International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL. VIII, NO. 2, SPRING 1977

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

ISEKI's mechanization system for farm works

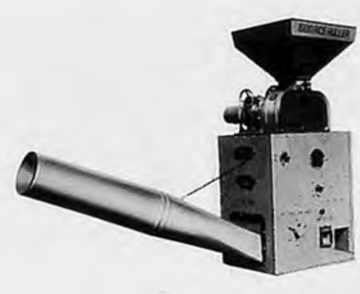
Rice Transplanting

Rice Transplanter

Harvesting (Reaper Binder)

Dryers ITC series

Thresher D series



Rice Huller (all steel type)

4-wheel driven
Tractor TXseries

4-wheel
Tractor TS series

Let ISEKI play the main role on your farm today!

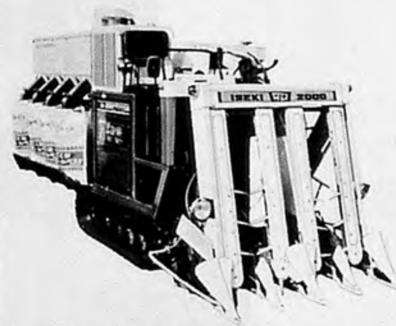
Power Tiller KC series

Power Tiller KS series

Power Tiller AC series

Reaper Binder RS series

Harvesting (Combine Harvester)



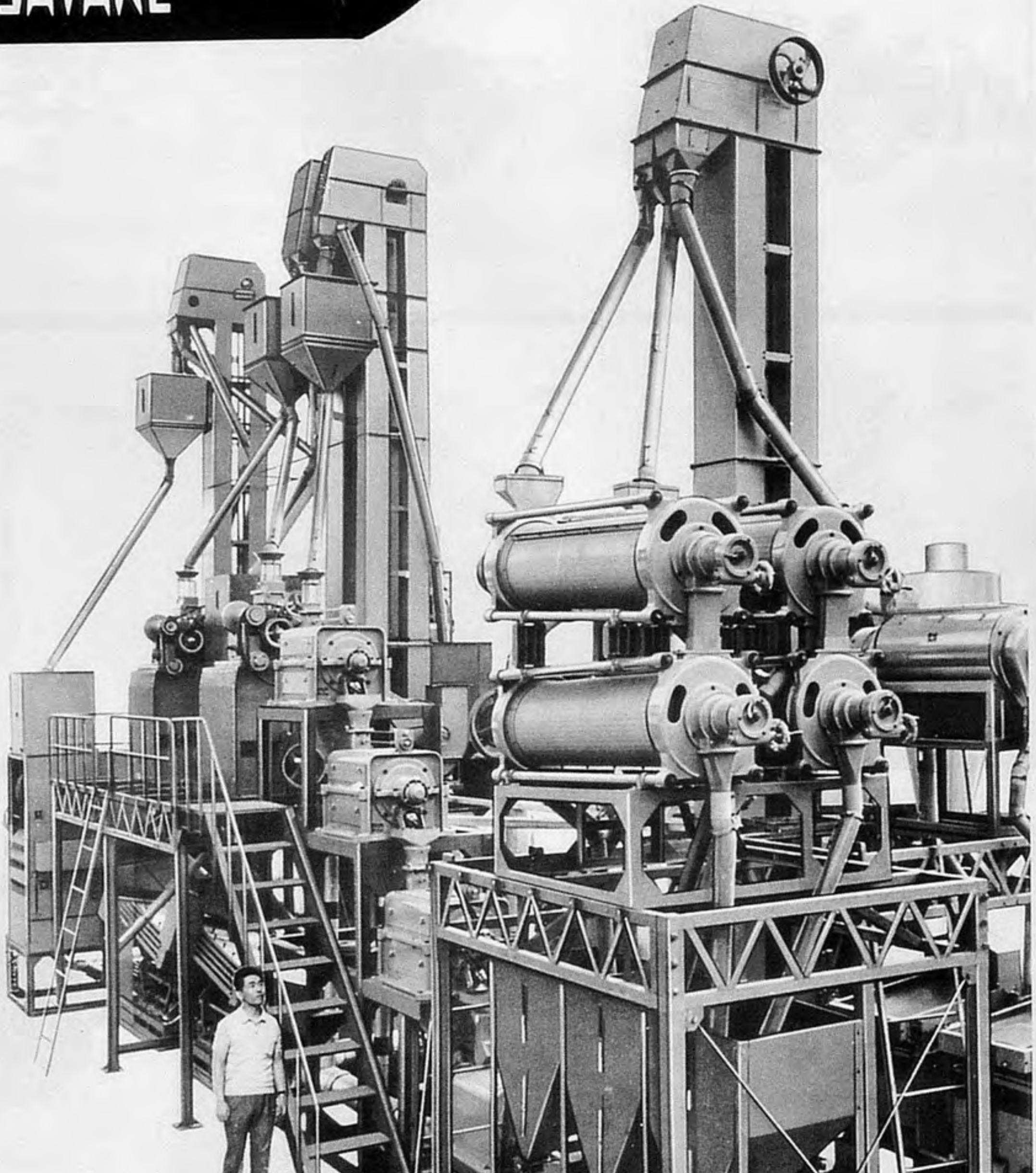
Combine Harvester HD series

Rice Polisher

FARM EQUIPMENT & MACHINERY

ISEKI AGRICULTURAL MACHINERY MFG. CO.,LTD.

Overseas Department
1-3, Nihonbashi 2-chome, Chuo-ku, Tokyo, 103 Japan
Cable Address: ISEKIRICE TOKYO
Telex: 222-2821, 222-2822
Phone: Tokyo 271-1271



4-TON TYPE RICE MILLING PLANT

International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL. VIII, NO. 2, SPRING 1977

Edited by

YOSHISUKE KISHIDA

Published by

Farm Machinery Industrial Research Corp.

Cooperated by

Shin-Norinsha Co., Ltd.

The International Farm Mechanization Research Service

TOKYO . JAPAN

Yoshikuni Kishida, Publisher
Yoshisuke Kishida, Director
Morio Kamijo, Advisor

SHIN-NORIN Building
7,2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101 Japan
The address of cooperators is same to above.
Printed in Japan

This is the 15th issue from the first issue, Spring 1971.

Preface

It has already passed six years since AMA was first published and also one year since it was changed to quarterly publication. Thanks to the help of many writers and readers, it has obtained a high reputation in the world as an important medium for specialists of agricultural mechanization.

At present, twenty-four co-editors in twenty countries including me, chief editor, participated in the publication of AMA. We have received quite a few letters regarding a various kind of problems from many countries. Recently, agricultural mechanization in developing countries is focussed on as the most important problem.

Not a few people discussed the problem of unemployment, due to the mechanization about ten years ago. However, this opinion almost disappeared now and the need for the promotion of the agricultural mechanization in developing countries is increasing more than ever. There are requirements of more technical and precise information to be offered and we have to improve AMA to meet these requests.

Although the standard of living in developing countries is getting high, the disparities between those countries and advanced countries is getting large on the other hand. Through communication, we have to approach the objective to realize comfortable and peaceful life of mankind whose population is expected to increase more and more on this

We would appreciate for your contribution and help from now on. We also welcome a new co-editor from other countries.

April, 1977

Chief Editor
Yoshisuke Kishida

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA

Vol. VIII, No. 2, Spring, 1977

Mechanized Tillage—Dryland Farming in Iraq

by
Md. S.U. Choudhury
College of Engineering

Abdullah A.K.Al-Fakhry,
Laith K. Ismail and
Karekin Y.Vartanian
College of Agriculture

Mosul University
Mosul, Iraq

Certain patterns of land use have evolved throughout history that characterize agriculture in the dry regions of the world. These patterns are extraordinarily similar over very wide areas despite the great diversity due to various combinations of topography, soil type, and climate.

The dryland areas of Iraq are characterized by semi-arid Mediterranean climate (1) with scanty precipitation ranging from 250 mm to 500 mm in the cereal belt—almost all falling in the months from October to May including little or no snow, and is followed by hot dry rainless summer. Clear skies predominate the days in the rainy season and permit a large amount of the solar energy to reach the earth. But a large portion of this energy is lost by radiation back to the atmosphere and to the space while a small portion is being used for warming the soil and for evapotranspiration by plants. Because of the northern mountains and partly due to the high convection during the day, there are frequent and strong winds. The usually sparse vegitation is not capable of reducing such air movements and thus the usual result is soil erosion.

The Northern part comprising Arbil, Sulaimanya, Dohuk, and Nineveh areas is the most important dry farm of Iraq (**Fig. 1**) In and around this area about 75% of the country's wheat and barley crops are grown (2). The total cropped area of this region is about 4,000,000 hectares (3) and constitutes a major part of the total cereal area of the country (**Table 1**). Sheep husbandy based

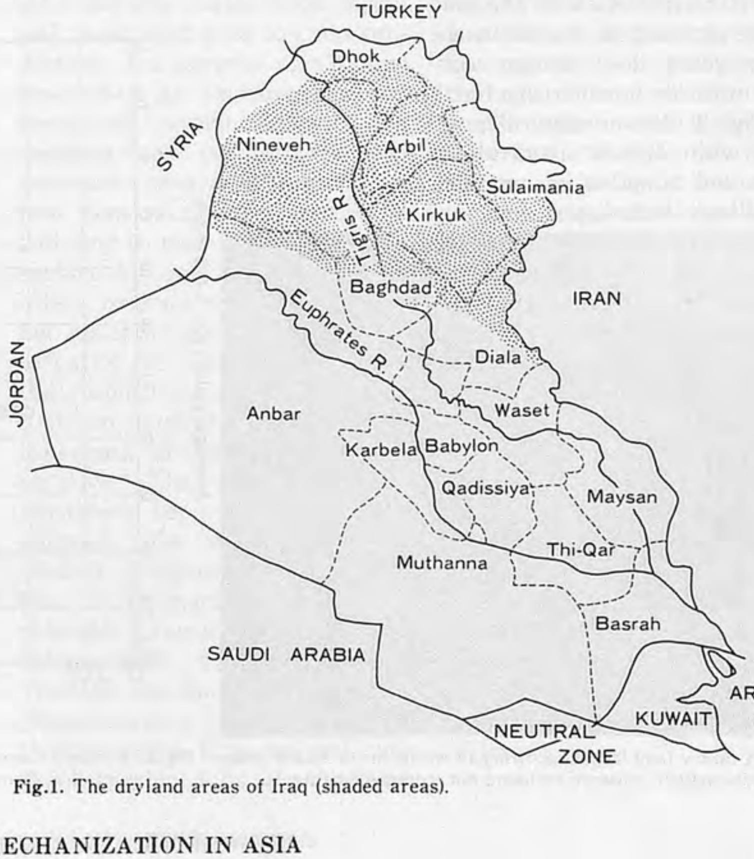


Fig.1. The dryland areas of Iraq (shaded areas).

on natural pastures is another equally important farming enterprise in this area. The crop production per unit area is very low (**Table 1**) due mainly to the lack of technical knowhow of the farmers about modern methods of dryland farming and secondly due to insufficiency and irregularity of rainfall. The rainfall here not only fluctuates as to quantity and distribution within the one season, but aluo from year to year (**Table 2**).

The soils of thıs area are reddish brown and calcareous in nature with a zone of carbonate accumulation at depths of from 30 to 50 cm (4). The stability of the soil structure is mainly dependent on the aboundance of annuals and their growth and decay season by season. These excellent rainfed soils are not salty and can be made to produce several times their present output (5) with meticulous use of tillage machines and techniques in combination with other mathrial and technical inputs.

The present crop-fallow rotation by the farmers with the land largely growing to weeds in the fallow years does neither conserve moisture nor increase fertility (**Fig. 2**). Better cultural practices with stricter control of weeds and adoption of appropriate tillage techniques and ma-

Table 1. Net area harvested with wheat and barley, production and percentages of area and production for Northern Iraq (rainfed arid region) as compared to whole of Iraq.*

Year	Area (hectare × 1000) Total in Iraq (1)	Northern Iraq Region	% of Total (1)	Production (ton × 1000) Total in Iraq (2)	Northern Iraq Region	% of Total (2)	Average kg./hect.	Average in Iraq kg./hect.
WHEAT								
1970/1971	948.30	531.63	56	822.3	304.5	37	572.8	867.1
1971/1972	1914.60	1429.30	75	2625.3	1727.8	66	1208.8	1371.2
1972/1973	1678.80	1207.95	72	957.0	340.0	36	271.5	570.1
1973/1974	1655.98	1231.03	74	1338.9	794.2	59	645.2	808.5
1974/1975	1447.75	1041.85	72	845.4	443.9	53	426.1	583.9
Average	1529.09	1088.35	71	1317.78	722.08	55	663.5	861.8
BARLEY								
1970/1971	396.08	72.30	18	432.4	15.4	4	710.9	1091.7
1971/1972	725.55	349.13	48	979.6	418.5	43	1198.7	1350.1
1972/1973	548.85	229.88	42	461.8	84.3	20	366.7	841.4
1973/1974	546.23	216.10	40	532.8	161.9	30	749.2	975.4
1974/1975	598.23	283.80	47	437.0	151.7	35	534.7	730.5
Average	562.98	230.22	41	568.72	173.56	31	753.9	1010.2

(*Source: Republic of Iraq Report of the Third Conference for the Arabic Field Crops held in Baghdad from May 8 to 13, 1976.)

Table 2. Precipitation amounts (mm) at Hammam Al-Alil, Iraq.*

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1968-69	9.5	35.5	85.6	144.3	23.0	117.7	67.4	35.4	—	518.4
1969-70	16.6	23.3	61.4	143.1	7.9	59.6	8.7	0.5	—	321.1
1970-71	—	28.6	28.6	1.9	12.0	51.9	130.9	0.6	—	254.5
1971-72	1.7	41.0	54.6	49.5	77.1	60.3	128.3	31.9	5.2	449.6
1972-73	18.5	31.5	49.0	39.8	54.0	17.3	19.9	27.0	—	257.0
1973-74	0.1	14.2	19.2	96.6	78.0	161.5	35.5	6.0	—	411.1
1974-75	—	32.8	39.7	47.5	102.9	8.8	70.2	9.1	—	306.0
1975-76	—	32.8	39.7	52.5	78.0	80.0	43.4	16.5	—	342.9

(*Source: Weather Station, College of Agriculture and Forestry, Hammam Al-Alil, Iraq).

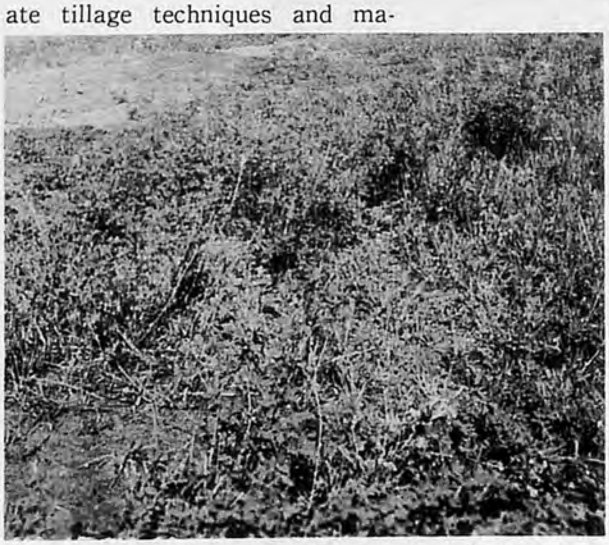


Fig.2. A fallow land largely growing to weeds in the fallow years does neither conserve moisture nor increase fertility.

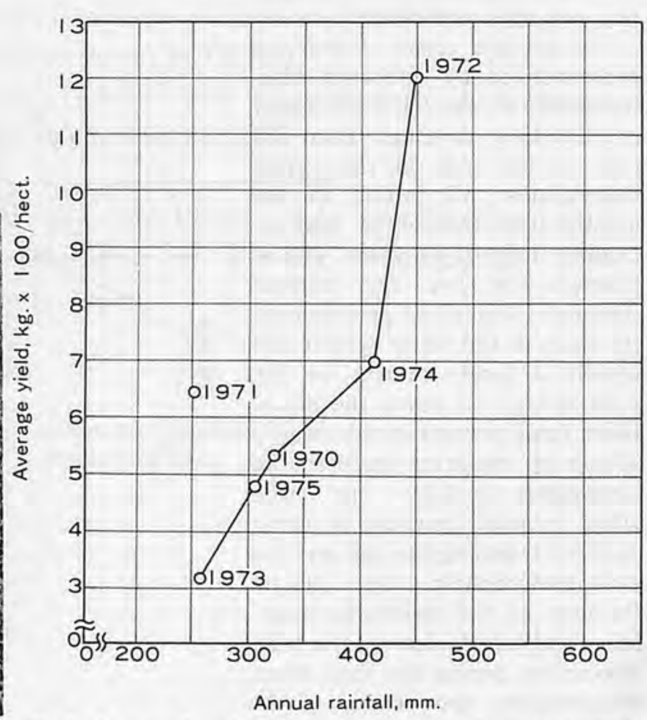


Fig.3. Average Cereal (wheat and barley) yield versus average rainfall at Hammam Al-Alil, Iraq.

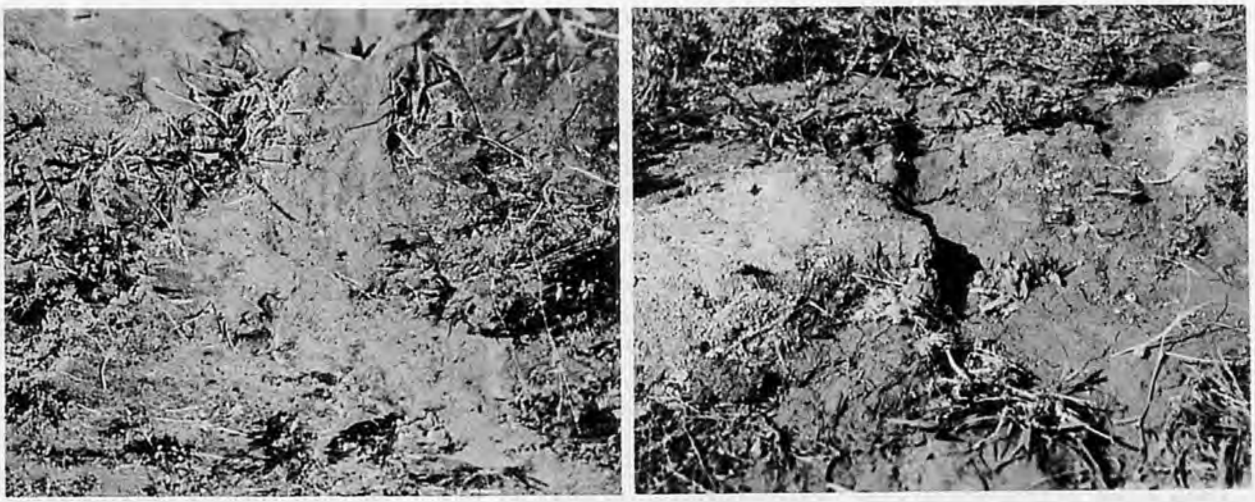


Fig.4. A fallow land with sparse natural vegetation affords very little protection to soil erosion. Picture at left shows run-off and erosion while the right picture shows erosion and formation of a gulley.

chines designed for maximum moisture conservation and soil protection can increase acreage production.

The soil moisture content is of major importance in arid regions. The soil at the root zone of plants constitutes a moisture reservoir that is vital to agriculture. Water that infiltrates into this region can be stored for fairly long periods with relatively little loss. The amount of precipitation taken in by the soil depends on infiltration and run-off. By increasing infiltration and reducing run-off, the amount of water stored in the soil can be increased for beneficial results of crop production. The amount of precipitation is, therefore, the limiting factor. Increase in the amounts of precipitation resulted in increase in the acreage production in Northern Iraq (**Fig. 3**).

In general, the drier the region the greater is the havoc caused by the rainfall. The sparse natural vegetation affords very little protection to soil against wind and rainfall. Some incidences of high rates of rainfall which occurs in arid regions rapidly reduces the infiltration rates while the run-off is increased. The result is water erosion of the soil (**Fig. 4**).

The agricultural engineers and agronomists working in dryland conditions have to make best use of the available soil and water regimes in order to maximize agricultural production. To achieve this various tillage techniques are practiced in dryland regions. Some typical tillage techniques are contoring is slope land, subsoiling, and mulching.

Most tillage operations have beneficial and detrimental effects in respect of improvement of soil structure and conservation of soil and water and thus to crop production. The purpose of a tillage practice is to improve the soil conditions to plant growth, soil aeration, soil permeability, soil inversion, seed bed preparation, root penetration, and weed control, and to maintain the soil and surface in such a condition that offers resistance to soil erosion but assist in infiltration and conservation of water. To achieve these objectives proper choice of tools/implements, methods and timeliness of operation are imperative. The tillage machine must have been designed for the purpose. The shape, size and method of operation of the tool head of the machine have a considerable influence on the kind of tillage that it will produce. Whether the machine is a disc, a ploughshare, a chiesel, or a cultivation point, it is the soil condition produced by the machine that affects the plant growth and yield in dryland farming. The crop yield is directly dependent upon the improved conditions of infiltration and moisture conservation of the limited precipitation.

The precipitated water is lost by surface run-off, through evaporation, by infiltration beyond root zone, and by transpiration by plants. The surface run-off can be reduced and infiltration into the soil can be increased by keeping the soil surface rough through tillage means which would resist crust formation. Care should be taken not to overtill the soil rather a balanced tillage technique should be adopted because when the soil surface is dry, the loss of water is more as water moves through porespaces as vapour and evaporation is greater.

The above discussion evidently shows that threre is a need to evaluate the suitability of tillage techniques for mechanical dryland farming in terms of soil and water conservation. The objective of this article is to make a general review of the tillage practices that have substantially benefited rainfed dryland farming and in view of this recommend some practices for dryland areas of Iraq.

Deep Ploughing

Deep ploughing adversely affects the moistre conservation, an extremely important objectis in dryland farming-especially if the tilled soil layer is inverted. Depth of ploughing has also a marked effect on costs: for every additional centimeter of increased depth, the amount of soil to be moved or turned is increased by about 150 tonnes per hectare. Deep ploughing was found not to increase wheat yield significantly (6).

Deep ploughing, however, has also some beneficial effects for dryland agriculture in respect of sanitation, improvement of soil structure and control of perennial weeds. In order to achieve these beneficial results the soil has to be completely dried out after deep ploughing which requires good soil management and about three months drying period. Experience showed that deep ploughing helps to maintain a high level of yield and a time interval of five to six years between one deep ploughing and the next gives a proper balance between the cofits of operation (7). Unless otherwise needed as such, deep ploughing is not recommended for dryland farming in Iraq.

Subsoiling and 'Vertical mulching'

Subsoiling in dryland farming is carried out for breaking up compacted or cemented soil layers in order to improve root penetration, aeration, and above all, water penetration. To be effective, it must be done in dry soil otherwise the soil may smear and become compacted along the track of the subsoiler shanks.

Unfortunately, the effects of subsoiling is not long lasting since the slots left by the subsoiler close and become sealed off within few months. In order to prolong the beneficial effects, 'vertical mulching' is coupled with subsoiling whereby the slots are filled by some suitable organic material during subsoiling. A conventional subsoiler can be modified by attaching a flail-type chopper to the unit which will chop the organic material in order to introduce them into the slots opened by the subsoiler and thereby keep them open and functioning for longer periods.

Stubble Mulch Farming

The traditional methods of 'clean tillage' when adopted indiscriminately in dryland regions may produce disastrous effects, mainly by increasing erosion. Under conditions of limited rainfall clean fallow is kept sometimes and maintained by frequent cultivations to keep it weed free. The result is a pulverized surface soil. This degraded and umprotected topsoil is then easily eroded by wind and rain. The stubble mulch farming has, therefore, been developed bo keep the soil surface protected for all time either by leaving the crop residue or by a growing crop.

The rates of erosion in a stubble mulched surface was found to be about one-fifth of those resulting from clean tillage with mouldboard ploughing (8). Furthermore, the stubble mulch tillage improves moisture conservation by reducing the rates of evaporation and run-off. It has been found that stubble mulch tillage significantly improved the moisture conditions in the root zone when compared with disc tillage (7).

The problems of stubble mulch farming due to residues left on the surface, interference during seed bed preparation, weed control and sowing operations could be met by using special equipments rather than by conventional tillage and sowing machines such as 'sweep cultivators' or 'blade cultivators'. For better

Fig.5. Deep ploughing by disc plough (or by mouldboard plough) adversely affects moisture conservation.

Fig.6. A spring loaded cultivator (usually called "Kharmasha" in Iraq) is a mostly used tillage tool but not economic for dryland farming.

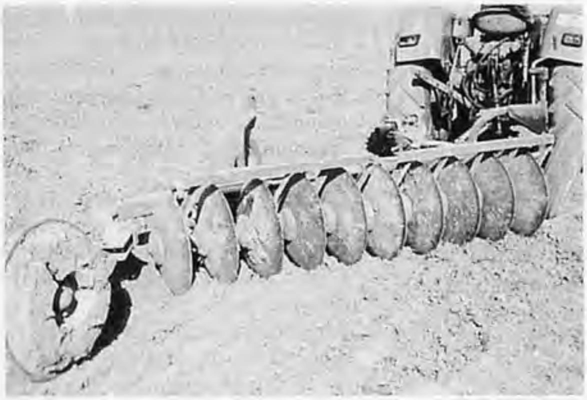


Fig.7. A disc-tiller or one-way tiller—an economic and widely used tillage tool for dryland farming is yet to be popularised in Iraq.

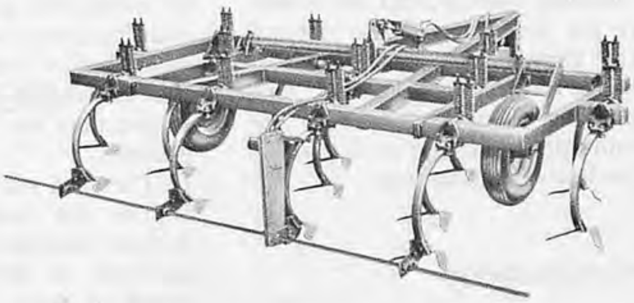


Fig.8. A rod weeder with attachment cuts off roots and closes the top layer of soil and controls weed as well as help prevent moisture loss.

weed control a 'rod weeder' may be used which is developed for dryland farming. The rod weeder operated at a depth of 10 cm compacts the sub-surface and moves clods and weeds to the surface.

Minimum tillage

Recent research has shown that frequent tillage operations are rarely beneficial, and frequently detrimental, in addition to being costly. Frequent uses of heavy equipment damages the soil structure and increases the soil compaction. These problems are more acute on soils having relatively little organic material content (9). In arid regions frequent tillage affects both water penetration and evaporation either by compaction or due to overpulverisation. Considerable emphasis, has, therefore, been directed towards reducing tillage operations to a minimum.

The success of minimum tillage methods depends on a number of factors such as soil, climate and cultural requirements. In addition, the production potential of such a method under a particular local condition require proper research studies.

Minimum tillage may be defined as a method of reducing tillage to a munimum necessary for ensuring a good seed bed, rapid germination, a satisfactory stand, and favourable growing conditions. Two complementary approaches have been evolved in order to achieve objectives: (i) to omit any tillage operation which contributes less than its cost for increased productivity, i.e. whose efficiency of production is less than its cost; and (ii) to combine farming operations.

Minimum tillage has become practical and economical due to the development of special equipment for combined tillage and sowing operations, and for the enormous progress in chemical weed control, both selective and general, which has rendered superflous many tillage operations previously indispensable. Minimum tillage may give as good as or even better yields than the conventional methods. The yield of maize obtained with minimum tillage was found to be even greater in years of low rainfall than in years of heavy rainfall (10).

The favourable results of minimum tillage are ascribed to improved soil physical conditions, higher rate of infiltration, less soil resistance to root penetration, and less soil compaction. Indirect effects such as fewer weeds, more root penetration and growth, better vegetative development and less lodging have been found with minimum tillage practices (11, 12). About two to three years are required before favourable effects of minimum tillage are fully appreciated and apparent (7).

Some of the minimus tillage practices that are developed by combining farming operations are:-

(i) Plough-planting: In this case a plough and a planter are pulled by a tractor and the seed row is made on the furrow slice in one operation. The area between the rows remains rough which minimizes the chance of weed germination.

(ii) Till-planting: A disc-tiller planter planter is generally used or a specially developed till-planter may be used. In case of a disc-tiller the seed is planted in the furrows made by the disc after it goes through seed tubes. In case of till-planter a seed bed is prepared and two rows of seed is planted in one operation.

(iii) Wheel-track planting: In this case the seeds are planted along the wheel track which is considered as a seed-bed. Additional wheels are fitted on the tractor so that four rows may be planted at a time. The planting is done as usual and after the field is prepared. The experiments show that tractor wheels make a firm satisfactory seed bed on cloddy soil ensuring rapid and even germination. The soil between the rows remain rough and loose and is favourable for moisture absorption, thus reduces runoff. Weeds lie dormant in the loose soil. Experiments show that wheel track planting saves 40% of tillage costs (13). Experience indicates that optimal soil moistre for ploughing is also optimal for germination. Therefore, for better results ploughing and planting should be done in the same day so that the top soil is not dry when planting.

Recommendations

Tillage operations should be reduced to the absolute minimum without reducing the efficiency of production. The detrimental effects of tillage can be reduced to a bare minimum by alternating different methods fo tillage and applying each method under the conditions in which its beneficial effects are maximized. An integrated and best approach is a rotation of tillage operations with crop rotation. In any case the benefits should balance or exceed the costs of operation for any new tillage practice or combination of practices.

The concept of minimum tillage appears very attractive for Iraq since there is a possibility of reducing the costs and also gaining benefits from the standpoint of soil and moistre conservation. Investigations should be conducted to find the best tillage practice for the particular regions of Iraq so that optimum crop production is achieved with available soil and moistre conditions.

Some guide lines are given below on the basis of analysis of practices:

i) Timeliness is very important as such land preparation and planting should be done, if possible, before rainy season so that continuous rain during the season may not delay such operations.

ii) The crop residues should be left on the land as much as possible specially on the fallow land and it should not be allowed to graze. Strict control of weed should be followed for all cases.

iii) Terracing and contouring in slope land must be adopted for both soil and water conservation.

iv) Minimum tillage practice should be adopted wherever possible. Research should be conducted in this direction.

REFERENCES

1. Brichambout, G. Perrin de. Similarities and differences in worldwide dryland farming. Proceedings of International Conference on mechanized dryland farming held in 1968 at Moline, Illinois, USA, 1970.
2. Tamimi, S.A., and Al-Fakhry, A.K. Some observations on crop production in rain-fed and irrigated areas of northern Iraq. Publ. No. 21, United Nations—FAO/University of Mosul, College of Agriculture and Forestry, Hammam Al-Alil Iraq 1973.
3. Al-Fakhry, Abdullah K. Improvement of dryland farming in Northern Iraq. Paper presented at the Scientific Conference on 'Recent Stages and Prospects of Agricultural Mechanization in developing countries'. Leipzig, GDR, July 1st—10th 1974.
4. Burringh, P. Soils and Soil conditions in Iraq. Ministry of Agriculture, Baghdad, Iraq, 1960.
5. Clawson, M., Landsberg, H.H., and Alexander, L.T. The Agricultural Potential of the Middle East. American Elsevier Pub. Co., Inc. N.Y. 1971.
6. Al-Fakhry, Abdullah K. et. al. The effect of depth of plowing on moisture depleting from the soil as reflected on wheat yield. Project Code No. FC2.2/71. Applied Agricultural Research Centre, College of Agriculture and Forestry, Mosul University, Hammam Al-Alil Iraq.
7. Arnon, I. Crop production in dry regions. Vol. I Leonard Hill, London, 1972.
8. Zingg, A.W., and Whitefield, C.J. Stubble-mulch farming in the western states. Tech. Bull. U.S. Dept. Agric., 1166, 56 pp. Illustr. 1957.
9. Free, George R. Minimum tillage for soil and water conservation. Agric. Engg. 41, 96-9, 103, 1960.
10. Doren, D.M. Van, and Ryder, G.J. Factors affecting use of minimum tillage for corn. Agron. J., 54, pp. 447-50, 1962.
11. Mayer, L.D., and Mannering, J.V. Minimum tillage for corn: its effects on infiltration and erosion. Agricultural Engg., ASAE, USA, 1961.
12. Rao. A.A. Swamy, Hay, R.C., and Bateman, H.P. Effects of minimum tillage on physical properties of soils and crop response. Trans. Am. Soc. Agr. Engrs., 3 (2), 8-10, 1960.
13. Peterson, A.E., George, O.K., Murdick, S.T., and Petersen, D.R. Wheel track corn planting, Circ. Wisc. Ext. Serv., 559, 1972.

■ ■

Mechanizing the Sugar Industry in the Philippines

by
Edilbert A. Uichanco
Vice President
Tractor and Implement Division of
G.A. Machineries, Inc.,
1200E. Delos Santos Avenue,
Quezon City, Philippines

The sugar industry is the most mechanized sector of Philippine agriculture. By and large, however, mechanization in cane production is limited to tillage—specifically plowing and harrowing. The industry still has a long way to go to achieve full mechanization and increased efficiency.

In the Philippines, the cost of producing sugar is one of the highest in the world in spite of our so-called low labor costs. This is partly due to low yield, and inefficiency in most aspects of production. Having enjoyed a premium market in the United States for so long has made our cane farmers complacent. Now that we are competing in the open market, the sugar industry must start modernizing its methods to increase yield and lower costs.

Several phases in the field production cycle can stand improvement through mechanization. These include tillage, crop care, land forming and drainage, irrigation, harvesting and loading, transport, and handling crops residue. In the following discussion, I will touch only on aspects of these operations which can immediately be modernized. I don't propose complete mechanization at the outset but rather a gradual but rational change in our methods.

Experience tells us that we can't adopt all the practices and equipment used in countries like Australia. One of these is row spacing. Australian equipment is designed to straddle rows spaced 1.4 to 1.5 meters apart. Studies conducted by experts of the Victorias Milling Company show that the yield of present cane varieties drops if row spacings are more than 1.3 meters. Some cane planters also obtained the same results when a farm machinery distributor introduced high-clearance tractors and Cuban tools in the early 1950s. Australia and other countries use wide row spacing for efficient mechanization. The tractor can move faster without damaging plants. To adopt this system, we must develop cane varieties which yield higher with wide row spacing.

Another constraint is high rainfall and frequent typhoons in the Philippines. These cause equipment to bog down and cane plants to lodge. This can be partly overcome by proper surface and sub-surface drainage, land smoothing, and deep tillage.

To introduce new machines and modernize operations, the various agricultural disciplines may have to make compromises for the sake of efficiency and

Fig.1. A sugarcane planter developed by Victrias milling Co.

bigger profits. For instance, plant breeders and agronomists may have to change varieties and/or their farming practices, so machines can handle these better and at a lower cost. Agricultural engineers and equipment suppliers must also try to adapt their machines to suit local conditions, or improve crop and field conditions with the objective of achieving immediate or long-term economic benefits.

Some equipment suppliers and a growing number of progressive sugar farmers, especially in Negros, are now testing and obtaining benefits from new equipment. Let's consider the various phases of cane production in which mechanization has been tested and found more beneficial than the present system:

The first is land forming. The main objective of this is to ensure efficient and uniform field drainage to prevent water-logging and to facilitate use of machinery and transport equipment. Land forming may also be desirable in fields where furrow or flood irrigation is to be employed; but, it done for this purpose only, it may be too expensive for cane farms which use sprinkler irrigation.

Ironically, most of the investment in cane farms is channeled to irrigation in spite of our annual rainfall of 200 to 300 centimeters (80 to 100 inches). Except for main field ditches, little attention has been given to land forming, drainage, and moisture conservation.

