International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL. VII, NO. 2, SPRING 1976

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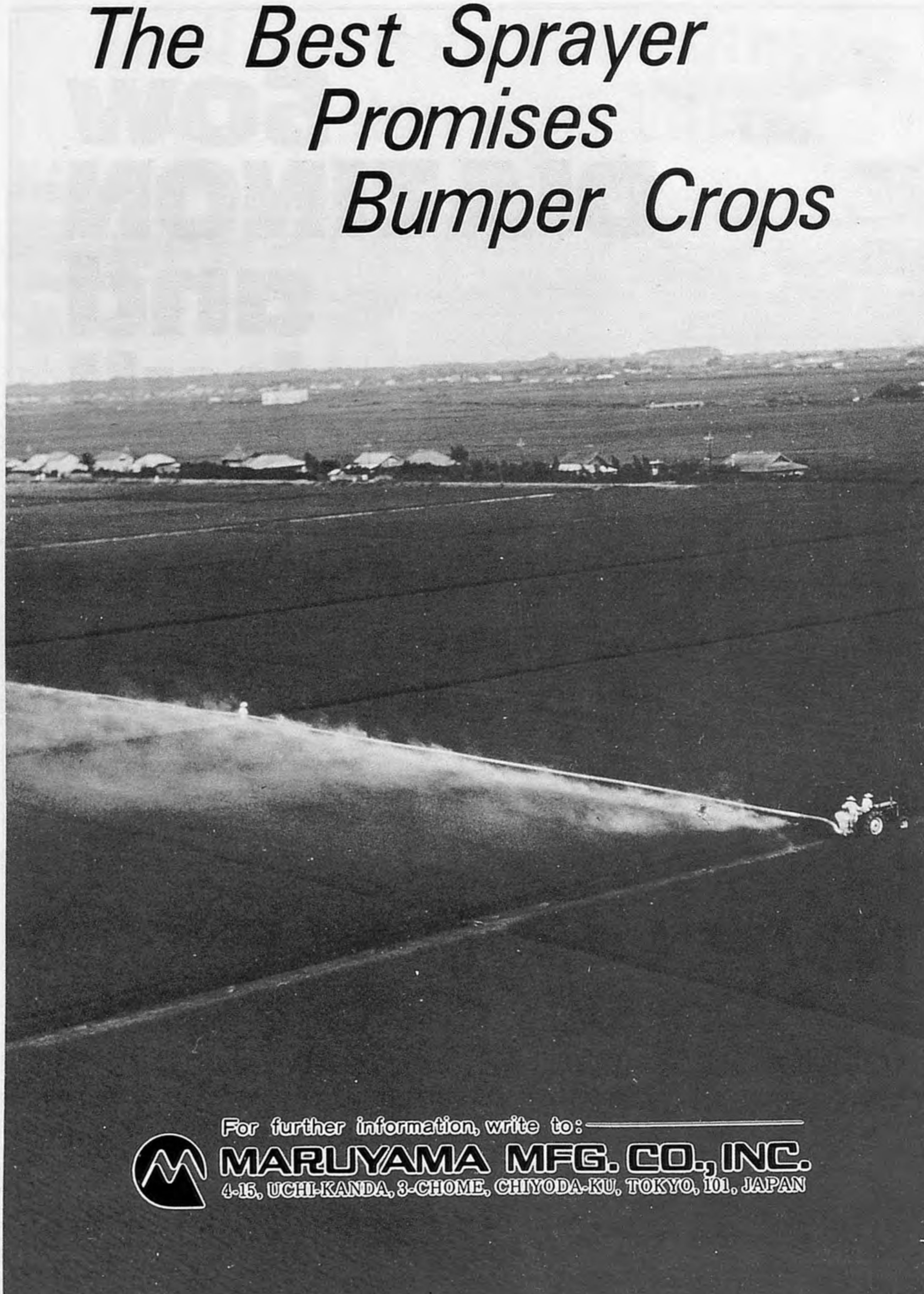
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YOSHISUKE KISHIDA

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Preface

Recenty I had an opportunity to visit Taiwan. I was able to drop in at several firms and institutes involved in the study of agricultural machinery there. I was also fortunate enough to be able to see the Taiwan Agricultural Industry Exhibition which was being held then. At the exhibition, I saw various kinds of parts for machines and also Deisel engines, combines, power tillers and many other things which were made in Taiwan, displayed.

My impression is that in Taiwan they already have the ability to manufacture most of the agricultural machines by themselves. I believe that not only in Taiwan but also in the Philippines and in other developing countries, the manufacture of machines is improving steadily. I think the industry in these countries will promote rapid progress in the agricultural mechanization of Asia.

It is essential for those countries to obtain technical aid so as to increase the productivity more, in their agricultural machinery industry.

I suppose, in that sense, these countries should not only import complete products or machine parts, but they should also accept capable researchers in agricultural machinery who are ready to settle down there permanently. At the same time advanced countries should prepare to send these experts rather than just send only those who write reports and stay there for a short time. I believe that the most important point is to bring up specialists, especially design engineers in plenty in order to accelerate the technology transfer to the developing countries.

I hope many of you will contribute to the special issue of AMA which we are planning to publish on this problem.

Chief Editor
Yoshisuke Kishida

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Row Cost Primary Cultivation-a Proposed system for developing countries

by T.B.Muckle, C.P. Crossley and J. Kilgour
National College of Agricultural Engineering
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The Snail Concept

The Snail tractive system has been developed to enable the traditional farmer in a developing country to achieve timeliness of cultivation at a price which he can justify as a result of the increased yield obtained.

The machine consists of two parts—a self-propelled winch powered by a small engine, and a modified ox tool frame implement which is attached by a cable to the winch unit. Two operators are required, one for each part, and operation is intermittent, allowing the operators to rest alternately. It is also self contained and can deal with any field size or shape.

The operating procedure is for the tractive winch unit to be driven forward a distance of 30m paying out the cable, while the implement remains stationary. A simple control on the tractive unit then allows drive to be disengaged from the wheels and engaged to the winch. As the cable tightens it causes an inclined plate or sprag on the rear of the tractive unit to penetrate into the ground so that it acts as a winch anchor, allowing the winch to draw the implement towards the tractive unit. The cycle is then repeated.

The advantages of this arrangement are that a high proportion of the engine power is transmitted direct to the implement without being lost in wheel slip, and that the pull exerted is three times the weight of the tractive unit. (A single axle tractor of equivalent size and weight would lose up to 40-50% of its power in wheel slip and its pull would be limited to approximately half its weight.)

The machine is designed to allow manufacture in developing countries using some bought in components. The production cost will depend on the manufacturing and marketing system applied, but material and component costs for the machine could be in the region of £100 (1973 figures).

Background to the project

When comparing farming systems in developed and developing countries, one striking difference is in the yield achieved per unit area. Many factors influence yield, and very considerable improvements follow the introduction of new crop varieties, fertilizers and pesticides. Another factor of primary importance is that of timeliness of cultivation. In those areas of the world where there are distinct wet and dry seasons it is important to plant as soon as possible after the beginning of the rains, since late sowing and delay in weeding depress yields. To achieve this objective it is necessary to carry out primary cultivation during the dry season, when the force required to pull even one tine through hard soil is very high.

Readers will then realize that they should interpret these figures in a more realistic way, if relating them to current price levels.

Fig.1. The plough remains stationary while the power unit drives off to the limit of the cable's length.

Fig.2. The power unit is now stationary and draws the plough towards itself by means of the cable and winch.

Power requirements for agricultural operations

Land preparation can commence as soon as the soil is in a suitable condition for the available equipment to operate. Where distinct wet and dry seasons occur, ploughing will normally await the onset of the rains when the shear strength of the soil reduces to a level suitable for the available power source, which, in many developing countries may be an animal.

In non-manual cultivation systems power is used to provide a tractive effort for ploughing, cultivating or ridging. FAO Development Paper No. 67 (**Appendix 1**) specifies the tractive effort required for various operations in medium loam soils, and also the potential pull from different animals. The figures show that one or two animals should be able to provide sufficient pull for the operations listed, but two factors affect the situation. The first is that the pull required is greatly increased in dry soil and rise to 4 to 5 kN for a single tine operating at a depth of 100 mm. The second is that the performance of individual animals varies greatly due not only to their weight, but also to their physical conditions, which is often poor during and shortly after the dry season. The farmer is therefore obliged to delay initiation of land preparation until the draught requirement has fallen to a level at which his animals can operate. The enforced delay frequently means late planting and consequent loss in yield.

Where the source of power is entirely manual, land preparation is the most energy consuming operation and this factor tends to limit the area under cultivation even where more land is available. The power output of man is about 0.075kW, but the same variations in performance must exist as with draught animals.

Other agricultural operations rarely require as great an energy input as land preparation, but some, such as grain harvesting, may require high inputs over a short period of time.

Availability of power

The power available per unit area cultivated varies greatly between developing and more developed countries and may be correlated with yields achieved. (Fig. 3).

To increase available power by introducing more men or animals is usually not feasible while, if mechanical power is to be used, it must be appropriate in quantity, form and price. In this context it must be noted that the size of the average family holding in developing countries tends to be small, of the order of 2 to 5 hectares, with 3 hectares as an approximate average figure. This paper will consider the power requirements of a holding of about this size.

Existing sources of mechanical power

The single axle tractor

These machines have been successful in some farming systems for certain operations, such as seed bed preparation and weeding in moist and wet soils. For primary cultivation requiring tractive effort they are not able to develop sufficient pull in hard dry soils.

The small tractor

It has been frequently assumed that small farms need small tractors, and many attempts have been made to produce suitable machines. The highly successful Ferguson Model 20 had a 17 kW engine and a mass of 1200 kg. It cannot be classified as a small tractor.

It is suggested that the small tractor is not a viable concept. This judgment is based primarily on two counts—cost and performance. The cost of even a fairly simple small tractor is at least half that of a larger conventional general purpose machine. This is far more than a small farmer in a developing country can normally afford for his own use. Since tractive effort through rubber tyres is generated by contact area and weight, the performance of the small tractor cannot approach that of the conventional machine. In many soil conditions the tractive effort available can be taken as half the weight of the tractor. Thus to achieve a pull of 4 to 5 kN would require a tractor of 1000 kg mass, which is greater than that of most small tractors. **(Ref. 11).**

The conventional tractor

The required power level could be provided by the use of a 33 kW four wheeled general purpose tractor. From a knowledge of the energy requirements for a cereal crop (Johnson 1963, ref 3) the number of hours required per hectare can be derived **(Appendix I table 3)**. It must be emphasised that the values quoted for tractor hours per hectare are lower than would be obtained in practice since for low draught operations the tractor would not be working at full power, while for primary tillage its power output would be limited, by its traction capability, to below its full potential.

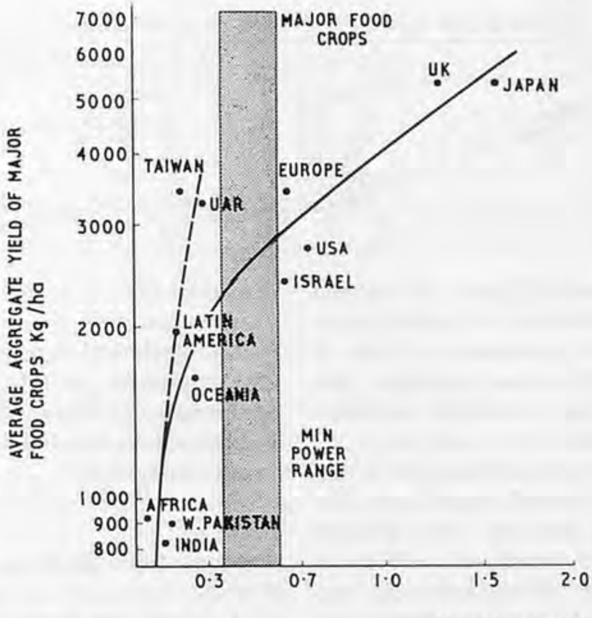

Fig.3. Relationship between yield and power input (From Verma S.R., Agricultural Mechanization in Asia 1972)

As a result the total tractor hours per hectare could well be twice the nominal figures shown in table 3, say 18 to 25 hours with a 33 kW tractor. Taking a 3 ha farm the requirement becomes 54 to 75 tractor hours per year. It is obvious that such a requirement cannot justify the use of a conventional tractor, except on the basis of a co-operative sharing scheme or tractor hire service. Such schemes are potentially viable economically and represent a feasible form of mechanisation, but past experience shows that there are many social and organisational problems in their successful implementation. **(Ref. 12, 13, 14)**

The characteristics of an alternative power source

Level of tractive effort required

A minimum pull of 4 to 5 kN is needed in order to overcome the potential draught of a single tine in hard soil. The form of the unit should be such that the performance characteristics are similar to those of the draught animal in that they do not decline with increasing levels of soil moisture, unlike the characteristics of conventional tractors.

Power required

For a given draught force, the power required at the implement depends on the speed of work. With the draught established above at 5 kN the speed of work could be selected to accord with the time available to carry out the necessary operations. In addition, however, the speed should be such that it is convenient for the operator. In the case of an operator on foot the working speed could reasonably correspond to a slow walking pace, similar to the ploughing speed of oxen, i. e. about 0.4m/s. Taking this figure together with the required pull of 5 kN, the power at the implement is 2 kW.

To assess whether this level of power gives a reasonable annual utilisation, a similar exercise to that for the large tractor **(Appendix I table 3)** can be carried out as follows:-

This leads to an annual utilisation of up to 564 hours, assuming that the machine can be used for

Table 1. Operating time with a 2 kW engine on a 3 ha holding

Operation	Energy input	Operating time with 2kW engine	
	(kW hours)	(hours)	(days)
Primary tillage	165 - 276	75 - 125	9 - 16
Secondary tillage	155 - 276	75 - 125	9 - 16
Planting	39 - 105	18 - 48	2 - 6
Weeding	99 - 198	45 - 90	6 - 11
Harvesting	384	175	22
		388 - 564	48 - 71

all operations listed. If the machine could also be used extensively for transport or as a stationary power source, the annual usage would be considerably higher.

It may be noted that for a 3ha holding a 2 kW power unit provides 0.7 kW/ha. The present level over much of Africa is about 0.04 kW/ha and it is suggested (**Ref.** 4) that a tenfold increase in the existing level, to 0.4 kW/ha, is necessary in order to achieve reasonable productivity. On this basis the 2 kW unit will provide a level comfortably in excess of the proposed threshold.

Economic assessment

The objective is to provide a powered device at a cost which can be justified on the basis of extra income accruing to the farmer from its use. Increased income may arise from an increase in the area which the farmer may cultivate effectively or from increased yields obtained by improved efficiency and timeliness of farming operations, together with the ability to realise in cash the value of the extra produce.

Appendix II shows a preliminary assessment of the operating cost (excluding wages) of a £ 150, 2 kW diesel unit operating for four years at a usage of 500 h/year. The operating cost would be in the region of £100/year. Whether this represents an acceptable cost depends on the circumstances of the individual case.

Summary of target costs and performance

Power requirement ······2 kW
Tractive effort ············4 to 5 kN
Annual use ··················500 h
Required life ···············2,000 h
Target cost ···················£ 150

The technical feasibility is to be examined at this stage. Economic feasibility will be investigated in the light of performance achieved.

Design of the Snail

Although two basic parameters were those of low cost and high pull, an additional requirement was taken into account. It is desirable to manufacture as much as possible in the country concerned in order to conserve foreign currency by minimising the import of finished components, to generate useful industry and employment, and to allow design changes to cater for local conditions. Thus the machine should be capable of being assembled and eventually manufactured in the developing country concerned, using indigenous labour and locally available materials (i.e. with the exception of bought-in components like engines and bearings). As a result of this requirement the manufacturing processes needed to construct the device were limited to sawing, drilling and welding and some simple lathe work. No grinding, milling or heat treatment should be required.

Design of the tractive unit

Having decided to investigate a device using a winch-drawn implement the basic design was established from a simple assessment of forces—firstly the tension in the cable must be resisted by a sprag in the ground, and secondly the overturning moment generated by the cable tension at a certain height above the ground must be resisted by a greater moment consisting of the weight of the device acting about the sprag contact point.

The layout consists of a rail chassis with the sprag plate across the rear and the engine across the front. The winch, to be driven by the engine, could from a functional point of view be placed in any suitable position, but its location was determined by the fact that the winch and wheel axle were to be coaxial. This was done so that only two bearings would be required for carrying both the winch load and the wheel loads.

Drive is taken via vee belts from the engine to a transverse tube located in plummer block bearings. The winch, which is a loosely fitting tube outside the "drive tube", can thus be driven by dogging it to the drive tube, the cable force being transmitted to the chassis via the bearings and thence to the sprag. Only when unreeling under light load does the winch rotate on the drive tube, which then acts as a simple large area bearing.

In a similar manner the wheel axle—a shaft passing through the drive tube—can be engaged, the load being carried on the same plummer block bearings, and the drive tube only rotates over the shaft during winching, when there is virtually no load on the wheels.

Given an engine power of 2.2 kW allowing if necessary, for the derating effect of temperature and altitude, and the specified minimum cable pull of 5 kN, the cable speed of up to 0.5m/s automatically follows. The only remaining consideration is the speed of the winch (and thus of the drive tube and axle) and the corresponding winch diameter. The possibilities vary from a small high speed winch to, at the other end of the scale, a large diameter winch rotating at a lower speed.

Freedom of choice was limited by two factors, the major one being that in order to keep the ground speed to a reasonable value the drive tube and axle must rotate quite slowly. In addition, there is a minimum winch diameter required in order to give reasonale cable life, and to avoid too much drop in pull as the effective drum diameter increases due to cable wind-on. As a result of these requirements, the vee belt step down was made as large as was feasible in one step (about 5 : 1) so that with a 6 : 1 reduction box on the engine the drive shaft would rotate at just over 100 rev/min.

Sprag design

Design of the sprag was carried out at the College by Spoor using theories developed by Payne (**Ref. 5**) and Reece (**Ref. 15**). The theory shows that in cohesive soils an inclined plate is effective as a sprag as long as it is allowed to penetrate deeply enough, although penetration to any significant depth is difficult in very hard soils. In friction soils however the effectiveness of the sprag is increased by incorporating a horizontal plate which uses the weight of the tractor and possibly the operator to apply a surcharge to the soil. It is stressed that cable height is important, too low a line of pull causing sprag breakout and too high a cable resulting in tractor rear. Maximum pulls are obtained with the tractor wheels about to leave the ground, when all of the weight of the machine is carried on the surcharge plate leading to maximum resistance to shearing of the soil under the sprag.

Investigation was made of some of the factors limiting Snail operation.

(1)Winch pull. With a cable length of 30 metres the build up of cable on the drum causes the pull to drop from 5 to 4.2 kN. The available winch pull is thus always between these limits.

(2)Implement draught. Depending on the soil being cultivated the draught for a single tine could be anything up to 4.4 kN. In lower strength soils the fitting of three or five tines would be possible.

(3)Rearing. Provided the cable overturning moment is less than the restoring couple produced by the tractor weight acting at a distance from the sprag, rearing will not occur. The cable height should be adjustable for different conditions and the application of weight to the front of the tractor should be considered.

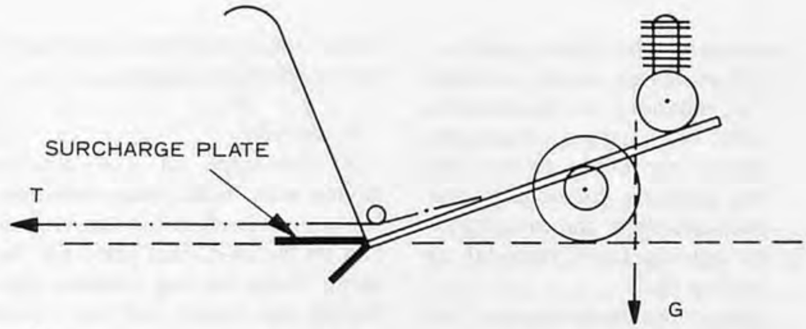

Fig.4.

(4)Sprag drag. The ratio between the cable pull and the tractor weight has considerable significance, since this affects not only the magnitude but also the direction of the resultant force. The sprag may fail in drag by moving significantly when engaged in soil which is too weak to sustain the pull being applied, or it may skid over hard ground due to inadequate penetration.

Predicted performance

The graph (**Fig. 5**) shows the predicted performance of the winch and sprag, together with the predicted draught requirement of 1,3 and 5 tines in soils of increasing cohesion. A number of

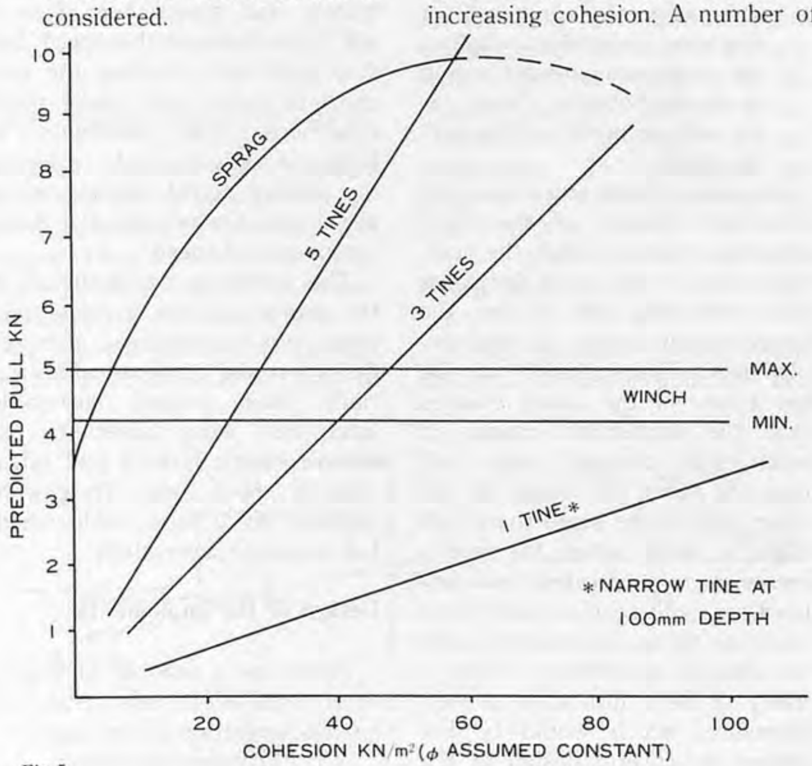

Fig.5.

simplifications have been made:-

(1)The sprag curve assumes the machine to be on the point of rearing at the lower end of the curve (where the top plate is important) and does not show the discontinuity arising from removal of the top plate.

(2)As cohesion increases, friction tends to drop for wet clays but to rise slightly for dry soils. The tine pulls were calculated for hard dry soils (the worst case), while the sprag resistance was calculated for wet clays (again the worst case).

(3)Sprag resistance is shown for full penetration. In practice in hard conditions the penetration would decrease, reducing the available resistance as shown by the dotted line, and in the limit penetration would be impossible.

(4)Soil cohesion values are shown up to 100 kN/m^2 above which the pull required by a single tine is likely to exceed that available from the power unit. At these high soil strengths however it becomes debatable whether the cohesion is greater within clods or between them, i.e. the soil is likely to "shatter" into slabs.

