ampere (A) was choosen. Selection of ampere resulted in the MKSA system or Giorgi system of units. In 1904, Prof. Giorgi also introduced the idea of refirming the electrical units which was originally proposed by Oliver Heaviside in 1882 and the system thus rationalized came to be known as rationalized MKSA (RMKSA) system.

3. Due to process of evolution of metric system by the middle of nineteenth century and because of increasing technological development, a need was felt for international coordination and improvements in the standard for the units of length and mass. This led to an international meeting in France in 1872, attended by 26 countries. This meeting resulted in an international treaty, the Metric Convention, which was signed by 17 countries in 1875. The Conference Generale des Poids et Mesures (CGPM) (General Conference on Weights and Measures), constituted at this convention, was given the responsibility regarding all international matters concerning the metric system. As a result of this convention, the basic units of mass and length, kilogram and metre, were established and defined internationally in 1879. The CGPM meets in Paris once in every six years and takes all major decisions with regard to new and revised definitions of metrological standards. The CGPM also controls 'The Comite International des Poids et Mesure' (CIPM) (International Committee on Weights and Measures). The CIPM meets once in every two years and if necessary earlier also. Its functions are to follow up the decisions of the CGPM and to look after the operation and management of the Bureau International des Poids et Measures (BIPM) (International Bureau of Weights and Measures). The CIPM also appoints its own specialist consultative committees which are presently seven in numbers each dealing with electricity, photometry, temperature, length, time, ionizing radiations and units. These committees besides guiding BIPM also guides to various national laboratories. The BIPM is a laboratory wing of CIPM and all the standards of the world authority are maintained by this.

4. The CGPM at its ninth meeting in 1948 adopted the rationalized form of MKSA system. The need for acceptance of other basic units, like the unit for thermodynamic temperature and luminous intensity was constantly felt. The 10th CGPM in 1954 accepted 'degree Kelvin' (now only Kelvin) and 'New Candela (now only Candela) for thermodynamic temperature and luminous intensity. As its 11th meeting in 1960, CGPM formally designated these six basic units (length, mass, time, thermodynamic temperature and luminous intensity) as 'System international d' units (International System of Units) and abbreviated 'SI' in all languages. Two supplementary units radian and steradian for plane and solid angles were also accepted. Decimal multiples and submultiples formed by using prefixes, and derived units were also accepted in this meeting. The CGPM at its 14th meeting in 1971 has also accepted 'Mole' (mol) as seventh basic unit for amount of substance.

Metric Change in India

1. After independence, India joined metric convention which made it obligatory for India to change from FPS system to metric system. The country completed its obligation and Parliament passed the Standards of Weights and Measure Act in 1956, by virtue of which metrication was made legal. The basic idea at that time was to introduce metric change in the field of trade and industry in the phased programme of 10 years. For implementation of the provisions of the Act, a central committee named as 'Standard Metric Committee' was set up. This committee remained up to 1966 and was then re-named as 'Directorate of Weights and Measures'. It is now contemplated to rename it as 'Directorate of Legal Metrology'.

Besides this Directorate, the Indian Standards Institution (ISI) and the National Physical Laboratory (NPL) carried out other important functions in this field. ISI acts as a technical Body for advising on the problem of preparation of specifications for various weights and measures and various types of weighing and measuring instruments. NPL acts as the custodian of the primary standards of weights and measures and also undertakes periodical verification of the reference standards of weights and measures supplied by the centre to states.

2. The Government of India revised in March 1976, the original Weights and Measures Act of 1956. In the revised version, the major changes made inter alia is the recognition of all the basic, supplementary and derived units under SI system for whole of the industry and education instead of only two units of length and mass that too for trade and commerce as envisaged in 1956.

Groups of SI Units

1. SI units consists of seven basic units, two supplementary units and a number of derived units.

2. Basic Units – The basic units of SI system along with their symbols and definitions are given below:

a) Unit of Length – The metre (m) is the unit of length. It is the length equal to 1650 763.73 wavelengths in vacuum of radiation corresponding to the transition between the levels 2 P_{10} and 5 d_5 of the krypton – 86 atom.

b) Unit of Mass – The kilogram (kg) is the unit of mass and is equal to the mass of the international prototype of the kilogram.

c) Unit of Time – The unit is second(s) which is the duration of 9192 631 770 periods of the radiation corresponding to the transition periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Caesium – 133 atom.

d) Unit of Electric Current – Ampere (A) is the unit. It is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed one metre apart in vacuum, should produce between these conductors a force equal to 2 x 10^{-7} newton per metre length.

e) Unit of Thermodynamic Temperature – The kelvin (K), unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

1) The unit of international practical temperature is degree Celcius (°C) on which the thermodynamic temperature of the zero point is 273.15K.

2) The degree Celcius and kelvin both may be used for expressing temperature interval (1°C = 1 K).

f) Unit of Luminous Intensity – The candela (cd) is the luminous intensity, in the perpendicular direction, of a surface of 1/600000 square metre of a black body at the temperature of freezing platinum under a pressure of 101325 newtons per square metre.

g) Unit of Amount of Substance – The mole (mol) is the amount of substance of a system which contains as many elementary entities, as there are atoms in 0.012 kg of carbon 12.

3. Supplementary Units – In the SI system, the quantities plane angle and solid angle, are treated as independent quantities with units radian (rad) and steradian (sr) respectively, and are called supplementary units.

a) One radian is the angle between two radii of a circle which cuts off on the circumference an arc equal in length to the radius.

b) One steradian is the solid angle which, having its vertex in the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

4. Derived Units – The expression

Table 1.

Physical Quantity	Name of Unit	Unit symbol
Area	square metre	m^2
Volume	cubic metre	m^3
Density (mass density)	kilogram per cubic metre	kg/m^3
Velocity	metre per second	m/s
Acceleration	metre per second squared	m/s^2
Angular acceleration	radian per second squared	rad/s^2
Specific heat	joule per kilogram kelvin	J/kgK

Table 2

Physical Quantity	Name of Unit	Unit Symbol	Derivation
Force	newton	N	$kg.m/s^2$
Pressure	pascal	Pa	N/m^2
Work, energy, quantity of heat	joule	J	Nm
Power	watt	w	J/s
Frequency	hertz	Hz	cycle/s (c/s)
Electric potential	volt	V	W/A
Electric charge	Coulomb	C	A.s
Electric resistance	ohm	Ω	V/A
Magnetic flux	Weber	Wb	V.s
Magnetic flux density	tesla	T	Wb/m^2
Inductance	henry	H	V.s/A
Luminous flux	lumen	lm	cd.sr
Illumination	lux	lx	lm/m^2
Electric conductance	siemens	S	A/V

for the derived units are stated in terms of the basic units (see 2.) and supplementary units (see 3.). There are basically two types of derived units; i) with names expressed in terms of base units and ii) with special names mostly based on the names of eminent scientists and engineers.

a) Some derived units expressed in terms of basic and supplementary units are given in **Table 1.**

b) Some derived units with special names are given in **Table 2.**

5. Considering that some units are commonly used in some specific fields, the CGPM have recognized them though they are not actually the SI units. These are as follows:

a) Plane angle – degree (... °) (π/180 rad), minute (...') (1°/60), second (...") (1'/60) and grade (...g) (π/200 rad).

b) Time – minute (min) hour (h), day(d), week, month and year(a).

c) Mass – quintal (q) (100 kg) and tonne (t) (1000 kg).

d) Area – hectare (ha) (10^4 m^2) and are (a) (100 m^2).

e) Volume – litre (l) kilolitre(kl), millilitre(ml) and hectolitre(hl).

f) Speed – Kilometre per hour (km/h) (1/3.6 m/s).

g) Rotational frequency – revolution per minute (rev/min) and revolution per second (rev/s).

h) Density (mass) – tonnes per cubic metre (t/m^3), kilogram per litre (kg/l) (kg/dm^3), gram per litre (g/l) (kg/m^3), gram per millilitre (g/ml) (g/cm^3).

i) Pressure – bar (10^5 Pa), hectobar (hbar) (10^7 Pa), millibar (mbar) (10^2Pa), microbar (μ bar) (10^{-1} Pa).

j) Dynamic Viscosity – Poise (P) (10^{-1} $N.s/m^2$), centipoise (cP)

k) Kinematic Viscosity – Stoke (St) (10^{-4} m^2/s), centistoke (cSt) (10^{-6} m^2/s).

l) Energy, Work – Kilowatt hour (kWh) (3.6 x 10^6 J = 3.6 MJ) electronvolt (eV) (1.602 x 10^{-19} J).

Use of Prefixes

1. Decimal multiple and sub-multiples of the SI units are formed by means of the prefixes given in **Table 3.**

Table 3

Multiplying Factor	Prefix	Symbol
10^{18}	exa	E
15^{15}	peta	P
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^2	hecto	h
10^1 (10)	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Rules for Use of SI Units

1. The CGPM held in 1960, 1964 and 1967 not only specified units but also guidelines for its practical usage. The rules are to be adhered strictly while using SI system. Some of them are listed below:

a) The prefixes should preferably be chosen from $10^{\pm 3n}$, n being an integer. It means that prefixes hecto, deca, deci and centi should be avoided. This would simplify the calculations.

b) Prefix should be applied to the numerator, e.g. MN/m^2 and not N/mm^2. Exception to this may occur when base unit kg appears in the denominator.

c) Double prefixes should not be used e.g. MW and not k(kW).

d) Unit symbols should be written in roman (upright) type and not in italics e.g. k and not *k*.

e) The letter 's' should not be used to indicate plurality of quantity e.g. 10 m and not 10 ms.

f) It should be written without final fullstop e.g. 10 m and not 10 m.

g) The symbols specified for various units are mandatory. No change should be made in the symbols e.g. 's' for second and not sec, 'm' should be for metre and not 'M'.

h) When using a prefix symbol, which coincides with the symbol for unit, special care should be taken to avoid confusion, e.g. newton metre should be written Nm or mN to avoid confusion with mN which is millinewton.

i) When a combined unit is formed by dividing one unit by other, this may be indicated in one of the following ways;

$$\frac{m}{s}, \quad m/s \text{ or } ms^{-1}$$

In no case, should more than one solidus sign (/) on the same line be used in such a combination unless parenthesis be inserted to avoid ambiguity.

j) Units with names of the scientists should not be capitalized when written in full e.g. newton and not Newton.

k) While writing number, a space should be left after every three digits. Commas should not be used while writing number e.g. 2 342 786 and not 2342786 and 1 305.315 and not 1,305.315.

l) When expressing a quantity by a numerical value and certain unit, it has been found suitable in most cases to use units resulting in numerical values between 0.1 to 1000, such as 12 kN and not 12000 N; 2.94 mm and not 0.00294 m.

m) A prefix is considered to be combined with the unit symbol to which it is directly attached, forming with it a new unit symbol which can be raised to a positive or negative power and which can be combined with other unit symbols to form symbols for compound units for example:

$$1\ cm^3 = (10^{-2} m^3) = 10^{-6}\ m^3$$
$$1\ mm^2/s = (10^{-3} m)^2/s = 10^{-6}\ m^2/s.$$

Application

1. Some of the units applicable in the field of agricultural engineering are given in **Table 4**. However for detailed information on various aspects of SI units reference may be made to SP : 5-1969 Guide to the use of International system (SI) units issued by Indian Standards Institution. For conversion from one system to other IS: 786-1967 and its SI supplement should be referred.

Conclusions

1. SI system is not entirely a new system. It is rationalized and coherent and non-gravitational form of the metric system. The Government of India through the revised Act on Weights and Measures have recognized this system as only legal system in all field of activities. It is intended that people engaged in the field of agricultural engineering would make use of SI units in their trade and profession.

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Table 4. Suggested Units

Space and Time

Quantity	Typical Example of Use	Unit Recommended	Symbol
Acceleration and deceleration (linear)	– Due to gravity – General use	metre per second squared	m/s^2
Plane angle	Rotational dynamics	radian	rad
	General use	degree minute second	$^\circ$ ′ ″
Area	Brake lining and clutch contact area	square centimetre	cm^2
	Land area	hectare square metre	ha m^2
	Radiator area Heat exchangers, etc.	square metre	m^2
	Small area	square millimetre	mm^2
Length, width, thickness etc.	General height, width, length Digging depth Row spacing Tyre size Track gauge Wheel base Transport height Cylinder bore and stroke Turning circle Field size Truck cargo platform dimensions Braking distance Tyre rolling circumference Width of cut Combine shipping dimensions	millimetre	mm
	Surface finish Paint and coating thickness Filtering capacity Filter particle size	micrometre	μm
Time	Approach time Hydraulic cycle time Hauling time	second	s
	General time duration	hour minute second	h min s
Velocity	Vehicle travel speed	kilometre per hour	km/h
	Surface speed Conveyor speed Lift speed Air velocity Gear pitch line velocity Linear speed Blade speed	metre per second	m/s

(Continued)

Quantity	Typical Example of Use	Unit Recommended	Symbol
Angular velocity	Engine flywheel inertia Rotational energy General use	radian per second	rad/s
Volume	Engine displacement Pump displacement Small volumes	cubic centimetre	cm^3
	Freight volumes Bucket capacity Grain tank capacity Gas volume Basket volume Shipping container volume	cubic metre	m^3
	Liquid volume Capacity: Fuel tank Hydraulic reservoir Coolant Wheel Ballast Lubricant	litre	l
Volume flow (Volume/time)	Air flow General use	cubic metre per second	m^3/s
	Hydraulic packing leakage	cubic millimetre per second	mm^3/s
	Oil or coolant flow Pump flow capacity	litre per second	l/s
	Fuel consumption	litre per hour	l/s
	Specific fuel consumption Specific oil consumption	gram per kilowatt hour	g/kwh

Periodic Phenomenon

Quantity	Typical Example of Use	Unit Recommended	Symbol
Frequency	Sound frequency Electrical frequency System vibrations	hertz (cycles per second)	Hz
Rotational frequency	Rated Speed (engine)	2π radians per minute	2π rad/min
	Gears, shaft Mechanical devices Rotational speed	revolutions per minute	rev/min
	PTO speed	revolutions per second	rev/s

Mechanics

Quantity	Typical Example of Use	Unit Recommended	Symbol
Density Specific mass Mass per volume	General use	kilogram per cubic metre	kg/m^3
		kilogram per cubic decimetre	kg/dm^3
Linear mass		kilogram per metre	kg/m
Force	Brake pedal force Drawbar pull Hand brake lever force Clutch spring force Bracket force Rim pull	newton	N
Force per length	Beam loading	newton per metre	N/m
	Spring rate	newton per millimetre	N/mm
Mass	Freight mass & axle rating Truck rating	tonne	t
	Vehicle mass (weight) Mass of object Rated load Lifting capacity Shipping mass Countermass Tipping load	kilogram	kg
	Small masses	gram milligram	g mg
Mass per unit area	Surface coating	gram per square metre	g/m^2
Moment of force (torque) Bending moment	Fastener tightening torque Engine torque Steering torque Gear torque Beam and shaft calculations	newton metre	N.m
Moment of inertia	Flywheel inertia General use	kilogram square millimetre	$kg.mm^2$
Power	Engine performance Flywheel Power take-off (PTO) Drawbar Engine heat rejection Heat exchanger dissipation Air conditioning	kilowatt	kW
	General use	watt	W

(Continued)

Pressure	Relief valve setting Hydraulic pressure Air pressure Proof pressure	Pascal	Pa
	Pressure drop Tyre pressure Ground pressure Turbo-charger pressure Barometric pressure	bar	bar
Resilience		joule per square metre joule per square centimetre	J/m^2 J/cm^2
Stress	Material stress Material yield Ultimate stress	newton per square millimetre	N/mm^2
Energy Work Heat quantity	Heat Energy Force length General use	joule	J
Viscosity (dynamic)		pascal . second	Pa.s
Viscosity (kinematic)	Fuel and lubricants Fluids	square millimetre per second	mm^2/s

Other Units

Quantity	Typical Example of Use	Unit Recommended	Symbol
Acoustics	Sound pressure level	decibel	dB
Area/time	Ripping rate	hectare per hour	ha/h
Mass/time	Machine work capacity: baler, forage, etc.	tonne per hour	t/h
	Dust	gram per minute	g/min
	Air flow Water flow Oil flow	kilogram per second	kg/s
Light	Luminous intensity (candle power)	candela	cd
	Luminous flux (output)	lumen	lm
	Illumination (density of light)	lux	lx
	Luminance (brightness)	candela per square metre	cd/m^2
Temperature	Used in thermodynamics	kelvin	K
	Other use the thermodynamic	degree Celsius	°C

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Power Tillers in Indian Agriculture

Their Place and Problems

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Introduction

Power tiller is a multi-purpose hand tractor designed primarily for rotary tilling and other farm operations. For its direction and control, an operator walks behind it. It is also known as a garden tractor, hand tractor and walking tractor. In view of its high maneuverability and versatility, it is ideally suited for agricultural operations in small fields and farms where larger conventional four-wheeled tractor is difficult or uneconomical to operate.

Various types of hand tractors specially designed and developed for different farming conditions are available. When they are fitted with a rotavator, either integral to the tractor or when rotary tilling blades are fitted to the wheel or drive shaft for tillage by rotavation, they are called power tillers. In these machines, most of the power developed by the engine is used by the rotavator; the wheels of the machine only regulate and maintain a uniform forward speed.

Diverse Uses

The types of power tillers manufactured in India have versatile features in that the same machine when fitted with a rotavator can be used for rotary tilling of dry and wet paddy lands. When the rotary tiller is removed, other implements such as plough, cultivator, seed-drill, harrow, ridger, leveller, etc. can be fitted to it and the machine works like a conventional four-wheeled tractor, except that the operator has to walk behind it. However, in the case of trailers, disc harrows, etc., an operator's seat is provided on the implement which permits faster operations and the tractor is steered and controlled by the operator in a sitting position. Some of the manufacturers also produce paddy wet-land levellers and tramplers where the operator either stands or sits on the implement. The tillers are fitted with independent clutches which makes steering and sharp turns easy.

The tillers are provided with flat and V-pulleys so that they can be used as stationary power units for operating irrigation pumps, corn shellers, threshers, winnowers, seed cleaners and graders, hullers and many other stationary farm equipments. Some manufacturers also offer mounted designs of irrigation pumps, sprayers and dusters, so that they could be used as mobile power units.

Grass mowing on lawns, gardens and public parks, electricity generation by mounted or stationary generators, transport of materials, etc., in factories by using trailers are some of the off-the-farm uses of power tillers.

The power tillers presently manufactured in India are fitted with single cylinder light diesel engines of 5 to 12 H.P., which are relatively economical for operations in small and medium farms. For adapting the tillers for boggy, wet paddy lands, special cage wheels/steel wheels for heavy traction jobs such as ploughing are offered. Besides small fields and farms, power tillers are suitable for orchards, nurseries and hilly areas. On larger farms using four-wheeled conventional tractors, they can be used as supplementary power units for light operations such as intercultivation, spraying and dusting, pumping and transporting farm inputs, etc.

Farm Holdings

A study of India's agricultural holdings pattern shows that 26% of area under cultivation is under medium holdings of 4 to 10 hectares.

Assuming that 30% of this area is irrigated, it is estimated that about 11 millions hectares of cultivated area under irrigated medium holdings are of 4 to 10 hectares in size. With a command

Table 1. Agricultural Holding Pattern

Size	Area (ha)	% Percent Distribution: Number	% Percent Distribution: Area under cultivation
Small	up to 4	85	40
Medium	4 up to 10	11	26
Large	More than 10	4	34
	Total:	100 70.5 million holdings	100 145 million hectares
Area under irrigation			45 million hectares

Table 2. Power Tiller Manufacturers

Manufacturer	Make & H.P.	Present H.P. Range	Annual Capacity: Licensed	Annual Capacity: Installed	Date of Issue of License	Unit Price Rs.
Indequip Engg. Ltd. Ahmedabad (a)	Iseki 8	5–7	10,000	–	15–2–73	14,000
J.K. Satoh Agricultural Machines Ltd. Kanpur	Jaykay sato 6	6–8	6,000	5,000	29–2–73	13,600
Krishi Engines Ltd. Hyderabad	Krishi (Akitu) 5	5–8	3,000	3,000	21–5–63	13,529
Kerala Agro Machy Corpn. Ltd. Athani (Kerala)	Kubota 12	8–12	12,000	3,000	9–2–72	18,500
Maharashtra Engg. Co-Op. Engg. Society Ltd. Kolhapur (a)	Yanmar 10	8–12	4,000	–	4–11–72	19,375
V.S.T. Tillers Tractors Ltd. Bangalore	Mitsubishi 10	8–10	5,000	5,000	6–4–66	16,500
Bihar Agro Patna	Kubota	8–12	5,000	–		
	Total	–	45,000 14,000 31,000	16,000 revoked/cancelled (a) effective		

area of 10 hectares, theoretically, requires 11 lakh power tiller to serve irrigated medium holdings only. Against this, at present, India has a population of 30,000 power tiller units. The growth of the power tiller industry has been slow for reasons discussed later.

The Industry

Table 2 lists the seven Power Tiller manufacturers in the country. Two licences have since been revoked/cancelled. Another unit in Bihar has been licenced. The power tiller story started in the early sixties. The first manufacturing licence was issued in 1963 followed by another in 1966. Four more parties were licensed in 1972 – 1973. Total licensed capacity is now 31,000 units a year in the horse power range of 5 to 12. Size-wise, they can be classified in two horse power groups: Iseki, Jaykaysato and Krishi fall in the H.P. range of 5 to 8 while Kubota, Yanmar and Mitsubishi are in the Horse Power range of 8 to 12. Half of the licensed capacity is in the range of 5 to 8 H.P.

Table 3. Power Tiller Imports Under Yen Credit, 1965–75

Make	Unit
Iseki	100
Satoh	100
Kubota	4,037
Yanmar	941
Mitsubishi	3,213
Robin	500
Others	712
Total	9,603

Table 4. Indigeneous Production of Power Tillers

Make	Up to 69–70	70–71	71–72	72–73	73–74	74–75	75–76	76–77	77–78
Iseki	–	–	155	100	136	113	58	42	–
Jaykay Sato	–	–	–	–	178	322	222	231	95
Krishi	1,677	315	123	131	141	165	159	404	182
Kubota	–	450	124	287	302	446	547	455	557
Yanmar	–	113	88	174	103	–	100	65	52
Mitsubishi	–	509	591	507	666	1,096	1,454	561	658
Total	1,677	1,387	1,081	1,199	1,526	2,142	2,540	1,758	1,544

Grand Total: 14,854

During the period 1965 – 1975, 9,603 power tillers were imported under various Yen credits **(Table 3)**.

Regular indigenous production commenced in early 70's and the progress during 70's is shown in **Table 4.**

The production of power tillers is still low as it is only about 200 units a month even as the industry is already in its second decade.

Slow Growth

Some reasons which have been responsible for the slow growth of the power tiller industry are identified in this section.

New Technology – This is a new technology being introduced to the Indian farmer who is slow to accept such an idea. Four-wheel tractors were introduced in India in the early 1920s and it took nearly 50 years before the tractor was accepted as a prime source of power on the farm. Today, there are about 40,000 tractors in use and the annual sale is over 50,000 units. Power tillers have been introduced at a stage when tractors were already well entrenched. Therefore, this is an intermediate step between the bullock and the tractor. The industry should make some breakthrough in the coming years.

It is interesting to study the contemporary scene in Japan, the home of power tillers.

Table 5. Tractor & Power Tiller Production in Japan

Item	1965	1976
Tractors		
Quantity	9,685	286,349
Value (Million Yen)	5,046	230,843
Power Tillers		
Quantity	436,858	354,713
Value (Million Yen)	43,344	47,546

Source: Survey of Status of Machinery Production in Japan by the Ministry of International Trade & Industry, AMA, Japan, Vol. VIII No. 4, 1977, p.85.

It will be noted that, while, there has been substantial growth (30 times) of the tractor industry from the annual production of 9,685 in 1965 to 286,349 in 1976, the power tiller production has declined 19% during the same period from 436,858 to 354,713. In value, tractor production was five times that of power tillers. In other words, even in Japan, the trend is towards tractors though, under certain conditions, power tillers continue to be in use. The growth of the power tiller industry has been overshadowed because of the popular acceptance of the tractor in India.

Less versatile – The Indian farmer is used to a dual purpose prime mover – for haulage and tillage. The bullock and the tractor meet this dual purpose requirement. The power fillter has its own limitation particularly, in haulage. A pair of bullocks (1 H.P.) can haul loads of 2 to 3 tonnes while a power tiller (8 to 12 H.P.) hauls around 1 tonne.

Imported attachments – In the early stages, ground tools for use with power tillers were all imported. Traditionally, these imported designs have continued. There has been little investment in research and development by the industry to develop a wide range of tools and implements to suit local conditions and to improve the utilisation of power tillers.

Less convenient – There is an urge on the part of farmers to get over the drudgery on the farm. The use of power tiller is still quite tiring. Walking behind a tiller for long hours and steering it during tillage operations are heavy-duty manual exercises. Ergonomics at present is not favourable.

Less favorable C/B ratio – The cost benefit ratio of the use of power tillers to the farmer has not been amply justified – while comparing cost of cultivation with bullocks and tractors. Because of its limited output, the power tiller has not been popular for custom operations (hiring).

Over-estimated demand – Unfortunately, the assessment of power tiller demand was not made on scientific basis. The Government estimated an annual demand of 80,000 units by the end of the Fourth Plan against, present sales of about 2,000 units. The Indian Society of Agricultural Engineers had detailed a study in this regard. After taking into consideration the utility of power tillers on irrigated, medium-sized paddy holdings, they estimated that the maximum demand the industry can reach in the foreseeable years will not exceed 20,000 units. With exaggerated demand estimates, the industry was over-licenced. It has high idle capacity and, therefore, the cost of production is high.

Poor promotion drive – Studies by various committees and groups have come to one unanimous conclusion that heavy investments are required for demonstrations, sales promotion, publicity and training programmes for popularising the power tiller. The industry has not been able to afford this; neither have they been able to organise country-wide after sales services. A logical step will be to identify 'green' belts so that concentrated sales efforts can be confined to such spots. Favourable areas will be medium-sized paddy holdings, plantations and holdings in hilly areas. It is to be appreciated that the least resistance will come from farmers with better financial returns. The industry will, therefore, have to look for prospects growing cash crops, vegetables, oilseeds and fruit crops, in addition, of course, to paddy.

Relatively costly – The price of a complete power tiller unit has been high even as excise duty has been removed. Taxes and levies total about 40% of the cost. All avenues of reducing the price will have to be tapped, though in contrast, heavy expenditure will have to be incurred on sales promotion. But there is still room for small low H.P. and lower priced power tillers in the country.

The power tiller industry is still in its infancy. An annual production of 2,000 to 3,000 units by 5 manufacturers is most uneconomical. Heavy investment has to be made by the industry and all concerned in popularising power tillers through identification of favourable 'green' belts, demonstrations and training. Though the industry has had a better acceptance in some pockets in paddy-growing tracts in Karnataka, Kerala, Andhra Pradesh, Tamil Nadu, West Bengal, Assam, Orissa and Bihar, there is lot to be done to push up the sales. Given a favourable climate, the annual sales may rise to 5,000 units in two years and, may be, to 10,000 units later.

Specifications

The specifications of power tillers being indigenously manufactured are shown in **Table 6.**

It may be noted from **Table 6** that there are two categories of engine weight,namely;90 to 115 kg and 145 to 150 kg. Four makes are water-cooled and two are air-cooled. Four makes have a gross weight in the range 315 to 393 kg and two makes have a gross weight of 490 to 495 kg.

The important components of the power tiller are the engine, transmission and ground tools, also called implements and attachments. A power tiller, in fact, is

Table 6. Specifications of Power Tillers

Make	HP	Engine RPM	Weight kg	Cooling	Speed kph	Wheel Track (mm) Min	Wheel Track (mm) Max	Tilling Width mm	Gross Weight kg
Iseki	8	1400	98	Air		420	690	660	313
Jaykay Sato	6	2000	90	Radiator		520	620	525	315
Krishi	7	2000	105	Radiator	1.5–17.6	660		600	340
Kubota	12	2000	145	Radiator	1.28–1.5	540	755	600	495
Yanmar	10	1600	150	Hopper	1.58–14.6	540	710	600	490
Mitsubishi	8	3000	115	Forced Air	1.12–15.30	480	770		393

Note: Common to all makes: Engine – single cylinder diesel, typre size 6 x 12, reverse speeds – 2, and forward speeds – 6.

an engine on wheels. Through the belt pulley, the engine power can be put to several uses like pumps, flour mills, etc. All engines installed on indigeneous power tillers operate on diesel fuel. Air and fuel should both be filtered adequately for better machine life and performance. The filters should be regularly cleaned and replaced at specified intervals.

A proper gear is selected for each operation. Puddling is done in a low gear at a speed of 1.5 – 2 k.p.h. Haulage speed in top gear is 13 – 18 k.p.h. A variety of ground tools can be used. Further research and development work in India is required in order to develop ground tools to suit operating conditions – both wet and dry farming applications.

Operator training is very important. He should use the power tiller without any undue strain on his shoulders. Steering the unit and walking behind it call for skill and experience, which come from practice. If done properly, operation is easy. The owner and the operator should thoroughly familiarise themselves with the machine and follow the instructions specified in the manual. The wheel track (distance between the two wheels) is adjustable from 480 to 700 mm and the correct setting should be used for the operation and the ground tool. Most of the power tillers have a tilling width of 600 mm.

Indo – Japanese Collaboration

Reputed Japanese manufacturers of power tillers like Kubota, Mitsubishi and Satoh have a collaboration in India for the manufacture of their models. There is no reason to doubt that the Japanese principals are extending all possible co-operation to the Indian ventures. But for many reasons, the power tiller industry does not seem to be making much headway, even though the earliest make was licensed for local manufacture 16 years ago. The Japanese manufacturers must be as disappointed at this progress as Indians are. With all the rich and valuable experience they have, they should study in depth the problems and suggest some practical remedial measures? After all, there is need for a farm prime-mover like power tillers in the Indian agricultural scene. The subject does require a study in depth with an object of preparing a practical action programme to accelerate the growth of this industry.

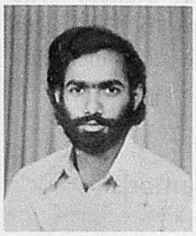
One convincing point is that no manufacturing unit in India will be a viable venture if they manufacture power tillers alone. They must diversify and widen their product mix. There are lots of other items of Japanese agricultural machinery which are needed badly and which can be manufactured locally in India without much difficulty, provided that the Japanese principals and their Indian partners identify these items and work along the same lines.

The power tiller is an item of great interest to the Indo – Japanese cooperation. The Japanese farm equipment industry is in a position to offer India benefits of the technology they have developed and which is suitable for developing countries like India. In spite of good intentions of the Japanese principals and their Indian counterparts, somehow or other, the progress on the farm equipment industry with Japanese collaboration is not entirely satisfactory. One suggestion is that the Japanese farm equipment industry should depute a team to visit India in order to accelerate the growth of the power tiller industry and to indentify the farm equipment items developed by the Japanese industry which may be suitable for use in India, with a view to licensing local manufacture of such items. Such a Japanese team will have to be assisted by Indian agricultural engineers.

Conclusion

In conclusion, the power tiller is a new technology to which the Indian farmer is being exposed. The acceptance has been slow but is catching up. For puddling of paddy fields, the power tiller has amply proven its utility. Its use on plantations, hilly terrain and small farms will considerably increase. Users of power-tillers are really torch bearers and their experience will in fact spread the technology. The cost of a power-tiller should be within reach of many Indian farmers who need a small size, low-cost unit with matching ground tools to suit local conditions. Looking from another angle, the haulage capacity desired is 2 – 3 tonnes. In fact India needs the common bullock cart powered by a diesel engine instead of bullocks. The industry, users, research institutions and the Government have an important role to play in developing the power tiller as an item of mass demand for small farms. ■■

Tubewell Irrigation System — Installation, Operation and Cost of Water



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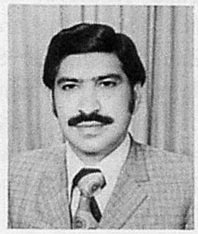

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Abstract

The study was undertaken to appraise the tubewell technology in the Sayedabad "tapa" of Hala "taluka" in Hyderabad district during 1975–76. The main objectives of the study were to examine the installation of tubewells, operation and cost of water. The average size of the study farms was 65 acres which were operated at 147 percent cropping intensity and used 245.37 acre feet of water. All the 20 tubewells studied ranked in first class water quality. These tubewells had design discharge of 1.55 cusecs for both diesel and electric tubewells which were operated for 4.56 hours a day. The tubewell investment averaged Rs. 40,350.00 which involved the basic cost of Rs. 3.51 and operating cost of Rs. 7.89 per hour delivering 152.01 acre feet of water to irrigate 53.97 acres per year. It involved Rs. 127.57 per acre foot of water costing Rs. 338.57 per acre irrigated through tubewells.

Introduction

Irrigation water is an essential input for increasing cultivated land areas and enhancing crop yields. The main cause of low agricultural production is the shortage of irrigation water. One cusec of a perennial canal discharge is supplied for 350 acres in Pakistan which is insufficient to meet the desired cropping intensity. Pakistan is estimated to have 79 million acres of cultivable land of which one-half is covered by canal irrigation. Not more than 31 million acres of a total of about 48 million acres of cultivated land receive irrigation water*. The annual flow of the Indus River System is about 168 million acre feet of which a large volume of water goes to waste into the Arabian sea. Annual water supply from different sources at the farms averages less than 2.0 acre feet for each cropped acre, whereas, about 3.0 acre feet or more is needed. Thus, sustained agriculture is not possible without supplemental water.

Ground water is a major supplementary source of irrigation. Fortunately, the substrata of the Indus Plain consists of a number of sand layers separated by more or less regularly appearing clay layers of 3 to 10 feet in thickness. The entire sand layer is saturated with water and assures a vast reservoir of ground water which can supply additional water by tubewell pump. Installation of tubewells is of more recent origin. The Department of Agriculture and some private drillers have been exploring water through tubewells for the last 25 years or so. The Punjab Government installed 20 tubewells between 1938 and 1940 in areas close to Shalimar Garden at Lahore for irrigation purposes. The other big schemes were the Rasul Irrigation Project and Central Tubewells Project under which about 1,500 tubewells were installed between 1944 and 1953. The Water and Power Development Authority in-

*Government of Pakistan, Pakistan Year Book (National Publishing House Ltd. Karachi, 1971) p.271.

stalled about 200 tubewells in the Salinity Control and Reclamation Project areas from 1959 to 1962. In addition, about 1,200 tubewells in the Khairpur and North Rohri Projects were installed during 1965–70 in Sind province. At present about 702,700 tubewells installed by public and private sectors are in operation at different places in Pakistan. Exact data about the capacity and efficiency of operation of these tubewells are unknown. Generally, the average discharge of these tubewells is about 0.75 cusecs and operate at about 30 percent efficiency. According to these assumptions about 30.8 million acre feet of ground water is being withdrawn by tubewells, the majority of which is owned by individual farmers.