Land forming basically involves smoothening the surface of the field and eliminating water basins (depressions where water accumulates). This may be done by a contractor or by the planter using equipment supplied by the mill. A carry-all scraper is used when large amounts of soil have to be moved. There are small three -to five cubic-yard farm scrapers which can be towed by an ordinary farm tractor. Ideally, the top soil should first be scraped and put aside to be spread back on top after leveling infertile subsoil. This may, however, be expensive. When soil fertility is disturbed through leveling, spread organic matter, such as filter press mud, and apply bigger amounts of inorganic fertilizer. If the field can be laid fallow for some time, plant legume and plow it in when it flowers. This practice also allows soil in filled areas to stabilize.

To eliminate small depressions, and as a final operation in tillage, pass a land plane across the field. This is a 12- to 14-foot grader blade with a long wheelbase.

The digging of drainage ditches bordering the field may also be considered a part of land forming. The use of a tractor-driven rotary ditcher, which can dig a one-kilometer long, one-meter deep trapezoidal ditch in one day, facilitates this operation.

Fig.2. Howard chisel plow for breaking the hardpan and for inter-row cultivation.

To increase internal drainage, make mole drains perpendicular to ditches with a sub-soiler equipped with a "bullet".

The most ideal drainage scheme is to lay clay or cement tiles or corrugated plastic pipes at a depth of one to two meters. This permanent land improvement method eliminates waterlogging and allows plant roots to extend deeper into the soil. The result is greatly increased yield.

There are some improved tillage practices that must be promoted. The most promising and economical is chisel-plowing. A chisel plow is a tined implement which looks like a cross between a subsoiler and an inter-row cultivator. Its tines or prongs are either rigid or spring-loaded. It can penetrate the soil from 12 to 18 inches deep in one or two passes.

The chisel plow can be used before disc plowing or harrowing. By taking off a few tines, you can use it between ratoon cane rows to cut old roots and improve internal drainage.

This implement is ideal for hilly farms where plowing downhill causes erosion. The chisel plow can easily be pulled across slopes to minimize erosion and promote internal seepage of water.

The chisel plow is fairly well accepted in Negros. It was recently introduced in Hacienda Luisita in Tarlac, where its use has improved cane stand. Since the hardpan or compacted soil layer was broken, water now seeps through the soil instead of "drowning" the plants. In dry periods, cane benefits from moisture stored in the soil.

Another important tillage implement is the rotavator. A versatile tool, it can be used to chop and incorporate cane trash in the soil, break up plow clods, cultivate between ratoon or plant cane rows, and make furrows. A front-mounted toolbar with two sub-soiler tines is now available; it breaks the soil before the rotavator blades pass, thus minimizing blade wear and increasing working depths. The use of rotavator ensures fine tilth, which improves germination of seedpieces and minimizes evaporation of soil moisture.

The average cane farmer usually burns cane trash because he can't plow it in. Three years ago, a flailtype trash chopper was introduced in Negros. Used with an ordinary farm tractor, this implement finely chops trash so it can easily be plowed under to enrich the soil. On ratoon crops, chopped cane trash can be left between the rows to serve as a mulch and minimize soil erosion, control weeds, and reduce evaporation of moisture. The chopper also shaves off old cane stubble. Farmers who plow in cane trash soon find to their delight that the soil has become more friable and easy to work on. The yield of their plantations has also greatly increased.

Spreading of filter press mud is more uniform when a manure spreader is used. Our company, G.A. Machineries, Inc., has sold a number of tank-type spreaders. This machine distributes solid or slurry material to one side. When the field is too wet for the machine to enter, it spreads material from the road.

Many cane farm tools are made locally and cheaply in Negros. There are, however, a few new tools which facilitate crop care. Some are described below:

- Subsoiler with furrowing wings which cut a slit at the bottom of the furrow for easier insertion of the cane point and for better drainage right under it. This has been used by the Canlubang Sugar Estate for years.
- The Australian Weeder Rake is a wide rake with closely spaced, light spring tines which can uproot young weeds without damaging young cane. It is passed over and between the rows to destroy emerging weeds.
- Disc and PTO-driven rotary cultivators, which facilitate inter-row cultivation.
- Inter-row Sprayer. There is now available a tractor-mounted sprayer with a conventional boom as well as an inter-row attachment. The spray nozzles are attached to a rod pivoted at the boom and trailed on skids between the rows. Nozzle height remains almost constant regardless of the movement of the tractor or main sprayer boom. Herbicides and other chemicals can be accurately sprayed between cane rows. When the first cane leaf sheet appears, a contact herbicide can be sprayed without harming cane plants.
- Compact tractors for inter-row cultivation. While most rice farmers still use carabaos for inter-row cultivation, some now use small 14- to 25-horsepower four wheel tractors. These machines can also be used for cultivating and spraying cane.

Harvesting, loading and transport are the most neglected phases of sugar production, and are thus the most inefficient links in the chain.

In the Philippines, cane is milled 36 hours after it is cut; as a result, much of the sugar produced by the plant in 12 months is lost. In contrast, the average lead time from cutting to milling in Australia is less than 14 hours. Almost 100 percent of Australia's cane crop is mechanically harvested and loaded. This country also has one of the world's most efficient cane transport systems.

But such systems can't be fully adopted in the Philippines because of technical and social constraints. These include narrow rows and small fields; lodging cane; wet, boggy fields; refusal of mills to receive burned, chopped cane; inefficient transport; and unsuitable mill unloading systems.

One progressive mill district in Negros has been testing a German harvester developed in Cuba, which can cut lodged green cane planted in one-meter rows. While this harvester can enter wet fields, soil compaction and limited transport pose problems. The mill district is now preparing its fields for mechanization by removing rocks with a mechanical picker so as not to damage the harvester's base cutter. Tile drains are also being installed in

Fig.3. Harvesting cane, a progressive planter in Negros Occidental uses machinery to facilitate this operation. Wider use of machinery will increase harvesting efficiency.

boggy fields to enable the harvester and transport equipment to enter the fields without destroying soil structure.

Cane loading is arduous and reduces the efficiency of manual harvesters. When most Australian cane was still cut by hand, a cane cutter could cut four to five tons a day because cane was loaded mechanically. In the Philippines, cane cutters can cut and load only one ton a day. Wider use of mechanical loaders by the country's sugar industry is a step towards improving harvesting efficiency.

Cane transport and mill unloading can stand a lot of improvement. At the present time, trucks in many mills serve as storage bins for eight to 24 hours. Our sugar people must do long-range planning before they make further investments in this area. They should seriously consider the harvesting systems which they should employ in the next five to 10 years as these would have a bearing on transport and unloading systems.

Let's discuss the tractor, the basic power unit in cane farms. Selecting a tractor depends on the work to be done.

The most popular tractor used in cane farms is the 70- to 80-horsepower general-purpose model. It can handle most of the chores in 50- to 100-hectare farms. The lighter tractors used in small farms are also used for cultivation and light jobs in bigger plantations.

Four-wheel drive tractors of 80 to 120 horsepower have become popular in the sugar industry because these machines achieve deep tillage, can be used in cane transport, and are suitable for hilly areas. In addition, they have the tractive and flotation characteristics of a crawler tractor, are highly mobile, and require less maintenance costs.

There is also growing interest in higher horsepower tractors (90 to 150 horsepower), which are capable of handling tougher jobs.

The average-sized cane farm in the Philippines is only 15.6 hectares. Ninety-four percent of the planters own less than 50 hectares, and their farms comprise 52 percent of the total hectarage planted to cane in the country.

Studies show that small cane farms have significantly lower yields than large ones. This is due to the lower level of management, lesser capital, and lesser mechanization available to small farmers.

Long-term credit for acquisition of better farm equipment has been made available to farmers with less than 50 hectares by rural banks through the CB-IBRD Rural Credit Programs. Loans to small sugar farmers, however, are being questioned because such farmers are still better-off than average rice and corn farmers. This credit facility should continue to be made available to small sugar farmers because they have no other source of long-term credit. The Development Bank of the Philippines grants tractor loans, but requires borrowers to have at least 50 hectares of land.

Another way by which small cane farmers can benefit from mechanization is to establish government or private farm equipment pools. Such pools could undertake operations like sub-soiling, and digging drainage and irrigation ditches that require expensive equipment. If small fields are not contiguous, equipment pools must acquire four-wheel drive tractors to meet the mechanization needs of farmers.

Sugar is one of the major Philippine exports and the sugar industry is an important sector of the economy. A rational program for mechanizing field operations to increase yield and lower production costs is crucial to its future growth. ■ ■

Fig.4. Versatile tractor performs many farm chores, including harvesting of cane.

Agricultural Engineering in India

—Its Relevance and Importance—

by
B.K.S.Jain
Vice President
Indian Society of Agricultural Engineers
7, Neeltarang 208, Savarkar Marg
Bombay 400016, India

Agricultural Engineering is comparatively a recent discipline. The first Agricultural Engineer obtained his Bachelor's Degree from the University of Allahabad in 1944. In a span of little over 3 decades, there has been a steady growth, keeping in tune with the national requirements. There are now 11 Universities, most of them Agricultural Universities, offering graduate and post-graduate courses in Agricultural Engineering. There are more than 3000 qualified chartered professional agricultural engineers in the country.

Agricultural Engineering is useful combination where a student is exposed both to agriculture and engineering with a view to preparing him for a dual role-in applying engineering principles to agriculture and in taking agriculture to engineers. In the context of our economy to-day, the profession assumes even greater importance:

Economic programme item	Agricultural Engineering contribution through
1. Bring down prices and streem-line production.	Farm mechanization and post harvest technology.
2. Agricultural land ceilings.	Appropriate technology for small farms.
3. House sites for landless.	Farm structures and layout.
4. Agricultural wages.	Higher wages through improved productivity, greater output and reduced drudgery.
5. Irrigation.	Soil and water resources development and manegement.
6. Power programme.	Rural electrification.

There are a number of national programmes and projects calling for agricultural engineering skills. Earlier, due to non-availability of such specialised personnel executives have been drawn from other disciplines, but now with imploved availability, it is being realised that persons with this specific background may be more suitable. Here is an illustrative list (not exhauetive) of some apt Departments/Projects under a State Government, where agricultural engineers can be gainfully and more advantageously utilised:

1. Departmbnte of Agriculture, Irrigation, Forst, Rural Development, Rural Electrification, Co-operation, Planning and Industries (small scale industry in particular).
2. Directorates of Agriculture, Soil Conservation and Minor/List Irrigation. Some States now have a separate Directorate of Agricultural Engineering.
3. Agencies, Authorities and Projects such as ground water survey and development, command area development, comprehensive area development, small farmers development agency, marginal farmers and agricultural labour agency, tribai/hilly area development, land development and river valley projects.
4. Corporations in the State Sector such as Agro Industries Development Corporation, Irrigation Development Corperation, Tube well Corporation, State Farming Corporation, Land Development Corporation and Corporations dealing with minor/lift irrigation, agro-industries and agro-based products.
5. Agricultural Universities, research institutions and extension agencies.

Similarly, agencies corresponding to the above, at the Central level can also draw on this profession. Central Corporations/ /bodies which can be identified in this context are State Farms Croporation of India, National Seeds Corporation, Rural Electrification Corporation, Central Ground Water Soard, Central Water Commission, Food Corporation of India, Fertilizer Corporation of India, Indian Oil Corporation, Hindusten Petroleum, IndoBurma Petroleum, Bharat Refineries, Indian Patrochemicals Corporation Ltd., General Insurance Corporation of India, Project Equipment Corporation, Agricultural Refinance and Development Corporation, Agriculture Finance Corporation and the proposed Central Agro-Industries Corporation.

In addition, there are requirements with the industry in various spheres including marketing, management, research development and extension. The industry includes those manufacturing and marketing equipment as well as ancillaries and accessories (tyres, batteries, fuels & oils etc.). Then, there are service activities like financing (Banks), underwriting (insurance), warehousing and logistics.

A recent survey indicated the employment pattern as under :

Employment Pattern	%
Education, research and training	70
Government Departments	18
Puplic sector corporations/ agencies	10
Private sector	2
TOTAL	100

This distribution pattern requres to be greatly altered.

Agricultural engineering, in fact, has a wide span; its major fields are:

1. Farm power and machinery (s. g. tractors, power tillers, pumpsets and machinery from seed bed preparation to harvesting).
2. Soil and water engineering, including land development, soil and water conservation, irrigation, drainage, water shad management, command area development, surface and ground water development.
3. Post harvest technology, including handing, storage, processing and bio-engineering (also equipment for poultry and dairy engineering etc.)
4. Farm stead including buildings, structures and layout. This field particulerly will interest the Habitat movement.
5. Rural electrification, including energisation of pumpsets.
6. Rural development, including water supply, sanitation, communications, recycling of agricultural wastes and environment.

ISAE

Serving this profession is a young Society celled the Indian Society of Agricultural Engineers (ISAE). Established in 1960, it is the only proffessional society representing the vocation. ISAE is in its second decade of service to the vocation. Its members are professional employed executives and scientists. In spite of its limitations on resources, it has randered yeoman service in accelerating the growth of agricultural engineering in the country. Its membership is about 2500. It brings together research scholars, academicians, government agencies, extension workers, manufacturers, agro entrepreneurs, bankers, farming institutions and self-smployed engineers, including Consultants. Its annual convention has become an important national event.

The 15th Convention was recently held Pune and its proceedings got a wide coverage from the communications media. Over 300 agricultural engineers from all over the country participated in the 3-day meet. Observers included some delegates from overseas, including the USA and the USSR. About 200 technical papers were submitted for presentation. There were six sessions:

1. (The theme session on) Agricultural Engineering Technology for small and maraginal farms.
2. Agricultural engineering edcation, research and extension.
3. Agricultural engineering industry.
4. Farm power and machinery.
5. Soil and water engineering.
6. Post harvest technology.

Items covered include bullock carts, water management, biogas plants and integrated rural development.

To get an idea on the type of business transacted and current situation in this field, here are some important points arising out of these deliberations:

1. The existing syllabi need to be recast in the context of the new pattern of 10 + 2 + 3. The courses have to be made more relevant to our current needs. The student should be prepared not only for technical and executive positions in the government and the industry, but can also be encouraged to take to self-employment. Lot of opportunities are now available in areas like agro service centres, agro industries, processing of agro based products and consultancy. There is a need for more indigenous text books. So as to encourage authors to write good text

books, an agency like the ICAR institute suitable awards. The academy, the industry and the government must get together to update the curriculum and make education more practical, topical and relevant to our own requirements, at the same time it should keep pace with the technological developments overseas. So as to give students more practical training, agricultural Universities should not only adopt villages, but should also participats in projects /schemes such as agro service centres, land development, water management and rural development.

2. It is important to ensure that only viable and marketable technology of practical use with favourable cost benefit ratio is released to the industry and the end user.

3. Biogas anergy holds a good future, but lot of R&D work is yet to be put in to make it practical and useful. There is a scops for technological improvement on gobaroges plants. Another item requiring better R&D work is the problem of debris lifting in open well digging; this programme is being taken up on a large acele with high priority.

4. Until late 60s, lot of research and development work was in progress on improving hand tools and animal drawn implements. In recent years, this tempo seems to have slowed down. Activities in this area need to be revived and R&O work updated. Items requiring urgent attention include harvesting tools (like sickles), bullock carts and power trensmission components such as the beam and the yoke. There is a need for a publication covering detailed technical specifications on available tools and implements and a list of research establishments and the projects they are working on. This will be of use not only to research workers themselves, but also to extension workers and the industry. It will avoid duplication and will ensure utilization of our limited resources, both in terms of men and money. While on one hand there is need for simple tools and implements for the small farms, but on the other hand, there is also a need for high output large size machines mainly for custom work. We must, therefore, offer a wide range of equipment to suit both.

5. Accuracy and timeliness of operations in agriculture has now become more important, particularly for the high yielding varieties. To enable small farmers to increase the cropping intensity and to ensure proper and timely seed bed preparation etc., it is necessary to substantially expand the custom hiring services. It is appreciated that in some cases experience on organized custom hiring has not been good. Such cases should be studied in depth and corrective measures taken. There is a acope for populerising custom hiring in a very big way, both through government and privats agencies. A start has made, but much more needs to be done.

6. We should taken stock of the situation on mechanization of farm operations on some of our important crops such as wheat, paddy, sugarcane, cotton and groundnut. Priority should be devoted to such items which will fill in the gaps. Mechanization does not means tractorisetion; it means a better operation faster and it covers all the equipment and operations on the farm whether by hand tools or by animal drawn equipment or with power operated machinery.

7. Current tractor population is ever 2.5 lakhs. Annual demand is in the range of 30,000 to 35,000. Over Rs. 500 crores are being invested every year in this input alone; (it includes costs of fuels and lubricants required). It is, therefore, a sizeable industry. Expressing concern over high prices, it is suggested that though on one hand the industry should continue its efforts to keep costs of production low, the farmer must be given the maximum possible relief through a rational taxation policy. There is a wide variation in taxation from State to State. There is some urgency in determining a national taxation policy. For keeping costs of farm operations low, it is adviseable to give the industry a tex holiday for couple of years. Gross taxation, including excise, sales tex, general tax, surcharge, octroi and all other taxes and levies, cumulatively works out to 40% to 50% of the cost of tractor and power tiller. Tax relief should cover not

only the tractor, but all other items of farm machinery.

8. Almost all the equipment to-day is bought on institutional finance. There is a fertilizer credit policy. On similer lines, there is a need to develop a national credit plan for all farm equipment inputs. Aggregats requirements work out to about Rs. 1000/-crores a year.

9. So as to increase the tractor utilization (hours per year), the industry must ensure proper after-seles sarvices. The farmer-/operator not only requires a thorough training, but also a fuil range of equipment so as to have a 'systems' approach. To-day some gaps in mechanization are seeding, intercultivation and harvesting equipment.

10. The pump-set is an item of mass demand. Current population is estimated at about 50 lakhs and the annual demand at 5 lakhs—both diesel and electric. About Rs. 300 crores are being invested every year on installation of new pumpsets (complete with accessories). So as to conserve energy and keep costs of operation low, it is necessary that

a) the farmer is recommended the most appropriate size, tailored to his needs.

b) the efficiency of the unit must be high.

c) an alternative fuel like gobargas should be encourage.

d) greater attention be paid to development of bullock driven pumps for low life and low discharge conditions obtaining on small farms.

11. To accelerate development of the processing industry, it is necessary to compils information on characteristics of the bic-material. Non-availability of such vital information is a serious handicap. In addition, we need proper assessment of demend for various types of equipment together with their priorities.

12. There is a scope for popularising sprinkler irrigation, particularly on cash crops in areas of undulating topography and high infiltration rate soils. Other methods of controlled irrigation such as gated pipes, perforated pipes etc. also require to be to be promoted. This will not only mean savings in water and land, but also ensure better quality and quantity of produce because of timely and optimum supply of moisture.

The Society has been quits alive to the needs of the small farmer. It has held/planned a series of 3 Conventions in a row to focus attention to this important area. The Convention themes are:

Year	Theme
1976	Transfer of agricultural engineering technology to rural masses.
1977	Agricultural engineering technology for small and marginal farms.
1978	Agricultural engineering technology for integrated rural development.

In sum, agricultural engineering has to play a very important rols in our national programmes and projects in the fields of agriculture, irrigation, rural slectrification and rural development. Mechanization has significently contributed to the rise in our agricultural production and productivity. Its pace will have to be accelerated not only to meet out domestic requirements, but also to cater to the export opportunities for agricultural commodities and agro-based products. In addition, of course, there is good potential for export of farm equipment as well as agricultural engineering technology. The technology we are in a position to offer is more relevant to the needs of the developing countries. In view of the vital role agricultural engineering discipline can play in our national development and the scope for its growth, it is expected that the discipline will recieve the attention it deserves from all concerned agencies, including the academy, the government, the industry, the farmer and the agricultural engineer himself. ■ ■

"**Bicycle Operated PTO Unit for Small Farms**" by Biswa N. Ghosh, which appeared in the previous issue of AMA Vol. 8 No. 1 Winter 1977, was the ASAE (American Society of Agricultural Engineers) paper, No.76-1011.

Tapioca Chips and Pellets —An Improved Technology

by

Zahid Mahmud
Project Engineer
Rainbow Manufacturing Co.
P.O.Box 70
Fitzgerald, Georgia 31750 U.S.A.

Nguyen Cong Thanh
Associate Professor
Env. Eng. Div. of AIT
Bangkok, Thailand

Introduction

Tapioca, Manihot esculenta crantz, also called cassava manioc, is a starch-producing tropical shrubby perennial root crop. It is the seventh largest producer of staple food in the world. The plant propagates vegetatively by means of stem cuttings and adventitious roots, or tubers, radiate from the base of these cuttings. The yield varies from region to region and strain to strain, with 2—3 kg of root per plant being common.

Tapioca as Food and Feed

Although tapioca is used as a staple food by about 200 million people in the tropics, large amounts are exported to temperate countries. The United States and the European Economic Community (EEC) are the main importers of tapioca products.

Future demand for tapioca will depend on : (a) consumption of livestock products; (b) changing composition of reared livestock ; (c) changing dependency on compound feed ; and (d) increasing livestock numbers. From these criteria and after examining the food situation in various EEC countries, it is expected that demand for tapioca products for inclusion in animal feed will increase in Belgium, Italy and Germany more rapidly than in France and the Netherlands. However, the main factor still to be determined is the stare of this growing market that tapioca products will command.

Until recently, Japan appears to have relied a great deal on imported maize as its main source of feed energy, but Japanese buyers now seem to be active in the tapioca market. This will present a promising opportunity for export market development in a number of tropical countries.

Table 1 indicates fluctuations in exports of the various tapioca products from Thailand from 1968 to 1974.

Increase in the market price of pellets and, consequently, chips and pulp are closely related to the prices of other constituents in a compound animal feed. Since the price of soybean meal is decreasing, livestock rearers are likely to use more tapioca in combination with this high protein source in compound feed and also shortages of human food encourage the use of maize and barley for human consumption at higher prices.

Tapioca Chipping Pelletizng in Thailand

The production of tapioca chips in Thailand is a relatively simple procedure consisting of cutting the roots into chips and

Table 1. Export of Tapioca Products from Thailand (Source: Commodity Standards Office, Board of Trade, Thailand)

Tapioca Product	1968	1969	1970	1971	1972	1973	1974
Starch	143,569	124,772	142,914	146,368	124,453	179,929	254,967
Meal (waste)	14,987	16,870	7,715	4,615	1,751	2,634	1,009
Chips	307,267	58,414	9,149	3,400	2,154	21,274	104,704
Pellets	314,788	773,908	1,061,065	966,278	1,109,363	1,508,598	1,924,647

then spreading them on large concrete surfaces in the open air. Sun-drying periods usually require 2—3 days with periodical turning of the chips until the moisture content reaches 13—15 percent, which is acceptable to pellet manufacturers. Sand and waste products, such as tapioca fibres, are often added to the chips to minize the drying time and make the process economically viable.

Tapioca pellets are obtained from dried chips by grinding and forcing into a cylindrical shape. These pellets are less than 1 cm in diameter and about 2 cm in length.

The purpose of this study was to investigate the parameters affecting the drying and pelletizing of tapioca chips in order to obtain a good product with constant and optimal quality under conditions typical of rural areas in Thailand and similar agro-economic regions of Southeast Asia.

Experimental Methods

Various shapes and sizes of tapioca roots were cut manually and dried on different drying media. The following shapes and sizes have been investigated :

	Size, cm			
	Diameter	Length	Width	Thickness
Circular	4.5			0.5
	4.5			1
Rectangular		8	2.5	0.5
		8	5	0.5
		8	2.5	1
		8	5	1
Cubic		1	1	1
		2	2	2
Strips		6	0.5	0.5
Slices				0.1-0.2

Chips mechanically cut using Thai and Malaysian machines were also tested. The Thai cutter was designed to produce irregular and substantially large chips with a capacity of about 9—14 tonnes/hr with 6 to 8 hp engines. The Malaysian cutter, designed by the National Institute for Scientific and Industrial Research (NISIR) consists of two blades producing tapioca slices (0.2—0.3 cm thick) at one side and strips approximately 8 × 0.65 × 0.65 cm on the other side.

Sun-drying of tapioca chips on plain cement floors is the common practice in Thailand. However, black surfaces absorb more heat energy and hence their temperature is relatively higher than plain surfaces. In an attempt to measure to what extent black-topped floors are more efficient than plain floors is terms of duration of drying, plain cement and black concrete floors were used to sun-dry tapioca chips of different sizes and shapes.

To study the effect of heat transfer by convection on drying period, a three-shelf tray drier was designed, as shown in **Fig. 1.** It consisted of four trays which could be adjusted to any of three positions, one horizontal and two tilted at an angle of 20° to the horizontal, either up or down.

Artificial drying was carried out on a thermostatically-controlled electric hot plate.

During drying tests, the moisture content of the chips was determined at regular intervals of one or two-hours. Thermometers were provided to record ambient

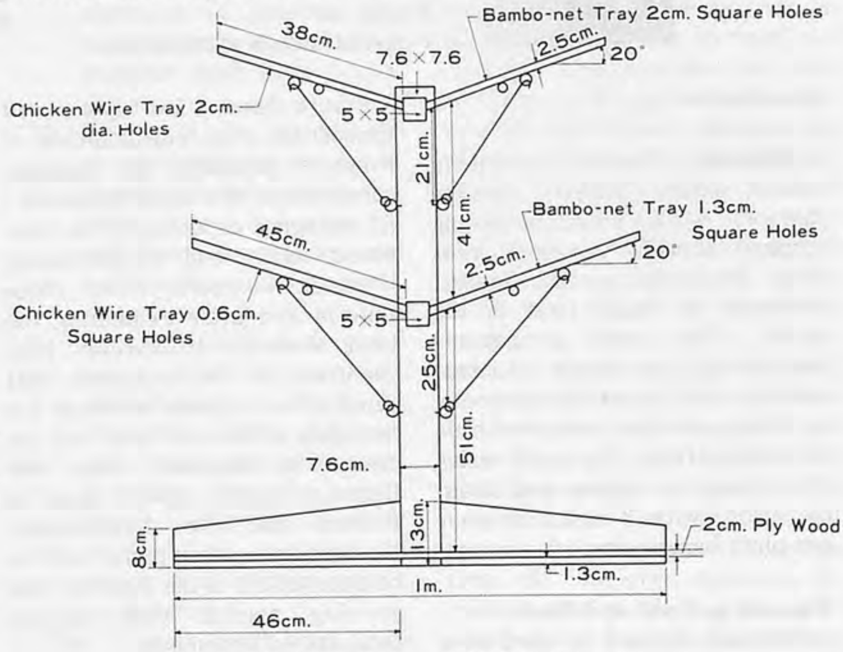


Fig.1 Cross-Section of Shelf-Tray Drier.

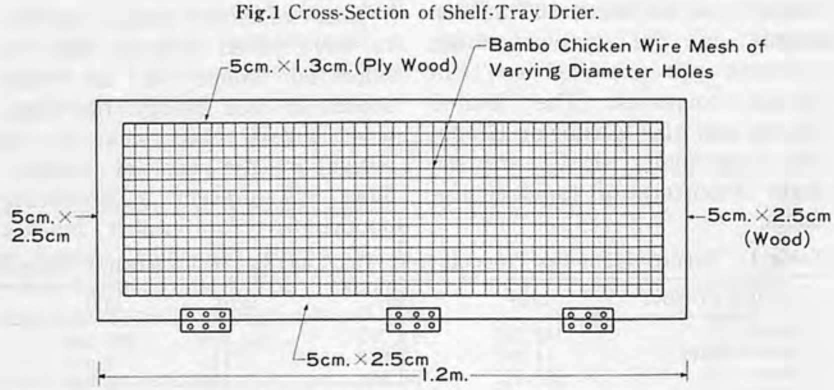


Fig.1 Details of Shelf-Drier's Tray.

and contact surface temperatures.

A laboratory study of pellet processing was carried out using a CPM Master Model Pellet Mill operated by a 20 hp motor, which produced about 0.5 tonne of pellets per hour. Steam was supplied at the inlet of the pelleting machine and served as a conditioning agent to the chips before being pressed against the die.

Results of Tapioca Chips Drying Study

Euploratory Results

This part of study was carried out during the hot season, between March and July 1975, when the air temperature varied between 28 and 35°C. Tapioca chips cut into various forms and sizes were dried under varying conditions and the exploratory results has been presented in the form of graphs.

(1) Cement Floor Drying

Using this type of floor, **Fig. 2** shows that a 14 percent moisture content was attained in 0.1—0.2 cm slices after about 12 hours of drying, indicating that no further heat treatment was required. However, this was not the case with other chip shapes and sizes. After 24 hours of solar radiation exposure, the majority of other chip sizes only reached 15—17 percent moisture levels. It was also observed that between 8 p.m. and 8 a.m. an increase in moisture content was noted due to absorption of condensation caused by cooling of the night air.

(2) Black Cement Floor Drying

Fig. 3 presents the results of chip drying on the black concrete surface. A substantial temperature gradient between the floor and the ambient air, up to as much as 13°C, was recorded and this accounts for the improved rate of drying. Slices, Cubes (1 cm^3) and strips reached 14 percent moisture content after only 9 hours of drying on this surface.

(3) Artificial Drying

The efficiency of solar drying is affected by meteorological factors and this method is therefore unreliable. The results presented in **Fig. 4** indicate that if a hot plate is maintained at 70°C tapioca chips of all sizes studied can be dried to about 14 percent moisture content in 4 to 5 hours. This drying method is quicker and more controlled but will require higher investment. There is the possibility of subsidization, due to the fact that, at present,

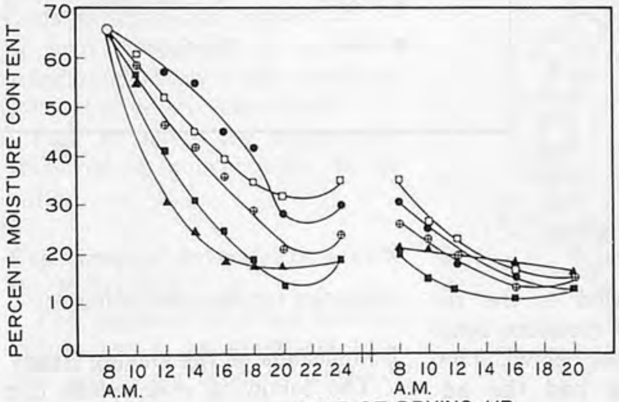


Fig.2 Solar Drying of Different Shapes of Chips on a Cement Floor.

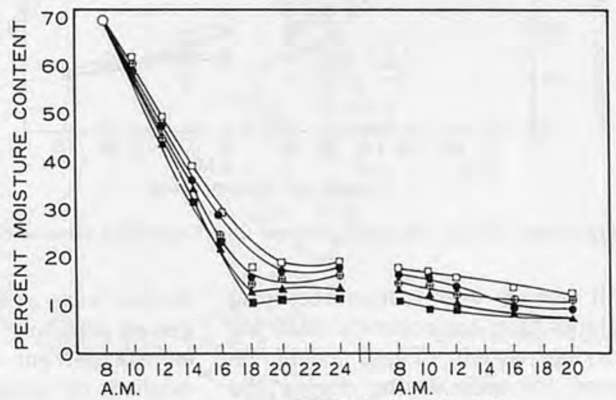


Fig.3 Solar Drying of Different Shapes of Chips on a Black Concrete Floor.

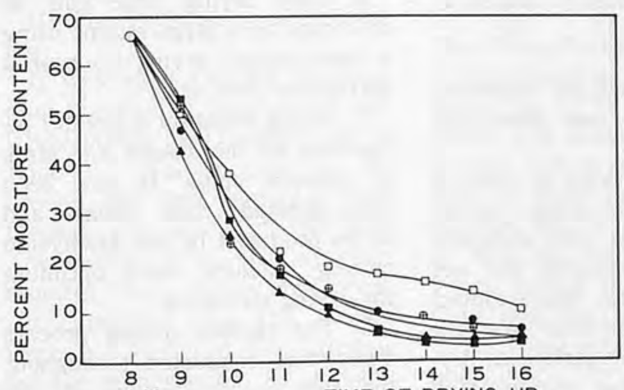
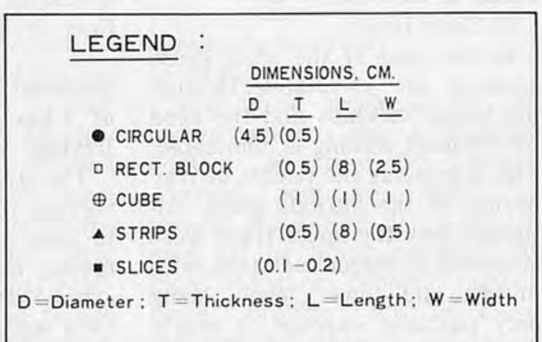


Fig.4 Artificial Drying of Different Shapes of Chips on an Electric Hot Plate.



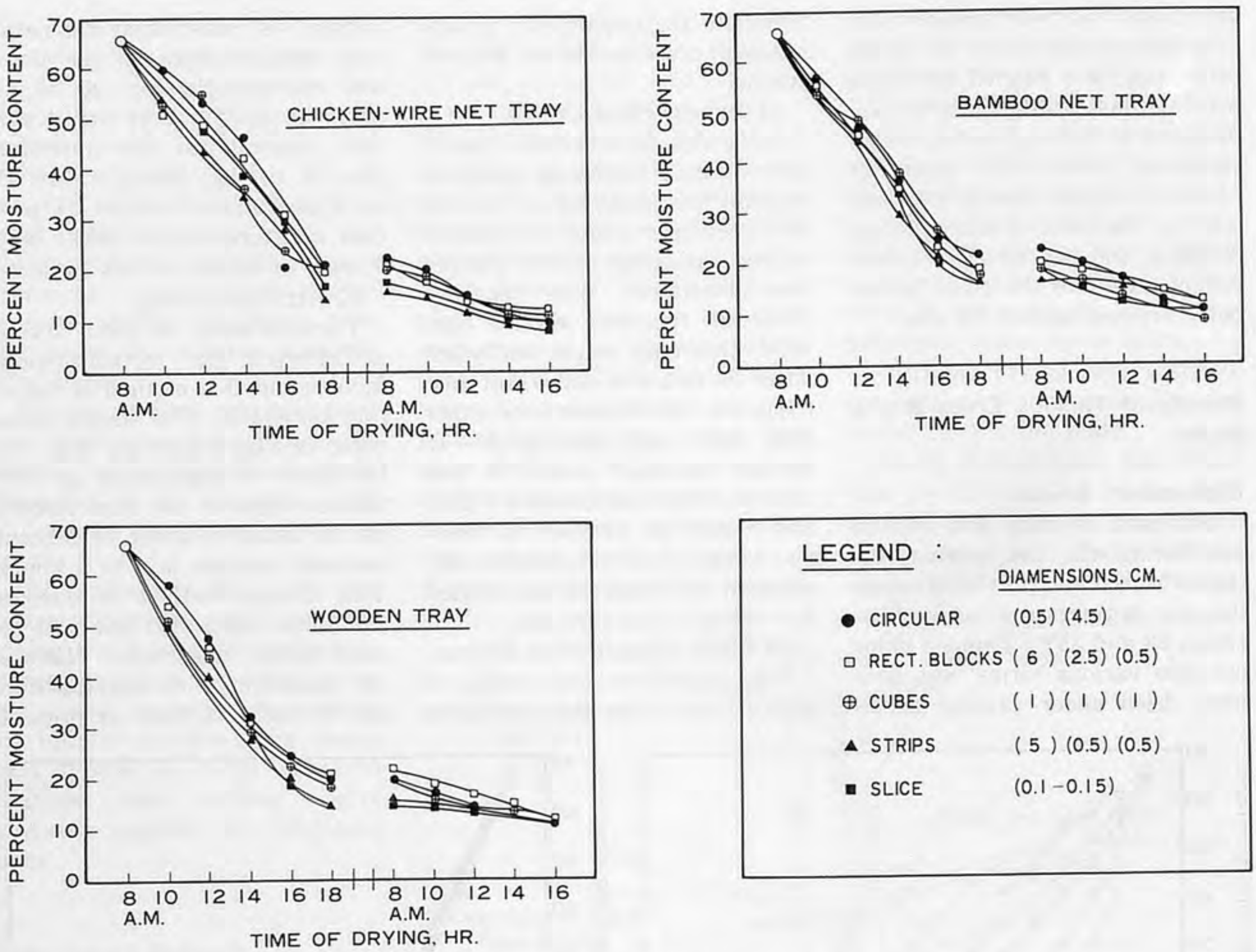


Fig.5 Solar Drying Curves for Different Chip Shapes and Sizes on Shelf-Drier

all tapioca starch manufacturing plants have hot concrete slabs for drying starch. These could be used for chip drying during the time they are not being used for starch and only operating costs would be incurred.