The graph illustrates clearly an important feature of the Snail principle—that although the holding power of the sprag decreases with weakening soil, so does the draught requirement of the implements. The inclusion of the top plate on the sprag ensures that the implement cannot in weak soils demand more pull than the sprag can exert. At the other end of the scale there will come a point when the implements, once penetrated into very hard soil, will require more force than the sprag can produce with its limited penetration. This is likely to be a limitation to performance, which would be improved by careful design of the sprag for maximum penetration in very hard conditions.

Prototype

A prototype of the tractor device was built using rectangular hollow section for the chassis and an inclined steel plate for the sprag. Separate dog clutches controlled the winch and the wheel axle, while the main drive clutch incorporated a principle already proved to work satisfactorily on a different machine (**Ref. 7**)—that a vee belt tensioner would operate as a clutch if a close fitting hood was provided around the small pulley.

The wheels used for the first prototype were from an existing single axle tractor but when the Snail was used to propel itself forwards a disadvantage of the simple transmission could be observed; this was that the forward speed was still inconveniently high for an operator walking behind. This drawback was reduced by constructing and fitting small diameter steel wheels, and by setting the engine so that it would run governed at approximately half speed. Less than 1 kW is available at this speed, but it is sufficient to allow the machine to move itself under most conditions. The possibility is being investigated of replacing the present petrol engine with a diesel, which would produce more torque at low speed.

The winching performance of the prototype was in most respects very satisfactory, although the nylon and terylene cables initially used proved unsuitable since they were subject to excessive elastic stretch and failed after a short time. They were replaced by a steel cable which has operated successfully.

Design of the implements

There are a number of operations required by the farmer in his mechanisation programme:—

(1) Primary cultivation
—chisel ploughing mould board ploughing
ridging tie ridging

(2) Secondary cultivations
—interow cultivation
weeding

(3) Planting
—seeders

(4) Spraying
—weed and pest control

(5) Harvesting
—in soil e.g. groundnuts
above soil e.g. cereals

(6) Stationary power unit
—water pumping
crop spraying, milling and processing

(7) Transport
—in field
on road

The present equipment has been designed primarily to deal with operation (1) and secondly operation (2). The first operation must usually be carried out in very hard, dry conditions just before the rains, at a time when draught animals are often in poor condition, a situation where mechanisation has a significant role to play.

There are a number of improved designs of ox equipment available which have proved satisfactory for (1) and (2). The Snail implements are based on a range of equipment designed by Stokes (Project Equipment Ltd., Newton Tony, Wiltshire) and modified slightly to make them suitable for cable traction.

Ox drawn implements

To understand what modifications are necessary a conventional ox plough and its operation is considered.

The forces are balanced by adjusting the height of A and the length of the draw chain AB so that the implement will run at the required depth with little effort required by the operator walking behind. To make the implement run deeper A is lowered and the chain lengthened. If the implement is set correctly it will run at a constant depth, but if it

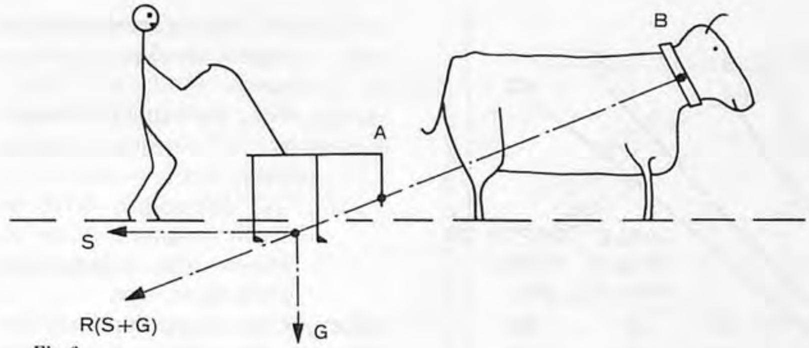

Fig.6.

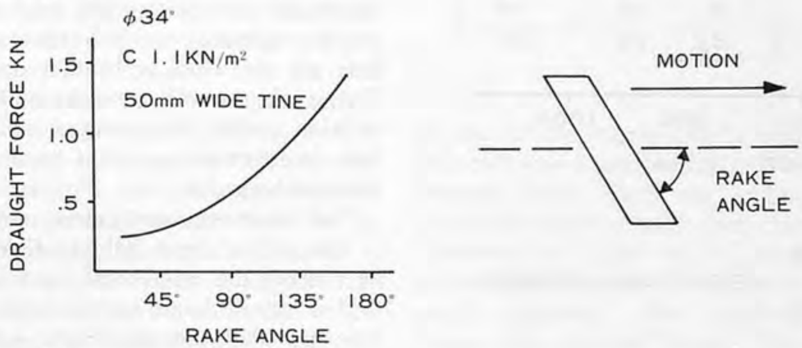

Fig.7.

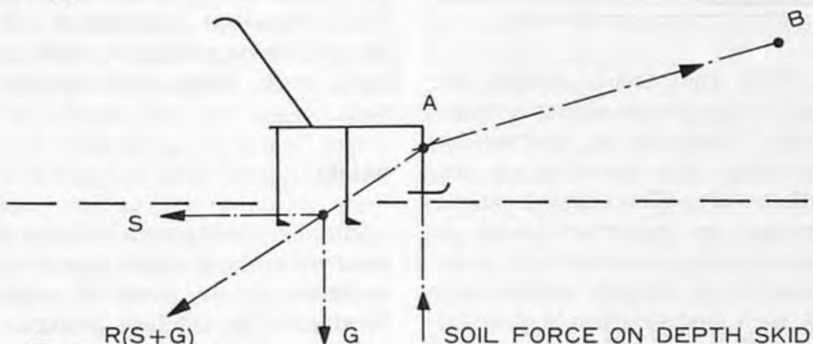

Fig.8.

encounters a hard patch it will tend to rise out of the ground. In hard conditions penetration may be a problem and here particular attention must be paid to the design of the tine to give adequate penetration, lowest draught and good soil shattering. The rake angle of the tine is the most significant factor and an angle of about 45° is the best compromise. (A : hitch point B : Yoke)

The best shattering effect also occurs up to about 45° and the soil forces are slightly downwards or horizontal, i.e. no upward forces to impair penetration. For light draught operations, i.e. type 2. the implement is too heavy and the animal cannot be coupled closely enough; here small skids or wheels are necessary to take part of the implement weight. They will also give better depth control which is often necessary for such operations.

In dry conditions the draught resistance of the skid is likely to be small, rising in wetter conditions but at most probably not more than 10% of the total draught requirement.

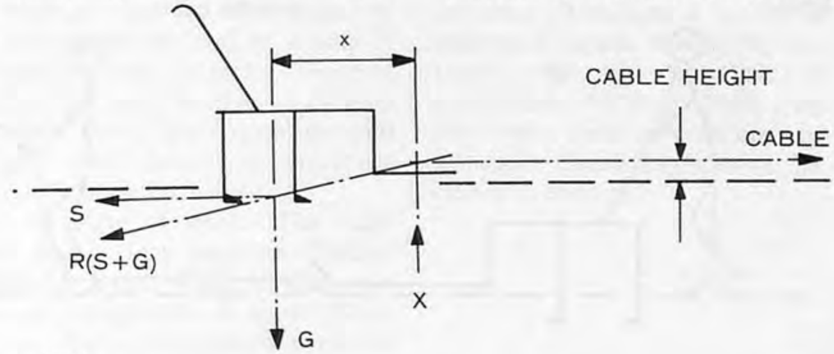

Fig.9.

Cable drawn implements

Cable drawn implements must be hitched differently (**Fig. 9**) because the line of pull is horizontal and just above the surface of the ground.

The soil force X supports the wheel or skid; the loads are higher than on the skids of the ox arrangement, but under the worst conditions the draught resistance will probably be no more than 20% of the total draught force. This is not too serious since with this type of operation the maximum draught which can be exerted is high and does not depend on direct traction from wheels.

The graph (**Fig. 10**) shows the skid position required for various pulls. The cable should be as close as possible to the ground to keep the overall length of the implement as small as possible.

To avoid the necessity for moving the skid backwards and forwards on the implement prototype design the skid was made long so that it would cover the whole range, and the depth was controlled by a simple vertical adjustment. To increase the depth of work the skid is raised. (**Fig. 11**).

Operation

Winch operation is not a new concept. It was used in the last

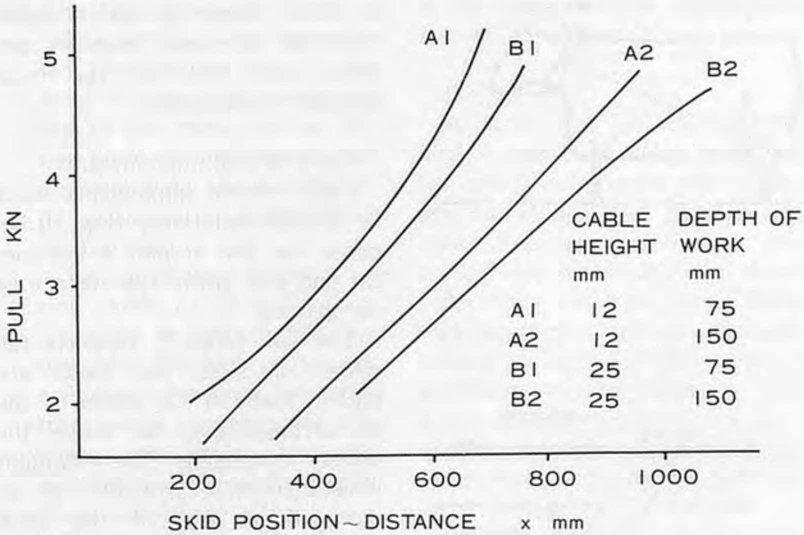

Fig.10.

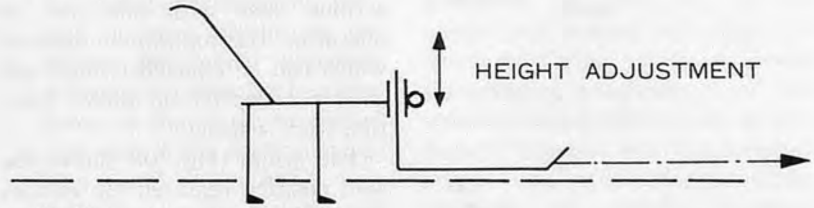

Fig.11.

century with steam ploughing, and is still used today in European vineyards for cultivating steep slopes. In both there cases however the anchored power unit stands on the headland and when the implement has been drawn up to the headland it is necessary either for the plough to reverse its direction or for it to be dragged back to its starting point manually. Another alternative, investigated by N.I.A.E. (Ref. 8) used a winch and plough mounted on a single axle tractor which drew itself up to an anchor on the headland and then reversed across the field to its starting point.

With the Snail, neither the anchor nor the reversing is necessary. Operation is intermittent, allowing the operators to rest alternately. This aspect is regarded as important since in many tropical conditions it is not possible to operate continuously at even moderate levels of activity without exceeding the body's anaerobic limit.

Two operators are required, (Fig. 12), one on the power unit and one on the implement. The sequence of operations is as follows:—

(1) "A" drives forward a maximum of 30m laying out the cable
(2) "A" disengages drive to wheels, engages drive to winch
(3) The implement, steered by "B", is drawn up to "A"
(4) "A" disengages drive to winch, engages drive to wheels and moves forward up to 30m.

For primary cultivation the area can be cultivated again if necessary at roughly right angles to the original direction to ensure that all the land is broken up. The work rate for primary cultivation under the worst conditions is estimated to be 0.4 ha for an eight hour day.

The implement and power unit is transported from field to field by placing the implement on top of the power units in the brackets provided and the whole outfit driven off by one operator. Field transport (operation 7) could be arranged by winching a pallet with 500kg payload on-skids.

Safety

Initially, doubts were expressed concerning the possible danger to operators in the event of cable breakage. The machine possesses an inherent safety factor in that the maximum pull which it can exert is only one-third of the rated breaking load of the cable, minimising the risk of cable breakage. To investigate the effect at breakage a quick release mechanism was constructed and attached at the implement end. When the maximum load

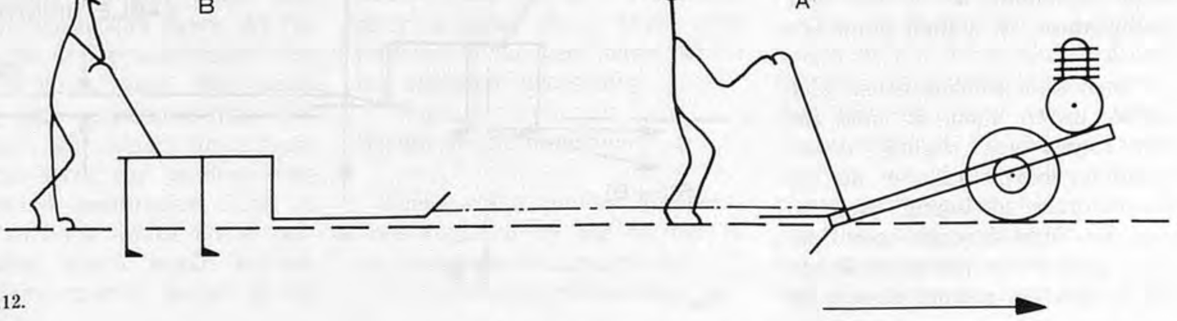

Fig.12.

was reached, it was released to simulate cable breakage. It was found that the free end of the cable only travelled a few metres along the ground and presented no hazard to either operator.

Utilization

The utilisation of different types of "power unit", including animal power, depends largely on whether the pull that the unit can provide is greater than the pull demanded by the simplest effective implement. Detaled performance will vary with a number of factors, but it is suggested that the general trend might be as shown on the diagram (Fig. 13).

The pull required to cultivate with one tine increases as the soil becomes harder until partway through the dry season the ox pair is unable to operate. Provided that a small tractor is made sufficiently heavy it can operate throughout the dry season, but with increasing moisture levels following the first rains it rapidly loses the ability to obtain traction; so that the required implement pull might drop to the level where the oxen are again able to cultivate, but the small tractor cannot.

The pull obtainable from the Snail will vary slightly with soil conditions, but should always be in excess of the required pull. Utilisation is thus possible throughout the year.

Cost

Material and component costs for the first prototypes as constructed were about £100, but it is stressed that the actual cost per unit of a production run would depend on such factors as the labour and material costs and the marketing system within the country in which the machine was being produced. A significant part of the component cost will be that of the engine and to keep this cost low a petrol engine is at present used. Such an engine could be either a very low cost "throw-away" type or a more robust version, the life of which could approach the machine design life of 2,000 hours. This would increase the initial cost, but reduce the running costs for repair and replacement.

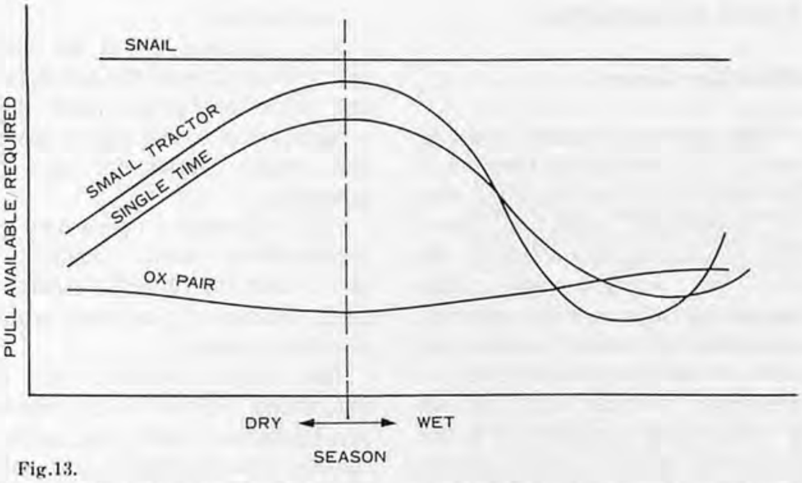

Fig.13.

Alternatively a diesel engine could be considered. Apart from the extra longevity which would be essential if the Snail were to be used for tasks such as pumping, the diesel would give more economical fuel consumption and more suitable torque characteristics. There would however, be a considerable increase in first cost. The answer might be to offer a choice of engines for different uses.

Disadvantages

(a) Cost: Even the bare material cost of £100 may be three times the cost of a pair of oxen in some countries. The fact that the Snail is able to develop three times their average pull may not always be sufficient justification for its use.

(b) Rate of work: The Snail is not a fast machine. Taking into account the transport and turn around time it seems likely that the overall speed over the ground will be of the order of 0.3m/s. The work done depends on the width of soil disturbed. With tined cultivation in normal soils the operator will have the option of a wide, shallow area of disturbance using several tines, or a deeper and narrow cut using fewer tines. In very hard soils a single tine will normally be used, its depth of engagement being set so as to load the engine to its maximum.

(c) Two man operation: This requirement cannot be avoided and can be regarded as a disadvantage in areas where labour is at a premium. Such conditions, however, are not the norm in most developing countries, where it is considered essential not to cause redundancies by introducing machines which displace labour. The Snail requires one man to guide the power unit and one to control the implement; a very similar situation to that of the traditional ox cultivation.

(d) Inflexibility: The present machine is designed basically to cultivate. Although it could be used as a power source for stationary work, it is not suitable at the moment for light direct traction work such as weeding and transport. These aspects are discussed in Section 7.

Future developments

Other operations

Secondary cultivation could be carried out by direct traction if the power unit was equipped with an additional reduction gear. This would add about 25% to the cost, but would enable these operations to be carried out more conveniently. Further operations such as spraying could then be attempted. With an additional set of wheels and a centre pivot the unit could be made into a powered trailer (using the implement skid as the trailer chassis) to carry out transport operations, with a speed of 9 km/h on a hard level road and 500 kg payload.

For harvesting operations a collector could be mounted on the unit for harvesting single rows of crops, the threshing and cleaning being done at the edge of the field or at the farmer's store using another attachment with the unit as the power source.

There is considerable scope for improving the versatility of the machine, but each change would probably result in an increase in cost, rapidly reducing the original cheapness and simplicity. At this stage in the development it is felt that the important constraint to food production—that of high pull requirement in primary cultivation—should be tackled first. If this can be done cheaply and effectively, other developments will follow.

Ride-on version

Proposed specification: Engine 5 kW diesel

- 2 forward speeds using chain and vee belts
- Winch 1.7 km/h max. pull 9 kN
- Secondary cultivation 6.4 km/h
- Transport 16 km/h
- Ride-on 3 or 4 wheel rubber tyres
- 1 metre track, 1.2 metre wheelbase

This machine could do field operations at twice the work rate and other operations more conveniently due to the higher power and longer chassis for ease of mounting.

For transport operations a conventional small trailer of about 1000 kg capacity could be used. Transport platforms would also be provided.

The larger version to be designated Spider, is a ride-on small tractor with the performance characteristics of the Snail. The two machines are intended to complement each other, using a common implement for winching. The cost of the larger machine is likely to be approximately three times that of the Snail, with a "minimum" pull of 9 kN even in poor soil conditions. This is approximately twice the pull that a normal small tractor could develop in such conditions and since the cost is likely to be less than that of a small tractor, the cost-effectiveness of the Spider should be several times as high. Whether this machine is viable in the agricultural context of developing countries remains to be seen as the programme develops.

Appendix I

Table 1. Draught requirements of some farm implements for operation on medium loam soils

Operation	Draught requirements
	kN
Ploughing fallow land with single mouldboard	
114 mm wide, 127 mm deep	0.87
140 mm wide, 127 mm deep	0.92
165 mm wide, 152 mm deep	1.19
250 mm wide, 180 mm deep	1.67
Ploughing fallow land with double mouldboard	
300 mm wide, 150 mm deep	1.14
Harrowing ploughed soil	
18-tine peg tooth harrow, 63 mm deep	0.45
5 spring tines, 114 mm deep	1.16
heavy harrowing 1650 mm-3200 mm wide	0.78 - 0.98
light harrowing 3200 mm wide	0.88
Levelling ploughed soil with a 1800 mm long-board ridden by a person of 53 kg	0.88
Rolling	0.94
Cultivating, 3-tine cultivator, 90 mm deep	0.52
Seed drilling 1750 mm-2000 mm wide, 11-13 openers	0.88
Wheeled transport of loads up to 1 tonne on average farm roads	0.88 - 1.18

Source: FAO development paper No. 67 (Ref. 1)

Table 2. Potential pull of various animals

Animal	Average weight	Approximate pull	Average speed of work	Power developed
	kg	kN	M/s	kW
Light horses	400 - 700	0.6 - 0.8	1.0	0.6 - 0.8
Bullocks	500 - 900	0.6 - 0.8	0.6 - 0.85	0.36 - 0.68
Buffaloes	400 - 900	0.5 - 0.8	0.8 - 0.9	0.4 - 0.72
Cows	400 - 600	0.5 - 0.6	0.7	0.35 - 0.42
Mules	350 - 500	0.5 - 0.6	0.9 - 1.0	0.45 - 0.6
Donkeys	200 - 300	0.3 - 0.4	0.7	0.21 - 0.28

Source: as above

Table 3. Energy requirements for a cereal crop. Man hrs. animal hrs. and rated kilowatt hours per hectare

Operation	kW hours/ha	Man hours/ha	Animal hours/ha	Tractor hours/ha
				(33kW)
Primary tillage	55 - 92	120 - 250	40 - 80	1.7 - 2.8
Secondary tillage	55 - 92	250 - 500	64 - 100	1.7 - 2.8
Planting	13 - 35	20		0.4 - 1.1
Weeding	33 - 66	80 - 330	10 - 24	1.0 - 2.0
Harvesting	128	80 - 160		3.9
	284 - 413	550 - 1260	114 - 204	8.8 - 12.6

Appendix II

Fixed cost at 500 h/year (2kW diesel engine)		
Initial cost £150		
Cost/yr depreciation (4 yrs. life)	£ 37.50	
Interest 6% on half original cost	£ 4.50	
Fixed cost per year		£ 42.00
Variable cost		
Fuel (0.38 l/kW/h at 3/2 rated output) ·250 l/year		
Cost of fuel at 7p/litre	£ 17.50	
Repairs 100% cost of unit/life	£ 37.50	
Variable cost per year		£ 55.00
Total cost per year		£ 97.00

Appendix III

Sprag Calculations

The sprag dimensions can be calculated using Reece's general soil equation (Ref. 15):—

$P = \rho g Z^2 N\gamma + C2Nc + C\alpha Z N\alpha + qZ Nq$

i.e. force per unit width = gravity effects + adhesion + surcharge effect.

Taking two types of soil liable to be limiting i.e. "friable" soil and "plastic" soil—the terms in the above equation can be given appropriate values.