In the sweet water zone of Sind province where electricity is also available, large numbers of tubewells have been installed during last 10 years. Loans and subsidy schemes of the Government have also encouraged the farmers to install tubewells. Inspite of the increase in the cost of material and labour, the interest of farmers in tubewells is increasing. In addition to augmenting water supply, tubewells have been helpful in lowering the water-table and reducing the twin menace of water logging and salinity.

Keeping in view the importance of tubewells, the present research was undertaken the main objective of which was to appraise tubewells in terms of installation, operation and cost with major focus on pumping cost per unit volume of water delivered. The variation in cost per acre foot of water with annual use in hours and annual pumping in acre feet was evaluated and appraised.

Geo-hydrology

The research was based on installation, operation and cost of tubewells. The "tapa" lies in the Southern reaches of the lower Indus Plain above the Indus delta. It is bounded in the north by Tapa Khutero; to its north east lies Tapa Pingharo, in east Tapa Zair Pir, and in South-West Tapa Jamalabad, all administrative units of Hala Taluka, Hyderabad district, and in north west is situated Taluka Sakrand of Nawabshah District (Map 1).

The climate of the area is arid and of marine tropical type. It is characterized by low rainfall, great fluctuations in temperature, low relative humidity and high rate of evaporation. The mean annual rainfall in mansoons, spread over July-September, varies from 150 mm to 175 mm with the exception of a few years when unexpected showers of higher intensity visited the area. The survey area lies partly in sub-recent flood plains and is slightly lower than the flood plains. It is protected from the seasonal floods by embankments. The geology of the area presents recent and sub-recent alluvial formations. The river Indus itself is eroding the piedmont plains of the western ranges and brings some material containing gypsum and other soluble sales. The Indus river controls the hydrology of the area. The river flows higher than the adjacent land. The river begins to swell in April, culminates during July and August, and declines from October to March. The area gets plenty of ground water through seepage from the river. The ground water table in the area is gradually rising due to seepage which fluctuates between 10 and 15 feet depth. Thus, the main body of the ground water originates from the river system. The largest of the fresh water (sweet) body occurs along the Indus river, but minor water lenses have also been found in areas adjacent to canals and old river courses. The water is sweet in the entire "tapa" due to the seepage of the present and old rivers on both sides. The Rohri canal feeds the irrigation system through its Hala branch. The ground water up to 200 feet deep is favorable to installing tubewells.

Material and Methods

The study was carried out by survey-cum-recall method, on 100% sample basis. Detailed information regarding the year of installation, discharge of tubewells, material used, quality of water, depth of tubewells, and cost of owning and operating was obtained. There were 49 tubewells in the "tapa" 30 of which were electric operated and 19 were operated by diesel engines. Almost all the tubewells were located in sweet water zone. A sample of 20 tubewells was taken from the list, primarily adopting a lottery system and then ascertaining the proper spread which finally represented random samples. The locations of tubewells are plotted **(Fig. 1)**. The entire area falls within 20 miles of the River Indus. The Rohri canal passes 5 miles from the eastern border of the "tapa".

All the tubewells installed in the area were drilled by hand cable tool method. The depth of tubewells varied from 105 to 218 feet with 6 to 8 inches diameter of screen and suction pipe with twin bore in one tubewell and coir string screens in all tubewells. Centrifugal pumps were used. Electric motors of 20 to 25 H.P. and diesel engines of 18 to 24 H.P. were used to drive the centrifugal pumps.

Owning or capital costs were true fixed costs or initial purchase

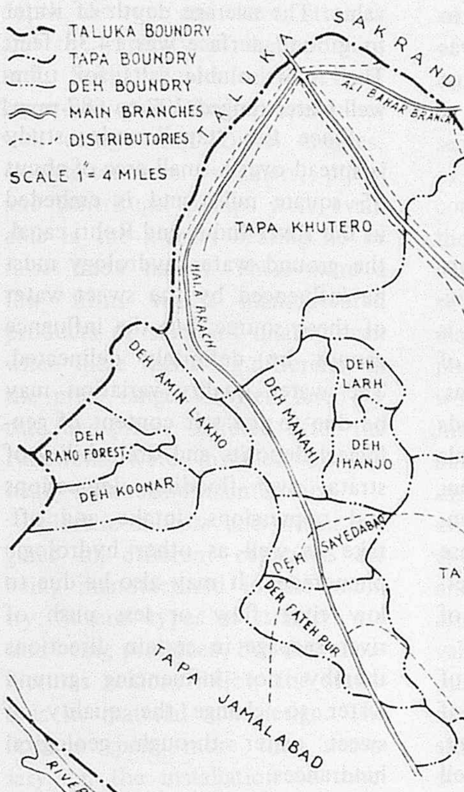

Fig. 1 Location of Sayedabad Tapa

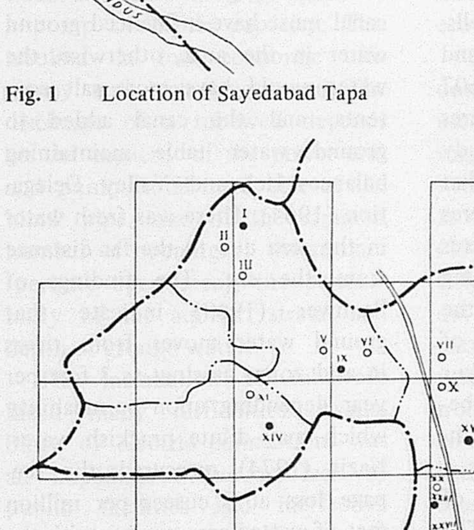

Fig. 2 Tubewell Locations in Tapa Sayedabad

prices. The basic cost of tubewells included depreciation and interest on investment based on bank loaning rates. Operating costs included the cost of labour, energy, and maintenance. The hourly owning cost was calculated by assuming 20 years life for both electric and diesel tubewells with average work hours a day. The depreciation cost was calculated by straight line method assuming 10 percent salvage value. The following formula was used:

$$P = \frac{P - .1P}{20} = 0.04P$$

Where:

P = Initial investment; and

.1P = Salvage value

The annual interest at the rate of 11 percent permissable for agriculture purpose was added. The following formula was used:

$$I = \frac{P + .1P}{2} \times .11$$

$$= 0.06P$$

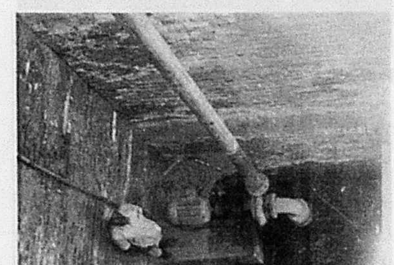

Plate 1 Inside view of well – Fillings of motor, pump and foot-valve above water surface

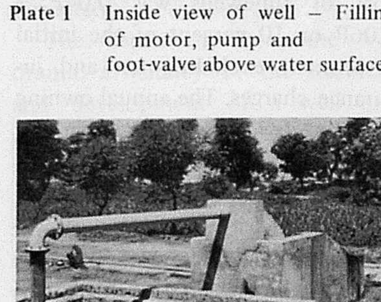

Plate 2 Tubewell structures

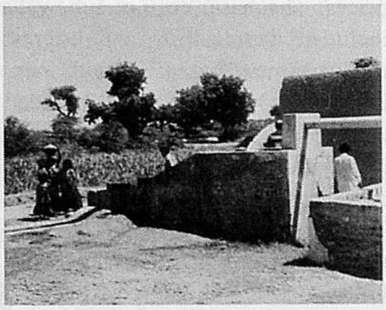

Plate 3 Water delivery system

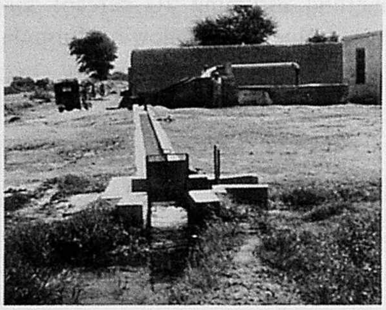

Plate 4 Water conveyance and controls

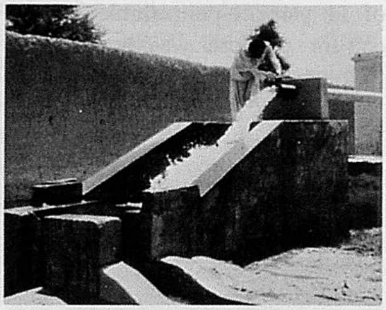

Plate 5 Tubewell discharge and flow measurement

Where:

I = Interest on investment;
P = Initial investment; and
.1P = Salvage value

Therefore, the annual owning cost of tubewells was 0.04P + 0.06P or 10 percent of the initial investment excluding tax and insurance charges. The annual owning cost was divided by annual working hours to calculate per hour cost as well as cost per unit water discharged.

Energy, maintenance and labour costs were calculated on actual expenses for the year and divided by yearly total work hours to determine per hour cost. Tubewell installation, its operation, and cost were recorded for cost per acre foot of water. Tubewell contribution in increased irrigated agriculture was analysed along the with annual cost of water per crop acre.

Results and Discussion

The improvement of water supplies during recent years is receiving a substantial boost. There is rapid increase in the number of tubewells in sweet water zones. The tubewell performance depends on the efficient drilling, materials used, diameter and length of screen, size of openings in the screen, power, and size of pipes. These components determine the performance of the wells and cost of operation.

The study appraised the stage of tubewell irrigation, materials of tubewells, ground water hydrology, water quality, and cost of tubewell installation and operation. It was found that 49 farms had tubewells, scattered on 3,177 acres of land with cultivated land areas of 4,607 acres or an average of 94 acres per farm unit in the year. The study of 20 selected farms showed that the average farm size was 65 acres with cultivated area of 95.96 acres in a year. The intensity of cropping was calculated at 147% on the tubewell farms against a total of 81% recommended for Sukkur Barrage command area. Thus, tubewells enhanced the cropping intensity by 66 percent.

The quality and quantity of water were important criteria. The ground water hydrology was one of the factors of consideration. The chemical properties of water, salt contents of the aquifers and the streams of ground water determined the quality of water, whereas the physical properties of the soil texture formed the strata to feed tubewells and determined the quantity of water. All tubewells yielded sweet water of the First Class category with almost normal pH value. The average depth of water to ground surface was 14.38 feet. The total soluble salts for tubewell water ranged 307 to 687 ppm.

Since the "tapa" under study is spread over a small area of about 35 square miles and is embeded in the River Indus and Rohri canal, the ground water hydrology must be influenced by the sweet water of these source, but the influence cannot be definitely delineated. The water quality variation may be due to the salt content of geological deposits and drainability of strata, river flooding, depressions and oppressions, intake and offtake as well as other hydrologic phenomena. It may also be due to low river flow or less push of river seepage in certain directions thereby not influencing ground water to change the quality of sweet water through geological hindrances.

The seepage from the Rohri canal must have influenced ground water in the area, otherwise, the water would have more salt contents, and the canal added to ground water table maintaining balance, Helmand Valley Delegation (1964). There was fresh water in the area due to the far distance from the sea. The findings of Panhwer (1969) indicate that ground water moves from rivers in arid zones as slow as 3 feet per year depending upon permeability which may dilute brackish water. Nazir (1974) measured the seepage loss at 8 cusecs per million feet of wetted area varying with the geological formations.

The land owners were convinced to install tubewells. Though the rate of installation of private tubewells has increased, yet the performance continues to be unsatisfactory. This is due to lack of technical advice to farmers. The farmers were unaware of an appropriate depth the tubewells should be installed, they sought advice from local borers to decide the depth, the type and size of strainer and the capacity of the pumping unit. Such advisers with a little know-how guide the improper tubewell components. Diesel engines, electric motors, strainers, pipes, and centrifugal pumps were available in the market bearing no or false trade names. There were a few firms which manufactured products of standard quality even when there was a big difference in the price range. Growers lured by the low prices suffered after the tubewells were installed due to heavy repairs and maintenance.

Electric motors and diesel engines of different capacities are being manufactured in the country. Several types of strainers are also being produced, but the manufactures seldom follow the standards in material and design. The farmers spent more than necessary on the installation of tubewells and used motors/engines or a pump of higher capacity. This resulted in low economic efficiency and high investment. The discharge of a tubewell depends on the capacity of the power unit and pump; total head, size of the blind pipe, size of the strainer, number of openings in the strainer (percent open area), the permeability of the aquifer, strata, and depth of ground water.

The installation of tubewells faced many difficulties. Availability of electric connections was an impediment due to lack of public facilities and ineffective approach of farmers in dealing with responsible authorities. Lack of skilled labour and mechanical equipment, like boring rigs, made tubewell installation a laborious and time – consuming process. Some tubewells yielded less after a few months pumping and the water table often declined due to insufficient recharge into the aquifer. This was the case with perched water table underneath which was exhausted after a few months of pumping. The slit size of strainers was not properly designed that caused the tubewells to start pumping sand and other sediments endangering the strength of the strainer and blind pipe, when coarse materials was present near the strainer made of coir string, damaged it resulting the lifting of silt and sand that ultimately damaged the pump impellers. The poor quality tubewell components were damaged after installation. Impellers were generally unbalanced, there was irregularity in discharge and the impellers became unworkable due to wear and tear and the bearing holding the shaft and other moving equipment was also damaged. The leakage of foot valve at the inlet of centrifugal pumps was also recorded which needed priming at almost every starting. The repair costs were so high that the overall investment made the whole affair very uneconomical.

Coir strings on iron bar with double or single winding were used for strainers. Nazir (1961) suggested the use of bambo strips with double or single winding to farm cheap strainers, while Nazir (1968) used iron pipes with drilled holes wire gauze for strainers which did not allow the formation of particles and feared brass wire to rust and also used cadium plated iron pipe and convoluted iron covered with brass wire to have little contact of iron pipe with brass. But this raised the cost even more. Whereas, Attaullah (1974) suggested maintaining, the size of screen opening according to siever of aquifer with 50 percent sand and suggested the design to base on velocity of water entry, which should be less than 0.1 ft. per second.

As regards the efficiency of tubewell installation and operation, the performance was more important than installation. Practically, the tubewells gave an average discharge of 1.02 cusecs for diesel tubewells and 1.15 cusecs for electric tubewells against 1 cusec calculated by Panwher (1969).

The unit cost of tubewells and water explored is dependent on many factors including initial cost of installation, yearly work hours and unit design discharge. It was found that an average of Rs. 39,816.33 were spent per tubewell as initial investment. The basic cost on depreciation and interest averaged Rs. 3.23 while the operating cost was Rs. 7.80 per hour. Making the average for all the 49 tubewells in the tapa, they were operated at an average of 1,795.09 hours per year discharging 164.52 acre feet of water per tubewell which could irrigate 53 acres per year irrespective of electric or diesel operated tubewells. **Table** provide data on the tubewells studied.

Conclusion

It is hoped that this tubewell study will serve as a guideline for the owners and those who intend to invest on tubewells for determining the optimum use of tubewells and to minimize pumping cost per unit of water. Researchers and planners will also have an idea about the efficiency of tubewells owned by individual farmers.

The depth of bore, the hydraulic efficiency of the strainer, and development of a well are other important factors which should be given careful consideration in the tubewell construction and design in order that the farmers may use ground water at minimum cost. However, the science of ground water exploration must be developed to meet increased needs of water which in all ways is beneficial for crop production.

Table. Tubewell Installation, Operation, Quality and Cost of Water for Unit Area Cultivated on Selected Farms/Tubewells

General Information

Tube-well No.	Farm Size (Acre)	Culti-vated Area (Acres)	Area Irrigated by tubewell (Acres)	Cropping Intensity %	Total Water used on Farm (Canal + Tubewell)	Water Delivered by Tube-wells Cucs)	Invest-ment (Rs)	Tube-well Cost (Rs)	Cost per Acre Ft. (Rs)	Cost per Acre Irrigated (Rs)
1	90	115	115.00	127.78	245.83	245.83	35,000	8.27	101.34	216.65
2	50	80	52.00	160.00	325.50	153.33	42,000	10.19	81.54	240.43
3	60	66	20.40	110.00	135.50	39.50	35,000	22.65	227.27	536.88
4	100	122	122.00	122.00	264.75	264.75	30,000	7.84	95.94	208.23
5	20	35	19.80	175.00	75.42	43.42	45,000	21.79	266.79	585.06
6	40	73	42.60	182.50	157.92	93.92	40,000	11.25	120.57	265.82
7	100	135	59.00	135.00	370.83	210.83	45,000	7.86	84.12	300.62
8	85	120	55.40	141.18	260.83	124.92	45,000	12.22	149.67	337.50
9	75	123	66.00	164.00	261.25	141.25	50,000	10.18	37.34	233.56
10	30	53	30.20	176.67	111.67	63.67	60,000	17.43	218.14	459.91
11	40	76	45.60	190.00	163.33	99.33	60,000	13.03	139.58	304.06
12	75	90	33.00	120.00	302.17	182.17	35,000	8.54	20.27	505.19
13	75	100	43.00	142.86	211.67	91.67	25,000	10.36	110.94	236.52
14	40	77	48.60	192.50	240.50	176.50	50,000	8.92	95.56	347.06
15	75	105	48.00	140.00	362.50	242.50	35,000	7.57	80.93	408.92
16	80	113	52.20	141.25	244.17	116.17	30,000	14.69	135.69	302.00
17	80	115	54.20	143.75	245.17	116.83	30,000	9.47	101.43	220.52
18	75	125	68.00	166.67	385.42	265.42	30,000	7.14	76.52	298.72
19	50	80	42.00	160.20	232.50	153.33	40,000	9.97	122.05	445.59
20	60	108	62.40	180.00	309.92	213.92	45,000	8.66	92.79	318.13

Tubewell Information

Tube-well No.	Year of Insta-llation	Average Daily Work Hours	Water Quality T.S.S. (ppm)	Water Quality pH	Design Discharge (Cusecs)	Source of Power	Horse-Power	Delivery pipe Head (ft.)	Delivery pipe Total (Length (ft.)	Casing Pipe Length (ft.)	Screen Length (ft.)
1	1972	8.25	310	7.6	1.5	Engine	20	14	27	40	110
2	1975	3.36	544	7.6	2.0	Motor	25	10	25	40	110
3	1975	1.33	370	7.6	1.5	Engine	18	12	30	50	110
4	1970	8.88	346	7.6	1.5	Engine	22	15	27	40	100
5	1974	1.46	549	7.8	1.5	Engine	18	13	26	40	120
6	1972	2.76	539	7.8	1.5	Motor	20	15	28	40	50
7	1971	6.19	551	7.6	1.5	Motor	20	13	28	50	130
8	1972	4.19	556	7.6	1.5	Engine	20	14	28	40	110
9	1971	4.15	548	7.6	1.5	Motor	25	10	24	40	110
10	1970	1.87	541	7.8	1.5	Motor	25	13	28	60	120
11	1975	2.92	383	7.6	1.5	Motor	25	10	24	50	110
12	1967	5.35	560	7.6	1.5	Motor	25	13	27	60	140
13	1966	2.69	545	7.6	1.5	Motor	25	13	28	60	120
14	1971	5.18	673	7.8	1.5	Motor	20	10	26	50	120
15	1973	7.12	367	7.6	1.5	Motor	25	14	30	50	130
16	1970	2.94	440	7.6	2.0	Engine	24	14	28	40	120
17	1972	3.46	486	7.8	1.5	Motor	25	13	28	50	110
18	1968	7.79	535	7.8	1.5	Motor	25	13	28	60	140
19	1972	6.28	400	7.8	1.5	Engine	18	14	28	40	120
20	1975	6.28	479	7.6	1.5	Motor	25	10	24	50	130

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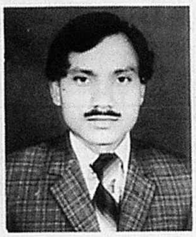
Development of Diaphragm Pump for Low Lift Irrigation



by
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Abstract

A hand – operated diaphragm pump consisting of two suction chambers has been developed at the Agricultural Engineering Division of the Bangladesh Rice Research Institute (BRRI) for low lift irrigation. The suction chambers were made of 14 gauge steel sheet. The diaphragm was prepared from a scrap piece of inner tube used in tractor or truck wheel. The pump is simple, cheap, and light weight. It is suitable for small and fragmented holdings. The power required for operation at 5.18 m (total) lift is only 0.5 hp. The pump has an optimum suction lift of 2.74 m with a discharge of 17,040 li. per hour about 1.54 ha-cm of irrigation per day. It is operated by two men making it a labour intensive farm equipment without dependence on fuel or power. It can be easily fabricated using local materials and thus is suitable irrigation device for he small farmers in Bangladesh.

Introduction

The most important factor contributing to high yield of crops is adequate and timely supply of water. This can be assured if proper arrangements for irrigation facilities is achieved. In Bangladesh, water is the primary limiting factor in crop production particularly during the winter. During the early part of Aus and later part of T. Aman seasons, crops suffer from lack of adequate rain. Thus, proper irrigation facilities will ensure the crop production in all seasons enabling the farmer to obtain higher yields. This will also enable the farmers to grow two or more crops a year.

Large capacity deep and shallow wells now used in Bangladesh are very expensive and they become frequently inoperative due to scarcity of fuel supply, spare parts and sudden mechanical disorders. The utilization efficiency of large pumps has been reported to be below 50 percent of their total capacity. Irrigation by mechanical fractional pumps is also beyond the capacity of small farmers due to high investment and cost of maintenance, fuel and spare parts. Hence it is better to introduce less complicated and dependable devices that are suited to small and fragmented holdings.

Several manually – operated diaphragm pumps have recently been developed by different organizations. Most of them are operated by the action of lever principle. The Rangpur-Dinajpur Rehabilitation Service (RDRS/LWF) introduced a pump discharging 13,608 li. of water per hour, but the lift was only 1 meter. Since the pump is made of wood, its life is short. Moreover, the energy loss is high because of its complicated suction and delivery arrangements. The International Rice Research Institute (IRRI) developed a Bellows Pump with a discharge capacity of 18,000 lit/hr at a head of 1 meter (IRRI - 1971).

Considering the lift, discharge capacities, cost, durabilities of the pumps so far developed, the project was undertaken to minimize these defects and to develop a pump suitable for Bangladesh farmers.

The Design

If a volume of confined air is evacuated in contact of free water, water would rise in the evacuated space up to the equivalent height of 76 cm of mercury, i.e. 10.36 meters of water. In practical purpose water could be lifted up to a height of 7.9 meters depending upon the degree of evacuation. This means that it is not possible to evacuate air completely even by a good pump. Moreover, the suction valve will not be able to open comparatively at a low pressure for its weight.

In a diaphragm pump it is difficult to lift water beyond 6.09 meters because the vacuum created in the suction chambers is related to the elasticity of the diaphragm (rubber tube) used in this pump. However, the lift can be increased if suitable materials for diaphragm is used.

The Model

Figs. 1, 2, 3 and 4 show the main components of the pump model. The suction chambers are made of 14 gauge steel sheet, with 28 cm x 28 cm at the base and 14 cm in height. Steel sheets were sliced into 0.61 x 0.61 cm size **(Fig. 2)** so that when it is folded, it forms an open-ended box, i.e., the suction chambers. The first bend of the sheet makes a 2.5 cm collar in all sides of the suction chamber then it bends again to make boxes of 28 cm x 28 cm at the base and 14 cm inches in height. The collars of the boxes thus prepared were drilled for nuts and bolts fastening. All corners of the boxes were sealed by welding. The inlet manifold was be made from 5 cm diameter G.I. pipe, having inclined faces **(Fig. 3)** where inlet valves are attached. The inlet manifold is then welded to the open-ended boxes to connect the boxes together with a single inlet **(Fig. 1)**. The inlet valves were made from M/S plate sandwitched together with rubber diaphragms with nuts and bolts. The valves are hanged from the adjacent walls of the suction boxes so that could operate easily over the inclined faces of the inlet manifold.

The lift arms are made from G.I. pipe. The lower ends of the arms are threaded for fastening of rubber diaphragms. The upper ends of lift arms are attached with the main lever by nuts and bolts. The diaphragms are prepared from inner tubes of trucks or tractor's. The tubes are cut in 38 cm x 38 cm and

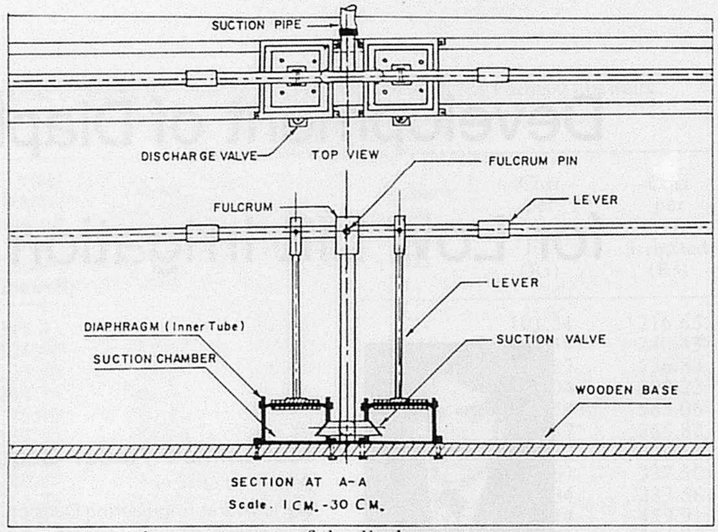

Fig. 1 Major components of the diaphragm pump

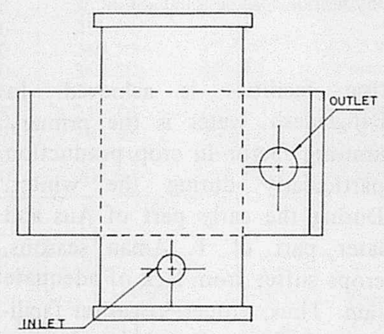

Fig. 2 M/S sheet cut for suction chamber

sandwitched between the two wooden planks. The wooden planks are then reinforced by a piece of metal plate. The fulcrum is made from G.I. pipe and welded to the base. The upper end of the fulcrum is attached to the main lever by a bolt. The main lever is made from 38 cm dia G.I. pipe. It rests on the fulcrum along with lift arms fixed by bolts. The main lever is lengthened with a strong wood or suitable bomboo poles. The diaphragm with the whole unit are fixed around the collars of the suction chambers by square frames made from angle iron.

In fabrication, more attention was given to its costs. The lever is partially replaced by local bamboo or wood to reduce extra cost. The scrapped inner tubes are used as diaphragms for low-cost and easy availability. The 5 cm diameter pipe was used for inlet manifold to minimize between frictional loss and capital cost. The cost of

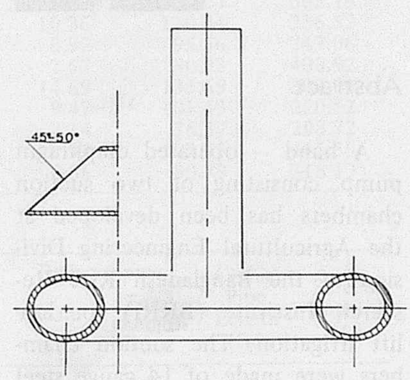

Fig. 3 Inlet manifold

Fig. 4 Operation of diaphragm pump

making one unit is roughly Tk. 545 (US$37) only. To minimize extra energy, there is no delivery lift. The valve seats are inclined for better air tightness.

Operation

The operation of the pump is simple. **Fig. 4** shows the actual operating features. Pulling the handle upward causes the pump's diaphragm to expand and thus draw water from a pond or a stream through a common manifold and into the pump's chamber. Pushing the handle downward causes com-

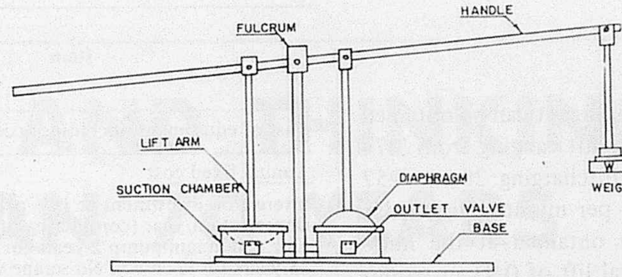

Fig. 5 Measurement of force and power of diaphragm pump

pression in the diaphragm and forces the water out from the chamber. Directional movement of water is controlled by a set of simple flapper valves on the inlet and outlet sides. Even one man can operate the pump with the help of a counter weight hung at the opposite side of the handle where the lift is below 1.5 m. The period of operation and energy requirement to operate the pump is dependent on the total lift and quantity of irrigation water required.

The Test

Head and Discharge

The tests were conducted at the BRRI farm. Six sites of different elevations (0.91 to 6 m) were selected for testing the diaphragm pump. The pump was operated by manpower for 8 hours, and average values of three observations of each test were taken. To collect the water a rectangular tray with a metal canal was used. Time was recorded by a stop watch.

Estimation of Force and Power

The force was measured by using counter weights at the end of the handle **(Fig. 5)**. The counterweights which were just enough to lift water in one second and considered horse power calculations. Maximum weight was 45 kg at 6 meter and mainimum was 27 kg at 0.91 meter.

Comparative Cost with Other Fractional Lowlift Equipments

A separate analysis to compare the performance of the diaphragm pump was made with an engine–operated, half cusec pump (gasoline) and a manually operated local "doon" **(Fig. 6)**. The discharge of water by a half cusec pump was calculated from design data (considering 70 percent efficiency), whereas, the amount of water discharged was measured by repeated tests at BRRI. In the case of the engine-operated, half cusec pump, the head was selected at 2.74 m and 0.91 m for that of the country doon.

Table 1 shows the overall performance of the diaphragm pump. The efficiency decreased with the increase of head. Maximum efficiency of about 74% was obtained at a vertical lift of 0.91 m and minimum of about 30% at 6 m. Results show that a satisfactory efficiency

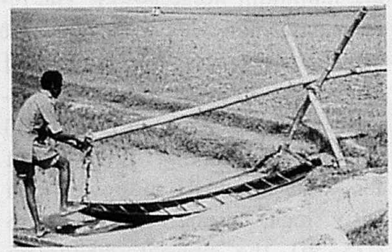
Fig. 6 Irrigation by country "doon"


Fig. 7 Irrigation by swing basket

Table 1. Test Results of Prototype Pump

Vertical Lift (m)	Frictional Loss (m)*	Total Lift (m)	Discharge Lit/Min (Actual)	Water Horsepower (Calculated)	Brake Horsepower (Calculated)	Efficiency Percent
0.91	2.13	3.04	359	0.240	0.328	73.60
1.82	1.72	3.54	317	0.246	0.354	70.00
2.74	1.27	4.01	284	0.250	0.381	66.00
3.35	1.22	4.47	257	0.253	0.446	56.50
4.57	0.60	5.17	211	0.240	0.520	46.00
6.09	0.30	6.39	101	0.160	0.545	29.40

*Frictional loss of hose-pipe is approximated from the Bulletin 1.481, Oregon Agricultural Experimental Station (Israelsen/Hansen).

Table 2. Comparative Delivery Performance of BRRI Diaphragm Pump, Half–Cusec Pump and a Manually Operated Country "Doon"

Vertical Lift (meter)	Name of Equipment	Discharge/ Hour (Liter)	Area Irrigable/Day (Hectare) a	Area Irrigable/Season (Hectare) b	Total Irrigation/Cost (Tk) c	Cost/h per/Season (TK)
2.74	BRRI-diaphragm pump	17,040	0.17	1.19	835	701
	½ cusec (engine operated) d	35,721	0.37	2.60	2,912	1,120
0.91 f	BRRI-diaphragm pump	18,144	0.18	1.30	485	373
	Country doon e	15,876	0.16	1.12	457	408

a 3.08 hec-cm of water per irrigation.
b Using 7 days rotational irrigation method.
c Considering 5 irrigation per season detailed cost is given in Appendix I.
d Considering high possible efficiency 70% at a head of 2.74 meter.
e Metal sheet doon 4.6 meter long.
f One-man operated.

of 56 to 66 percent can be obtained at a vertical lift ranging from 2.74 to 3.35 m discharging 284 to 257 li. of water per minute. Higher discharge was obtained at the minimum vertical lift of 0.91 m requiring minimum horse power. The reverse happened when the vertical lift was increased. A satisfactory level of efficiency of most pumps is considered to be between 50 to 60 percent. Considering the amount and kind (manual) of power at a fairly high vertical lift (2.74 to 3.35 m) the present diaphragm pump discharged a high quantity of water (257 – 284 li./minute) with a satisfactory level of efficiency. It is noteworthy that the power consumed by the diaphragm pump is in terms of body weight of operator rather than direct energy lost by him as in the case of the doon or a swing basket **(Fig. 7)**.

A comparison of the performance **(Table 2)** of diaphragm pump, one-half cusec, pump and the doon shows that discharge of water by ½ cusec pump is about double that of either diaphragm pump or doon but from the economic point of view the ½ cusec pump is inefficient. Although the discharge of water and the operational cost of the doon is comparable with the diaphragm pump, the later is economical and efficient since the vertical lift of water by the diaphragm pump is three times higher.

The comparative cost analysis of diaphragm pump, doon and ½ cusec pump (Appendix I) shows that the capital cost of the ½ cusec pump is about 10–11 times higher than either diaphragm pump or doon. Moreover, there are difficulties in maintaining the engine operated pumps since spare parts are not always available. On the other hand, the diaphragm pump is very easy and cheap to maintain and to operate.

Appendix I. Comparative Cost Analysis of Different Types of Fractional Pumps.

Item	BRRI Developed Pumps (Tk)	Country "doon" (Tk) a	½ Cusec Pumps (Tk)
Cost of equipment, including accessories	900	830	8,000
Annual fixed cost			
Interest on investment at 10% per year	90	83	800
Depreciation/year (considering life, 4 years for diaphragm pump 2 years for doon, 5 years for ½ cusec). No scrape value	225	208	1,600
Total fixed cost/year	315	291	2,400
Fixed cost/season	105	97	800
Operating cost/season			
Labour at 2 manday (8 hours) at Tk. 10 per manday, considering 5 irrigations per season, 7-day rotational irrigation.	700/350 b	350	–
Fuel cost gasoline at 0.92 li./hr. i.e. 7.56 li./day, 7.56 x 7 x 5 = 264.6 li./season at Tk. 5.58/li. (7-day rotational irrigation, 5 irrigations/season.)	–	–	1,476
Lubrication/season per 100 hour 1.9 li. i.e. 3 times/season at Tk. 15.90/li.	–	–	90
Repair/season at 10% of new value/year	30 c	30 d	266
Attendent/season	–	–	280
Operating cost/season	730/380 b	380	2,112
Total irrigation cost/season (Fixed + operational)	835/485 b	457	2,912

a Metal sheet (16 gauge).
b One manday below 1.5 meter.
c Diaphragm and other.
d Bamboo poles, fulcrum etc.

Considering the investment, operational cost and water lifting efficiency, the diaphragm pump seems to be a very promising substitute as a water lifting equipment for the Bangladesh farmers.

The diaphragm pump has the following advantages over the water lifting equipments now available in Bangladesh:

- Low investment than any other engine operated pump.
- Low operational cost.
- Low maintenance cost.
- Can be repaired and maintained even by an unskilled person.
- Can be owned individually by small farmers.
- Easy operation and transportation.
- Simple to manufacture.
- High efficiency in low lift irrigation.
- Operative up to 4.5 meter vertical lift.
- Farmers can save the operating cost by providing their own labour.
- Versatility of adaptation to sources, pond, river, canal dugwell, hand-tube-well, etc.
- Labour intensive and provides facilities for labour employment.
- Longer durability.
- All materials locally available.
- More dependable than engine operated pumps.