(4) Shelf Drier

In the case of the shelf drier, ambient air circulates through the layers of chips and the need for frequent turning is eliminated. **Fig.** 5 presents the results of tray drying of the various chips. Although only the upper trays were subjected to direct radiation, with middle and lower levels being only partially exposed, a nearly uniform rate of drying was achieved for all three shelves. After 14 hours of solar radiation exposure, the samples (slices and strips) were reduced to the required standard of moisture content (14 percent and below). This method of drying had the advantage of producing better looking, more uniformly dried chips compared with those produced by floor drying.

Rational Approach in Selection of Chip Forms and Sizes for Drying

The study on drying of chips of various forms and sizes exposed to solar radiation over different drying media indicated the net superiority of the black-topped floor and the shelf-drier over the plain cement floor. Artificial drying is attractive but involves high operating costs and is not practically applicable in developing countries for the time being.

Conclusions of the Drying Study

The following conclusions can be drawn from the tapioca chips drying study :

1. Chip drying time can be shortened to a large extent using a black-topped drying floor or a perforated shelf-drier.

2. Drying duration is greatly influenced by the shapes and sizes of tapioca chips. It has been demonstrated that slices and strips produced by the Malaysian cutting machine were optimum for drying efficiency.

3. The tapioca drying process study was conducted throughout the two major seasons of the year, the hot season and the rainy season, and no noticeable

difference in drying efficiency was observed.

4. The efficiency of conventional plain floor sun-drying could be improved by reducing the size of the tapioca chips to thinner forms in strips or slices.

Results of Tapioca Chips Pelletizing Study

Principles of Pelletizing

The process of producing feed pellets can be defined as a plastic moulding operation of the extrusion type. When sufficiency controlled compression is applied to the "conditioned" feed ingredients they will form a dense mass, shaped to conform to the die against which they are pressed. When the heat and moisture is again withdrawn (dried and cooled), the shaped mass (pellet) retains its shape and density and is of such "toughness" as to withstand moderately rough handling without excessive breakage.

Fig. 6 shows the component parts of a conventional pellet mill.

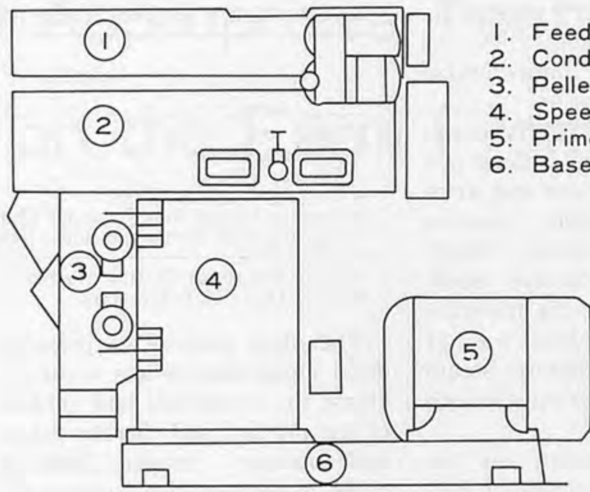


Fig.6 Component Parts of a Conventional Pellet Mill

Experimental Investigation with the Pellet Mill

The pressing of dried tapioca into pellets is an important process and, if not properly conducted, the quality of pellets suffers, both from the nutritional and technological point of view.

(1) The Technology of Pelletizing

It was observed that the common practice of the tapioca pelleting plants in Thailand was to grind the tapioca chips in the presses and then compress them through the holes in the dies. This reduction in size of chips requires much energy and pressing capacity, since the presses were not designed for grinding but for compressing. As a result of the over-heating of the tapioca in the dies, their is considerable.

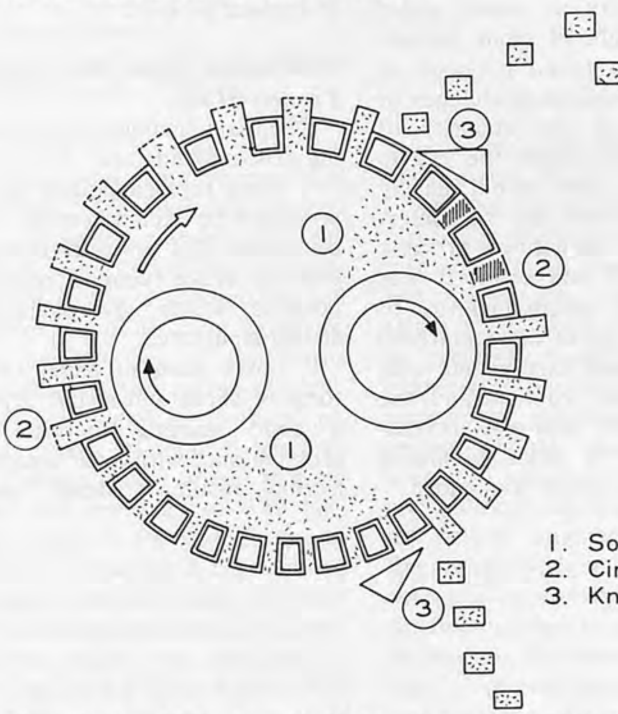


Fig.6 Typical Die and Roller Assembly Used for Producing Hard Pellets

Experimental investigations using the CPM "Master Model" pellet mill coupled with an electrically heated autoclave revealed that, in order to produce good tapioca pellets, it was necessary to heat the feed to about 120°C which makes the chemical reactions possible, giving the pellets their strong structure and glossy appearance. In this study, the steam temperature was kept around 120°C for 2—3 min before pelleting.

The chips produced by the native pelleters had a moisture content of about 20 percent, whereas moisture levels of around 18 percent were encountered at the brand pelleters. At high moisture content tapioca chips provide an excellent medium for bacterial and mould growth during the storage period. The pellets produced from chips with a moisture content higher than about 17 percent were of inferior quality because they are soft and have an unfavourable weight to volume ratio.

No apparent difference in quality was observed among pellets derived from slices and strips dried using different systems (plain concrete floor, black-painted floor, perforated shelf-drier) provided that the moisture content in these chips was 14 percent or lower before steam admission and pressing through holes of the die.

(2) Effect of Steam on the Weight per Unit Volume of Pellets

The quantity of steam added per unit weight of input ingredient was also found to have an effect on the physical changes of the pellets. If the quantity of steam was too high, the pellets become soft and would hardly extrude from the die thus interrupting the pelleting process. Through trial and error, it was found that a steam quantity of 0.152 kg per kg of input material gave glossy and hard pellets with minimum meal content and the capacity of the mill also increased by 2.5 to 3 times compared with when no steam was added.

Table 2. Weight per Unit Volume of Tapioca Products

Samples	Sample Weight (g)	Weight/ Volume (g/cm³)
* Pulp	217.7	0.288
+ Tapioca Strips	285.6	0.378
+ Tapioca Slices	288.7	0.382
* Irregular Tapioca Chips	311.0	0.412
* Tapioca Pellets from Irregular Chips (without steam)	429.8	0.569
+ Tapioca from Strips and Slices (with steam)	610.1	0.808

+ From Malaysian Cutting Machine
* From Local Manufacturers

The main purpose of pressing dried chips into pellets is to increase the weight per unit volume of the product and thereby make sea transport cheaper. **Table 2** gives a comparative assessment of the densities of different types of tapioca product.

Conclusions from the Pelleting Process Study

The main findings of the pelleting process study are :

1. Goog tapioca pellets can be produced by steam-heating chips to around 70°C before pressing, in order to make chemical reactions possible which give pellets a strong structure.
2. Small sizes of chips, in the form of slices and strips, provide a good starting material for pressing and, with prior steam injection, result in dense, glossy and strong pellets.
3. The moisture content in the chips to be pressed is an important parameter. Experimental investigations demonstrated that chips with a moisture content from 12 to 14 percent gave excellent pellets.
4. No apparent differences in quality were observed among pellets derived from tapioca slices and strips dried on different drying media provided that the moisture content in these chips was about 14 percent.
5. The quantity of steam per unit weight of input ingredient affects the quality of the final product. It was found that a quantity of 0.152 kg of steam per kg of input material gave dense glossy and hard pellets. ■ ■

Prospects of Appropriate Technology Applications on the Farm Front in Pakistan

by
S. H. Mahmud
Engineering Research Fellow,
Agricultural Engineering
The International Rice Research Institute,
Los Baños, Laguna, Philippines

Pakistan is striving hard to attain self-sufficiency in food. The pattern chosen by the People's Government is to bring about an agricultural revolution.

The goverment has given great emphasis on agriculture in order to bring our agricultural economy from bullock cart to tractor era, and as first step, has given remission of revenue and introduced passbook system for small farmers to take to take loan against land.

It is a truism that, so far increase in cultivated area has not matched the rapid population growth. The only alternative to feed such an expanding population is to increase the per acre yield of farms. This can be achieved through high yielding seeds, extensive use of fertilizers and farm mechanization. Thiu article iu limited to discussion of the prospects of farm mechanization in attaining self-sufficiency in Pakistan.

Mechanizction of agriculture is the process of creating or improving machines, and fitting them together with crop and production methods to achieve more efficiency. This can be done by the introduction of imported equipment or by improving the present farm implements and machines. The existing agricultural situation, coupled with the law of inheritance has already resulted in much subdivision and fragmentation of farm holdings. The average size of the farms according to the recent agricultural census and agricultural reforms report is about 4 hectares for Pakistan as a whole varying from 3.24 hectares to 6.80 hectares. Thus, in Pakistan, majority of farmers own land between 4-8 hectares, who for lack of water and additional mechanical power, however, have not par-ticipated fully in Green Revolution. For this size of holdings, we need small and low-cost equipment, wihch can be manufactured at village level from Torkham to the Karachi coastal areas. Unfortunately, the only group we think about in mechanization efforts are those owning above 20 hectares who can participate in a modern, progressive and highly mechanized agriculture. In this respect, it is unfortunate that our agricultural economy has only been trying to blindly emulate the economically advanced countries.

Aside from modifying the existing technology, the mechanization process should be such that it can be fitted to our present farm size holding structure and farm machinery design work for any developing country must relate to its specific needs. This is because interaction between engineering design and society is increasing. Optimal engineering designs should, more than ever, take into account socio-economic and political implications as well as purely engineering factors. Equipment designed in developed countries is often unsuitable for a developing country because of the differences in customs and culture. Unfortunately, the latest technology is often supplied, resulting in too great a technological jump and possible disturbances to the environmental balance. It is therefore imperative for Pakistan to seek to establish its own corps of designers and to train and develop than to meet its own needs. An example of such an effort is the fact Pakistan's first tractor Model M-10, was rolled out from Heavy Mechanical Complex, Taxila in 1973 (**Fig. 1**). The entire design and engieering was done by the author based on 100% local compo-

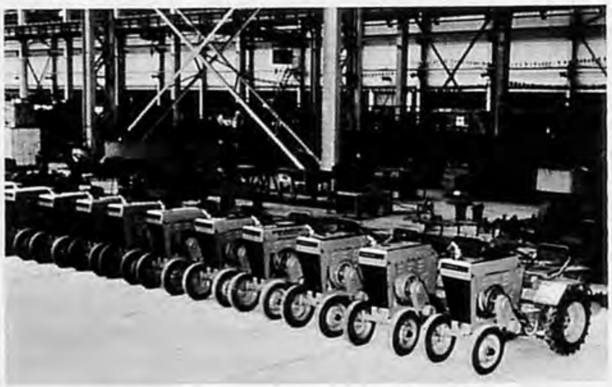


Fig.1. Pakistan's first 10-horsepower tractor M-10 under production.

Fig.2. Chinese 10-row transplanter.

Fig.3. Savonius vertical axis windmill.

nents and taking into consideration the report made by Mr. Javeed Hamid, Deputy Chief of Planning, in 1968 that an optimal tractor size for Pakistan is about 10 horsepower. Dr. Amir U. Khan, Head, Agricultural Engineering Department, International Rice Research Institute, Philippines (now in Pakistan) and recipient of several awards by the Philippine Government (including Presidential awards) for uplifting the agricultural economy of Filipino farmers through the introduction of Appropriate technology, has pointed out that "to mechanize agriculture, a commensurate growth of the indigenous farm equipment industry is absolutely essential. Yet almost all efforts and geared towards the transfer of mechanization technologies from the industrially advanced countries without any consideration of the manufacturing capabilities of the developing countries. The development of demand-oriented farm equipment to suit local needs, manufacturing know-how and other factor endowments is a problem that the engineering communities must face squarely in the developing countries". To select a functional equipment to match the needs of a farmer from the production lines of industrial countries is no problem. In practice, however, such equipment is often too expensive and too complicated. Robustness and simplicity of design are much more important than fine adjustments and controls. The latter seldom contribute to increased efficiency of operation for which they are designed but only to add appreciably to the first cost of the equipment.

People's Republic of China is perhaps the only country in the world which has well utilized its own resources in bringing up the agricultural economy. The machines developed in China are well suited and adapted according to the needs of the farmer. It has simple but efficient machines (like 10-row rice planter given to Pakistan, see **Fig. 2**) having, whrever necessary, sufficient automation incorporated into them. The country has used to the maximum all its resources; even a small machine like 12 horsepower Dong Feng power tiller serves multipursoses such as cultivation, pumping water, spraying, threshing, harvesting, running generators and hauling loads. The canal water in China is not only used for irrigation purposes but also for generating even a fractional KW power. Pumping and generating stations can be seen all along the canals and wherever there is a small fall, a small electric generator has been installed, to lessen the load on the grids or to minimize transmission network and power breakdowns. This technology is actually not new to us. We can see mini flour mills along Lieh Nala and in Hazara District on the streams known as Junders used by villagers for grinding grains. Pakistan has best canal network in the world, and with a little effort, this "Junder Technology" can contribute substantially to our revolution in agriculture. In many cities and villages of Sind, where the wind from sea is conducted from the top of the house down to the sitting room as natural airconditioning, we might use windmills fabricated out of tar coal drums for water pumping and other fractional power generation (*see* **Fig. 3**).

Tractor Power

According to Mr. Francis Coleman's "Problems of introducing machines to small cultivators", a paper presented in a FAO conference in September 1966, small plots impaired by irrigation requirements (i.e., the necessity for water control bunds and the difficulty of levelling large areas) do not allow power machines to have high speeds over the ground. Consequently, combined with good maneuverability and mounted implements, the smaller wheeled tractor makes a better investment than larger, high-powered units. According to Coleman, the rates of working of tractors ranging from 25 hp wheeled to 50 hp crawlers, all pulling tined cultivators (the same implement is commonly used in Pakistan) in heavy soils of Nile delta, in no case was an output of more than 17 drawbar horsepower reached. The best utilization of available engine power was being obtained with 20 to 30 horsepower wheeled tractors. In fact, when the indigenous 4-wheel tractor and power tiller productions, in the neighboring country of India from

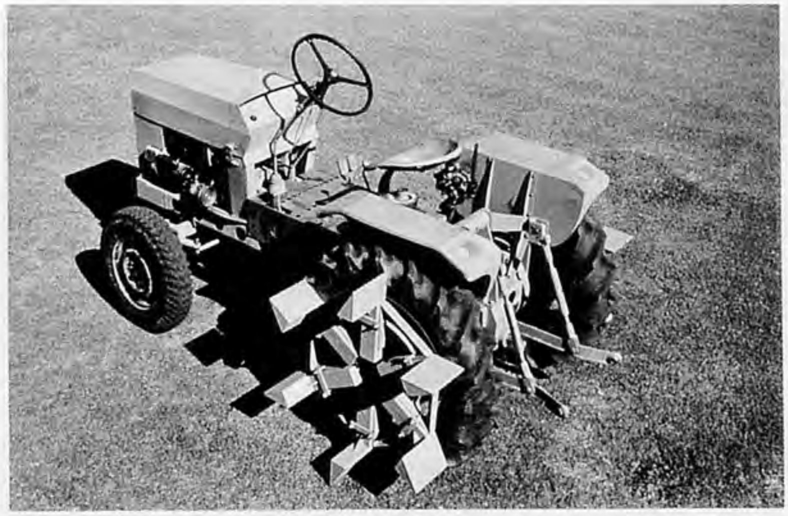


Fig.4. 17 hosepower jeep component 4-wheel tractor.

December 1975 to March 1976, were 13,861 four-wheel tractors and 2,502 power tillers, only 2,634 were above 35 hp 4-wheel tractors. The most popular brand was HMT 25 horsepower 4-wheel tractor and 8 to 10 horsepower tiller. In direct constract, most of the tractors in Pakistan are both imported and with sizes above 45 horsepower. At the same time in this country, Rana tractors (now Millat tractors) was established during the early sixties for progressive tractor manufacturing in the country. Ironically enough, till it was taken over by the People's Government in 1972, not a single tractor component was produced in the factory, except the 5 transmission gears that were actually developed by Pakistan Machine Tools Factory, Karachi. What to speak of production, not even manufacturing facilities were available, and the technical level of enterprise had never gone above a footpath assembly work.

A 17 horsepower 4-wheel tractor is being developed with jeep components at the International Rice Research Institute, Philippines (see **Fig. 4**). We can manufacture 25 horsepower four-wheel tractors with CJ5 jeep components which are already being produced by Pakistan Machine Tools Factory, Karachi. The tooling is already available there which will cut down heavily the initial investments.

Threshing & Water Management

We lose 10 to 15 percent grains during harvesting and threshing due to non-availability of proper machines. Our threshers which are more like hammer mills, are the same as originally produced in the country 20 years back. These threshers are mostly run by tractor P.T.O. shaft which consume much tractor power, whereas properly designed thresher of the same capacity does not require more than 7 to 10 horsepower.

In Pakistan, common tube well sizes are one cusec which are powered by stationary 15-20 horsepower slow speed diesel engines, unlike East Panjab where most of the tube wells and pumping sets deliver a fraction of a cusec are powered with 5 to 6 horsepower mobile high speed diesel engines. These are light enough to be carried by two persons and easily transported from field to field and also can be coupled with low capacity or shallow pumping sets. This mobility of power also makes it possible for the farmer to use the engine with his thresher and in this way their mechanical threshing reaches up to 95%. The mobile engine needs

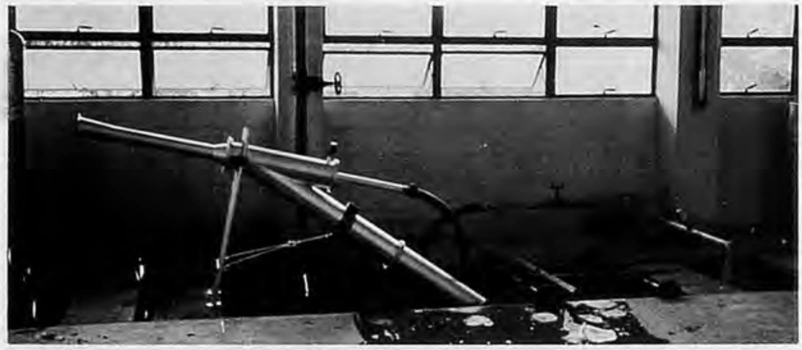


Fig.5. Jet pump attachment.

lesser investment, and in addition, increases farm income through increased annual usage. A case in point here is to consider what should be the investment a progressive farmer should be called on to make in such inputs. Schumacher in his book " Small is Beautiful" considers that the maximum investment an entrepreneur can safely make would amount to his total earnings during a given year. In advocating large size tube well, we often exceed many times over these limits and as such economic sizes of pump installations in relation to investing capacity of ordinary farmers would be very desirable for our country. Many innovations are also possible at intermediate technology level to improve performance of existing pump installations. For instance, it is noteworthy to mention that IRRI has recently reported of a low-cost jet pump attachment (**Fig. 5**) to improve discharge capacity of centrifugal pumps without any additional power input requirement in low-lift pumping situations.

Fertilizer Application

In 1973, when there was world fertilizer shortages, the advanced countries reutricted their fertilizer export to the developing countries although in agriculturally advanced countries, already fertilizer is being used excessively. Applying an additional kilogram of fertilizer does not add very much their agricultural income whereas in developing countries, an additional bag of fertilizer can bring 20 or bags of grain. Food production is thus being constrained and hence future grain import needs in developing countries will be more than ever before. It is ironical, in the words of Norman E. Barlang, that "whereas Japan and several countries of Western Europe use more than 300 lbs. per acre while India uses 14 lbs., Pakistan 12 lbs., Bangladesh 7 and Nigeria 1 (1972 figures)". This disparity was further aggravated when the cost of fertilizer prices tripled or quadrupled later. The monopolistic tendencies of the fertilizer market was clear from the fact "In the first half of 1974, farmers in Farnce and Germany paid 165 to 180 dollars for a ton of Urea at their farm gates, because of domestic price controls; but the average FOB export price at that time for developing countries was 370 dollars per ton". To meet such situation and to supplement the losses sustained due to uncertainty of weather wherein rains and floods wash usable nitrogen deep into the earth or to the sea, the development of indigenous capability for fertilizer produce is all the more urgent and essential. This is an established fact that we do not have rich iron ore or any other metal resources, but on the other hand, God has gifted, in abundant measure, the country with other natural resources such as natural gas, lime stone and gypsom. What can't we make out of these three resources? Fertilizers, cement, paint, artificial fiber, P.V.C., etc. using natural gas as feedstock, they provide the greatest economic potential for significantly expanding low-cost nitrogenous fertilizer production. We have already overcome the difficulty of producing an indigenous sulfuric acid plant at Heavy Mechanical Complex, Taxila for Fertilizer Corporation. Similar ventures can easily be taken up in such organizations to make local manufacture of fertilizers possible. Burning gas is a burning of gold. To save natural gas for other useful purposes, we should pursue more vigorously the use of bio-gas. Bio-gas plants will not only serve as fertilizer but also fuel for cooking, lighting, running irrigation pumps, gas refrigerators and cottage industry motors.

To conclude, it may be remembered that every engineering design cycle involves repeated attempts for a solution often involving trial and error. Some of these attempts may be even discouraging in the beginning but their end results improve man's standard of living diminish his toil. To give confidence and to develop creative imagination, like in other countries, innovations of our scientists and engineers should be recognized at national level. This alone will help in the development of new machines and production processes.

The development of a productive small farm agriculculture will certainly contribute to integrated rural development and national growth as these small farms in return create market demand for the consumer goods and tools necessary for the growth of national industries. To this end, we may look forward to foreign aid, but should not depend on it. Then only we can achieve our natinal goals and move forward in the path of prosperity. ■ ■

Small Farm Mechanization in Pakistan

by
Amir U. Khan
Representative
The International Rice Research Institute
P. O. Box 1237
Islamabad, Pakistan

Present Situation

1. Agricultural land holdings in Pakistan are predominantly small; 60% of holgings are below 10 acres (small), 31% holdings are from 10-50 acres (medium), remaining 9% holdings are over 50 acres (large).
2. Pakistan is importing substantial number of larger tractors and other farm equipment from the industrialized countries. Such machines are primarily serving the needs of the larger farmers.
3. Introduction of such equipment to small or medium farmers through cooperative ownership or custom hiring is a limited solution towards mechanizing such farms. Most cooperative or custom operations cater only to specific farm operations & do not serve the overall needs of the small & medium size farmers.
4. Most farmers are beginning to encounter seasonal shortage of labor specially during the land preparation, transplanting & harvesting-threshing season.
5. The new wheat and rice varieties require more intensive cultivation to develop full yield potential. With Seasonal shortages and increasing costs of labor, it is becoming difficult for small farmers to tap full potential of the new varieties with traditional methods & equipment.
6. Past efforts to mechanize agriculture in Pakistan have been directed primarily towards the utilization of imported farm machines. Little attention has been paid to tackling all the elements which make the farm mechanization system, i.e. machinery development, manufacture, marketing & utilization.
7. Mechanization in the farmers field and the manufacture of agricultural machines are intimately related issues and these will have to be tackled simultaneously to successfully mechanize Pakistan's agriculture.
8. Pakistan, like most other developing countries, is facing shortages of foreign exchange and must develop indigenous production of tractors & other farm machines to save foreign exchange, create new industrial employment and achieve industrial growth.
9. Pakistan has a reasonably well developed small scale metal working industry with the capability to produce simpler agricultural machines to meet local demand.
10. Quite often arguments have been put forward specially by manfacturers from the industrialized countries, that economical production is only possible when a mass demand exists. Recent experiences in the Philippines, Thailand, India and Pakistan indicate that fairly complex machines such as power tillers, threshers, machine tools, oil engines etc can be economically produced in small numbers provided appropriate designs are made available to local entrepreneurs.

Mechanization Strategy

Pakistan must place a major emphasis on the development & local manufacture of appropriate tractors & farm machines which could meet the needs of the medium size farmers 10-50 acres which could be manufactured by small scale metal working firms in the country.

Agricultural mechanization requirements of the larger farm holdings can continue to be met for some years from imported equipment, however, immediate efforts must be made to provide appropriate designs of farm machines for the medium size farmers who have the resources to afford an intermediate level of mechanization. Small farmers

※Paper presented at the meeting of the Principal Investigators of the PL-480 Projects at Lahore, Dec. 10, 11, 1976.

with holdings of less than 10 acres do not have adequate resources to acquire mechanically powered equipment. Maximum incentives however meeds to be provided to contractors & large and medium size farmers to develop tractors & equipment, hire services to cater to the needs of the small farmers. Experience in the Philippines & Thailand indicate that mechanized farms can sucessfully organize contract hire operation for small farms to make more economic use of this equipment. Parallel attempts must also be made to improve animal drawn implements although many years of experience in India and some African countries, indicate that the cost benefit ratios of improved animal drawn implements are not su,,iciently favorable for widespread acceptance.

A high dugree o, versatality is needed from machines for medium size farms since farmers cannot afford to own different equipment for each farming operation. Animal power is widely used in Pakistan by farmers for transportation as well as farming operations. Modern farm equipment for small & medium farms must serve the cultivation and transportation needs of the farmers.

The development of farm equipment for commercial production is a complex function which has not received adequate attention in Pakistan. Facilities & expertise for this specialized field are almost non-existent. Universities and other public research institutions, where agricultural engineering research is currently undertaken, have little experience in the commercial product development, manufacturing and marketing of agricultural machines. Since local farm equipment industry is not in a position to divert their meagre resources towards machinery development, appropriate research & development organization need to be established in the public sector. The Government must play a leading role in establishing commercially oriented research and development organizations which could work closely with the local metal working industry in Pakistan.

IRRI-ARC Program

The Agricultural Research Council has established an Engineering Cell to conduct research and to develop appropriate farm machines for local manufacture in the country. ARC's Engineering Cell is collaborating with the IRRI in adapting and introducing the IRRI developed rice machines in Pakistan. IRRI has set up an agricultural machinery program under which IRRI designed ma-

Fig.1. The office of Regional Agri. Mechanization Program IRRI, in Rawalpindi, Pakistan. The shop is located on the back of office building.
The adaptation of IRRI thresher to suit local condition has been completed. The thresher marketability has been increased due to its wide range threshing ability of all cereals i.e. wheat, rice sorghum, millets etc. The Power tiller Project is near to start.

Fig.2. Field testing of IRRI design axial flow rice thresher at Rice Research Institute, Kala Shah Kaku, Lahore. The satisfactory performance on local condition has been achieved after in corporating some modification in the original design.

Fig.3. The IRRI thresher is now in regular commercial production in Pakistan. This unit is manufactured by Lohore Engineering Foundry Limited (Lefo).

chines are brought into the country, and are extensively tested and adopted to suit local conditions. Considerable progress has already been made under this collaborative program to introduce new farm machines.

The IRRI rice thresher has been modified to suit local farming condition. The machine can now thresh not only paddy but also wheat, sorghum, millet and other small grain orops. Five manufacturers have been provided drawings and technical assistance in starting the local production of this thresher. Ten locally built threshers were field tested during the last rice threshing season. Work is currently under way to test these machines in various parts of the country. It is hoped by next cropping season, these threshers would be available in the market.

A Liquid Chemical Applicator for paddy rice has been evaluated at the Rice Research Institute, Kala Shah Kaku and a local company. has been assisted in fabricating limited number of machines for more extensive field evaluation. This machine applies fertilizer and other chemicals in rootzone thereby resulting in considerable savings in the amount of fertilizer and chemicals required for rice production. This applicator is a simple device with a portable tank that the operator carries on his back. It has a manually held applicator nozzle which places chemical few inches below the surface next to the plant. Regular production of this applicator will be encouraged as soon as the extensive evaluation has been completed.

A few prototype units of the diaphragm have been procured from local manufacturer. This machine can pump 50 to 60 gallons of water/min at 1 to $1\frac{1}{2}$ meters heads. This is a high delivery low lift portqble pump which can be used by farmers for pumping water from shallow streams and ponds. The mach-ne is being field tested now.

A new Mini Thresher for threshing of small grain crops is also being built. This machine uses the axial flow principle but is much cheaper in cost than the thresher that has recently been introduced. This thresher is especially designed for the individual farmers who are not in a position to invest sufficient capital to acquire the larger capacity thresher that is now being produced in the country. A manually operated 6 row transplanter has been imported and is being evaluated in the country. This machine is fairly simple to produce and operate and will be introduced if the performance is found satisfactory. Similarly IRRI designed Power Tillers have been imported into the country and are now undergoing field evaluation. These machines will be extensively tested and adopted to suit local farming conditions as well as local production requirements. It is hoped that a number of prototypes will soon be produced by local companies. ■ ■

Fig.4. The locally produced diaphram pump is being used at Rice Research Institute, Kala Shah Kaku, Lahore, Pakistan.

Co-Operating Editors


A. H. Abdoun


Bilash Kanti Bala


M.A.K. Bedri


W.J. Chancellor


Md.S.Choudhury


Chang Joo Chung

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

Bilash Kanti Bala
Head, Dept. of Farm Power & Machinery, Bangladesh Agricultural University Mymensingh, Bangladesh

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

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

Md. Shahansha-ud-Din Choudhury
Professor, Farm Power & Machinery Department Bangladesh Agricultural University Mymensingh, Bangladesh (on leave to Iraq: 4/74, Sherej Khana Mosul, Iraq)

Chang Joo Chung
Associate Professor and Acting Head, Department of Agricultural Engineering, College of Agriculture, Seoul National University, Suweon, Korea

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

Manbahadur Gurung
Horticulture Extention Officer Ministry of Development Dept. of Agriculture, HA Bhutan
P.O. HAA, Bhutan

George B. Hanna
Engineer, Farm Mechanization Consultant, 160, 26 July St., Agouza, Guiza, Egypt

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

Chul Choo Lee
Project Engineer, Projects Department, Asian Development Bank P.O. Box 789, Manila, Philippines

A.M. Michael
Professor, Water Technology Center, Indian Agr. Research Institute, New Delhi 110012, India


M.L. Esmay

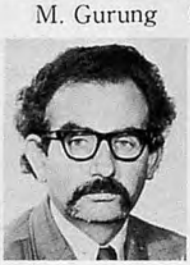

M. Gurung


George B. Hanna


C.C. Lee


A.M. Michael


Adrian Moens


T.B. Muckle


A.A. Mughal


T.T. Pedersen


G. Pellizzi

Tien-song Peng   Jun Sakai   B.K. Shrestha   Siswadi Soepardjo   R.P. Venturina

Adrian Moens
Head Professor, Dept. of Agr. Engineering, Agricultural University, Dr S.L. Mansholtlaan 12, Wageningen, Netherlands

T.B. Muckle
Senior Lecturer, National College of Agricultural Engineering, Silsoe, Bedford, U.K.

A.A. Mughal
Assistant Professor, Agricultural Engineering in the Faculty of Agricultural Engineering, Sind Agriculture College, Tandojam, Sind, Pakistan

T. Touggaard Pedersen
Professor, Agricultural Engineering at the Royal Veterinary—and Agricultural University, Copenhagen, Denmark.

Giuseppe Pellizzi
Professor, Universita Degli Studi, Facolta Di Agraria, Instituto Di Meccanica Agraria, Via G Celoria 2-20133 Milano Italy

Tien-song Peng
Specialist, Plant Industry Division Joint Commission on Rural Reconstruction 37, Nanhai Road, Taipei, Taiwan

Jun Sakai
Associate Professor, Department of Agricultural Machinery, Faculty of Agriculture, Mie University, Kamihama-cho, Tsu City, Japan 514

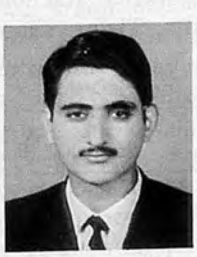
Bala Krishna Shrestha
Assistant Agr. Engineer, 4/141, Pulchowk Behind the Fire Brigade Latipur, Nepal

Siswadhi Soepardjo
Chairman, Agricultural Engineering Dept., Bogor Agricultural University, Japan Gunung Gede, Bogor, Indonesia

Ricard P. Venturina
Assistant Scientist for Agricultural Research, National Science Development Board, P.O. Box 3596, Rizal, Manila, Philippines

New Co-Operating Editor

Mohammad Ilyas



Date of Birth:
January 15, 1952

Education:
B. Sc.-1975
(Agricultural Engineering)
Faculty of Agricultural Engineering, University of Agriculture, Lyallpur, Pakistan

B.Sc. Thesis:
"The study of Grain Losses in Combine Harvester"

Professional Activities:
1974-75, Editor, Agricultural Engineering, Journal of Society of Agricultural Engineers University of Agriculture, Lyallpur, Pakistan.

Employment:
Agricultural Engineer (Testing) Regional Agricultural Machinery Program, International Rice Research Institute, P.O. Box 1237, Islamabad, Pakistan.

Specific Assignment:
Testing, evaluation and industrial extension of IRRI designed machines and to modify them to suit the local conditions.

Agricultural Mechanization in Bangladesh

by
Bilash Kanti Bala
Assistant Professor,
Department of Farm Power & Machinery,
Bangladesh Agricultural University,
Mymensingh, Bangladesh.

Introduction

Bangladesh is an agricultural country. The total area of the country is 55,598 square miles and its population according to 1974 census is 7, 14, 79, 071 (10). It is densely populated having a population density of 1286 per square mile including reverine area. The annual birth rate is 50 per 1,000 and the annual death rate is 20 per 1,000 (10).

The arable land is a limited resource in Bangladesh and the increasing population has already put a heavy stress on it. The feed back loops of population, capital, agriculture and pollution using systems concept are shown in **Fig.1.** Since the annual growth in population is 3 percent with a limited land resourse ; the food per capita can be increased by increasing agricultural capital, for example, tractor, power tillers fertilizers etc. Bangladesh is now suffering from a shortage of food grains. So, it is obvious that Agricultural Mechanization in Bangladesh is a necessity.