The corresponding Reece soil factors are:—

$N\gamma$	1.8	1.1
Nc	0	1.7
$N\alpha$	0	0.13
Hq	3.6	1.7

		Friable soil	Plastic soil
ϕ	(angle of shearing resistance)	35°	10°
δ	(angle of soil/metal friction)	20°	20°
α	(sprag inclination angle)	45°	45°
ρ	(density)	1660kg/m³	2660kg/m³
$C\alpha$	(cohesion)	0	40kN/m²
C	(adhesion)	0	85kN/m²
q	(surcharge pressure)	10kN/m²	10kN/m²

The components of the available soil reactions for a sprag 150mm deep are found to be:

$P = (0.66 + 0 + 0 + 5.4)$ kN/m for friable soils and

$P = (0.65 + 10.2 + 1.66 + 1.65)$ kN/m for plastic soils, giving available soil reaction forces of 3.6 and 8.5 kN respectively for a sprag 150 mm deep and 600 mm wide.

It can be seen that for friable soils the surcharge effect, that arising from the application of weight to the sprag top plate, is the most significant, (it is assumed that in these circumstances the operator will stand on the top plate) but even then the total resistance is somewhat less than the pull which the Snail winch will be capable of producing. In these light soil conditions however the implement draught force would be correspondingly reduced.

The plastic soil gains most of its resistance from the cohesive component although a certain effect is felt from the surcharge. In practice the top plate would be removed in these conditions to prevent build up of soil beneath it, and the sprag would penetrate more deeply into the soil much as a conventional sprag drags the back of the tractor down.

Acknowledgments

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Agricultural Mechanization Program of China to be Realized in 1980

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The Fifth Five Years Plan and the Policy for Agricultural Modernization

China expressed the main subjects of the Fifth Five Years Plan which will be excuted from this year in the general report by Vice Prime Minister Hua Kuofeng on November 19 last year on the closing of the National Conference on Learning from Techai in Agriculture.

They are:

a) The general principle to develop national economy taking agriculture as the foundation and industry as the leading factor, which is Chairman Mao's directive, should be followed and accomplished,

b) The Farmland Capital Construction, which includes three agricutural civil works, i.e. leveling of land, perfection of irrigation facilities and soil improvement, should be pushed forward in large scale,

c) Implementation of agricultural machinery at the people's commune, which remains average 30% at present, has to be promoted to about 70% in five years by 1980 and overall agricultural mechanization should be realized basically. Such agricultural mechanization will be a key factor in agricultural modernization and will increase productivity of agriculture specially of food grains thus attaining firm self-suffciency level.

At present there are over 300 advanced counties of Tachai-level which have food productivity of 750 kg per ten are and about 700 moderately advanced counties whose productivity exceed the target set by the National Programme for Agricultural Development(※) among 2200 counties all over the country. The important task and the target of the Fifth Five Years Plan which is going to be excuted from this year, are to increase the number of the advanced counties of Tachai-level by average hundred annually during five years, making more than one-third of the counties or over 800 counties into Tachai-level, and at the same time, backward counties, which count more than half of all at present, will be promoted to moderately advanced ones as far as possible that exceed the target of the National Programme for Agricultural Development.

It is stipulated that, in this nation-wide mass movement "in agriculture, learn from Tachai", the county Party Committees, which are the leading organizations to communes and brigades directly, are to be leading cores. The resolution of the National Conference also clarifies that the provincial, municipal and autonomous regional Party Committees, the various departments under the Party Central Committee and the government, the Central Committee and the State Council have to be responsible to the movement according to their duties in its own level.

Then, how China can push forward the Farmland Capital Construction in large scale and promote implementation of agricultural machinery in communes from 30% to 70% and realize agricultural mechanization basically, within such a short span of time of five years?

Regarding the former, which consists of large scale civil construction work, it has been carried out mobilizing about 100 million people during farmer's slack season, bringing forth 1600

(※) The grain yield targets set by the National Programme for Agricultural Development for different areas of the country are: 300 kg pen 10 are for areas north of the Yellow River, the chinling Mountains and the Pailung River; 375 kg for areas south of the Yellow River and north of the Huai River; 600 kg for areas south of the Huai River, the Chinling Mountains and the Pailung River.

Generally, to surpass the 200 kg per mu (one-fifteenth of a hectare) target is described as "crossing the Yellow River" and to exceed the 400 kg target as "crossing the Yangtze River."

thousand hectare of land into irrigated area annually. It is supposed that from this year on, such a mass mobilization will be strengthened much further. On the other hand, research and development works of medium/large construction machinery and the production increase will be accelerated, in parallel with the importation of the machines to save the accute shortage.

As for the latter, promotion of agricultural mechanization, it is clarified that this will be performed making five small industries i.e. ironaond steel, coal, chemical fertilizer, cement and machinery, which have been constructed and developed taking advantage of individual situation and exploiting local resources in each prefecture and county, with the aim of attaining self-sufficiency system within province and county by the Fourth Five Years Plan, as nuclei for that. These five small industries are defined as agriculture-supporting industries and are expected to supply machines and other materials necessary for agricultural mechanization, chemical fertilizer, agricultural chemicals, etc. to communes and brigades thus assisting development of agriculture and agricultural machinery industry which are in agreement of each prefecture and county. It follows that establishment of some counter-measures for the production increase of these five small industries will be hastened as an urgent task in order to cope with quantitative demand to these industries which will increase year by year in proportion to the progress of the Fifth Five Years Plan.

China has clarified that they are going to start their magnificent strategic programme to push the national economy forward so that she will be advancing in the front rank of the world before the end of this century by the achievment of modernization of industries, agriculture, defence, science and technology, in the Industrial Activity Programme on the occasion of National People's Congress, January last year. The Fifth Five Years Plan which includes realization of agricultural modernization as the most important target is the starting point for this great strategic programme. If the modernization of agriculture could be realized, then it will induce modernization of industries, defence, science and technology and as result constructs strong material foundation to protect China from war and natural disastars. This is the basic principle of the Fifth Five Years Plan.

Fig.1. A view of Taichai

Present Status of Agricultural Mechanization in China

Summing up present status of agricultural mechanization in China, it can be said that it is on the way to extend and develop mechanization on and around tractors as the case of Japan in the past. Taking the example on rice cultivation, overall farm mechanization system, starting from nursery, and then plowing, puddling, transplanting, weeding, desease and pest control, reaping and harvesting, drying, husking, milling and storage, is not yet completed unlike that of Japan. It seems research and development work of upland farm mechanization system is much advanced compared to that of rice cultivation. However it also is not yet completed to form overall farm mechanization system which includes various types of working machines.

Adding to this, there are basic problems they have to solve prior to farm mechanization. In China, southern rice growing area and northern upland one are distinktly different in natural and climatic conditions. In the case of the former, there must be irrigation and drainage facilities such as pump station in order to extend agrarian land utilizing abundant supply of water. In the case of the latter, there must be irrigation facilities such as deep-well pump station in order to cope with draught. Such equipment has to be studied, developed and supplied in huge quantity. Above that, total area of agrarian land of China is so wide that the required quantity of various types of farm machinery inclusive of tractors is quite large.

They have to accelerate research and development of underdeveloped farm machinery and production increase of machines already completed but not yet sufficiently distributed.

How these problems will be solved will make a great influence on the success of the Fifth Five Years Plan.

Now let us have a look at the present state of progress of agricultural mechanization and its research and development work in southern rice growing area and in northern upland area which represent agriculture in China today.

Southern rice growing area

As this area is endowed with the most advantageous climatic conditions in China, they can practise double or tripple cropping in a year. It follows that working time of tractors can be as long as two to three hundred days or 1000 to 1200 hours in a year, either for plowing of paddy field and upland or trailing and stationary use as pumping, depending on the place to use. Their programme of agricultural mechanization in this area is to use small and medium size tractors, i.e. 20 to 40 hp wheel tractors, 10 to 12 hp hand tractors of driving type and 2 to 5 hp hand tractors of traction type for hilly land and minor tillage.

Rice transplanters and reapers are developed already and they are going to be distributed from now on.

Most of sprayers are of manual type. Smaller types of power sprayers, dusters, and mist blowers such as knapsack type are going to be used.

Regarding to the machines related to harvesting, the only one used now is power threshers made in people's communes. They are now putting much emphasis on research and dvelopment work on Japanese type combine harvesters, both thresher type and ear-cutting type. They say that practical experiment of trial machine with 15 to 20 hp engine is now on the way. Utilization of combine harvesters necessitates grain dryers and drying facilities. These are being studied in each level of central, provincial, county and commune. However it is reported that research and development works of combine is going ahead of these.

In short, in this area, present stage of progress is on the expansion of agririan land with the aforesaid irrigation facilities and agricultural mechanization with the introduction of small and medium size tractors. In the case of Japan, it took about 30 years to attain establishment of overall farm mechanization system of rice cuitivation starting from the introduction of driving type hand tractors right after the end of war. As China still stays on introductory stage of tractors

Fig.2. Power tiller before the shipment

Fig.3. Rice hervesting by reaper

Fig.4. Rice harvesting by head feed combine

which are the main core of mechanization, she will not be able to attain similar degree of mechanization as in Japan by the end of the Fifth Five Years Plan which starts from this year. It is assumed that it will not be until 10 years after from now to attain that, when the coming Sixth Five Years Plan will be over.

Northern upland area

In this area, contrary to southern rice growing area, agricultural mechanization have been pushed forward consistently aiming at the completion of medium or large machinery utilization system. Main tractors used here are crawler type of 80 to 120 hp. When wheel tractors are used they are over 40 hp. Farming works such as plowing, harrowing, leveling, seeding, fertilizer application, etc. are performed by use of attachments to these larger type tractors. All of the harvesting of main crops i.e. wheat, maiz, sorgham and beans is carried out by use of larger type combine harvester of 100 hp class. Farm mechanization by larger machines in this area has progressed ahead of southern area, being assisted by technical coopertion of Soviet Russia in the begining stage after the liberation. This has been steadily advancing since then even after Russian engineers had gone in 1960, keeping the slogan of self-riliance.

However in this northern area, utmost priority has to be given to the countermeasures against draught. The prerequisite for the completion of farm mechanization by use of medium or large machines is to increase the irrigated acreage by digging wells, constructing pump stations and arranging irrigation channels.

Today in China, irrigation system has almost completed around the large cities such as Shenyang, Peking, Tientsin, Shanghai, Nanking, Kwangchow, thus bringing forth advanced agricultural mechanization to those communes in these territories. However, what matters greatly is the progress of irrigation construction works and agricultural mechanization in the remote area other than suburbs of cities, which are rather difficult to observe for us. It is assumed that backward communes and brigades in such a remote area are highly considered in the Fifth

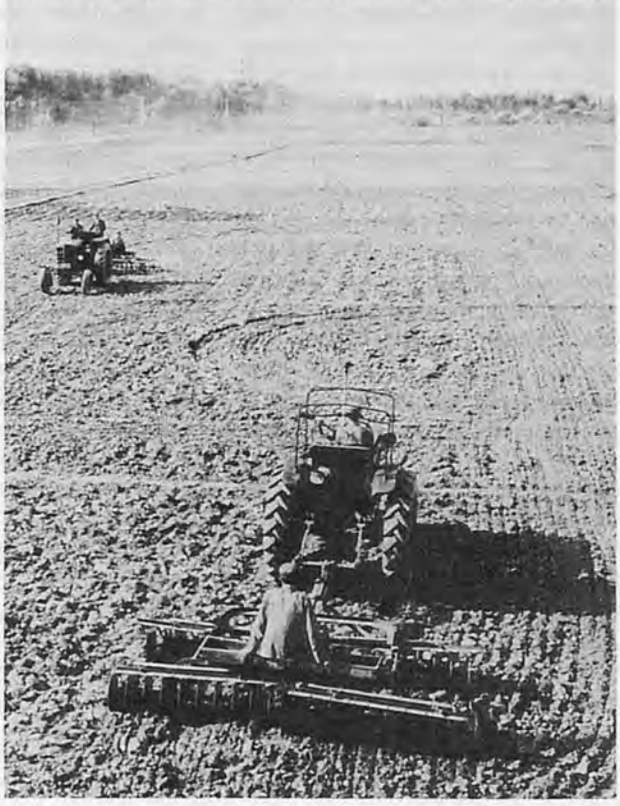

Fig.5. Harrowing by tractor-drawn disc harrow

Five Years Plan which mobilizes mass movement "in agriculture, learn from Tachai".

Problems and Subjects of Study in Promotion of Agricultural Mechanization Programme

The author has already reported on November 1974 in my lecture titled "Present Status of Agricultural Mechanization in China" on the occasion of the lecture meeting held by International Agriculture Mechanization Committee that China has adopted four principles for agricultural mechanization long before starting the Fifth Five Years Plan. They are;

a) Progressive promotion of the Farmland Capital Construction,

b) Improvement and replenishment of management, facilities and technology concerning the production of farm products and agricultural machinery, in other words, overall practice of Eight-Point Charter for agriculture,

c) Combination of full-mechanization and semi-mechanization according to the situations,

d) Education and training of farmers for the machine utilization technology.

In the Fifth Five Years Plan also, these four principles are adopted as the keys for the promotion of agricultural mechanization. In regards to above a) and b) specifically, there are several difficult problems and some subjects to be studied. They are as follows;

(1) The Farmland Capital Construction, which has been carried out since 1970 with mass mobilization in winter season, consists of three major components : leveling of land, expansion of irrigation facilities and soil improvement. Each of these involves large scale agricultural civil construction works. If the Farmland Capital Construction should be promoted in much larger scale than ever in the Fifth Five Years Plan, then the way to do this as in the past which have been chiefly relying upon mass mobilization partly assisted with minor number of machines will not be sufficient. Naturalily larger number of heavy construction equipment such as bulldozers, power shovels, dump trucks, etc. are required. From this point of view, much emphasis has to be placed on the production increase of these machines and the importation might be necessary in considerable quantity from abroad as Japan, as the production capacity in China is extremely low at present.

(2) In the southern rice growing area, following points have to be solved in order to promote agricultural mechanization.

a) How to expand the production facilities and increase the production capacity rapidly on small and medium size tractors, irrigation equipment and facilities which are expected to increase the demand urgently.

b) How the production of rice transplanters, weeders, reapers, etc. can be increased and they could be successfully introduced to people's communes who are seeking for leveling up of mechanization in order to improve the productivity and promote modernization of agriculture.

c) How the research and development works and the mass production of combine harvesters, grain dryers and drying facilities for rice can be attained which are essential for the completion of overall farm mechanization system.

(3) In the northern upland area, following two points make the basis for the promotion of mechanization.

a) One is the expansion of irrigated area which is one of the important tasks of the Farmland Capital Construction. Contrary to central and southern areas, water resources is short, rainfall is less and much dry climate is there in this area. In order to expand irrigation, they have to locate underground water and dig deep wells there at the various points so as to cover the vast range of the north-east area which is the main farming area of China. Adding to this, of course, deep-well pump facilities, irrigation channels, water gates etc. have to be equipped to these.

To what extent these large scale agricultural civil construction works can be performed in the Fifth Five Years Plan? It is supposed it will take considerable time for such an achievment even for China who is striving for the construction of the nation unanimously under a slogan of "Catch up and surpass".

b) The other is how to increase the mumber of larger type combine harvesters whose production is rather low compared to that of larger type tractor of 80 to 100hp class which are also necessary to be increased. Even if the tractor production might suffice the demand, well-balanced agrirultural mechanization cannot be completed in upland area if combine supply falls short of. It is reported that considerable percentage of harvesting is still being manually performed even though it might be in the poorly irrigated land.

Thus, the pressing problem to be solved in the northerm upland area for agricultural mechanization is not the study of underdeveloped agricultural machines but the improvement and the production increase of existing machines.

As can be concluded from above (2) and (3), the greatest problem for up-lifting the deggree of agricultural mechanization to 70% within the term of the Fifth Five Years Plan lies in the strengthening of the production of the various types of agricultural machinery. For this purpose Vice Prime Minister Hua Kuofeng stressed, in his general report on the National Conference on Learning from Tachai in Agriculture, the importance of agriculture-assisting five small industries in each county to cooperate for the development of agricultural machinery industry, to supply machines, steel and other necessary material for agricultural mechanization, chemical fertilizer, agricultural chemicals, etc. to people's communes and production brigades, and the necessity of setting up self-sufficient system in each prefecture and county. Production increase of five small industries in each prefecture will call for the development of basic heavy chemical industry such as iron and steel, electricity, fertilizer, petro-chemicals, run by provinces or central government. From this point of view, trade between Japan and China will be expanded further on the basic materials such as steel or fertilizer which are in short in China for the execution of the Fifth Five Years Plan and the plants for the production of these, rather than Japanese agricultural machinery whose durability does not fulfil their requirement.

Conclusion

Main targets of the Fifth Five Years Plan are, as mentioned above, to carry out large scale agricultural civil construction work named the Farmland Capital Construction to the full extent, to complete agricultural mechanization by leveling up degree of implementation to about 70% from 30% at present thus modernizing agriculture and increasing food production efficiently and to attain self-sufficiency of food and to establish sufficient food storage system by 1980.

This programme makes starting point of executing the grand strategic scheme that makes the national economy advance in the front rank of the world before the end of this century. It makes us understand how China highly regards the importance of agriculture as the foundation of national economy. To perform all of above within short time span of only five years must be really spectacular one. Quick and rapid production increase of construction machines, agricultural machines, iron and steel, fertilizer, electricity, etc. must be pushed forward vigorously. The fund for importation might be secured to some extent by production increase of petrol.

The first key in making the Fifth Five Years Plan result in success lies in the fact whether or not the production and supply of above mentioned machines, basic material, electricity, etc. can be increased keeping pace with the annual operation programme of the Farmland Capital Construction Five-year Programme and farm mechanization five-year programme.

The second key lies in the fact whether or not the completion of overrall farm mechanization system suited to each area in China, and then the production and supply of various types of farm machinery needed for the modernization of agriculture at the communes can be successfully completed and achieved with the annual operation programme of farm mechanization five-year programme. Taking the example on southern rice growing area, it means that various tasks such as a) quick completion of thresher type combines, dryers and drying facilities which are still being researched and developed, b) establishment of the mass-production system of rice transplanters, reapers etc. which are already developed but not yet distributed sufficiently and c) education and training of farmers on the operation technology of these. Those are very ardous tasks as the proverb—"it is easier to preach than to practice"—goes.

Judging from the present state of affairs in China at any rate, to achieve all of above with short time span of only five years must be super troublesome works required to be matched against the biggest trial.

Now let us estimate whether China can successfully attain the targets of the Fifth Five Years Plan.

First we make rough estimation of future on important items basing upon the accomplishment of past four Five Years Plans and simple extrapolation.

Next we work out the expectable figures in five years after from the trend curve of second degree drawn out from above data eliminating noises by the method of least squares.

In these two ways we predict the average growth rates of important items in these five years and assume that agricultural mechanization progresses in proportion with these growth rates. Then we can predict that there exists the possibility of attaining 70% of degree of agricultural mechanization in five years after, starting from the figure of 30% at present.

Of course above is only a bold trial of estimation. However, on estimation, the fighting spririt of Chinese people cannot be disregarded. They are trying extremely hard against difficulties, being lead by Chairman Mao Tse-tung under the banner of self-reliance. They look forward tomorrow and the day after hopefully, trying to "catch up and surpass". Considering this factor together with the above estimation, the auther myself firmly believes that they are sure to perform the Fifth Five Years Plan successfully. The author wants to clearly mention also that, as a friend of Chinese people, supports from the bottom of his heart for their success in the digantic strategic National Economy Construction Programme before the end of this century.

■ ■

Transfer of Agricultural Engineering Technology to Rural Masses

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A good starting point is to identify the Agricultural Engineering Technology. It covers:

1. Farm Power and Machinery.
2. Soil & Water conservation engineering, including watershed management, command area development, conservation irrigation and field drainage.
3. Irrigation Engineering, including surface/ground-water development and irrigation equipment (such as pumpsats, sprinkler irrigation, drip irrigation).
4. Rural Electrification.
5. Agricultural Processing Engineering, including post-harvest technology, handling and storage of farm produce.
6. Farm structures and farmstead layout, including rural water supply, sewage, roads and landscape.
7. The Agro-industry—its production, marketing and management aspects.

Next, we must identify various Agencies concerned with the transfer of this technology; they are:

1. The academy—teaching, research, training & extension institutions; where the technology is developed, adapted, received and transformed.
2. The government—various departments such as Agricultural Engineering, Agriculture, Soil Conservation, Irrigation, P.W.D., Rural Development, Local Self Government, Forests, Ground Water Survey & Development etc.
3. Semi-government, such as Municipal Corporations, Civic Bodies, Zilla Parishads, Panchayats etc.
4. Public Sector Corporations, such as State Agro-Industries Corporations; Corporations dealing with manufacture of Tractors and Farm Equipment, State Farms, Irrigation Development, Land Development, Ground Water Development and Warehousing etc; Fertilizer Corporation of India, Food Corporation of India, Indian Dairy Development Corporation, National Seeds Corporation, Rural Electrification Corporation; Commodity Corporations such as those dealing with cotton, tea, coffee, cashew etc.; Oil Corporations (IOC, HP, IBC, NOC); Insurance Corporations (LIC & GIC) with emphasis on safety.
5. Financing Institutions, including ARC, AFC, IDBI, ICICI, IFCI, State Bank Group, nationalised Banks and others.
6. The Agro-Industry—manufacturers, producers, distributors, dealers, stockists, agents, representatives; marketing, sales and service organizations.
7. Voluntary service organizations; Trusts, Welfare Agencies, Foundations, Charitable Institutions, Trade Bodies, Farmers' Assosiations, Professional Bodies /Societies, Co-operative Institutions and Consultants etc.

8. Self employed entrepreneurs.
9. Farmers, their families, associates and employees.
10. Advertising Agencies and Specialists in mass communications.

Next, let us identify the Rural Masses; they are:

1. Farmers, their familities, associates and employees.
2. Landless labour, farm labour.
3. Rural youth.
4. Small-scale industry, cottage industry.
5. Artisans, including operators, cleaners, mechanics, blacksmiths, carpenters.

MEDIA

Having identified the technology, the agencies and the audience, we can now take stock of Media available to us for this purpose. The items are films, cinema slides, cinema vans; Hoardings, wall paintings and posters; books, periodicals, journals, magazines, newspapers and rural publications; and audio-visual training material, training aids, charts, models, cut-outs, hand-outs etc.

Literacy in the rural areas being poor, below 20%, the choice of effective media of communication to reach our message to the rural audiences has to be essentially visual or audio, preferably a combination-audio-visual.

The most effective medium for reaching rural audiences, therefore, would be films—particularly those which have been specially produced with a simple visual treatment and a direct varbal meggage.