Acknowledgement

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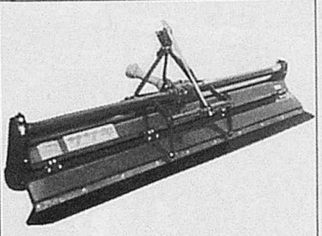

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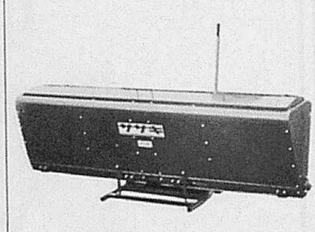

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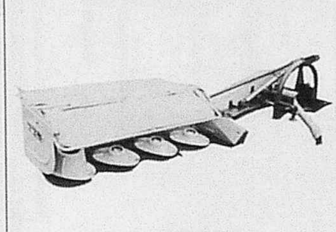

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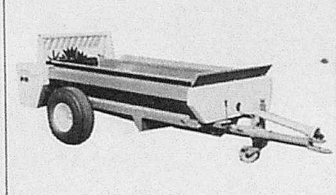

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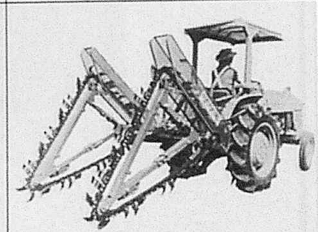

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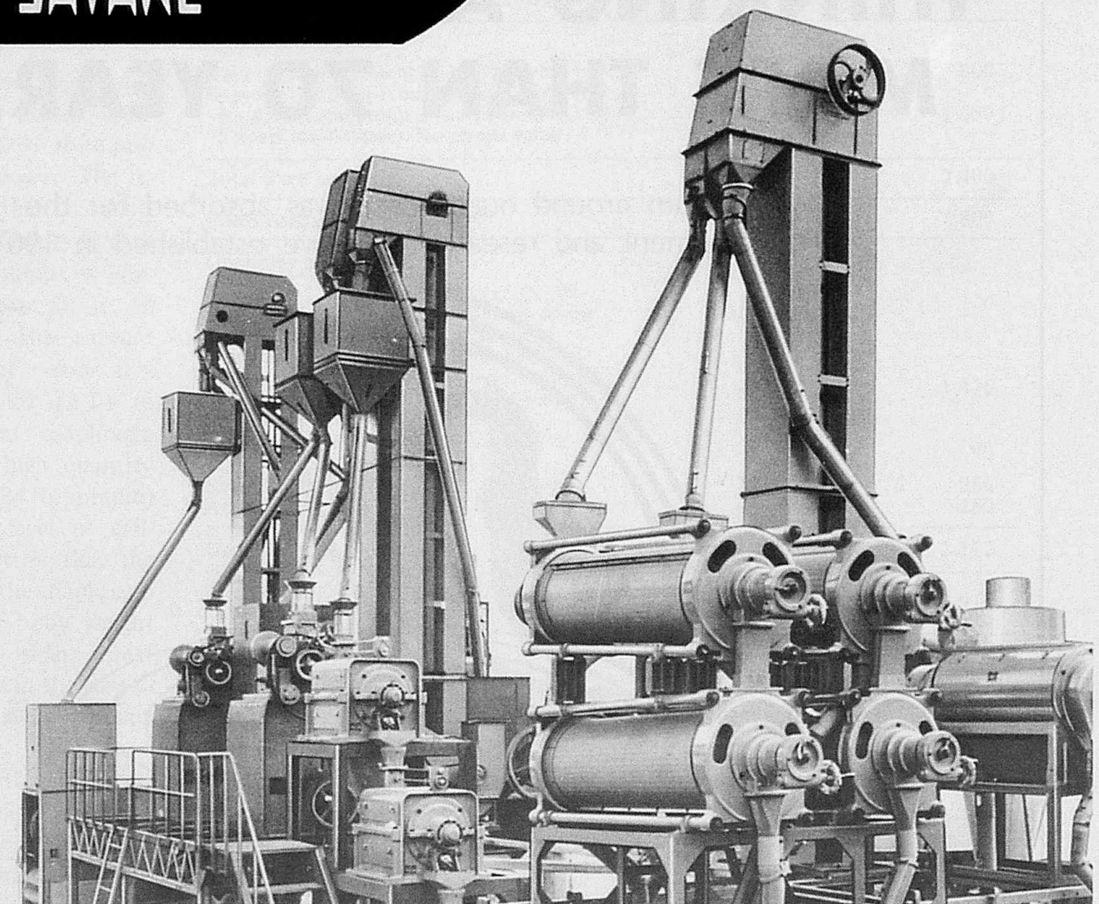

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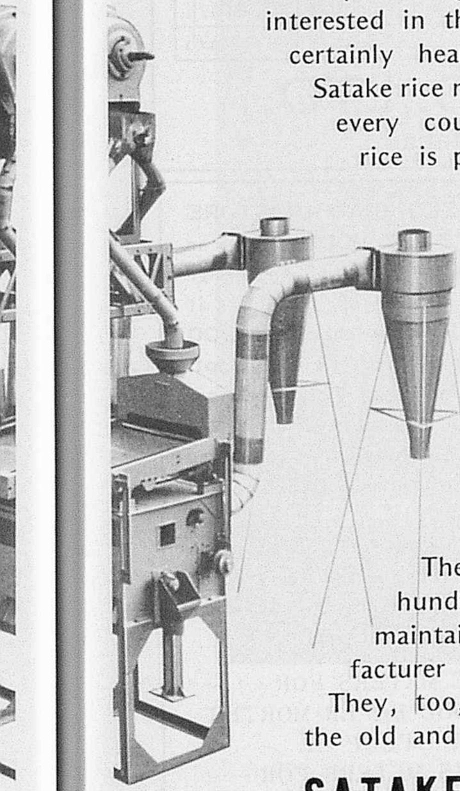

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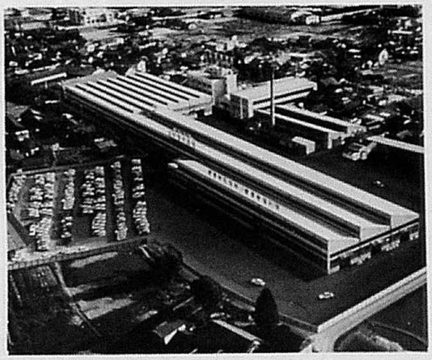

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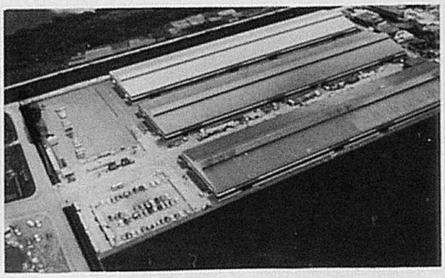

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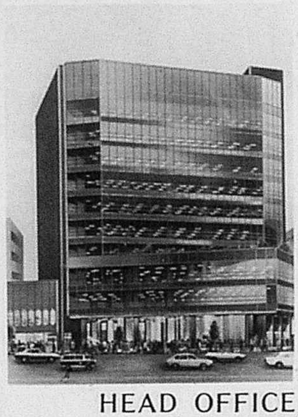

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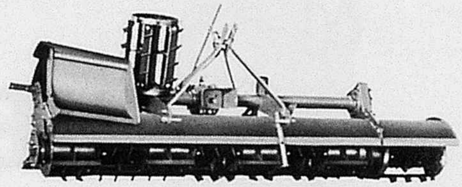

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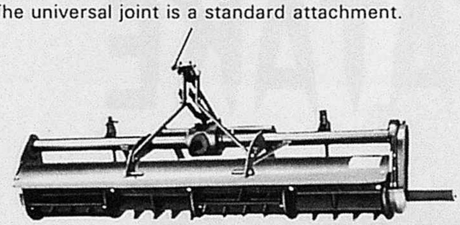

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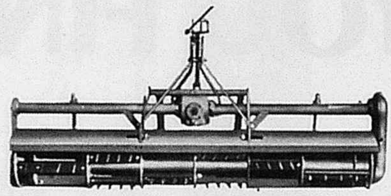

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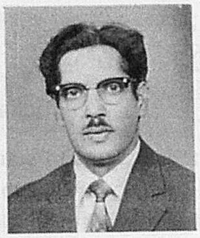
Modelling of Farm Irrigation and Drainage Structures



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Abstract

This study on modelling of irrigation and drainage structures was undertaken with a view to developing prediction equations with the help of the principles of similitude for predicting the performance of pumping machines, open channels porous media, underground drains, pipes and sewers. It was found that viscous forces for pumping machines, gravitational forces for open channels and pressure head with gravity for underground drains are the most important parameters for making predictions.

Introduction

In modern engineering practice, hardly any new structure or machine, be it a bridge, a canal, a drain, or a pump, is constructed until a model is built and tested in a laboratory. The observations made on the model are used to predict the behaviour of the final structure or machine. Further, in most of the cases, an engineer is interested in determining a relationship between the variables for a specific design. Under such circumstances a model may give the desired result quickly and cheaply.

Modelling techniques can be used by irrigation and drainage engineers in the design, construction and operation of canals, water courses, open ditches, underground drains and pumping machines. In this study, an effort was made to develop prediction equations from models for the estimation of flow in irrigation and drainage systems. The following systems were considered: Pumping machines, open channels and porous media and underground drainage.

In order to develop models for the above hydraulic structures and machines, the Buckingham Pi theorem and dimensional analysis were used. The design conditions were established for the models and prediction equations were evolved for predicting the flow characteristics.

Classification of Models

The models may be classified as follows:–

True model – This is a model in which all significant characteristics are exactly produced to scale. Not only is this model geometrically similar but also satisfies all the design requirements for a model.

Distorted model – This is a model in which two or more scales are used (one scale may be used for length and breadth and a different scale for depth or height.) Further, in such a model, some of the design conditions may be disregarded.

Dissimilar model – This is a model which does not bear a direct semblance of a prototype. For example, the characteristics of a mechanical system may be predicted from observations made on an electrical system.

Dimensional Analysis

This is a method of finding the dimensionless groups of variables involved in a certain phenomenon. The dimensionless groups should be independent of each other so that a relationship between them may be evolved. These groups are built up with the help of the Buckingham Pi theorem which states that the number of dimensionless and independent groups or quantities required to express relations among the variables is equal to or greater than the number of quantities involved minus the number of basic dimensions. The dimensionless and independent quantities are usually called Pi terms.

After some sets of Pi terms are found, they can be expressed in a functional form

$Pi = f(Pi_2, Pi_3, Pi_4, \ldots\ldots\ldots)$

The function 'f' cannot be de-

Table 1. Variables and Dimensions

Variable		Dimensionally equal to
P =	Power = energy/unit time	$FLT^{-1} = (MLT^{-2})(LT^{-1}) = ML^2 T^{-3}$
H =	head = energy/unit mass = (Potential energy)	$FLM^{-1} = (MLT^{-2})(LM^{-1}) = L^2 T^{-2}$
Q =	flow rate	$L^3 T^{-1}$
N =	rotational speed	T^{-1}
D =	any convenient length	L
L_1 =	any general length	L
r =	density of fluid	ML^{-3}
u =	viscosity of fluid	$ML^{-1} T^{-1}$
e =	bulk modulus of elasticity (compressibility)	$FL^{-2} = (MLT^{-2})(L^{-2}) = ML^{-3} T^{-2}$

termined by dimensional analysis. It is found by using the governing equations, laws, theoretical equations, or by experimentation. The results of experiments are expressed as plots of Pi terms. The relationship among Pi's is thus determined. The fundamental dimensions usually used are mass (M) or force (F), length (L), and time (T). In heat transfer, other basic dimensions used are temperature (ϕ) and quantity of heat (H). The dimensions of force may be taken as F or MLT^{-2}, since force, according to Newton's Law is equal to the mass multiplied by acceleration. Further, it must be recognized that H (quantity of heat) is dimensionally equal to FL, or energy for performing mechanical work. Since F may be regarded as MLT^{-2}, the dimensions of H are FL or ML^2T^{-2}.

Prediction equations will now be developed from the models for designing irrigation and drainage structures and estimating the fluid velocity and discharge.

Pumping Machines

Pump models for tubewells can be made and tested in a laboratory for predicting the behaviour of large pumping sets used in irrigation and drainage tubewells. The most important problem faced by the design engineers is the selection of pertinent variables. These variables and their dimensions are indicated in **Table 1.**

A functional relationship between the dependent variables P and H may be expressed thus:

$$\frac{P}{rN^3D} = f_1\left(\frac{D}{L_1}, \frac{Q}{ND^3}, \frac{rND^2}{u}, \frac{rN^2D^2}{e}\right) \qquad (1)$$

$$\frac{H}{N^2D^2} = f_2\left(\frac{D}{L_1}, \frac{Q}{ND^3}, \frac{rND^2}{u}, \frac{rN^2D^2}{e}\right) \qquad (2)$$

Equations (1) and (2) can be used both for models and prototypes. It may be noted that rND^2/u and rN^2D^2/e are respectively the forms of Reynolds Number and Mach Number. The variables, e and u can be ignored from the list of variables, since water is assumed to be incompressible and of constant density. It is, therefore, reasonable to assume that the Reynolds and Mach Numbers have little effects on most pump operating conditions.

Equations (1) and (2) can, therefore, be written for models and prototypes as follows:

$$\text{Prototype: } \frac{P}{rN^3D} = f_1\left(\frac{D}{L_1}, \frac{Q}{ND^3}\right) \qquad (3i)$$

$$\text{Model: } \left(\frac{P}{rN^3D}\right)_m = f_1\left(\frac{D}{L_1}, \frac{Q}{ND^3}\right)_m \qquad (3ii)$$

$$\text{Prototype: } \frac{H}{N^2D^2} = f_2\left(\frac{D}{L_1}, \frac{Q}{ND^3}\right) \qquad (4i)$$

$$\text{Model: } \left(\frac{H}{N^2D^2}\right)_m = f_2\left(\frac{D}{L_1}, \frac{Q}{ND^3}\right)_m \qquad (4ii)$$

The following design conditions, which should be satisfied in the construction and operation of a model can be derived from the above equations:

Design conditions

$$\text{(i) } \frac{D}{L_1} = \left(\frac{D}{L_1}\right)_m$$

.... length scale

$$\text{(ii) } \frac{Q}{ND^3} = \left(\frac{Q}{ND^3}\right)_m$$

$$\text{or } \frac{Q}{Q_m} = \frac{ND^3}{(ND^3)_m}$$

.... discharge scale.

The subscript m stands for the model. Without a subscript the quantity stands for the prototype.

If the above design conditions are satisfied, the prediction equations for predicting the power and head of the prototype pump are determined from Equations (3i) and (4i) as indicated below:

$$\frac{P}{rN^3D} = \left(\frac{P}{rN^3D}\right)_m \text{ or } P = rN^3D\left(\frac{P}{rN^3D}\right)_m \qquad (5)$$

$$\frac{H}{N^2D^2} = \left(\frac{H}{N^2D^2}\right)_m \text{ or } H = N^2D^2\left(\frac{H}{N^2D^2}\right)_m \qquad (6)$$

If the same fluid (say, water is used in both the model and prototype pumps, Equation (5) can be written as:

$$P = N^3D\left(\frac{P}{N^3D}\right)_m \qquad (7)$$

Equations (6) and (7) can be used for predicting the head and power generated by the prototype pump.

Open Channels

Models of open channels like rivers, irrigation canals and drainage ditches can be constructed for the determination of flow characteristics. The variables involved and their dimensions are shown in **Table 2.**

No. of Pi terms = No. of variables – No. of basic dimensions = 11–3= 8.

One of the possible forms of

Table 2. Variables of Open Channels

Variable	Dimensionally equal to
V – velocity of flow	LT^{-1}
B_1 – length of channel	L
B_2 – width of channel	L
B_3 – other horizontal distance	L
B_4 – other vertical distance	L
d – depth of channel	L
f – roughness coefficient of channel	L
r – density of fluid	ML^{-3}
u – viscosity of fluid	$ML^{-1}T^{-1}$
s – surface tension	$FL^{-1} = (MLT^{-2})L^{-1} = MT^{-2}$
g – acceleration of gravity (because of slope of channel)	LT^{-2}

equations is:

Prototype:

$$\frac{v^2}{gd} = f_3\left(\frac{B_1}{d}, \frac{B_2}{d}, \frac{B_3}{d}, \frac{B_4}{d}, f, \frac{rvd}{u}, \frac{r^2vd}{s}\right) \quad (8i)$$

It may be noted that v^2/gd, rvd/u, rv^2d/s are respectively the forms of Froude Number, Reynolds Number and Weber Number.

$$\text{Model: } \left(\frac{v^2}{gd}\right)_m = f_3\left(\frac{B_1}{d}, \frac{B_2}{d}, \frac{B_3}{d}, \frac{B_4}{d}, f, \frac{rvd}{u}, \frac{rv^2d}{s}\right)_m \quad (8ii)$$

The following design condition for constructing a model can be derived from Equations (8i) and (8ii):

Design conditions

(i) $\frac{B_1}{d} = \frac{(B_1)_m}{d}$

$\frac{B_2}{d} = \frac{(B_2)_m}{d}$

$\frac{B_2}{d} = \frac{(B_3)_m}{d}$

$\frac{B_4}{d} = \frac{(B_4)_m}{d}$

$f = f_m$

These conditions show that model and prototype should be geometrically similar

(ii) $\frac{rvd}{u} = \frac{(rvd)_m}{u}$ (Reynolds Number should be the same for model and prototype)

(iii) $\frac{rv^2d}{s} \frac{(rv^2d)_m}{s}$ (Weber Number should be the same model and prototype)

If the above conditions are satisfied, the prediction equation is

$$\frac{v^2}{gd} = \frac{(v^2)_m}{gd} \quad (9i)$$

(This equation states that the Froude Number should be the same for model and prototype.)

For economic reasons, usually water is used in the model of a prototype open channel. If water is considered as a working fluid both for model and prototype, the design conditions and prediction equation (9i) would give rise to conflicts, as indicated below:

From design condition (i) $\frac{B_1}{d}$

$= \frac{(B_1)_m}{d}$

Let n = length scale ratio for prototype and model

$$= \frac{B_1}{(B_1)_m} = \frac{B_2}{(B_2)_m} = \frac{B_3}{(B_3)_m} = \frac{B_4}{(B_1)_m}$$

$$= \frac{d}{d_m}$$

$$\text{Thus } n = \frac{d}{d_m} \quad (10)$$

From design condition (ii) $\frac{rvd}{u}$

$= \frac{r_m v_m d_m}{u_m}$ (Reynolds Number)

Since water is used in model and prototype, $r = r_m$, $u = u_m$

Thus $vd = v_m d_m$

or $\frac{d}{d_m} = \frac{v_m}{v}$

$$\text{or } n = \frac{v_m}{v} \quad (11)$$

From design condition (iii) $\frac{rv^2d}{s}$

$\frac{r_m v_m^2 d_m}{s_m}$ (Weber Number)

Since water is used in model and prototype, $r = r_m = s = s_m$

Thus $v^2 d = v_m^2 d_m$

or $\frac{d}{d} = \frac{v_m^2}{v^2}$

$$\text{or } n = \sqrt{\frac{v_m}{v}} \quad (12)$$

Further, prediction equation (9i) can be written as

$\frac{v^2}{gd} = \frac{v_m^2}{g_m d_m}$ (Froude Number)

$g = g_m$, as both model and prototype are used in the same gravitational field (earth).

$\frac{v^2}{d} = \frac{v_m^2}{d_m}$

$\frac{d}{d_m} = \left(\frac{v}{v_m}\right)^2$

$$n = \left(\frac{v}{v_m}\right)^2 \quad (13)$$

Equations (10), (11), (12) and (13) are in conflict with each other. These equations can hold good only if n = 1.

This means that the size of the model must be equal to the size of the prototype. To overcome this unpleasant situation, some of the unimportant variables should be deleted from the list. Since water may be regarded as incompressible for most operating conditions of open channels, the viscosity as a variable may be deleted from the list of variables. This means that the Reynolds Number, as one of the Pi terms, may be ignored form Equations (8i) and (8ii), resulting in the elimination of Equation (ii). Further, the effect of surface tension, which forms spherical surface of water can be eliminated by using in the model a detergent or oil. This will improve the surface capability of fluid. The variable s, thus, is relatively unimportant and can be also deleted from the list of variables; thereby, resulting in the elimination of Equation (12). Thus the Weber Number, as one of the Pi terms, may also be discarded from Equations (8i) and (8ii). This analysis shows that the Froude Number is the governing criterion for the operation of open channels. In other words, gravitational effects are considered most important in the movement of water in open channels.

One more problem is yet to be

solved. In designing a model of an open channel, according to a reasonable scale ratio (n), the depth may be reduced to an insignificant level. For example, if n = 100 and the depth of water in a canal under study is 5 feet, the depth of water in the model should be 5/100 = 1/20 feet. This is too low for making observations on this model. Further, the effect of surface tension would be very high, if water alone were to be used in such a model of two shallow a depth. Under these circumstances, the depth of models for open channels is usually distorted.

It is interesting to note that the Froude Number and the Chezy's formula for open channels give rise to identical design equations for models. Equation (13) was developed from the Froude Number for model and prototype. The same equation may be deduced from Chezy's formula as follows:

Chezy's formula:

$$v = c\sqrt{MS} \text{ (for prototype)} \quad (14)$$

Where:

v = velocity of flow

c = Chezy's coefficient of roughness

M = Area/wetted perimeter

S = Slope of channel.

$$\text{Now } v_m = c_m\sqrt{M_m S_m} \text{ (for model)} \quad (15)$$

From Equations (14) and (15)

$$\frac{v}{v_m} = \frac{c\sqrt{MS}}{c\sqrt{M_m S_m}} \quad (16)$$

If c = cm and $S = S_m$

then $\frac{v}{v_m} = \sqrt{\frac{M}{M_m}}$

or $\frac{v}{v_m} = \sqrt{\frac{M}{M_m}}$

$$\text{or } n = \left(\frac{v}{v_m}\right)^2 \quad (17)$$

The above results indicate that Equations (13) and (17) are identical. Prediction equation has thus been verified by theory.

Porous Media and Underground Drains

Water flows through the layers of soil by the following processes before it enters the drain through the spacings kept between the times:

i) movement of water from high to low pressure side;
ii) movement of water vapours associated with heat transformer; and
iii) movement due to gravity.

The movement of water through soil and underground drain is thus expressed by the following functional relationship:

$$v = f_4 (H, A, i, K_1, K_2, P, T, r, d, L_2, r_1, r_2, c, u, s, g, e, Q, t) \quad (18)$$

Where:

V = velocity of fluid = LT^{-1}

H = height of soil column considered = L

A = cross sectional area of soil segment = L^2

i = hydraulic conductivity of soil = LT^{-1}

k_1 = coefficient of thermal conductivity of water = $MLT^{-3}\Theta^{-1}$

k_2 = coefficient of thermal conductivity of soil = $HT^{-1}\ L^{-1}\ \Theta^{-1}$ = $MLT^{-3}\ \Theta^{-1}$

p = drop of pressure head of water through the segment of soil = $FL^{-2} = ML^{-1}\ T^{-2}$

T = temperature drop = Θ

r = roughness coefficient of tile drain = –

d = diameter of tile = L

L_i = length of tile = L

L_2 = spacing between tiles = L

r_1 = density of fluid = ML^{-3}

r_2 = density of soil = ML^{-3}

c = specific heat of water = $HM^{-1}\Theta^{-1} = L^2T^{-2}\Theta^{-1}$

u = viscosity of fluid = $ML^{-1}T^{-1}$

s = surface tension of fluid = MT^{-2}

g = acceleration of gravity = LT^{-2}

e = bulk modules of fluid (compressibility) = $FL^{-2} = ML^{-1}\ T^{-2}$

Q = rate of heat transfer = HT^{-1}

t = time required for the movement of water from one location to another = T

Pi terms = 21 – 4 = 17

One of the possible forms of equations is:

$$\frac{v}{i} = f_5 \left(\frac{H^2}{A}, \frac{D}{H}, \frac{L_1}{H}, \frac{L_2}{H}, \frac{k_2}{K_2}, \frac{p}{r_1 v^2}, \frac{v^2}{c_2 T}, r, \frac{r_1 v^2 d}{s}, \frac{r_1 vd}{u}, \frac{v^2}{gd}, \frac{uc}{k_1}, \frac{r^1}{r^2}, \frac{gt^2}{d}, \frac{r_1 v^2}{e}, \frac{Q}{L_1 k_1 T}\right) \quad (19)$$

From the above equation, it may be concluded that the following parameters govern the movement of water in soil and the tile drain (different Numbers have been mentioned in decreasing order of importance):–

1. Euler Number = $\frac{p}{r_1 v_2}$
2. Froude Number = $\frac{v^2}{gd}$
3. Prandtle Number = $\frac{uc}{k^1}$
4. Reynolds Number = $\frac{r_1 vd}{u}$
5. Nusselt Number = $\frac{Q}{L_1 K_1 T}$
6. Weber Number = $\frac{r_1 v^2 d}{s}$
7. Mach Number = $\frac{r_1 v^2}{e}$
8. Ratio of thermal conductivities water and soil = $\frac{k_1}{k_2}$
9. Ration of densities of water and soil = $\frac{r_1}{r_2}$

Equation (19) is very complicated and difficult to use. To simplify this equation, the following assumptions can be made:

Assumptions:

1. Flow is saturated so that water in soil is similar to flow of water in conduit or open channel.
2. Surface tension does not affect flow (s).
3. Fluid velocity is not high so that compressibility effects can be ignored.
4. Flow is steady and linear so that time can be ignored from the list of variables. (t)
5. Viscosity of water does not affect its movement. (u)
6. There is no heat transfer so that Q, c_1, c_2, k_1, k_2; and T can be liminated from the list of variables.

On deleting the above variables, Equation (18) reduces to:–

$$v = f_6\,(H, A, d, L_1, L_2, i, p, r, r_1, r_2, g) \qquad (20)$$

Pi terms = 12 – 3 = 9

$$\frac{v}{i} = f_7\,(\frac{H^2}{A}, \frac{d}{L_1}, \frac{L_1}{L_2}, \frac{p}{r_1 v^2}, \frac{r_1}{r_2}, \frac{v^2}{gd}, r) \qquad (21)$$

Equation (21) indicates that flow in a saturated soil and tile drain is governed mostly by Euler Number ($p/r_1 V^2$) and Froude Number (v^2/gd).

If flow of water in a saturated soil is considered similar to flow in a conduit (with full flow), where Euler Number is most important, i.e., difference of pressure head governs the movement of flow,

$$\frac{v}{i} = f_8\,(\frac{H^2}{A}, \frac{D}{L_1}, \frac{L_1}{L_2}, \frac{L_2}{d}, r, \frac{r_1}{r^2}, \frac{v^2}{Cd}) \qquad (22)$$

Equation (22) holds good also for the movement of water in underground drain.

In flow of water in a saturated soil is considered similar to flow in an open channel, Froude Number is most important, i.e., gravity governs the movement of water,

$$\frac{v}{i} = f_9\,(\frac{H^2}{A}, \frac{D}{L_1}, \frac{L_1}{L_2}, \frac{L_2}{d}, r, \frac{r_1}{r^2}, \frac{v^2}{gd}) \qquad (23)$$

Modeling of flow in soil and tile can be carried out with the help of Equation (21), as follows:

$$\text{Prototype: } \frac{v}{i} = f_8\,(\frac{H^2}{A}, \frac{D}{L_1}, \frac{L_1}{L_2}, \frac{L_2}{d}, r, \frac{p}{r_1 v^2}, \frac{v^2}{gd}) \qquad (21)$$

$$\text{Model: } (\frac{v}{i})_m = f_8\,(\frac{H^2}{A}, \frac{D}{L_1}, \frac{L_1}{L_2}, \frac{L_2}{d}, r, \frac{r_1}{r_2}, \frac{p}{r_1 v^2}, \frac{v^2}{gd})_m \qquad (21_1)$$

Design conditions

i) $\frac{H^2}{A} = (\frac{H^2}{A})_m$

ii) $\frac{D}{L_1} = (\frac{D}{L_1})_m$

iii) $\frac{L_1}{L_2} = (\frac{L_1}{L_2})_m$ — Gemetrical similarity conditions

iv) $\frac{L_2}{d} = (\frac{L_2}{d})_m$

v) $r = r_m$

vi) $\frac{r_1}{r_2} = (\frac{r_1}{r_2})_m$

vii) $\frac{p}{r_1 v^2} = (\frac{p}{r_1 v^2})_m$

viii) $\frac{v^2}{gd} = (\frac{v^2}{gd})_m$

If the same gravitational field, water and soil conditions are used both for model and prototype, the design conditions (vii) and (viii) can be written as

$$\frac{p}{v^2} = (\frac{p}{v^2})_m \text{ as } r_1 = (r_1)_m$$

$$\text{and } \frac{v^2}{d} = (\frac{v^2}{d})_m \text{ as } g = g_m$$

If the above design conditions are satisfied, prediction equation for estimating the velocity of flow is

$$\frac{v}{i} = (\frac{v}{i})_m \qquad (24)$$

$$\text{or } v = i\,(\frac{v}{i})_m$$

Conclusions

1. The effect of Reynolds and Mach Numbers may be ignored in designing models for pumping machines.
2. Froude, Reynolds and Weber Number should be equal for model and prototype in the case of open channel flow. Froude Number, however, is the most important parameter in predicting flow characteristics. The depth of flow in models of open channels is usually distorted.
3. Euler, Froude, Pandtle, Reynolds, Nusselt, Weber and Mach Numbers in decreasing order of importance affect the movement of flow through porous media and underground drains. Euler and Froude Numbers, however, may be considered as the most important parameters in the design of models for such a type of flow.

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Design and Construction of Manually Operated Seed Cleaning and Grading Machine

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Introduction

Priority is normally given to land preparation and fertilizer application in the farmers' effort to increase crop yields. Priority should likewise be given to the quality of seeds. Cleaning and grading are the two important steps in the production of high quality seeds and grains.

There are several methods for cleaning and grading of seeds and grains. Wind is the main source of power for performing this operation. Farmers generally winnow the grains against natural wind causing the chaff and other light impurities to fly away form the seeds. But natural wind is not available all the time. Farmers also use the 'kula' (a piece of buffle made of bamboo) to produce air blast by swinging the buffle up and down. For this purpose human muscle is the only source of power.

What ever the methods cleaning grains, efficient results cannot be expected all the time. These methods are only applicable in dry weather and require sufficient dry area. Therefore, an improved seed/grain and grading is very essential, particularly for the small farms where neither electrical nor mechanical energy is usually not available.

This report pertains to a manually-operated seed/grain cleaning and grading machine developed at the Department of Farm Power and Machienry, Bangladesh Agricultural University, Mymensingh, Bangladesh. The machine is simple in construction and easy to operate. It is designed to reduce operation costs.

Review of Literature

Magee, A.I.(1953) designed a machine with an upper screen large enough to allow the seeds to pass through. Round sieve was most effective for removing trash and the oblong holes for seperating out weed and grass seeds. To keep long trash in a horizontal position, a piece of oil cloth was fastened just above the screen.

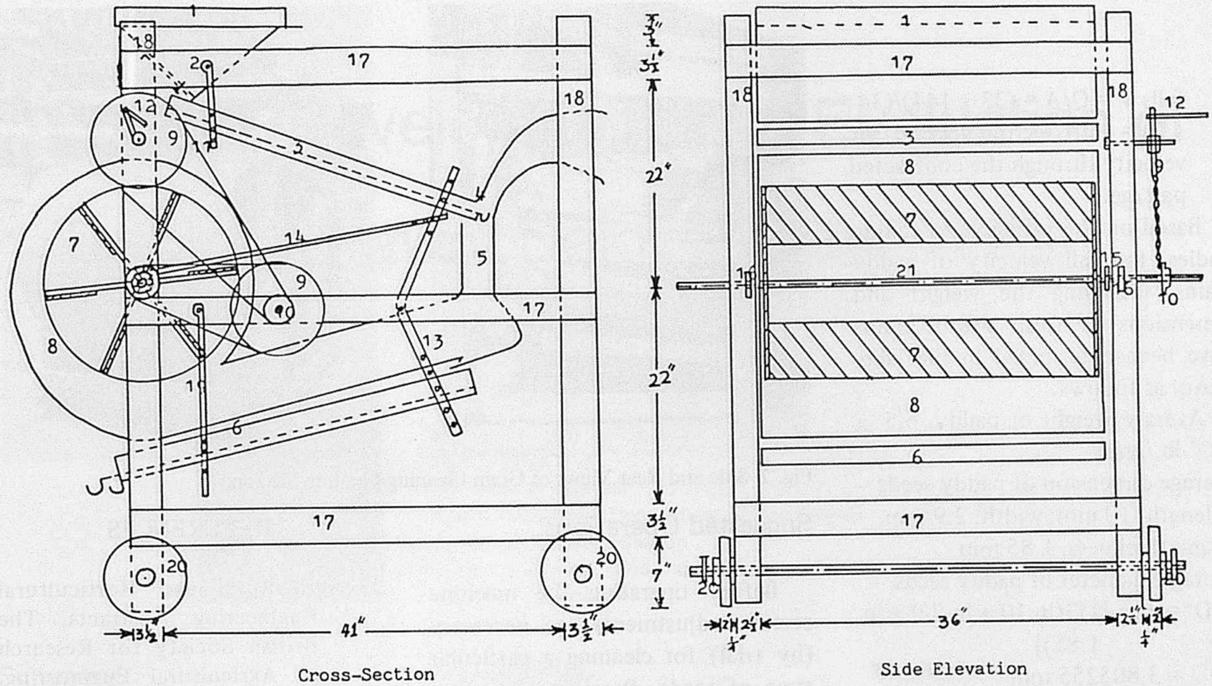
Forsch, Landw (1957) designed a laboratory equipment for dealing with seed samples in which samples of rape or mustared seeds are difficult to separate from the chaff. Even feeding, with the use of special hopper, facilitated the operation. A filter cloth tube was used at the outlet to reduce dust and assist in the collection of the samples.

Lainchbury (1958) designed a precleaner for grading finished grain samples. An initial air blast removed light trash from the grain which passed through a primary sieve. Mech. e.S. (1959) designed a machine for cleaning and grading of bulk wheet. Mukom (1959) developed a machine for separating wild oats using indented discs and cylinders with cells of 8.5 mm dia. Trudy (1960) made an investigation of the operation of flat screens. The experiments were carried out with flat screens of 2.75 x 25 mm mesh (for bulk wheat) or circular mesh (for bulk wheat). Dtsch. Agrar. Tech. Berl. (1960) designed a seed cleaner to clean various seeds and grains employing various seeds and grains employing various methods of separation, according to width, length, thickness and weight of grains.

Basic Principles and Design

The machine which is the subject of this report was designed on the basis of aerodynamic principles of falling bodies. It consists of a wooden frame, a blower, two sieves provided with oscillating mechanism, a seed hopper, and a power transmitting gear contraption.