Back ground and Farming conditions in Bangladesh

Bangladesh is bounded by the Bay of Bengal in the South, The India in the North, North-West and North-East, and by Burma in the South-East. It lies roughly between 20/30 to 26/45 North lattitudes and 88.00 to 92/56 East lattitudes (10). Barring hilly regions in the North and South-East, it is constituted mainly by the deltas formed by the Ganges, Brahmaputra and Meghna rivers. This region is intersected by a network of water ways and is conspicuous by its high rainfall. It has an average rainfall of 85 inches a year and subtropical climate. Altough the minimum temperature is 38°F and a maximum of temperature is 105°F, there is not however very much fluctuations in the general temperature of country and its climate is more or less warm, pleasant and humid throughout the year.

The soil is very fertile and alluvial type because of the three great river systems spreading over most of the country. Generally the reaction of the soil is acid the PH value varies from 6.0 to 7.0 (3).

Small-sized Farms

A unique feature of land holdings in Bangladesh is that the agricultural land is divided into small subdivisions and fragmentations among 6.50 million holdings averaging 3.5 acres per family as shown in **Table 1.** The extremely small field sizes of acres made effective use of the tractors difficult. Thus, large scale consolidation of crop fields into large sized plots is necessary.

A co-operative Machine station at Comilla Thana showed that

Table 1. Farm Size Pattern of Bangladesh.

Size of Farms (acres)	Numbers of Farms (Million)	Percentage
Below 1.00	1.00	17.00
1.00 — 2.50	1.75	26.60
2.51 — 5.00	1.76	26.80
5.01 — 7.50	0.83	12.60
7.51 — 12.50	0.64	9.70
12.51 — 25.00	0.31	5.60
25.01 — 50.00	0.09	1.40
Over 50.00	0.02	0.30
Total	6.50	100.00

Source: (3)

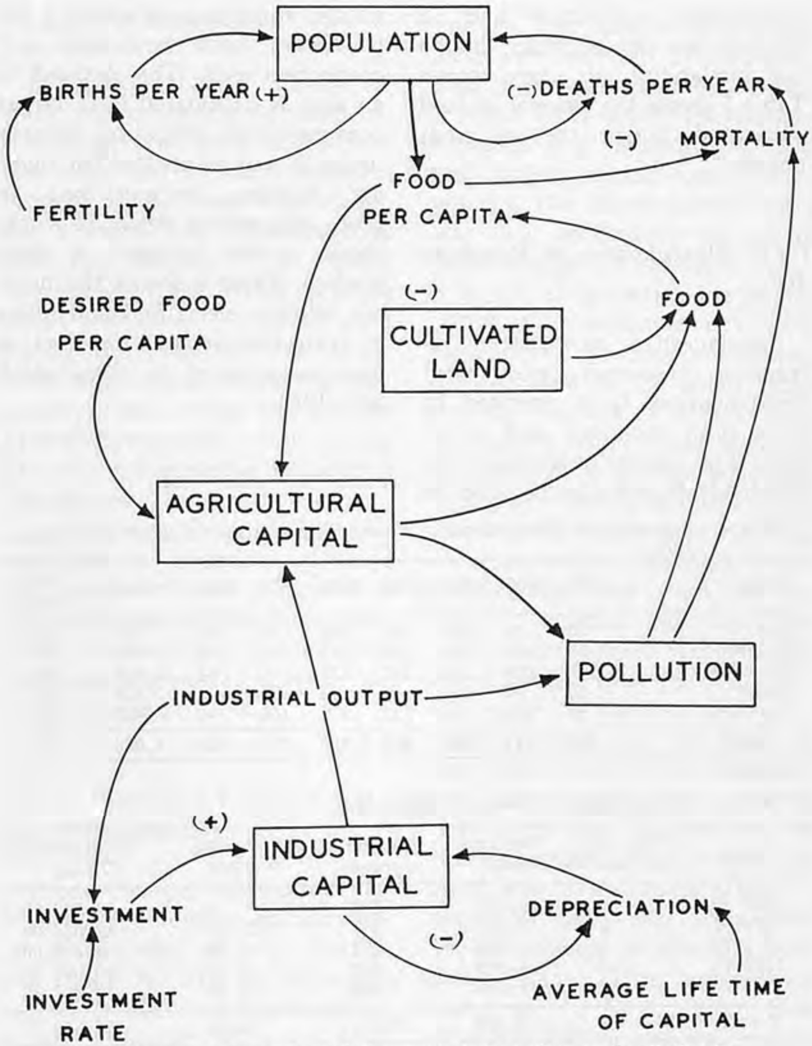


Fig.1. Feedback loops of population, capital, Agriculture and pollution (8).

farmers with adjoining fields could group them together so that the tractor could be operated on a large area.

Multiple Cropping Systems

The two traditional cropping seasons are the early part and later part of the monsoons period. In the winter, a third crop is possible where water can be procured. Experiences show that small farmers can adopt new varieties and practice multiple cropping where mechanized irrigation has been practised.

Many crops other than rice are grown by rotation. In the rice growing areas, jute, sugar cane, tobacco, potato and several varieties of vegetables and fruits are also produced. So, selective mechanization of certain agricultural practices with labour intensive methods may be used to prevent unemployment and possible displacement of rural people.

Present State of Agricultural Mechanization

In 1950-51, Agricultural Directorate undertook the scheme Mechanized Cultivation and Power Pump Irrigation, and a Systematic approach to Agricultural Mechanization was initiated in 1953. During the period 1959-60, the Government supplied 1150 pumps and 47,000 acres were brought under irrigation, 346,000 acres were covered with plant Protection and 7,000 acres waste land was developed.

During 1960-65, the use of power pumps was increased to 2,238 and 131,000 acres were covered under irrigation; 200 tractors were imported; 13,828 hand sprayers, power sprayers, and dusters were distributed and two workshop were established.

During 1965-70, Agricultural Mechanization was stressed further. The number of tractors was increased to 2,072, the number of power tillers used was 2,571. Power pumps introduced were 18,603 and 1,230 deep tubewells were installed. During last five year 1971-75, maximum stress was given on pump and tubewell irrigation and upto July, 1974, 35,000 pumps and 3,300 tubewells were installed, covering an area of 16,07,760 acres.

In July 1972, a scheme on mechanized cultivation was prepared by BADC with 500 tractors and 750 power tillers for emergency rehabilitation works in the 7 war devestated border districts and flood affect district of Sylhet. Under the scheme 200 MF-tractors under U.K. grant, 300 Bayelarus tractors under USSR credit and 450 power tillers against cash foreign exchange were procured.

Farm Power in Bangladesh

Although the use of tractors and power tillers is increasing in all the districts of Bangladesh, still animal drawn implements perform the major farming operations. The total number of draft animals were about 23 million (1970-71) at which cattle 96%, buffaloes 3% and horse 1%. The draft animals are small, under fed, and competing with man for food. These conditions prevent farmers from using improved implements and necessitates ploughing the land for several times, still the land can not be

Table 2. Distribution of Tractors in Bangladesh, 1975.

Sectors.		No. of Tractors
Private		1,657
Public Agencies.		
i) BADC	757	915
ii) BIDC	111	
iii) BWDB	14	
iv) Dept. of Agri.	16	
v) BARD (Comilla)	17	
Total		2,572

Source: (2)

brought upto the mark. Many farmers do not have any draft animals. All these factors lead to less production in Bangladesh.

The number of tractors in Bangladesh upto June, 1975 was 2572 of which 40 were crawler type and the rest wheel type. In public Sector, there were 915 tractors while in private sectors, the figure was 1,657 as shown in **Table 2.**

Considering economic limitations and farm size, power tillers were employed in Bangladesh. By the end of the June, 1975, 4,064 power tillers were imported of which 3,021 were distributed. **Table** 3 shows the distribution of power tillers in Bangladeuh.

Mechanized Cultivation in G.K. Project

Bangladesh Water Development Board is maintaining a section of Farm Mechanization through Thana Central Co-operative Association. There are altogether 5 tractors, 79 sprayers, and 341 WAPDA plough (Benwick and Co. of Kustia town in colleboration with WAPDA manufactured a special type of improved plough known as WAPDA plough). **Table** 4 shows the performance of tractors for mechanized cultivation in G.K. Project area.

Mechanized Cultivation in KTCC

In Comilla KTCC total number of Tractor is 35, out of which 20 are working for the purpose of mechanized cultivation and 15 tractors are out of order due to non-availability of spare parts. **Table** 5 shows the amount of land cultivated under the different unions.

Rural Electrification in Bangladesh

Bangladesh is now putting increasing resources into rural electrification. It is intended to serve both economic and social aims. The variety of purposes for which electricity can be used in village areas is surprisingly wide. It covers both household and productive uses. The demand in an area is dominated by a larger consumer with irrigation. In near future it will be utilized for lighting, heating, refrigerations in shops and motive power in workshops in the villages of Bangladesh. **Table** 6 shows the number villages electrified and miles of transmission and distribution lines constructed in Bangladesh upto 1972.

Table 3. Imports and Distribution of Power Tillers in Bangladesh upto June, 1975.

Make	1965	1966	1967	1968	1969	1970	1974	Imported	Distributed.
Iseki	50	15	217	117	195	—	218	812	644
Kubota	50	100	142	223	301	—	126	942	727
Mitsubishi	128	105	184	192	333	—	84	1,026	693
Satoh	50	96	—	—	96	70	22	334	221
Yanmar	50	395	—	127	278	100	—	950	736
Total	328	611	543	659	1,203	170	450	4,064	3,021

Source: (2).

Table 4. Performance of tractors: 1969—74.

Year	No. of Tractors.	Working hours	Ploughing acerage	Levelling acerage	Total income (Taka)
1969-70	5	1,192	782	—	9,642.00
1970-71	5	1,537	567	32.00	12,026.00
1971-72	5	516	172	1.25	4,837.00
1972-73	4	1,099	368	10.00	10,502.00
1973-74	4	1,355	482	9.30	19,362.75
Total	23	5,699	2,371	52.55	56,369.75

Source: (9).

Table 5. Acres of land cultivated in different Unions (November 1974 to July 1975).

Type of Implement	Kali Bazar	Durgapur	Beyjoypur	Comilla Town	Goganath Pur.	Chowara.
Harrow	306.5	355.5	143.5	407.30	400.60	276.90
Rotovator	13.5	62.7	108.8	233.30	47.50	158.80
Disc plough	3.0	27.5	7.2	47.50	3.00	1.00

Source: (2).

Table 6. Villages Electrified and Miles of Transmission and distribution lines in Bangladesh.

Year	Number of Village Electrified.	Transmission line (Mile).	Distribution Line (Mile).
1960-61	—	144	689
1961-62	—	170	987
1962-63	—	170	1,200
1963-64	—	170	1,712
1964-65	138	170	2,130
1965-66	150	223.5	2,775
1966-67	200	412.5	3,450
1967-68	215	457	4,207
1968-69	230	540	4,807
1969-70	250	647	5,553
1970-71	250	647	5,972
1971-72	250	647	6,100

Source: (10).

Irrigation in Bangladesh

Bangladesh has a plenty of water resources and a rough estimate gives a figure of 925 million cubic feet of water annually brought by the three main rivers, the Ganges, the Brahmaputra, and the Meghna. The water courses of these rivers provide about 2700 miles of channel open during the monsoon, and about 1,800 miles open during the dry season. These water courses can provide irrigation water during dry season if pumping equipments are applied.

Irrigation in Bangladesh is being done in a variety of ways ranging from power pumps, deep tube-wells and shallow tube-wells, tanks and minor irrigation and drainage schemes to several major canalized projects.

Power Pump and Tube-well Irrigation in Bangladesh

Production per acre can be increased by cropping during winter season with the help of artifieial irrigation. The use of irrigation water also facilitates applications of higher doses of fertilizers.

1950-51, the Agricultural Directorate took up the Mechanized cultivation and Power Pump Irrigation (MCPPI) scheme which was the first attempt in this direction. The scheme was extended to a few districts and remained mostly confined within the haor areas of Mymensingh and Sylhet districts. In 1962-63, the operation of the scheme was taken over by the BADC and gradually the number of the pumps was also increased. Both these sponsoring agencies had to subsidize the operation heavily. But heavy arearers of pump rental accumulated and the operations of the Scheme remained confined to a limited area. However, they demonstrated the use of low-lift pumps and their potentialities. The large irrigation projects were built up by the water and power Development Board (Former EPWAPDA) like Ganges Kabadak and Thakurgaon tube-well projects at the cost of huge amount. But utilization of water was long delayed due to lack of farmers organization there.

By the early sixties, the importance of irrigation in increasing agricultural production became quite evident to the policy makers and planners. The experts of agriculture began to put stress on the need of providing irrigation and other modern facilities to the farmers. But they were looking for a model for adoption in expanding the operation of the MCPPI Scheme all over the country. Bangladesh Academy for Rural Development (BARD) Comilla came forward to develop a model scheme, on the basis of past experiences of the agencies and departments mentioned above and its experiments in Mechanization of agriculture and rural works programme over a period of five years from 1960-1965 conducted in Comilla Kotwali Thana. This model was tested by the Govt. in ten Pilot Thana in 1966-67 and was evaluated by the Planning Commission. On the recommendation of the evaluation committee the decision to use the model for its quick expansion was taken by the Government. This model has been called Thaha Irrigation Programme. Implementation of this programme throughout the country began in the year 1967-68. **Table 7** shows the progress of Thana Irrigation Programme.

Irrigation Projects of BWDE (Former EPWAPDA)

The BWDB (Former EPWAPDA) has so far completed 5 multipurpose flood control-cum-irrigation projects. It has got 7 more projects in hand. All these projects including other projects will cover about 3 million acres of land directly under irrigation facilities.

G.K. Project—This is a multipurpose agricultural development project for Kushtia, Jessore and Khulna. The name Ganges Kobadak Project is from the name of the source of water from the rivers the Ganges and the Kapatakks. The preliminary planning was made by FAO in 1952. The three phases, the Kushtia Unit, the Jessore Unit, and Khulna Unit cover a total irrigable area of 17,65,000 acres. It is mainly an irrigation project (Lift cum gravity flow irrigation) with the provision for flood control and surface drainage. The main features of the project are:

a) The Intake Channel—1.20 miles.

b) Pumping plant—3 Nos. main pumps of capacity 1300 cusecs each and 12 Nos. subsidiary pumps with total capacity of 1500 cusecs. This includes the requirement of phase II also.

c) Irrigation Canal System.
   - i) Main Canal ·········46 miles.
   - ii) Secondary Canal 133 miles.
   - iii) Tertiary Canal 318 miles.
   - 497 miles.
   - iv) Field channels ···1722 Nos.

d) Drainage canal system.
   Major drain. ······133 miles.

Table 7. Progress of Thana Irrigation Programme.

Item.	1969-70	1970-71	1971-72	1973-74
No. of pumps used.	17,844	22,590	23,892	35,000
No. of deep tubewells	300	—	710	3,300
Total area irrigated (acres)	705,671	784,890	828,067	1,607,760
i) Irrigated by pumps	—	—	774,680	1,434,048
ii) Irrigated by tube-wells.	—	—	18,633	173,712
Total cusec.	—	—	43,802	67,200
Acres per cusec.				
i) By tube-wells	20.38	21.45	17.69	21.34
ii) By pumps.	37.81	33.00	25.25	52.64

Minor drain. ······130 miles.
263 miles.

e) Flood enbankment.···65 miles.

f) Hydraulic structures (Regulators, sluices, Syphons, checks and drops) ············1749 Nos.

g) Brfdges and culverts. 2174 Nos.

Sprayers and dusters for Plant Protection

A recent survey conducted by the Farm Power & Mechinery Department of the Bangladesh Agricultural University indicated that 44 percent of the farmers of Bangladesh want one or other kind of sprayers for plant protection. Thus there is a demand for mechanization of plant protection operation.

During early sixties 13,828 power sprayers, hand sprayers and duster were introduced. At present 15,000 power sprayers and 38.000 hand sprayers and duster are in use.

During 1972-73 Government introduced 125,000 sprayers to spray 17,606 tones of pesticides over an area of 136,150 spray acres.

Other machineries and Implements

The ministry of Agriculture estimated the following machinery and implements in the Development plan (1972-77) for the country.

Sprayers··················125,000 Nos.
Paddle Threshers ······25,000 Nos.
Power Threshers·········2,500 Nos.
Small Driers. ················800 Nos.
Seed drills. ···············25,000 Nos.

Conclusion

Agricultural Mechanization in Bangladesh should not adopt perse the complex, labour efficient mechanical power units and equipments. As Bangladesh has too many people to feed, she must adopt selective mechanization:

1) to increase the yield per /acre and production of food crops,
2) to increase better utilization of labour force and
3) maximize the benefits from lowest possible energy input.

In order to increase the yield per acre, the use of high yielding varieties and fertilizer in conjuction with better water control and management, and introduction of multiple cropping will necessitate machines. Systems Analysis can provide greater in sight into critical and rapidly changing agricultural problems in Bangladesh. Guide engineers, planners, and Govt. officials can use the systems technique in the selection and transfer of appropriate technology for the current servival and future development.

REFERENCES

1. ALAM, MD. MANJUR-UL, AND CHOUDHURY, ZULFIQUR HAIDER, (1976), Report on the evaluation of Thana Irrigation Programme in Bangladesh (1973-74).
2. BALA, B.K. and MATIN, NURUL (1975), Agricultural Mechanization in Bangladesh, Project Report, submitted to Department of Farm Power and Machinery, BAU, Mymensingh.
3. CHOUDHURY, M.S.U. (1973), Agriculture and Agricultural Mechanization in Bangladesh, Int. Jour. Agricultural Mechanization in Asia, Farm Machinery Industrial Research crop, Tokyo, Vol.IV. No.1, PP 128-138.
4. COWELL, P.A. (1973). The role of Agricultural Machinery in Agricultural Development, Workshop on Agro-Industrial Development in the lower Mekong Basin, 26 Nov.-18 Dec. 1973, Bangkok, Thailand.
5. ESMAY, M.L. and GAISER, D (1976). The interdependance of selective Agricultural Mechanization and local manufacturing in Developing countries, Inter. Journal of Agricultural Mechanization in Asia, Vol. VII, No.1, Winter 1976.
6. FRAIDLEY, L.W and ESMAY, M.L. (1975). Systems Analysis as a guide to technology Transfer, Inter. Journal Agricultural Mechanization in Asia, Vol. VI, No.2, Autumn 1975.
7. GILES, G.W. (1975), The Reorientation of Agricultural Mechanization for Developing countries, Part 1, Policies and attiludes for action programmes, Inter. Journal of Agricultural Mechanization in Asia, Vol VI, No.2, Autumn, 1975.
8. MEADOWS, DONELLA H., MEADOWS, DENNIS L., RANDERS, JORGEN and BEHRENS III, WILLIAM W., (1972). The limits to growth, New American Library, New York.
9. RAHMAN, MOHIBBUR, (1974), Survey report on existing Agricultural Technology in Northen Bangladesh, Task force on appropriate Technology, Bangladesh Research Council, Dacca.
10. Statistical Digests of Bangladesh No.9: 1973 (1974), Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning. ■ ■

INQUIRY and REQUEST to AMA

Please tell us your inquiry and request. We will respond to them for reader. Inquire any catalog you want on advertisement in AMA. We may serve them. And please tell us your editorial request to AMA.

Fill this card and send us by sealed letter.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7-2 Kanda Nishikicho, Chiyoda-ku, Tokyo-Japan 101

ADVERTISED PRODUCTS INQUIRY

Product	Advertiser	Vol. No. Page.

EDITORIAL REQUEST TO AMA

Your Name :

Adress :

Occupation :

ORDER FORM

AGRICULTURAL MECHANIZATION IN ASIA (AMA)

Please supply the following:

☐ Yearly Subscription—Quarterly

US $ 15.00—per US $ 4.00—(inc. surface mail postage)

☐ Back Numbers in 1971 - 1975 (per copy: US $ 8.00)

Spring, 1971	Autum, 1971
Vol.3 No.1, 1972	Vol.3 No.2, Summer, 1972
Vol.4 No.1, Spring, 1973	Vol.4 No.2, Autumn, 1973
Vol.5 No.1, Summer, 1974	Vol.6 No.1, Spring, 1975
Vol.6 No.2, Autumn, 1975	

(Check which you would like to order)

☐ Back Numbers from 1976 (per copy: US $ 4.00)

Vol._____No._____, _____________197_____, _____________copy/copies

☐ Please invoice me/us

☐ I/We enclose remittance for US $ _______________

****

Name: ____

Firm: ____

Position: ______________________________________

Address: ______________________________________

(block letters)

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

Tokyo 101 Japan

Tel. (03)–291–3671–4, 5718

STAMP

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

FOLD HERE

FOLD HERE

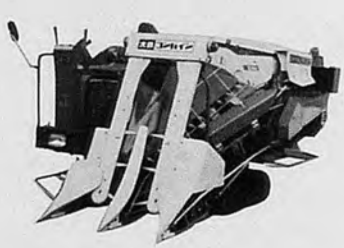
Oshima AGRICULTURAL MACHINES

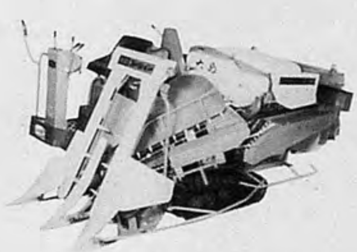
OSHIMA is the only manifacturing company that can provide you with machines which cover all the operations, from harvesting to hulling.

〈Combine harvester series〉

The Best combine Works Under Any Condition!

* Unnecesity for hand harvesting, having placed harvesting mechanism at front part.
* Excellent threshing and separating by work of threshing mechanism as well as heart of combine.
* Easy operation with all driving equipments around drivers' seat.
* Adjustable range cutting height 600-1200 m/m by free operating lever.
* Two outlets with safety device into paddy bags.
* Light movement even in puddy field for low ground contact pressure.





- model RS-601 · 601A
  Engine=7～9HP · 9～12HP
  Cutting wide=650mm 2row cotting
  Efficency=80～120minutes/10ares

- model RS-880 · 880A
  Engine=9～12HP · 10～12HP
  Cutting wide=800mm 2～3row cutting
  Efficiency=40～70minutes/10ares

- model RD-1000
  Engine=11～13HP
  Cutting wide=800mm 2～3row cutting
  Efficiency=40～60minutes/10ares

- model RD-2300
  Engine=25HP
  Cutting wide=1300mm 4～5row cutting
  Efficiency=30～60minutes/10ares

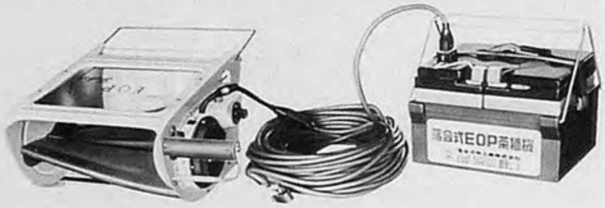
OSHIMA AGRICULTURAL MACHINERY MFG. CO., LTD.

Head Office: 10-17, Teramachi 3-Chome, Joetsu City, Niigata Pref: Japan

Branch Office: Takada, Niigata, Matsumoto, Toyama, Fukui, Yamagata, Miyagi, Akita
Tokyo, Nagoya, Osaka, Okayama, Sikoku, Fukuoka, Asahikawa

OCHIAI'S

TEA-LEAF PICKERS
TWIG CUTTER & SHEARS



EOPA8

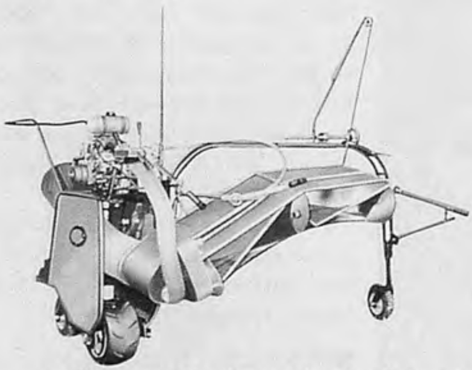
Features:
Light, safe, and efficient.

C-8A KARRY

Features:
Light and efficient, making little noise while in operation. In Japan, it is capable of picking tea leaves on 60 to 80 ares of tea plantation in a single day.

riding typed tea-leaf picker

Features:
The first riding typed tea-leaf picker in the world, with a hydraulic linkage, can reap completely.



self-propelled tea-leaf picker

Features:
The first self-propelled tea-leaf picker in the world, with an original mechanism, OCHIAI developed, can be operated easily by one person.

GUIDE TO OCHIAI

- Succeeded in devising Japan's first automatic tea-leaf picker in 1959.
- Received the Director of the Board of Scientific Technology Award in 1967.
- During the intervening period (1959-1967) obtained a number of patents, as well as receiving a variety of awards and prizes in the domain of science and technology.
- The top-ranking tea-leaf picker and tea-tree trimmer producer, holding 60% of the shares in the same line of business in Japan, surpassing the other manufacturers in sales and product, and leading the related business worlds in its expansion and development.

OCHIAI HAMONO KOGYO CO., LTD.
OCHIAI SHOJI CO., LTD.

Head Office: 38, Chokaiji, Kikugawa-cho, Ogasa-gun, Shizuoka-ken, Japan Tel. Kikugawa (05373) 6-2161~5

Some Design Know-hows of Edge-curve Angle of Rotary Blades for Paddy Rice Cultivation

by
Jun Sakai
Associate Professor
Department of Agricultural Machinery
Faculty of Agriculture, Mie University
Kamihama-cho, Tsu City, Japan 514

Background of This Study

There is a problem of grass and straw on wet soil, when we have to develop tillage machinery fit to Asian paddy rice fields.

Generally, the system of paddy rice cultivation is divided into two methods of direct sowing and transplanting. Each method needs enough tillage, except the method of special minimum tillage, e.g. sowing without tillage.

The tillage depth of Asian paddy rice is generally shallower than around 20 cm, the standard depth of Europe and America, in order to utilize water efficiently and also to make the works of paddy rice field by men or cattle easier.

The depth is a little less than 10 cm in case of men and cattle in many tropical countries, and in case of Japanese machinery, it is 13 to 15 cm. Such traditional tilling depth has been kept through so many years in Asian paddy fields.

The experiments in this report were done by author's group in 1962 in Japan and 1969 in the Philippines. The design theories of lengthwise portion of the rotary blades were reported in reference (3) and (6).

Under the tilth, there has been the hard-pan to support working men, cattle and machines made naturally. Advisors from advanced countries have to notice a sudden deepening of tillage will cause the working machine to sink easily, by destroying the pan, and also increasing amount of necessary irrigation water. Actually such occasions as too deep tilth makes the machine sink down easily are increasing, because of rapid import of advanced culture.

The direct sowing method is sometimes applied to the unirrigated rice fields in Southeast Asia. They till the dry soil before rainy season, in 3 to 4 cm depth, using disk plows with weights, seed directly and wait for rainy season, expecting natural germination. Generally, however, they till the soft soil in rainy season. When they till the soil in the beginning of rainy season, a little amount of grass is on the field.

When the timing of tillage becomes late, because of shortage of labour, the rice grains fallen off the previous harvest have begun to grow as well as grasses, and they tend to twine round the tilling machine. However, in case of unirrigated districts mentioned above, treating grass and straw is not so serious problem.

Fig. 1 shows Japanese fields after harvesting paddy rice plants. They are cut close at their roots traditionally. Their cutting height from the soil surface is 3 to 10 cm in general. Rice plants in the fields of poor drainage are necessarily cut higher.

Even in such fields, if the threshed straws without chop were scattered on the soil as organic material, and some rice plants regrew from the stubbles after the previous harvesting as shown in **Fig. 2**, weeds, which have begun to grow since rainy season came again, together with stubbles and those straws which have not been decomposed because of Japanese cold weather, tend to be hooked by the tilling machine.

Fig. 3. shows the rice field after the harvest of heading system in the Philippines. As rice plants are cut and harvested at about 40 cm from their tip with panicles, at least more than 60 cm stem straws are left standing

Fig.1. Normal field after harvest in Japan

Fig.2. Grassy fields in Japan

on the field.

Accordingly, when the farm area of such a traditional harvesting system is fully equipped with irrigation facilities, the fields as shown in **Fig. 3** should be tilled just after harvesting.

Fig. 3 is an example under comparatively better conditions for designing rotary blades.

Fig. 4 shows the fields after a harvest by heading, without enough weed control. It must be recognized by the designers of rotary blades that there are rather a lot of such fields, in actual farming districts of Southeast Asia.

Japonica rice variety has a character of difficult shattering of grains, which has promoted the popuralization of lower-cutting harvest, while tropical rice variety in general has an easy shattering character that has made the heading method of harvest popular.[1] All social and labour structures of the rural area are being systematized so as to fit the harvesting method.

For a better agrlcultural mechanization in Japan, it was tried to make an advice to cut plants off the stubble as lower as possible. The change of harvesting method in tropical countries needs three important conditions as follows:

The dryness of rice field at harvesting
  … drainage control of irrigated water

Few weeds
  … diffusion of weed control technologies

The harvesting method without shattering loss of grains
  … developing and diffusing low shattering varieties of rice by breeding technologies or improved harvesters

Without those conditions, the present system of agriculture will be scarcely changed and still have difficult problems.

In Japan, rotary-tillers have come into wide use since about 15 years ago. Rotary-tillers which have no twining trouble of grass and straw on the rotary axle and blades have developed in answer to farmers' complaints.

Recently, rotary-tillers are being spread in many Asian countries. It is desirable for developing countries to have local-made blades of rotary tillers, as consumptive parts. Because a 1 to 1.5 dollar blade in Japan will become 3 to 4 dollars in developing countries who import it.[2]

Some design know-how of the rotary blades for paddy rice fields, especially to prevent grass and straw from coiling round them, will be discussed in this report.

Fig.3. Standing straw after head-harvest in tropical Asian countries

Fig.4. Straw with thick weeds after harvest in tropical paddy fields

The Characteristics of Grass and Straw on the Blade and Edge-Curve Angle

When an agricultural machine has to be newly designed, it is a general principle to design and develop it so as to perform its possible farm works without any trouble-shooting from farmers, after deciding the worst conditions in the range of its possible farm works.

The easy condition of tilling fields for the problem of grass and straw are comparatively dry and hard soil, tilling with new blades and a little amount of grass and straw on the fields. In case of dry and hard soil condition, grass and straw between the soil and blade are easily cut by the blade.

On the contrary, the worst condition is to till grassy fields of the soft soil with worn dull edges. Especially in case of tilling flooded soft soil, grass and straw are sometimes very difficult to be cut. The blades for Asian paddy rice cultivation should be designed and developed under such a worst condition.

As shown in **Fig. 5**, when a rotary blade is cutting into the soil, the angle α between the radius direction of the turning blade and the tangential line of its edge-curve becomes the clue to get this technical know-how.

The author's group named this angle "Edge-curve Angle" in English, "Hairaku-kaku" in Japanese.[3][4]

When α is small value, the lengthwise portion of the blade tends to become straight and easily hooks grass and straw. When α is large value, on the contrary, grass and straw slip easily off the blade to be pushed into the soil.

The larger value of α, however, makes the area of the blade which goes into the soil (the obliquely lined part in **Fig. 5**) wider. This means the enlargement of friction area between the blade and soil has a tendency to increase tilling resistance.

(In general, a blade with small α has a tendency to hook grass or straw easily but to reduce tilling resistance. This means that comparatively straight rotary blades are useful to till the fields without grass and straw.)

Accordingly, with such a smallest α as grass and straw will not be hooked by edge-curve, a good blade of smaller tilling resistance will be possibly designed. **Fig. 6** shows the force relation of

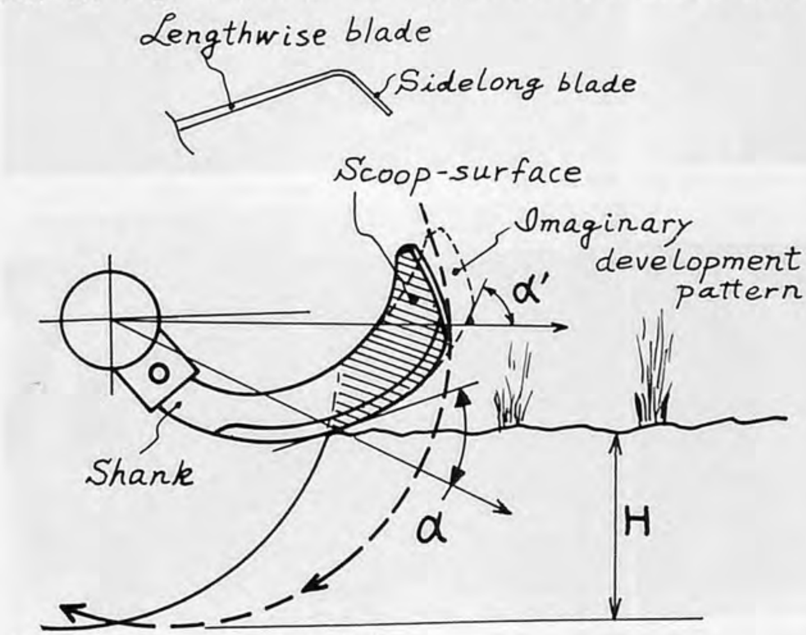


Fig.5. Shape and action of a rotary blade

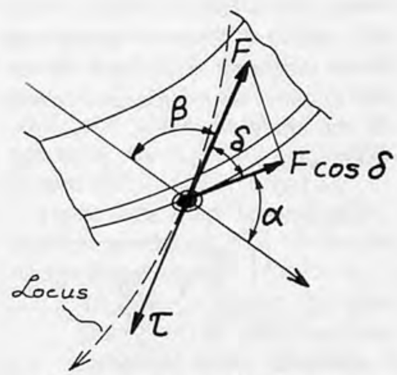


Fig.6. Edge-curve angle α and forces

α. When the tillage force of the turning blade is presumed τ, a stalk hooked by a knife has a pushing action toward the knife with reaction force F equivalent to τ.

When the angle between force F and tangent of edge-curve is δ, the removing force of grass and straw along the edge-curve to the blade tip is "F cos δ".[3]

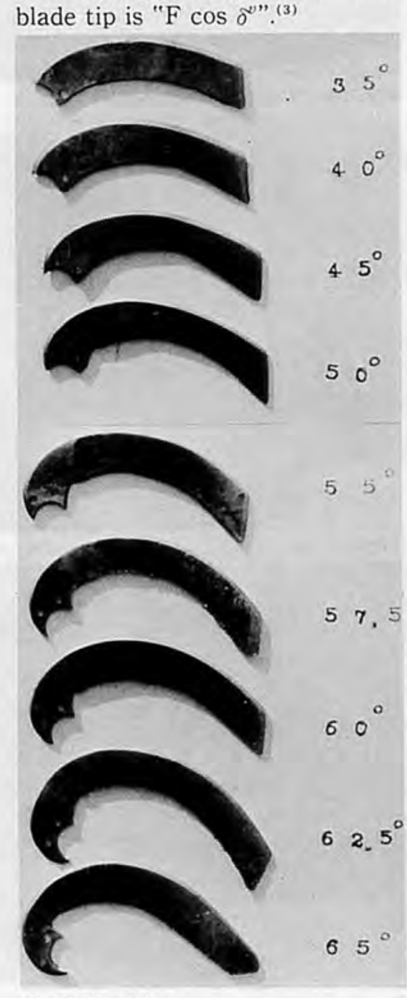


Fig.7. Test pieces

When this force is bigger than the adhesive force of grass and straw including sticky soil to the blade, they will slide and move off the blade.

Then,

$$\delta=180^\circ-\beta-\alpha$$

Where:[5]

$$\beta=\cos^{-1}\left\{\frac{\frac{30v}{R}\sqrt{(30v)^2-H(2R-H)}}{60n\pi v(R-H)+(Rn\pi)^2}\right\}$$

R: radius of any point on edge-curve, cm

v: travel speed of the machine, cm/sec

H: depth of any point on edge-curve from hard-pan surface, cm

n: rpm of rotary axle

The First Experiment on the Angle α of the Edge-Curve[4]

The author's group prepared such various lengthwise blades as shown in **Fig. 7.** The edge-curve applied to those blades was Archimedes' spiral of selected values of angle α, which were 35°, 40°, 45°, 50°, 55°, 60° and 65°.