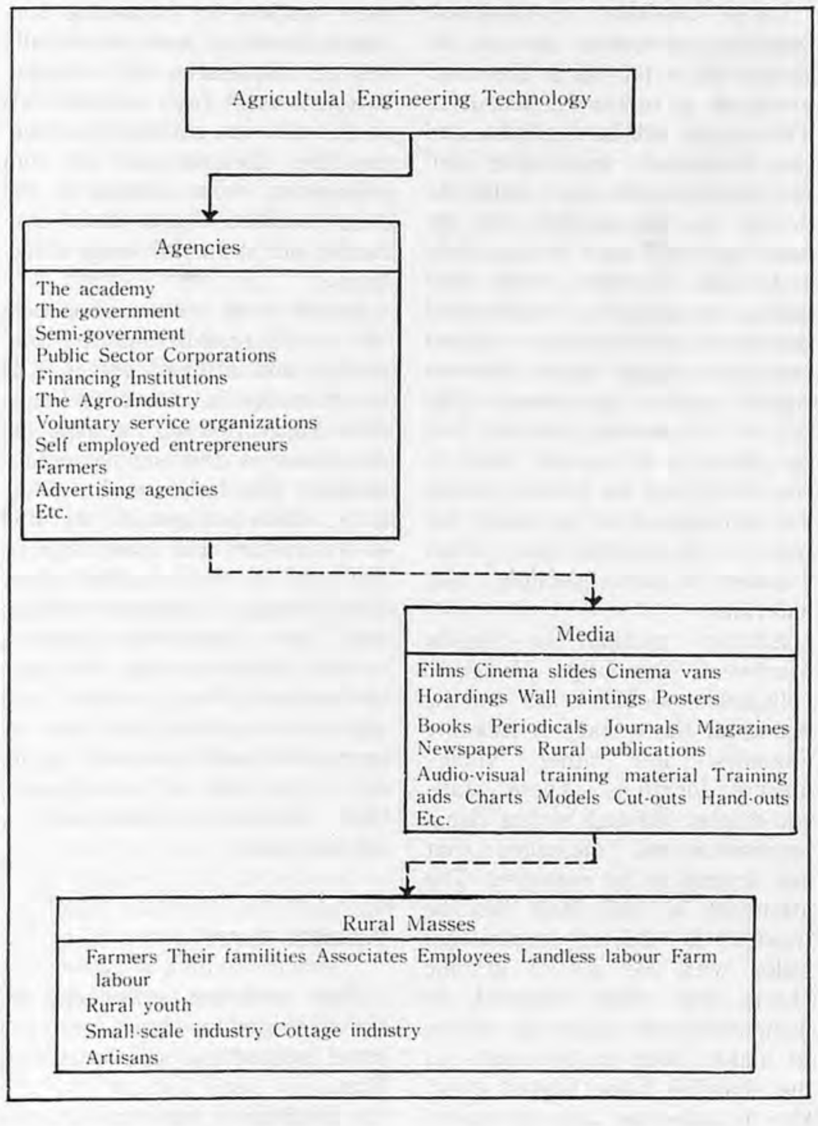
Films can be shown to the rural people through touring cinemas which camp at a central and strategic village, or a small 'mandi' town, for about six months and then move on to the next village or 'mandi' town. Villagers from nearby villages usually visit such cinemas in a fair number every evening for relaxation and a visual treat.

The only problem would be how to physically check and ensure that our film, for which we are paying to the touring cinema, is really exhibited to the audiences. Perhaps, some satisfactory system, through the aid of village school teachers or Postmasters, can be evolved.

The other effective method to reach our message to the rural audiences is through the use of Mobile Cinema Vans. The Mobile Vans can be operated as Propaganda-cum-Cinema Vans or only as Cinema Vans.

Propaganda-cum-Cinema Vans can, during the day time, conduct verbal propaganda sessions among groups of audiences collected at strategic points by playing recorded local music or conducting other interesting activities such as Puppet Shows or Jugglers' Shows, etc.

Even during the day time film exhibitions can be arranged by building special Mobile Units which have sheltered viewing screens to avoid glare of sunlight ant on which the projection of the film is done from within the van by using special lenses. Day



time Cinema Vans have also proved fairly successful.

Besides films a liberal use of large size (30"×40" or 20"×30") printed posters which are specially designed to put across the message to illiterate or semi-literate audiences through a strong visual consent, can prove exceedingly useful and economical. Such posters can be easily put up all over the selected villages as space for putting them up is freely available. There being very few such colourful posters in the small towns and villages, these usually command good attention and interest.

Large, medium or small-size hoarding structures can be arranged to be put up in the rural areas at a relatively low cost. The rentais will be negligible and the Municipal restrictions will not hinder their use. Only the design to be painted on the hoardings will have to be basic and bold. Written words will need to be as few as possible and the message should be conveyed visually through human interest which involves the viewer. The life of a hoarding structure can be taken to be around three to five years and the painted design can be expected to last easily for four to six months even when exposed to direct sunlight, dust and rain.

Another medium is Shandy Markets. Specially designed, collapsible, mobile stalls can be put up at the weekly or monthly Shandies and other village market locations. These stalls can display, through strong visual representations, messages that are desired to be conveyed. The attendant at the stall can be trained to deliver occassional talks, with the aid of graphic charts and other material, to demonstrate the points he wishes to make. Such mobile stalls at the shandies have proved effective in collecting large groups of people and have evoked considerable interest.

For reaching our message to the rural audiences eigher we have to pull the people to the spot where we have stationed ourselves by promising them entertainment, fun and education; or we have to go to the spots where they have already gathered. Fairs and Festivals, which are large in number in all the parts of the country, provide a very good opportunity for the communicator to set up a small show of his own and put across the message that he wishes to.

Some Companies, who have been leaders in marketing consumer products, have successfully set up impressive, yet inexpensive, shows at fairs and festivals in the different parts of the country for the purpose of communicating their message to the rural audiences and have eminently accomplished their objectives.

In the rural areas, newspapers are usually read by only the well-placed and affluent villagers. If the message is meant to reach this Target Group, newspapers can prove a fair supplementary medium. Similarly, rural publications, which are specially devoted to Agriculture and allied subjects, are read by the so-called 'elite'. The Village Panchayat Offices and the Community Centres, usually, keep a copy of such publications for reading and reference by those who are interested in such journals. Again, as in the case of newspapers, these publications have only a limited reach.

ACTION PLAN

Now, with the background we have covered so farm here are some suggestions on an Action Plan:

1. Establish a National Institute of Agricultural Engineering (NIAE)—a premier research station well equipped with properly qualified and experienced personnel, required equipment and other ancillary facilities.
2. Establish a National Institute for Training in Agro-Services (NITA)—an apex Training Institute for training of trainers and production of training material.
3. Organize a net-work of training centres for training of all concerned on a mass scale.
4. Adapt polytechnics, industrial training institutes and similar establishments into "agro-technics" for training of operators, artisans, field workers, 'bazar mechanics', owners and employees of way-side garages etc.
5. Ensure proper after-sales services on farm equipment including warranty services, prompt supply of spare parts, training in operation, maintenance and repairs, supply of well illustrated operators' manuals and spare parts catalogues in regional laguages, refresher courses, service clinics, check-up camps, service contracts, 24-hour service during the season etc. Establish proper inspection agencies. If such services are not forthcoming voluntarily from the input suppliers, suitable measures will have to be devised. Items like crankshafts and tractor rear tyres are reported to be in short supply.
6. Establish a large number of agro-service centres, not only for retail sales of inputs but also for contract and custom services of a wide variety, including topographical surveys, land development, lift irrigation schemes, farm operations such as ploughing, cultivating, harrowing, puddl-

ing, spraying/dusting, chaff cutting, harvesting, threshing, haulage etc. Some of these services are required on a turn-key basis.

7. Ensure uninterrupted power supply, at least during the season. Prevent wide voltage Fluctuation. Attend to breakdowns promptly. Cut down delays on new installations/connections. While number of pump-sets energised and villages electrified do make an impressive reading, do not ignore the quality of power supply.
8. Ensure prompt and ragular supplies in required quantities close to points of use of unadulterated fuels (hsd, ldo, kerosene, motor spirit etc.) and lubricants. Organize a Farm Fuels Advisory Service, now that all the fuel supply for farm primemovers is through the nationalised Oil Companies. Develop patrol pumps as an important base of operations in agro-services.
9. Reduce hazards arising out of farm mechanization and greater use of farm chemicals. Arouse safety consciousness. Impart training on safety measures. Install protective frames on tractors to prevent overturning. Fit 'cats' eyes' (reflectors) on bullock-carts to make night plying safe. Get Life Insurance Corporation and General Insurance Corporation to take a meaningful interest and play a positive role in promoting farm safety and providing proper under-writing services on the equipment, owners, operators, livestock, farm structures, and farm produce (crops).
10. Survey farmers' needs on equipment and services. Work out a time bound, result oriented programme to cater to his needs. Identify gaps in mechanization. Today, farmers are looking out for good seed-cum-fertilizer drills, harvesting equipment for wheat, paddy and sugarcane (something more than a sickle/harvesting knife). Don't they need an improved pneumatic tyred bullock-cart and a low priced tractor? Proper assessment of demand is a good starting point.
11. Compile classified lists of input manufacturers and suppliers, tractor owners, farmers etc. for direct mailing campaigns and developing communications.
12. Get financino institutions to play a more practical role, particularly in developing logistics, technical guidance, training and encouraging better services and ethics of business by input suppliers. Farm financing policies require to be streamlined and priorities determined.
13. Establish a National Farm Equipment Council—a forum which will bring together the industry, the government, the academy and the farmer. The Council should be an effective link for co-ordination.
14. Reorganize government departments at the centre and in the States so that all matters pertaining to the Agricultural Engineering discipline are handled by an effective authority, say of a Commissioner's rank. Technical personnel should be encouraged and developed to head technical activities and take overall responsibilities including administrative.
15. Revitalise academic institutions to shoulder greater responsibilities as seats of learning, beacon light for development and catalyst for accelerating transfer of technology and its practical utilization. Quantity and quality of institutions should both receive dus attention.

SUMMARISING, the direct need of the hour is Training of trainers and of all concerned agencies on a mass scale, also preparation of training material suitable for our local conditions.

Emphasis should be both on quantity and quality; this applies to all aspects of transfer of technology, including teaching, testing and research institutions, agro-service centres, villages electrified and pumps energized, retail outlets etc.

Give the farmer a good quality product, backed by prompt and efficient after-sales services. Only then will he really benefit from the technology provided. Provide logistics to enable the beneficiary to derive maximum benefit.

Research, development, teaching and extension should be practical, topical, result oriented, with emphasis on immediate benefit to the masses and with a high cost-benefit ratio. ■ ■

Agricultural Mechanization in Turkey

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Agricultural Structure

Turkey is a predominantly agricultural country with a population of about 40 million and an area of about 78 million hectares. The ratio of the rural population has decreased to 62% in 197 (1), but still very high compared to industrially developed countries. The average of this rate in Asia is 64%, in Europe 23%, in World 52% and in the U.S.A. 6% extremely (2). The goal of the planning in Turkey is to decrease this ratio to 53% in 1977. Also the ratio of the agricultural active group to the total economic active population is very high with about 66% (3). The ratio of the consumers to the agricultural workers in Turkey for 1970 was 3.6, whereas the same relation in England is 54.2, in the U.S.A. 40.4, in Spain 7.7 (2).

Soil and climatic conditions, cropping systems and farming methods vary greatly in Turkey. **Table 1.** shows the distribution of arable land and forest area in 1973. About one third of the total area is under cultivation. The distribution of water sources and the land used enables to irrigate 8.5 million hectares of the cultivated area. But for the time being only about 2.4 million hectares can be irrigated, which is only about 10% of total used land.

The total area of arable land and forests per active person in agriculture is 2.8 ha in Turkey (if meadows and pastures included 5.7 ha). Such a vast area can not be productive without mechanical power. In order to increase the agricultural production, a large additional acreage could not be taken into consideration. Thus the only possibility is to increase the yield or in other words "to realize higher production through less population."

Most of the farms in Turkey are small and about three quarters of the farmers own their land. The rest are part owners or share operators. **Table 2.** shows the distribution of farms and cultivated area by farm size. It is clear that very many farms are small ones between 0.1—5 hectares. Furthermore, a single farm is generally composed of many land pieces in different places. **Table 3.** shows the distribution of farms by field pieces. For example, an average field piece of all farms is of 5 pieces, in fact very high (4). Optimum mechanization in small and excesively divided farms is financially and technically very difficult.

Turkey's economy is supported above all, by agricultural produc-

Table 1. Land use 1973 (1000 hectares).

Area cultivated		Area of vegetables, vineyards, olive and fruit and fruit trees				
Area sown	Fallow	Vegetable gardens	Vineyards	Orchards	Olive groves	Forests
16,061	8,950	530	816	1,153	775	19,136

Source: Agricultural Statistics of Turkey (Note: Meadows and pastures are excluded).

Table 2. Distribution of farms and cultivated area by farm size.

	1963		1970	
Farm size (decar)	Distribution of farms (%)	Distribution of cultivated area (%)	Distribution of farms (%)	Distribution of cultivated area (%)
1-50	68.8	24.4	75.1	29.6
51-100	18.1	23.9	14.7	23.2
101-200	9.4	23.7	7.1	21.8
201-500	3.2	17.0	2.6	14.3
501-1000	0.4	4.5	0.4	5.7
larger	0.1	6.5	0.1	5.4

Source: Agricultural Statistics of Turkey.

Table 3. Distribution of farms by field pieces.

Number of field pieces of a single farm	1950 (%)	1963 (%)	1970 (%)
1	5.4	9.5	16.0
2 — 3	22.7	20.8	30.4
4 — 5	23.2	19.9	21.4
6 — 9	26.1	24.9	19.4
more	22.6	24.8	11.6

Source: Agricultural Statistics of Turkey.

tion. The share of the agriculture in gross national production is about 28%, although it decreases year by year. The largest section in agricultural production is the vegetal products with a share of about 62%. Among others the major products are the field crops such as cotton, tobacco, sugar beets, cereals, pulses with a share of about 65% of total vegetal production value (3). Many kinds of other crops, such as olives, figs, nuts, grapes, citrus fruits, tuber crops, sunflower, opium, hemp and flax are also important.

Recently the export of miscellaneous manufactured articles have grown up, however major commodity export group is still agricultural products, with a share of about 70% of total.

Present State of Mechanization

It is clear that the role of the mechanization is very important in making use of the agricultural potential of a country. According to the researches made by FAO to find the minimum HP/ha to increase the production and optimize the output, it has been found as 0.5—0.8 HP/ha for developing countries (5). **Figure 1.** shows that Turkey is just at the beginning of the production increase curve. The tractor fleet of Turkey has been increased to 159, 139 in 1973 (3), but still the mechanical power per unit area is very low, such as 0.18 HP/ha. As it is seen from these figures, there is a great mechanization deficit in Turkey. If 0.8 HP/ha is taken as the aim, in according to the State Planning Organization researches and certain statistical data, 30,000 tractors must be added to the park annually. But latest experiences have been showed that, this amount is also far from being sufficient. In 1975, 50,000 additional tractors were necessary, and for 1976 it has been cal cul ated as 70,000.

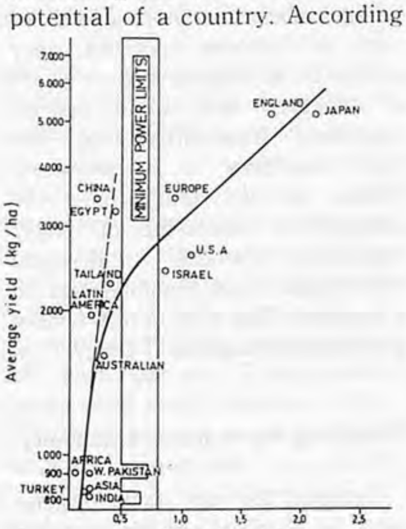

Fig.1. Minimum power limits for the optimum yield (5)

Although tractor use is increasing all over the country, animal drawn implements still perform the major part of farm operations especially in some districts. The amount of draft animals in Turkey is about 2 million pairs. The ratio of tractor power to the total power needed is only about 30%. The same ratio in 1965 was 90% for Europe and 98% for U.S.A.

On the other hand the rural electrification degree of Turkey, which is a scale for indoor mechanization, was 4% in 1970. The agricultural use of electric power in the total consumption is only 0.6%. The Average specific electric power consumption in 1970 was 2 kWh/ha, which is only 2% of the aimed level of 100 kWh/ha (6).

Present state of the agricultural machinery park can be followed from **Table 4.** Some of the coefficients for the planning of Turkey's agricultural fleet are being selected as follows: For every 100 tractors 100 plows, 50 cultivators, 50 spike tooth harrows, 30 disk harrows, 5 rollers, 5 rotovators, 30 walking cultivators, 20 grain drills, 5 other planters, 30 fertilizers.

Table 4. Number of agricultural equipment and machines (1000).

Equipment and machinery	1969	1973
Tractor	96	156
Plows, tractor drawn (all kinds)	119	168
One ways	6	8
Disks	37	61
Cultivators	22	34
Rollers	28	33
Rakes (all kinds)	520	495
Walking plows	1447	1480
Walking cultivators	38	46
Spike tooth harrows	33	55
Wooden plows	1908	1555
Trailers	80	133
Grain drills (all kinds)	98	106
Mowers	26	23
Binders	4	5
Combines	8	10
Threshers	11	29
Fanning mills	74	77
Seed cleaners	3	3
Cylinder cleaners	8	7
Corn shellers	5	6
Hay mowers	5	4
Hay rakes	23	13
Balers	2	3
Sprayers (all kinds)	202	255
Centrifugical pumps (farm-use)	26	36
Motor-pumps (farm-use)	69	101

Source: Agricultural Statistics of Turkey.

Trends Relating to Farm Machinery Use

The benefits of the agricultural

mechanization is not only to increase the yield but also shorten the duration of operations and improve the quality, thus making it possible to yield a second round of crop. On the other hand the pastures used for draft animals can be also economized. Besides, the agricultural mechanization helps to improve the comfort, health and standard of living of the farmers. The conservative behaviours against machinery have been overcomed today, but there are some aspects based on the above stated agricultural structure and the social structure, which retard the mechanization in Turkey.

The agricultural income per farm in Turkey is very low and the initial cost of the machinery is often beyond the means of individual farmers. Lack of adequate and easy credit facilities is an additional obstacle. Thus an investment for mechanization is rather difficult. The optimum ratio of yearly purchased machinery costs to the gross product of a farm is calculated about 1.0 for large farms and 1.5 for small farms(7).

Fig.2. Harvesting cotton with machine

Since the contractors in Turkey do not have enough machinery to meet these mechanization demands, Topraksu (Soil Conservation and Farm Irrigation Directorate) has been organized to become well equipped in order to supply, by renting the necessary machinery for soil improvement and land leveling to the farmer, who can not purchase them by their own. The activities of Topraksu had been given positive results and previously unknown machines in Turkey such as float, scraper, subsoiler, chisel and two-way plow had been manufactured with local possibilities completely. But this organization has enough machinery to meet the need of only 25,000 hectares.

On the other hand, although the ratio of rural population is quite high, in some places, specially at harvest time and when other agricultural operations overlap, a shortcoming of workers is noticed, thus bringing the worker's wages up. According to the statistics of the Social Insurance Institution for the years 1965-69, total cost of living is increased by 21.6%, while an increase of 100% in the wages of the insured agricultural workers has been ascertained. In anticipation of such increases of wages and considerations like the difficulty in finding a great number of wokers available at a short notice and if available, the social problems that may arise from a great number of workers working together, the farmer is inevitably led towards the employment of mechanization. Consequently, though none of the demands of mechanical harvesting of cotton is fulfilled as yet, mechanized harvesting is actually being employed (**Fig. 2**). But at the same time one can observe a team of bullocks drawing a cart of straw (**Fig. 3**) and may use the term "contradictions of agricultural mechanization".

Fig.3. A team of bullocks drawing a cart (Dincer's collection)

In consequence of the socio-economic factors, an entirely new type mechanized service has come into existance. The majority of combine harvester owners in Turkey have either no land or land not big enough to furnish a need for a combine. Since harvesting time graduallv recedes from the coast line into the hearth of Anatolia, these so-called contractors rent their combines throughout a period of almost three months. Thus the farmer who can not afford to own a combine has an easy access to it. Also private owners of tractors and some special machines frequently hire out their machines to other users. Hence, it is clear that, the cooperative ownership of costly machines, where individual ownership is not feasible, can be a solution. But this is not widely practised throughout Turkey.

Supplying Agricultural Machinery

Demand for the farm machinery in Turkey exhibit a rapid increase in relation to mechanization rate. The agricultural machinery industry has increased in the years between 1962-72 from 3.9% to 9.3% among other investment commodity manufacturing industry groups (1). In fact only the increase in tractor manufacturing was carried out successfully in planned development period. Manufacturing of the other farm machines has not shown the same improvement. The State supports the national industry through some precautions and import limitations. Thus the number of the manufacturers in this industry group has been growing up. But very many of the about 400 firms, which manufacture agricultural machines are only small workshops. To solve the problems of labourer shortage, process methods, high quality material, marketing and the yearly fluctuations of demand are far beyond the capacity of such small firms with inadequate capital.

Table 5. shows the consumption of some agricultural machinery and the share of Turkey's production with the share of imported ones. As it is seen from this table, most of the machines are made locally but some specialized parts and machinery are imported.

An important organization is the TZDK (Turkish Agricultural Machinery Organization), which is a symbol of a nation-wide operation concentrating on the supply and repair of agricultural machinery. TZDK was also given the authority to supply seeds, fertilizers and pesticides. The machinery production through this organiwation represents a significant fraction of the total for all Turkey. As a governmental organization TZDK is in competition with private Turkish importers and manufacturers. This conflict gives rise to several unfortunate situations. However, TZDK have some effect toward regulating prices (10).

The farmer usually gets his implements either from the local manufacturer or an agent selling the machinery of well-known manufacturers. Credit for purchasing farm machinery is supplied by T.C. Ziraat Bankasi (Turkish Agricultural Bank). Usually farmers make an advanced payment and the Bank provides a loan to cover the balance. Although the interests are pretty low, the farmers must furnish security for the loan in the form of property, which brings some serious problems.

Table 5. Consumption, production and import of agricultural machines in 1972 (million TL.-1 dollar is about 15 TL.).

	Consumption	Production		Imports	
	value	value	%	value	%
Tractors	1377.0	1320.0	95.9	57.0	4.1
Plows	84.0	84.0	100.0	—	—
Seedbed refining implements	16.0	16.0	100.0	—	—
Cultivators	70.0	70.0	100.0	—	—
Seeding machines and fertilizers	33.0	33.0	100.0	—	—
Combine harvesters	147.0	105.0	71.4	42.0	28.6
Treshers	66.5	62.0	93.1	5.0	7.5
Crop processing machines	9.0	7.0	77.8	2.0	21.2
Other machines	90.8	74.0	81.6	17.0	18.7
Spare parts	258.7	9.0	3.4	250.0	96.6
TOTAL	2152.0	1780.0	82.7	373.0	17.4

Source: Yearly programs of State Planning Organization.

Research and Developement of Agricultural Machinery

It is indisputable that the development of the agricultural mechanization, of the industry and of other activities are interdependent. The question is not whether or not machines to be introduced in agriculture, but rather the nature, degree and pace at which they should be introduced. In other words to choose the best suitable mechanization model that fits socio-economic structure.

At the present there are five Farm Machinery Institutes in Turkey, which have access to research and development of farm machinery. Four of them are the Institutions of Agricultural Faculties in Ankara, in Izmir, in Adana und in Erzurum. The other is the Institution of the Technical University in Istanbul. They examine the mechanization models as well as the usefulness and adaptability of machines to the requirements of this country. Recently a new department has been established at the TZDK which is oriented mostly toward progress. Tests and experiments with plant protection equipment are performed by the Plant Protection Institute in Ankara.

In addition to these Institutions, there are numerous regional technical schools of agriculture. Additional education and training facilities outside of school for farmers is carried on by the Extension Service of the Ministry of Agriculture.