The blower is mounted on the wooden frame. Hand-operated blower speed varies from about 250 rpm to 300 rpm. The grain hopper, with a capacity of 240 lbs. is placed on top of the blower. The seed hopper is furnished with a



Legend:

1) Seed hopper, 2) Grain flow rate control, 3) Top seive (scalper), 4) Outlet channel, 5) Contracted passage, 6) Lower seive, 7) Fan blade, 8) Volute, 9) Sprocket whell, 10) Free wheel, 11) Chain, 12) Handle, 13) Angled bar, 14) Connecting bar, 15) Cam-bearing 16) Bearing, 17) Span, 18) Legs, 19) Hanger, 20) Ground wheel, 21) Shaft.

Fig. 1 Design of Grain Cleaning/Grading Machine

mechanism for controlling grain flow. A sieve (with large holes) that permit grains to pass through the holes is mounted below the grain hopper and above the blower. Another sieve with smaller holes that permit grass seeds or other smaller seeds to pass through it, is placed beneath the blower. The grains screened by the top sieve fall on the lower sieve through the air blast supplied by the blower. When grains fall through, the upward moving air-blast blows away the chaff, dust particles and light admixtures. Thus the grains are cleaned, fall on the lower sieve, and screened of small seeds and other small particles. The admixtures seperated by the sieves are collected into different places for easy removal. Both sieves are provided with an oscillating mechanism and another mechanism for setting the sieves at different inclinations.

Specifications

The outside dimension of the machine measures 50 inches in length, 40 inches wide and 60 inches high. The main structure of the machine is made of seasoned wood.

The blower is made of 22 gauge galvanized iron sheet. The dimension is shown in **Fig. 1**. Radial flow blower-blade is used for easier construction and trouble-free operation in dirty air.

The sieves are 35 inches long and 34 inches wide. A provision is made for replacing sieves of varying sizes depending on grain size.

The blower is hand-operated and runs between 250 rpm and 300 rpm against the hand speed of 35 rpm to 50 rpm. The speed is accelerated or discelerated with the use attached intermadiate gear and socket wheel mechanism for bicycles. The unit is designed to be operated by one-man power.

Blower Design

The radial flow straight blade blower supplies air blast. Air enters axially into the blower and leaves radially through an outlet.

The specifications are:

1) Absolute air angle at inlet = 90°
2) Vane angle at inlet = 90°
3) Impeller speed n = 250 rpm
4) Vane angle at outlet = 90°
5) Inlet diameter D_1=8"
6) Blade velocity at inlet
   U1 = D1n/60 = 8.75 ft/sec
7) Outlet diameter D2 = 20"
8) Blade velocity at outlet
   U2 = D2n/60 = 21.9 ft/sec
9) Absolute angle of air at inlet = 15°
10) Absolute air velocity at outlet
    V2 = U2/cos = 23 ft/3 sec.
11) Radial component of absolute air velocity at outlet
    Vr2=V2 sin =23 sin15° = 6.0 ft/sec
12) Discharge of air at outlet
    Q2 = A2V2
    A2 = 34x 6/144 = 1.44 sq ft
    Q2=1.44x 23 = 33 cu ft/sec
13) Air velocity at the contracted passage through which grain

falls $V = Q/A = (33 \times 144)/(34 \times 3) = 46$ ft/sec the upward air velocity through the contracted passage.

Based on the principle of falling bodies, the fall velocity of paddy grains, including the weight and dimensions of fresh paddy grains have been determined in the laboratory as follows:

Average weight of paddy, 6.5×10^{-5} lb./grain

Average dimension of paddy seeds – length, 10 mm; width, 2.9 mm, and thickness, 1.85 mm

Average diameter of paddy seeds –

$D = 3xp\ [1/3(\ln 10 + \ln 2.9 + \ln 1.85)]$

$= 3.805255$ mm

$= 0.0124844$ ft

Average projected area of paddy seeds, 1.3916×10^{-4} sq ft

Specific weight of air 0.078 lb/cu ft

Specific weight of paddy 36 lb/cu ft

Viscosity of air 1.22×10^{-5} ob/ft sec

Factor, $CRe = \frac{2gWD^2 (\quad)}{-A}$

$= [2 \times 32.2 \times 6.5353 \times 10^{-5} \times (0.0124844)^2 + 0.078 (36 - 0.078)] \div [(-1.22 \times 10^{-5}) \times 1.39136 \times 10^{-4} \times 36] = 2.4653 \times 10^6$

From table (Ref. 7) for CRe = 2.4653×10^6, Re = 2409

Approximate downward velocity of paddy,

$$V_p = \frac{Re\ 6}{D}$$

$$= \frac{2409 \times 1.22 \times 10^{-5}}{0.0124844 \times 0.078}$$

$\because V_p = 30$ ft.sec.

The air velocity must be less than 30 ft/sec to allow the downward fall of paddy seeds. The air flow can be controlled at the inlet of the blower. The cleaning capacity of the machine is about 400 lbs of paddy/hour with blower capacity of 2,500 cfm of air.

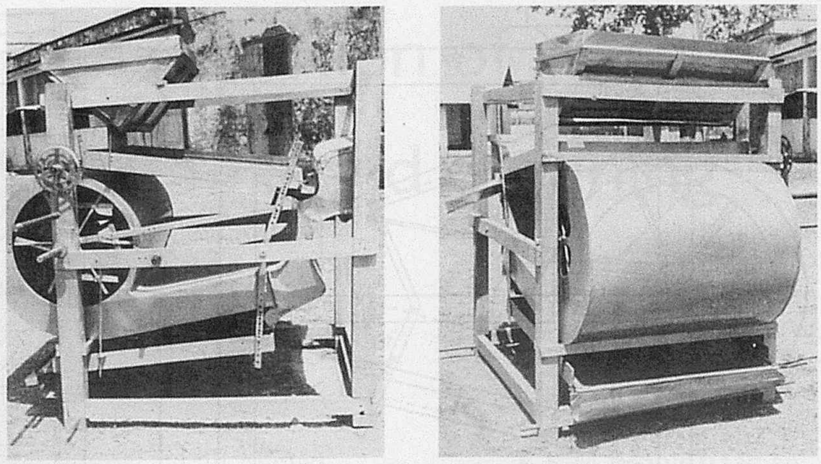


Fig. 2 Side and Rear Views of Grain Cleaning/Grading Machine

Suggested Operations

Before operating the machine certain adjustments are necessary (by trial) for cleaning a particular type of seeds. Bearings and other rotating parts should properly be lubricated to minimize friction and for smooth operation. Proper size of sieve should be selected and fitted in the sieve block. The adjustments should ensure thorough cleaning of grains.

The feed rate should be controlled by adjusting the hopper shutter and the rate of cleaning per unit of time should be controlled by adjusting the sieve inclinations. The air-flow rate should be controlled by adjusting the inlet opening of the blower.

Loose adjustments of rotating or oscillating parts may cause undue side vibration of the sieve assembly, hence the need to tighten properly all parts in contact with the sieves.

Any lubricating oil may be used for the purpose of lubricating all contact-moving points of the machine.

Acknowledgement

The authors are indebted to Bangladesh Agricultural University for financial support in the study.

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■■

Design, Development and Evaluation of Tractor-Drawn "Dalo" Planter in Fiji

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Summary

A recently developed tractor drawn "dalo" (taro) planter being used for experimental purposes to mechanize dalo production is described here. Field evaluations have indicated that this planter requires 7.5 manhours to plant 0.4 hectare (one acre) of dalo whereas the traditional method requires a minimum of 80 manhours to plant a similar area. The planter developed is a simple machine consisting of a series of attachments to a tractor drawn ridger which can be dismantled and assembled whenever required by the user. Design features include a wooden box for carrying the planting material, seats for the two planters and covering devices for filling the soil around the plants in the furrows. The depth and width of planting in the field can be adjusted depending on the moisture conditions and spacing recommendations. Plantings made with this machine are in straight rows and uniform which facilitates inter-row cultivation, fertilizer application and application of chemicals for weed control.

*Reprinted from the Fiji Agricultural Journal, (1978) 40, 101-103, with the voluntary contribution of the author.

Introduction

The only published report on dalo mechanization comes from Hawaii (Plucknett and de la Pena, 1971). A machine designed to plant tobacco or tomato seedlings was modified to plant dalo suckers under dryland conditions. Compared to hand planting this machine using two setts into the machine plus one tractor operator reduced the time required to plant by 63%.

Planting is the major labour consuming operation in the production of root crops like dalo. Previous trials on mechanized production of dalo in Fiji by Haynes (1977) was confined to Koronivia Research Station and was based on small scale operation. Although due to small scale of operation, the results may not be very reliable there was a strong indication that labour input and cost of production decreased considerably with increase in the levels of mechanizations. The factors involved indicate that it may be difficult to completely mechanize dalo planting using small machines. However, development of simple equipments and methodologies suitable to local socio-agro-climatic conditions can result in considerable saving in labour and costs.

Methods

Planting of taro has always been and still is a tedious job. Observational studies in the field have indicated that at least 80 man hours are required to plant 0.4 hectare (one acre) of dalo under normal conditions using animal power for making furrows and manual power for fixing the taro suckers in the furrows. The tractor drawn taro planter developed for these experimental purposes substantially reduces labour requirements and requires only two and a half hours to complete the same area with three men, i.e., one operator and two persons to place the planting materials in the furrows which are made by the furrow openers simultaneously. The only manual operation is the placing of the planting material in the furrows. As soon as the planting materials are placed in the soil around each sucker is covered by a covering device which follows the furrow opener. The planting materials are loaded in a wooden box from where they are picked up and dropped in the furrows. The time required in picking and placing the material very well synchronises with the recommended spacing between plant to plant (60 cm) provided the tractor speed is kept at 6 km per hour. In the usual hand labour method of planting taro, plants are dropped on the furrow beds by one man and another following him pushes them into the ground with foot and hand.

Design Features

A photograph of the planter mounted on a tractor is shown in **Fig. 1** and a brief description of the parts comprising the planter is given below:

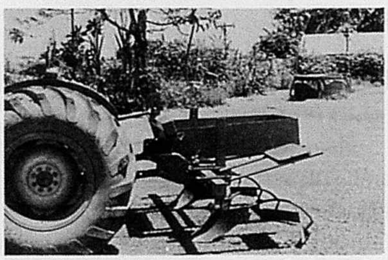

Fig. 1 The planter mounted on a tractor

1. The Ridger – The ridger is an imported item from Napier Company of Australia on which the whole assembly of the planter is mounted, and it can easily be assembled and dismantled depending upon the use. Initially the ridger had three mouldboard furrow openers but only two are being used so that the planter is light enough in weight for use by a medium size tractor. The length of the ridger is 230 cm and the minimum spacing between two rows is 106 cm. This spacing can be increased if required.
2. The Covering Device–The covering device is made up of a mild steel 4 mm thick plate and is connected with the main body of the ridger mouldboard with twisted iron bar of 20 mm diameter. The iron bar has been given a curved shape whose centre of gravity passes through the line of pull. The beginning end of the covering device is connected with the ridger mouldboard by the sunk type nut and bolt fastener which can be removed when the machine is used only as a ridger for ridging and earthing operation in the field.
3. Mounted Type Wooden Box – This box is used for carrying the planting materials (taro suckers) and is mounted on top of the ridger bar. It is made up of plywood of 1 cm thickness and is rectangular in shape. The size of this box is 107 cm x 25 cm. It has a carrying capacity of nearly 400 plants. The total number of planting material required for planting 0.4 hectare (one acre) crop is nearly 6,000 taro suckers. The size of the box is so designed that it does not exert excessive load on the tractor for the safety of the hydraulic pump of the lift system.
4. Planters' Seat – Two wooden seats have been provided for the comfortable sitting of the planters to drop planting materials in the furrows formed just behind the curved body of the ridger mouldboard. The picking of the planting materials from the wooden box and dropping them in the furrows is accomplished in one easy movement.

Fig. 2 Taro being planted in an experimental field

Results and Discussion

The data for the evaluation of the planter in the field were collected both by using traditional method and the planter. It is evident from the **Table 1** that this planter reduced the labour cost required in the planting operation to nearly one-third.

Fig. 3 Use of the planter has made commercial production easier and labour saving over the traditional method

It clearly shows that the dalo planter is much more efficient than the common method of planting employing manual and animal power. This planter has several advantages over conventional transplanting method. It is simple and not expensive as this is an attachment over a ridger which can be easily assembled and dismantled by farmer or tractor operator and is suited to the small as well as the large acreages. Plants can be set to any desired depth up to 15 cm in the furrows. The percentage germination is high because enough moisture becomes available to the plants early as the soil is well

Table 1. Time and Labour Cost of Planting 0.4 Hz of Dalo

	Planting by Traditional Method Using Human Animal Power (manhours)	Cost (F$)	Planting by Tractor Drawn Dalo Planter (manhours)	Cost (F$)
Dalo mechanization plot – Muaniweni	72	27.00	6	7.80*
Dalo mechanization plot – Natogadravu	88	33.00	9	11.97**

* Includes the working cost of a 40 h.p. Tractor.
** Includes the working cost of a 35 h.p. Tractor.

packed around them by the covering devices. Planting is quick, in straight lines and at uniform spacing. These facilitate inter-row cultivation at the early stages of the crop for the control of weeds and application of fertilizer and chemicals. Seats provided on the planter offer very little body

Fig. 4 An experimental crop planted by machine

strains and fatigue to the planters. Tractor and ridger can be conveniently used for ridging during early stages of crop development which facilities corm development.

While conducting the evaluation of the machine in the field it has been observed that the following factors may affect the efficiency of the machine:

1. Preparation of the field before planting;
2. Moisture content in the soil;
3. Physical properties of the soil;
4. Speed of the tractor operating the machine;
5. Depth of planting;
6. Length and thickness of the planting material;
7. Topography of land; and
8. Experience of tractor operator and planters.

Acknowledgements

The author is indebted to Dr. Satish Chandra Assistant Director of Agriculture (Research) for the guidance he provided during the evaluation and development of this planter. The cooperation and assistance extended by Mr. Param Sivan, Senior Research Office (Root Crops) and Mr. Isireli Lagai. Thanks are also due to the farmers on whose farms the field evaluation of the machine to determine its capacity was carried out at the two sites where dalo mechanization trials have been located.

Acknowledgement of AMA

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A Manual Seeder for Soybean

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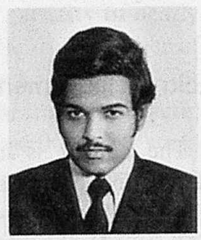

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Abstract

In an effort to increase the use of paddy growing land during the dry season, farmers in Taiwan and Thailand plant soybean directly into rice stubble, thus avoiding the need for tillage. Most of the work is performed by women and is both back-breaking and time consuming. In order to improve the planting both in efficiency and convenience, a simple manually operated soybean seeder with a roller metering device was developed. The seeder is being tested, both on experiment stations and in farmers' fields, in Taiwan and Thailand and the results are very promising.

Introduction

Soybean is frequently sown in paddy fields following rice harvest without any land preparation in Taiwan and Northern Thailand. This technique is referred to as "no-tillage, rice-stubble soybean culture" [1]. As the soil is not disturbed, weed growth is reduced, and soil moisture is retained in the entire soil profile. The seeds are sown close to the rice stubble so that soybean roots will penetrate the puddled soil by growing in the decomposing root channels of the rice plant. Possibly, additional nutrients may be available to the soybean plant from the decaying rice roots.

In Taiwan, soybean is sown by making an opening (about 2 cm. deep) close to the rice stubble with a small hand trowel. Two to four seeds are dropped in each opening. Most farmers do not cover the seeds. The rice stubble provides a simple guide for sowing soybean at a plant density of approximately 200,000 hills per hectare.

Need for a Soybean Seeder

Female labor is generally employed in both Taiwan and Thailand for sowing. These workers are required either to bend over or squat while sowing soybean using no tillage technique. Soybean production could be increased by simply adopting this technique in countries where soybean is currently broadcast such as in Indonesia. However, the introduction of new sowing technique is as it reduces or eliminates the need to bend over or squat.

The Kaohsiung District Agricultural Improvement Station (DAIS), Taiwan [1] began work on the development of an economical planter in the late 1960's. A manually operated, spring action jabbing planter was developed and tested in farmers' fields. However, when the soil is too moist, mud plugs the device. Also, farmers complained that it was not as fast as their traditional method. Other seeders designed by Chairakul and Suwanark [2], Okudo [3] and Toye Ige [4] also did not prove successful on account of the assembly of tillage technique. The Asian Vegetable Research and Development Center (AVRDC), Taiwan, proposed to the Asian Institute of Technology (AIT) to develop a simple, efficient, and economical soybean seeder.

*This paper was presented at the World Soybean Reserach Conference, held at North Carolina State University, Raleigh during March 26–29, 1979.

Soybean Seeder

Niyom [5] under the supervision of Cowell developed two different prototypes. Prototype 1 consisted of two main parts, viz., body and sliding valve. The lower end of the seeder is pushed into soil and the sliding valve is manually operated to release seeds into the hole made by pushing the seeder body. This prototype encountered problems of wet soil plugging the seeder opening and also the seed used to get sheared by getting trapped between the valve and body. A second prototype was built having a long handle, sliding valve, soil opener, sliding tube and a metering device. In this model the valve and metering device operate automatically associated with the seeder movement. After some initial trials, two jab planter designs were constructed; one with a sliding valve metering device, the other with a roller metering device. In testing, it was found that the performance, based on the distribution of seeds dispatched per stroke, was superior for the seeder with the roller metering device.

The details of the seeder are shown in **Fig. 1 and Fig. 2.** It consists of a long handle, a metering roller, cut-off plate, soil opener, inner and outer sliding plates. The handle serves as seed tube and carries about 2 kg of seeds. The metering roller has two seed cells. Every time the sliding tube moves up and down the roller rotates and seeds drop in the opening.

Testing

One prototype of the seeder was given to the Asian Vegetable Research and Development Centre, Taiwan for testing in 1978. There were few mechanical problems which have been solved in the redesigned prototype. The size of the seed cells on the metering roller should be adjusted to the seed size as given below:

Seed Size (g/100 Seeds)	Size of Seed Cells (mm)
20	13
19	12
18	11
16	10
13	9
12	8

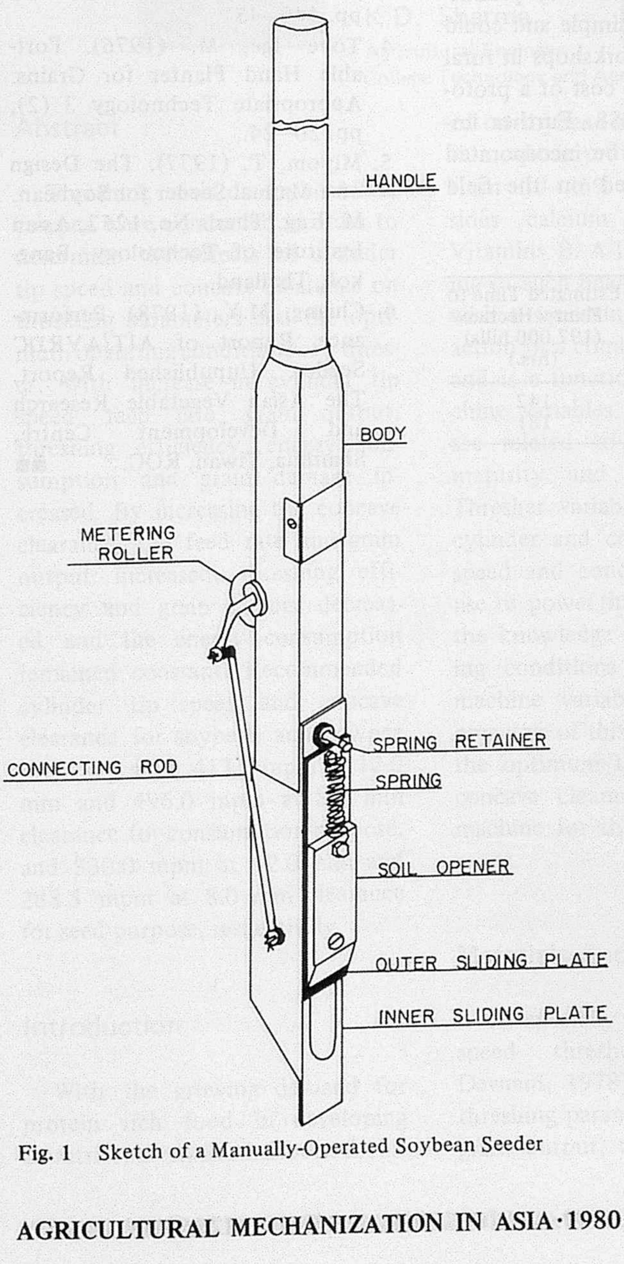

Fig. 1 Sketch of a Manually-Operated Soybean Seeder

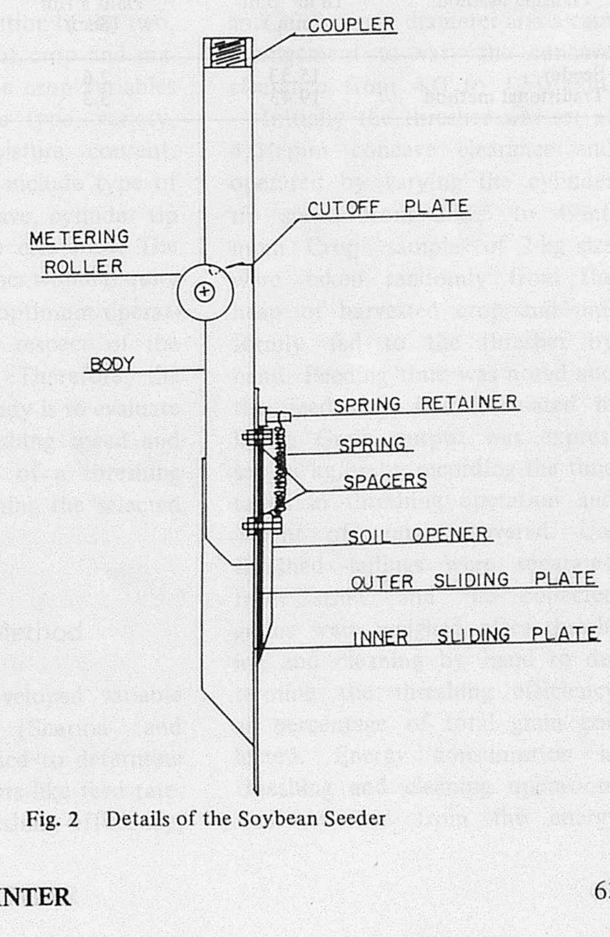

Fig. 2 Details of the Soybean Seeder

The above combinations of seed and seed cells sizes give a mean delivery rate of 2.5 – 3 seeds/stroke.

In the traditional rice stubble culture, the time needed to plant one hectare with soybean ranges from 120 to 160 man-hours. In a comparative study, Chiang [6] found that for small areas, the seeder was faster than the traditional method **(Table 1)**. For the seeder, the average time needed to plant a hill was 2.6 seconds; but he reported that under the best conditions, the seeder could be operated at the rate of 2 seconds per hill. Based on this figure, a farmer could plant one hectare of 197,000 hills in about 110 hours. Using 140 man-hours as the average time needed to plant one hectare by the traditional method, a saving of 20% in time could be accomplished by using the seeder.

A prototype of the seeder has been given to the Division of Agricultural Engineering, Ministry of Agriculture and Cooperative, Thailand. After preliminary testing, the Division decided to fabricate a number of these seeders in their workshop for the testing on farmers' field during the subsequent season. Also, a prototype has been given to the Institute of Agricultural Technology, Chiang Mai for testing in Northern Thailand.

Conclusion

It can be concluded that the results of testing are very promising. The seeder is simple and could be fabricated in workshops in rural areas. The average cost of a prototype is about US$8. Further improvements could be incorporated in the design based on the field performance reports. After thorough testing the seeder would need to be designed for durability.

Table 1. Comparison of Planting Time Between Two Methods

Planting Method	Time to Finish 18 m^2 plot (min.)	Average Time to Plant a Hill (Sec.)	Estimated Time to Plant a Hectare (197,000 hills) (hrs.)
Seeder	15.33	2.6	142
Traditional method	19.43	3.3	181

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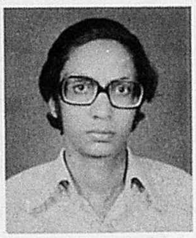
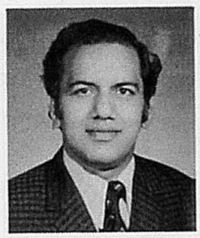
Threshing Studies on Soybean and Cowpea





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Abstract

Threshing trials on soybean and cowpea were conducted in order to determine the effects of cylinder tip speed and concave clearance on threshing parameters and the optimum operating conditions of thresher. With increase in cylinder tip speed, feed rate, grain output, threshing efficiency, energy consumption and grain damage increased. By increasing the concave clearance, the feed rate and grain output increased, threshing efficiency and grain damage decreased and the energy consumption remained constant. Recommended cylinder tip speed and concave clearance for soybean and cowpea threshing were 413.5 mpm at 12.0 mm and 496.0 mpm at 8.0 mm clearance for consumption purpose, and 330.0 mpm at 12.0 mm and 288.5 mpm at 8.0 mm clearance for seed purpose, respectively.

Introduction

With the growing demand for protein rich food in developing countries, attention has been focused on soybean and cowpea production whose protein content ranges from 30–45% (Bates, 1963) besides calcium, phosphorus and Vitamins B. A large part of threshing of such bean crops can be done with a squeezing action, a rubbing action or a combination of the two, and is a function of crop and machine variables. The crop variables are related to the type, variety, maturity and moisture content. Thresher variables include type of cylinder and concave, cylinder tip speed and concave clearance. The use of power thresher would require the knowledge of optimum operating conditions in respect of the machine variables. Therefore, the objective of this study is to evaluate the optimum threshing speed and concave clearance of a threshing machine for threshing the selected crops.

Materials and Method

A specially developed variable speed thresher (Sharma and Devnaṇi, 1978) used to determine threshing parameters like feed rate, grain output, threshing efficiency, energy consumption and grain damage for soybean (Variety – Bragg) and cowpea (Variety – Deshi) at the sun-dried moisture contents of 6.10% and 6.50%, respectively. The thresher has a rasp cylinder of a length of 30.5 cm and 20.0 cm in diameter and a cam arrangement to vary the concave clearance from 4.0 to 12.0 mm.

Initially the thresher was set at 4.0 mm concave clearance and operated by varying the cylinder tip speed from 288.5 to 496.0 mpm. Crop samples of 2-kg size were taken randomly from the heap of harvested crop and uniformly fed to the thresher by hand. Feeding time was noted and the feed rate was calculated in kg/hr. Grain output was expressed in kg/hr by recording the time taken in threshing operation and weight of grain recovered. Unthreshed tailings were separated from straw and the collected grains were weighed after threshing and cleaning by hand to determine the threshing efficiency as percentage of total grain collected. Energy consumption in threshing and cleaning operations was recorded from the energy meter. Visible grain damage was obtained by dividing the quantity of total broken, skinned and damaged grains to the total weight of grains and expressed in percentage. In order to determine the internal grain damage, 100 grains were taken randomly from each sample of threshed grain and germinated by following the laboratory technique, which gave the percentage of internally damaged grain indirectly.

Results were statistically analysed and mathematical models for each threshing parameter were determined by multiple regression technique (Snedecor and Cochran, 1968).

Results and Discussion

The effects of cylinder tip speed and concave clearance on each threshing parameter of soybean and cowpea are plotted in **Figs. 1 and 2**, respectively. It is clearly observed that the feed rate increased with the increase in cylinder tip speed at all concave clearances, which resulted in subsequently higher grain output. Statistical analyses **(Tables 1 and 2)** also indicate a greater dependency of the feed rate on these two variables (R=0.9981 and 0.9942). Multiple correlation coefficients of 0.4198 and 0.4728 for soybean and cowpea, between the grain output and feed rate, cylinder tip speed and concave clearance revealed that the grain output depends upon crop variables rather than the machine variables. The correlation coefficient for soybean was comparatively lower than cowpea because of its higher dependency on crop variables (Richey et al. 1961).

It can also be seen from the **Fig.**, that the threshing efficiency was affected by cylinder tip speed, concave clearance and the quantity of material passed through the thresher per hour (feed rate) which

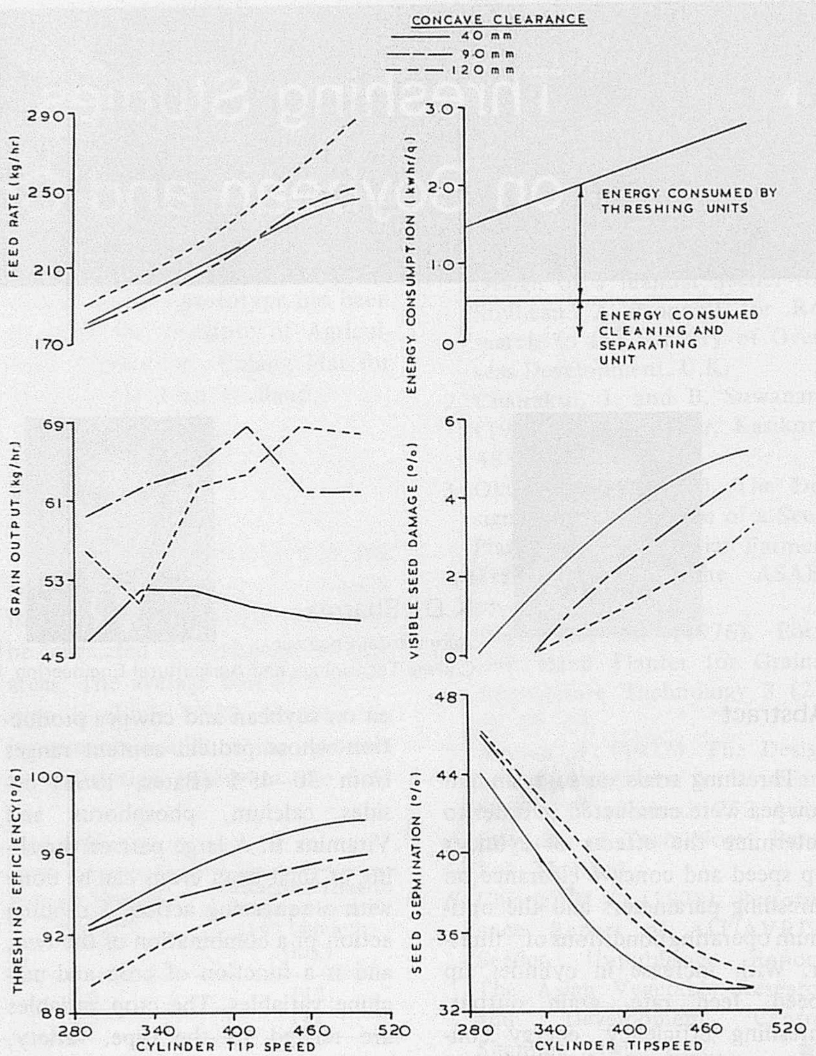

Fig. 1 Effects of cylinder tip speed and concave clearance on various threshing parameters of soybean (Variety–Bragg)

increased with the increase in the cylinder tip speed and decrease in the feed rate and concave clearance. About 80.71% variation in the threshing efficiency for soybean was accountable to these three variables as against 90.58% variation for cowpea. The lower multiple correlation coefficient for soybean (R=0.8984) than cowpea (R=0.9517) was perhaps due to higher feed rate for the former than the later.

Energy consumption in threshing was found to be directly proportional and highly correlated with the feed rate and cylinder tip speed, irrespective of the concave clearance. At the same rate of material flow and cylinder tip speed, the energy consumption for cowpea was higher than for soybean. Also, the cleaning and separating units consumed 0.625 kw hr/g for cowpea as against 0.50 kw hr/q for of soybean. This higher energy consumption at same speed and feed rate was associated with the more bushy nature of the crop.

It can be noted that the peripheral speed of the cylinder and concave clearance were the most important factors that caused grain damage. An increase in the cylinder tip speed increased the visible grain damage and reduced the percentage of seed germination. The same is true for the decrease in the concave

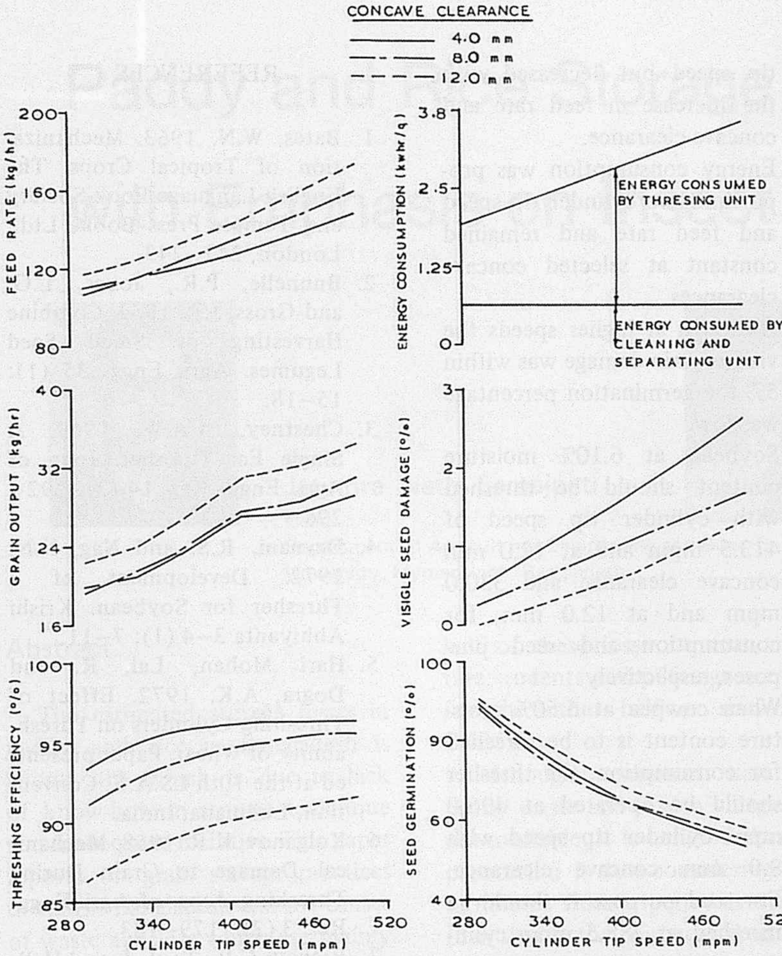

Fig. 2 Effects of cylinder tip speed and concave clearance on various threshing parameters of cowpea (Variety–Deshi)

clearance. For the same cylinder tip speed and concave clearance the visible grain damage was greater for the soybean, whereas the internal grain damage was greater for the cowpea. It can also be seen that, although at higher speeds, the visible grain damage was below 5%, the internal damage to grain was very high as determined by germination test.