The experiments were done using a power tiller equipped with those test pieces for the straws spread over the crayey wet soil. The travel speed of the tiller was about 40 cm/sec and

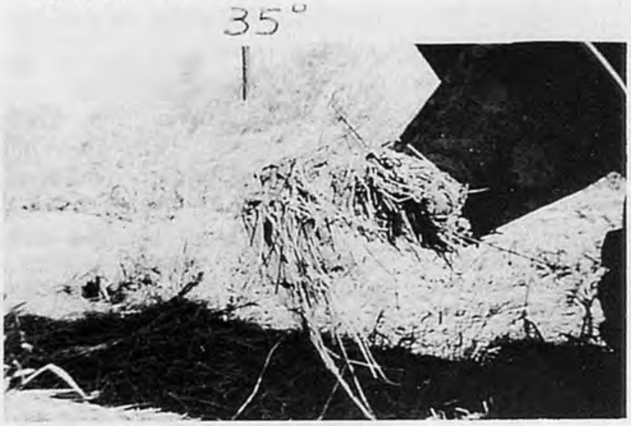


Fig.8. $\alpha=35^\circ$

Fig.9. $\alpha=40^\circ$

Fig.10. $\alpha=45^\circ$

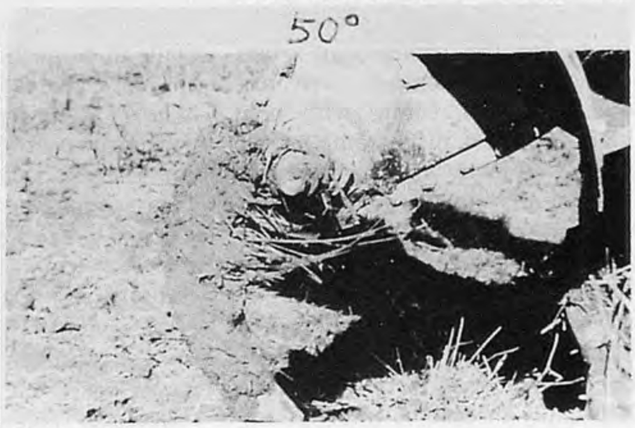


Fig.11. $\alpha=50^\circ$

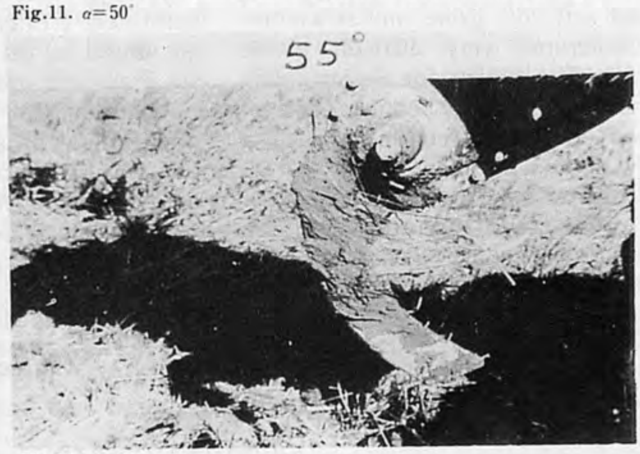


Fig.12. $\alpha=55^\circ$

Fig.13. $\alpha=57.5^\circ$

rpm of the rotary axle was 120 and 200 rpm. The 120 rpm is the possible minimum rpm to be considered in tilling wet soil, such as puddling before transplantation of rice plants.

As it is difficult to express the hooking character of blades to straws in numerical values, experimental results were judged by only observation including many pictures.

Fig. 8 to 13 show the results of the test.

Fig. 8 and 9: In case α is equal to 35° and 40°, the whole blade is apt to hook straws in quantities.

Fig. 10 and 11: In case α is 45° and 50°, the tip of the blade can be seen with no straw on it.

Fig. 12: In case α is equal to 55°, about one third of thu whole blade, from the tip, has no straw.

Fig. 13: In case α is 57.5°, about half of the whole blade, from the tip, appears without straws.

These tests show the tip part of the lengthwise blade (200 to 250 mm radius in general) with α in the range of 55° to 57.5° has the performance to remove straws. It also shows the shank portion of 57.5° α will be still coiled by straws.

The reason is presumed that the blade tip has higher speed of motion than the shank portion of the blade, resulting in bigger centrifugal force of the grass or straw on the tip portion than that on the shank portion.

The Second Experiment of Edge-Curve Angle α_n of Blade Holding Portion [4]

As the grass removing performance of the shank or holding portion of a blade with 57.5° α was not complete, the second experment was held continuously.

The blades with four Archimedes' spirals of 62.5°, 65°, 67.5°, and 70° α were tested, and the results as shown in **Fig.** 14 to 17 were obtained under the same couditions mentioned above. The blades with 62.5° to 65° α of 200 rpm or 120 rpm hooked straws, while the blades with 67.5° α did not hook them as shown in **Fig.** 15 and 17.

These first and second experiments produced the following design know-hows.

(1) In order to design the edge-curve of a blade without grass or straw hooking, in the case of tilling soft and sticky soil, the edge-curve angle α_t at the tip of lengthwise blade should be larger than the edge-curve angle α_n of its holding portion.

(2) α_t is about 57.5°, and the α_n is about 67.5°. α_n is preferable to be about 10° bigger than α_t.

(3) It is proposed that some design equation to calculate edge-curve angle α, which has to have reason-

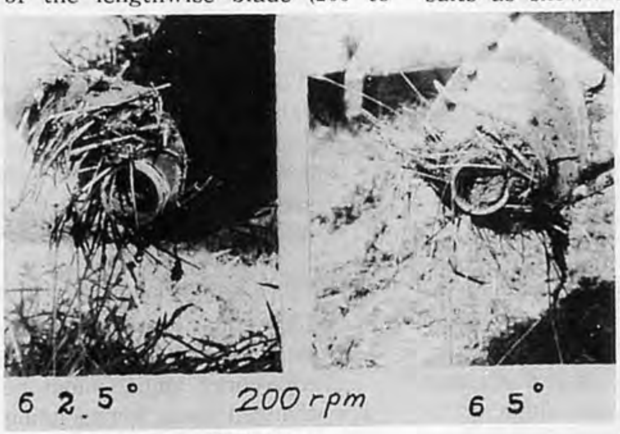


Fig.14. 62.5° and 65° of 200 rpm

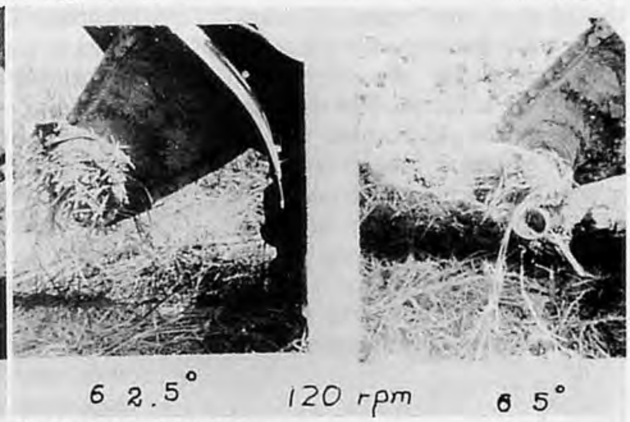


Fig.16. 62.5° and 65° of 120 rpm

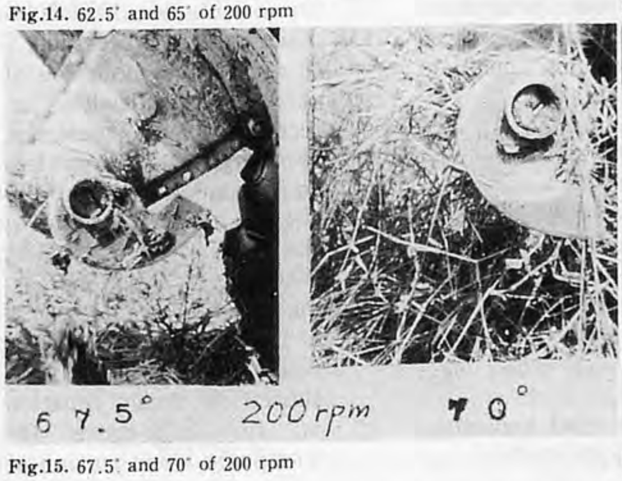


Fig.15. 67.5° and 70° of 200 rpm

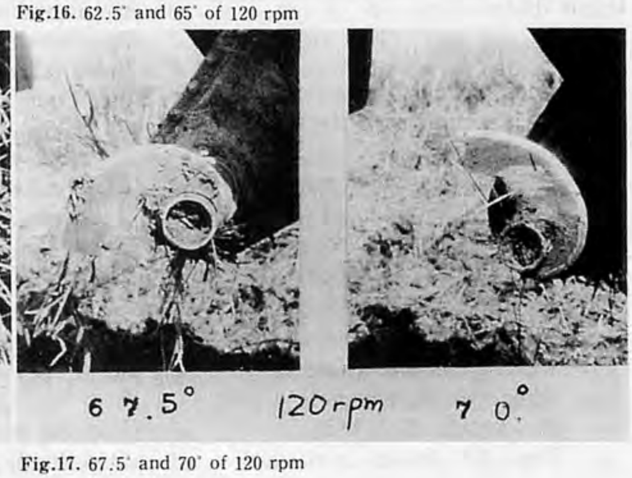


Fig.17. 67.5° and 70° of 120 rpm

able change, has to be analized for designing rotary blades for Asian paddy rice fields.

Analysis of Design Equations of Blade Edge-Curve [6]

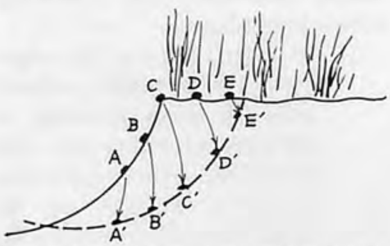


Fig.18. Desirable movement of grass and straw

When the grass and straw on the fields (A, B, C, D, E in **Fig. 18**) are not cut off by the blade, if they move down to the peripheral curve and slip off the edge-curve at points A′, B′, C′, D′ and E′ in **Fig. 18**, they may be thrown back with tilled soil and buried in the soil. Analizing their motions with the idea of slip forces of grass and straw on the edge-curve, it was proved that the edge-curve to give the slip motion to them as shown in **Fig. 18** accords with a spiral of polar coordinates in which the edge-curve angle α is expressed as the linear equation of polar angle θ.[6] This means that, by expressing r and θ of the edge-curve, the following differential equation is formulated;

$$\frac{dr}{r} = -\cot\alpha \, d\theta \qquad (1)$$

If α is $f(\theta)$,

$$\frac{dr}{r} = -\cot f(\theta) d\theta \qquad (2)$$

Two kinds of spiral equation are obtained, depending on $f(\theta)$ condition as follows;

1) $f(\theta) = \alpha_o$ ... which means a constant angle α of α_o. In this case, the curve is an equiangular spiral as the following equation;

$$r = r_0 e^{-(\cot \alpha_0)\theta}$$

where r_o is the value of r when θ is zero degree, e is the costant of 2.71828....

Fig. 19 shows such six

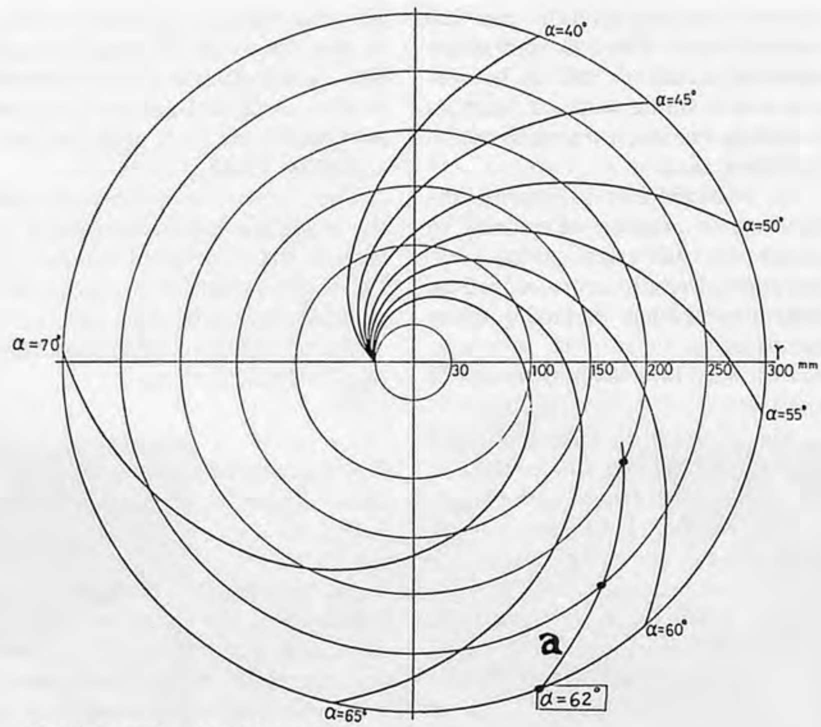


Fig.19. Several equiangular spirals

curves as r_o is 250 mm, α_o are 45°, 50°, 55°, 60°, 65°, 70° and θ changes every 10 degrees. These curves are used in a part (tip curve of lengthwise blade portion) of rotary blades in the market. However, they are not ideal curves, as proved by the first experiment.

2) $f(\theta) = \alpha_o + k\theta$

where α_o and k are constants, $\theta < f(\theta) < \pi/2$

This equation shows that the curve starts from r_o with the angle α_o, and edge-curve angle α increases linearly depending on increasing θ.

Substituting this condition into Equation (2),

$$\frac{dr}{r} = -\cot(\alpha_o + k\theta) d\theta \qquad (4)$$

If $\sin(\alpha_o + k\theta) = t$,

$$k_o \cos(\alpha_o + k\theta) d\theta = dt$$

Then, Equation (4) is integrated as follows,

$$\int \frac{dr}{r} = -\int \frac{1}{k} \frac{dt}{t}$$

$$\log r = -\frac{1}{k}\log t + C \qquad (5)$$

C is an integral constant. Changing Equation (5),

$$r = e^C t^{-\frac{1}{k}}$$

If e^c is C′,

$$r = C' t^{-\frac{1}{k}} = C' \sin^{-\frac{1}{k}}(\alpha_0 + k\theta) \qquad (6)$$

When θ is zero degree, the value of r is r_o.

$$C' = r_0 \sin^{-\frac{1}{k}} \alpha_0 \qquad (7)$$

substituting Equation (7) into (6)

$$r = r_0 \sin^{\frac{1}{k}} \alpha_0 \sin^{-\frac{1}{k}}(\alpha_0 + k\theta) \qquad (8)$$

This equation means that, as shown in **Fig. 20**, the edge-curve angle α can be changed linearly depending on variable θ as 10°20°30°…. Linear rate of increasing α is decided by the value of the constant k that is selected by the designer. When the designer prefers to increase linearly α by 10 degrees at 180 degrees of θ, the value of k is 10/180, that is, 1/18. When increasing linerly 10 degrees of α at 90 degrees of θ, k is 1/9. Namely, Equation (8) is the theoretical design equation of the edge-curve for lengthwise blade portion of

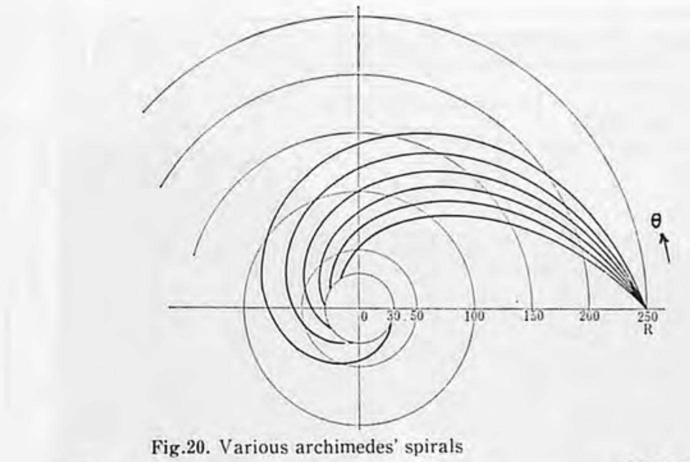


Fig.20. Various archimedes' spirals

the rotary blade. The designer is possible to design any suitable edge-curve of lengthwise blade portion fit to field condition, by selecting optimum values of α_o, r_o and k.

Design Theories of Edge-Curve of Scoop Surface

The rotary blade consists of the lengthwise and sidelong (tip) portions as shown in **Fig. 5**. Author's group calls the inside surface of the sidelong blade "Scoop Surface"(7), "sukuimen" in Japanese. In general, the motion of a rotary blade is a trochoid curve as following equations;(5)

$$x = vt - R \sin \omega t$$
$$y = R(1 - \cos \omega t)$$

where;

- R; turning radius of the blade, cm
- v; travel speed of the machine, cm/sec
- ω; rotation speed of the blade, rad/sec
  $\omega = n\pi/30$, n: rpm of rotary axle
- t; time as parameter, sec

The gradient θ' at any point B of the trochoid curve is;(5)

$$\frac{dy}{dx} = \frac{dy/dt}{dx/dt} = \frac{R\omega \sin \omega t}{v - r\omega \cos \omega t} \quad (9)$$

$$\therefore \tan \theta' = \frac{R\omega \sin \omega t}{v - R\omega \cos \omega t}$$

$$\theta' = \tan^{-1} \frac{R\omega \sin \omega t}{v - R\omega \cos \omega t} \quad (10)$$

$$\therefore \theta' = \tan^{-1} \frac{n\pi\sqrt{H(2R-H)}}{30v - n\pi(R-H)} \quad (11)$$

θ' of Equation (11) is minus value in the range of about $-89°$ to $-86°$.

When the peripheral motion is expressed by gradient of Equation (11), removing performance of the lengthwise blade with 57.5° of edge-curve angle α was practically excellent to till grassy fields.

This means the edge-curve of imaginary development pattern of the scoop surface ought to be given edge-curve angle α' as follows:

$$\alpha' = \alpha_t + (90° - |\theta'|)$$
$$= \alpha_t + (\theta' + 90°)$$
$$\therefore \alpha' = \alpha_t + \left[\left\{ \tan^{-1} \frac{n\pi}{30v - \frac{\sqrt{H(2R-H)}}{n\pi(R-H)}} \right\} + 90^0 \right] \quad (12)$$

In general, the edge-curve angle α' necessary to design the scoop surface will become about 4° bigger than α_t of the lengthwise blade portion, as shown in **Fig. 5**.

Some Applications of Design Theories

The curve of the thick line in **Fig. 21** was calculated with $r_0 = 300$ mm, $\alpha_0 = 55°$, and $k = 1/18$.

The author named it "an ideal edge-curve of rotary blades" for Asian paddy rice cultivation. The curve with α' about 4° to 5° wider than α of the thick line, the line a in **Fig. 19**, is applied to the edge-curve of the imaginary development pattern of scoop surface design. In this way some examples of the blades in today's market are shown in **Fig. 22**.

As the holder of Japanese blades is attached perpendicularly to the rotary axle, generally, the grass removing performance of the holder is not so excellent. In Japan, however, its performance is practical enough, for the weed control and chopping straw has been prevalent and besides the part of the blade which goes into the soil actually is the tip portion, as shown in **Fig. 5**.

In the fields of Southeast Asia as shown in **Fig. 3** and **4**, the shank part of the blades and holders sometimes hook grass and straw and cause a trouble. An example of its solutions will be the shape as shown in **Fig. 23**.

These special blades and holders were applied to the big rotary axle of 120 mm diameter and tested in the university farm of Central Luzon State University. **Fig. 24** is the picture of the test. Even in the wet paddy rice field where grass and straw were as tall as men's thigh, the holders hooked very few grass and straw, and the machine showed good performance enough to till grassy wet soil continuously.

Conclusions

1. It is important for the designer to understand that there will be left a lot amount of grass and straw on the rice fields after harvest in many Southeast Asian countries because of traditional condition including social and natural structures.
2. When the rotary tiller has to till the field with irrigation water just after their harvest, farmers are apt to have machine truble of grass and straw twining round the rotary blades and axle, if the

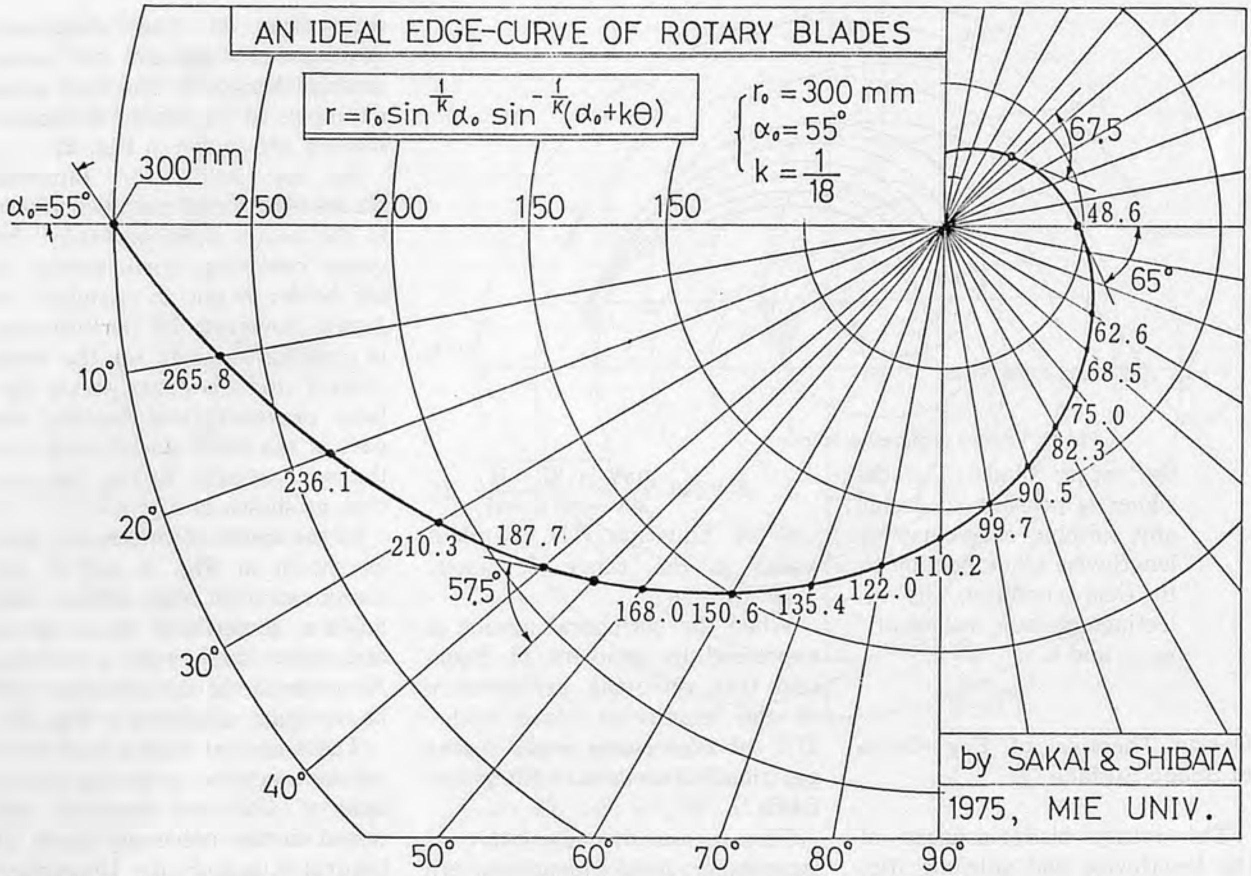


Fig.21. An ideal edge-curve of rotary blades

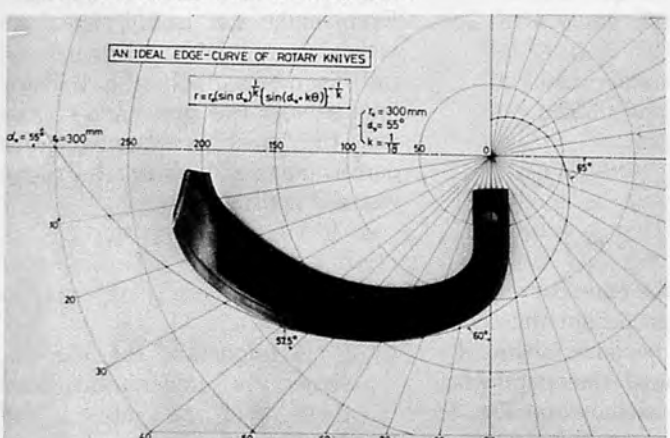


Fig.22. An example of actual blades

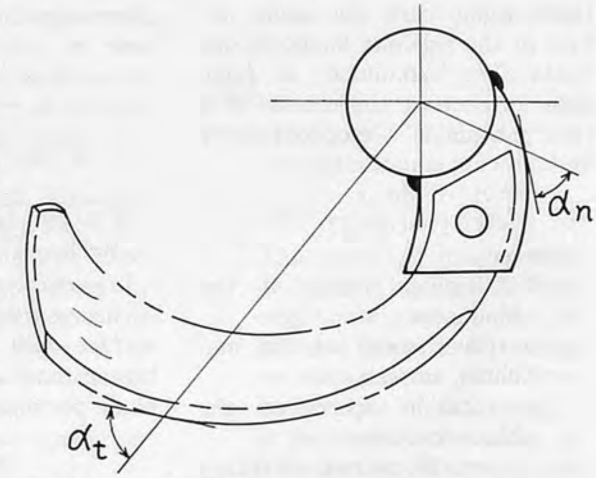


Fig.23. A better holder

blade shape is not suitable to their grassy wet field conditions.

3. The element of the blade shape related to the twining phenomena of grass and straw depends on the angle α between the direction of its turning radius and tangent of edge-curve, which is called "Edge-curve angle".
4. The experimental results in Japan show that grass and straw do not twine round the blade, when α of the lengthwise blade is 57.5° at the tip and 67.5° at the holding portion and 61° to 62° at the sidelong portion.
5. The design equations of the edge-curve of the blade which has no hooking of grass and straw are calculated by Equation (8), for the lengthwise portion, and Equation (12), for the sidelong portion.
6. Applying the results of the tests into Equation (8), an ideal curve shown in the Fig. 21 is obtained.

Fig.24. Performance test of a production model (1969, at Central Luzon State University, Philippines)

REFERENCES

1. IRRI : Rice Production Manual, Revised Edition 1970, Chapter 17, Harvesting and Threshing, pp 240-246.
2. Sakai : Analysis on Market Price Concept of Imported Farm Machinery in Developing Countries, AMA, Vol.3, No. 2, pp 23-27, 1972.
3. Sakai, Shibata : Studies on the Design Engineering of Rotary Knives for the Rotary Tillage of Tractors (Part 1), The Bulletin of the Faculty of Agriculture, Mie University, No. 49, pp 163-181, 1975.
4. Taguchi : Research on Rotary Tiller in Kobashi Industry Co., Ltd., 1962 (unpublished, courtesy to the author)
5. Sakai : A Theoretical Approach to the Mechanism and Performance of the Hand-tractor with a Rotary Tiller, together with Practical Application, Ph. D. Thesis, Kyushu University, 1960, published in 1962, 160 pages, Shin-norinsha Co., Ltd.
6. Sakai, Shibata, Taguchi : Design Theory of Edge-curves for Rotary Blades of Tractors, Journal of JSAM, Vol. 38, No. 2, pp 183-190, 1976.
7. Salas : Basic Research on Rotor Tillage and Its Application, Dr. Thesis, Kyushu University, 480 pages, 1975, unpublished. ■ ■

Use of Parameter Influence Co-efficient in Model Matching Technique of Human Operator

by
A.A. Mainul Hussain
Associate Professor,
Department of Farm Power & Machinery,
Bangladesh Agricultural University,
Mymensingh, Bangladesh

Introduction.

An important problem in the design of control panels and equipments for Tractor and Vehicles is that of describing the dynamic response of human pilot or driver mathematically in changing environmental conditions. Adaptation is a fundamental characteristic of a living organism, since they attempt to maintain homeostasis in the midest of changing environmental conditions. It is man's adaptibility which makes him a desirable element in any control system, unless his adaptation rate is too slow in comparison with the rates of change of environmental variables. While adaptation in human performance is a well-known phenomenon, the mathematical models commonly employed to present the human operator tend to ignore his adaptive characteristics. The model commonly used to represent a human operator in a control system describe him as a linear, continuous, time invariant system. In actual practice the human operator is perhaps best represented as a non-linear, or at least time varying, adaptive sample data system. Therefore to describe the dynamic response of a human operator involves matching of human performance with mathematical model.

The method of Parameter optimization are based on the comparison of performance of an assumed mathematical model with that of a human operator. An automatic parameter adjustment programme must be developed with will determine the optimum value of the model parameters in the sense that the model performance approximates as closely as possible the human pilot performance. The programming of automatic parameter optimization involves three primary considerations.

i) A mathematical model must be selected based on past research works and experience and adjustable parameters fully indentified.

ii) A criterion function must be selected which can serve as an index of the validity of the mathematical model. Minimization of this criterion of performance function by adjustment of model parameter results in the closest possible agreement between pilot output and model output.

iii) An analog programme for performing the required parameter adjustment must be developed and tested as regards its performance.

The philosophy of model matching is based on the output error method. The same input signal 'X' is applied to the human operator and to an adjustable mathematical model. The output of the model and operator are compared and the output error 'e' used in generating an appropriate performance function. The parameter adjustment programme utilizes the performance function and compute the parameter changes required to minimize the performance function. The input and output quantities are obtained by having the human operator perform a simple close loop control task.

The continuous method of parameter adjustment uses the parameter influence co-efficient technique. The principle of the technique are explained first in terms of a simple second order differential equation.

Consider the homogenous linear equation in 'X'

$$\frac{d^2\chi}{dt^2}+\mu\frac{d\chi}{dt}+\lambda(\chi)=f(t) \quad \cdots(1)$$

with specified initial conditions x

(0) = a and $\dot{x}$ (0) = b. Differentiating equation (1) with respect to λ and μ respectively

$$\frac{\partial 3\chi}{\partial\lambda\,\partial t}+\mu\frac{\partial^{\nu}\chi}{\partial\lambda\,\partial t}+\lambda\frac{\partial\chi}{\partial\lambda}+\chi=0$$

$$f(t)\neq f(\lambda)$$

Interchanging the order of differentiation with respect to t and λ equation (2) can be written in the form

$$\frac{\partial^{\nu}}{\partial t^{\nu}}\left(\frac{\partial\chi}{\partial\lambda}\right)+\mu\frac{\partial}{\partial t}\left(\frac{\partial\chi}{\partial\lambda}\right)+$$

$$\lambda\frac{\partial\chi}{\partial\lambda}=-\chi \quad \cdots\cdots\cdots(3)$$

$$\partial\chi/\partial\lambda=\mu_1$$

Therefore equation (3) can be written in the form whre u_1

$$\ddot{u}_1+\mu\dot{u}_1+\lambda u_1=-x \quad \cdots\cdots\cdots(4)$$

must satisfy the initial conditions $U_1(0)=\frac{du_{1(0)}}{dt}=0$ since the initial values of x and $\frac{dx}{dt}$ do not depend on λ. Equation (4) is known as sensivity equation of the system with respect to λ. Similarly differentiating with respect to μ.

$$\frac{\partial^3\chi}{\partial\mu\partial t^{\nu}}+\mu\frac{\partial^{\nu}\chi}{\partial\mu\partial t}+\frac{\partial\chi}{\partial t}+\lambda\frac{\partial\chi}{\partial\mu}$$

$$=0$$

$$\frac{\partial\chi}{\partial\mu}=u_2$$

$$\ddot{u}_2+\mu\dot{u}_2+\lambda u_2=-\dot{x} \quad \cdots\cdots\cdots(5)$$

$$u_2(0)=0,\ \dot{u}_2(0)=0$$

Equation (5) is the sensitivity equation with respect to μ. U_1 and U_2 can be generated very casily in analog computer which gives the parameter influence co-efficient.

Parameter Optimization for Human Model

The parameter optimization technique described here are based on the formulation of a suitable model equation for representing the unknown system. A finite number of parameters are to be adjusted in the model to minimize the particular criterion function. The rationale used here for postulating a general model structure for the human conform to the approach commonly used in Engineering analysis namely to formulate the model equation on the basis of the past experience and research finding by other investigators. In many single axis tracking tasks human operator may be characterized by quasi linear describing function of the form:

$$H(s)=\frac{K(1+T_1S)}{(1+T_2S)(1+T_3S)} \cdots(6)$$

where K, T_1, T_2 and T_3 are the parameters which depend on forcing function bandwidth and the controlled element dynamics. Equation (6) can be written in the form:

$$\ddot{Z}+\alpha_1\dot{Z}+\alpha_2 Z=\alpha_3\dot{X}+\alpha_4 X \quad \cdots\cdots(7)$$

where X is the input and Z is the output.

$K=\frac{\alpha_4}{\alpha_2}$, $T_1=\frac{\alpha_3}{\alpha_4}$ and T_2 & T_3 are the roots of the equation;

$$\left(\frac{1}{\alpha_2}S^2+\frac{\alpha_1}{\alpha_2}S+1\right)=0$$

Analog computer is used to simulate controlled element dynamics, human pilot model, and parameter optimization process. Before optimization is done a criterion function is selected as follows:

$$f=\frac{1}{2}(e+q\dot{e})^2 \quad \cdots\cdots\cdots(8)$$

$$e=(Z-Y),\ \dot{e}\ (\dot{z}-\dot{y})$$

y = human operator output.

where q is a constant and $q\dot{e}$ constitute a rate compensation term. Steepest descent method require parameter adjustment at a rate proportional to local slope of the error criterion function

$$\dot{\alpha}_1=-x\bigtriangleup f$$

where K is a positive gain constant. The gradient components $\frac{\partial f}{\partial\chi}$ are expressed in terms of parameter influence co-efficient $\frac{\partial z}{\partial\alpha_i}=U_i$ of the model output variable Z. Differentiating equation (8) with respect to α_1 we get

$$\frac{\partial f}{\partial\alpha_1}=(e+q\dot{e})\left(\frac{\partial e}{\partial\alpha_1}+q\frac{\partial\dot{e}}{\partial\alpha_1}\right)$$

$$\beta u\gamma\frac{\partial e}{\partial\alpha_1}=\frac{\partial z}{\partial\alpha_1}=u_1$$

$$\frac{\partial\dot{e}}{\partial\alpha_1}=\frac{\partial\dot{z}}{\partial\alpha_1}=\dot{u}_1$$

$$\therefore\frac{\partial f}{\partial\alpha_1}(e+q\dot{e})(u_1+q\dot{u}_1)$$

$$\dot{\alpha}_1=-k(e+q\dot{e})(u_1+q\dot{u}_1)$$

$$\alpha_1=-\int\chi(e+q\dot{e})(u_1+q\dot{u}_1)+$$

$$\alpha_1(0) \quad \cdots\cdots\cdots(10)$$

To determine parameter influence co-efficient on a continuous basis a set of additional differential equations must be programmed on the computer. By partial differentiation of equation (7)

$$\frac{\partial}{\partial\alpha_1}(\ddot{z})+\alpha_1\frac{\partial}{\partial\alpha_1}(\dot{z})+\dot{z}+\alpha_2\frac{\partial}{\partial\alpha_1}$$

$$(z)=0$$

Since X is independent of

$$\frac{\partial^{\nu}}{\alpha t^{\nu}}\left(\frac{\partial z}{\partial\alpha_1}\right)+\alpha_1\frac{\partial}{\partial t}\left(\frac{\partial z}{\partial\alpha_1}\right)+$$

$$\alpha_2\frac{\partial z}{\partial\alpha_1}=-\dot{z}$$

Equation (II) is known as sensitivity equation. The other three equations are obtained by differentiating equation (7) with respect to α_2, α_3 and α_4

$$\ddot{u}_1+\alpha_1\dot{u}_1+\alpha_2 u_1=-\dot{z} \quad \cdots\cdots\cdots(11)$$

$$\ddot{u}_2\times\alpha_1\dot{u}_2+\alpha_2 u_2=-z \quad \cdots\cdots\cdots(12)$$

$$\ddot{u}_3+\alpha_1\dot{u}_3+\alpha_2 u_3=\dot{x} \quad \cdots\cdots\cdots(13)$$

$$\ddot{u}_4+\alpha_1\dot{u}_4+\alpha_2 u_4=x \quad \cdots\cdots\cdots(14)$$

where $u_2=\frac{\partial z}{\partial\alpha_2}$, $u_3=\frac{\partial z}{\partial\alpha_3}$,

$u_4=\frac{\partial z}{\partial\alpha_4}$

All initial values must satisfy the conditions $U_i(o)=0$, $U_i(o)=0$. From the sensitivity equations it is evident that

$$\left.\begin{aligned}U_1&=U_2\\U_3&=U_4\end{aligned}\right\}\cdots\cdots\cdots(15)$$

The relationship of equation (15) simplifies generating parameter influence co-efficeint. **Figures 1** and 2 show the generation of parameter influence co-efficient in Analog computer. **Figure 4** shows generation of criterion function (e + qė) and the Analog Computer circuit for automatic adjustment of the parameter.