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Demonstration & Calibration of Sprayers

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Demonstration is the best available method for extending improved agricultural production practices to our farmers. To achieve desired resuits in plant protection, proper attention should be given to select the Sprayer, its demonstration and calibration. Improved agricultural practices have got three phases of developments: investigation, demonstration and implementation. Demonstration should be conducted to describe the basic research or investigation to adopt them as routine operation activities. The purpose of demonstration is to show the farmers what the practice is and how to be benefitted by adopting it.

The field workers are the bridge between research and practice. They should convince the farmers with the help of demonstration, about the new improved practice and induce them to accept it. It is very essential to conduct good demonstration so that the new improved practices can be accepted by the farmers in the shortest period. The field workers should be convinced for the new improved practice which he is going to demonstrate to the farmers. If there is any doubt in his mind, then he must conduct further trials by himself before demonstrating it to the farmers.

Our farmers have accepted in principle that "prevention is always better than cure" to keep green revolution going. In plant protection techniques the spray chemicals should be applied in proper dosages at proper timings similar to fertilizers and irrigation. To apply proper dosages of spray chemicals, good demonstration and correct calibration of sprayer is very essential. This has not been taken care of by our field workers. To obtain the maximum efficiency in terms of insect and pest control, crop production and economy, it is necessary to know the automization produced by a Sprayer and application rate of a Sprayer. The automization produced by the Sprayer should be uniform. The particle size of spray chemicals should depend on automization capacity of a Sprayer. It has been found by field experience that better the automization, the finer the spray particles. However, it is difficult to control the placement of finer particles. The more automization, the larger the number of spray particles, and the better the distribution of spray chemicals on leaves and foliage. Field studies have proved that larger number of fine particles doposited per unit gives better control of insects and pests. Thus control achieved from a certain dosage of spray chemicals would depends upon how the same has been applied and how much material has been drifted away by wind and how much has been dripped or fallen on the ground.

Calibration of spraying equipment means to determine how much material the spraying equipment is applying at preselected settings and then to make adjustment to apply the desired quantum.

The application rate of spraying equipment is governed by the following factors:

1. The discharge rates of nozzles with set or prescribed spraying pressure at which application is going bo be carried out.
2. The swath width of the nozzle or in other words the

number of nozzles used and their placement.

3. The spraying speed.

The above details can be found out as under:

1. Nozzle discharge rate:
This can be known from the manufacturer. Each Nozzle supplied with the Sprayer is tested and its discharge rate has been marked on it.

2. Swath width:
This depends on the nozzle used with the Sprayer. The swath of the nozzles will depend on the following 3 points.
   a) The working pressure at which spraying work is to be carried out.
   b) The cone angle of the nozzle.
   c) Spraying height from the nozzle tip to the spraying surface.

Swath Width can be found out as under:—

Measure the cone angle of the nozzle and the spraying height. With the help of the table swath width can be found out or we can measure the swath by the help of a measuring tape.

3. Spraying speed:
Speed of the operator at which he is going to walk in the field while spraying. Spraying speed can be found out as follows:—
   a) Measure in feet the distance covered in 15 seconds.
   b) Repeat the procedure to obtain average speed.
   c) Convert the walking speed in M.P.H.

Distance covered in 15 seconds.	Average speed in M.P.H.
22 ft.	1 m.p.h.
33 ft.	1.5 m.p.h.
44 ft.	2 m.p.h.
55 ft.	2.5 m.p.h.

Normal spraying speed with a manually operated sprayer is 1.5 m.p.h.

To show the importance of demonstration and calibration as described above, one field trial had been conducted with a Knapsack Sprayer and a Compression Sprayer. No doubt Compression Sprayer is going fast out of use because of certain inherent limitations. The Compression Sprayer cannot maintain uniform pressure and the pressure goes on progressively falling as the spraying continues. Secondly, there is a lot of wastage of time in charging and re-charging the Sprayer because the Compression Sprayer is filled to only 2/3rd of its capacity. As against this, Knapsack Sprayer is a more efficient and useful Sprayer. However in some parts of the country Hand Compression Sprayers are still being used in preference to Knapsack Sprayers mainly due to the fact that they are not aware of these limitations of Compression Sprayers and about the advantages of Knapsack Sprayers.

Usually a team of two people is required for operating either a Knapsack Sprayer or a Hand Compression Sprayer. One person

Table 1. Various details noted during field trial

1. Type of Sprayer.	Hand Compression Sprayer.	Knapsack Sprayer.
2. Brand Name:	Marut 12.5 lit.	Sikar-59.
3. Tank Capacity.	12.5 lit.	16 lit.
4. Filling Capacity.	8.2 lit.	16 lit.
5. Filling Time.	2 minutes.	2 minutes.
6. Strokes required for pressurising.	55 strokes.	8 strokes.
7. Time required for pressurising.	1.5 minutes.	0.5 minutes.
8. Charged Pressure.	50 psi.	45 psi.
9. Nozzle Data.	450 cc/min. & 60° cone angle.	450 cc/min. & 60° cone angle.
10. Strokes required per minute to maintain spraying pressure at 40 psi.	Not tried.	6 to 8 strokes per minute.
11. Time required to empty full charge of the Tank.	$27\frac{1}{2}$ minutes.	37 minutes.
12. Effective swath width in feet.	Varied from 20" to 21".	19" to 21".
13. Spraying speed.	1.5 miles/hour.	1.5 miles/hour.

Table 2. Data obtained from field demonstration with hand compression srpayer and knapsack sprayer

At the end of minute.	Hand Compression Sprayer Marut 12.5 LIT.			Knapsack Sprayer Sikar-59.		
	Discharge in CC/min.	Tank PSI.	Discharge Pressure in PSI	Discharge in CC/min.	Tank PSI.	Strokes per minute.
1.	480	42	39	470	45	8
2.	430	38	32	450	45	7
3.	410	35	30	430	35	6
4.	390	33	28	455	40	7
5.	380	30	25	470	45	8
6.	370	28	33	452	40	7
7.	360	25	20	438	35	6
8.	350	23	20	455	40	7
9.	340	22	19	475	45	8
10.	330	21	18	450	40	7
11.	320	20	17	430	35	6
12.	310	18	15	450	40	7
13.	300	16	13	470	45	8
14.	295	15	12	455	40	7
15.	290	14.5	11	435	35	6
16.	285	14	11	455	40	7
17.	280	12	9	465	45	8
18.	275	12	8.5	445	40	7
19.	270	11	8	425	35	6
20.	265	10.5	7.5	450	40	7
21.	260	10	7	470	45	8
22.	250	9	6	450	40	7
23.	245	8	5	430	35	6
24.	240	8	5	448	40	7
25.	230	8	5	472	45	8
26.	225	8	5	445	40	7
27.	220	8	5	425	35	6.
27.5	100	8	5	From 28 minutes to 37 minutes the above type of pattern has been found.		

is engaged in operating the Pump and another person is engaged in preparing the chemical and helping the operator. For practical demonstration, both the Sprayers were operated one by one with a team of two people for one charge only. In Hand Compression Sprayers, the spray chemical was filled to 2/3 the overall capacity and 1/3 space was kept for charging air. In Knapsack Sprayers, there is no need of keeping space for air and as such it was fully filled.

Knapsack Sprayers or Hand Compression Sprayers are usually supplied with cone nozzles, having discharge rate of 450 cc/min. and 60° cone angle at 40 psi. For spraying purpose the following procedure was adopted.

a) Spraying work was carried out between 35 to 45 psi., (especially for Knapsack Sprayer).

b) Spraying height was kept between 18" to 20". The swath width of cone nozzles having working pressure of 40 psi., and spray height of 18", will be 20".

c) Spraying work was done at a speed of 1.25 m.p.h. to 1.5 m.p.h.

A graph has been drawn from the tabulated results obtained by field demonstration. From the graph the following observations are made:—

1. Spraying pressure

In case of Marut Hand Compression Sprayer it was falling down minute by minute. In the beginning it was 50 psi., and at the end it was 5 psi. This is abnormal. In case of Sikar-59 Knapsack Sprayer it was fluctuating between 45 psi. to 35 psi. This is quite normal.

2. Discharge rate.

In case of Marut Hand Compression Sprayer it started reducing minute by minute. In the first minute it was 480 cc/min., and at the end it was about 200 cc/min. In 27.5 minutes 8.2 litres of liquid was discharged. This means that the average discharge rate per minute was about 300 cc/min., which was very much below the nozzle specified rate.

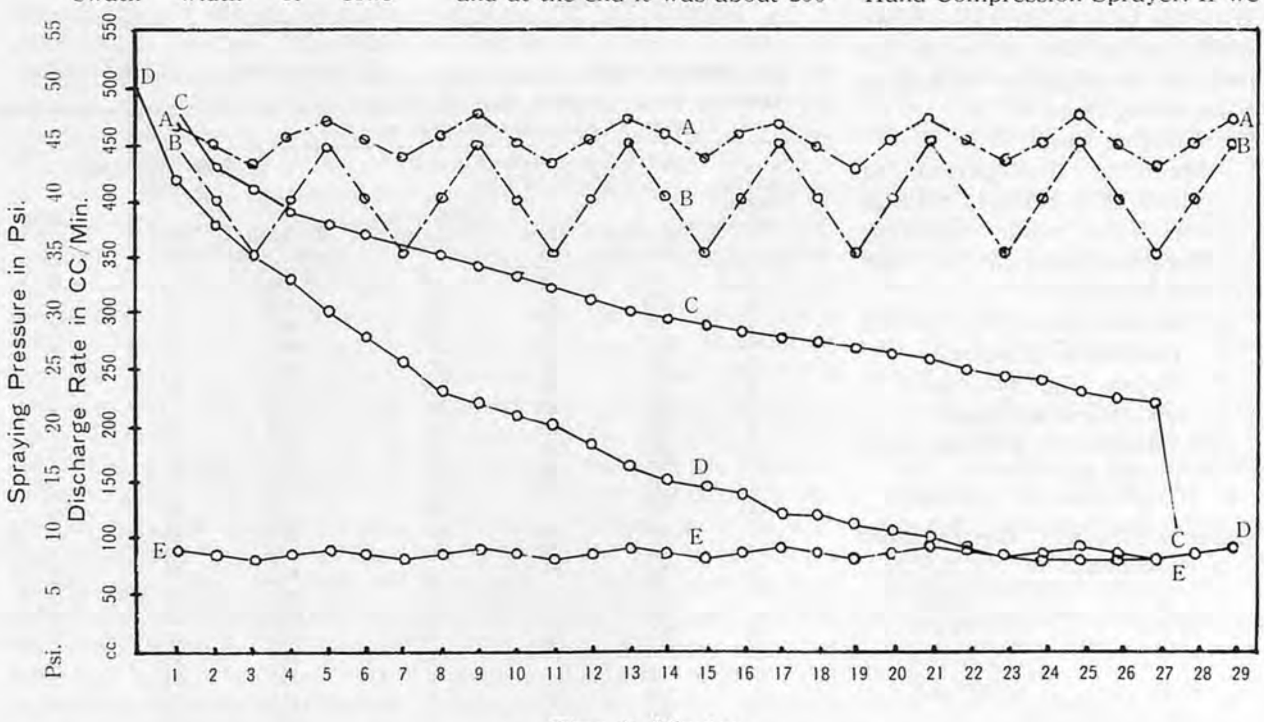
In case of Sikar—59 Knapsack Sprayer it was fluctuating between 475 cc/min., to 430 cc/min. In 37 minutes 16 litres of liquid was discharged. This means that the average discharge rate per minute was 430 cc/min. This discharge rate is in the tolerance range.

3. Swath width:

In Marut Hand Compression Sprayer, due to the fluctuation in spraying pressure, it has fluctuated from 20" to 12".

In case of Sikar—59 Knapsack Sprayer, it was between 19" to 21". This is quite normal.

Thus the spraying work done by Sikar—59 Knapsack Sprayer was more uniform than by a Hand Compression Sprayer. If we



Graph Line A - Shows discharge rate in cc/min. of Sikar-59 knapsack sprayer in relation with time.
Graph Line B - Shows spraying pressure in psi. of Sikar 59 knapsack sprayer in relation with time.
Graph Line C - Shows discharge rate in cc/min. of Marut 12.5 lit. hand compression sprayer in relation with time.
Graph Line D - Shows spraying pressure in psi. of Marut 12.5 lit. hand compression sprayer in relation with time.
Graph Line E - Shows number of strokes required per minute to maintain spraying pressure for Sikar-59.

want to get uniform spray pattern by a Hand Compression Sprayer, then the Hand Compression Sprayer has to be re-charged in between during the spraying operation. This will consume more time. Thus the working efficiency of a Hand Compression Sprayer will be reduced. To obtain maximum efficiency in plant protection, it is essential to select Sikar—59 Knapsack Sprayer, which is producing better automzation and spraying at uniform application rate.

We can find out the application rate per acre and the time required to cover one acre of land, by the data as explained above.

To find out the application rate per acre we have to use the following formula:

$$\text{Application Rate in CC. per Acre} = \frac{\dfrac{495\ \text{(constant figure)}}{\text{Effective swath width in feet.}} \times \text{Nozzle Discharge Rate in CC/Min.}}{\times\ \text{Spraying speed in miles/hour.}}$$

By substituting the obtained data from **Table 1**, in the above formula, it can be worked out as under:—

$$\text{Application Rate in CC. per Acre} = \frac{495 \times 450}{20/12 \times 1.5}$$

Application Rate in CC. per Acre. = 89,100 CC.

= 89.1 Litres

To find out the time required to cover one acre of land, we have to use the following formula:—

$$\text{Time required to cover one acre of land in hour.} = \frac{\dfrac{8.25\ \text{(constant figure)}}{\text{Spraying speed in miles/hour.}}}{\times\ \text{Effective Swath Width in Feet.}}$$

By substituting the obtained data from **Table 1**, in the above formula, it can be worked out as under:—

$$\text{Time required to cover one acre of land in hour.} = \frac{8.25}{1.5 \times 20/12}$$

Time retuired to cover one acre of land in hour. = 3.3 Hours.

= 198 Minutes.

The application rate obtained by the formulas for the types of Sprayers in terms of "Litres per Acre" and "Acres per Hour", are based on LAND AREA and not SPRAYED AREA. In these cases the application rate, Litres per Acre means spray chemicals required to cover one acre of land or LAND APEA. if the application rate for SPRAYED AREA is to be found out, then it will depend on the crop spacing and its growth. It will also depend on the type of spraying.

If the application rate found by calibration is not as per the requirement, then it can be-changed by various ways.

1. If higher application rate is required, then increase the nozzle discharge rate, or reduce spraying speed.
2. If lesser application rate is required, then decrease the nozzle discharge rate, or increase spraying speed.

To obtain the desired application rate, we have to adapt a trial and error method, as described above.

To calibrate the spayer for spraying trees of bushes, one should find out the liquid consumed in spraying the leaves to stage of uniform dripping, for one number. From this figure the rate per trees or per acre can be calculated.

Many chemicals are recommended in terms of the concentration of solution to be applied in order to control the pests and diseases perfectly. In such cases the trial run as described above should be made to find out how much liquid is required and at what speed the machine should be operated and spraying work should be done to obtain the correct coverage and concentration. In high volume application to get the correct coverage the leaves must be sprayed in such a way that they just begin to drip and care should be taken that there should not be any pronounced run-of. In low volume application individual leaves must be inspected to get the correct application.

There are various calibration methods. The mathematics involved in different methods are not complicated. It should be noted that it should be accurate, easy and fast.

I. Formula method.

Spraying should be carried out for a test run of 200 ft. Select the area for test run similar to the field to be sprayed. The sprayer tank should be filled and the water level should be marked. Spraying operation should be carried out for test run of 200 ft. at the prescribed or set pressure, and at the constant spraying speed. (In a normal practice spraying work a carried out at 40 psi; and 1.5m.p.h.) At the end of a run re-fill the sprayer tank and find out the amount of water that has been used in litres. Use the formula to find out the application rate:

$$\text{Application rate in Litres/Acre.} = \frac{217.8\ \text{(Constant figure).} \times \text{Amount of water sprayed in test run of 200 ft. in litres.}}{\text{swathe Width.}}$$

II. Tabular method.

III. Graphical method.

IV. Slide rule method.

The last three methods have not been described this article, as they are a bit complicated for our farmers. ■ ■

Topics on and around Post-Harvesting Stage of Rice

Is Small Rice Mill Wastefull ?

by
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Preface

It was several years before that they discussed about "the second stage of green revolution" or rationalization of post-harvesting process of food grain. Wastage of food grain during the processes after harvest and before cooking is estimated to be over 20% and sometimes it amounts as much as 50% in developing SE countries (see APO reports).

All of such wastage not only annuls materials and toils invested for the production proportionally but also it means to throw the fertility of soil away the field. If this should be innevitable, it had better happen in the field before the harvest.

However it is by no means innevitable. The percentage of wastage and loss of food grain in the post-harvesting process greatly differs by countries and localities. It is a matter of technology and its application, even though it is closely associated with the socio-economic situation as is usual with agricultural technology. What we regret for this is that academic research and study have been rather scarce in this field compared to that of farming works for growing plant.

In the case of Regarding to the post-harvesting technology of grain, it has to be understood that great difference exists between that of wheat and rice. The former being grown in dry or arid zones, there is little problem for the drying and the storage. And the technology of the milling have been studied over 5000 years intensively in western countries. On the other hahd, the latter, rice, whose majority is grown and processed in Asia where humid climate prevails and whose industries have not developed well, has been totally left in the hand of small farmers and the traders. It is a combination of adverse conditions and negligence. Small unit of the production, less extent of commercialization and less degree of required processing might have fostered such a drift. It is quite clear that it enhance various problems to be solved. It is explicitly shown on the above figures of the percentage of wastage.

Suppose only some of such wastage should be cut off, then most of Asian countries need not spend millions of dollars annually for their importation of rice but can keep surplus of rice for the emergency, because their difficiency is nothing but few percents' difference between their production and the demand. The very fact of difficiency, even though it is small proportion, makes their internal supply unstable and necessitates importation, as rice is the vital food for those people.

Of course supply of rice can be increased by increase of the production also. However, besides what we discussed above, expansion of paddy field costs enormously specially in the marginal area and any improvements in the productivity of land cannot be attained without much cost. Compared to these, reduction of wastage can be much cheaper to attain the same result.

This is the ground for our starting this column, "Topics on and around post-harvesting stage of rice". It may not offer complete solution for all of the various problems of post-harvesting process of rice. But it at least aims to attract readers' eyes to this problem so as to stimulate further discussion and study.

Is Small Rice Mill Wasteful ?

In some of developing countries, it is often argued that small scale rice mills are wasteful and had better not be allowed to set them up. The main ground of such an arguement lies in the fact that small scale rice mills are liable to give lower milling recovery of rice compared to large scale ones.

Form such a point of view, setting up of small rice mills is sometimes discouraged by authorities in some of developing countries. This might appear to be a manifestation of an effort to improve rice processing and its circulation.

In term of small scale rice mills, they mean those rice mills whose milling capacities are less than one ton per hour and are composed of one or more number of huller (sometimes called "Engelberg" type, kiskisan or planter's mill, etc.) or other types of husking and whitening units.

Fig.1. An example of small rice mill in Pakistan. A gang of hullers are arranged.

Fig.2. Huller: it is marked it was manufactured in 1884. Probably this was re-moulded from the original.

And in term of large scale rice mills, they mean integrated rice mills which are composed of several numbers of independently functioning machines such as paddy cleaners, paddy huskers, paddy separators, rice whiteners, graders, etc.

In most cases, the former, small scale rice mill, give much inferior milling recovery compared to the latter, large scale mills. This is attributable to the fact that the most of old-fashioned small rice mills are of huller type.

As is well known, hullers have long been manufactured and used in small rice mills extensively since the last century almost without any modifications. This machine peforms its function to husk and whiten paddy into white rice in the same cylinder all at conce by exerting high and accute pressure to grain. This inevitably lowers the milling recovery extremely, i.e. not only the overall recovery (rate of recovered quantity of all of white rice to paddy) is poor but the head recovery (rate of retained head rice or whole grain to all of white rice) also very low. It is quite natural that some of the governments banned the production of hullers.

However, the milling recovery of newer types of small rice mills need not be inferior always if proper types of husking and whitening units be employed in place of hullers, even though it cannot cope with large rice mills in regard to the labour productivity. Actually it is not rare cases that small rice mills with advanced machines surpass large but obsolete rice mills in performance.

Fig.3. An example of advanced husking-whitening unit to be used by small rice mills. (Capacity: 200kg/h on paddy in above photo, capacity: 500kg/h on paddy in below photo.)

This fact being confirmed, it is not necessary or rather wrong to discourage setting up of small rice mills unanimously on account of inferior milling recovery.

Apart from such a discussion from a technical point of view, still there lie some other significant problems to be considered. They are socio-economic problems.

When farmers bargain with rice dealers, middlemen or rice collectors who are working for large scale rice mills, their standpoint is quite weak. The price of paddy is apt to be decided almost one-sidedly. However, if farmers can sell their paddy throgh their own rice mill, their economic situation must be greatly improved. Small rice mills can be set up by an agricultural cooperatives and they really do exist in Southeast Asia in considerable mumbers.

It is universal truth that producers get more profit on selling their products by processing more.

Or even they sell their paddy to privately-owned small rice mills directly, still their position can be much stronger than to fewer number of rice dealers, etc. Farmers can choose any small rice mill whoever gives best price.

Thus, existance of small rice mills by no means contradicts to the benefit of farmers, even though it may to that of large scale rice mills. As a nature, large scale rice mills tend to live on speculative profit from the difference of buying price of paddy and selling price of white rice, while small scale ones on their marginal profit from milling charge. Therefore, the former tries to beat down the price of paddy as much as possible and the latter tries to assure suppliers to them with reasonable buying price.

Another point may be added to defend small rice mills. Other than milling loss discussed above, there always exist handling loss which accompanies to bagging, collection, transportation, storage and all other handling. This is produced more by large rice mills, counting all of that starting from field to final storage of white rice, due to its lengthy transportation, handling and storage. On the other hand, small mills collect paddy from short distance, process it rather quickly and sell white rice on the spot. Most of handling loss of rice is supposed to occur durind paddy stage.

Summing up all of above, there can be no reason to blame or reject small scale rice mills as far as they are of advanced type.

■ ■

We have mentioned about the subject "Is Small Rice Mill Wasteful?" in "Topic on and around Post-Harvesting Stage" this time. We are planning to take up following subjects in the next issues, from Vol. VII, No.3 Summer 1976.