Recommendations

For better storage quality of grain, the reported visible grain damage was less than 2% (Bunnelle et al., 1954; Kolganov, 1958 and Harimohan et al. 1972), which suggest a cylinder tip speed of 413.5 mpm at 12.0 mm concave clearance for the soybean threshing. The feed rate, grain output, threshing efficiency and energy consumption at this setting were 240.0 kg/hr, 64.4 kg/hr, 93.3% and 2.25 kw hr/q of feed rate, respectively. These were quite comparable to results reported for

Table 1. Statistical Analyses for Soybean Threshing

Regression Equation	Multiple Correlation Coefficient (R)	Coefficient of Determination (R^2, %)	Standard Error of Estimate (%)
FR = 36.3868 + 0.3742 + 4.6354 CC	0.9981*	99.62	0.89
GO = −39.4896 + 2.022 FR − 0.7264 CS − 7.8767 CC	0.4190	17.56	19.43
TE = 96.6499 − 0.0765 FR + 0.0452 CS − 0.5859 CC	0.8984*	80.71	4.55
EC = −0.2417 + 0.00006 FR + 0.0060 CS	0.9990*	99.80	0.05
VGD = 5.1302 + 0.0231 CS − 0.2167 CC	0.9683*	93.76	1.47
GP = 58.9140 − 0.0587 CS + 0.2500 CC	0.9566*	91.51	2.00

* Significant at 1% level.
Explanation of symbols:
FR – Feed Rate (kg/hr).
CS – Cylinder tip Speed (mpm).
CC – Concave Clearance (mm).
GO – Grain Output (kg/hr).
TE – Threshing Efficiency (%).
EC – Energy Consumption (KW hr/q of feed rate).
VGD – Visible Grain Damage (%).
GP – Germination Percentage (%).

Table 2. Statistical Analyses for Cowpea Threshing

Regression Equation	Multiple Correlation Coefficient (R)	Coefficient of Determination (R^2, %)	Standard Error of Estimate (%)
FR = 24.9716 + 0.2366 CS + 1.2958 CC	0.9942*	98.85	0.27
CR = 1021.8595 − 4.2549 FR − 0.9425 CS − 7.5311 CC	0.4628	21.42	18.51
TE = 93.5819 − 0.1148 FR + 0.0481 CS − 0.5470 CC	0.9517*	90.58	2.22
EC = 0.3851 − 0.0030 FR + 0.0067 CS	0.9985*	99.69	0.07
VGD = −1.1066 + 0.0077 CS − 0.1082 CC	0.9855*	97.11	0.68
GP = 130.2476 − 0.1611 CS + 0.3125 CC	0.9829*	96.61	0.80

* Significant at 1% level.

threshing with rasp bar type cylinder in one pass (Devnani and Nag, 1972) Richey et al., 1961 and Saxena, 1972). Similarly, the cowpea could be threshed at 496.0 mpm cylinder tip speed and 8.0 mm concave clearance, for visible grain damage up to 2%. Other threshing parameters at this setting were 160.0 kg/hr feed rate, 31.6 kg/hr grain output, 95.6% threshing efficiency and 3.25 kw hr/q energy consumption.

When the soybean and cowpea are to be threshed for seed purpose, the recommended cylinder tip speed and concave clearance are those at which internal damage to the grain lies below 5% (Bunnelle et al., 1954; Chestney, 1969 and Kolganov, 1958). Therefore, for seed purpose the soybean should be threshed at 330 mpm cylinder tip speed and at 12.0 mm concave clearance to obtain 91.8% threshing efficiency. Similarly, the suggested cylinder tip speed and concave clearance for cowpea were 288.5 mpm and 8.00 mm respectively, for 91.7% threshing efficiency, when used for seed purpose.

Conclusion

1. Feed rate and grain output increased with the increase in cylinder tip speed and concave clearance. The grain output was dependent upon crop variables rather than machine variables.
2. Threshing efficiency increased with the increase in cylinder tip speed but decreased with the increase in feed rate and concave clearance.
3. Energy consumption was proportional to cylinder tip speed and feed rate and remained constant at selected concave clearances.
4. Although at higher speeds the visible grain damage was within 5% the germination percentage was low.
5. Soybean at 6.10% moisture content should be threshed with cylinder tip speed of 413.5 mpm and at 12.0 mm concave clearance and 330.0 mpm and at 12.0 mm, for consumption and seed purposes, respectively.
6. When cowpea at 6.50% moisture content is to be threshed for consumption, the thresher should be operated at 496.0 mpm cylinder tip speed with 8.0 mm concave clearance. For seed purpose it should be threshed at 288.5 mpm cylinder tip speed and 8.0 mm concave clearance.

Acknowledgement

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Paddy and Rice Storage in Bangladesh with Emphasis on Insect Infestation

by

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Abstract

The estimated storage losses in paddy and rice in Bangladesh is about 20% which is due to lack of know-how in storage technique and inadequate facilities. This paper reports on grain storage practices in transit Bangladesh and the causes of waste and loss which are mainly insects, rodents, and birds. Preventive measures are recommended.

Introduction

The problem of storage of paddy and rice is common among the rice consuming countries. In many of these countries, waste and loss of stored paddy and rice is substantial. In Bangladesh losses in stored paddy and rice have been reported to be as high as 20%. Insect infestation accounts for fully half of these losses; transit, moisture, rodents and pilferage account for the other half as shown in **Table 1**.

Table 1. Commercial Storage Losses of Paddy and Their Causes, 1964–70

Cause	Percent
Insects	10.00
Transit	5.00
Moisture	1.80
Rodents	2.70
Pilferage	0.20
Total	19.70

Source: World Bank through Carl Bro. International and others (1975).

Although empirical data on paddy waste and loss in villages are not available, it is believed that the proportion is low considering that farm-level storage period is shorter than that in the commercial scale.

In Bangladesh where rice is harvested by hand, there is considerable delay between harvesting and threshing. As a rule, cut rice stalks with panicles are left on paddy fields before the grains are threshed. Such temporary storage of grain with high moisture content (usually as high as 30%) leads to development of high temperature, serious deterioration in the form of discolouration and, ultimately, leads to the growth of harmful micro-organisms. The percentage distribution of damage and their causes during storage in some Asian countries is shown in **Table 2**.

Table 2. Percentage Distribution of Paddy Storage Damage and Their Causes in Selected Asian Countries

Country	Insects	Rodents	Moulds	Spoillage	Situation
Bangladesh[1]	10	2.7	–	5.2	Commercial level
Philippines[2]	12	48	3	2	–
Vietnam[2]	10	40	–	25	Local market
Thailand[2]	8	50	–	8	Farm level
India[2]	33	42	–	–	–

Source: 1. World Bank through carl Bor. International and others, 1975.
2. Ritsuya Yamashita, Laboratory of Agri. Process Machinery, Kobe University, Japan, 1975.

Principles of Storage

A bulk of grain may be regarded as a mass of living organism (the grain itself, moulds and insects) that consumes oxygen and the

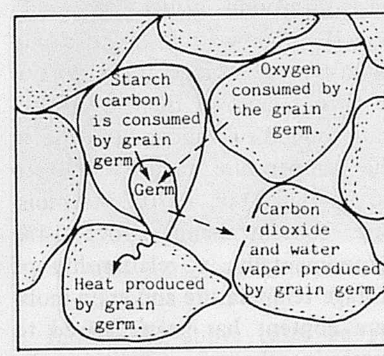

Fig. 1 Intergranular atmosphere, which is initially similar to ordinary air, is modified by the respiratory action of the grain germs, mould and insects resulting in carbon-dioxide and heat.

reserve food materials of the grain and produces carbondioxide, water vapour and heat in the same manner as many other forms of life. **(Fig. 1)**. In ordinary bulk storage, the heat produced by grain generally occurs if the grain moisture content is high.

The lower atmosphere of much of southeast Asia is warm and moist with an average temperature of 30°C and an average relative humidity of 85%. (Araculloet al, 1976). This warm, moist atmosphere is of course subjected to intermittent solar radiation that alters its relative humidity. Most food stuffs characteristically lose or gain moisture passively until they are in equilibrium with the relative humidity of the surrounding air. At a particular level of humidity, different food stuffs have different moisture content equilibria. **Fig. 2** shows the moisture content, relative humidity equilibria for milled rice, paddy and other products. The temperature and moisture content have profound effect on mould growth. Below 70% relative humidity most storage fungi do not grow and most of them have optimum conditions above 80% and in the temperature range of 20 to 40°C (Hall D.W, 1970), the moisture content being above 14%. Experimentally, a relationship of storage temperature and grain moisture content has been derived to determine the safe storage in relation to insect heating, fall in germination and fungal heating in cereals which is shown in **Fig. 3**.

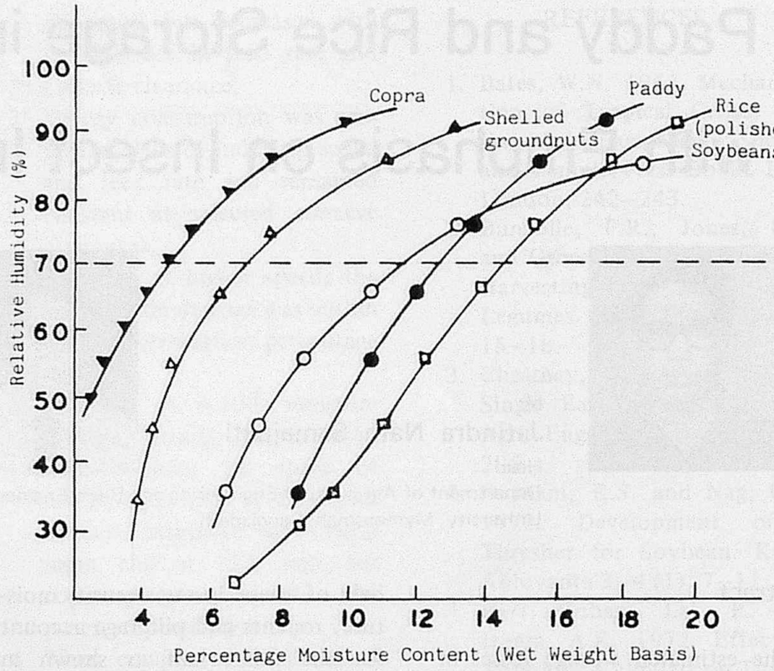

Fig. 2 Moisture content/relative humidity equilibrium curves. (Source: Miss P.M. Davy, Tropical Stored Products Centre, England)

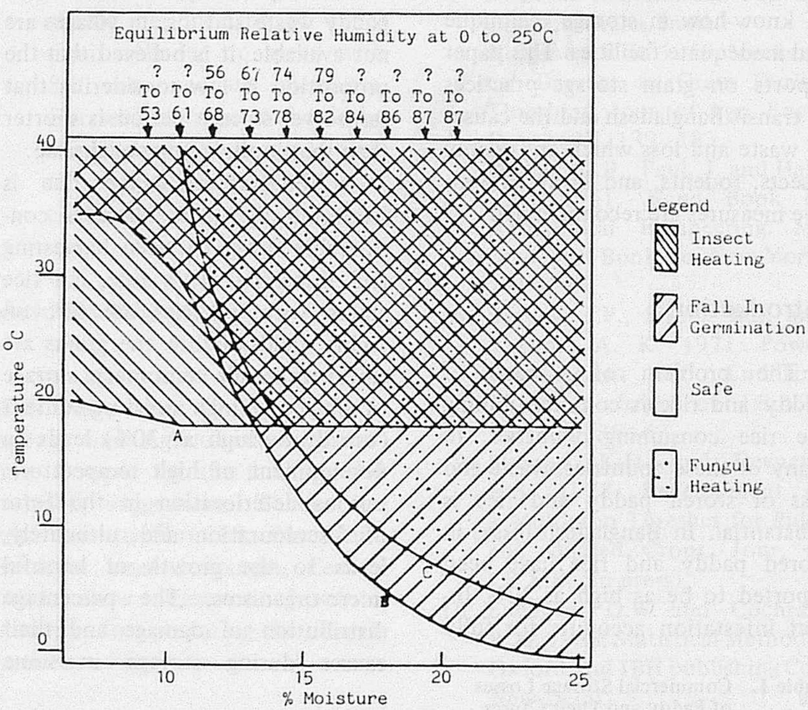

Fig. 3 Relationship of storage temperature and grain moisture content to insect heating, fall in germination, and fungal heating in cereal grains (A = lower limit of insect heating; B = lower limit of germination; and C = lower limit of fungal heating).

Common Pests in Bangladesh

Grain losses due to insects amount to about 10%. The common pests in Bangladesh are shown in **Table 3**.

Chemical Measures Employed in the Control of Pests of Stored Paddy and Rice

The number of insecticides used for pest control in Bangladesh is rather limited. The following insecticides are generally used by the Govt. and private organizations:

Table 3. Common Pests of Paddy and Rice in Bangladesh

Common Name	Scientific Name	Family	Order
Rice weevil	Sitophilus oryzae (L)	Curculionidae	Coleoptera
Lesser grain borer	Rhizopertha deminica (F)	Bostrichidae	Coleoptera
Grain beetle	Tribolium castaneum (Hbst) Tribolium confusum	Tenebrionidae	Coleoptera
Saw-toothed grain beetle	Oryzaephilus surinamensis (L)	Cucujidae	Coleoptera
Khapra beetle	Trogoderma granarium (Everts)	Dermestidae	Coleoptera
Yellow meal worm	Tenebrio moliter (L)	Tenebrionidae	Coleoptera
Rice moth	Sitotroga cerealella (01)	Gelechiidae	Lepidoptera
Rice meal moth	Corcyra cephalonica (S)	Pyralidae	Lepidoptera
Brown beetle	Latheticus oryzae (W)	Tenebrionidae	Coleoptera
Brown beetle	Laemophloeus minutus (O)	Cucuyidae	Coleoptera
Black beetle	Alphitobius diaperinus (P)	Tenebrionidae	Coleoptera

a) Malathion dust and b) Sevin dusts. These are used as preventive as well as curative measures of storing paddy or rice.

c) Phostoxin pellets. These tablets are available in the local market and are used in large scale and small scale paddy or rice storage.

d) Ethylene dichloride/Carbon tetrachloride (Ed/Ct). The mixture of these two chemicals in the proportion of 3:1 is kept in a beaker so that it comes in contact with air in the rice go down. It forms a gas which is heavier than air and is a contact poison.

e) DDVP. This chemical is in liquid form and used in the same method of Ed/Ct.

f) Cyanogas dust. This is highly poisonous and are used for killing rats.

g) Carbon bisulphide (CS_2). This is used in small scale paddy or rice storing in the rural areas of Bangladesh. About 2,718 grams of the liquid is used for 28.32 cubic metres of the food grain.

i) Hydrogen cyanide (HCN). This is a mixture of water, sulphuric acid and sodium cyanide but rarely used in this country.

j) Mythyl bromide. About 453 grams to 680 grams of this chemical is used for 28.32 cubic metres of paddy or rice and are generally used by farmers in Bangladesh.

Storage Practices in Bangladesh

Grain storage practices in Bangladesh can be divided into three categories: small-scale storage; commercial storage; and storage by government organizations. In all these three categories paddy and rice are stored in open or air-tight structures according to their requirements.

Small-Scale Storage – Farmers store paddy for their own needs between harvest seasons the quantity of which varies with the size of the family. Storage structures used by the farmers vary in different parts of the country and are earthen containers (matka, jala, jar, etc.); woven bamboo containers (dele, gola, etc.); and metal containers (steel drum, kerosene tin, etc.).

Commercial Storage – Commercial paddy and rice storage is generally made in gunny bags. The capacity of these bags vary from 50 kg to 100 kg and are kept on platforms about six inches above the ground level.

Storage by Government Organization – The government organizations have storage godowns of their own. The capacity of different godown in different districts of Bangladesh is shown in **Table 4**.

Most of these godowns and silos have concrete floorings and cross ventilation, and many of them are ratproof. Rice or paddy is stored in hessian sacks of 50 kg to 100 kg capacity and these are piled in staks on wooden pallet dunnage **(Fig. 4)**.

Table 4. Storage Capacity of Government Godowns and Silos (Unit: mt)

District	L.S.D.	C.S.D.	Silo
Dacca	35,937	2,555	1,866
Mymensingh	45,574	1,015	–
Faridpur	35,616	–	–
Tangail	14,308	–	–
Chittagong	22,352	3,733	3,733
Chittagong Hill Tract	8,229	–	–
Noakhali	26,467	–	–
Comilla	35,788	454	1,866
Sylhet	27,541	–	–
Rajshahi	50,218	–	–
Dinajpur	56,210	1,829	–
Rangpur	47,502	–	–
Bogra	29,487	746	933
Pabna	22,729	1,307	–
Khulna	26,722	2,504	–
Barisal	35,200	896	–
Patuakhali	12,860	–	–
Jessore	17,547	–	–
Kustia	19,275	–	–

Source: Monthly Statistical Bulletin of Bangladesh, Vol. – VII, Nov. 8, 1978.

Fig. 4 Rice storage in Govt. godowns

In all the above cases people do not maintain airtight conditions of storing but they store the grain at a moisture content of about 14%. Farmers, in some cases, store paddy and rice in air-tight structures like doles, matka, jala etc. They fill these structures with grains at a moisture content below 14% and make them airtight by placing lids in their opening and plastering the lids with mud and cowdung. Some oil treated earthen containers (big matkas) are also kept underground (in floor of dwelling house) in some southern districts of

Bangladesh and these are mostly used as airtight rice storage structures. The common people, including farmers, generally do not use any standard insecticide in storing paddy and rice. The government organization, in some cases use insecticides as mentioned earlier.

Observations and Comments

As discussed earlier, about 20% of the produced paddy and rice is lost during storage, of which 10% is due to insects. This is a great loss for the food deficit country like Bangladesh. The losses occur due to the lack of knowledge on the part of the farmers. Secondly, the traditional storage structures used by the farmers are frequently of poor construction and susceptible to rodent and insect attack.

Four modern deep vertical food silos have been constructed by the Food Department in different districts of Bangladesh where the percentage loss is very low. But in many of its old food godowns food grain losses are high.

According to Booker et al (1974), the following management practices will limit or prevent the development of insect in paddy or rice stored for one year or more. These are more applicable in the case of Government organizations:

1. Throughly clean and spray all bins and grain storage structures at least two weeks before the grain is stored.
2. Store grain in well constructed bins.
3. Store grain at low moisture content.
4. Store only clean grain.
5. Close off all bird and rodent entrance to the bin.
6. Fumigate the grain at the prescribed time.
7. Inspect the grain at frequent interval (every 30 days).
8. Fumigate immediately if insects are found.

In the rural areas where fumigation is a problem, farmers can store paddy or rice in structures which can be made air-tight. In such cases, they need to store paddy at a moisture content below 14% and structures should be kept at least one foot above the ground level.

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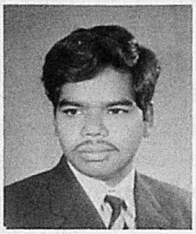
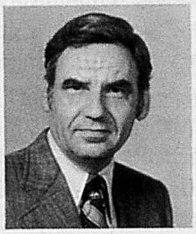
Development of Soil-Moisture Model to Predict Soil Moisture and Tractability for Harvesting





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Introduction

Soil tractability affects the machine performance. For some field conditions, the soil is in such a moisture state that sizeable sinkage and slip limit machine movement. The upper layer of the soil loses water faster than the lower layer because of air circulation and elevated temperatures. Rutledge and McHardy (1968) suggest that a day is considered to be a non-working day if the moisture content in the upper zone of soil is above 95 percent of field capacity. From the studies made by Hassan and Broughton (1975) for different kinds of soils in five different zones (0-1 in, 1-3 in, 3-6 in, 6-9 in, 9-12 in), it was suggested that the tractability of soil is affected by the moisture state in the top two zones, regardless of the water contents of the zones below. Therefore, it is assumed that the soil moisture in the upper six-inch soil layer largely determines whether the soil is tractable or not.

Rainfall largely regulates the significant moisture increases in the upper soil layer. Relative himidity, temperature, wind, radiation and percent sunshine on or above the soil surface directly influence the moisture loss in upper soil layers. The lower the atmosphere's relative humidity, the more pronounced is the effect on evaporation and transpiration. Sometimes relative humidity increases to 100 percent saturation; then evaporation ceases and condensation on the soil may begin. Wind and high temperature on a sunny day replaces the air mass surrounding the crop and soil surface. This causes the soil surface to dry more quickly. Thus, the soil strength is mainly a function of moisture. Tractable and trafficable terms are similar in use and meaning.

A soil moisture model which estimates the soil moisture on a daily basis would be of great help in anticipating the trafficability of a combine on a particularly day. Available daily climatic data should be the required inputs, particularly those parameters that influence the condition of soil in the upper layer. Fortran codes are used for mathematical expressions.

Development of a Soil Moisture Model

In relation to the harvesting of grain sorghum, soil moisture then is a very usable criterion to characterize the field for trafficability. In this model, infiltration and runoff will be estimated and after the soil has reached field capacity, moisture loss will be estimated due to surface evaporation or plant evapotranspiration. Only the upper six-inch layer will be considered for trafficability purposes.

The detailed description of different phenomena for computation of soil moisture is given as follows:

1. Evapotranspiration for the sorghum crop;
2. Soil moisture evaporation from the soil surface;
3. Estimate of surface run-off; and
4. Moisture addition due to snow melt and rain.

Abstract

The runoff and infiltration (entry of water in soil profile) are

inter-related to each other. Runoff decreases as infiltration increases. The interception losses, surface storage and water which infiltrates the soil prior to runoff, form the initial abstraction. The initial abstraction was considered equal to 0.2 times the maximum potential difference between rainfall and runoff in inches (Schwab, et al., 1966). The Soil Conservation Service (SCS) method was used to predict runoff. The input runoff curve number, 86, was used for the present soil and cover crop as small grain. For less than 0.5 of field capacity, the runoff curve number is calculated as RCN = RCN * 0.39 $e^{-0.009RCN}$. For soil moisture greater than 0.8 of field capacity, RCN = RCN * 1.95 $e^{-0.0063RCN}$ (Schwab, et al., 1966).

Hydrological Phenomena in Estimating Soil Moisture

1. Evapotranspiration (ETP) of the sorghum crop – The Penman combination equation has been used to estimate the evapotranspiration for this crop. For the Manhattan, Kansas, area some constants were used, established by Zovne and Nawaz (1975) which were most suited for the Manhattan area. With empirical approximations for some factors, ETP is given by

$$ETP = \frac{\Delta}{\Delta + \gamma} (RN - G) + \frac{\gamma}{\Delta + \gamma} (EA)$$

ETP = Potential evapotranspiration in millimeters, converted to inches.

G = Heat flux to or from the soil in calories per square centimeter as a result of rapid changes in air temperature. [G = (average air temperature minus the average air temperature for the three previous days in °F) x 5]. During the summer months, where day-to-day temperatures do not change greatly and day-to-day radiation is similar, soil heat flux is relatively small and can be neglected. During the winter months, as ET is inhibited, G's effect upon ET is small, and can be neglected, thus, G = 0 in the program.

RN = Daily heat budget at the surface in millimeters of water,

Δ = Slope of the saturation vapor pressure-temperature curve, and

γ = Psychrometric constant.

EA = A function of wind speed and humidity explained subsequently as PENMAN (RA, PS, AT, DP) = (1-RC * RA * (0.22 + 0.54 * PS-2.010E-09 * AT ** 4[0.98 * (1.0 - [WCP1 + WCP2 * SQRT (DPVP)])] * (0.1 + 0.9 PS).

RC is shortwave reflectance and is estimated to be 0.2 to 0.25 for most of the crops $(\Delta/\Delta + \gamma)$ and $(\gamma/\Delta + \gamma)$ are mean air temperature weightings whose sum is 2.0 $(\Delta/\Delta + \gamma)$ = .039 (T) where T is temperature in degrees, Kelvin.

The vapor pressure has been calculated by an empirical equation (Linsley Jr., et al., 1975) and the vapor pressure corresponding to the minimum temperature has been regarded as the saturation vapor pressure.

ES (T) = 33.9 * [(0.00738 * CT (T) + 0.8072) ** 8 - 0.000019 * ABS (1.8 * CT (T) + 48.) + 0.00136]

Daily weather parameters, namely TMAX, TMIN, WIND, PSUNS, RHD, RA, PREC are read from data supplied during the season. Once ETP is calculated, actual evapotranspiration is found applying the Blaney Criddle method (Schwab et al., 1966). This method is used to modify the ETP are using a plant consumption factor. During the harvest season, the evapotranspiration is very low because the plants are not active in exacting water from the rootzone.

2. Moisture Evaporation from Soil Surface – To estimate evaporation from the soil surface, two stages of evaporation suggested by Zovne et al., (1977) have been considered. In the first stage, evaporation proceeds at constant rate, but after the moisture falls below field capacity, a second stage of evaporation begins according to the relationship:

FSE = C * (T ** 0.5) - C * ((T-1) ** 0.5),

where T = Time after stage 1 evaporation in days, and C = Hydraulic coefficient of soil (0.2).

FSE = Free surface evaporation, inches of water per day.

The two conditions have been considered to calculate:

FSE = ACTVAL (FSE)
IF ((SMUZ - UZPW) . LT . FSE)
FSE = SMUZ - UZPW
IF (FSE . GT . (PETBS - FWET))
FSE = PETBS - FWET

3. Estimate of Surface Runoff and Percolation – The Soil Conservation Service (SCS) method has been used to estimate runoff. Runoff from the field occurs only when rainfall exceeds the demands of evaporation, interception, infiltration, surface storage or surface detention. Based on the crop cover and tillage practices, the runoff varies, depending on the intensity of rainfall. Runoff is designated by numbers, called runoff numbers (Schwab et al., 1966).

In this model curve, the numbers are based on antecedent rainfall (which is an average value for annual floods) between 0.5 and 0.8 of field capacity. It is calculated as follows:

RUNF = ((RAIN - 0.2SI) ** 2)/(RAIN + 0.8 * SI)

where RCM is a modified runoff

$$SI = \frac{1000}{RCM} - 10.0$$

where RCM is a modified runoff curve number varying between 0 and 100.

IF (CROP (NM) . GT . 0.0)

THEN DO
T10 = 0.00
IF (SMUZ . LT (UZPW + 0.5 * WAVLP)) T10 = RCN1 (RCN)
IF (SMUZ . GT (UZPW + 0.8 * WAVLP)) T10 = RCN2 (RCN)
RCM = T10
IF (T10 . EQ . 0) RCM = RCN.
ELSO DO
T10 = 0.0
IF (SMUZ . LT (0.5 * FCAP)) T10 = RCN1 (RCN)
IF (SMUZ . GT . (0.8 * FCAP)) T10 = RCN2 (RCN)
RCM = T10
IF (T10 . EQ . 0) RCM = RCN
END IF

After runoff, interception and storage losses are calculated, the soil moisture rises to 0.9 saturation with the excess amount being percolated to the lower zone.

4. <u>Moisture Addition Due to Snowmelt and Rain</u> – Moisture additions because of snow have been considered in developing soil moisture model, although in the Midwest Region, the chances of getting snow in September and October are very low. It has been arbitrarily considered that snow less than 0.2-inch will not have any significant effect on moisture addition and the combine would run efficiently. If snow cover is retained on the ground continuously for a long period and if the snow cover is 0.2-inch or more, the evaporation of snow is equivalent to potential evapotranspiration. Snowmelt because of changes in atmospheric temperature and rainfall have been considered.

IF (SNOCOV . GT . 0) THEN DO
SNOATM = ACTVAL (0.05 * (TAVG - 34)).
IF (SNOCOV . GT . SNOATM) THEN DO
SNORN = PREC * (TAVG - 32.)/144.
TMS = SNOWN + SNOATM
IF (SNOCOV . GE . TMS) THEN DO
SNOCOV = SNOCOV - TMS
WATER = TMS + PREC.

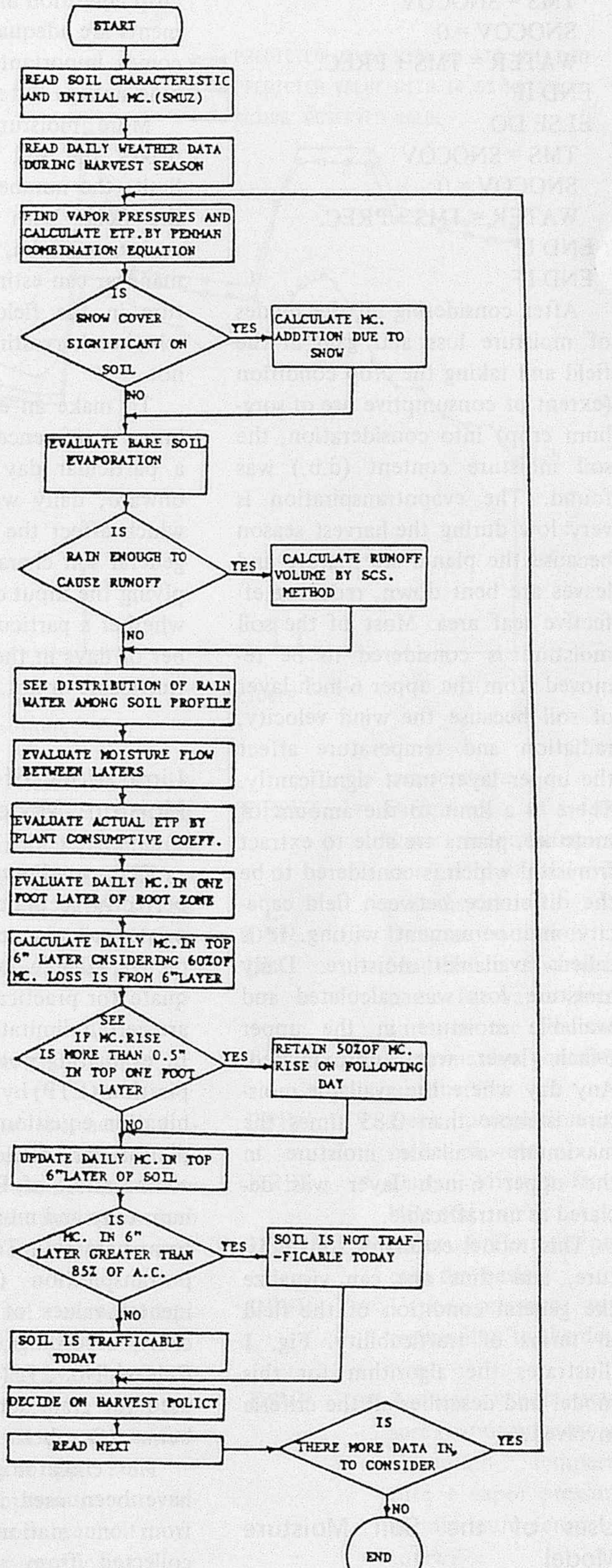

Fig. 1 Algorithm for soil moisture prediction model to decide soil trafficability

```
ELSE DO
  TMS = SNOCOV
  SNOCOV = 0
  WATER = TMS + PREC.
END IF
ELSE DO
  TMS = SNOCOV
  SNOCOV = 0
  WATER = TMS + PREC.
END IF
END IF
```

After considering all the modes of moisture loss and gain in the field and taking the crop condition (extent of consumptive use of sorghum crop) into consideration, the soil moisture content (d.b.) was found. The evapotranspiration is very low during the harvest season because the plants are mature and leaves are bent down, reducing effective leaf area. Most of the soil moisture is considered to be removed from the upper 6-inch layer of soil because the wind velocity, radiation and temperature affect the upper layer most significantly. There is a limit to the amount of moisture, plants are able to extract from soil which is considered to be the difference between field capacity and permanent wilting. It is called available moisture. Daily moisture loss was calculated and available moisture in the upper 6-inch layer was approximated. Any day where the available moisture is more than 0.85 times the maximum available moisture in the upper 6-inch layer was declared as untrafficable.

This model estimates soil moisture, and thus one can visualize the general condition of the field in terms of trafficability. **Fig. 1** illustrates the algorithm for this model and describes all the criteria involved.

Uses of the Soil Moisture Model

Soil moisture becomes a relevant factor to be considered before going to the field provided that the crop condition and machine adjustments are adequate. This factor becomes important because of combine sinkage and slippage.

More moisture than described makes the soil untrafficable and limits the number of work days in the field. With the help of this moisture model, a farmer or farm manager can estimate the soil moisture in the field and can decide whether harvesting can be done or not.

To make an estimate, one must know a reference soil moisture on a particular day, and from there onward, daily weather parameters which affect the soil moisture and general soil characteristics. By supplying the input data one can assess whether a particular day or a number of days in the harvest season is trafficable or not.

Limitations of the Soil Moisture Model

This prediction may not be perfectly accurate but given appropriate soil characteristics, the predicted value would likely be adequate for practical purposes. There are certain limitations in this model. In evaluating potential evapotranspiration (ETP) by the Penman combination equation, the moisture depletion has been considered to be a combination of ETP for the sorghum crop and moisture evaporation from bare soil. To find actual evapotranspiration (ACTET), judgemental values of the crop coefficient, according to USDA. Tech. Release No. 21, (1967), have been used for grain sorghum in September and October.

The climatological data which have been used in the model are from one station only and data collected from more stations in the same vicinity would give a higher confidence in the daily variability of soil moisture. Further, this model should be checked in different areas using both calculated values and field-observed values measured during the same season. This will characterize the moisture-estimate departures from the actual field observations.

Comparison of Observed and Predicted Soil Moistures

The soil moisture model is very sensitive to rainfall which is a main factor influencing trafficability. The predicted moisture trend is the same when compared to the actual observed field moisture trend except late in the harvest season. From 1 September to 15 September, both predicted and observed moisture are nearly the same. Because of rain observed on 16 September, the actual moisture increased by 78 percent, whereas the model predicted a little over 65 percent moisture increase. Average percent variations of the predicted moisture contents compared to the observed moisture during the month of September is only 0.34 percent. Similarly, this value is 29.88 percent during 1 October to 14 October. However, the percent mean variation is 9.74 percent for both September and October. The trend is shown in **Fig. 2**. It is clear that from 4 October onward, the model is overpredicting the soil moisture content.