Figures 5 and 6 show the Analog Computer circuit for obtaining display rate x and human reasonse rate y.

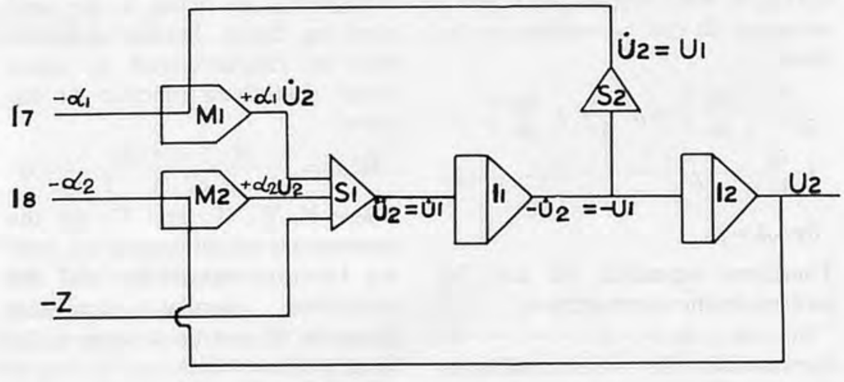
Results and Discussion

When error term 'e' and so F the criterion function reaches a relative minimum value the parameter α_1, α_2, α_3 and α_4 reaches a steady state value and at this point human operator is approximated by the transfer function with the calculated parameter value.

It has been observed that the parameter α_1, α_2, α_3 and α_4 vary with the change in control dynamics and the variation are different with each subject. For example when the control element dynamics was changed from 1 to $\frac{1}{1+S}$ and lead time constant of pilot transfer function increased and the lag time constant increased only slightly and the static gain remained approximately the same. The pilot therefore can effectively be considered to be cancelling the lad introduced in the dynamics and thus maintaining the overall dynamics of the closed loop system unchanged. With oscillatory dynamics $\frac{10}{S^2+3S+10}$ in control dynamics the static gain decreased noticeably. With the dynamics that included integration all subjects displayed a decrease in lag time constant in going from rate system $\frac{2}{S}$ to an acceleration system $\frac{10}{S^2}$ the pilots lag with the system $\frac{10}{S(S+1)}$ being intermediate between the latter two.

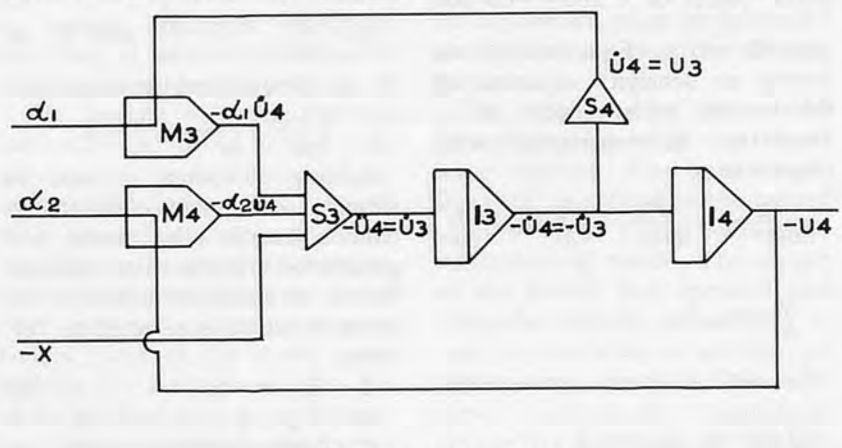
Both frequency and damping ratio decrease in going from a rate system to acceleration system. With the rate system most of the subject had a frequency of approximately 3.5 radians per second. The damping ratio was approximately 0.7. With the acceleration dynamics, the closed loop frequencies dropped to approximately 2.5 radians per second, and damping ratio dropped to approximately 0.2.

The reason for the decrease in the lag time constants in going from a rate to an acceleration system might be explained by the fact that, with well behaved easy to handle rate system, the pilot



$$\ddot{U}_2 = -Z - \alpha_1\dot{U}_2 - \alpha_2 U_2$$

Fig.1. Generation of parameter influence co-efficient U_2 and U_1 in analog computer.



$$\ddot{U}_4 = X - \alpha_1\dot{U}_4 - \alpha_2 U_4$$

Fig.2. Generation of parameter influence co-efficient U_4 and U_3 in analog computer.

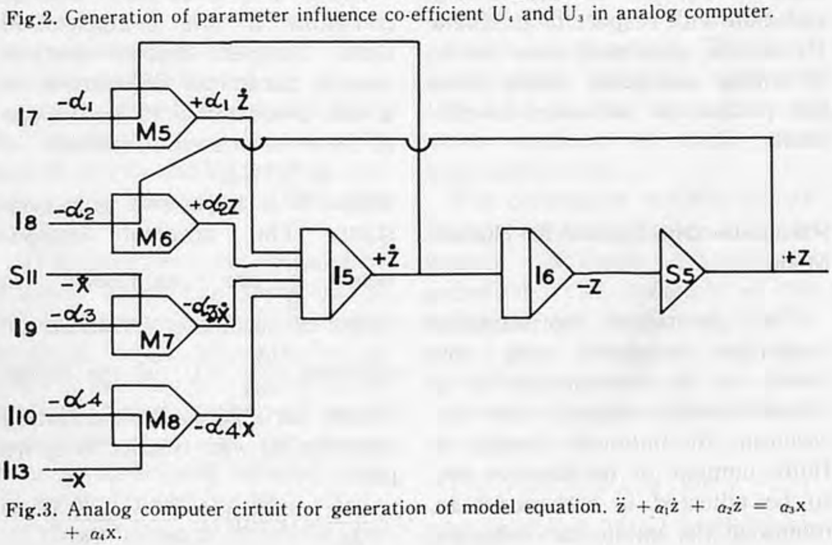


Fig.3. Analog computer cirtuit for generation of model equation. $\ddot{z} + \alpha_1\dot{z} + \alpha_2\dot{z} = \alpha_3 x + \alpha_4 x$.

can achieve what he considers to be satisfactory control with a large lag. He therefore takes advantage of this allowance. But with the more difficult acceleration dynamics, the pilot must reduce its own lag to get satisfactory control and he does.

Variation of pilots transfer function was also observed from person to person, from day to day for the same person. Display sensitivity also effects the pilots transfer function. The closed loop system oscillatory characteristics show a reduction in frequency and an increase in damping ratio. Increasing the display sensitivity to 1.5 volts/inch the static sensitivity increased, the closed loop system oscillatory characteristics show an increase in frequency and decrease in damping. Variation in transfer function has also been observed with the change in control sensitivity.

Conclusion

Tests in which the transfer function of human pilot has been measured show that the pilots change their transfer function whenever any element of the control loop is changed. However fairly consistent results in terms of closed loop characteristics are obtained. Display sensitivity, controlled element dynamics, break frequency of the random signal all of these effect the transfer function of human pilot as discussed earlier.

The method described in this article matches the unknown parameters automatically with the human pilot so that error criteria function is minimized. Thereby a mathematical representation of the dynamic response characteristics of human pilot is obtained. This is of great importance in developing control element dynamics for Aircraft, Automobile and Satellite. ■ ■

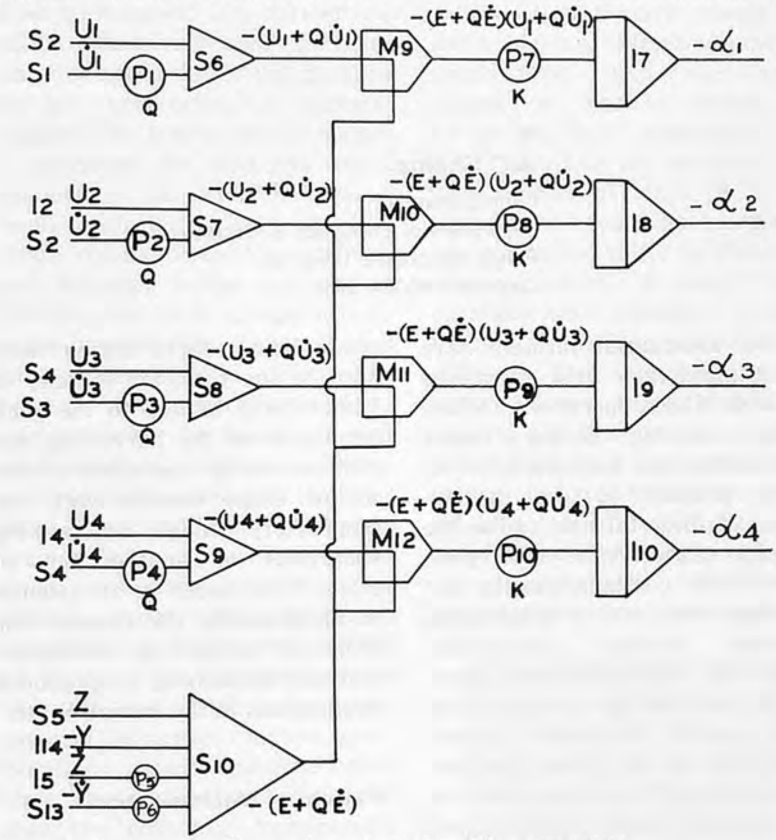


Fig.4. Analog computer diagram for optimization of four parameters.

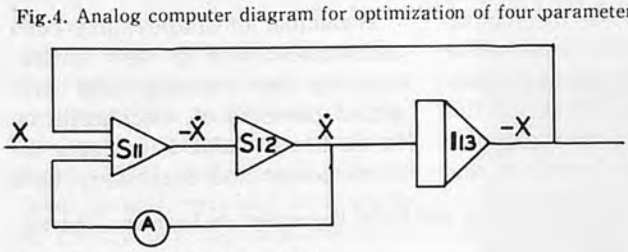


Fig.5. Input gain circuit number 1.

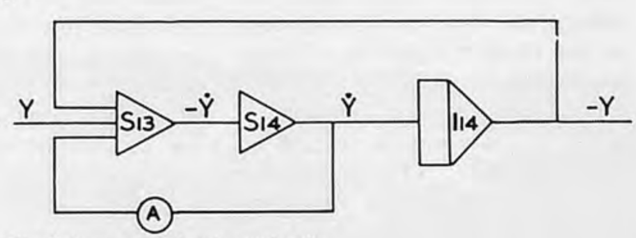


Fig.6. Input gain circuit number 2.

SYMBOLS USED IN FIGURES

S1 SUMMER AMPLIFIER NO. 1.
I1 INTEGRATOR AMPLIFIER NO. 1.
M1 MULTIPLIER NO. 1.
▷ ELECTRONIC MULTIPLIER.
▷ SUMMER.
▷ INTEGRATOR.
O POTENTIOMETER.
X DISPLAY ERROR MODEL & HUMAN PILOT INPUT.
Z MODEL PILOT OUTPUT.
Y HUMAN PILOT OUTPUT.
Ui PARAMETER INFLUENCE CO-EFFICIENT.

Farm Mechanization in Punjab

by
A.C.Shama
Farm Economist
Department of Economics & Sociology
Punjab Agricultural University
Ludhiana-141004, India

The process of mechanizqtion of crop farms in the Punjab was accelerated as a consequence of the progressive adoption of seed-irrigation-fertilizer technology and the system of multiple cropping in the green revolution period and afterwards. The increasing emphasis on production per unit of area and time has neceusitctet greater power inrut on individuql farmu for completing all agricultural operations with thoroughness and on time. The growth and improvement in farm technology would likely increase still further, the demand on power for more intensive practices for meeting the ever increasing need for the rapid completion of farm operations.

The concept of stationary power use is a unique feature of mechanization of individual farms. Such stationary farm operations as irrigation, crushing, shelling, threshing and chaffing, are mechanised using such motive power as tractors, diesel engines, electric motors and their associated equipment for (i) releasing a part of human and bullock labour during peak labour load periods; (ii) making timely operations possible; and (iii) improving the efficiency of labour and other complementary factor inputs. Some of the substantial farmers have mechanized their field operations as well. These operations include tillage, sowing, hoeing, timely harvesting, and transportation of farm produce to the market. Some of these farmers utilize the surplus capacities of their power-machine combinations by extending their use to neighburing farmers through custom-hire. Again the Agro-Industries Corporation and the Agro-Service Centres recently established in various parts of the State also perform selected farm operations on cultivators' fields against payment. The pattern of mechanization that has finally emerged is consistent with the peculiar characteristics of crop farms in this State, viz., capital shortage and the cxa-lability of abundant and cheap labour force during most parts of the year; the scarcity of labour being limited to the peak periods when the harvesting and post-harvesting operations of one set of crops overlap with the preparatory tillage and sowing operations of another set of crops. This paper is an attempt at investigating the present and projected pattern of mechanization and examining its economic implications in the Punjab State.

Pattern of Mechanization

A number of studies have been undertaken with a view to examining the existing and projected patterns of mechanization in the State. **Table 1** indicates the farm power and machinery used

Table 1. Number of Power Units and Farm Equipment in Ludhiana District, 1973-74 Through 1977-78

Farm Power and Equipment	1973-74	1974-75	1975-76	1976-77	1977-78
1. Tractors					
a) 25-30 h.p.	3,860	4,520	5,180	5,840	6,500
b) 15-25 h.p.	2,440	2,880	3,320	3,760	4,200
2. Diesel Engines	32,300	33,400	34,500	35,600	36,700
3. Electric Motors	21,800	22,500	23,200	23,900	24,600
4. Threshers	3,800	4,300	4,800	5,300	5,800
5. Drummies	16,900	17,500	18,100	18,700	19,400
6. Corn Shellers	2,200	2,500	2,800	3,100	3,400
7. Seed-cum-Fertilizer Drills	3,090	3,580	4,070	4,560	5,050
8. Trolleys	5,900	6,900	7,900	8,900	9,900
9. Harrows	4,400	5,100	5,800	6,500	7,300
10. Cultivators	4,800	5,500	6,200	7,000	7,800
11. Levellers	3,600	4,100	4,600	5,100	5,700
12. Spray Pumps	100	100	200	200	300

by the farmers in Ludhiana district of the State in 1973-74 and its extended use through 1977-78.

It will be seen from **Table 1** that the use of such stationary power source as diesel engines and electric motors for energizing such operations as lifting irrigation water, threshing of wheat, and shelling of maize, has been wide spread. The farmer are more extensively used as compared with the latter due perhaps to the uncertainty of electric supply. The tractor power source is possessed by relatively small number of farmers, the reason being high initial cost and the small volume of work on individual holdings. Large tractors of 25—35 h.p. are comparatively more popular than the small ones in the category of 15—25 h.p. The tractors are generally used to provide power for the use of such equipment as harrows, cultivators, levellers, seed-cum-fertilizer drills and trolleys. Sometimes tractors are also used to mechanize stationary jobs including lifting water for irrigation, threshing of wheat and shelling of maize. The trends indicate that the use of the entire complement of power-machine combinations would increase over time. It is, however cautioned that the economic management of farm power and machinery is one of the most significant factors affecting farm income. For example, if it needs only 5.0 h.p. to pump water for irrigation from 15-20 feet below ground level, it will certainly be a waste of energy if a 25.0 h.p. tractor is used as a stationary engine for this purpose. Again, some farmers continue to use high horse power tractors for operating small threshing machines. This also is an uneconomic use of available power. For economy, a machine should use no more power than necessary because power is another cost of machine performance. The individual operations in a machine system must be adjusted and combined in such a manner that their overall performance is determined at a minimum cost to ensure maximum profits to the farm business. Farm machinery systems analysis has indicated that small power units (5.0 h.p. diesel engine/electric motor) and their ancillary equipment for the mechanization of stationary operations, and a 14.0 h.p. tractor alone or in combination with the diesel engine or electric motor for energizing both stationary and field operations are surplus to the requirements of large (10.12 hectare) farms even after incorporating normative shifts in the cropping schemes. Further, farm organizations using electric motor for stationary work earn 10.5 per cent more profits as compared with those using diesel engines for this purpose. Again, when both field and stationary operations are mechanized, the use of a 14.0 h.p. tractor for field work and a 5.0 h.p. electric motor for stationary jobs yields 6.9 per cent more returns than the farms where a 14.0 h.p. tractor is employed as a versatile machine for both field and stationary operations, and 9.7 per cent higher than those with a 5.0 h.p. diesel engine for stationary work and a 14.0 h.p. tractor for field jobs. Farms operated with a 14.0 h.p. tractor alone earn 2.6 per cent more than those equipped with a 14.0 h.p. tractor and a 5.0 h.p. diesel engine. The extended use of surplus power machinery partly through renting-in of additional land and partly through custom-work on other farms increases income on mechanized farms. These findings are a clear indication of the need for rational decision-making in the choice of power-machine combinations for individual farm organisations. In fact, the immediate problem facing the Punjab farmers today is the lack of availability of matching equipment for the power units they have already acquired from the market. In the long-run, however, the agricultural engineers would have to design and develop new power-machine combinations

suiting the pockets and requirements of the farming community. Further, new and diversified uses of available power-machinery will have to be discovered for their extended use so that per unit over head costs associated with this equipment could be kept as low as possible.

Economic Implications

Controversies have been raised from time to time about the impact of mechanization on productivity and employment in Punjab agriculture. The results of recent studies provide evidence that mechanization contributes to increased productivity while at the same time involving little displacement of human labour on Punjab farms. In the central plainu and south-western districts of the Punjab State, the output per unit area is higher on tractorized farms than the bullock operated ones. It is particularly so when the tractor operated farms are compared with the large bullock operated holdings. The average returnu on the former category of farms are 28.47 per cent higher than the latter. The higher income on tractor holdings is attributed to shifts in the cropping patterns in favour of more remunerative enterprises, increased cropping intensity, higher expenditure on the yield increasing technology, and better preparation of land, timely performance of operations and better placement seeds and fertilizers. The study of the comparative statistics of labour input per hectare on the two types of farm organizations suggest that, on the whole, labour use is slightly (1.96 per cent) higher on the mechanized farms as compared with the bullock operated organizations. An additional uupport to these results is provided by the quantitative analysis of the impact of farm size and technological inputs on the level of human labour employment in Ferozepur district at two points of time, xiz., the beginning of the green revolution period (1967—68) and the post-green revolution period (1973—74). This functional analysis brought out that the expenditure on farm machinery and equipment did not significantly influence labour employment in both the years. Employment was, in fact, affected by farm size, expenditure on seed and insecticides, fertilizers and irrigation. The variable for fertilizer use did not, however, turn out significant in 1973—74.

Thus, recent studies support the hypothesis that farm mechanization in the Punjab has increased productivity by facilitating the intensive use of such crucial and technological inputs as irrigation, fertilizers, pesticides and multiple cropping without affecting human labour employment. It is however, feared that if mechanization is extended too far and such big machines as combines are introduced on a very large scale, farm labour employment would be adversely affected. It has been found that wheat harvesting with combine requires only 1.85 man days per hectare as against an average of 22.23 man days with other methods of harvesting and threshing. But such sophisticated power machinery has not yet been extensively used in the State and hardly 2 per cent of the wheat crop is being harvested with it.

It can now be observed that the concept of stationary power use which is new to most parts of the world has come to stay in the Punjab where a large number of such stationary power units as diesel engines and electric motors have been installed by the farmers on their individual holdings for lifting underground water for providing assured irrigation to their crops and mechanising such stationary operations as threshing of wheat and shelling of maize enterprises. Tractors are also used for this purpose. But in most cases, these are employed as mobile sources of power to mechanise field jobs like tilling, seeding and fertilizing, interculturing, harvesting, and transportation of the produce to the market. The mechanisation of selected farm operations is likely to expand in the future particularly because the controversies about its impact on human labour employment on individual holdings have been set at rest. Again, the contribution of this input alongwith the use of other technological inputs of farm productivity has been fully established. Further, the process of progressive mechanisation of selected operations is likely to be speeded up with the setting up of a net work of Agro-Service Centres and the extension of the fleet of mobile service vans of the Agro-Industries Corporation for taking up repairs of farm power and machinery in the villages. Besides, the recent developments in the country have eased the situation in the spare parts markets so much so that anything can now be procured without having to make over payments. Such a situation is bound to give further impetus to the mechanisation of crop farms in the State. These trends would likely pose serious challenges to the agricultural engineers for the designing and development of prototypes of power machinery which could satisfy the growing aspiration of the community in this direction. Such machinery, for obvious reasons, would have to be cheap and relatively less sophisticated so that it could be handled by an ordinary farmer after a small training. ■ ■

Institutional Growth and Disparities in a Growing Economy-The Punjab Case

by
Karam Singh — Farm Economist
Rajinder Sondhi — Lecturer
Department of Economics and Sociology,
Punjab Agricultural University,
Ludhiana—141004, India.

As an economy moves on a development path, the role of institutions as variables within the economic domain, i.e. variables in response to the dynamics of economic growth becomes important. The institutions are viewed as suppliers of economic services and the process of growth stimulates such forces which affect demand for these services. The demand for these services is mostly function of economic variables but their supply is influenced by both economic and non-economic variables. Thus, the sources of growth in demand and supply of institutional variables do not converge to common factors. This creates disequilibrium between the demand and supply of institutional services which rather gets accentuated in the process of growth, and as a consequence, the regional disparities in economic development become apparent. This phenomenon is not unheard of in the context of very broad regions as that of a state in a vast country of the size of India. But for all practical purposes, this phenomenon needs to be investigated at a lower level too. We, therefore, started this study to examine the disparities in the institutional development within a small, fairly homogeneous and a growing economy-the Punjab.

Again in the process of growth, different institutions respond differently thereby creating disequilibrium between the levels of various institutions for the same region. This distorts complementary effects of various institutions. This complementarity between the growth of different institutions over time was also examined.

The credit institutions are listed at the top of all the institutions for they provide the initial stimulus to the process of growth, And in this respect the co-operatives, so far, are at the top in the Punjab. We, therefore, investigated the disparities in the institutional (co-operative) loans between different districts of the state. Finally, we examined the other institutional factors along with their contribution, which led to disparity in the institutional credit in the state.

In particular, the specific objectives of the study were—

1. To examine the inter-district disparity in the institutional developments.
2. To examine the impact of inter-district disparity in the institutional developments on agricultural development.
3. To examine the complementarity between different institutional development.
4. To examine the institutional factors affecting institutional credit and their contributions towards inter-district disparity in the institutional credit.

Approach of the Study

The districtwise data on various institutional variables were obtained from Statistical Abstracts of Punjab. We approached the problem in a sequential manner. The economic development of an area considered in terms of agricultural production of the area is a function, other things remaining the same, of a paraphernalia of institutional variables like density of population, per capita availabilities of land, net irrigated area, rural literacy, irrigation infrastructure and institutional finance which determine the agricultural productivity directly and which then accelerate the development of those variables plus such institutions as road net work, regulated markets and processing industries, etc. The districtwise data on some of these variables were not available which, therefore,

Table 1. Agricultural Productivity and Population Density, 1960-61 and 1970-71

District	Agricultural Productivity (Rs. per hectare)			Population density (000/Sq. Km.)		
	1960-61	1970-71	% increase	1960-61	1970-71	% increase
Bhatinda	319.60(1)	661.26(1)	106.90(9)	153(1)	186(2)	21.56(7)
Ferozepur	412.45(2)	699.91(3)	69.69(4)	158(2)	176(1)	11.39(1)
Kapurthala	432.02(3)	861.98(4)	99.52(7)	210(5)	263(5.5)	25.23(8)
Hoshiarpur	441.09(4)	666.19(2)	51.03(2)	224(6.5)	271(7)	20.98(6)
Ropar	443.90(5)	964.97(9)	117.38(10)	224(6.5)	263(5.5)	17.41(2)
Sangrur	456.55(6)	870.65(5)	90.70(5)	187(3)	225(3)	20.32(5)
Amritsar	474.94(7)	960.33(8)	102.20(8)	305(10)	365(9)	19.67(4)
Ludhiana	513.02(8)	1,464.35(11)	185.43(11)	292(9)	374(10)	28.08(11)
Gurdaspur	529.72(9)	883.19(7)	66.72(3)	276(8)	346(8)	23.36(9)
Jullundur	545.24(10)	1,051.20(10)	92.79(6)	361(11)	428(11)	18.55(3)
Patiala	585.72(11)	873.08(6)	49.06(1)	206(4)	259(4)	25.75(10)

<u>Rank correlations</u> Agricultural productivity and population density

1961	0.66
1971	0.76
% increase	0.26

* Source, Singh, Karam, "Agricultural Productivity in the Punjab State-Growth, Gap and Variation" <u>Journal of Research. P.A.U.</u>, XI (2), June, 1974 214-18.

** Figures along side in the parentheses are the ranks.

had to be kept out of the scope of this study.

Disparity in Agricultural Productivity and Population Density

The gross value of agricultural output per cultivated hectare at constant prices of 1960-61 and population density during 1960-61 and 1970-71 for the 11 districts of the state are given in **table 1.** The percentage increase in these variables and the correlations between these variables for 1961, 1971 and percentage increase are also given in **Table 1.** We tested the following hypotheses. At a point of time, higher the agricultural productivity higher the population density. Secondly over time, greater the relative increase in population density, greater world be the relative increase in agricultural productivity.

The rank correlation between agricultural productivity and population density was 0.66 and 0.77 during 1961 and 1971 respectively, thereby it conformed to the first hypothesis formed above, viz, more productive areas were more densely populated. The rank correlation between per cent increase in agricultural productivity and per cent increase in population density during the decade 1961-71 was 0.26 and not significant. This indicated a tendency, albeit not strong, for the growth in population to be higher in the regions marked by higher growth of productivity.

Since agricultural productivity in different districts of the Punjab increased at a much faster rate than the population growth rate, table shows this, the growth and disparity in agricultural productivity and hence agricultural development have to be related to factors, which are more powerful, other than the population variable.

Land Resources and Agricultural Productivity

Another alternative to study the effect of population density on agricultural productivity is to correlate land resources with agricultural productivity. Gross cultivated area and net irrigated area per capita are the two broad measures of land availability in a particular region. During 1960-61, the gross cultivated area per capita was the lowest in the Hosiarpur district and the highest in the Bhatinda District being 0.20 and 0.61 acres respectively. But during 1971 the gross cultivated area per capita was the minimum in the Julludur District (0.20 acres) and the maximum was in

Table 2. Disparities in cultivated area and net irrigated area per capita, 1960-61 and 1970-71

(Acres/capita)

Districts	Gross cultivated area		Net irrigated area	
	1960-61	1970-71	1960-61	1970-71
Bhatinda	.6069	.4925	.2714	.3591
Ferozepur	.5351	.4741	.3108	.5351
Kapurthala	.3549	.3161	.1862	.2442
Hoshiarpur	.1952	.2394	.0309	.0528
Ropar	—	.2287	—	.0728
Sangrur	.3178	.4007	.2217	.3103
Amritsar	.2443	.2260	.1894	.1956
Ludhiana	.3006	.2247	.1381	.1829
Gurdaspur	.2571	.2115	.1094	.1095
Jullundur	.2368	.2046	.1527	.1569
Patiala	.3761	.5761	.1489	.2061

<u>Rank correlations</u> Agricultural productivity and gross cultivated area per capita

1961 −0.42
1971 −0.80

Agricultural productivity and net area irrigated

1961 −0.41
1971 −0.47

Table 3. Disparities in rural literacy in different districts of the state, 1960-61 and 1970-71

District	Rural literacy as percentage of total population			% increase
	1961	1971	Increase	
Bhatinda	11.38(3)*	15.19(1)	3.81(2)	33.47(5)
Ferozepur	13.35(4)	17.61(3)	4.25(3)	31.83(4)
Kapurthala	17.76(8)	22.91(6)	5.15(5)	29.00(2)
Hoshiarpur	16.97(7)	34.35(11)	17.38(11)	102.41(11)
Ropar	18.60(9)	28.77(10)	10.17(10)	54.67(8)
Sangrur	8.08(1)	16.29(2)	8.21(8)	101.60(10)
Amritsar	14.19(5)	19.18(5)	4.99(4)	35.16(6)
Ludhiana	21.64(11)	23.16(7)	1.52(1)	7.02(1)
Gurdaspur	15.72(6)	24.08(8)	8.36(9)	53.18(7)
Jullundur	18.10(10)	24.70(9)	5.96(6)	31.80(3)
Patiala	11.07(2)	17.61(4)	6.54(7)	59.07(9)

*Figures alongside in the parentheses are the ranks.

Rank correlations	Agricultural productivity and rural literacy
1961	0.16
1971	0.43
% increase	−0.43

the Bhatinda District (0.49 acues). In terms of net irrigated area per capita the Hoshiarpur District had the minimum which was 0.0309 and 0.0528 acres during 1961 and 1971 respectively and the Ferozepur district had the maximum which was 0.3208 and 0.3357 acres during 1961 and 1971 respectively.

The rank correlations between agricultural productivity and gross cultivated area per capita were found to be negative for 1961 and 1971 i.e., −0.42 and −0.80 respectively. The rank correlations for agricultural productivity and net irrigated area per capita was also negative for 1961 and 1971 i.e. −0.41 and −0.47 respectively. These correlations again confirmed that there were compensatory changes in the land-man ratio which meutralized to some extent, the wide interregional variations in productivity per hectare.

Agricultural Productivity and Rural Literacy

Rural literacy is one of the important determinants of human capital formation in agriculture but was found to be rather low in all the districts of the state. It was the lowest at 8.08 per cent in the Sangrur District in 1961 and the highest was in the Ludhiana District where it was 21.64 per cent. Likewise, the minimum and maximum rural literacy during 1971 was in the Bhatinda and Hoshiarpur districts which was 15.19 and 34.35 per cent respectively.

The growth in rural literacy was very uneven between different districts. It was particularly noticeable in Hoshiarpur and Sangrur districts where it doubled during the decade 1961-71 i.e., from 16.97 to 34.35 per cent in the Hoshiarpur District and from 8.08 to 16.29 per cent in the Sangrur District. In Ropar, Gurdaspur and Patiala districts, the per cent rural literacy increased by 10.17, 8.36 and 6.54 points or 55, 53 and 59 per cent respectively. In all other districts the increase in rural literacy was around 30 per cent except in the Ludhiana where it was only 1.52 points or 7.02 per cent.

Again the rank correlations between agricultural productivity and rural literacy for 1961, 1971 and the percentage increases during 1961-71 were estimated. It was found that overtime, the rank correlations between percentage increases in agricultural productivity and rural literacy was negative at −0.43. But at a point of time, the rank correlation between agricultural productivity and rural literacy was positive being 0.16 and 0.43 during 1961 and 1971 respectively. Thus although the increases in rural literacy have not been positively associated with increases in productivity, but over time inter-district productivity variation is tending to show higher positive association with the inter-district variation in rural literacy. Hence, the importance of education in determining the agricultural productivity is increasing and greater significance, therefore, has to be attached to increase the literacy rate in rural areas.

Irrigation Infrastructures

The irrigation infrastructures measured as irrigation intensity i.e., percentage of net area sown under irrigation in different districts of the state during 1960-61 to 1972-73 is given in **table 4.** It can be seen from **table 4** that Amritsar had the highest proportion of irrigated area throughout where during 1960-61, 90 per cent of cultivated area was irrigated

Table 4. Disparities in the irrigation infrastructure (Net irrigated areas as percent of net area sown)

District	1960-61	1961-62 to 1965-66 (Average)	1966-67	68-69	69-70	70-71	71-72	72-73
Bhatinda	48	51	58	71	74	73	78	66
Ferozepur	64	65	62	76	76	77	77	72
Kapurthala	54	65	72	74	79	79	79	81
Hoshiarpur	13	16	19	22	22	22	22	29
Ropar	—	—	20	27	30	33	35	35
Sangrur	47	50	61	77	81	79	77	82
Amritsar	90	86	90	89	91	92	93	94
Ludhiana	53	52	61	65	75	82	85	84
Gurdaspur	51	49	53	44	49	52	52	54
Jullundur	70	67	68	75	79	80	81	81
Patiala	40	38	45	61	65	63	67	70

Table 5. Disparities in road infrastructure (Road density as Kms. of metaled road per 100 sq.km. of area), 1960-61 through 1972-73

District	1960-61	62-63	63-64	64-65	65-66	66-67	67-68	68-69	69-70	70-71	71-72	72-73
Bhatinda	7.94	9.03	9.24	9.57	10.12	10.42	10.48	12.08	14.14	16.73	18.61	20.27
Ferozepur	8.01	8.59	8.92	9.02	9.44	9.89	10.54	22.25	15.95	18.08	20.59	29.56
Kapurthala	13.52	13.89	14.56	14.74	15.18	15.29	15.24	18.78	22.76	25.82	28.15	39.67
Hoshiarpur	12.50	14.53	14.99	10.75	10.57	11.19	11.55	14.64	17.80	22.43	24.90	34.06
Ropar	—	—	—	12.53	13.18	13.69	13.87	16.95	21.84	28.87	31.11	44.29
Sangrur	13.62	15.12	15.64	11.24	11.91	12.26	12.81	14.46	17.38	20.78	23.52	34.45
Amritsar	13.81	14.86	15.34	15.62	16.16	17.25	18.21	20.47	24.95	27.98	28.93	36.45
Ludhiana	11.04	12.57	12.67	14.39	15.00	15.29	15.45	18.32	25.88	31.55	35.51	46.71
Gurdaspur	13.20	14.84	15.80	16.51	16.64	16.78	17.99	20.52	25.30	27.61	28.95	39.04
Jullundur	13.51	15.07	15.37	15.81	16.64	16.81	17.73	21.11	26.08	31.15	34.15	44.11
Patiala	12.26	16.88	13.59	12.54	12.82	15.18	15.41	18.19	23.23	32.98	36.09	46.68

and it showed a further improvement to 94 per cent during 1972-73. During 1960-61, Jullundur and Ferozepur districts had 70 and 64 per cent irrigated area respectively ; and all other districts had less than 54 per cent irrigated area. Those districts where irrigation made some good progress during the periods 1960-61 to 1972-73 were Ludhiana, Ferozepur, Sangrur, Patiala, Jullundur and Kapurthala. A perceptible jump in irrigated area was around 1968. In some of the districts especially in the semi hilly areas i.e., Gurdaspur, Hoshiarpur and Ropar districts, the performance of irrigation had remained very poor upto the end of the year of study. In the Hoshiarpur District, there was a seven point increase in the irrigated area as percentage of net area sown during 1972-73 over the preceeding year but over all performance was still 29 per cent.