1) Significance of Mechanization of Rice Processing
2) Health in Place of Medicine
3) Key-factor for Milling Recovery Improvement
4) Overlooked Importance of a Process
5) Heart of Rice Mill
6) Rice Mill Designing
7) Paddy Drying
8) Storage of Paddy and Rice
9) Rice Processing Complex

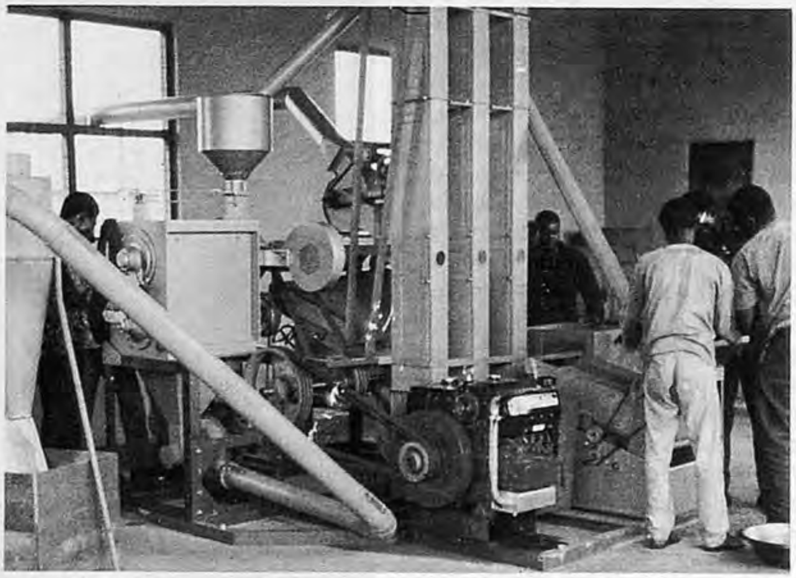

Fig.4. An example of advanced small rice mill used in Nigeria (Capacity: 1000kg/h on paddy)

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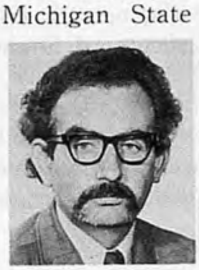
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Introduction

In the past decade or so, considerable efforts have been made to promote the mechanization of farming operations. The pace is slow, however. For one thing, the development of agricultural machinery/implements has to consider their adaptability to the local conditions such as climate, types of land and soil, and kinds of crops; for another, farmers' readiness to adopt mechanical farming is also something to be reckoned with.

With the exception of pedal threshers, paddy-field weeders and improved animal plows, which are all modified versions of those introduced from Japan, most of the farm implements used in Taiwan are exactly the same as those in mainland China.

For several centuries there had been very little change in the designs of farm implements. However, shortly after its inception in 1952, the Joint Commission on Rural Reconstruction (JCRR) drew up a blueprint for agricultural mechanization. Since then, steady progress has been made in this regard.

In 1965 or so, after the implementation of three successive 4-year economic development plans, Taiwan's agriculture began to turn to a new phase which marked an end of labor slack in the face of rapid industrialization. Under the government policy of stepping up industrial development, it experienced a labor shortage for the first time in its history. This change has hastened the tempo of agricultural mechanization, however.

This paper attempts to describe briefly the process of agricultural mechanization in Taiwan and the problems related there to.

Background and Farming Conditions

Land and Soil

Taiwan is a province of the Republic of China. It comprises Taiwan proper, the Pescadores or Penghu Islands, and a number of offshore islets, with a total area of 13,885 square miles. The island of Taiwan is 246 miles long and 90 miles broad at the widest points. Latitudinally, it lies athwart the Tropic of Cancer which cuts across the south of Chiayi city.

The Central Range divides the island into the east and west parts. In the west there spread gentle slopes and fertile plains, while in the east the terrain is rugged with numerous steep slopes. Mountains and foothills cover approximately two-thirds of the island, and most of the cultivated land is located in the west part of the island.

Of the total 917,000 hectares of cultivated land, some 540,000 hectares are paddy-fields. The rice crop is usually grown on the alluvial soil either in the plain or along the river valleys. The paddy soil of slate and sand-stone origin is rich in plant nutrient, while those of saline alluvium is generally inferior in soil fertility. Rice is also grown on the lateritic soil of the tableland where irrigation is available.

Generally speaking, most of the soil in Taiwan is of loamy texture, and sandy soil is confined largely to a limited area along the sea coast. The heavy soil of slate and mudstone parent materials seldom contains over 40 per cent of clay particles. Therefore, with a few local exceptions the soil in Taiwan poses no or little problem to the utilization of agricultural machines.

Climate and Water Resources

The annual mean temperature is 21.6°C at Taipei in the north and 24.3°C at Kaohsiung in the south. The highest temperature recorded was 38°C and the lowest 1°C. In the summer months, the temperature along the island's entire coast is about the same (around 28-30°C). The summer time usually extends from May to September, while winter is short and mild, lasting only from December to February.

The monsoons usually bring in enough rainfall, averaging

2,500mm a year. Its distribution, however, does not fit in well with the growing seasons of rice on the island as a whole. Roughly speaking, the high mountain range lying between the Suao township (east coast) and the mouth of the Ta-an River (west coast) divides the island into two different regions insofar as the rainly season is concerned. In the northern part, a strong northeast monsoon blows steadily during the period from October to March, bringing to this area sufficient rainfall, thus facilitating the growing of rice; but, if the long-drawn rainy days stretch into the harvest season, it may cause various degrees of grain loss. In the summer months, when southeast monsoon prevails, abundant rainfall in all parts of the island furnishes the second crop of rice with ample irrigation water.

It is estimated that a total of 8,800,000,000 cubic meters of rain water fall on this island annually. Of this amount, about 21 per cent has been harnessed for irrigation and/or for power generation. Well-developed reservoirs and canal systems are now under the administration of a total of 16 irrigation associations, mostly in the southern part of the island. About 92 per cent of the planting acreage of 780,000 rice-growing hectares is irrigated (including reservoir and deep well irrigation), while the remaining 8 per cent is rain-fed.

The warm temperature and adequate rain-water affect the rice culture greatly, and so the climate also has something to do with the adaptability of agricultural machinery.

Small-sized Farms

The land holdings per household in Taiwan average only about one hectare in size as shown in **Table 1.**

A unique feature of land holdings in Taiwan is that a farm does not necessarily consist of one single plot, but in a number of plots averaging about 0.1-0.2 hectare per plot. This is due partly to the centuries-old custom of all the sons going shares in the land holdings handed down from their father.

Small-sized plots and a labyrinth of foot-paths in the paddy-fields render the agricultural machinery extension work exceedingly difficult. Thus, the large-scale consolidation of crop fields into large-sized plots is necessary. Under the government program of land consolidation in recent years, about 300,000 hectares of small paddy-fields have been consolidated and 100,000 hectares more are scheduled to be consolidated within the decade so as to facilitate agricultural mechanization.

Multiple Cropping Systems

Since the implementation of the land-to-tiller program in Taiwan in 1953, the tenant farmers who have become land owners have been working doubly hard, thereby increasing greatly the land productivity. This psychological factor is applicable to the ownership of agricultural machines as well. When a farmer owns a machine, he will take good care of it and try to use it to its fullset extent.

In Taiwan, many crops other than rice are raised by rotation. In the rice-growing areas, wheat, tobacco, soybean, flax, sweet potato, peanut, corn, sorghum, jute, etc. are also grown. Therefore, farmers need a multi-purpose machine to work not only in the paddy-fields but also in the fields for raising other crops, as the existing cropping systems require relay-interplanting cultivation after a preceding crop has been harvested. However, due to increasing farm labor cost, the intensiveness of the cropping system has decreased somewhat in recent years, as shown in **Table 2.**

Development and Extension of Agricultural Machinery

Before 1952, except for the introduction of pedal threshers from Japan, for about three centuries agriculture in Taiwan remained almost unchanged as far as the utilization of agricultural machinery and/or implements by farmers is concerned. The movement of adoption of power machinery in individual farmlands started with the importing of garden tractors and power tillers from the United States and Japan since 1954. Then, it continued on with the manufacture of power tillers in 1958 by 22 small local machine shops. Since 1961, with the establishment of bigger agricultural machinery plants, domestic production of power machines has been stepped up.

Up to 1965, the agricultural mechanization movement had

Table 1. Number and size of rice farms in Taiwan

Size of Land Holdings	1960		1970	
	No. of Rice Farms	%	No. of Rice Farms	%
Under 0.5 ha.	179,760	30.3	242,473	38.8
0.5–1.0	185,940	31.3	188,081	30.1
1.0–1.5	103,730	17.5	91,247	14.6
1.5–2.0	57,190	9.6	47,924	7.7
2.0–3.0	45,210	7.6	36,111	5.8
3.0 ha. & over	22,240	3.7	19,234	3.1
Total	594,070	100.0	625,070	100.0

Table 2. Changes of multiple cropping index in Taiwan

Year	1953	1957	1961	1965	1969	1974
Index	173	179	182	185	184	179

been centered on encouraging the farmers to adopt power tillers to replace draft animals for land preparation. Since then, with Taiwan's economy entering another phase of development after the implementation of three economic development plans, the emphasis in agricultural mechanization has been gradually shifted to replacing men with machine power. Under the government policy of rapid industrialization, the emigration of rural labor has accelerated and agriculture for the first time has experienced a labor shortage. Hence, laborsaving machines, such as rice transplanters, power sprayers and rice combine harvesters, have been adopted. It is planned that in the years to come, new cultural methods and newly developed agricultural machines will replace old ones and all the farming practices will be mechanized.

A brief account of the development of the various kinds of agricultural machinery and their adoption by the farmers follows:

Power Tiller and Tractor

Early in 1953, when the first 4-year agricultural production plan was initiated, there were some 400,000 head of draft animals, most of which were water buffaloes. The number of cattle was not enough, as some 100,000 more head were needed for intensive cultivation. However, it was very difficult to get the required number of animals in a short time. Even if it were possible, each animal would need 0.8 hectares of land for growing feedstuffs, and so a total 80,000 hectares must be diverted from food-growing when more and more land was needed for feeding the teeming millions on the island. And when the total amount of work done during the lifetime of a buffalo is tallied against the total cost involved, it is far obvious that animal power is from economical as compared with mechanical power. Therefore, only through using agricultural machines and implements can the problem of rural power shortage be solved once for all.

As an attempt to solve the problem of anticipated labor shortage, seven different makes and medels of garden tractors in the power range of 1.5—10 hp were introduced into Taiwan by JCRR from the United States in 1954. In the following year, a 5 hp rotary-type and a 2.5 hp tiller-type single-axle, two-wheel tractor now called "power tiller" were purchased from Japan. They were tested at various agricultural research and improvement stations and agricultural schools, thus marking the beginning of power tiller extension in Taiwan.

The rotary-type tiller was the typical diesel-engined tiller developed and widely used in Japan over the past three decades. A smaller one called "Merry tiller" was originally an American design but remodelled and improved for use in irrigated paddy-field in Japan. It is compact and light and simple in construction. In the preliminary field tests, both of the machines showed their outstanding performances in irrigated rice fields, especially the smaller one which has found acceptance with the local rice farmers, because its high versatility and low cost. Moreover, it can perform various farming operations, such as tillage, transportation and cultivation.

In 1956, JCRR again imported 13 small Merry tillers for testing and demonstration at the various agricultural stations. During the demonstrations, local farmers showed at the onset an interest in the machine, and their demand for it became so strong later that the local machine factories began to produce the machine by copying the imported models. Several small farm machine shops also added this machine to their manufacturing lists. A number of plants formally making motorcycles or small oil engines started producing power tillers as a sideline. Up to 1958, a total of 22 small factories came into being and began producing power tillers. Most of them concentrated on making the tractive-type power tillers, with only two plants producing the driven-type rotary tillers.

In the meantime, the imported power tillers increased to 16 different brands including some 200 Marry tillers imported by the Taiwan Provincial Farmers' Association, offering a strong competition to the local manufacturers.

However, small factories whose products were of doubtful quality and some of whom built only a few units, soon found themselves in financial straits. Thus, owing to insufficient operating funds and for lack of proper manufacturing techniques, all the local manufacturers, except two, either went bankrupt or changed to making other products at the end of 1960. The two remaining manufacturers have managed to turn out a small number of power tillers each year. In 1961, two groups of Taiwan industrialists, in cooperation with Japanese agricultural machinery companies, set up two factories to produce power tillers with some parts imported. From that time on, the import of power tillers, except spare parts, stopped altogether.

In Taiwan today, Mechanization of land preparation is no longer in its experimental stage but has become well established. The wide use of power tillers is a good example. They are mostly used in paddy-fields, especially on water-logged soil which adds traction to rather than retard the propelling unit of the machine. Before the end of 1974, a total of 42,123 units of power tillers were used. On the basis of 917,000-hectare cultivated land and 877,000 farm households, there was ap-

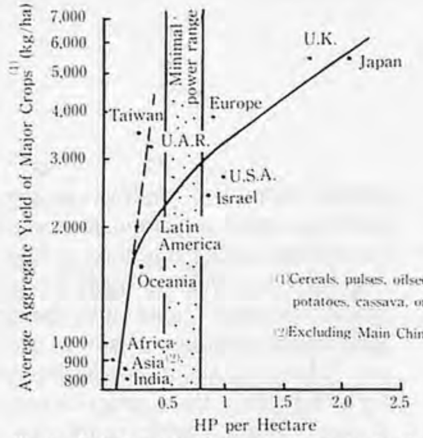

Fig.1. Relationship between yield in kg/ha and power in hp/ha (Source : President's Science Advisory Committee, "The World Food Problem", Vol. II "Washington: U.S. Government Printing Office, May 1967).

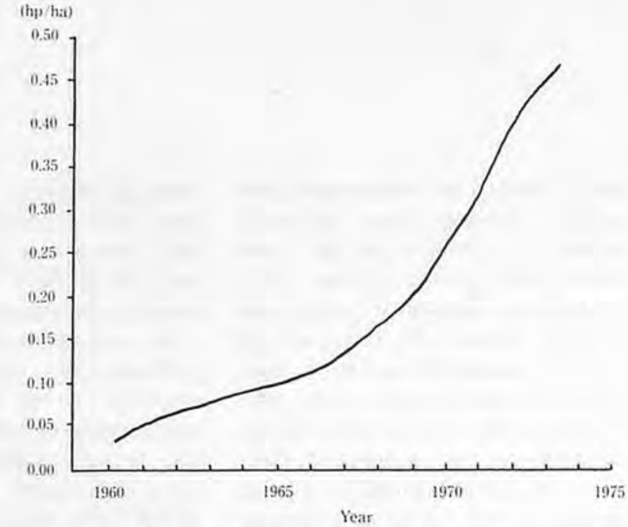

Fig.2. Available hp/ha of arable land in Taiwan.

proximately a power tiller among every 20.8 farm households for every 21.8 hectares of land. With the power tillers increasing, the draft cattle have since 1966 decreased in number at the rate of about 20,000 head annually (**Table** 3).

On the other hand, power tillers have been getting bigger and better with their maximum horsepower raised to 18 hp in the past four years and their prices lowered in terms of per unit of horsepower (**Table** 4). This trend has led the farmers to replace obsolete machines with newer ones so that they can work more efficiently.

While power tillers remain the backbone of mechanized rice-farming, small Japanese-made tractors of 25 hp or so are also used by local farmers and big wheel tractors with a maximum of 70 hp have been introduced into Taiwan. In 1971, about 500 hectares of paddy-fields were prepared by tractors equipped with rotary tillers under a demonstration program conducted by the Taiwan Sugar Corporation and the Taiwan Seed Service. Since then, a small number of farmers as well as township farmers' associations have begun to adopt this more efficient implement.

Since power tiller and tractor are the prime mover of agricultural mechanization, their available horsepower per hectare of cultivated land may reflect the progress or extent made in this regard. A study on "The World Food Problem" conducted by the President's Science Advisory Committee of the United States in 1967 reported the horsepower available per hectare for differnt regions as shown in **Table** 5 and **Figure** 1.

According to the same study, the higher input horsepower per hectare, the higher yield of crops will be achieved (**Figure** 1).

The input of tractor power per hectare in Taiwan has increased rapidly in the past years. At present, an estimated 0.46 hp/ha is available (**Figure** 2). It is very close to the minimum power range as shown in **Figre** 1.

Roughly speaking, about one half of farming operations in Taiwan have been mechanized insofar as tillage is concerned.

Seeder and Transplanter

Rice transplanting is still done manually in Taiwan. To facilitate the operation, only a rolling disk-type marker is available for marking both directions across the field for straight planting. It is nevertheless a backbreaking and time-consuming job. According to a study on the labor-hour requirement for eleven kinds of crops conducted by the Agricultural Engineering Department of the National Taiwan University, about 19 per cent of the total labor hours required for rice cul-

Table 3. Number of power tillers and draft animals in Taiwan

Year	Number of Power Tillers (unit)	Number of Draft Animals (head)
1955	9	412,018
1960	3,708	417,122
61	5,313	414,208
62	7,504	405,056
63	9,079	389,448
64	10,201	379,973
65	12,213	370,370
1966	14,272	360,294
67	17,240	337,878
68	21,153	323,085
69	24,640	305,237
70	28,292	275,007
1971	32,030	245,109
72	35,222	227,077
73	38,393	204,620
74	42,123	194,906

Table 4. Changes in average prices of power tillers

Year	Average price NT$/hp	Adjusted by price index		Year	Average price NT$/hp	Adjusted by price index	
		NT$/hp	%			NT$/hp	%
1961	5,217	5,553	106	1968	4,437	4,039	77
1962	5,216	5,423	104	1969	4,479	3,881	74
1963	5,196	5,288	101	1970	4,546	3,807	73
1964	5,039	5,137	98	1971	3,805	3,105	59
1965	5,348	5,455	104	1972	3,707	2,851	55
1966	5,228	5,228	100	1973	4,447	3,003	57
1967	4,820	4,663	89	1974	5,000	2,564	49

Table 5. Available horsepower per hectare of arable land by region

	Asia*	Africa	S. America	U.S.	Europe
Tractor	0.02	0.03	0.18	1.00	0.78
Power tiller	0.03	0.00	0.00	0.014	0.02
Draft animal	0.09	0.01	0.05	0.00	0.08
Manual labor	0.05	0.01	0.04	0.003	0.05
Total	0.19	0.05	0.27	1.02	0.93

*Excluding Japan and Mainland China.

ture is devoted to transplanting operation.

During the transplanting seasons, farmers are usually faced with the problems of labor shortage, as the labor force in the rural areas has been gradually absorbed by the mushrooming industry. However, attempts at supplementing manpower with machinery have shown good promise.

In 1966, JCRR assisted the Taipei District Aaricultural Improvement Station in modifying two Japanese rice transplanters—a motor-driven type and a hand-pushing one—according to the actual needs and agricultural conditions. The preliminary results obtained from the experiments conducted in 1967 were very encouraging, as the transplanter can save two-thirds of the labor required for seedling nursery, and is four times quicker than hand trans-planting. In addition, the yield in the mechanically-transplanted plots was higher than that of the hand-transplanted plots. Presumably the increase was due to: a) healthy seedlings; b) uniform planting depth of seedlings; c) wide-row and close-hill spacing; and d) even number of hills.

The use of transplanter is also helpful for the extension of the newly developed wide-row and close-hill planting system in rice culture, which is capable of increasing the rice yield by more than 10 per cent as compared with the commonly practised square-shaped spacing.

In order to accelerate the general adoption as well as to show the advantages of using the transpanter, JCRR and the Provincial Department of Agriculture & Forestry (PDAF) jointly helped the local township farmers' associations and groups of farmers to grow healthy seedlings in a cooperative manner. About 30 nursery shelters each supplying 30 ha. of seedlings have been constructed in northern Taiwan. Up to the present, about 2,500 units of the transplanters have been adopted by rice farmers (**Table 6**). Judging from the good results of using the machine, it is predictable that mechanized transplanting of rice can be extended widely in the near future.

Besides hand transplanting, direct seeding for the second rice crop has also been adopted. About 3,500 hectares of paddy-fields are directly seeded with some 480 seeders annually. The seeders are locally developed. They are of manual-pulling type and simple in construction. Hence, a 6-row seeder costs only NT$1,300 or US$34.

On the other hand, several kinds of planters for dryland crops have been imported and/or locally developed for demonstration purposes. Among them is a local-made peanut planter which is equipped with a belt-type seed metering device and has shown promising results in a preliminary field test.

Water Pump

Water pump was introduced into this island from Japan about 50 years ago. However, its usage is somewhat different from other countries on account of the intensive farming patterns adopted, since rice fields have to be irrigated or drained very often in order to grow assorted crops. Sometimes large pumps are used, but most of the time small centrifugal pumps driven by 3-5 hp kerosene or diesel engines can serve the purpose better, as they can be easily moved from one place to another. When farmers began to realize the advantages of using water pumps, several small machine shops were engaged in producing the machines by importing oil engines from Japan. This is considered the beginning of agricultural machinery manufacture in Taiwan.

After World War II, the local machine manufacturers turned out about 2,000 units of pumps annually to meet the local requirements. At present, estimatedly about 120,000 units, including deep well pumps, are owned by farmers for irrigation purposes (**Table 6**). Now more than a dozen local manufacturers are producing water pumps for local use and export.

Sprayer

Some 20 years ago most sprayers and dusters in use were imported from Japan, although there was a government-operated plant turning out hand sprayers on an experimental basis and a total of 874 small family-sized factories or machine shops

Table 6. Number of major agricultural machinery in Taiwan

	1960	1965	1970	1971	1972	1973	1974	June 1975
Power tiller	3,708	12,213	28,292	32,030	35,222	38,393	42,123	45,470
Tractor	—	—	107*	133*	139*	257*	892	1,323
Rice transplanter	—	—	280	454	658	972	1,914	2,471
Power sprayer	317	4,489	17,820	27,038	25,309	43,176	45,399	—
Water pump	8,378	32,107	52,794	61,660	65,755	112,998	119,905	—
Rice thresher	177,338	205,784	186,398	195,784	196,637	177,714	135,158	—
Power thresher (with cleaning device)	—	—	—	—	146	316	379	1,205
Grain dryer	—	150	198	214	361	708	1,008	1,303
Rice combine	—	—	20	75	154	329	1,127	1,792

*Excluding tractors of the Taiwan Sugar Corporation.

engaged in the manufacture of hand and animal-drawn tools. In fact, chemical spraying for control of rice insects and diseases was not widely practised until Parathion and Endrin came into wide use for controlling rice borers in 1955. Since then more than a dozen private factories have been established to manufacture both sprayers and dusters, including some power sprayer.

In 1974, about 200,000 sprayers, 20,000 hand dusters, and some 45,000 power-driven sprayers and dusters were owned by local farmers (**Table 6**). Since 1967, aerial pesticide applications over paddy-fields and banana plantations by mounting sprayers and dusters on helicopters were practiced by the government and farmers associations.

Weeder or Cultivator

In countries with large farms, weed control is not difficult in crop fields. However, in Taiwan, most of the weeding operation is still done by hand. The hand-operated rotary weeder originally introduced from Japan is now made exclusively in Taiwan for the sandy soil in which the paddy rice is planted in check-rows. However, due to the wider adoption of herbicides, the number of weeders in use remained around 40,000. Each weeder has one or two rotors mounted on a small-boat-shaped framework and a push handle. It can perform well on 0.3 to 0.4 hectares of paddy field per day.

Fertilizer Applicator

It is a common practice of Taiwan farmers to apply chemical fertilizer by hand. The fertilizer is put either in a basket or in a sack hanging on a farmer's shoulder by means of a strap. The farmer takes a handful of the fertilizer and scatters it by hand on the field as top dressing.

Up to the present, although there are some imported fertilizer applicators for dryland crops, no suitable ones are available for paddy rice. Chemical fertilizers used in Taiwan are mostly of straight types and in powder form. Application of them in mixture, thus, poses a technical problem. However, it can be applied by a mist-blower if granulated fertilizer is used.