The explanation for the overpredicting of soil moisture in October likely involves several factors. The crop coefficient, parameters concerning soil properties, coverage of soil by the plants, late in the season are some of these factors. The exact values of these parameters are not known and better values will give a more accurate prediction in October. The program was tested by substituting different parametric values and was found to be sensitive. In addition to this, some of the

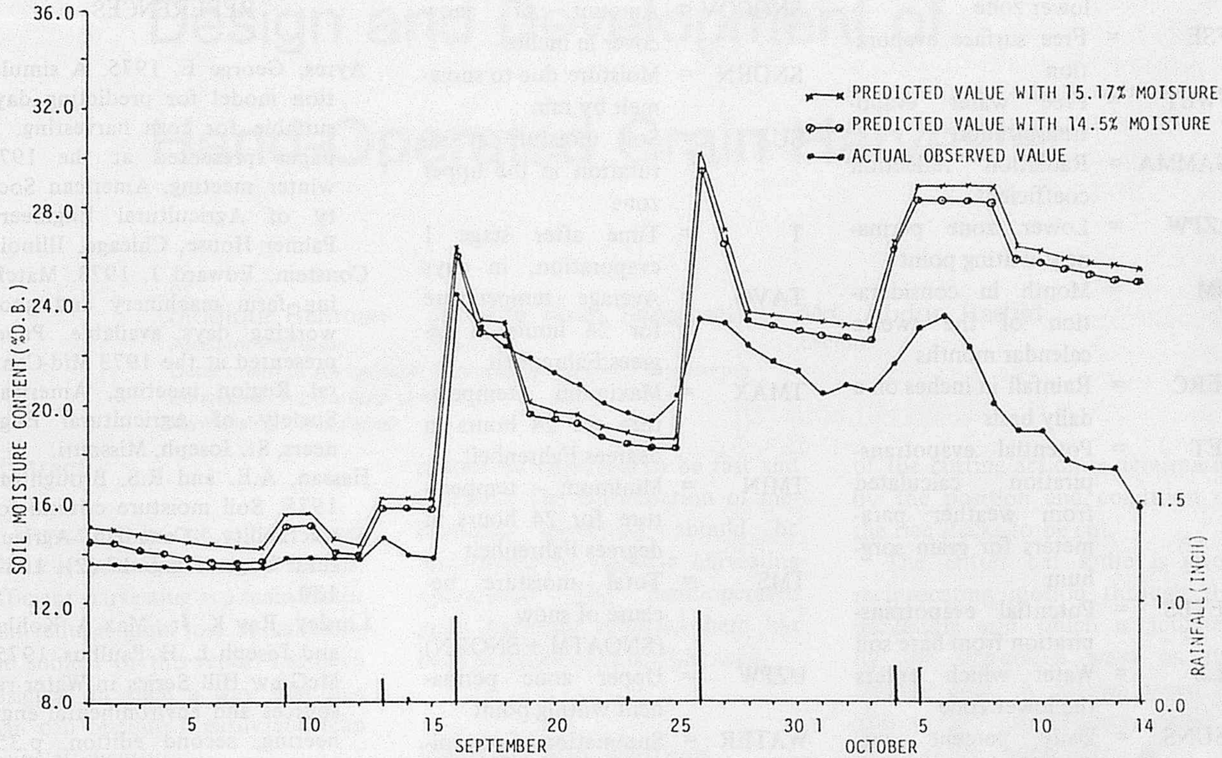

Fig. 2 Comparison of observed field moisture from given initial moistures

weather data used were not exactly from the location where the crop was standing which might have caused errors in the intermediate calculation like potential evapotranspiration. In general, it is believed that as long as one can supply correct input data, a relatively accurate prediction can be expected.

Summary

This model was developed taking hydrological phenomena in consideration for clay soil growing a sorghum crop. The climatological data for 1976 were taken as input data for this model. The model is very sensitive to rainfall and it predicted the soil moisture very well in the month of September; however, in October it significantly overpredicted soil moisture.

The model takes care of daily weather parameters, namely; maximum and minimum temperatures, wind velocity, percent sunshine, relative humidity, terrestrial radiation and precipitation. Thus, if projected values of such parameters are known along with the characteristic of soil and crop to be harvested, the model can predict moisture reasonably well.

Glossary of Terms

ABRNF = Initial abstraction (interception loss, surface storage and water which infiltrates into the soil) prior to runoff

ACTET = Actual evapotranspiration

ACTVAL = Actual available moisture

AETUZ = Actual evapotranspiration in upper zone

CT = Temperature in degrees Fahrenheit

CROP = Crop coefficient

DELTA = The slope of the curve of vapor pressure at saturation versus air temperature

DEPET = Difference of free water evapotranspiration and potential evapotranspiration

DNR = Daily net radiation

DP = Modified variable name for vapor pressure in the Penman combination equation routine

DPRC = Deep percolation in inches of water

DRBS = Daily radiation from bare soil

DSMUZ = Moisture content, per cent dry basis

DPVP = Vapor pressure corresponding to the dew point

DSVP = Average vapor pressure (vapor pressure at maximum temperature + vapor pressure at minimum temperature)/2

FCAP = Field capacity in the upper zone

FCAPL = Field capacity in the

lower zone

FSE = Free surface evaporation

FWET = Free water evapotranspiration

GAMMA = Radiation reflection coefficient

LZPW = Lower zone permanent wilting point

NM = Month in consideration of the twelve calendar months

PERC = Rainfall in inches on a daily basis

PET = Potential evapotranspiration calculated from weather parameters for grain sorghum

PETBS = Potential evapotranspiration from bare soil

PLZ = Water which enters the lower zone

PSUNS = Daily percent sunshine

PUZ = Water which infiltrates soil

RA = Daily terrestrial radiation in millimeters of water

RAIN = Water due to rainfall

RCN = Run-off curve number

RHD = Percent relative humidity on a day-to-day basis

RUNF = Run-off water in inches

SI = Maximum potential difference between rainfall and runoff in inches starting at the time when rainfall begins

SMLZ = Soil moisture in the lower zone of soil in inches of water

SMUZ = Soil moisture in the upper zone of soil in inches of water

SNOATM = Moisture due to snowmelt at atmospheric temperature

SNOCOV = Amount of snow cover in inches

SNORN = Moisture due to snowmelt by rain

SUZ = Soil moisture at saturation in the upper zone

T = Time after stage 1 evaporation, in days

TAVG = Average temperature for 24 hours in degrees Fahrenheit

TMAX = Maximum temperature for 24 hours in degrees Fahrenheit

TMIN = Minimum temperature for 24 hours in degrees Fahrenheit

TMS = Total moisture because of snow (SNOATM + SNORN)

UZPW = Upper zone permanent wilting point

WATER = Summation of precipitation and total moisture due to snow melt

WATLZ = Available water in lower zone

WATUZ = Available water in upper zone

WAVLL = Maximum available water for plants in lower zone

WAVLP = Maximum available water for plants in upper zone

WCP1 and WCP2 = Wind coefficients in the Penman combination equation

WC = Wind coefficient

WIND = Average velocity of wind in miles per hour for 24 hours

WINDD = Wind velocity in miles per day at a height of two meters

WLCT = Convective loss in millimeters of water and is function of vapor pressure and wind velocity

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Design and Development of Hand-Operated Grain Harvester

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Abstract

Harvesting is one of the most labour–consuming farm operations. Efficient harvesting is a main factor that reduces grain loss. A harvester, the subject of this report has been designed in such a way that one man can operate it easily and reap grains efficiently.

Introduction

Bangladesh is in need of self-sufficiency in food. Agricultural production can be increased through farm mechanization. But farming practies are still very traditional. Harvesting is done by manual labour and the operation cannot be expected to be fast and efficient. The introduction of mechanized harvesting should be undertaken to improve harvesting operations. The hand-operated grain harvester reported here has been designed to meet that need.

Materials and Methods

The harvester (Figs. 1 & 2) is a push type machine which is operated by human power. During the forward motion, power from the traction wheel is transmitted to the larger sprocket makes the cam wheel rotate. Then from the cam wheel power is transmitted to the knife with the help of the knife actuating lever arm. The efficiency of the cutting action is determined by the position and condition of the rice stacks to be cut.

The cutter bar knife is given reciprocating motion through the oscillating arm which is actuated by the sine-sodial wave on the circular cam. A cutting speed of 200 to 225 rpm (Bainer, 1956) is taken as the design criterion.

The speed of the operator is assumed to be one mile per hour. The functional components of the machine are as follows:

Frame arm – The frame arms are made of M.S. sheet. Each frame arm is 61 cm long and 12.7 cm wide which tapers to 6.35 cm. Two holes of 1.27 cm diameter each are located at the lower corner at the rear end for the wheel shaft

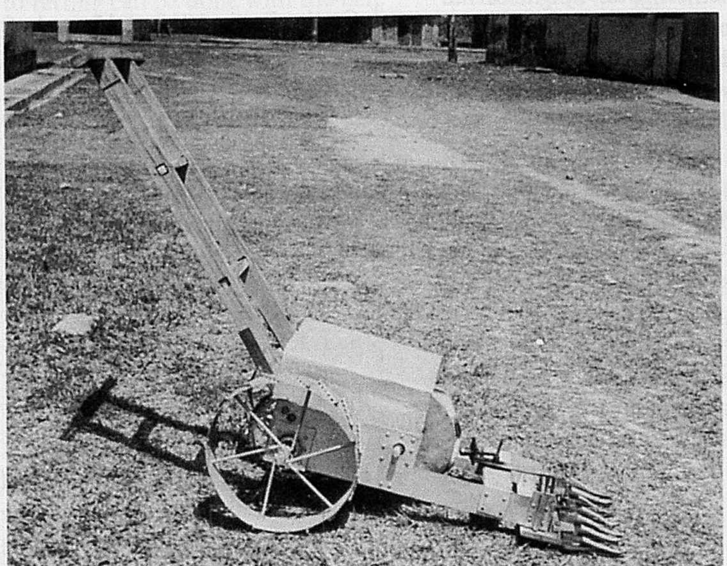

Fig. 1 Side view of the harvester

Fig. 2 Rear view of the harvester

and at upper corner of the front end for the cam shaft.

Traction wheel – The traction wheel is 30.48 cm in diameter. One 1.27 cm diameter mild steel rod of 35.56 cm length is used for traction wheel shaft.

Cutter bar assembly – The assembly is composed of two plates; the ledger plate, which is fixed and the knife plate which moves over the ledger plate. Both knife and ledger plates are made of spring steel and are 35.56 cm long, 7.62 cm wide and 0.32 cm thick. There are seven tines of triangular shape with 40° corner in both plates.

Chain and sprockets – A gear with 48 teeth and a pinion with 18 teeth are selected. The pitch of both gear and pinion is 1.27 cm and a chain of 1.27 cm pitch is also selected.

Cam wheel – The cam wheel is circular in shape and its diameter is 25.4 cm and thickness is 7.62 cm. In the outer face, a sine-sodial wave of 1.27 cm width and 1.27 cm thick is made. The cam wheel is fixed to the shaft of the pinion and its velocity is equal to the velocity of the pinion.

Knife actuating lever arm – It is made with 2.54 cm flat iron plate, one end of which is held to the knife and the other end is held in contact with the cam with two double roller bearings. The arm is pivoted to the pivot bridge in a suitable position.

Handle – These are made of wood to form the arms. The alignment of the handles are limited to 45° with the horizontal.

Table 1. Construction materials

Part	Dimension	No.	Material
Frame arm	1858.06 sq. cm.	1	12 gauge G.I. sheet
Iraction wheel	929.03 sq. cm.	2	12 gauge G.I. sheet
Cutter bar and ledger plate	35.56 cm. x 7.62 cm. x 0.32 cm.	2	spring steel
Gear	pitch – 1.27 cm. no. of teeth – 48	1	steel
Pinion	pitch – 1.27 cm. no. of teeth – 18	1	steel
Ball bearing	–	4	steel
Bearing case	–	4	steel
Chain	1.01 metres	1	steel
Belt and nut	–	5 dz.	steel
M.S. rod	1.27 cm. dia, 1.52 metres	1	steel
	0.63 cm. dia, 3.04 meters	1	steel
Cam wheel	25.4 cm. dia, 7.62 cm. Thick	1	wood
Handle	3.81 cm. x 2.54 cm. x 76.2 cm.	2	wood

Results and Discussion

The design approach of fabrication of the machine is ideal. Only one man will push the machine forward and the mature paddy plant will be cut at a height of 10 to 15 cm from the ground. The performance of the machine is not satisfactory is due the following factors:

a) During operation the bearing attached to the cam wheel does not move smoothly on the sine-sodial wave on the cam periphery due to the friction between the bearing and cam surface. Aluminium cam should be a better material.

b) Due to the lighter weight of the machine, the available traction force in the wheel for overcoming the various friction forces is not sufficient. If these minor points are fulfilled during fabrication, the machine should work in full efficiency. At perfect running condition, its performance should be equivalent to five to seven times that of man.

This attempt is very preliminary and much work is yet to be done in the future. The design features of this machine reveal bright possibilities with some minor modifications, hence the machine represents a base for future research work.

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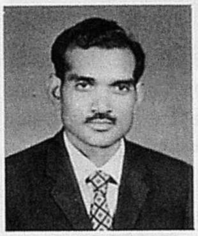
Design and Development of Jute Decorticator



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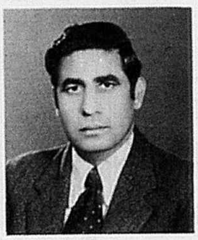

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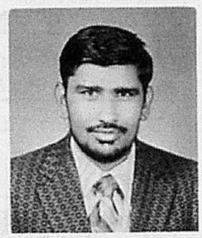

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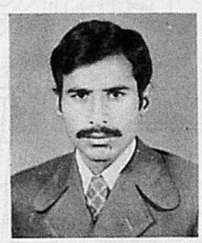

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Abstract

Jute is becoming more popular amongst the farming community as it is an important source of foreign exchange earning. Preparation of jute fibre by conventional method is uneconomical and laborious as it requires large amount of water for retting. To overcome this problem separation of jute ribbon prior to retting can be done with the help of jute ribbon separating machines desined and fabricated by Pakistani engineers. Preparation of jute fiber by decorticating method has given a net saving of rupees 23(US$2.3)/ 40 kg of dry fibre. It is expected that with the introduction of these machines the area under jute cultivation will expand considerably.

Introduction

Prior to the separation of East Pakistan, now Bangladesh, there were two jute mills in Punjab, one at Muzaffargarh and the other at Jaranwala (Faisalabad district). The total capacity of these two jute mills was 950 metric tons annually. The riverine areas along Indus, Chanab, Jehlum, Ravi, and Satluj rivers have great potential for jute cultivation. To meet the requirement of jute fibre from local production, the cultivation of this crop is being expanded in the riverine areas of Pakistan when the land usually remains fallow during the Kharif season. For 1979 3,200 hectares have been put under the crop in Punjab whereas during the year 1978 it was 1,480 hectares. Jute is a tall growing plant which is not affected by floods and is a source of sure and cash income to the farmers in the Kharif season. The average production of green sticks is about 30 metric tons per hectare. The ribbon separated from sticks is equal to 1/3 of the sticks by weight and 1/5 that of the sticks by volume. The fibre extracted from the ribbon ranges from 1/5–1/6 by weight of the ribbon. Prior to retting separation of jute ribbon by power operated jute decorticating machines designed and fabricated under a collaborative programme of the University of Agriculture, Faisalbad and Directorate of Agricultural Engineering, the study gave very encouraging results. It is expected that with the introduction of these machine the area under jute cultivation will expand considerably.

Justification

Retting and ribbon separation of jute by hand are the main problems in the expansion of crop cultivation. The ribbon is separated by conventional method after soaking the jute sticks in large water ponds which is laborious and time consuming (**Fig. 1**). The water management for retting of jute fibre is a problem in Pakistan specially in those areas which are far from the river sides as the water is changed occasionally during the retting period.

To overcome this difficulty and to use less water for retting, there was no alternative except to reduce the volume of retting crop. For this purpose different trials have been made for designing and fabrication of simple, efficient and low-cost jute ribbon separating machines made from locally available materials. These machines were both power-operated and animal-drawn. The performance of the animal-drawn ribbon separating machine was not encouraging, as it is time consuming and uneconomical (**Fig. 2**). Moreover, the grooves in the roller of the sugar cane crusher damage the fibre and at a certain pressure cut the fibre into pieces. Due to these shortcomings the animal-drawn device was not considered proper for use in large scale. The results of power operated machines, two roller and three rollers, were encouraging and they were further modified to get better results. These two machines are discussed separately below.

Fig. 1 Separation of jute ribbon by hand (Conventional method)

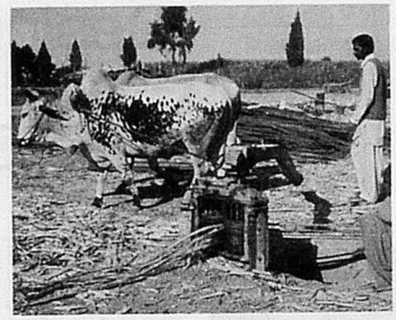

Fig. 2 Animal-drawn jute ribbon separating machine (Conventional sugarcane crusher)

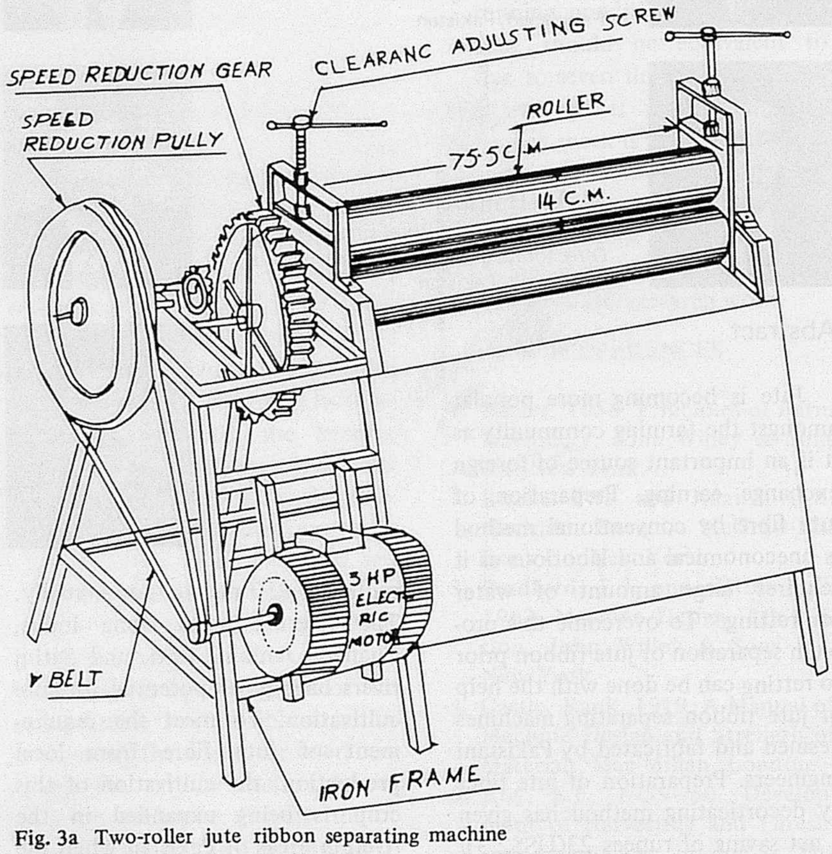

Fig. 3a Two-roller jute ribbon separating machine

Development of Power-Operated Jute Decorticating Machines

Two-Roller Jute Decorticator

A two-roller machine was designed and developed from locally available materials as shown in **Figs. 3a and b**. Two rollers of 14cm dia each and 75.7 cm in length to run in opposite direction at a constant speed of 90 r.p.m. were installed on a horizontal metal frame. These rollers provide enough pressure to crush green jute sticks and separate the jute ribbon from the pith. The ribbon is not damaged as the rollers have no significant grooves on the surface as on the roller of sugar cane crusher. Clearance adjusting screws have been provided on both the ends of the crushing rollers to provide a clearance range of 0 – 4 cm for crushing jute, "khip", cotton, sisal and such other fibr-

Fig. 3b Jute sticks being passed through two-roller jute decorticator

ous crops. A 3 HP electric motor or 5 HP petrol engine can be used as a prime mover for this machine.

First reduction in speed has been done by V-belt pulley system and the second by spur gear arrangement to run the roller at 90 rpm. Both the pulleys are of aluminium alloy having 5.08 cm dia of the driver and 38 cm dia of the driven pulley. The driver and driven spur gears are 6 cm and 40.5 cm in diameter, respectively, with 10 mm groove depth. These steel gears have 6 mm pitch in each case and have 17 teeth and 125 teeth, respectively. The other four steel gears used on the other side of the machine are all of 11 cm dia, 11 mm pitch and 24 teeth each. These gears run the two rollers in opposite direction at the same speed. The gears used on both the sides of the machine provide stable power transmission system and exert equal pressure at the adjusted clearance during operation. The weight of the pressure rollers of this machine was not proper and thick and hard sticks were not decorticated effectively.

Three-Roller Decorticator

To overcome the shortcomings observed in the two-roller machine, another machine with four rollers, two supporting and two pressure rollers, was designed based on the principle of sheet rolling machine. The first supporting roller helps in feeding the crop and the second supporting roller which is in the opposite direction of the two pressure rollers does not allow the pressed crop to fall immediately after passing through the pressure rollers. The fitting arrangements of the three rollers is such that the central longitudinal axis of the third rollers comes parallel and at equal height of the peripherial coinciding line of the other two rollers. Thus when the sticks pass through the roller, it gets a curve-like turn which breaks the pith of the sticks into pieces.

The first supporting roller had problems in feeding the sticks properly and it was replaced with a bed as shown in **Fig. 4**. This bed serves two purposes: one to support the lengthy jute sticks and,

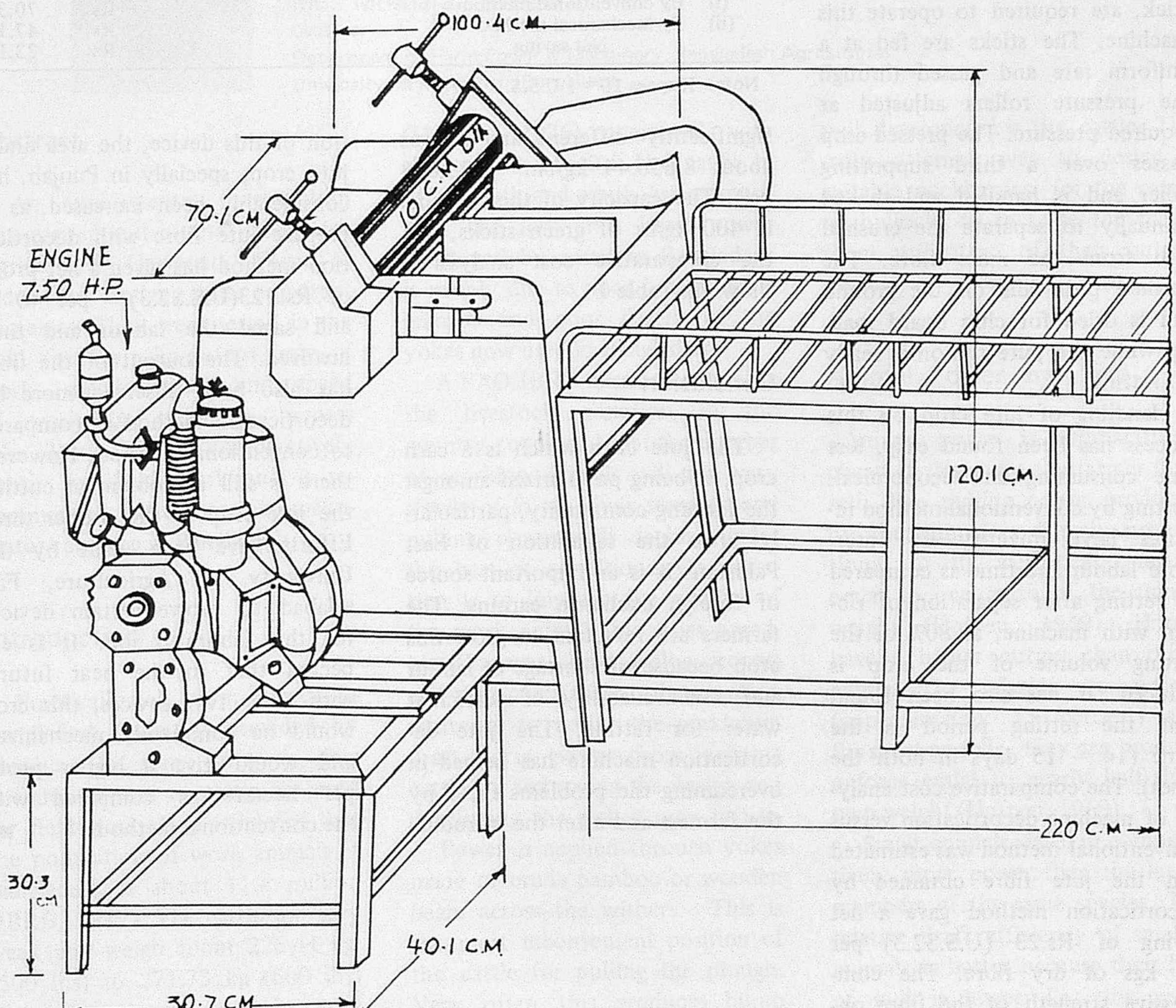

Fig. 4 Three-roller jute decorticating machine with bed

the other, to help in feeding the sticks uniformly. A 7.5 HP engine can be used to operate this machine. The three roller jute ribbon separating machine was found easy and effective in operation as compared to the two-roller machine. It was more acceptable to the farmers as compared to the bullock-drawn or two roller machine and a local manufacturer is fabricating this machine for large scale production.

Operation

Two men, one for feeding the sticks and the other for handling and shaking the pressed fiber and stick, are required to operate this machine. The sticks are fed at a uniform rate and passed through the pressure rollers adjusted at required pressure. The pressed crop passes over a third supporting roller and is handled and shaked manually to separate the crushed pith from the main fibre. The crushed pith falls on the ground and is dried for chip board making while the pure ribbon is ready for retting.

Handling of jute crop by this process has been found easy, less time consuming and economical. Retting by conventional method requires large quantity of water, more labour and time as compared to retting after separation of ribbon with machine, as 80% of the retting volume of the crop is reduced. It has also been found that the retting period is the same (14 – 15 days in both the cases). The comparative cost analysis of machine decortication versus conventional method was estimated and the jute fibre obtained by decortication method gave a net saving of Rs.23 (U.S.$2.3) per 40 kgs of dry fibre. The compressive strength of the fibre obtained in both the cases was not significantly different and it was about 8,656.44 kg/cm^2 (123,013 psi). The capacity of the machine is 400 kg/hr of green sticks, and the comparative cost analysis is shown in **Table 1** .

Table 1. Comparative cost analysis of conventional versus machine decortication method for jute fiber

Conventional Method	Tons or Rupees
Average output of green sticks/ha	= 30 mt
Average output of ribbon/ha (1/3 rd of green sticks by weight)	= 10 mt
Average output of fibre/ha (1/5 to 1/6 of ribbon by weight)	= 1.85 mt
Transportation of bundles to the ponds (15 men days @Rs.15/day)	= Rs: 225
Filling in pits and dipping weights (15 men days @Rs.15/- per day)	= Rs: 225
Water renewal for four times (1 man for 4 hours/renewal)	= Rs: 30
Fibre removal, washing (200 women @Rs.7.50/day + 75 men @Rs.15/day)	= Rs: 2,625
Tying into bundless (10 men days @Rs.15/day)	= Rs: 150
Total	= Rs: 3,255
Machine Decortication Method	**Tons or Rupees**
Cost of machine with 7½ HP diesel engine	= Rs: 17,500
Operational cost per hour (including P.O.L., labour & depreciation cost)	= Rs: 13
Output (crushing of green sticks/hour)	= 400 kg/hour
Cost of ribbon extraction per/ha	= Rs: 975
Retting charges of ribbon/ha (5 men days @Rs.15.00/day)	= Rs: 75
Water renewal (4 – times) (1 man for 1-hour/renewal as 80% of retting volume has been reduced)	= Rs: 7.50
Fibre washing & tying into bundles (75 men days @Rs.15.00/day)	= Rs: 1125.00
Total	= Rs: 2182.50
Cost of fibre extraction/40 kg	
(i) By conventional method	= Rs: 70.37
(ii) By mechanical method	= Rs: 47.18
Net saving	= Rs: 23.19

Note: Rupees 10 = 1 U.S.$.

Conclusion

The jute crop which is a cash crop, is being popularized amongst the farming community, particularly after the separation of East Pakistan. It is an important source of foreign exchange earning. The farmers are reluctant to grow this crop because of shortage of labour and non-availability of sufficient water for retting. The jute decortication machine has helped in overcoming the problems faced by the farmers and after the introduction of this device, the area under jute crop, specially in Punjab, has considerably been increased, as to prepare jute fibre with decortication method has given a net profit of Rs. 23(U.S.$2.3)/– per 40 kg and saved the labour and time involved. The output of the fibre has also been observed more by decortication method as compared to conventional method. However, there is still a problem of cutting the jute crop at the proper time. Efforts have been made by the University of Agriculture, Faisalabad to evolve certain devices for this laborious job. It is expected that in the near future, with these two devices, this crop would be completely mechanized and would give a higher profit per hectare as compared with the conventional method. ■■

Design and Development of Neckharness for Catlle in Bangladesh

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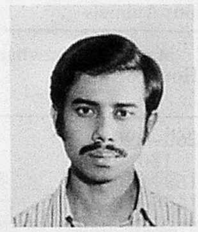

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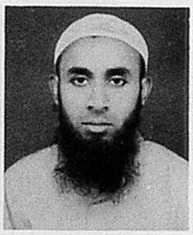

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Abstract

An experimental investigation was carried out at the Bangladesh Agricultural University Farm in order to design and construct harnesses. They were tested in the field for their hp-output, rate of work, specific draft and speed of work. A particular harness (No. 3) was found comparatively better for field work and is recommended for commercial manufacture and use in Bangladesh.

Introduction

Practically all farm power in Bangladesh today is provided by animals. In some areas a few buffalos instead of cattle are used for field work. It is estimated that the population of work animals in Bangladesh is about 11.4 million (IBRD, 1972). The cattle are very weak and weigh about 226.41 kg. (500 lbs) to 271.73 kg (600 lbs) on the average and each cattle produces about 0.24 kw (0.33 Hp) (Metrick, 1976) compared with about 0.37 kw (0.5 Hp) cattle in other south and south Asian countries. The low draft horse power developed by cattle in Bangladesh is mainly due to poor health of the animals and poor design of the yokes now used in Bangladesh.

A FAO/IBRD mission examining the livestock situation in the country concluded that the number of working animals will rise very slowly if at all, their strength and pulling power will decline under the best of conditions. One solution is to improve the quality of the work animals by cross breeding. However, this is a slow process and time-consuming. A better alternative is to derive the maximum draft horse power from existing cattle by improving the design and developing the yokes now in use.

Power is applied through yokes made of crude bamboo or wooden beam across the withers. This is the most inconvenient position of the cattle for pulling the plough. Very often this produces hump shore diseases which reduces the pull developed by the cattle. The main attempt was to design a suitable neckharness for the cattle or bullocks to increase the maximum utilization of their output power.

Animal Power and Size

Animal power is comparatively cheap if raised by the farmer himself. The pulling power produced by the animal is directly proportional to its weight and nearly equal to one tenth of the animal weight (Hofpen, 1969). Horses have a higher output than other animals in relation to weight (approximately 15 percent) and for short periods, they can produce a force equal to nearly half their own weight (Hofpen, 1969).

Small animals develop comparatively more power than the larger members of the same species. The relative draft efficiency of smaller animals is better because their line of pull is lower; i.e., the more accurate the angle of pull that can

Table 1. Normal Draught Power of Various Animals

Animal	Average Weight kg	Approximate Draught kg	Average Speed of Work m/s	Power Developed kg m/s	Hp
Light horse	400–700	60–80	1.0	75	1.0
Bullock	500–900	60–80	0.6–0.85	56	0.75
Buffalo	400–900	50–80	0.8–0.9	55	0.75
Cow	400–600	50–60	0.7	35	0.45
Mule	350–500	50–60	0.9–1.0	52	0.70
Donkey	200–300	30–40	0.7	25	0.35

Source: Hopfen, J.H., Farm Implements for Arid and Tropical Regions, FAO, Rome, Revised Edition, 1969. FAO. Agricutural Development Paper No. 91.

Table 2. Results of Drawbar Tests with Various Animals

Animal	Maximum Drawbar Pull (kg) Two Hours of Work	Four Hours of Work
Heavy horse	260–290	240–270
Light horse	180	160
Mountain oxen (draught cow)	160–170	140–150
Oxen from plain (draught cow)	140–150	120

Source: Hopfen, H.J., Farm Implements for Arid and Tropical Regions, FAO, Rome, Revised Edition, 1969. FAO. Agricutural Development Paper No. 91.

be made with the ground, the less is the power required to pull the implement.

A pair of small light horses and draft oxen provide enough pulling power for most of the work required under small farming conditions **(Tables 1 and 2). Table 2** summarizes the maximum drawbar pull obtained in the investigations carried out in the Federal Republic of Germany on the draft power output of different animals in relation to requirement for normal farm operations. The draft power varies from time to time, animal to animal, lack of proper care and feeding of the animals, breads, type of harness or yokes, and period during which animals are used.

In Bangladesh, the most common form of farm power is a pair of bullock. In other Asian countries only one animal is used to pull an implement. One healthy bullock is sufficient to do the field work now being done by a pair. Improved implements could be designed which would require even less power.

The effectiveness of the animal can be increased by improving the method of hitching. In the case of a bullock or cow, maximum power is obtained if the implement is pulled from a point just in front and halfway down the shoulder blades (Staut, 1966). In 1944, Vough conducted detailed studies regarding the methods of hitching bullocks for agricultural work. He noted that yokes which restrict the movement of bullocks (except sideways) were undersirable.

Criteria of a Good Yoke

It was observed from this investigation that a good yoke should have the following characteristics:

i) The side and hump plates, together with the pads, should fit the contour of the respective surface of the neck of the bullocks or cows.

ii) The point of hitch on the yoke should be as low as possible.

iii) They yoke should not squeeze the neck under load.

iv) The yoke should be adjustable to fit different sizes of animals.

v) The means of attachment to the implement should not impede free movement of the animal.

vi) The yoke should be rigid to facilitate coordination between the animals (when a pair is used).

vii) The yoke should be economical and simple in construction and the material should be available locally.