Road Infrastructure

The disparity in road infrastructure between different districts was measured by comparing the density (Kilometers of metaled road per hundred Sq. Km. of Geographical area) (**Table 5**). It was observed that the road construction activity caught up significant momentum since 1968-69. Thus up to 1967,68 in most of the districts the road density increased only a little, when it was the maximum in the Amritsar District which was 18.21. In some of the districts, rather, there was a decline which indicated that the metaled roads were not properly maintained. These districts were Sangrur, Hoshiarpur and Patiala.

However, after 1967-68, the road construction received attention and the road density increased considerably upto 1971-72. It was also observed that in some of the years, in some of the districts the construction of road infrastructure was at a very top gear. Thus during 1969-70, the road construction in the Ludhiana District attained a density of 25.88 Km. from 18.32 in 1968-69. Similarly during 1970-71 relatively very high increase in road density was observed in Ropar and Patiala districts where the road density reached 28.87 and 32.98 during 1970-71 from 21.84 and 23.23 during 1969-70, respectively. Another spurt in building the road infrastructure was observed during 1972-73 when in all the districts road density increased by 7.52 (Amritsar) to 11.52 (Ludhiana). The minimum road density during 1972-73 was in the Bhatinda District which was 26.27 Kms. per 100 Sq. Kms and the maximum was in the Ludhiana District which was 46.71 Kms per 100 Sq. Kms.

The disparity in road infrastructure between different districts can be seen by comparing the minimum and maximum road density during the period of study (**Table 6**). Thus during 1960-61, the maximum road density 13.81 was in the Amritsar District and Minimum at 7.94 in the Bhatinda District. The minimum figure in 1968-69 was 12.09, again, in the Bhatinda District. Thus in 8 years the minimum road density did not achieve the maximum level of 1960-61. By this time, the maximum had also increased to 21.11 which was in the Jullundur District. The ratio of maximum to minimum was the same during 1960-61 and 1968-69 at 1.74. Afterwards, the minimum road density reached 18.61 by 1971-72 in the Bhatinda District which in comparison to maximum density in some previous year compared with 18.21 in 1967-68 in the Amritsar District thereby reducing the time gap of bringing the minimum figure nearer to the previously maximum figure to four years. However, the ratio of the maximum to munimum was 1.94.

Table 6. Minimum and maximum road density, 1960-61 through 1972-73 (Kms/100 sq. Km. of area)

Year	Min.	Max.	Ratio of max. to min.
1960-61	7.94(B)*	13.81(A)	1.74
1962-63	8.59(F)	15.12(S)	1.76
1963-64	8.92(F)	15.80(G)	1.77
1964-65	9.02(F)	17.74(G)	1.96
1965-66	9.46(F)	16.64(G)	1.76
1966-67	9.89(F)	17.23(A)	1.74
1967-68	10.48(B)	18.21(A)	1.74
1968-69	12.09(B)	21.11(J)	1.74
1969-70	14.14(B)	26.08(J)	1.88
1970-71	16.74(B)	32.98(P)	1.97
1971-72	18.61(B)	36.09(P)	1.94
1972-73	26.27(B)	46.71(L)	1.78

* Alphabet in the parentheses alongside indicates the initial alphabet of the district.

Again, during 1972-73, the minimum road density was 26.27 (Bhatinda) which compares with the previously maximum of 26.28 in 1969-70 (Jullundur) and thus the time gap of pushing the minimum to some previously maximum was further decreased to three years. Thus two things emerge from this discussion. The disparity in road infrastructure between different districts increased over the period. But the time gap of attaining a certain previously maximum level as the lowest level has been considerably reduced from about eight years to about three years within a period of 12 years.

Institutional Credit

Co-operative credit still remains the most dominant source of institutional finance throughout the state. But there existed acute skewness in the co-operative credit advanced in different districts of the state (**Table** 7 and 8). Ludhiana and Jullundur were the only two districts where co-operative credit was much ahead of other districts. Thus during 1972-73, upto which data were available, the co-operative credit in Ludhiana and Jullundur districts was Rs. 578.53 and 349.34 per cultivated hectare respectively whereas in other districts it ranged from Rs. 68.04 (Bhatinda) to Rs. 183.94 (Ropar) per cultivated hectare.

The growth of co-operative credit was even more haphazard. There was a considerable decline in co-operative credit during 1969-70 in Bhatinda, Ferozepur, Hoshiarpur, Sangrur, and Patiala districts by about Rs. 20 to 116 per cultivated hectare. Subsequently, there was an increase in the credit advanced by co-operatives in these districts but this increase was so slow, or was even sometimes negative, that even by 1972-73 the co-operative credit did not come up to the amount that was advanced in 1968-69. In the Gurdaspur District, the co-operative credit showed an up and down trend, it was Rs. 127.27 per cultivated hectare during 1971-72 which decreased to Rs. 109.37 per cultivated hectare during 1972-73.

There was almost a consistent increase in the co-operative credit in Kapurthala, Ropar, Ludhiana and Jullundur districts where cooperative credit during 1968-69 to 1972-73 increased by 81.32, 27.92, 26.23 and 37.81 per cent respectively. In the Amritsar District, the co-operative credit increased from Rs. 94.53 per cultivated hectare during 1968-69 to Rs. 109.16 per cultivated hectare during 1969-70 but subsequently there was only little increase or decrease and thus even during 1972-73 the co-operative credit was Rs. 110.45 per cultivated hectare.

The ratio of maximum and minimum credit advanced in any district would show the gap in the distribution of co-operative credit. It was seen that the credit advanced remained minimum in the Bhatinda district and the maximum in the Ludhiana district throughout the period. The ratio of maximum to minimum was 3.88 during 1968-69 which increased to 5.61 during 1969-70 and 5.56 during 1972-73. Thus, the co-operative credit advanced was more than five times in the Ludhiana district, which was at the top, of the credit advanced in the Bhatinda district, which was at the lowest ladder of the scale.

Table 7. Co-operative credit per cultivated hectare, Punjab, 1968-69 through 1972-73 (Rs.)

District	1968-69	1969-70	1970-71	1971-72	1972-73	Percent increase in 1972-73 over 1968-69
Bhatinda	77.11*	56.43*	63.16*	60.87*	68.04*	−11.76
Ferozepur	111.92	83.73	94.88	87.64	97.39	−12.98
Kapurthala	86.59	99.90	111.89	150.81	157.01	81.32
Hoshiarpur	178.91	158.92	147.45	156.48	152.61	−14.70
Ropar	143.79	162.84	170.08	176.30	183.94	27.92
Sangrur	166.58	122.11	121.17	138.51	136.73	−17.91
Amritsar	94.53	109.16	113.62	108.63	110.45	16.84
Ludhiana	299.87**	316.77**	345.29**	380.46**	378.53**	26.23
Gurdaspur	116.21	121.50	115.67	127.27	109.37	− 5.88
Jullundur	253.49	243.31	278.62	315.86	348.34	37.81
Patiala	218.87	102.24	124.00	136.57	119.87	−45.23
Ratio of Maxi. to Minimum	3.88	5.61	5.47	6.25	5.56	—

* Minimum   ** Maximum

Table 8. Co-operative Credit per cropped hectare, Punjab, 1968-69 through 1972-73 (Rs.)

District	1968-69	1969-70	1970-71	1971-72	1972-73	Percentage increase in 1972-73 over 1968-69
Bhatinda	63.34*	43.03*	47.08*	51.37*	50.95*	−19.56
Ferozepur	99.98	71.18	78.28	70.93	72.15	−27.83
Kapurthala	73.75	87.01	97.45	130.38	137.51	86.45
Hoshiarpur	135.47	117.98	105.74	107.11	99.16	−26.80
Ropar	102.47	115.38	105.97	123.11	127.57	24.49
Sangrur	122.40	86.06	87.39	96.15	93.05	−23.97
Amritsar	60.91	78.71	79.88	76.37	77.63	27.45
Ludhiana	201.63**	207.68	222.47**	237.51**	235.85	16.97
Gurdaspur	85.22	87.37	82.21	89.47	75.05	11.93
Jullundur	198.64	186.13	209.32	224.75	243.87**	22.76
Patiala	182.61	82.00	90.24	99.76	82.05	−60.54
Ratio of Maximum to Minimum	3.18	4.83	4.72	4.62	4.78	—

* Minimum   ** Maximum

Table 9. Rank correlations of Agricultural Productivity and Institutional variables

	Institutional Variable	Rank correlation during	
		1960-61	1970-71
1.	Population density	0.66	0.76
2.	Rural literacy	0.16	0.43
3.	Net irrigated area (percentage)	0.01	0.44
4.	Road density	0.29	0.82
5.	Institutional credit	0.33*	0.64

* Relates to 1969-70

Agricultural Productivity and Institutional Variables

The inter-district variation in agricultural productivity could be explained by the inter-district disparity in the institutional variables. The rank correlations between agricultural productivity and institutional variables during 1960-61 and 1970-71 were all positive (**Table 9**). It was also found that all the rank correlations were higher during 1970-71 than during 1960-61 thereby indicating the increasing significance of the institutional variables in explaining the inter-regional (district) disparities in (agricultural) productivity. For some of the institutional variables, the rank correlations during 1960-61 were rather very low, for instance, for irrigation and rural literacy being 0.01 and 0.16 respectively but these improved to more than 0.40 during 1970-71. The road density, also had a low correlation of 0.29 during 1960-61 but it appeared to be a very dominant variable with a rank correlation of 0.82 in explaining productivity difference of agricultural sector which by 1970-71 in the Punjab had witnessed a great technological transformation that needed the vast net-work of roads to facilitate movement of the technological inputs to the hinterpants and of the resultant output to the market towns. The institutional (co-operative) credit was also a significant variable in that it had high correlation of 0.64 with agricultural productivity during 1970-71.

Institutional factors affecting inter-district disparity in the institutional credit.

Since institutional credit is considered to be the sine-que-non of development and thus provides the initial stimulus to the process of growth, we examined the institutional factors which led to co-operative credit advanced at a large scale in some districts and at a very low scale in some others. Multiple regression technique was used to study the relative significance of different factors in affecting co-operative credit. The independent variables considered were irrigation, rural literacy, road infrastructures and cropping intensity. The cross-sectional data for different districts pooled for 1968-69 through 1972-73 were used. The coefficients of linear regression are given in **Table 10.**

It was found that rural literacy and road density had significant effect on the inter-district variations in co-operative loans. The elasticity of credit per cropped hectare and per cultivated hectare with respect to rural literacy was 0.7201 and 0.7048 respectively which means 1 per cent increase in the rural literacy would increase the co-operative credit by more than 0.70 per cent. Similarly the elasticity of credit per cropped and per cultivated hectare with respect to road density was 0.5702 and 0.5419 respectively which means 1 per cent increase in road density would increase co-operative credit by more than 0.50 per cent. The per cent irrigated area in a district did not have significant effect on co-operative credit. Thus, the analysis shows that in order to gear up the co-operative credit in the lagged districts, the efforts should be directed to improving the rural literacy and the road density.

Complementarity of Institutional Variables

It was hypothesized that those districts which had lower productivity were also having all the institutional variables at a lower rank and those where productivity was higher all the institu-

Table 10. Coefficients of multiple linear regression of institutional loan on important variables

Dependent variable	Pure constant intercept	Independent variable				R^2
		Percentage irri. area	Percentage rural literacy	Road density (Kms/100 Sq. Km.)	Cropping intensity.	
1. Co-operative loan per cropped hectare	− 35.5938	0.0358 (0.3150)	3.7180** (1.1923)	2.4979** (0.7513)	—	0.2690**
Elasticities	—	0.0206	0.7201	0.5702	—	
2. Co-operative loan per cultivated hectare	−238.7221	0.1699 (0.4984)	5.0379** (1.8463)	3.2856* (1.3371)	1.3806* (0.6763)	0.2880**
Elasticities	—	0.0708	0.7046	0.5419	1.1891	

Note Figures in the parentheses are the standard errors of the respective coefficients
** Significant at 1 per cent level
* Significant at 5 per cent level

Table 11. Complementarity of different institutional variables, district-wise, Punjab, 1961 and 1971.

District	Ranking during 1960-61 of						Coefficient of	Ranking during 1970-71						Coefficient of
	AP	PD	RL	II	RD	IC	complementary	AP	PD	RL	II	RD	IC	complementary
Bhatinda	1	1	3	4	1	1	.76	1	2	1	5	1	1	.76
Ferozepur	2	2	4	2	2	2	.18	3	1	3	6	2	2	.55
Kapurthala	3	5	8	7	8	6	.79	4	5.5	6	7.5	5	9	.76
Hoshiarpur	4	6.5	7	1	5	8	.10	2	7	11	1	4	7	−.69
Ropar	5	6.5	9	—	—	9	—	9	5.5	10	2	8	8	−.14
Sangrur	6	3	1	3	9	5	−.11	5	3	2	7.5	3	6	.34
Amritsar	7	10	5	10	10	3	−.37	8	9	5	11	7	4	.14
Ludhiana	8	9	11	6	3	11	−.45	11	10	7	10	10	10	.78
Gurdaspur	9	8	6	5	6	7	.85	7	8	8	3	6	3	.24
Jullundur	10	11	10	9	7	10	.72	10	11	9	9	19	11	.86
Patiala	11	4	2	2	4	4	.86	6	4	4	4	11	5	−.12

AP-Agricultural Productivity, PD-Population Density, RL-Rural Literacy
II-Irrigation Intensity, RD-Road Density, IC-Institutional Credit.

tional variables had higher ranks. This means that institutional variables were complementary. The coefficient of complementarity was measured by rank correlation between all possible pairs of ranks of different institutional variables. There were five institutional variables, viz., population density, rural literacy, irrigation intensity, road density and institutional credit, thus there were 10 possible pairs. The coefficient of complementarity between different institutional variables for different districts during 1960-61 and 1970-71 are given in **Table 11**.

The coefficient of complementarity between different institutional variables for the three districts which had the lowest agricultural productivity during 1960-61, viz., Bhatinda, Ferozepur and Kapurthala was 0.76, 0.18 and 0.79 respectively; and for the three top districts in agricultural productivity viz., Gurdaspur, Jullundur and Patiala was 0.85, 0.72 and 0.86 respectively. For other districts, the coefficient of complementarity during 1960-61 was very low and mostly negative. Again, during 1970-71, the coefficient of complementarity for the same three bottom districts was 0.76, 0.55 and 0.76 respectively; and for the same three top districts was 0.24, 0.86 and −0.12 respectively. But by 1970-71, the Patiala District which was at the top in agricultural productivity during 1960-61 slipped down to the sixth position and the Ludhiana District improved to the top. The coefficient of complementarity for the Ludhiana District during 1970-71 was 0.78. The coefficient of complementarity for other districts was again very low and also negative in some cases.

These findings confirmed our view that the institutional variables moved in a complementary fashion. It was particularly so at the two extremes viz., the regions where the productivity was the highest or the lowest. This showed that in order to bring improvements in (agricultural) productivity via institutional variables, all the institutions in the lowest productivity regions have to be tackled; for those in the middle range, the lagged institutions have to be identified and given top priority ; and again, for those already in the top gear, all the institutional variables have to be further improved.

To sum up

The growth of important institutional variables which affect agricultural productivity significantly were examined for small regions (districts) in a growing economy (The Punjab State) from 1960-61 to 1970-71. The variables for which detailed data were available were population density, rural literacy, irrigation infrastructures, road density and institutional credit.

It was found that more productive areas were more densely populated. Also a tendency of population growth to be higher in more productive areas was observed. However, agricultural productivity increased at a much faster rate than the population growth rate, it was, therefore, evident that the growth and disparity in agricultural productivity and hence agricultural development have to be related to factors which are more powerful, other than the population variable.

The growth in rural literacy was very uneven between different districts. The rank correlation between agriculural productivity and rural literacy was 0.16 and 0.43 during 1961 and 1971 respectively. It showed the increasing significance of rural literacy in explaining agricultural productivity. The irrigation infrastructures measure as irrigation intensity, i.e. irrigated areas percentage of net area sown, was found to vary from 13 to 90 per cent during 1960-61 and from 29 to 94 per cent during 1972-73. Again, the rank correlation between agricultural productivity and irrigation intensity improved from 0.01 in 1960-61 to 0.44 in 1970-71.

The road infrastructures increased by more than 3 times during the period 1960-61 to 1972-73 although the real spurt in the road construction activity was observed only after 1967-68. The road density (Kms per 100 Sq. Kms) varied from 7.94 to 13.81 during 1960-61 and from 26.27 to 46.71 during 1972-73. The disparity in road infrastructures between different districts increased over time. But the time gap of attaining a certain previously maximum level at the lowest level was convsiderably reduced from about eight years to about three years within a period of 12 years. The road density had a low rank correlation of 0.29 during 1960-61 but it emerged out to be vary dominant variable with a rank correlation of 0.82, in explaining productivity differences of agricultural sector which by 1970-71 in the Punjab had witnessed a great technological transformation that needed the vast net work of roads to facilitate movement of technological inputs to the hinterlands and of the resultant output to the market towns.

The co-operative oredit per cultivated hectare varied from Rs. 77.11 to 299.87 during 1968-69 and from Rs 68.04 to 378.57 during 1972-73 in different districts of the state. The institutional credit was a significant variable in explaining agricultural productivity in that there was a high rank correlation of 0.64 during 1970-71.

The institutional factors which led to co-operative advance at a large scale in some districts and at a very low scale in some others, were examined. It was found that rural literacy and road density had significant effect on the inter-district variations in co-operative loans. The elasticity of credit per cropped and per cultivated hectare was 0.7201 and 0.7048 with respect to rural literacy ; and 0.5702 and 0.5419 with respect to road density respectively. Thus in order to gear up the co-operative credit in the lagged districts, the efforts should be directed to improving the rural literacy and the road density.

The coefficient of complementarity between different institutional variables was found to be high for the three top and the three bottom districts in agricultural productivity both during 1960-61 and 1970-71. It was very low and generally negative for other districts. This showed that the institutional variables moved in a complementary order particularly at the two extremes. Thus in order to bring improvement in (agricultural) productivity via institutional variables, all the institutions in the lowest productivity region have to be tackled ; for those in the middle range, the lagged institutions have to be identified and given the top priority ; and again, for those already in the top gear, all the institutional variables have to be further improved. ■ ■

INDEX TO ADVERTIZERS

The Collection of Photo and Specification

The Recent Condition of Tractor, Transplanter and Combine in Japan

by Farm Machinery Industrial Research Corp.

Wheel Tractor


Hinomoto E15


Iseki TS1910


Hinomoto E14


Iseki TX1000


Iseki TS2210


Hinomoto E14D


Iseki TX13000


International 272

NEW PRODUCTS

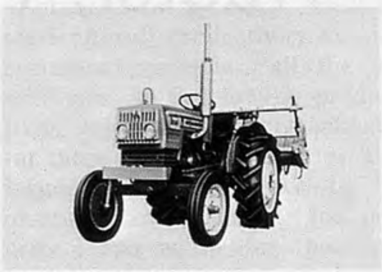

Kubota B5001


Kubota B7001E


Kubota L3001DT

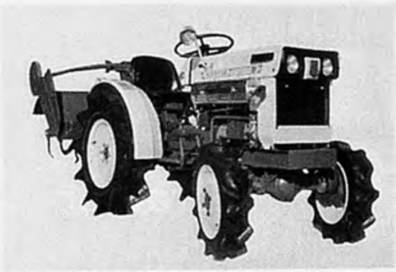

Kubota B5001E


Kubota L1511


Mitsubishi D2500 II


Kubota B6001


Kubota L1501AC


Satoh ST1300


Kubota B6001E


Kubota L2201G


Satoh ST1801

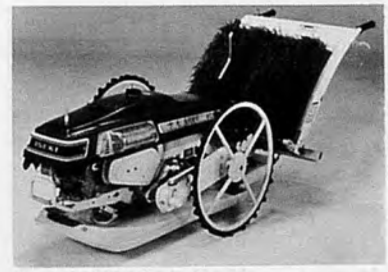

Kubota B7001


Kubota L2601DT


Satoh ST2501

Satoh ST4000

Yanmar YM1100D



Iseki PF210

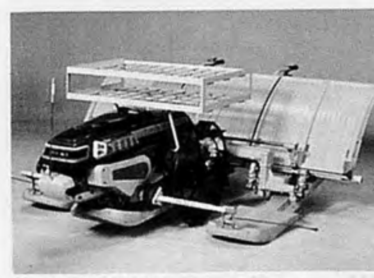
Shibaura SD3000

Yanmar YM2210

Iseki PF410A

Shibaura SD4000A

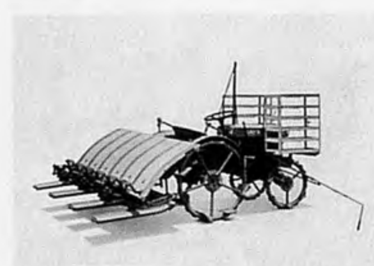
Yanmar YM2210D



Iseki PF610A

Suzue M1301D

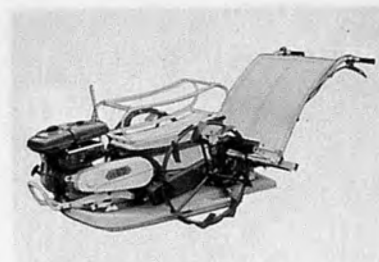
Yanmar YM2500



Kubota SPR600

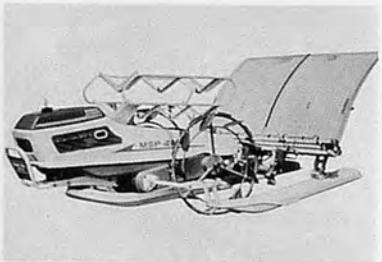
Yanmar YM1100

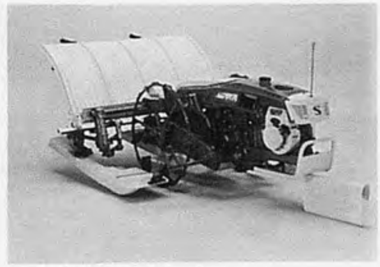
Rice Transplanter



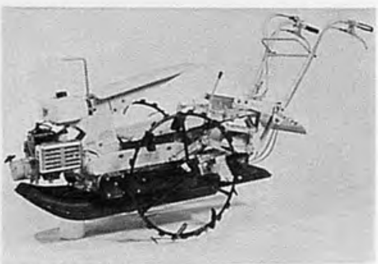
Mametora MSP-2A

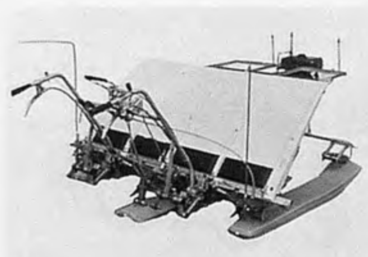
NEW PRODUCTS

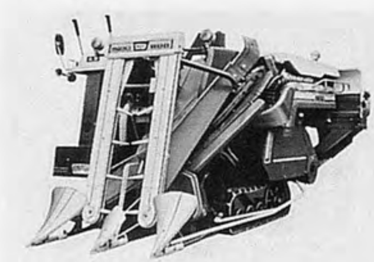

Mametora MSP-4A

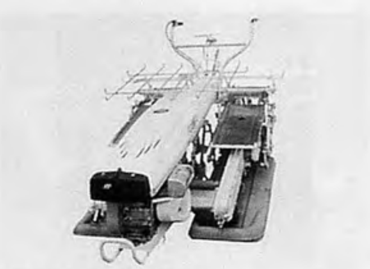

Satoh PS-410

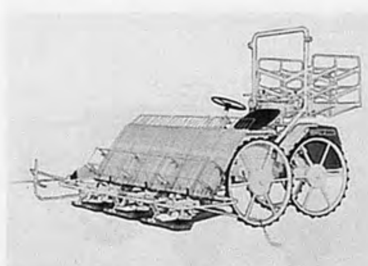

Iseki HD1300

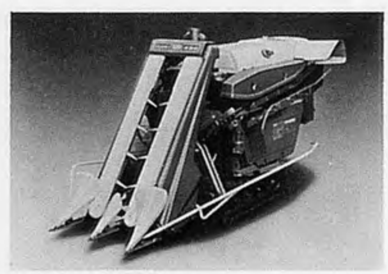

Minoru LT-2F


Suzue PP4A


Iseki HD800

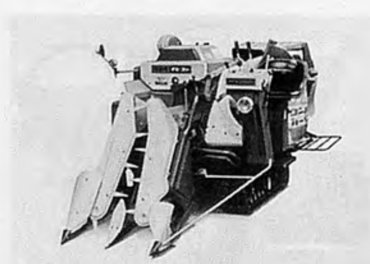

Minoru LT-4F-D


Yanmar YP6000


Iseki HD400

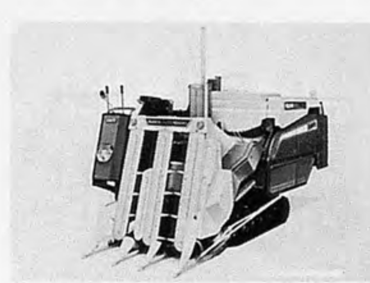

Mitsubishi MP206

Head Feed Combine

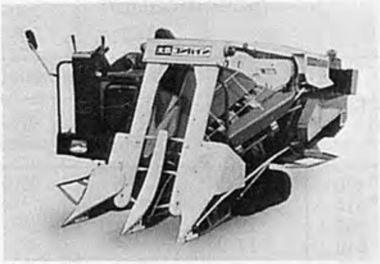

Kubota HX350


Satoh PS-230


Iseki HD3000

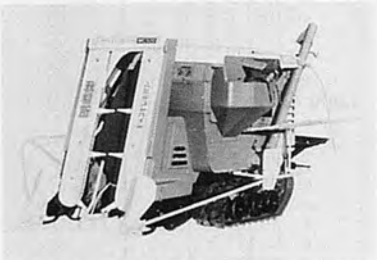

Kubota NX1800

Kubota NX3000

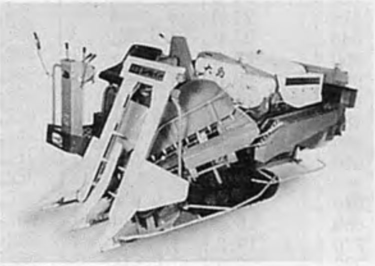


Oshima RS880A

Satoh H1100

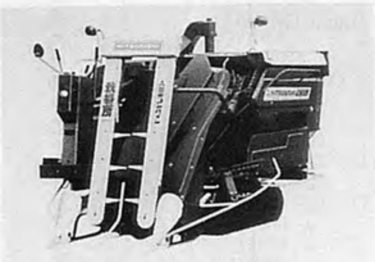


Mitsubishi MC500

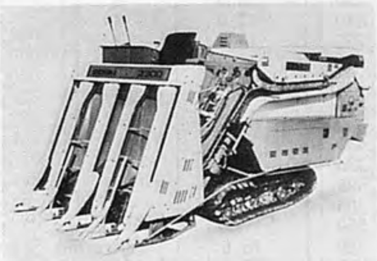


Oshima RD1000

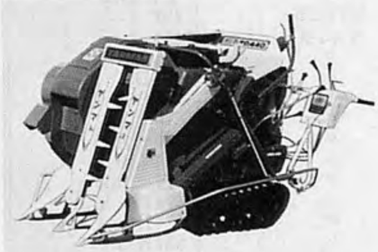
Satoh H3000



Mitsubishi MC600



Oshima RD2300

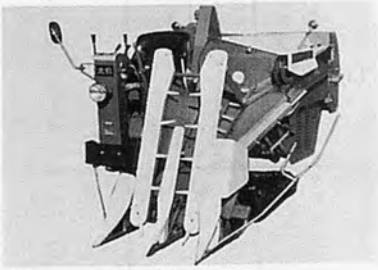


Yanmar TC440

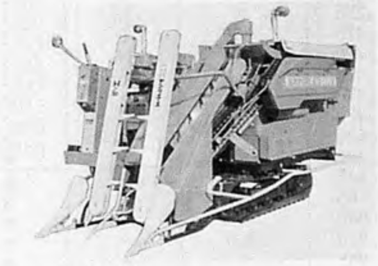
Noda HC450

Satoh H500

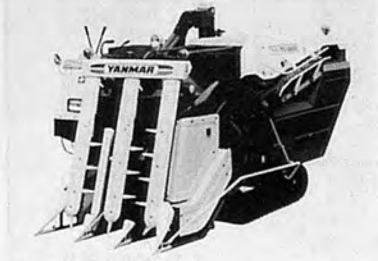
Yanmar TC1400



Oshima RF500



Satoh H600



Yanmar TC1800

Specification

Tractor (Wheel Type)

Brand	Model	Weight (kg)	Engine Output (ps)	Transmission		Fuel	Riding Arrangement	
				For-ward	Re-verse		Four Wheel Drive	Rear Wheel Drive
HINOMOTO	MB1100	470	11.0	6	2	Kerosene		○
〃	MB1100D	510	〃	〃	〃	Light Oil		○
〃	MB1500	562	15.0	〃	〃	Kerosene		○
〃	E14	610	14.0	〃	〃	Light Oil		○
〃	E14D	675	〃	〃	〃	〃	○	
〃	E15	635	16.0	〃	〃	〃		○
〃	E16	675	〃	〃	〃	〃		○
〃	E18	720	18.0	〃	〃	〃		○
〃	E21	815	21.0	8	〃	〃		○
〃	E23	846	23.0	12	3	〃		○
〃	E25	860	25.0	〃	〃	〃		○
〃	E28	989	28.0	〃	〃	〃		○
ISEKI	TX1000	450	11.0	6	2	Light Oil		○
〃	TX1000F	485	〃	〃	〃	〃	○	
〃	TX1300	480	13.0	〃	〃	〃		○
〃	TX1300F	510	〃	〃	〃	〃	○	
〃	TX1500	〃	14.8	〃	〃	〃		○
〃	TX1500F	540	〃	〃	〃	〃	○	
〃	TS1610	690	16.0	9	〃	〃		○
〃	TS1910	720	18.2	〃	3	〃		○
〃	TS2210	930	22.0	〃	〃	〃		○
〃	TS2510	1,050	25.0	〃	〃	〃		○
〃	TS2810	1,120	28.0	〃	〃	〃		○
〃	TS3510	1,250	35.0	8	2	〃		○
INTER-NATIONAL	272	1,040	27.0	8	2	Light Oil		○
	444	1,755	45.0	〃	〃	〃		○
〃	455	1,810	46.0	〃	4	〃		○
〃	464D	2,170	57.0	〃	〃	〃		○
〃	464D—AD	2,380	〃	〃	〃	〃	○	
〃	576	2,330	66.0	〃	〃	〃		○
〃	576—AD	2,630	〃	〃	〃	〃	○	
〃	674	2,325	78.0	〃	2	〃		○
〃	674—AD	2,595	〃	〃	4	〃	○	
〃	674D	2,305	〃	〃	2	〃		○
〃	674D—AD	2,550	〃	〃	4	〃	○	
〃	574HS	2,430	75.6	Variable Speed		〃		○
〃	776	3,095	85.0	16	8	〃		○
K—O	M7000	440	13.0	6	2	Light Oil		○
KUBOTA	B5001	400	9.5	6	2	Light Oil	○	
〃	B5001E	390	〃	〃	〃	〃		○
〃	B6001	455	12.0	〃	〃	〃		
〃	B6001E	440	〃	〃	〃	〃	○	○
〃	B7001	500	14.0	〃	〃	〃	○	
〃	B7001E	480	〃	〃	〃	〃		○
〃	L1501	670	15.0	16	4	〃		○
〃	L1501DT	750	〃	〃	〃	〃	○	
〃	L1501AC	670	16.7	〃	〃	〃		○
〃	L1511	〃	〃	Variable Speed		〃		○
〃	L1801	702	18.0	16	4	〃		○
〃	L1801DT	783	〃	〃	〃	〃	○	○
〃	L2201	720	22.0	〃	〃	〃		○
〃	L2201G	770	〃	〃	〃	〃		○
〃	L2201DT	820	〃	〃	〃	〃		○
〃	L2601	1,015	26.0	〃	〃	〃		
〃	L2601DT	1,100	〃	〃	〃	〃	○	○
〃	L3001	1,210	30.0	8	2	〃		
〃	L3001DT	1,225	〃	16	4	〃	○	
〃	L3500	1,475	36.0	6	2	〃		○
〃	M4000	1,770	45.0	16	4	〃		○
MITSUBISHI	D1100	430	11.0	6	2	Light Oil		○
〃	D1100FD	490	〃	〃	〃	〃	○	
〃	D1300	470	13.0	〃	〃	〃		○
〃	D1300FD	535	〃	〃	〃	〃	○	
〃	D1500V	490	15.0	〃	〃	〃		○
〃	D1500VFD	547	〃	〃	〃	〃	○	
〃	D1600L	765	16.0	9	3	〃		○
〃	D1600FDL	840	〃	〃	〃	〃	○	
〃	D1800II	870	18.0	〃	〃	〃		○
〃	D1800II FD	845	〃	〃	〃	〃	○	
〃	D2000II	890	20.0	〃	〃	〃		○

〃	D2000II FD	965	〃	〃	〃	〃	○	
〃	D2300	895	23.0	18	6	〃		○
〃	D2300FD	970	〃	〃	〃	〃	○	
〃	D2500II	1,030	25.0	15	3	〃		○
〃	D3000II	1,115	30.0	10	2	〃		○
〃	D4000	1,535	40.0	9	3	〃		○
NODA	N7000	400	12.0	6	2	Light Oil		○
SATOH	S T1100	430	11.0	6	2	Light Oil		○
〃	S T1100D	480	〃	〃	〃	〃	○	
〃	S T1300	〃	13.0	〃	〃	〃		○
〃	S T1300D	510	〃	〃	〃	〃	○	
〃	S T1510	485	15.0	〃	〃	〃		○
〃	S T1510D	545	〃	〃	〃	〃	○	
〃	S T1600	735	16.0	9	3	〃		○
〃	S T1600D	840	〃	〃	〃	〃	○	
〃	S T1801	740	18.0	〃	〃	〃		○
〃	S T1801D	860	〃	〃	〃	〃	○	
〃	S T2001	880	20.0	〃	〃	〃		○
〃	S T2001D	965	〃	〃	〃	〃	○	
〃	S T2300	885	23.0	18	6	〃		○
〃	S T2300D	970	〃	〃	〃	〃	○	
〃	S T2501	1,030	25.0	15	3	〃		○
〃	S T2501D	1,145	〃	〃	〃	〃	○	
〃	S T3000	1,115	30.0	10	2	〃		○
〃	S T3000D	1,230	〃	〃	〃	〃	○	
〃	S T4000	1,520	40.0	9	3	〃		○
SHIBAURA	S U1100	500	11.0	6	3	Light Oil		○
〃	S U1140	560	〃	〃	〃	〃	○	
〃	S U1300	530	13.0	〃	〃	〃		○
〃	S U1341	585	〃	〃	〃	〃	○	
〃	S D1500B	750	15.0	8	2	〃		○
〃	S D1540B	780	〃	〃	〃	〃	○	
〃	S D1800	〃	18.0	20	4	〃		○
〃	S D1840	850	〃	〃	〃	〃	○	
〃	S D2000D	1,000	22.0	24	8	〃		○
〃	S D2000D—O	1,060	〃	〃	〃	〃	○	
〃	S D2600D	1,125	26.0	〃	〃	〃		○
〃	S D2640D	1,225	〃	〃	〃	〃	○	
〃	S D3000AD	1,420	30.0	〃	〃	〃		○
〃	S D3000AD—O	1,540	〃	〃	〃	〃	○	
〃	S D4000AD	1,445	40.0	〃	〃	〃		○
〃	S D4000AD—O	1,565	〃	〃	〃	〃	○	
〃	S D4800	2,070	48.0	16	4	〃		○
〃	S D4840	2,270	〃	〃	〃	〃	○	
〃	S D5800	2,100	58.0	〃	〃	〃		○
〃	S D5840	2,300	〃	〃	〃	〃	○	
〃	S D7340	3,200	73.0	〃	〃	〃	○	
〃	S D8340	3,300	83.0	〃	〃	〃	○	
SUZUE	M1101D	430	11.0	6	2	Light Oil		○
〃	M1200	440	12.0	〃	〃	〃	○	
〃	M1301	400	13.0	〃	〃	〃		○
〃	M1301D	450	〃	〃	〃	〃	○	
〃	M1501	410	15.0	〃	〃	〃		○
〃	M1501D	460	〃	〃	〃	〃	○	
〃	M2000	820	20.0	9	3	〃	○	
〃	M2500	1,050	25.0	10	2	Kerosene	○	
YANMAR	Y M1100	430	11.0	6	2	Light Oil		○
〃	Y M1100D	475	〃	〃	〃	〃	○	
〃	Y M1110	565	〃	9	3	〃		○
〃	Y M1110D	600	〃	〃	〃	〃	○	
〃	Y M1300	475	13.0	6	2	〃		○
〃	Y M1300D	515	〃	〃	〃	〃	○	
〃	Y M1500	605	15.0	8	〃	〃		○
〃	Y M1500D	650	〃	〃	〃	〃	○	
〃	Y M1700	720	17.0	〃	〃	〃		○
〃	Y M2000	755	20.0	〃	〃	〃		○
〃	Y M2210	945	22.0	15	5	〃		○
〃	Y M2210D	995	〃	〃	〃	〃	○	
〃	Y M2500	1,040	25.0	16	4	〃		○
〃	Y M2500R	1,085	〃	〃	〃	〃		○
〃	Y M3000	1,160	30.0	8	2	〃		○