Manure-spreading machine is lacking in local farming. The use of a manure fork is the only way to spread manure in the crop-field before plowing as compost manure is only used for basic application. The manure forks introduced from Japan about ten years ago are now mass produced by two tool factories for the local market as well as for export.

Harvesting Machine

In Taiwan, the paddy is still harvested with a small, light-weight hand-sickle. Pedal thresher with a threshing cylinder mounted on skids is pulled around the field to follow the reapers. One man can cut about one-half acre of paddy per day with a sickle, and two men with a pedal thresher can thresh two or three tons of paddy in a day. After threshing, the grain is carried to the courtyard for drying, winnowing and cleaning on a concrete ground.

Thresher driven by a small 3-5 hp gasoline engine instead of a pedal has been developed and widely adopted by local farmers in recent years. At present, there are about 135,000 rice threshers still being used in rural Taiwan. The figure is less than that of a few years ago, serving to show that more farmers have adopted the highly efficient power-driven threshers. Improved power threshers equipped with cleaning devices have been developed and extended to local rice farmers as shown in **Table 6**.

In 1967, two kinds of hand reapers, pushing and pulling, modified from Japanese-designed ones were manufactured locally for extension. However, they have not been extensively used due to higher grain loss and other drawbacks. So, the production of the reapers were soon abandoned. To make this device adaptable it will require either a new variety of rice or a change in the field size. As the present rice varieties in Taiwan were developed for threshing by manual labor, the straw is tough and flexible and the grain shatters very easily. Even a simple cradle can not be profitably used because the grain will be shatterd by the impact of the cradle fingers. Both the hand pushing and pullfng reapers were no longer in use. Meantime, a small number of power driven reapers or binders have been introduced from Japan for trial use.

In 1970, a number of small Japanese-made rice combines

Table 7. Construction of big grain-drying plants

Location	Drying capacity (tons/day)	Cost for the dryer (NT$)	Cost for the plant (NT$)	Main purpose
Neipu, Pingtung	30 (Corn and sorghum seed) 16 (Soybean)	3,670,000	5,820,000	Corn, sorghum and soybean seeds
Yuanchang, Yunlin	6 (Peanut) 30 (Paddy)	1,350,000	1,350,000	Peanut and paddy
Hsilo, Yunlin	120	2,270,000	1,790,000	Paddy
Lotung, Ilan	60	1,450,000	1,643,000	Paddy
Chiaohsi, Ilan	60	1,950,000	1,472,000	Paddy
Tungshan, Ilan	60	1,950,000	1,492,000	Paddy
Tachia, Taichung	60	1,950,000	1,458,000	Paddy
Tali, Taichung	20	530,000	350,000	Paddy

consisting of a reaper and an ordinary automatic power thesher were introduced by the local manufacturers for testing purposes. So far some 1790 small combines have been extended to rice farmers and there are two local manufacturers ready for production of such machines. However, there are still some shortcomings of the machine such as:

a. The grain shatters very easily as the cutting and gathering devices of the machine are not gentle enough to keep the grain intact.
b. The gathering mechanism of the machine fails to gather up all the lodging stalks.
c. Some rice-fields are too soft at the harvesting time to support the heavy machine.
d. The small, uneven rice-fields of Taiwan make the use of the combine less efficient as its working capacity is only 1/2 to 1 hectare a day.
e. The machine does not operate well, particularly with respect to its cleaning device when the moisture content of the grain is too high during such operating times as early mornings or after rainfall.

For the harvesting of dryland orops, the Taiwan Sugar Corporation has been widely adopting sugarcane harvesters; some 70 such harvesters have been imported from abroad in the past few years. Besides, JCRR has assisted the Tainan District Agricultural Improvement Station in importing several units of peanut combines with diggers drawn by tractors for a trial use in the tedious job of collecting ripe peanuts in the field. According to preliminary results, this mechanized operation not only could save much labor but also reduce the cost of production about 30% as compared with the conventional method.

Artificial Grain Dryer

It goes without saying that adequate rain-water hastens the growth of various crops, particularly rice. But when the long-drawn rainy days coincide with the harvest season, the full-grown rice in the field or the newly-harvested grains spread on the drying ground may sprout and sustain various degrees of damage.

According to an island-wide survey by the PDAF in 1954, the loss of rice grain per hectare due to spreading, turning, winnowing, etc. on the drying ground was 28.8kg. However, the actual annual loss throughout the whole island should be much higher, because the harvesting time of the first rice crop in southern Taiwan and that of the second rice crop in the north usually fall in the rainy season. When the rain comes in the midst of harvesting, the farmers have no choice but to pile their grain on the drying ground and cover it with straw and pray for the end of the foul weather. If the rain lasts for several consecutive days, the wet grain pile will gradually get warm as a result of heat accumulated through transpiration. The temperature in the center of the pile will thus go up, resulting formenting, sprouting or molding. Heavy damage to rice has been repeatly reported in the past decade.

In order to save a sizable amount of rice from spoilage by rain or high humidity, several types of rice dryers had been purchased from the United States by JCRR for testing purposes during the past decade. These are: a portable rice dryer made by the Behlen Manufacturing Co.; a column type rice dryer by the American Drying Systems, Inc.; and a small portable rice dryer by the American Drying Equipment Company. Preliminary tests revealed that the Behlen portable dryer entailed the lowest drying cost, while the other two produced rice of better quality. However, all the dryers are either too bulky or too expensive for the individual farmer to own. A lighter drying bin with a motor blower and a burner for artificial drying of rice was developed for extension by the PDAF experiment stations, in cooperation with the China Agricultural Machinery Co., Ltd. in 1966.

The bin-type artificial grain dryer is portable, weighing about 270kg. In the ordinary harvesting time, the grain dryer could reduce the moisture content of the grain from 20 to 13 per cent and turn out about 1,500kg. of dry rice every 12 hours. In rainy season, the dryer could even be operated 24 hours a day. The fuel for the burner of the dryer is kerosene, while its 1/2-hp motor blower uses electricity as source of power. Up to the present about 1,100 units of the dryer have been extended to local farmers for adoption. Meanwhile, some 200 units of circulation-type dryers of local made ones were also adopted by farmers in the first half of 1975.

In the meantime, several farmers' associations and some agencies concerned have constructed bigger dryers for commercial purposes (**Table 7**).

Grain Cleaning Equipment

Paddy grains after drying up have to go through a winnower once or twice before being sent to the market. The winnower is generally made of wood, but some factories are producing winnowers made of sheet metal. A revolving fan inside of it is cranked by hand to produce an air blast for removing the chaff, straw, dust and unripe grains. Plain bearings were usually used in the revolving mechanism. Only in recent years ball bearings have been adopted by the manufacturers. On an average, 180 hectoliters of paddy can be cleaned by a winnower on a one-run basis.

Since electricity is available in most of the rural areas, some winnower factories have developed an electric motor-driven winnower to replace the hand-cranked one. Some of them are even equipped with an auger elevator to transport the grain into the hopper of a winnower at higher speed with less labor.

Meanwhile, due to wider adoption of power threshers without cleaning units, a kind of grain and straw separation device has been developed locally and extensively used for cleaning the newly threshed grains. The separater equipped with a sieve and a blower driven by a $\frac{1}{4}$-hp electric motor can save lots of labor for cleaning the grain after the harvesting operation.

Processing and Handling Facilities

Rice hulling and polishing equipment is mostly operated by local farmers' associations and some businessmen to serve all the farmers in the respective areas. The machine equipped with an oil engine of 7 to 12 hp or $7\frac{1}{2}$-hp electric motor has a capacity of hulling and milling 2 to 4 metric tons of brown rice per hour. Recently, a number of smaller rice hullers and polishers have been adopted for individual and/or cooperative use by the farmers.

Meanwhile, many kinds of processing machines and facilities, such as jute decorticators, peanut shellers, corn shellers, sorghum threshers, etc., have been locally developed and extended to the farmers.

Problems Encountered in Agricultural Mechanization

Although considerable efforts have been made for promotion of the agricultural mechanization program dnd steady progress has been achieved in the past few years, there are still many problems left unsolved, such as:

General Problems of Mechanized Farming

The mechanization of small-farm agriculture in Taiwan may serve as an example for countries with similar conditions. The problems encountered at the beginning of mechanized farming are briefly described below:

1. Small farms and fragmentation of land: As the average size of the farms in Taiwan is about one hectare, the use of large type machinery is, of course, impractical and costly.
2. Diversified and intensified cropping systems: Almost all the small farms are run in a diversified way with very little use of specialized machinery. And under the intensive cropping system, farmers grow one crop after another, and practice relay-interplanting before the harvest of the previous crop. For this reason, compact machines that can be easily maneuvered between rows are what the farmer needs.
3. Lower purchasing power of individual farms: Low purchasing power is a common phenomenon in countries dominated by small farms. This is due to the limited produce of the farms, the simple and inefficient tools employed and the fact that production is mainly for family consumption. To sell agricultural machinery to farmers with low purchasing power is necessarily difficult.
4. Farm population not mechanically minded and rural youth not enthusiastic over farming: Individual farmers are, as a rule, devoid of mechanical sense. This is also a bottleneck to agricultural mechanization that should be overcome in the shortest possible time through an extensive program of educating the rural population.

The rapid development of industry has led to a decrease of full-time farm hands and a concomitant increase of part-time labor on the farm. The part-time workers, especially the young ones, lack interest in making new trials or efforts to better utilize agricultural machines.

Infant Agricultural Machinery Industry

1. High cost of agricultural machinery: High interest rates, limited output and the need to import some of the materials from abroad are the main reasons for the high cost of the machinery produced. Only when the farmers' purchasing power is raised can the agricultural machinery manufacturers be willing to lower the price of their products for bigger business turnover. Before 1970, the average price of a locally made power tiller was about 30 per cent higher than that of the same type pold in Japan. However, the difference has been gradually narrowed down during the past four years.

In the past, most of the farmers, who purchased agricultural machines with bank loans had to pay an average annual rate of interest of 11.52 per cent. The present interest rate has been lowered drastically to 8.5 per cent.

2: Lack of operating fund and poor management: According to a 1959 survey, most of the small factories were short of operating funds and has to pay high interests for loans from private sources, thus making them reluctant to produce lower priced products. As most of the machine parts are made by small factories, the lowering of machinery prices has to begin with the availability of low-interest loans offered by local banks. One of the major companies—the China Agricultural MachineryCo •—was at a time on the verge of bankruptcy because of poor management plus lack of operating fund.

3. Lack of suitable farm machines: While some of the power tillers, water pumps and power sprayers and dryers in use are locally manufactured, tractors, rice transplanters and combines are mostly imported. Besides being expensive, the imported machines need to be modified in order to be fully adaptable to local conditions. Furthermore, machines for such work as fertilizer application, harvesting and cultivation, for various crops are still lacking. Even land preparation, such as the levelling of paddy field, is sometimes dependent on animal power and conventional tools. It shows the need for specially-developed attachments to adapt to local conditions.

4. Insufficient number of qualified engineers and low technical level of manufactures: In the early days of industrialization in Taiwan, only "family sized" machine shops were engaged in manufacturing farm implements. Without saying, these small factories had neither qualified engineers nor sufficient capital to produce machinery of good quality. According to a 1959 survey, the manufacturers needed help to solve such manufacturing problems as gear making, heat treatment, gauge-making, and jig and fixture making. Evidently, the small factories could not afford to purchase the necessary facilities and equipment for solving these problems.

The survey also indicated that the products ofeach machine shop were not uniform in quality. This is obviously due to the lack of an effective quality control system and unavailability of precision manufacturing and inspection tools. Furthermore, the equipment used in the shops were in most cases obsolete and inefficient. Under these circumstances, one can not expect them to produce things of high quality, unless technical guidance can be given to elevate the efficiency in the management of the machine shops. Although the situation has since been much improved as the local industries have been absorbing new manufacturing know-how, technical experience and foreign investments to set up larger factories; yet, for lack of qualified research engineers, the work progress has been rather slow.

5. Lack of standardization of machine parts and attachments: Since each agricultural machinery factory is turning out products in limited quantities of its own design, cost of production of the machines is necessarily high. If some of the parts and attachments are standardized and made interchangeable among different brands of a particular type of machine, it may enable the local manufacturers to lower their production costs.

Problem of Fuel Supply in Rural Areas and Heavy Burden of After-sale-service

1. Needed for better fuel oil: The fuel for power machines can be purchased from fuel stores at all principal townships, but its impurities affect the sevice life of machines, especially the diesel engines. It is also not convenient for a farmer to purchase better fuel oil from distant downtown gas stations.

2. Heavy burden of after-sale-service: The machine owners are apt to use the machines too long without maintenance during the farming season. Because of the short interval between two crops and a tight farming schedule, each farming operation has to be done within a certain period. The after-sale-service for the machines after prolonged use by unskilled hands naturally imposes a heavy burden on the infant agricultural machinery industry.

Measures Adopted in Mechanized Farming

Today, farmers in Taiwan are facing a number of problems arising from the impact of rapid industrialization. The increasing cost of labor and the high cost of such inputs as chemical fertilizers, pesticides and power machines have lowered the profit of farming and at the same time widened the income gap between the farmers and non-farmers. Therefore, not only the young generation but the agricultural labor with agricultural capital are flowing into non-agricultural sectors. Obviously, Taiwan is now experiencing an important episode of agricultural structural transformation.

At the critical stage, the problem of how to promote agricultural mechanization so as to increase the agricultural income has been given increasing emphasis by the government authorities. Measures taken for improving the environment for agricultural mechanization in the past years are as follows:

Providing Agricultural Machinery Purchase Loans and Subsidies

The cost of agricultural machinery either imported or made locally is still too high for general adoption. A power tiller with the necessary attachments costs four or five times as much as a buffalo. It is out of reach of the average small farmer who can not afford to pay for the machine in a lump sum.

Under the Program for Accelerating Rural and Agricultural Development announced by the government in September 1972, NT$2 billion was earmarked for overall agricultural development, with an additional NT$1.82 billion appropriated for use as a loan fund. Under this program, a farmer or farmers' organization is to be subsidized at 10 per cent of the cost for purchase of tractors of more than 40 hp and 20 per cent for purchase of combines, rice transplanters, swath power sprayers, power threshers equipped with separating devices, rice reapers, and other newly developed power machines. During the period of August 1970 through June 1971, to enable more farmers to purchase larger machines, a subsidy of NT$5,000 was granted each farmer who bought a power tiller of upwards of 10 hp.

The Provincial Taiwan Food Bureau (PFB), the Land Bank of Taiwan, the Provincial Cooperative Bank and the Farmers Bank of China have all established agricultural machinery purchasing loan programs over the past decade. Farmers may borrow the total purchasing cost from PFB if they agree to repay the loan in paddy rice. Loans from the three banks had first been extended to cover 70 per cent of the purchasing price, but were later changed to finance the entire cost. Recently, PFB also offered loans for covering 100 per cent purchase cost on the same terms as the three banks. All the loan agencies have lowered their interest rates on the loans over the years —from 0.012 monthly in 1961 to 0.0096 in July, 1967, and to 0.006 in July, 1972. The present interest rate is 0.007.

Repayment of loans for power tillers, tractors and rice combines is to be made in 14 installments over a period of seven years. Loans for other machinery are to be repaid in six to ten installments over three to five years, depending on the amount of the loan.

Meanwhile, in order to strengthen the agricultural mechanization program, a three-year (1972-1975) loan plan was jointly supported by the Central Government, three banks and JCRR (**Table 8**). Carrying a total of NT$829,200,000, it ended up on June 30, 1975, with an aggregate loan of NT$1,094,762,000 extended to individual farmers, an increase of NT$265 million over the original figure (**Table 9**).

Measures for Improving the Quality and Lowering the Price of Agricultural Machinery

To make sure that agricultural machines purchased by individual farmers are of good quality, the government makes it a rule that any new madel of agricultural machines should be thoroughly inspected and tested in the field before it is put on the market. All imported new types of agricultural machines, such as combines and rice transplanters, should be put to trial in a 20-hectare field to test their performace and durability. This kind of tests has been conducted by the Taiwan Agricultural Research Institute (TARI) and District Agricultural Improvement Stations (DAIS) during the past four years.

Meanwhile, the government drew up a set testing standards for conducting inspections of power tillers. Manufacturers and importers were required to send in samples of new madels for inspection. Only those farmers who bought machines of models that have satisfactorily passed the inspections have the right to apply for low-interest loans and subsidies.

The prices of iocally made agricultural machines are rather high when compared to farmers income, as are the prices of imported machines. The government has strengthened the supervision of manufacturers and importers to prevent them from making unfair profits, with the consequence that the prices of the machines have lowered considerably. The changes in the price of power tillers in past five years as shown the **Table 10** provides a good example of the price reductions.

Rural Repair Service

A few years ago, many of the small agricultural machinery manufacturing or assembling plants operating in the major townships offered no after-sale-service for the machines they sold. After they stopped producing a particular type of machine (or when no more such machine was imported), many machines of that type broke down and have remained out of repair for lack of spare parts. This has caused the farmers to lose confidence in the manufacturers and added to the difficulties in the machine-extension program later on.

It is a long-felt need that the

Table 8. Financial sources for agricultural mechanization loans

Unit: NT$1,000

	1st Year (July 1972-June 1973)	2nd Year (July 1973-June 1974)	3rd Year (July 1974-June 1975)	Total
Central Government Fund	100,000	100,000	100,000	300,000
JCRR/SAFED Fund	25,000	35,000	35,000	95,000
JCRR Unified Agriculture Credit Loan Fund	41,700	31,700	31,600	105,000
Three Agri. Banks	109,700	109,700	109,800	329,200
Total	276,400	276,400	276,400	829,200

Table 9. Progress of loanings for agricultural machine procurement under 3-year plan

Unit: NT$1,000

	1st Year (July 1972-June 1973)	2nd Year (July 1973-June 1974)	3rd Year (July 1974-June 1975)	Total
Farmers' Bank of China	23,728	10,170	86,920	120,818
Land Bank of Taiwan	62,145	123,412	282,658	468,215
Cooperative Bank of Taiwan	71,566	123,430	310,733	505,729
Total	157,439	257,012	680,311	1,094,762

Table 10. Price changes of 14 hp power tillers

Date	Price (NT$)	Amount of Price Change (NT$)	Government Subsidy (NT$)	Farmer's Cost		Remarks
				(NT$)	(%)	Annual int rate (%)
Before May 8,1970	60,000	—	—	60,000	100.0	11.52
May9-July 31, 1970	57,000	−3,000	—	57,000	95.0	11.52
Aug. 1970-June 1971	55,000	−2,000	5,000	50,000	83.3	11.52
July-Dec. 1971	53,000	−2,000	2,000	51,000	85.0	11.52
Jan.-Oct. 1972	53,000	—	1,000	52,000	86.7	7.2
Oct. 1972-Sep. 1973	51,000	−2,000	—	51,000	85.0	7.2
Oct. 1973-Feb. 1974	57,000	+6,000	—	57,000	95.0	7.2
Feb. 1974-Now	70,000	+13,000	—	70,000	116.7	9.0—8.5

repair service should be available and accessible to the agricultural machine users. Throughout Taiwan, there is a market square at almost every township, which the farmers visit at least once a week to sell their products and replenish their larders. To meet this need, government agencies concerned have selected 20 market squares in 1959 and 48 more in 1960 at those townships where many farmers are owners of power tillers and the other machines, and named in each of these market squares a machinery repair shop or motorcycle repair shop as the "appointed agricultural machinery repair shop." Each of these appointed shops was asked to send at least one of its technicians to the technical training class conducted jointly by JCRR, PDAF and farmers' associations. These repair shops rendered fairly satisfactory service to machine owners at reasonable charges in the early stages of the island's agricultural machinery extension program.

In 1961, the two newly established major agricultural machinery companies initiated an island-wide after-sale-service system and put into operation a number of roving service cars. This attested to the earnest efforts made by the manufacturers to educate their sales agents and users on how to use their machines properly with a view to increasing sales.

In 1966, as a new attempt to expedite the agricultural mechanization progam in Taiwan, a network of Agricultural Mechanization Promotion Centers (AMPC) at principal township was established by the government and farmers' associations concerned. Up to the present, 37 AMPCs have been established in different townships. These centers' main functions are: a) to maintain and repair farm machines owned by individual farmers, b) to fully utilize agricultural machines, especially power tillers, rice transplanters and combines, by making their service available to other farmers through arrangements with the center, c) to assist any farmer who wants to buy agricultural machines but is lacking in funds by helping him complete the bank loan procedures, d) to assist the research institutions in field testing and demonstration of newly developed agricultural machines, and e) to carry out a farmers' training program in each of the townships where a promotion center has been set up. However, the number of AMPCs is still limited and their activities need to be strengthened.

Fuel Supply in Rural Areas

In employing power machines, fuel supply and economy in the use of fuel are matters of practical concern. Although Taiwan has its own petroleum refinery to process imported crude oil, yet how to supply enough fuel of good quality to farmers at reasonable prices remains a problem. To help the farmers get quality fuel, the Chinese Petroleum Corporation, with the assistance of JCRR, has established a number of small fuel stations in suitably located townships, but more fuel stations are needed to eventually serve all the townships. Some township farmers' associations are procuring fuel in bulk to meet the need of the farmers.

Training of Farmers and Technicians

The farmers know how to drive and tend water buffaloes, but are mostly ignorant of the use and maintenance of power mechines. This is also true of the agricultural extension workers. To help them acquire a basic knowledge of agricultural machinery, government agricultural agencies have, in collaboration with the agricultural colleges and farmers' associations, conducted a number of training classes.

Training of farmers has been given special emphasis in Taiwan. In the early days of agricultural machinery extension, the small number of power machine owners were taught individually to operate and take care of the machines in their possession with good results. However, it is impossible to keep up such intensive training because the number of instructors can not be increased proportionately with the rapid increase of farmers using power machines.

Over the years, training classes have also been conducted for farmers who have owned machines or who wish to own one in the immediate future. Since this type of training can not be continued on a year-round basis, chances are that some farmers want to acquire a practical knowledge of farming machines but have not had the opportunity to attend a training class. Therefore, some farmers who know power machines well and are willing to offer their services have been selected to serve as "honorary power machine demonstrators." They act as consultants to farmers in the selection and use of machines in their own villages. However, as things later turn out, the honorary demonstrators offer advice only when they are approached and seldom take the initiative in giving instructions.

A third approach adopted for training the farmers is the institution of township—or village—level training system. Under the system, in a town or a village where 15 to 30 farmers own power machines, a "mechanized-farming training unit" may be organized. Members of each unit elect their own leader and deputy leader. Leaders of all the training units are to be given intensive technical training for a period of one month. After the training, the members will meet at least once a month for group discussions, lectures by invited specialists, question-and-answer sessions, maintenance and repair exercises, field chore competitions, etc. This type of training has met with satisfactory results in the early stages of mechanized farming in Taiwan. In 1960-61, a total of 50 such training units were organized. Since the establishment of the major agricultural machinery manufacturers in 1961, training of extension and service personnel and the farmers has been taken over by the companies themselves.