Experimental Investigations

Three harnesses were designed and constructed in the department of Farm Power and Machinery for experimental investigations **(Figs. 1, 2 & 3)**. The material used for the construction of the harnesses were wood, cotton, coconut fibre, jute bag, raxin, leather, etc. A local variety of wood 'rongi' was used for the manufacture of these harnesses. Harness No. 1 was constructed from wood only; Harness No. 2 from wood and coconut fibre covered with raxin; and Harness No. 3 from wood and cotton covered with leather. The detail

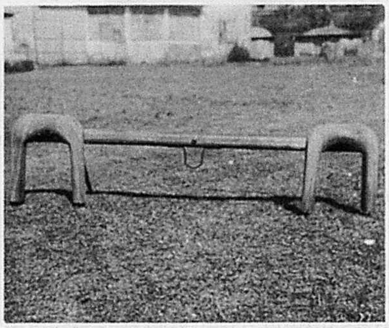

Fig. 1 Harness No. 1

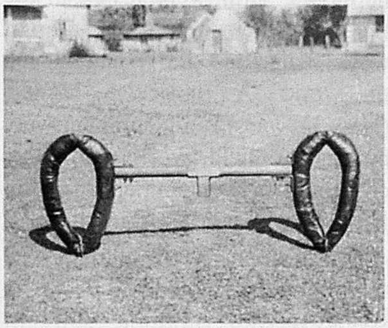

Fig. 2 Harness No. 2

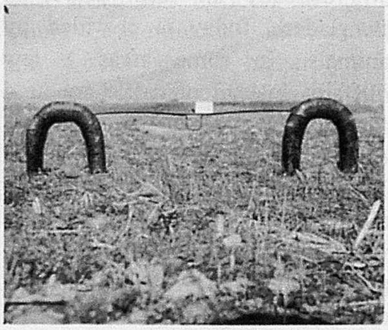

Fig. 3 Harness No. 3

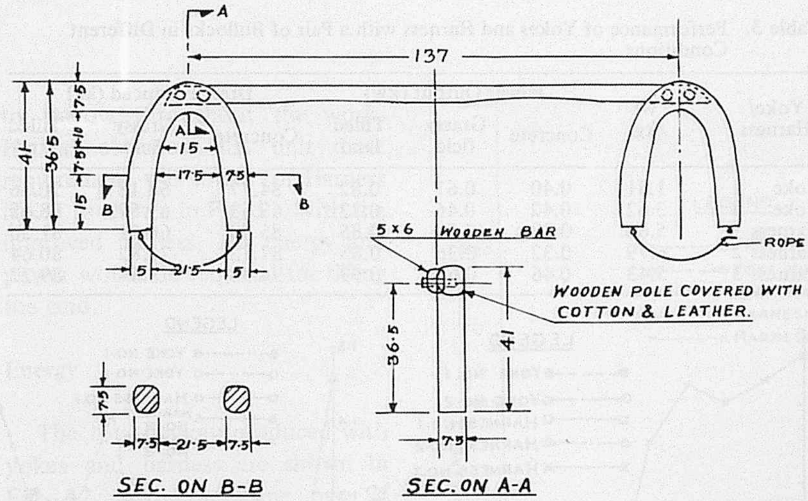

Fig. 4 Detail design of the harness No. 3

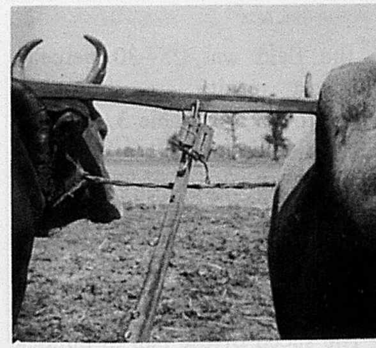

Fig. 7 Method of measuring the pulling force with the spring balance dynamometer

Fig. 5 Yoke No. 1 (made of bamboo)

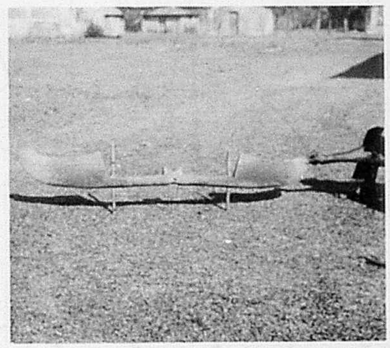

Fig. 6 Yoke No. 2 (made of wood)

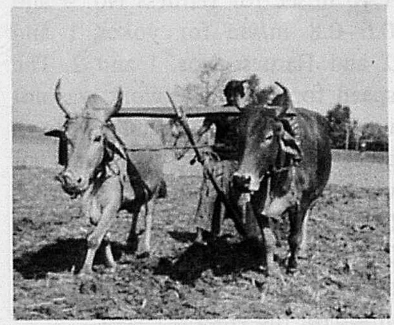

Fig. 8 Farmer tilling the land with the harness No.3

design of Harness No. 3 is shown in **Fig. 4**. Two conventional yokes collected from the local farmers were also used in the investigations and are shown in **Fig. 5 and 6**. The procedure of measuring the pulling forces of Harness No. 3 with plough is shown in **Fig. 7 and Fig. 8** shows the Harness No. 3 in working condition. Similar methods were used in other harnesses and yokes for measuring pulling forces.

The working speed, specific draft produced with the plough, power output, energy output, and total area tilled were determined.

Results and Discussion

Performance tests of the harnesses (**Figs. 1–3**) and yokes (**Figs. 5 and 6**) were done in the Agriculture Farm of Bangladesh Agricultural University. The soil of the field was sandy clay loam. The tests were performed in the untilled paddy field and the approximate moisture content of the soil during the test

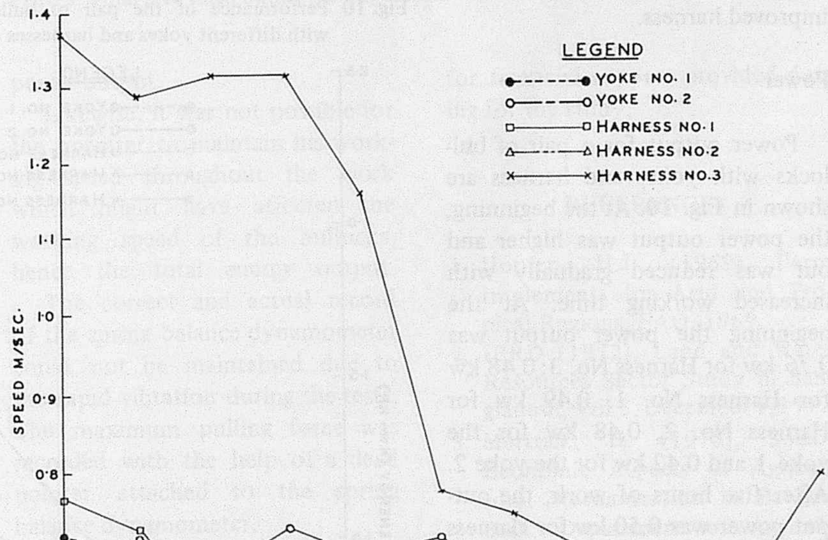

Fig. 9 Working speed of a pair of bullock with different yoke and harness

in the field was 25–30 percent. The test results are shown in **Fig. 9 to 13 and Table 3**. All tests were done with the same pair of bullocks and operator. The weight of the pair of bullocks was 410 kg.

Speed

The speed of the pair of bullock with yokes and harnesses are shown in **Fig. 9**. The speed of the bullock at the beginning of the work was 1.40 m/sec for Harness No. 3 and 0.6–0.8 m/sec for yokes 1 and 2 and Harness Nos. 1 and 2. The speed for the entire work was not uniform and was reduced to a great extent after five hours of work to 0.79 m/sec for Harness No. 3, 0.51 m/sec for Harness No.1, 0.50 m/sec for Harness No. 2, 0.56 m/sec for the yoke 1 and 0.60 m/sec for the yoke 2.

Therefore, the speed of a pair of bullocks could be increased with improved harness.

Power

Power output for a pair of bullocks with yokes and harness are shown in **Fig. 10**. At the beginning, the power output was higher and out was reduced gradually with increased working time. At the beginning the power output was 0.76 kw for Harness No. 3; 0.48 kw for Harness No. 1, 0.49 kw for Harness No. 2, 0.48 kw for the yoke 1 and 0.42 kw for the yoke 2. After five hours of work, the output power was 0.50 kw for Harness No. 3; 0.28 kw for Harness No. 1; 0.38 kw for Harness No. 2; 0.35 kw for the yoke 1; and 0.36 kw for the yoke 2. With the same pair of bullock, power output could be increased with improved harness.

Unit draft

This refers to the draft per unit area of furrow cross section and varied from time to time, furrow

Table 3. Performance of Yokes and Harness with a Pair of Bullocks in Different Conditions

Yoke/ Harness	Wt (kg)	Power Output (kw)			Draft Produced (kg)		
		Concrete	Grassy field	Tilled land	Concrete	Grassy field	Tilled land
Yoke 1	1.81	0.40	0.67	0.82	84.77	68.18	70.36
Yoke 2	3.62	0.42	0.46	0.73	69.63	69.59	68.18
Harness 1	5.68	0.39	0.64	0.85	85.00	66.54	81.36
Harness 2	6.79	0.32	0.36	0.85	87.72	71.82	80.64
Harness 3	5.43	0.46	0.65	0.99	94.54	78.64	89.27

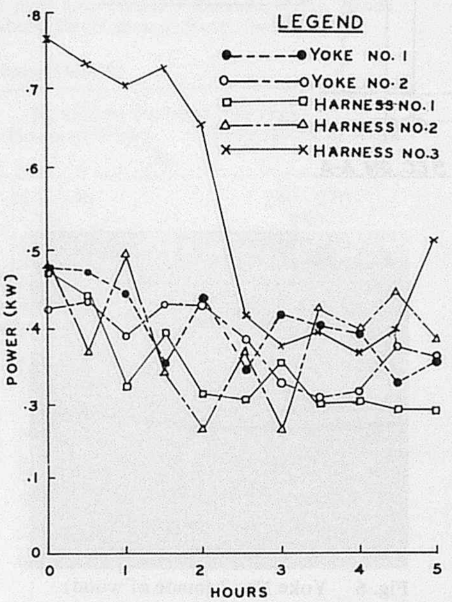

Fig. 10 Performance of the pair of bullock with different yokes and harnesses

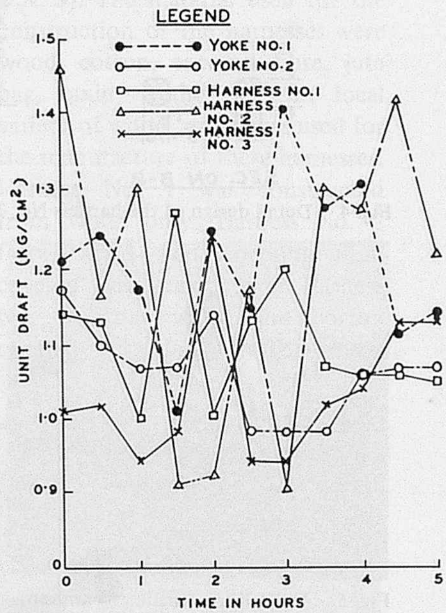

Fig. 11 Unit draft produced with different yokes and harnesses

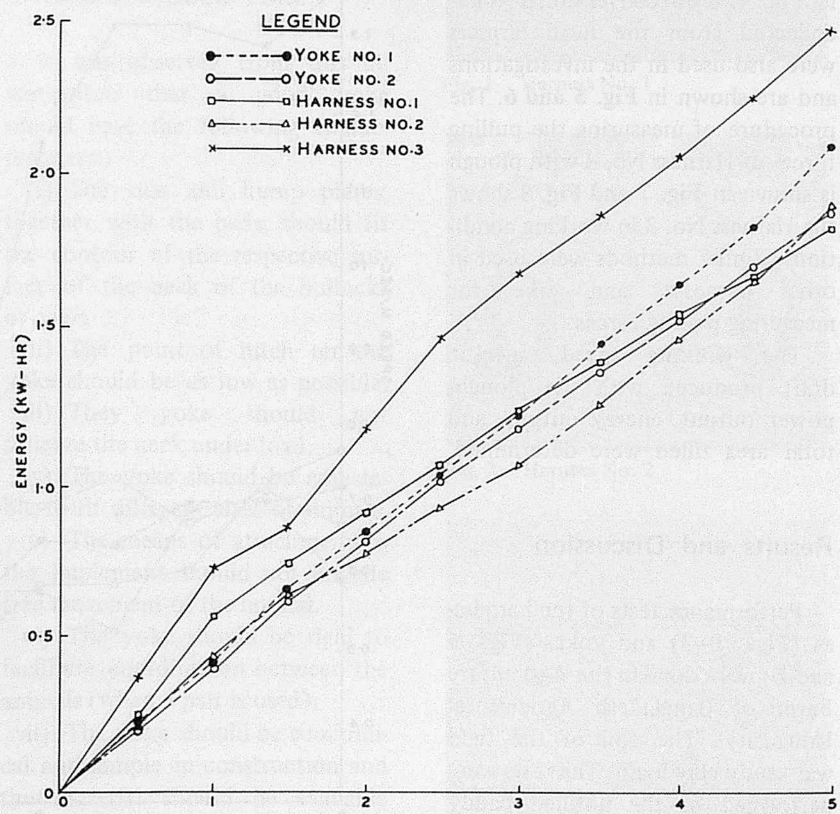

Fig. 12 Total energy produced with yokes and harnesses

to furrow throughout the work. It was observed that unit draft requirement was lower for Harness No. 3 as shown in **Fig. 11**. With the improved harness, less energy and power would be required for tilling the land.

Energy

The total energy produced with yokes and harness are shown in **Fig. 12**. With the same pair of bullocks and operator the energy output after five hours of work were 2.46 kw-hr, 2.07 kw-hr, 1.82 kw-hr, 1.90 kw-hr, 2.08 kw-hr for Harness No. 3, Harness Nos. 1 and 2 and yoke 2–1, respectively. Therefore, with improved harness more energy could be produced with same pair of bullocks and operator.

Tilling area

The total area tilled using yokes and harness is shown in **Fig. 13**. During the five hours of work the tilled area were 0.20, 0.18, 0.15, 0.17, 0.19 hectares for Harness Nos. 3, 1, 2 and yoke 1 and 2, respectively.

The yokes and harneses were also tested in three conditions such as on concrete, grassy field and tilled land for the maximum draft force and power output. The draft force and power output were found higher for Harness No. 3 as shown in **Table 3**.

During the investigations, it was observed that the soil moisture content was not uniform throughout the field and the soil was hard and sometime roots of paddy were present in the field. As a result, the pulling force as well as specific draft differed in the same furrow.

Also, it was not possible to maintain a constant pressure on the plough by the operater throughout the whole experimental work which might have affected the draft of the plough as well as in the horse power output.

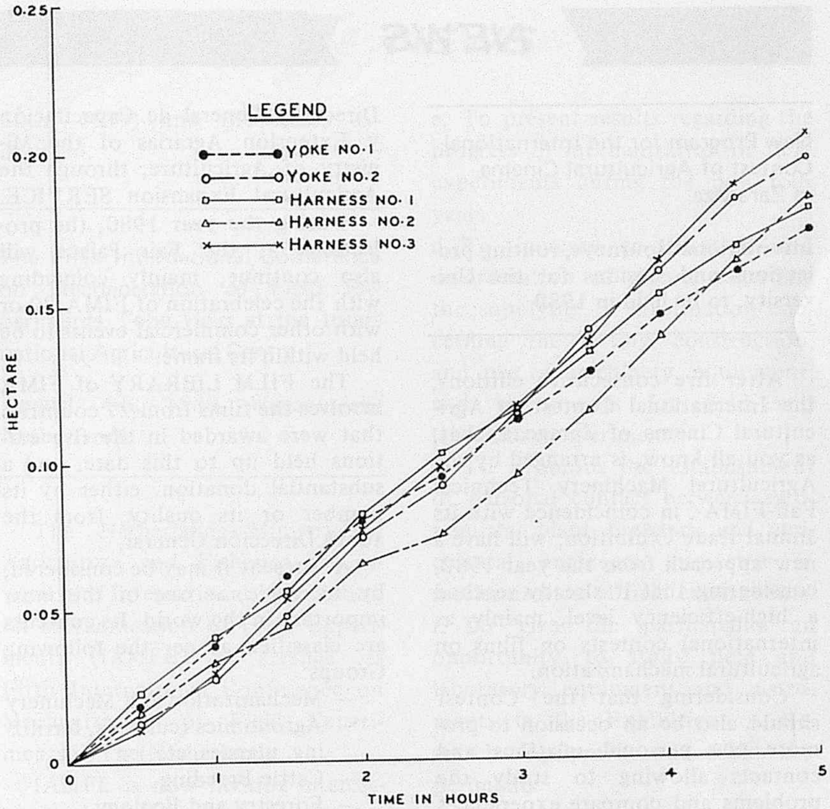

Fig. 13 Total area tilled during the experiment

Likewise, it was not possible for the operater to maintain his working speed throughout the work which might have affected the working speed of the bullocks, hence the total energy output.

The correct and actual record of the spring balance dynamometer could not be maintained due to the rapid vibration during the tests. The maximum pulling force was recorded with the help of a dead pointer attached to the spring balance dynamometer.

The working speed, power output, rate of work, energy output, tilling area, etc. were found greatest for Harness No. 3.

Acknowledgement

The authors are indebted to the farmers of Bangladesh for supplying ploughs and yokes and to the Bangladesh Agricultural University for financial support provided during for the study.

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NEWS

New Program for the International Contest of Agricultural Cinema in Zaragaza

International Journeys, routing projections and sessions for the University, to be held in 1980

After five consecutive editions, the International Contest of Agricultural Cinema of Zaragoza, that, as you all know, is arranged by the Agricultural Machinery Technical Fair-FIMA-, in coincidence with its annual trade exhibition, will have a new approach from the year 1980, considering that it already reached a high-efficiency level, mainly as international contests on films on agricultural mechanization.

Considering that the Contest should also be an occasion to promote the personal relations and contacts allowing to study the problems and compare experiences related to agricultural cinema and that besides, one of its goals is to cooperate in the task of teaching and divulgation of the agricultural production techniques, the CONTEST organizers desire to promote these aspects and from now on, it will have a competitive character in the old years, holding on the even years some International Journeys of Agricultural Cinema.

Therefore, on the 28th March 1980 will take place in – FIMA/80 a Round table in which leading local and foreign experts and representatives of entities and bodies related to agricultural divulgation, will disclose the subject: "Films on Agricultural Machinery and Mechanization. – Production and Utilization Systems". The official languages will be Spanish, French and English, with simultaneous translation.

Similarly, within the next year, a wide cycle of routing Productions all throughout Aragon will be held for the farmers, as well as several sessions specially directed to the University of Zaragoza, showing films from the FIMA FILM LIBRARY commented by people skilled on agricultural questions.

For this wide schedule we have the invaluable cooperation of the Dirección General de Capacitación y Extensión Agrarias of the Ministry of Agriculture, through the Agricultural Expansion SERVICE.

During the year 1980, the projections at the Fair Palace will also continue, mainly coinciding with the celebration of FIMA/80 or with other commercial events to be held within its frame.

The FILM LIBRARY of FIMA involves the films from 27 countries that were awarded in the five editions held up to this date, and a substantial donation, either by its number or its quality, from the above Dirección General.

At present it may be considered, by its topic, as one of the most important in the world. Its contents are classified as per the following Groups:

- Mechanization and Machinery
- Agronomics (cultures, fertilizing, plagues, etc.)
- Cattle Breeding
- Forestry and Ecology
- Agricultural Action and Expansion
- Development of Communities
- Miscellaneous

International Farm Machinery Exhibition in Korea – To Be Held March 1980 for the First Time

The first International Farm Machinery Exhibition will be held from March 31 to April 4 at the permanent site for machinery exhibition located in Seoul. This exhibition is sponsored by the Korean Farm Machinery Industry Cooperative with assistance by the Ministries of Agriculture and Industry.

This exhibition is the first of its kind and aims at the promotion of mechanization of Korean agriculture through the introduction of foreign machines and also expects the industry will study the internationally selected machines, some of which are to be operated on this occasion.

The exhibits cover all kinds of machinery and equipment related to rice-growing, field planting, horticulture, fruit-growing, livestock breeding, etc.

Exhibitors are broadly invited from among Korean and foreign manufacturers, trade firms, etc.

1.5 Billion Yen Granted for Facilities to be Set Up in Paraguay

On October 13 Foreign Ministry announced that Japan and the Republic of Paraguay Governments exchanged official letters on the grant for facilities of Southern Paraguay Integrated Agricultural Development Center on July 25 at Asuncion.

This grant is intended for the provision of materials and services for the construction and machines for research and training including the cost of transportation and installation. This grant amounts to 1.5 billion yen to be executed by March 31, 1980.

The Royal Smithfield Show 1979 held in Earls Court

The 168th Royal Smithfield Show was held for 5 days from December 3rd to 7th in Earls Court, London as usual.

Agricultural Machinery, Gardening Machinery and Implements, Attachment, Parts and Repairing Equipments were exhibited in the ground covering about 30,000m^2. In addition to these, livestocks and their products were also put on

Plate 1. Main Entrance to Earls Court Exhibition Centre

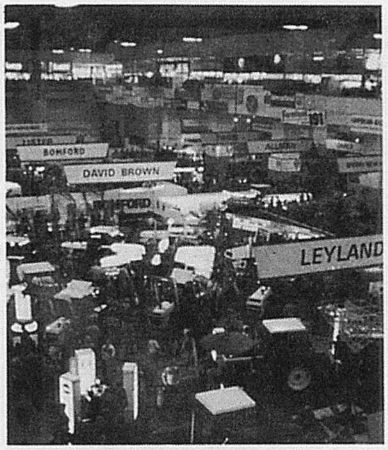


Plate 2. The indoor exhibition of agricultural machinery covered over 30,000 square metre of space at Earls Court

exhibition. Competitive fair and spot sales of them were also held.

This time 354 firms sent their products to the exhibition. The visitors counted about 80,000 for five days.

With regard to the remarkable new products which were presented this time, I introduce them at page 94 in the new products page.

The Royal Smithfield Show is to stay at Earls Court until 1999, when it celebrates its 200th anniversary. The agreement between Earls Court and Olympia Ltd., – owners of Earls Court – and the Smithfield Show Joint Committee was signed today (October 30th, 1979) and the leases exchanged.

The Fifth International Conference on Mechanization of Field Experiments Tobe Held at the International Agricultural Centre

August 4-8, 1980, Wageningen/ Netherlands

The Netherlands Ministry of Agriculture and Fisheries has invited the International Association on Mechanization of Field Experiments (IAMFE) to arrange its Fifth International Conference on Mechanization of Field Experiments in The Netherlands.

IAMFE is now inviting interested parties to participate in this conference and present papers and films.

The objectives of the Fifth International Conference on Mechanization of Field Experiments are:

a. To hold a General Assembly of IAMFE to discuss the philosophy, policy, and work of the organization.

b. To discuss the IAMFE plan for establishing an International Centre on Mechanization of Agricultural Research (ICMAR).

c. To present results regarding the progress of mechanization of field experiments during the past four years.

d. To increase co-operation and co-ordination of efforts regarding the supplying of information concerning the testing, construction, and use of machinery, equipment, and instruments for field and laboratory experiments.

e. To promote the establishment of personal contact between agronomists, plant breeders, and agricultural engineers interested in mechanization of field experiments.

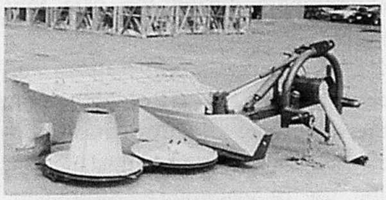
f. To give the participants an opportunity to study field and laboratory equipment and instruments in the Exhibition of Research Equipment for Field Experiments.

Regarding presentation of papers, reports, and discussions the following groups of equipment are suggested as the main subjects: Methodic questions, Implement carriages, Fertilizer application equipment, Plot seed drills and planters, Pesticide application equipment, Plot forage harvesting equipment, Plot combines and threshing equipment, Cleaning and sorting equipment, Potato planting and harvesting equipment, Root crop harvesting equipment, and Measuring devices. ■■

INDEX TO ADVERTIZERS

NEW PRODUCTS

Sasaki AD-120 Disc Mower, 20–35 PS



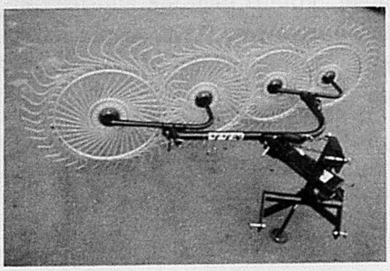
Application: Cutting forage and straw for hay.

Features: Cutting disk are durable and have sharp edge; Safety device helps cutter disc to retract from obstacles and minimizes cutter disc or frame breakage; Light weight and sturdy construction ensures good balance with tractor; Easily mounted to tractors by 3-point linkage; Highly efficient and has working speed about two times that of trailing type; and cutting discs swing free and this ensures minimum damage due to obstacles or undulation of the field.

Specifications: Size (L.W.H.), 850 x 2,470 x 900 mm; Weight, 185 kg; Working width, 1,200 mm; Efficiency, 60–120 a/h; Working speed, 6–12 km/h; Mounted by 3-point link.

(Sasaki Noki Co., Ltd.: 259–1, Satonosawa, Towada, Aomori 034, Japan)

Sasaki AR–400 Finger Rake, 25–45 PS



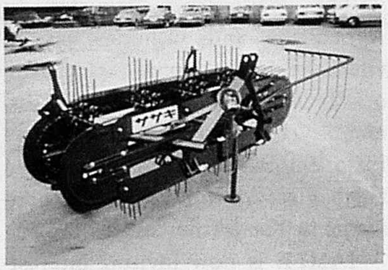
Application: Gathering, turning, loosening of straw or hay.

Features: Tines have good spring action and are durable. Fingerwheels rotate by ground friction, hence practical. The width can be narrowed for ease of transportation; and the direction of fingerwheel surface is set by simply adjusting the turnbuckle according to hay conditions.

Specifications: Size (L.W.H.), 2,600 x 4,000 x 1,450 mm; Weight, 200 kg; Working width (gathering), 2,250, (turning) 2,250, and (loosening) 3,200 mm; Efficiency (gathering) 150–200, (turning) 150–200, and (loosening) 200–300 a/h; Working speed, 8–12 km/h; Mounted by 3-point link; and Number of tines, 40/wheel.

(Sasaki Noki Co., Ltd.: 259–1, Satonosawa, Towada, Aomori 034, Japan)

Sasaki AH-200 Haymaker, 25-45 PS



Application: Turning, gathering, loosening of hay. Treatment of straw.

Features: Simple design. Strong frame construction. Trouble free and durable; tines are made of high and strong quality material, can handle big quantity of hay in any condition and have long life; and roller chain assembly with tines has long life. Functional parts are made of abrasion-resistant materials.

Specifications: Size (L.W.H.) 1500 x 2450 x 1100 mm, Weight 225 kg, Working width (turning) 1700, (gathering) 2000 mm, Efficiency (turning) 80-120, (gathering) 80-125 a/h, Working speed (turning) 6-9, (gathering) 5-8 km/h Mounted by 3-point link.

"Kett" Grain Moisture Tester

Kett Electric Laboratory is world-famous for its variety of moisture measuring testers for different purposes. Kett grain moisture tester, in particular, has been designated by the Government of

Burma for official use during the past 20 years, as well as by the Japanese Government.

Over 250,000 sets of RICETER have been sold domestically, and 10,000 sets have been distributed in foreign markets since 1961.

In Japan where rice is purchased by the government from the producers, the RICETER is employed by inspectors at the time of sale, or beforehand by the producers themselves, to determine whether or not the rice meets government specifications.

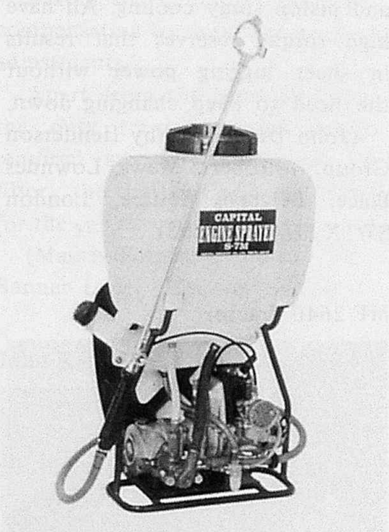
[Specifications]

1) RICETER Model 3, Types A & B Measuring range: Paddy 11–30%; Rice 12–20%. Accuracy: ±0.5%. Batteries: DC 6V (UM3x4). Dimension & weight: 70 x 150 x 90 mm, 1 kg. *(photo.: above)*

2) Digital Tester, Model Eyezer (for Far Eastern market only) Nondestructive, no adjustment needed, digital readout; Type A: Direct readout for corn. Type B: Direct readout for paddy. Measuring range: Paddy 12–30%; Rice 11–20%. Accuracy: ±0.5%. Batteries: DC9V (006 x 1). Dimension & weight: 180 x 240 x 120 mm, 1.4 kg. *(photo.: below)*

(Kett Electric Laboratory: 8–1, 1-chome, Minami-Magome, Ota-ku Tokyo, Japan).

Capital High Pressure Knapsack Sprayer



In Capital High Pressure Knapsack Sprayer New S-Series there are three types – S-5F, S-7F and S-8. Each of these types carries 2 cycle air cooled gas engine. The features are high pressure, outstanding performance, plunger pump with patented differential system, corrosive resistant, durable reliability, lowest maintenance and easy operation. Applications of these types are 1) Insecticidal Spraying and watering for Nursery, 2) Sanitation of Pultry and Animal Cote and 3) General sterilizing of Sewerage and Lavatory. For accessories they have Nozzle (3-Head or 1-Head), 1.2 m spray hose and tools.

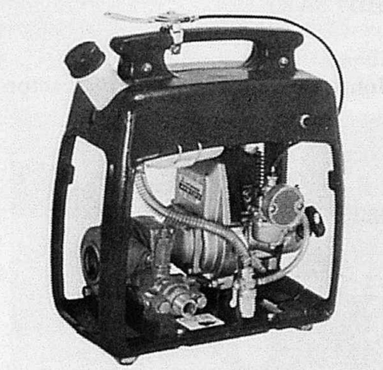
[Specifications]

1) S-5F
Dimensions: 285 x 400 x 650 mm, Weight: 9.8 kg, Pressure: 21 kg/cm^2, Capacity: 3.7 l/min., Liquid Tank Capacity: 16 l, Engine: 1.2/6,500 ps./rpm. (Max. Power), and Engine Ignition: Magneto with Recoil Starter.

2) S-7F
Dimensions: 350 x 370 x 610 mm, Weight: 11 kg, Pressure: 21 kg/cm^2, Capacity: 5.7 l/min., Liquid Tank Capacity: 18 l, Engine Max. Power: 1.5/6,000 ps./rpm, and Engine Ignition: Magneto with Recoil Starter.

3) S-8
Dimensions: 360 x 370 x 610 mm, Weight: 12 kg, Pressure: 21 kg/cm^2, Capacity: 7.8 l/min., Liquid Tank Capacity: 18 l, Engine Max. Power: 1.6/7,000 ps./rpm., and Engine Ignition: Magneto with Recoil Starter.

Capital E-7M Handy Type Power Sprayer

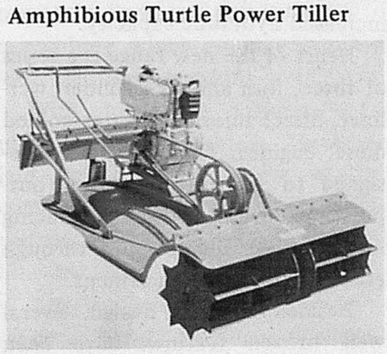


This sprayer is designed for compact, portable, simply carried and easy to operate. The features are high performance, high pressure, corrosive resistant and everlasting. This sprayer carries 2-cycle air cooled engine.

[Specifications]

Dimensions: 360(L) x 230(W) x 370 (H) mm, Net Weight: 9 kg, Total Displacement: 24 cc, Output: 0.8 ps./6,000 rpm. (Max. 1.2 ps.), Ignition Plug: NGK-4-B, Mixing Ratio: 20 (Gasoline) and 1 (Eng. oil), Tank Capacity: 1,000cc, Starting System: Recoil Starter, Pump Type: Horizontal and 1 plunger, Plunger x Stroke: 22.6 x 7 mm, Operating Speed 1,400 to 1,800 rpm., Discharge Capacity: 4.7 l/min./1,800 rpm., Reduction Ratio: 1:3.7, Operating Power: 0.5 ps., Discharge Post Dia.: PF 1/4".

Amphibious Turtle Power Tiller



Technological and Economic Advantages of the Tiller are as follows:

1. It has a vacuumatic housing float which prevents it from sinking and bogging in marshy and water-logged fields in the course of plowing.
2. It can plow fields where mud is knee-deep or deeper.
3. It can work on fields choked by tall reeds and on farm lands that has been abandoned.
4. It can cut weeds and rice straw from newly harvested fields.
5. It has the ability to trim and clean near corner dikes.
6. Spare parts locally available.
7. It is equipped with high speed transmission. Can finish 1.5 hectares or 3.7065 acres in 8 hours with a consumption of 4 to 8 liters of diesel and 16 to 20 liters of gasoline.
8. Very economical, uses used oil only for transmission, less moving parts to maintain and an ocular inspection may easily determine the malfunctioning parts.
9. Suited for fishpond operations. It solves the fishpond problems of:
   a) cleaning and removing grasses in the fishpond;
   b) loosening the hard pond soil in the fishpond to produce more moss or "lab-lab"; and
   c) leveling the hard pond soil after loosening.
10. Easy to operate and can level rice paddies as well as rainfed lands.
11. The engine can be easily dismantled and utilized for irrigation, threshing and generating purposes.
12. The tiller can be fitted with an 8 to 11 HP Diesel engines and/or 10 to 16 HP Gasoline engines at the convenience of the farmer.

(SV Agro-Industries Enterprises, Inc.: 65 Commission Civil, Jaro, Iloilo City, Philippines)

NEW PRODUCTS

The Products was introduced at the Royal Smithfield Show

DB 1690 Tractor

The 103 hp 1690 model is star of the new David Brown '90 series' tractor range – the most powerful DB tractor ever built and the first to exceed 100 hp.

The completely new safety cabs have been designed in close collaboration with specialist manufacturers, Sekura Ltd., as an integral part of the overall tractor concept. All cabs are of de luxe quality and set new standards in driver comfort and operational efficiency.

In general styling the 1690 matches the rest of the new DB 90 series tractors and is available with the new safety cab (described in News Release T/79/H/41).

In common with all other DB tractors the 1690 is powered by an engine designed and built at the Meltham factory. This new naturally aspirated 6-cylinder unit has been under development for several years and has undergone extensive field trials.

Rated at 103 DIN hp (76 kW) it develops up to 89 PTO hp (65.5 kW) at 2300 r/min maximum engine speed. This high capacity is matched by high lugging power and modest fuel consumption.

Three versions of the 1690 are available: 2-wheel drive with 12 forward 4 reverse synchromesh gearbox; 4-wheel drive with similar transmission; and 2-wheel drive with the unique DB Hydra-Shift transmission providing 4 clutchless speed changes in each of four ratios – creep, field, road and reverse.

(David Brown Tractors Ltd.: Meltham, Huddersfield, England HD7 3AR)

John Deere 3140 97 hp Tractor

John Deere's new range of under 100 DIN hp tractors have been designed to meet the widest possible range of farming conditions. New features, coupled with John Deere's reputation for reliability, give the farmer the ideal package where timeliness of operation is of primary importance. Hence their title – THE SCHEDULE MASTERS.

There are seven new tractors in the range:
1040–50 hp, 1140–56 hp, 1640–62 hp, 2040–70 hp, 2140–82 hp, 3040–90 hp, 3140–97 hp.

Among the new features are synchronised 8-speed transmissions; Power-Synchro (Hi-Lo) units; mechanical front wheel drives and increased hydraulic capacity.

Heart of the new range is a series of three, four and six-cylinder, wet-liner, direct injection, water cooled diesel engines. They have been designed to give higher power outputs, achieved not by producing higher speed engines, but through greater cylinder displacement.

Besides their new design, several well proven features have been built in – like pressure lubrication, replaceable wet cylinder sleeves, and piston spray cooling. All have high torque reserves that results in sheer lugging power without the need to keep changing down.

(John Deere Ltd. by Henderson Group: 1 Roberts Mews, Lowndes Place, Belgrave Square, London SW1X 8DA, England)

MF 2640 Tractor

Available in two and four-wheel drive versions, the MF 2640 sets new overall standards of machine reliability, ease of operation and comfort for the driver in order to achieve highest productivity on farms.

Outstanding new features have been incorporated to reduce 'down-time' through eliminating or simplifying servicing requirements and, allied to advanced operating systems, they are designed to meet the most demanding customer expectations for output and reliability.

Hydraulics are used extensively. As well as the basic system for powering the linkage and external services, hydraulic actuation is provided for the clutch, brakes, differential lock, independent 2-speed rear pto, optional front pto and engagement or disengagement of front wheel drive.