NEW PRODUCTS

Rice Transplanter

Brand	Model	Dimensions L × W × H (cm)	Weight (kg)	Engine Output (ps)	Number of Row	Efficiency (min/10a)
ISEKI	P F210	200 × 90 × 85	75	2.5~3.5	2	60
〃	P F210A	200 × 93 × 85	〃	〃	〃	50
〃	P F410	240 × 148 × 82	155	〃	4	30
〃	P F410A	240 × 157 × 82	〃	〃	〃	〃
〃	P F610A	252 × 223 × 92	190	〃	6	20
K—O	R T20G	200 × 86 × 94	80	2.0~2.5	2	50~70
KUBOTA	S 200A	175 × 86 × 90	60	1.2	2	50~90
〃	S 200B	175 × 88 × 90	〃	〃	〃	〃
〃	S 300A	205 × 76 × 75~85	85	2.6	〃	40~70
〃	S 300B	205 × 88 × 75~85	〃	〃	〃	〃
〃	S 400A	225 × 142 × 98	138	〃	4	30~40
〃	S 400B	225 × 146.4 × 98	〃	〃	〃	〃
〃	S 400C	225 × 155 × 98	〃	〃	〃	〃
〃	S P R600—B	298 × 209 × 180	530	9.0	6	20~30
〃	S P R600—C	298 × 221 × 180	〃	〃	〃	〃
MAMETORA	M S P—2 A	210 × 88 × 85	87	2.5~3.5	2	60
〃	M S P—4 A	240 × 148 × 86	120	〃	4	30
MARUMASU	Satsuki 3	210 × 88 × 85	83	2.5~3.5	2	60
〃	Satsuki 4	238 × 148 × 86	125	〃	4	30
MINORU	L T—2 F	195~211 × 67.5 × 78.5~95.5	76	1.2~1.7	2	50~90
〃	L T—2 F II	〃	〃	〃	〃	〃
〃	L T—2 F—D II	〃	〃	〃	〃	〃
〃	L T—4 F	234~245 × 122.5 × 83.5~93.5	158	2.3~3.3	4	30~40
〃	L T—4 F—D	〃	166	〃	〃	〃
MITSUBISHI	M P206	280 × 90 × 95	75	2.0~2.5	2	40
〃	M P410	235 × 150 × 95	150	2.5~3.5	4	30~40
〃	M P600C	235 × 225 × 95	170	3.5	6	20~30
NODA	N P301	200 × 90 × 85	75	1.5~3.0	2	60~70
〃	N P902A	242 × 146 × 81	150	〃	4	30~40
SATOH	P S—230	200 × 90 × 95	75	2.0~2.5	2	40~60
〃	P S—410	235 × 150 × 95	150	2.5~3.5	4	30~40
SUZUE	S P 2 D	201 × 86 × 95	72	2.5	2	50~70
〃	S P 4 A	205 × 146 × 100	115	3.5	4	30~50
〃	P P 2 C	201 × 95 × 98	75	2.5	2	50~70
〃	P P 4 A	205 × 185 × 100	125	3.5	4	30~50
YANMAR	Y P20	190~200 × 86 × 79~89	70	2.2	2	60~90
〃	Y P20K	〃	〃	〃	〃	〃
〃	Y P40	205~220 × 145 × 95	120	3.2	4	30
〃	Y P43	205~220 × 155 × 95	〃	〃	〃	〃
〃	Y P6000	290 × 220 × 190	400	4.5~7.0	6	20

Head Feed Combine

Brand	Model	Walking or Riding	Dimensions L × W × H (cm)	Weight (kg)	Engine Output (ps)	Cutting Width (cm)	Efficiency (min/10a)
ISEKI	H D3000G T A	Riding	479 × 168 × 199	2,820	28.6	150	15~30
〃	H D2000D C	〃	384 × 168 × 189	2,030	25.0	140	〃
〃	H D1500D H	〃	369 × 168 × 188	1,295	18.5	105	30~50
〃	H D1300H	〃	330 × 151 × 162	880	15.0	100	〃
〃	H D1000D H	〃	〃	820	12.0	75	35~60
〃	H D800F—E	〃	323 × 158 × 150	680	9.5	〃	50~70
〃	H D400	Walking	240 × 145 × 128	380	6.0~7.5	65	80~150
K—O	C M—500	Walking	202 × 120 × 122	300	5.5~7.5	45	90~100
〃	C M—70G	〃	227 × 150 × 127	400	6.5~8.0	65	65~70
〃	C H—70G	Riding	283 × 165 × 177	670	8.0~11.0	60	45~50
〃	U F1000	〃	260 × 152 × 142	850	9.0	80	90
KUBOTA	H X350	Riding	220 × 140 × 128	350	9.0	65	84~138
〃	H X450	〃	240 × 150 × 140	550	7.5~10.5	65	75~100
〃	H X—D 5—A D	〃	349 × 163 × 152	900	10.5	75	42~75
〃	H X—D 7	〃	〃	〃	12.5	〃	〃
〃	H X—550— 2 A	〃	248 × 158 × 152	720	11.0	〃	〃
〃	H X—700— 2 A	〃	〃	757	13.0	〃	〃
〃	H T900—C D	〃	370 × 165 × 180	1,085	〃	90	40~75
〃	H T2200	〃	400 × 165 × 195	1,750	22.0	130	20~30
〃	N X1800	〃	336.5 × 165 × 182	1,270	18.5	102.5	30~60
〃	N X3000	〃	422 × 165 × 195	1,950	28.0	140	15~30
MITSUBISHI	M C3000	Riding	457 × 238 × 197	2,035	28.0	150	15~25
〃	M C1200D	〃	395 × 256 × 198	1,580	23.0	125	45~60
〃	M C1100	〃	300 × 166 × 177	905	15.0	100	40~70

〃	MC850	〃	300×180×176	705	〃	81	50~80
〃	MC850K(E)	〃	〃	〃	13.0	〃	〃
〃	MC800	〃	〃	690	11.0	〃	〃
〃	MC810	〃	〃	710	12.0	〃	〃
〃	MC600	〃	282×163×150	620	10.0	70	60~100
〃	MC500	Walking	229×140.5×127.5	350	6.0	65	80~140
NODA	KF1000	Riding	260×152×142	850	9.0	80	90
〃	HC450	〃	225×130×135	420	7.0~8.2	65	70~100
OSHIMA	RF500	Riding	224×137×148	460	6.0~8.0	65	120
〃	RS601	〃	301×159×145	620	7.0~9.0	〃	80~120
〃	RS601A	〃	〃	625	9.0~12.0	〃	〃
〃	RS880	〃	310×168×147	708	〃	80	50~80
〃	RS880A	〃	〃	720	10.0~12.0	〃	〃
〃	RD1000	〃	〃	752	13.0	〃	〃
〃	RD2300	〃	374×167×165	1,350	25.0	130	35~60
SATOH	H3000	Riding	457×238×197	2,035	28.0	150	15~25
〃	H1200D	〃	395×256×198	1,580	23.0	125	45~60
〃	H1100	〃	300×166×177	905	15.0	100	40~70
〃	H850D	〃	300×180×176	705	13.0	81	50~80
〃	H850	〃	〃	〃	15.0	〃	〃
〃	H800	〃	〃	690	11.0	〃	〃
〃	H810	〃	〃	710	12.0	〃	〃
〃	H600	〃	282×163×150	620	10.0	70	60~100
〃	H500	Walking	229×140.5×127.5	350	6.0	65	80~140
SUZUE	KM70B	Walking	227×150×127	400	6.5~8.0	70	75~120
〃	KM50	〃	250×185×122	350	5.0~7.0	40	90
〃	NC600A	Riding	296×136×183	580	8.0~11.0	65	80~120
〃	NC772	〃	302×184×166	750	〃	70	60~90
〃	CP730D	〃	257×121×152	700	11.0~15.0	73	60~100
YANMER	TC400	Walking	226×172×136	350	6.5	50	100~150
〃	TC440	〃	239×162.5×145	425	8.2	60	100~150
〃	TC600	Riding	278×169×156	650	7.0	75	60~85
〃	TC700K	〃	268×164×155	760	8.0	〃	〃
〃	TC750K	〃	288×164×157	900	10.5	〃	50~75
〃	TC850	〃	296×167×176	990	13.0	85	40~60
〃	TC1400	〃	318×166×180	1,130	14.0	105	37.5~54.5
〃	TC1800	〃	330×165×190	1,360	18.0	〃	30~50
〃	TC2000D	〃	382×243×165	1,470	20.0	130	25~33
〃	TC3000	〃	412×165×197	2,170	30.0	135	15~20

Manufacturer's Brand, Name and Address

KUBOTA	Kubota, Ltd.…22, 2-chome, Funade-cho, Naniwa-ku, Osaka, Japan.
MAMETORA	Mametora Agric. Machinery Co., Ltd.…9-37, Nishi-2-chome, Okegawa-city, Saitama-city, Japan.
MARUMASU	Marumasu Machinery Co., Ltd…2, Wakasugi, Kamiichi-cho, Nakaniikawa-gun, Toyama Pref., Japan.
HINOMOTO	Toyosha Co., Ltd.…55, Joshoji 16, Kadoma-city, Osaka, 571 Japan.
INTERNATIONAL	Komatsu-International Mfg. Co., Ltd.…Komatsu Bldg., 3-6, Akasaka 2-chome, Minato-ku, Tokyo, Japan.
ISEKI	Iseki Agricultural Machinery Mfg. Co., Ltd…1-3, Nihonbashi 2-chome, Chuo-ku, Tokyo, Japan.
MINORU	Minoru Industrial Co., Ltd.…447, Shimoichi, Sanyo-cho, Akaiwa-gun, Okayama Pref., Japan.
MITSUBISHI	Mitsubishi Kiki Hanbai Ltd. …Hibiya Kokusai Bldg., 3-2, 2-chome, Uchisaiwai-cho, Chiyoda-ku, Tokyo, Japan.
NODA	Noda Industrial Co., Ltd.…3-41, Asahi-cho 5-chome, Takamatsu-city, Kagawa Pref., Japan.
K—O	Uemori Agricultural Implement Mfg. Co., Ltd.…Kannonji, Kannonji-city, Kagawa Pref., Japan.
OSHIMA	Oshima Agricultural Machinery Mfg. Co., Ltd.…10-17, Teramachi 3-chome, Joetsu-city, Niigata Pref., Japan.
SATOH	Satoh Agricultural Machine Mfg. Co., Ltd.…Hibiya Kokusai Bldg., 3-2, 2-chome, Uchisaiwai-cho, Chiyoda-ku, Tokyo, Japan.
SHIBAURA	Ishikawajima-Shibaura Machinery Co., Ltd.…Seiwa Bldg., 6-8, 1-chome, Nishishinjuku, Shinjuku-ku Tokyo Japan.
SUZUE	Suzue Agricultural Machinery Co., Ltd.…144-2, Gomen-cho, Nangoku-city, Kochi Pref., Japan.
YANMAR	Yanmar Agricultural Equipment Co., Ltd.…62, Chaya-machi, Kita-ku, Osaka Japan.

NEW PRODUCTS

Broadcaster

Sasaki GH-350···This implement is one of the series (GH—150, GH—250 and GH—350) under successful light weight. All spreading parts are made by stainless steel for preventing the rust.

The unique design of hopper can protect for scattering of fertilizer during the transportation and by the wind. Flat and uniformity spreading provided with stable let down of fertilizer by special designed aditator. Even small volume spreading is also available under very high precision, this high precision kept by special structures of shatter.

When use our canvas attachment then you can spread the fertilizer even strong wind. And this canvas attachment collapsible when running the road.

〔Specifications〕

Capacity : 350 l, Implement mounting system : 3-point linkage, Dimensions (L × M × H) : 955 × 995 × 1,290 mm, Weight : 78 kg, Tractor power : 30ps ~, Spreading width—P.T.O 540 rpm : 10m (granulated fertilizer) · 3.5m (pulverized fertilizer)

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

Lime sower

Sasaki MR-180···With the P.T.O. joint drive agitator, you can spread evenly not only granular but also powdered lime and fertilizer. Main parts are used stainless steel, so it's free from corrosion and its durability strengthened.

The improved dropping throat allow to spread melted phosphorous in small volume. It can spread evenly under the less influence of wind because of the dropping throat at low position.

You can regulate easily spreading volume with a regulating lever as you get on a tractor. It does not overweight on a tractor because light weight and turning sharply. Since mounted type, moving is very easy, even when crossing over a footpath.

〔Specifications〕

Capacity : 240 l, Implement mounting system : 3-point linkage, Dimensions (L × W × H) : 660 × 1,870 × 1,040mm, Weight : 85kg, Tractor power : 20ps ~, Working width : 1,800mm.

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

Grain Moisture Tester

Wady PH-70···Developed for use in elevators, the unit is easy to operate, and accurately measures moisture content of highly representative samples up to approximately 100 grams in 10 short seconds. It automatically corrects for impurities present in the sample, thereby ensuring total reliability under all circumstances. Incorporating a special circuitry that received the American William B. Tuller Memorial Award in electronics, it has been patented in the U.S., Great Britain, West Germany and Soviet Union.

〔Specifications〕

Sample weight : Approx. 100g, Measuring range : Paddy —10~30% · Brown rice and polished rice—10~20%, Accuracy : Within 0.5%, Power source : AC 100~220V · 50 or 60Hz, Dimensions (H × W × D) : 29 × 37 × 23cm, Weight : 20kg, Accessories : Measuring cup × 2 · Power cord · Thermometer · Vinyl cover.

(Kett Electric Laboratory : 8-1, 1-chome, Minami-Magome, Ota-ku, Tokyo 143, Japan)

Hedge Trimmer

Tas Hedge Trimmer THT-23···By attaching a Walbro Diaphram carburetor to our newly designed T-23 engine we have combined the best features of portable and simple running.

The even positioning of control grips ensure the operator of handling the most evenly balanced hedge trimmer on the market.

By adopting 30 inch (760mm) blades, the operator is relieved from many of the problems associated with short blade electric hedge trimmers. Both blades are double reciprocating which allows the THT-23 to cut through hardwood branches up to 3/4" thick. Due to the special hardening of the blades, the unit is also acceptable for cutting soft woods and grasses.

[Specifications]

Cuting speed : 950mm/sec, Blade length : 760mm, Blade pitch : 30mm, Engine : 1 hp two cycle gasoline engine with centrifugal clutch, Dimensions (L × W × H) : 253mm × 211mm × 301mm, Weight : 4.8kg.

(Tanaka Kogyo Co., Ltd. : 7-1460 Yatsu, Narashino, Chiba, Japan)

Powered Pallet Truck

Bishamon Pallet Truck HP-20···Simple and easy to operate and no need to push or to pull with physical forces, on transporting.

Further this unit has so many exclusive features as follows : ① Driving wheel with speed reduction system and economical motor. ② Battery controller for smooth starting. ③ Automatical return type, and with forward 3 speeds backward 3 speeds accel lever. ④ Tandem Roller with swing mechanique and with highly touching on ground.

[Specifications]

Capacity : 2,000kg, Dimmensions (L × H × W) : 2,138 × 1,300 × 800mm, Fork length : 1,150mm Fork height : Min. 8.5mm~Max. 205mm, Fork width : Outside 570mm • Inside 220mm, Weight : 550kg, Min. raurding radius : 2,000mm.

(Sugiyasu Kikai Kogyo Co., Ltd. : 47-4, Nikawasaki, Nishi-asai-cho, Nishio-city, Aichi-pref., Japan)

Hand Pallet Truck

Bishamon Pallett Truck BM 15···Economically use in carrying in or out from small warehouse, removing materials in factories and in small scale of transportation works.

Rapid lift device is patented over the world and this device is in good reputation in carrying empty pallet and light weight goods.

[Specifications]

Capacity : 1500 kg, Fork length : 810~1,220mm, Fork height : Min. 85mm~Max. 205mm, Fork width : 150mm Fork outside width : 520~685mm, Weight : 70~86kg.

(Sugiyasu Kikai Kogyo Co., Ltd. : 47-4, Nikawasaki, Nishi-asai-cho, Nishio-city, Aichi-pref., Japan)

High-Temperature Washer

Kinsen HC-650N···This is

compactly designed for a small space. There are HC-850N and HC-1300D in the series.

The burner is applied the upper combustion system, so combustion is perfect and washing and buring noise is almost none. High pressed washing liquid (20°—85°C) from a high pressure plunger pump spreads in fan-shape and washes dirt quickly by washing gun.

Operation : Switch on first and then set a self-regulator. The heat coil and washing hot water tank are made of stainless steel and the outside is painted melamine, so the durability is very excellent. Since the temperature of washing liquid keeps at 20°—85°C, you can use it all the time. You can operate it at seeing the washing place, so the working efficiency is very high without wasting liquid.

[Specifications]

Dimension : 620mm (width) × 1,040mm (length) × 1,010mm (heigh), Weigh : apprex. 210kg, Output : 400 1/h, Pressure : 40kg/cm^2, Temperature : 20°—85°C, Fuel Consumption : 2.8 1/h, Motor : Single phase 100V 0.75kw, Water supply : Connect directly to a waterwork, Fuel tank : 30l, Fuel : Kerosene,

(Hasebe Co., Ltd. : 1-5- Atago-cho, Shiba, Minato-ku, Tokyo, Japan) ■ ■

BACK NUMBERS

◇ ◇ ◇

◇ ◇ ◇

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA
(Vol. 8 no 1. winter, 1977)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (vol. 8 No. 2, Spring, 1977)

MAMETORA DEDICATES TO AGRI

It is the motto of MAMETORA that we manufacture goods in order to meet customer's benefits with originality' trusty and hearty. In addition to the head office in Okegawa' Kisakata Factory has been established. Now that we have formed the much steadier basis as a comprehensive manufacturer. We are always making efforts to manufacture goobs of high quality and are pleased to devote ourselves to the food industry in the world as well as that in Japan.

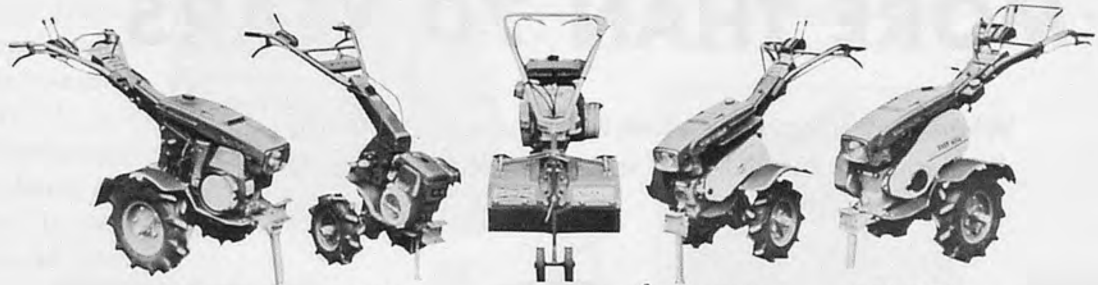
EASY PERFORMANCE MAKES YOU MORE EFFICIENT

1. Mametora Planter MSP-2A works with its variety of application, planting of seedings, from small to grown-up seedlings.
2. Control lever of quantity of seedings per shot at three stages.
3. Control lever of distance of planting, from 12 to 21cm with interval by 1cm.
4. Two wheel traction and floating device go up and down automatically according to the unevene field.
5. Hydraulic system of MSP-2A pass through the footpath of paddy field.
6. In addition, there is another-tipe, 4—Rows MSP-4A

MAMETORA AGRIC. MACHINERY CO., LTD.

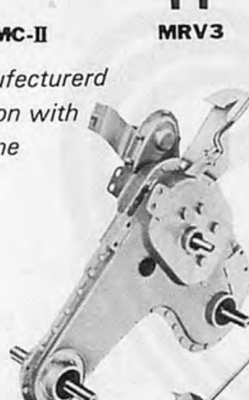
HEAD OFFICE ADD : 9-37, NISHI-2 CHOME, OKEGAWA-SHI, SAITAMA-KEN, JAPAN.
TELEPHONE : 0487-71-1181 TELEX : 2922561 MAMETO-J

CULTURE ALL OVER THE WORLD

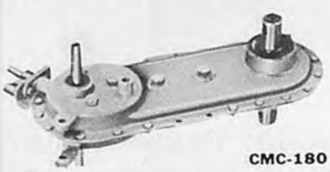


PM-350 DMC-II MRV3 SKD-II HMD-250

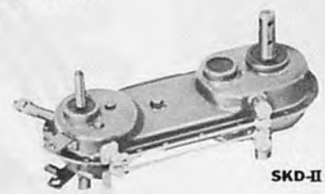
We are provided other Japanese manufacturerd with the transmission only.
We believe you can find the satisfaction with MAMETORA AGRICULTURAL MACHINERY.
We have not only the tiller but also the transmission under oder.



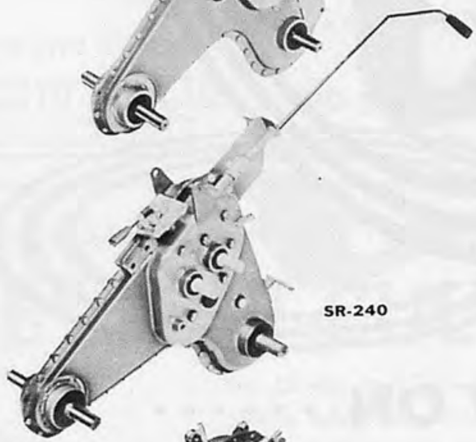
MRV3



CMC-180

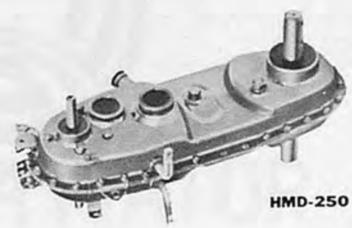


SKD-II

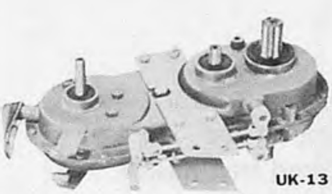


SR-240

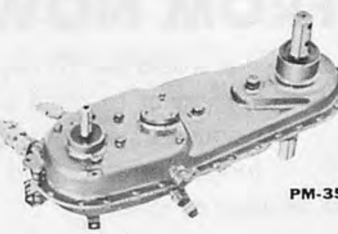
DMC-180



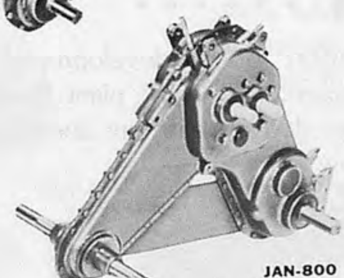
HMD-250



UK-13



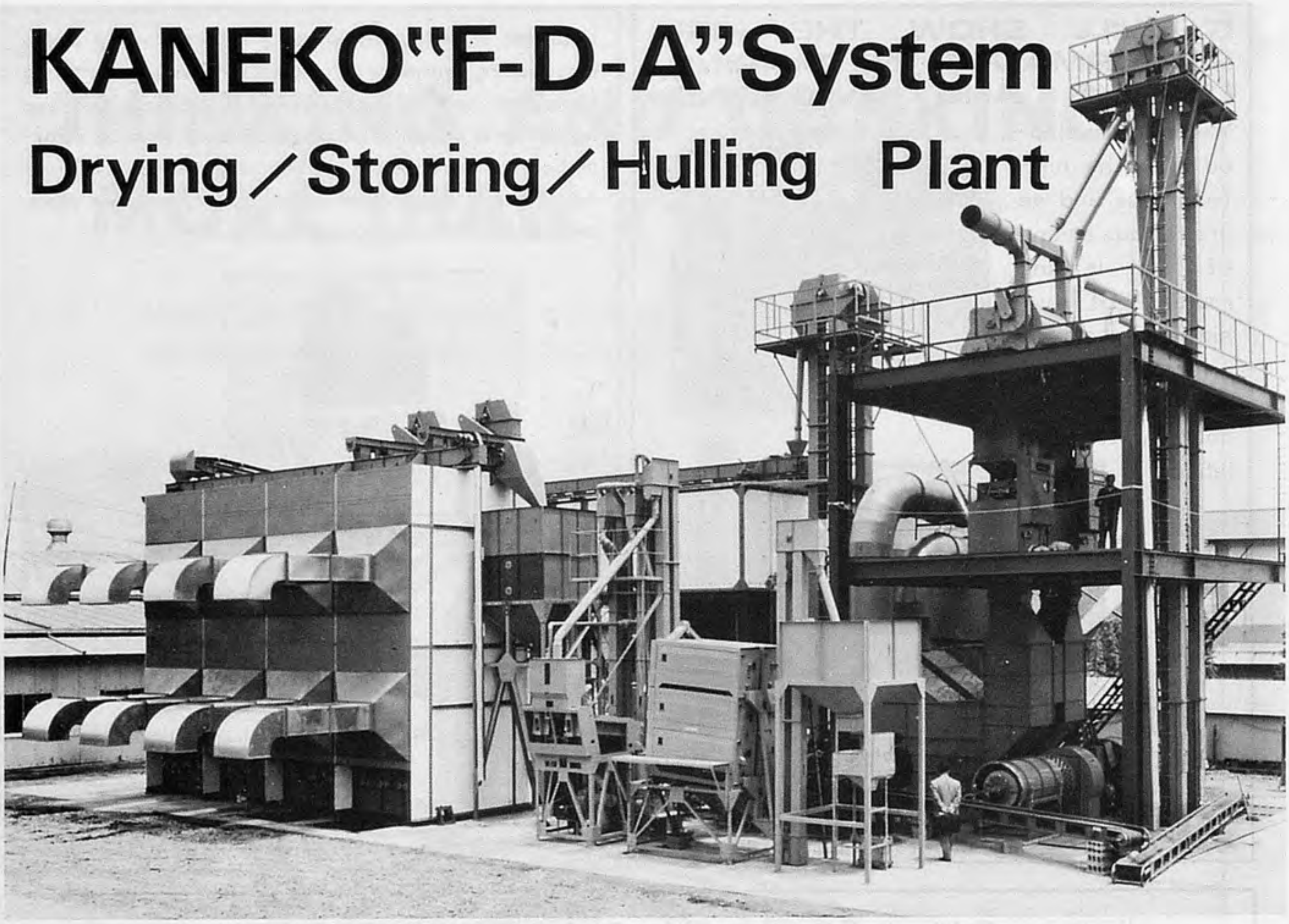
PM-350



JAN-800

Model		MC-80	MCF-130K	CMC-180	DMC-180	DMC-II	SKD-18	SKD-II	SKD-III	HMD-250	PM-350	UK-13	MH-750	MT-40
Applications(PS)		1·8~2·5	2·0~3·5	3·0~4·5	3·0~4·5	3·0~4·5	3·0~4·5	4·5~6·0	4·5~6·0	5·0~7·0	6·0~8·0	3·0~4·5	3·0~4·5	3·0~4·5
Shifiting Stages		F1	F1, R1	F2, R1	F2, R1	F3, R1	F2, R1	F2, R1	F3, R1	F4, R2	F6, R2	F2, R1	F1, R2	F1, R2
Sidecluch		—	—	—	—	○	○	○	○	○	○	○	○	○ with Lock
Gear Ratios		F_1=1:21·71	F_1=1:18·16	F_1=1:25·41	F_1=1:25·41	F_1=1:41·31	F_1=1:21·21	F_1=1:31·06	F_1=1:66·07	F_1=1:70·03	F_1=1:53·97	F_1=1:32·13	F_1=1:25·54	F_1=1:37·62
			R_1=1:27·24	F_2=1:15·38	F_2=1:15·38	F_2=1:19·40	F_2=1:10·28	F_2=1:11·34	F_2=1:18·96	F_2=1:38·73	F_2=1:37·41	F_2=1:16·92	R_2=1:29·37	R_1=1:32·83
				R_1=1:35·58	R_1=1:35·58	F_3=1: 9·35	R_1=1:21·33	F_1=1:44·52	F_3=1:11·43	F_3=1:15·81	F_3=1:18·50	R_1=1:32·77	R_1=1:20·22	R_2=1:10·69
						R_1=1:49·91			R_1=1:81·09	F_4=1: 8·74	F_4=1:19·42			
										R_1 1:105·04	F_5=1:13·47			
										R_2 1:23·71	F_6=1: 6·66			
										:	R_1=1:66·67			
											R_2=1:24·0			
Dimensions	A	170	170	170	170	202	192	192	224	234	243·5	192	192	192
	B	434	434	434	435·5	532	492	492	545	578·5	603 3	467	467	467
	C	289·5	289·5	289·5	289·5	344·7	336·75	336·75	336·75	319·7	402·5	409·9	287	287
	D	15	15	15	15	16	16	17	19	19	19	16	16	16
	E	31	31	31	31	31	31	31	31	34·5	34·5	31	31	31

KANEKO "F-D-A" System
Drying / Storing / Hulling Plant

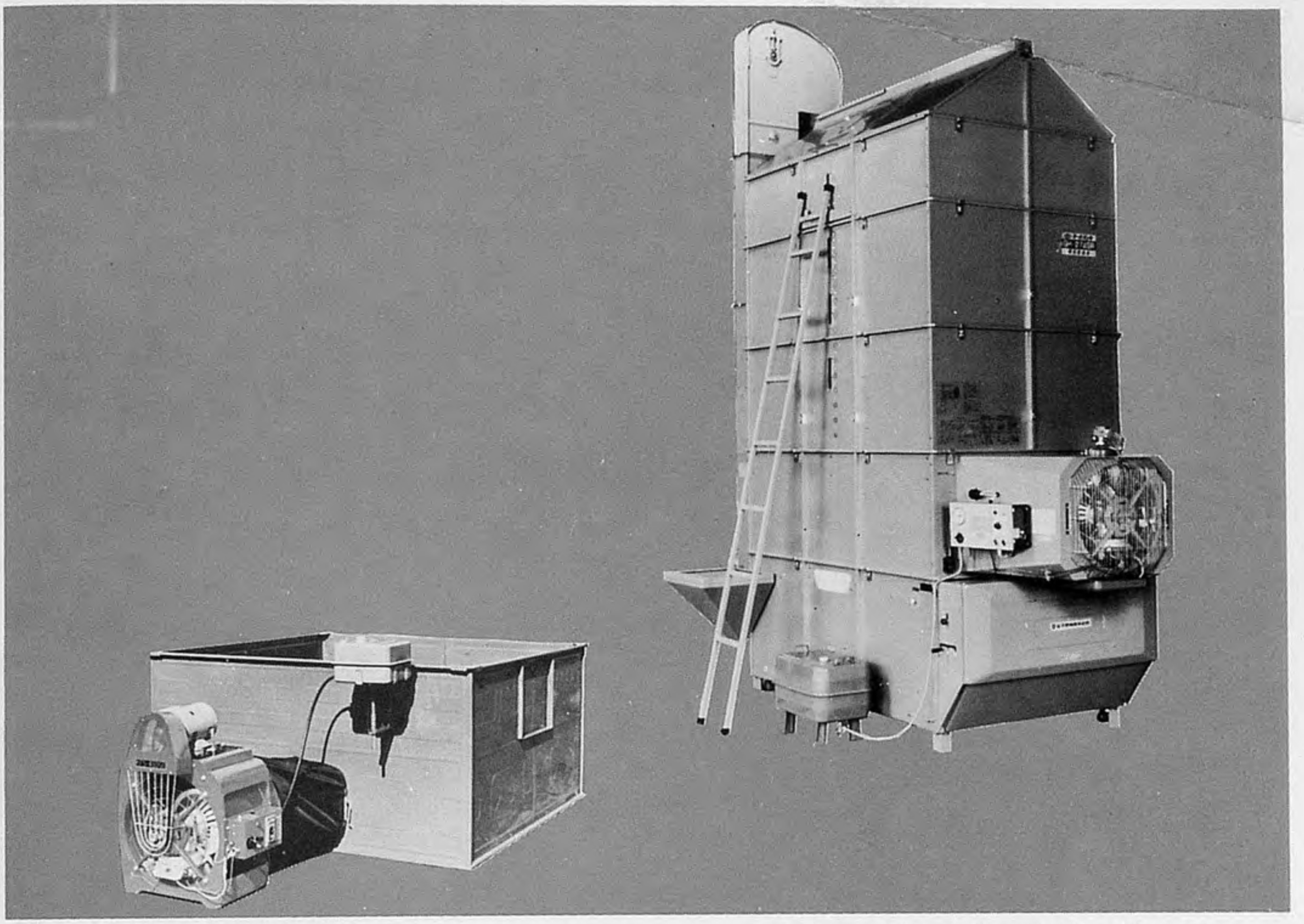


New "F-D-A" system, the most reliable in the world, dries paddy and corn of high moisture contents quickly, in large amount, with good quality, and, even more, at low cost.
Firstly, large amount of raw paddy and corn is rapidly pre-dryed in succession by means of the FLOATING Dryer.
In this stage, it exhibits the optimum function in continuous drying and simultaneous rough-separating.
Secondly, large amount of paddy and corn pre-dryed by the FLOATING Dryer is given the last finish drying in the large-scale finishing dryer.

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

* FLOATING Dryer --pre-dries quickly paddy and corn by floating and mixing them in hot air blown upward through the perforated plate.

* Large -scale Finishing Dryer-- completes slowly the last finish drying process by giving large volume of low-temperature air onto paddy and corn to get marvellous results.



Flat Type Ventilation Dryer
Model HD Series

Anyone can operate easily in complete safety. Compactly constructed. Perfectly even drying, free-from cracked grain. Top efficiency with minimum power consumption.

"Supering" Circulating Suction Type Dryer

This type is of a Circulating type which can dry raw paddy after harvested immediately by combine harvester. The powerful suction type blower completely absorbs and discharges all dirt and dust through discharge duct during the drying process, so workshop is kept always clean.

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

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

The Most Experienced and Artful Professional
in Manufacturing "Air" and "Heat"
in the World.

KANEKO AGRICULTURAL MACHINERY CO.,LTD.

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

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