All gears have synchromesh providing 16 forward and 12 reverse speeds with a 2-speed power shift. A manual shuttle makes it possible to change from a forward gear into reverse without declutching.

Brakes and clutch are fully self-compensating for wear and need no adjustments.

Apart from the basic oil levels, the only routine service checks required are for the engine air filter, the battery and the filter for the cab air conditioning.

(Massey-Ferguson (UK) Ltd.: Banner Lane, Conventry, England)

John Deere 985 'Big' Combine

There are two versions, the standard 170 DIN hp 4-speed model and the new 195 DIN hp Hydro-4 version.

All have the same huge six-walker capacity. Each long straw walker has four steep steps to increase throw and achieve optimum tumbling action and aggressive separation. A synchronised rear beater directs material onto the walkers. Grain pan and chaffer are designed to move in opposition to the sieves to reduce material build-up and save grain. The sieves are centrally supported and, along with the chaffer, are fully adjustable.

At the heart of the JD985 are two turbocharged six-cylinder diesels – the 195 DIN hp version in the Hydro-4 and the 170 DIN hp mechanical shift transmission. Both engines, specially designed for turbocharging, have high torque curves to handle difficult crop conditions. They are also quiet running.

The large diameter 6-bar reel is fully adjustable to every crop condition. The individual tines can be removed in a matter of minutes without removing the reel. The direct knife drive is by chain and will therefore keep cutting in damp conditions where other belt drives would tend to slip. The JD985 is fitted with a fully air-conditioned cab, which sits the driver in arm-chair comfort high above the centre of the cutting platform. The rear windows open for easy access to the large capacity grain tank and the right hand side to check tailings.

(John Deere Ltd. by Henderson Group: 1 Roberts Mews, Lowndes Place, Belgrave Square, London SW1X 8DA, England)

Sampo Rosenlew 500 Combine

The Sampo Rosenlew 500 is a new combine harvester designed for demanding harvesting conditions. Behind its concept and design lies the entire harvesting expertise of the researchers and farmers.

The result is a completely dependable Sampo Rosenlew 500 – a combine which copes admirably with rigorous harvesting conditions.

With harvesting efficiency in mind, special emphasis has been laid on the construction of the cutting table, concave and straw walkers. Cleaning out the combine has been made simple and fast.

The large tyres keep the Sampo stable in soggy working conditions.

The new Sampo Rosenlew 500 is an efficient combine designed for the demanding 1980's. In all kinds of weather.

(Oy W. Rosenlew Ab Agricultural Machinery Factory: P. O. Box 51, SF-28101 Pori 10, Finland)

Wright Rain Frost Protection Sprinkler

The Wright Rain frost protection sprinkler is designed for reliable operation under arduous conditions. Manufactured from corrosion resistant materials, it incorporates design features developed through the company's long experience in irrigation technology.

Able to operate effectively at temperatures as low as $-10^{\circ}C$ ($14^{\circ}F$), the sprinkler will rotate at under sixty seconds per revolution, giving smooth, regular water distribution through its high quality plastic nozzle. This nozzle has a built in extension against which the swing arm acts.

A plastic, anti-icing cap houses the swing arm pivot assembly which includes a simple spring tension adjuster – necessary to achieve the precise rotation times so important in frost protection.

The unit is soundly engineered, water passages in the cast gun metal body are smooth and evenly contoured, the self lubricating bearings will give reliable rotation over a long operational life, in a variety of climatic conditions, with minimum maintenance.

The male connection has a 3/4" BSP thread.

(Wright Rain Ltd.: Ringwood, Hampshire, BH24 1PA, England)

Howard Rotamix

Over three years of development work and field trials have gone into the new British-made Howard Rotamix – a mixer wagon which is Howard Rotavator Co's first venture into complete diet feeding of livestock.

The Rotamix is suitable for tractors of 50 hp upwards and capacities are:–

5.3 cu metres of volume, and capable of mixing up to 1500 kgs of forage depending on type and density.

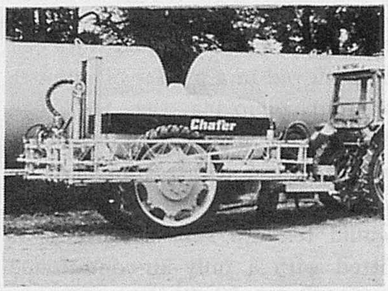
Unloading time is three to four minutes depending on the layout of the cattle feeding area.

Other specifications are:–

1. A simple, slow rotating rotor ensures efficient mixing, and also assists unloading.
2. Choice of rotor speeds to suit the mix.
3. An efficient side delivery conveyor.
4. Unladen weight is around 2.5 tonnes, height 2.06 m (6'9"), length 4.42 m (14'6") wheel width 2.24 m (7'4").

(Howard Rotavator Co., Ltd.: Saxham, Bury St. Edmunds, Suffolk, England)

Chafer Tramliner



A Revolutionary new high-capacity trailed applicator for liquid fertiliser and agrochemicals, incorporating such advanced features as tramline tracking, gimbal boom suspension, independent wheel suspension and electronic control, has been introduced by J. W. Chafer, Doncaster, the UK's largest manufacturer of liquid fertiliser.

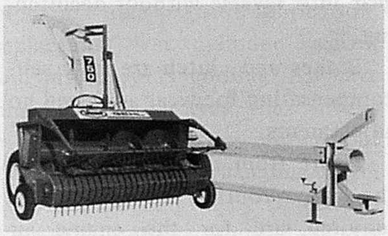
'Tramliner' is the result of several years' development work and is designed especially for the large arable set-up where fast and safe work rates, and minimum operator fatigue are of the essence.

Chafer designed hollow cone spray jets are fitted as standard at 35 cm centres. Each quick-fit jet body incorporates a filter and a large anti-drip diaphragm check valve, while the colour-coded interchangeable nozzles can be changed quickly without tools. Liquid fertiliser jets are available to apply from 100 to 4000 litres per hectare and pesticide jets from 125 to 1500 litres per hectare.

(J. W. Chafer Ltd.: Chafer House, Doncaster, South Yorkshire, DN1 2HQ, England)

Vicon Gohl CB750 Forage Harvester

The CB750 is suited to tractors offering 75-120 p.t.o. horse power, standard features include an 8 knife 21" cylinder, 120 sq. in. feed roll throat opening, a 36" 4 paddle



blower, tungsten carbide faced knives and a reversible self sharpening cutter bar, adjustable axles and 11.L x 5 flotation wheel equipment complete the specification.

Options include a hydraulic knife grinder, vertical and horizontal deflector extensions, hydraulic remote controls, hydraulic trailer hitch and 2 row maize attachment.

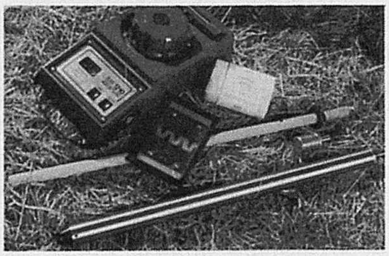
The HA1000 6 ft. windrow attachment features open sides and pneumatic wheels.

Routine maintenance has been simplified by the swing-away blower, remote greasing to the left hand side feed roller bearings together with improved adjustment of the cutter-bar and rear roller scraper.

Price of the unit complete with 6 ft. windrow attachment is £5,385.

(Vicon Ltd.: P. O. Box 10, Lovetofts Drive, Ipswich, Suffolk, IP1 5NS, England)

The 1210 Forage/Grain Moisture Tester



N. J. Froment & Co. Limited, Manufacturer of the "1210" Forage/Silage/Grain Moisture Tester, have now extended the capability of the "1210" still further by the introduction of a hay testing kit.

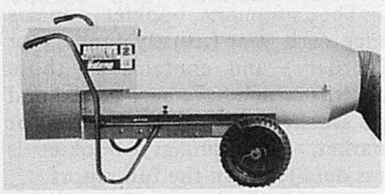
Extending the concept of the all purpose, total Moisture Tester package, the kit for hay comprises a core sampler, and a special "electronic" plate to fit into the Tester.

The "1210" is a portable field Tester. Developed to be easy to use and to give rapid results. It is battery powered and completely self-contained, with built-in storage for log cards and sample bags. It will test forage, silage and high moisture grain from 25% to 75% moisture, cereal grains from 8% to 30% moisture and hay from 10% to 40% moisture.

The Tester costs £98 and the optional hay testing kit £47.

(N. J. Froment & Co., Ltd.: Cliffe Road, Easton on the Hill, Stanford, PE9 3NP, England)

Andrews Ventacrop Heater



Today, there is a new choice of air heater specifically design built for crop/grain drying installations.

Andrews Industrial Equipment Limited, Britains No. 1 manufacturer of Portable Air Heaters have united with the agricultural development and marketing experience of Entecon Limited to bring you a choice of Universal LP Gas and Diesel Oil Fired Air Heaters.

What ever type of drying fan installation you may operate–or purchase in the future–the new Andrews Ventacrop Heaters can be utilised to provide the required temperature rise. 100% Efficient..... Choice of Output.....Choice of fuel.

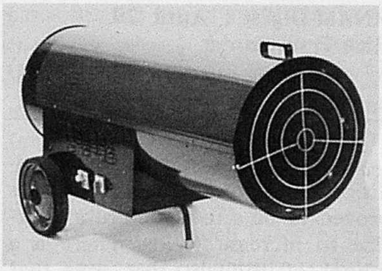
The two new Andrews Ventacrop Heaters are of the direct fired variety and therefore all the heated air is utilised 100% with the use of flexible ducting to direct the heated air into the fan system.

The model 300 TA/D provides an output of 300,000 Btu/h, fired by 30 second Diesel Oil whilst the G350 TA/D gives a controllable output from 107,500 to 350,000 Btu/h fuelled by LP Gas. Both can be fitted with thermostat or humidistat anciliary control equipment.

Mounted on large diameter, wheels for ease of manoeuvrability over rough terain, Andrews Ventacrop Heaters are tough yet fully portable–being as easy to move as a standard wheel-barrow and almost as simple to maintain. Manufactured in Britain with 15 years of portable heating expertise behind them, Andrews Ventacrop heaters carry a comprehensive warranty and are supported by the Entecon established nationwide parts/service agricultural dealer network.

(Entecon Ltd.: Blackwater Bridge, London Road, Camberley, Surrey GU17 9AP, England)

Kongskilde GA100 Heater



Kongskilde UK have added a gas fired model to their Thermobile range of oil fired heaters. Known as the GA100, the heater is equipped with wheels and handle for easy movement, weighs only 51 kg and delivers 4000m^3/h working off the normal mains voltage of 230 v. The direct fired burner can be adjusted to give a heat output from 45,000 to 100,000 K cal/h, (180,000 – 400,000 BTU/h).

The heater is equipped with motor overload protection, overheat cut-out, burner control box and thermo-electric ignition. It comes complete with gas pressure regulator, pressure gauge and 3m of gas hose.

A non-wheeled version suitable for fixed installations, the GAS100, is also available.

(Kongskilde U.K. Ltd.: Hempstead Road, Holt, Norfolk, NR25 6EE, England) ■■

NEW PUBLICATIONS

RNAM-Digest 1 April '79
Rice Transplanter

(Philippines)

Transplanting under proper conditions and in proper manner has proved to be a useful cultural practice to increase yields. There is a school of thought that says that seed drilling is more productive than transplanting. But considering the climate, soils and other features of cultivation in this part of the world, transplanting still remains a step that will increase yields and ensure optimum use of the water that is available. Transplanting also helps to fight, though not necessarily eliminate, weed growth because for a long time after transplanting the ricefield is under water.

The need for transplanting machinery is obvious when we realize the fact that transplanting is a "back-breaking" job. We have become too used to employing women and children and temporary labour for transplanting operations but we are also becoming more and more aware of the fact that competent labour for transplanting is not available in sufficient numbers at the time it is needed.

In view of the importance of transplanting, and on the recommendation of the Technical Advisory Committee (TAC), the Regional Network for Agricultural Machinery (RNAM) decided to make it one of its subnetwork activities; RNAM has compiled this Digest reviewing the work done by the development and testing of rice transplanters in this region. I sincerely hope that the 'Digest will prove useful to research engineers, small-scale manufacturers, farmers and administratiors concerned with farm mechanization, and that it will promote mechanization of rice cultivation in the region which would lead to increased output and higher incomes for farmers.

The Digest measures 15.5 cm x 22.5 cm and within its soft covers are 43 pages of useful reading.

Published by Regional Network for Agricultural Machinery, Institute of Agricultural Engineering and Technology, University of the Philippines at Los Baños, College, Laguna, Philippines.

Development Forum Business Edition.

(Switzerland)

Development Forum Business Edition is again expanding bringing three new services into operation for the benefit of its worldwide readership. First is the monthly operational summary (MOS) of the Inter-American Development Bank. This, like the World Bank MOS, is included at no extra cost and gives details of the state of play every month of over 150 development projects from first mention to loan signature.

The second new service offers the procurement notices of another major bank, the African Development Bank. Opportunities to bid from the AFDB correspond to another US$ 423 million of development loans at this time with rapid future expansion foreseen. Like those from the World Bank and the IDB, the AFDB notices will appear in comprehensive and timely fashion.

The third service introduced is "Government · Notices". Opening the columns of the Business Edition to such notices means that business opportunities arising from an even wider range of financial sources can be included. Many development projects arise from bilateral agreements between governments and may not involve the major development banks. Information about these can now be included in Development Forum Business Edition thus promoting international competitive bidding and permitting a wider choice of participants.

Development Forum Business Edition is the fortnightly United Nations newspaper bringing subscribers full and up-to-date information on business opportunities arising from World Bank, Inter-American Development Bank (IDB), Asian Development Bank (ADB), and African Development Bank (AFDB) loans and from UNDP and other United Nations financial assistance to developing countries.

Subscription information is a available from:
Development Forum Business Edition.
Subscription Department
United Nations
CH 1211 Geneva 10
Switzerland
Development Forum Business Edition
Room E-1035
The World Bank
1818 H Street NW
Washington DC 20433
USA

Nebraska Tractor Test Reports and Summary Booklets

(U.S.A)

The reports are usually available within two months of the test termination date. They contain detailed data of the test.

The summary booklet appears once each year (usually January or February) and contains all those tractors which have been tested and are still available on the new tractor market. The summary booklet is less detailed than the full report.

For older tractor models, reports (from 1920) and booklets (from 1965) are available (booklets for as long as supplies last).

Price List for Reports and Booklets January 1, 1978

1. Test Reports	Prices
1-30 of the same report	15¢ a copy
31-100 of the same report	14¢ a copy
101-1000 of the same report	$13.00 per 100
Any number of different reports	15¢ a copy
2. Summary Booklets	
1-50 copies of booklets	$1.00
51-100 copies of booklets	.95
101-500 copies of booklets	.90

501-1000 copies of booklets .85
1001-2000 copies of booklets .83
2001-3000 copies of booklets .80
3001-4000 copies booklets .77
5000 or more copies of booklets .75

3. Mailing Costs
Small orders of booklets or reports 15¢ per mailing
Large orders will be billed (according to weight, zone and mailing preference).

4. Yearly Subscriptions
At $3.50 per year you can purchase a subscription to the Nebraska Tractor Test Reports. You will receive individual tests, as they are printed, and the Nebraska Tractor Test Data (Summary Booklet) at the end of the test season.

Subscription information is available from: The Agricultural Experiment Station, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, Nebraska, U.S.A.

Farm Power and Machinery Management

(U. S. A.)

Farm machinery management is concerned with the efficient selection, operation, repair and maintenance, and replacement of machinery. This text contains the latest information on machines and practice. Material new to this edition explains recent government regulations for operator safety, separate treatment for chemical application machinery, and updated data on the prices and use of farm machinery.

Written by Donnel Hunt. 7th ed., 1977 365 pp., ill., $11.95

Published by the Iowa State University Press, South State Avenue, Ames, Iowa 50010

The Economics of Tractors in South Asia – An Analytical Review

(U. S. A.)

Tractorization of agriculture in low-wage countries has been the center of one of the most virulent and emotional choice-of-techniques debate for the past 20 years. In particular, there are now available a large number of farm-level tractor surveys from practically every agro-climatic zone in the Indian subcontinent. The main effort of this paper is to assemble the studies and present their findings in a way which makes them comparable across agroclimatic zones.

It should be clearly noted at the outset that conclusions reached in this paper are conditional to the agroeconomic environment which is studied. What we observe on farms in the Punjab is caused by the agroclimate, the availability of land and irrigation, the farm sizes, and the factor prices. Conclusions from South Africa Asia are only transferable to those developing resions which have similar agronomic and economic environments.

Written by Hans P. Binswanger

Size: 22.5 cm x 15 cm, 96 pp, with paper cover

Published by Agricultural Development Council, 630 Fifth Avenue New York, N.Y. 10020

Computations for Studies of Soil Fertility and Fertilizer Requirements

(U. K.)

The procedures described in this book have been developed to derive bases for the use of fertilizers from the data of soil fertility research projects, both for the guidance of individual farmers and for the formulation of general recommendations for regions or countries considered as a whole.

The need for such bases, to plan the best use of fertilizers for a variety of situations has become particularly important in recent years because of a dramatic increase in world fertilizer prices, threats of fertilizer shortages and the continuing demand for agricultural development.

The book is especially directed to the needs of developing countries where soil fertility problems are both most important and most difficult to overcome.

Written by J.D. Colwell

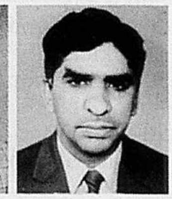
A4, paper covers, 297 pp., 1978, Post Free UK £12.50, Overseas £15.00

Published by: Commonwealth Agricultural Bureau, Farnham House, Farnham Royal, Slouth SL2 3BN, UK.

ERRATA

Vol. X, No.4, Autumn 1979.
p.67: What Losses at the Threshing and Winnowing Stages in title of article should read *Wheat* Losses at the Threshing and Winnowing Stages.

Co-operating Editors

B. K. Bala M.A. Mazed M. Gurung T. T. Pedersen G. B. Hanna Satish Chandra A. P. Sharma A. M. Michael

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 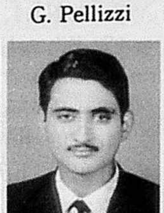    

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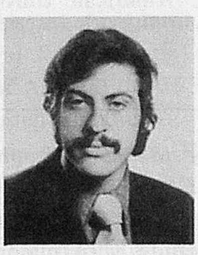
Chau Van Khe
Chairman, Agricultural Engineering Div. National Agricultural Center in Saigon, Ministry of Education Republic of Vietnam, 45 Chungde Saigon, Vietnam

New Co-operating Editors



Bassan A. Snobar

Date of Birth: November 13, 1943

Nationality: Jordan

Present Appointment:
Associate Professor in the Faculty of Agriculture at the University of Jordan.

Academic Degrees:
B. Sc. in Agricultural Engineering, Alexandria University (Egypt) 1967; M. Sc. in Agricultural Engineering: Michigan State University (U.S.A.) 1970; Ph.D. in Agricultural Engineering, Michigan State University (U.S.A.) 1973.

Professional Experience:
Research Assistant in Agricultural Engineering Department, Michigan State University and Colorado State University, from 1968 till 1973, Assistant Professor in the Faculty of Agriculture, University of Jordan 1974 to February 1979. Associate Professor Feb. 1979 to present.

Specific Assignment and Academic Field:
Teaching and Research in the areas of farm power and machinery, harvesting and post harvest handling, and physical properties of agricultural products.

Organization Memberships:
American Society of Agricultural Engineers.

Paris Andreou

Date of Birth : July 15, 1946

Place of Birth : Nicosia, Cyprus

Nationality : British

Address:

Business – Department of Agricultural Economics, Business and Extension, American University of Beirut, Beirut, Lebanon.

Education:

Pancyprian Gymnasium, Nicosia, Terra Santa College, (Grammar School), Nicosia, Cypurus. Catford College of Commerce, Promley, Kent, England.

Academic Qualifications:

Ph.D. in Agric. Economics and Agric. Marketing, School of Economic Studies, Faculty of Economic and Social Sciences, University of Leeds, England, June 1973.

M.A. (Master of Arts), in Agric. Economics and Agric. Marketing, Faculty of Economic and Social Science, University of Leeds, England, July 1970.

Dip. Econ. Devel. (Post Graduate-Diploma in Economic Development), University of St. Andrews, Scotland, July 1969.

H.N.D. in Business Studies (Higher National Diploma) City of Westminister Polytechnic, London, England, July 1968.

Dip. M. (Diploma in Marketing), June 1968. Issued by the British Institute of Marketing on Completion of ten three-hour papers written successfully.

Specializations and Areas of Research Interest:

Agricultural Economics, Rural Development, Agricultural Development; Marketing, Cooperatives, Economic Development.

Professional Qualifications:

The following qualifications have been obtained by passing successfully all written papers required and fulfilling all academic and experience requirements. In addition, holding oral interviews with the Institutes Directors.

G. Inst. M. (Graduate of the Institute of Marketing), London, England, 1968.

M. Inst. M. (Member of the Institute of Marketing), London, England, 1972.

A. M. B. I. M. (Associate Member of the British Institute of Management), London, England, 1972.

M. R. I. I. A. (Member of the Royal Institute of International Affairs, U.K.), England, 1973.

Has Worked in or Made Prolonged Visits to:

Cyprus, Greece, Italy, Rhodes, France, Yugoslavia, Belgium, Wales, England, Austria, West Germany, Canada, Scotland, Kenya, Pakistan, Bangladesh, Bubai, Lebanon, Jordan.

University Teaching and Research Experience: 1970–1979

Research Scholar in Economic Studies, 1970–73 at the School of Economic Studies, Leeds University, England.

Assistant Professor in Agricultural Economics and Marketing, 1974–76, Department of Agricultural Economics, University of Manitoba, Winnipeg, Manitoba, Canada.

Senior Lecturer in Agricultural Economics, Marketing and Economics Development, Department of Agricultural Economics, University of Nairobi, Kenya, 1976–77. M. Sc. Programme Organizer 1976–77.

Senior Lecturer in Agricultural Economics, American University of Beirut, 1977–79.

Associate Professor in Agricultural Economics American University of Beirut from April 1979.

Chairman, Department of Agricultural Economics and Business (12 Dec. 1978– Dec. 1981). American University of Beirut.

Reynaldo M. Lantin

Date of Birth : April 18, 1939.

Place of Birth : Batangas, Philippines

Nationality : Filipino

Educational Attainment:

1968, Ph. D. in Agricultural Engineering with specialization in farm power and machinery and with minor in mechanical engineering and statistics at Iowa State University, Ames, Iowa, U.S.A.

1965, M. S. in Agricultural Engineering with major in farm power and machinery at University of the Philippines, College of Agriculture.

1959, B. S. in Agriculture, cum laude with major in agricultural engineering at University of the Philippines, College of Agriculture.

Professional Experience:

Dean, Institute of Agricultural Engineering and Technology, U. P. at Los Baños, October 1, 1978 to present.

Philippine Counterpart to the

Project Manager, Regional Network for Agricultural Machinery, sponsored by UNDP, UPLB, College, Laguna, June 1, 1978 to present.

Acting Dean, Institute of Agricultural Engineering and Technology (INSAET), UP at Los Baños, October 1, 1976 to September 30, 1978.

Chairman, Department of Agricultural Machinery Engineering and Technology, INSAET, UPLB, July 25 – September 30, 1976.

Associate Professor, Institute of Agricultural Engineering and Technology, U. P.' at Los Baños, September 1, 1977 to present.

Assistant Professor of Agricultural Engineering, U. P. at Los Baños, College of Agriculture and Head, Farm Power and Machinery Section, Department of Agricultural Engineering, 1968 to 1974.

Farm Mechanization and Transport Expert, in connection with the ADB-financed East Java Sugar Project, Indonesia, 1974–1976.

Reserach Scholar, The International Rice Research Institute, 1962–1964.

Research Instructor in Agricultural Engineering, U. P. at Los Baños College of Agriculture, 1961–1962.

Assistant Instructor in Agricultural Engineering, U. P. College of Agriculture, 1959–1961.

Student Laborer U. P. College of Agriculture, April–May, 1956.

nternational Experience:

Philippine delegate to the First Consultation Meeting on the Agricultural Machinery Industry, Stresa, Italy, 15–19, October, 1979.

Vice-Chairman, Committee on Agricultural Engineering, International Society of Sugar Cane Technologists, 1979–1980.

Team Leader, Agricultural Engineering, Philippine Council for Agriculture and Resources Research, January 1, 1979 to present.

Coordinator, Subnetwork Activity on Rice Transplanters, Regional Network for Agricultural.Machinery.

Head, Philippine delegation to Regional Preparatory Meeting on Agricultural Machinery sponsored by UNIDO, Manila, May 24–29, 1979.

Member, Steering Committee for the Study on "Socio-Economic Impact of Farm Mechanization", a Central Bank 9 the Philippines, World Bank Study, 1978 to present.

Participant, Workshop on "Energy Research Planning", East West Center, Honolulu, Hawaii, May 6–19, 1979.

Participant, Seminar on "Mechanization of Small Farms", sponsored by ASDAC Food and Fertilizer Technology Center, Taipai, Taiwan, September 18–24, 1978.

Chairman and Philippine Representative to the Regional Network for Agricultural Machinery Joint Sub-Network/Technical Advisory Committee Meetings, Los Baños, Laguna, October 17–19, 1978: September 26–28, 1979.

Participant, German Foundation for International Development Study Tour, West Germany, July 29–August 14, 1978

Government Representative and Chairman, Sub-Committee Meeting of the Regional Network for Agricultural Machinery, UN/ESCAP, University of the Philippines at Los Baños, June 19–21, 1978.

Government Representative, Technical Advisory Committee Meeting, Regional Network for Agricultural Machinery, UN/ESCAP, Bangkok, Thailand, January 16–20, 1978.

Session Chairman, National Tripartite Conference on Improving Working Conditions and Environment. Sponsored by the Ministry of Labor and International Labor Organization; Manila, December 12–14, 1977.

Participant, 4th Southeast Asia Seminar for Agricultural Education: Training of Manpower and Research for Experiment and Practice in Farm Machinery, Tokyo, Japan, December 4–10, 1976.

Farm Mechanization and Transport Expert, East Java Sugar Project, Indonesia, 1974–1976.

Participant, Joint UNDP/IRRI Expert Group Meeting on the Design and Manufacture of Wetland (Rice) Mechanization, Harvesting and Threshing Machinery in Developing Countries of Asia and the Far East Region, March 12–17, 1973.

Participant, Seminar on "Application of Systems Analysis in Research on Agricultural Machanization", sponsored by the Southeast Asia Development Advisory Group (SEADAG), San Francisco, California, U.S.A., September 20–21, 1971.

Resource person in national and international training programs:

a. Fram machinery management – U.P. Institute of Small Scale Industries
b. Mechanization of multiple cropping – IRRI
c. Rice production machinery – IRRI
d. Legume production machinery – U.P.L.B.
e. Harvesting, Threshing and Cleaning Rice – UNDP
f. Tillage practice – UPLB

Participated in the annual regional and national conventions of the American Society of Agricultural Engineers, U.S.A., 1964–1968, 1971.

Visited Agricultural Engineering departments in U.S.A., Japan and Taiwan, 1971. ■■

A NOTE TO AMA CONTRIBUTORS

The Editorial Staff of the AMA requests contributors of articles for publication to observe the following editorial policy and guidelines in order to improve communication and to facilitate the editorial process :

Criteria for Article Selection

Priority in the selection of articles for publication is given to those that —

a. are written in the English language ;
b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100 word-abstract, preferably preceding the main body of the article ;
f. are typewritten, double-spaced, about 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.

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c. The AMA does not pay for articles published. However, the writer(s) is given 10 free copies of the AMA issue wherein the article appears, including 50 off-prints of the article so published.

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b. Contributors of articles for the AMA for the first time are required to attach a passport-size ID photograph (black and white print preferred) to the article. The same applies to those who have contributed articles three years earlier. In either case, ID photographs taken within the last 6 months are preferred.
c. The article must bear the writer(s) name, title/designation, office/organzation, nationality and complete mailing address.

Format/Style Guidance

a. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
   i) a brief and appropriate title ;
   ii) the writer(s) name, designation/title, office/organization ; and mailing address ;
   iii) an abstract following ii) above ;
   iv) body proper (text/discussion) ;
   v) conclusion/recommendation ; and a
   vi) bibliography
b. The pages must be numbered (Arabic numeral) successively at the top center. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e. g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top, center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e. g., "Figure 1. View of the Farm Buildings".
c. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
d. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
e. Express measurements in the metric system and crop yields in metric tons per hectare (mt/ha) and smaller units in kilogram or gram (kg/plot or g/row).
f. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
g. Convert national currencies in US dollars and use the later consistently.
h. Round off numbers, if possible, to one or two decimal units, e. g., 45.5kg/ha instead of 45.4762kg/ha.
i. When numbers must start a sentence, such numbers must be written in words, e. g., Forty-five workers . . . , or Five tractors . . ." instead of 45 workers . . , or, 5 tractors.

BACK ISSUES

(Vol. 10 No. 1, 1979~)

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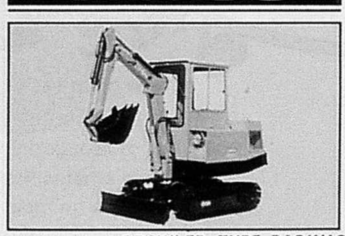

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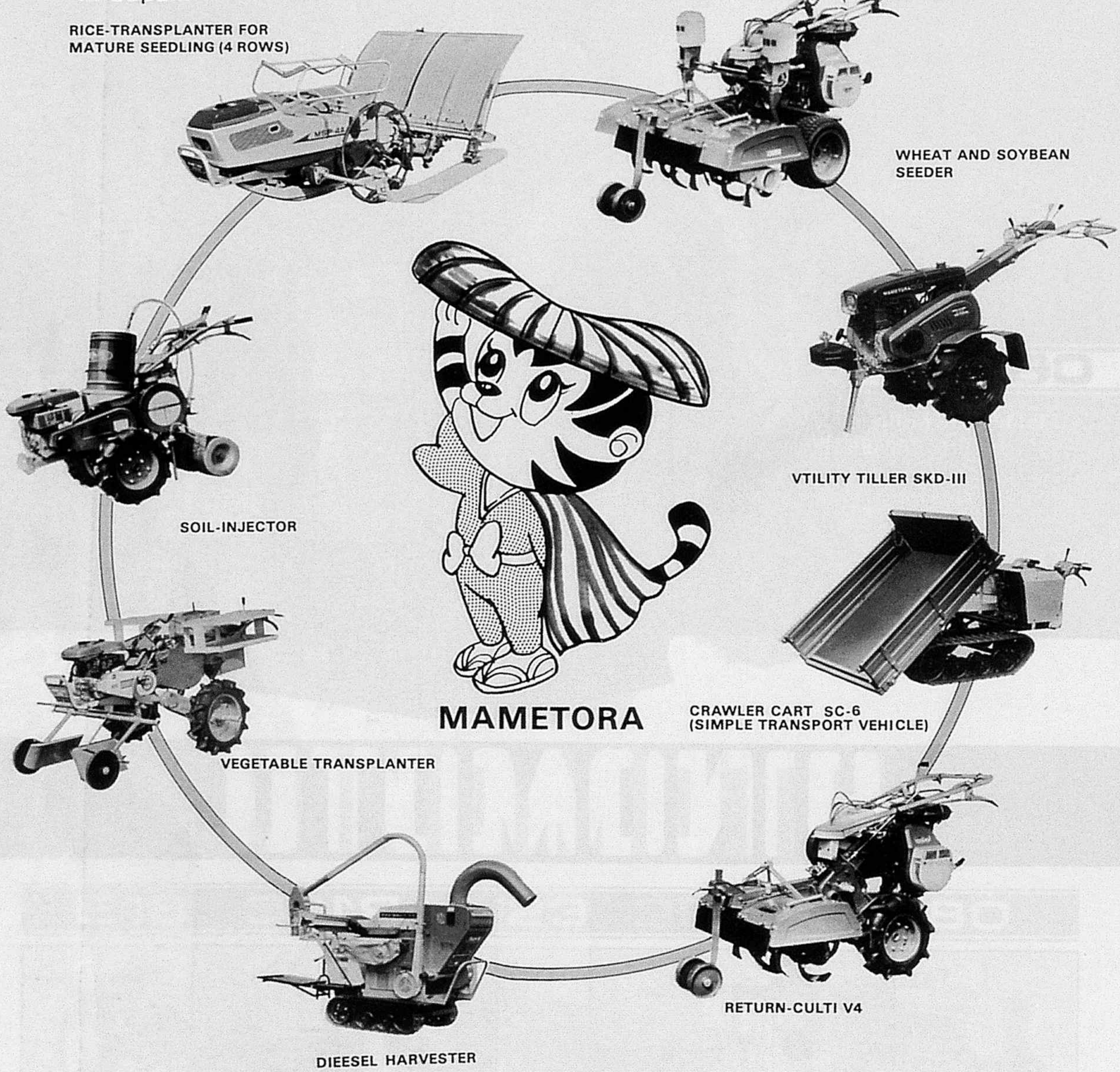

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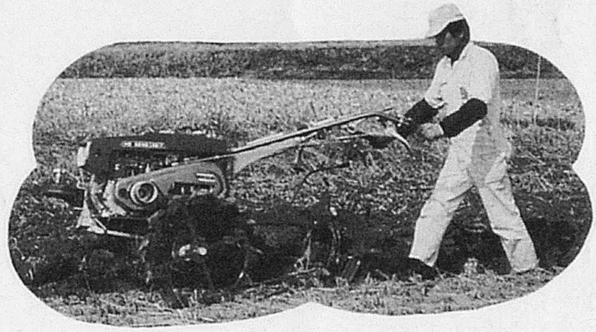
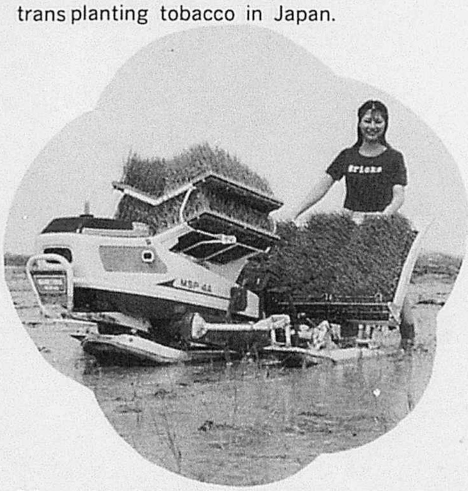


Plowing operation by Mametora Tiller.



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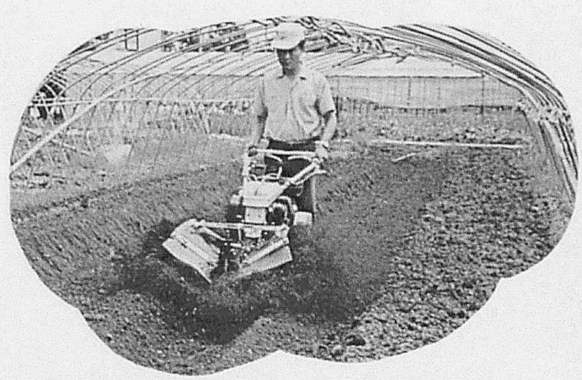

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