Another type of training is conducted specially for agricultural machinery research workers and trainers. Altogether 52 promising young technicians were selected from TARI and DAISs in 1958, 1967 and 1971 and were given one-year training in the Agricultural Engineering Department of the National Taiwan University. These young men have contributed much to various types of training for the farmers besides carrying on research and experimental work on agricultural machinery.

In view of the fact that administrative officials and extension workers in various government agencies concerned and farmers' associations also need a general knowledge of agricultural machinery in order to more efficiently perform their tasks of promoting agricultural mechanization, classes have been held for these personnel. In the first five years of Power tiller extension, altogether 940 government officials and extension workers attended classes lasting from a week to a month, depending on the nature of the training. As a measure to extend new machines, such as tractors, rice transplanters, combines, etc., thousands of agricultural workers and farmers from various townships have been trained during 1971-75.

Joint Organization for Mechanized Farming

As the number of part-time farmers has increased, government agencies concerned have encouraged farmers to organize themselves for joint operation to facilitate efficient use of modern techniques and machinery. Such joint operation has gradually developed from primarily labor cooperation to capital utilization. In the meantime, the scope of cooperation has expanded from single crop production to the entire farm business. The number of participating families has also become larger, ranging from a few families to an entire village. The scope and types of joint farming being carried on under the supervision of government agencies for experimentation and demonstration purposes are as follows:

1. Joint ownership of machines: The township AMPCs have been motivated to promote a program for joint ownership of agricultural machines since 1970. Joint ownership teams, each composed of 10 or more neighboring farmers, are organized by the township farmers' associations and AMPCs under agreements effective for at least five years. From among the members of each team, a specialized machine operator is chosen to operate and take care of the power tiller. (Later on some teams have added transplanters and combines). Besides cultivating his own land, the operator does contract work for the team members at charges covering expenses for labor, fuel, oil, machine maintenance and repairs. Up to the present, 447 such teams have been organized.
2. Experimentation of cooperative farming: In 1966, the government launcehed an ambitious project for promoting cooperative farming, namely, the initiation of a cooperative farm management program to cover the entire activities of the cooperating farmers and to improve their efficiency in farm management as well as their livelihood. Groups of three to seven neighboring farm families with altogether about five hectares of farmland are encouraged to get organized into cooperative farms. The major items of cooperation are joint procurement and utilization of new machinery and installation of such farm facilities as underground water for irrigation and domestic use, which are usually too expensive for a single farm. Up to the present, this program was still in the experimental stage, 80 cooperative units including 374 farm famililies with altogether 465 hectares of land were operating and demonstrating under the supervision of the various DAISs.

Development of Contract Work

Since 1970, the PFB has been subsidizing township farmers' associations for the organization of mechanized farming service teams for doing contract work for the farmers in the respective townships with the use of power tillers. (Some teams have also been using rice transplanters and combines). Up to the present, 310 such teams have been organized. To encourage the establishment of similar service teams by businessmen or interested farmers, the government is now granting subsidies at 10 per cent of the machine cost for purchases of repair and maintenance facilities so as to strengthen their repair capabilities.

Strengthening of Research and Experiment Work

To expedite the extension of mechanized farming in Taiwan, research and development of agricultural machinery has been actively promoted, with emphasis laid on modifications and improvements of the existing types of machines and designing of new ones to suit the farming conditions in Taiwan. Imported power tillers and their attachments are usually in need of some modification in order to fully meet the local requirement. When a machine of foreign design is produced locally, part of the structural design and/or the materials used often have to be changed.

According to a survey made by PDAF in 1966, part of the power tiller owners still retained their draft animals. In the survey, a total of 192 head of draft cattle are still kept by 302 power tiller owners, compared with 401 head before they bought the power tillers. This clearly shows that there is still a need for more specially-designed attachments to replace the animal power completely. Presently, the major manufacturing companies in Taiwan have their own research departments and engineers to undertake designing and improvement of agricultural machines.

Since 1957, all the agricultural research and improvement stations on the island have engaged in experiments for improvement of the performance of existing machines and development of new ones. Up to the present, progress in the research work of these stations has been slow due to a shortage of qualified research engineers. Recently, through JCRR's promotion, cooperation between the research workers of government agencies concerned and the local manufacturers has been stepped up. Meanwhile, an Agricultural Mechanization Research and Development Center jointly supported by the government and local agricultural machinery manufacturers will be set up in the near future.

Conclusion

The program for promotion of mechanized farming initiated by JCRR in 1952 with the purpose of increasing land productivity and saving farm labor has been progressing steadily, and plans have been set afoot for accelerated extension of various kinds of agricultural machines in order to offset the labor shortage which is being increasingly felt in areas close to industrial towns. However, a number of new problems such as rises in wages, decline of farm land price and decrease of cropping index, together with such old problems as the small size of the farms, and low purchasing power of the farmers have greatly hindered agricultural mechanization as well as agricultural modernization in Taiwan. To cope with these problems and to raise farm income, agricultural mechanization have been given first priority among the various development measures programmed under the nation's new agricultural policy.

Power tillers, which still take the leading role in Taiwan's agricultural mechanization program, totalled 42,123 units in 1974. For every 20.8 farm households or every 21.8 hectares of cultivated land there was a power tiller. The annual increase in the number of power tillers was about 3,500 units in the past few years, Besides the power tillers, some tractors have also been adopted for use by farmers recently. As the real wage has increased much faster than the rate of charges for contract work by power machinery teams, the ever-widening difference will accelerate the adoption of machines.

At present, the demand for such other machines as power transplanters and combines, while being on the increase, is still rather limited. This may be attributed not only to low purchasing power of the farmers, the small size of the farms, lack of experience in using new machines, but also to a want of new cultural methods to match with the new machines. Indeed, further intensification of farm management of Taiwan will depend to a large extent on advanced technologies and science on the one hand and to the study of the practical problems arising from the fields on the other.

As the agricultural mechanization on rice field and on dryland crop progresses, several new type of machines of larger capacity will be extended to the farms through contract teams or for joint use under cooperative programs. However, social and economic research should be strengthened along with technical experimentation. Therefore, some positive measures to bring about an expansion of the size of the private farms, improvement of farmers' organizations and encouragement of joint and/or cooperative farming will have to be effectively pushed forward in order to fulfill the objectives of agricultural mechanization. ■ ■

Agricultural Mechanization and Machinery Production in China

by
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Introduction

As a member of the U.S. National Academy of Science delegation* the author had the privilege of visiting the People's Republic of China for four weeks. During our tour of China we visited rural communities and saw many land development and irrigation projects, agricultural machinery and related manufacturing plants, and small machinery repair shops at national, provincial, city, country, commune, and brigade levels. These were located in the Peking and the Shanghai municipalities, and in Shansi, Honan, Kiangsu and Kwangtung provinces (Fig.1). We were generally exposed to somewhat better-than-average areas since many of the development projects that we saw have been well publicized in local and foreign publications.

Our tour covered three major agroclimatic areas: the irrigated dryland agricultural areas of the North China plain near Peking; the problem soil and water-deficient areas in Shansi and North Honan provinces; and the wetland rice-growing areas of Kiangsu and Kwangtung. It was apparent to us that the mechanization of field operations is superseded only by the introduction of improved seed-fertilizer technology and irrigation and of land development program in their agricultural development priorities. High-yielding dwarf varieties of wheat and rice have been widely introduced in most parts of the country. We were impressed with the progress made in irrigation, water control and land development, without which increased crop production would not have been possible. Increased attention is now being directed towards land consolidation and farm mechanization.

China has obviously placed a high priority on the mechanization of its agriculture. We were repeatedly told that they are aiming for a complete mechanization of Chinese agriculture by 1980, a target which is perhaps a little too optimistic. The Chinese political leadership is strongly

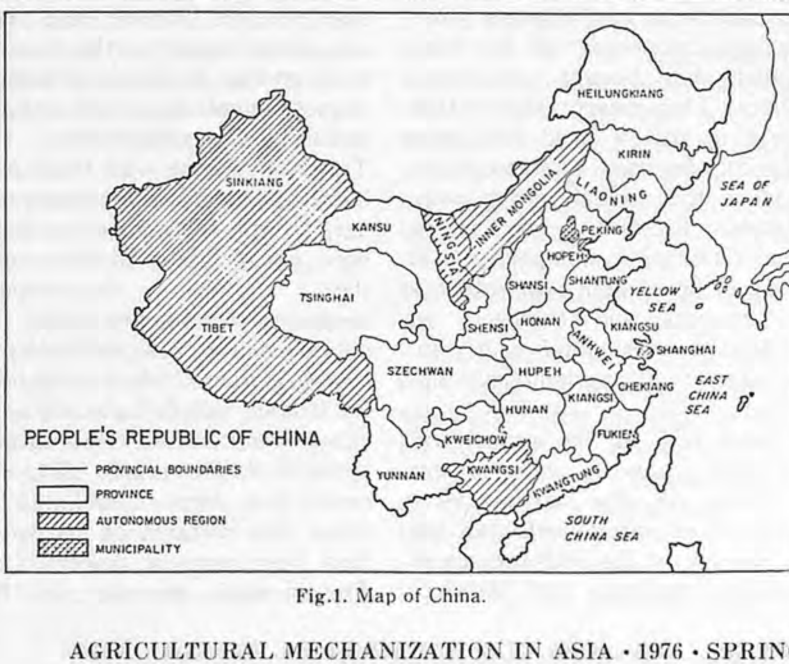

Fig.1. Map of China.

*The United States NAS small-scale rural industries delegation visited China during June-July 1974. The delegation was composed of four economists, two social scientists, one historian, and three engineers.

Assistance provided by J. Samuel, Research Fellow, IRRI, in writing the paper is acknowledged.

committed to the full mechanization of agriculture which is reflected by Chairman Mao's statement, "The fundamental way out for agriculture lies in mechanization." In fact, mechanization is being progressively introduced in most parts of China with the more power-consuming and labor-intensive operations being mechanized first. Consequently, manual labor and draft animals continue to be of considerable importance to Chinese agriculture and are widely used all over China.

It is of interest to note that throughout our visit we were repeatedly told that the mechanization of Chinese agriculture will release farm labor for more intensive cultivation and for capital farm construction. This positive attitude toward mechanization has played an important part in introducing agricultural mechanization in the country. We did not hear a single comment indicating fears of displacing labor or of creating unemployment as a result of agricultural mechanization, a view popularly expressed in most developing countries. Through an effective communal form of government, China has been able to make good use of its idle and underemployed manpower in the construction of irrigation and land development projects, in rural industries and in more intensive agricultural production. In traveling to the Great Wall, northwest of Peking, we saw large numbers of students and city workers assisting in the busy wheat harvest season in the rural areas, exemplifying China's efforts to mobilize and effectively utilize all of its labor force.

In spite of the labor-intensive nature of their agriculture, the variety of locally produced tractors and agricultural machines is surprisingly broad in China. While their long-range aims are to mechanize agriculture with larger farm equipment, present emphasis is on the production of a wide variety of machines ranging from simple manual and animal- drawn implements to fairly sophisticated tractors and combines. China's tractor and power tiller (fig. 2) designs are generally similar to those of other industrialized countries. Most of the imported designs have been well adapted and modified for heavier-duty service to meet local requirements. It appears that China has been quite successful in transferring and adapting a wide variety of mechanization technologies from all over the world. For understandable reasons it has placed relatively less emphasis, in the early stages of mechanization, on finding indigenous solutions to their specific mechanization problems. In comparison, the diversity in the indigenous designs that originated from Japan during its early stages of development was far greater than what we see today in China. This shortcoming, however, is being rectified now for most agricultural engineering research institutions are working on the development of new machines to solve local mechanization problems.

Mechanization level

In agricultural mechanization, the Chinese priorities seem to be: (a) water conservation and irrigation, (b) food and fodder processing, (c) farm transport, (d) threshing, (e) land preparation, (f) harvesting of crops, and (g) paddy transplanting.

Only 11 percent of land in China is cultivated and we saw ample attempts of increasing arable areas through land reclamation and improvement projects. In the Shansi province, we observed badly eroded mountainous areas, with the yellowish wind-deposited loess soils, being reclaimed into good arable land. Similarly in the nearby Hui-hsien and Hin-hsiang

Fig.2. A Chinese power tiller—Model Tung Fung-12, produced in Kiangsu province.

areas, north of the Yellow River, we could see many land development, irrigation, and water control projects which have helped to transform poor lands as well as sandy and marshy riverbeds into productive agricultural areas.

Modern seed-fertilizer technology, improved irrigation, and land consolidation schemes have helped the introduction of farm mechanization in the dryland agricultural areas of Peking municipality and the Shansi and Honan provinces. The climate and the agricultural production practices do not present any major technical bottlenecks to mechanization; hence, mechanization is progressing rather well in these areas.

The variety of tractors, power tillers and other agricultural equipment that we came across seemed unusally broad probably because in the early stages, China imported almost all kinds of tractors and farm equipment from all over the world and successfully adapted many of these machines for local conditions. The machinery designs as well as the plants producing a given design are numerous which lend some credibility to the claim that the production of tractors has increased by 520 percent in China during 1964-1974, with a recent annual growth of 20 percent, and that the number of power tillers has increased 30 times since the Cultural Revolution.

Mechanization of direct seeding

Fig.3. A conventional wheat thresher manufactured by the Red Star Commune near Peking.

in dryland areas is well advanced and equipment for tractor and animal-drawn seeders are, in almost all cases, locally produced. We were told that 90 percent of wheat in the Peking municipality was sown by mechanized equipment and nearly 80 percent of the seeding equipment is built at the commune plants. The practice of transplanting wheat and corn after harvesting rice has recently been introduced in Northern China and is now gaining popularity.

The wide diversity in the design of the simple throw-in type wheat threshers in this area was indicative of the numerous independent efforts of developing machines to suit local conditions. We saw threshers with cylindrical and conical drums; with axial flow and through-flow material movement; and with a variety of grain-cleaning devices. Exsept for a few larger threshers which were of conventional design (**fig. 3**), the simpler Chinese thresher designs required considerable further development. The development of such threshers has been done mostly at the brigade level by mechanics and farmers who have good practical experience. Their expertise in machinery design and development, however, is understandably not as advanced.

Rice is an important crop in the irrigated wetland northern areas of Shanghai municipality and Kiangsu province, where two annual crops of wetland rice and one of winter wheat are raised. The relatively short rainy season of only one month, from mid-June to mid-July, facilitates the use of modern machines for land preparation and threshing. These operations are almost fully mechanized through the use of four-wheel tractors, small power tillers, and stationary power threshers.

Direct seeding for wetland paddy is not practiced in China since it is felt that this reduces yields. Mechanization of the paddy transplanting operation has received considerable attention over the last two decades. Manually operated six-row tweezer-type planters (**fig. 4**) have been popular in China for many years. One man can transplant 1/30 hectare per day with these machines which are fairly low-priced, about 60 Yuans.* These manual transplanters are now being gradually replaced with mechanically powered riding type transplanter that was developed a few years ago in Shanghai (**fig. 5**). This machine can transplant seedlings which are grown in conventional field nurseries and does not require special nursery grown seedlings like the Japanese transplanters. These machines are available in 10, 12, 14, and 16-row sizes. Three men can transplant 2 ha/day with a 12-row machine. Current efforts to mechanize paddy transplanting in China are presently directed towards popularizing this particular machine.

Harvesting of paddy is still a manual operation and the development of small rice harvesters and combines is just beginning to receive increased attention from central and provincial agricultural machinery research institutes. We saw two side-delivery cutter-bar type paddy harvesters (**fig. 6**) of about 4 ft width at a commune in Kiangsu province and were told that these are now in the trial production stage. We also learned that field tests are being carried out in Kwangtung province on a two-row combine attachment for power tillers which is different in concept than the Japanese combine harvesters.

Again in the Kiangsu and Shanghai area, we found little variety in the thresher designs. Paddy and wheat are threshed on threshing floors with simple hold-

* 1US$ = 1.90¥ in 1973.

Fig.4. Manually operated Chinese transplanter.

Fig.5. Riding type power operated Chinese transplanter developed in Shanghai.

Fig.6. Side-delivery paddy harvester in Kiangsu province.

on type threshers (fig. 7) that basically consist of a 6- to 8-ft long power-operated wire loop or spike tooth type threshing drum. Paddy or wheat bundles are manually held by four to six men against the rotating drum to strip the grain from the panicles. Grain is then manually separated from straw and cleaned. We did not see any throw-in type of threshers being used for paddy in China, which probably was due to the fact that paddy straw is utilized for paper-making, roofing, and other industrial use. Hold-on type threshers do not damage straw and are quite labor-intensive in comparison to the throw-in type machines.

In the southern province of Kwangtung, two rice and one sweet potato crops are grown annually. This is an area of relatively heavier rainfall spread over a much longer period. Rice production practices in this area are quite similar to those in Southeast Asia. Mechanization of agriculture has not made as much headway here as in the other parts of China that we visited. Harvesting of the first and planting of the second rice crop occur

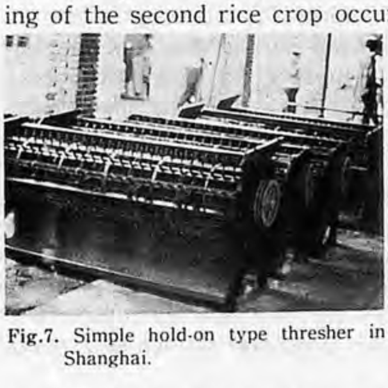

Fig.7. Simple hold-on type thresher in Shanghai.

during the long rainy season. Field and crop conditions during the rainy season make it difficult to mechanize rice production. Poor tractor mobility in wet paddy fields limits the use of larger tractors for paddy cultivation in this area. Mechanization of wetland paddy under such difficult conditions continues to be an unsolved problem in China. It seems that greater efforts are needed on the development of light-weight four-wheel tractors, lighter power tillers, improved traction-assisting wheels, and portable power threshers to mechanize the production of rice in this southern part of the country.

In general the mechanization of some of the farming operations that are typical to Chinese agriculture also requires increased machinery development efforts. For example, we observed that large quantities of organic fertilizer, anywhere from 3,000 to 12,000 kg/ha, are applied in most parts of China. The collection, composting, and distribution of this large quantity of organic fertilizer is almost entirely done by human labor. We did not come across any signs of mechanizing the organic fertilizer handling and distribution system, and it was not clear to us if any efforts were being made to mechanize this labor-consuming operation.

However, in all three areas we visited, most communes have set up centralized food and fodder processing plants to handle a substantial part of the commune's production. We were told that mechanization of food and fodder processing has been emphasized in China to release the women labor that was traditionally involved in these operations. Interestingly, the same reason was given at a textile mill in Linhsien county for the setting up of a special yarn spinning section for home weaving. Previously women in this area were spending two to four times as much time in spinning the yarn than than weaving the cloth. The mill had mechanized the higher labor consuming operation of spinning to release the women labor for more productive work. Weaving is still done at home by women in their spare time. This concentrated effort to release women from traditional chores seems to have been quite effective, for today women are an important part of the labor force in China and are actively engaged in agricultural, industrial, and capital construction projects.

In the transportation of farm products, we were surprised by the diversity of the transportation modes in the rural areas: baskets, manual and animal-drawn carts, power tillers, and tractor-trailer combinations. Tractors and power tillers with trailers are widely used for farm transpout all over the country. This practice is, to a large extent, responsible for the high degree of annual machine use, which is estimated to be 2,000 to 2,500 h/yr.

Manufacturing

The Chinese government is committed to a policy of decentralization of small-scale industries to the rural areas. It was apparent to us that the farm machinery manufacturing industry in China is currently passing through a rather dynamic stage in which products and production processes are being rapidly changed and upgraded. Production of agricultural machines is being gradually decentralized to the rural areas with a carefully planned startification of the manufacturing operations. The complexity of the machine and the production process dictate the level at which a machine is produced.

The local production of tractors and farm machines is one of the five important industrial

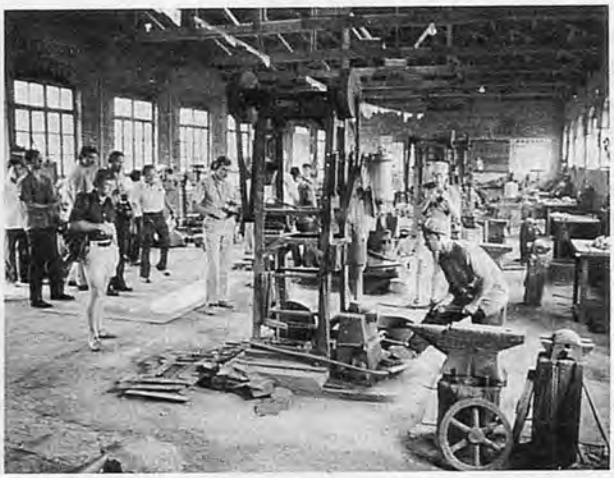

Fig.8. Simultaneous use of simple and advanced production methods at a farm machinery plant in Shansi province.

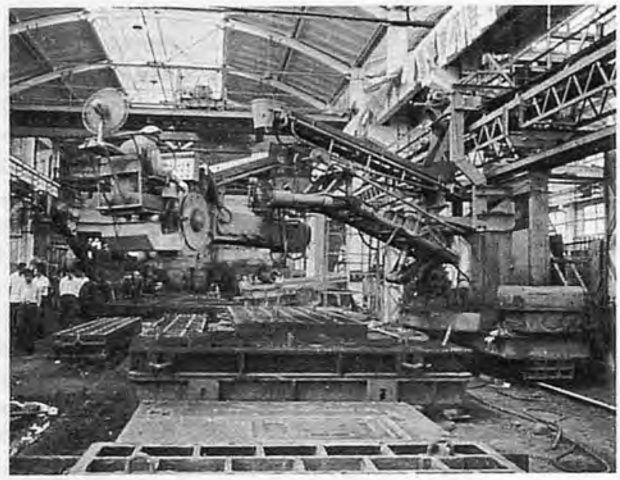

Fig.9. Mechanical sand thrower for filling large moulds at a machine tool plant in Shanghai.

activities which have received major attention during recent years; the others being iron and steel, power, cement, and fertilizer. To facilitate production of some of the machines at the local level, more complex machine elements such as carburetors, fuel injection equipment, electrical and hydraulic components, and gasoline and diesel engines, have been standardized and these are produced at selected centralized plants in the country. Generally the more complex agricultural machines, such as larger four-wheel tractors of over 20 hp size and the larger four- and six-cylinder diesel and gasoline engines, are produced by national or provincial factories. Machines of medium complexity, such as small one- or two-cylinder diesel and gasoline engines, smaller four-wheel riding tractors of less than 20 hp, power tillers, and irrigation pumps, are produced at county or city-managed plants. The least complex machines, such as threshers, transplanters, feed grinders, tractor implements and trailers, are produced at the commune level. Production of simple animal and manual tools and implements is often done at the brigade level plants.

Production of the smaller four-wheel tractors and engines of less than 20 hp size is being decentralized to the county and commune level plants. We were impressed by the rapidity with which this decentralization is takingplace. Many of the county and commune-level farm machinery plants that we visited had only recently recently started production of new machines on a trial basis and were planning to start regular production sometime next year.

The limited size of the local market and decentralized production necessitate a highly flexible manufacturing operation with minimum investments in jigs, fixtures, and special production equipment. The factories often switch to the production of new machines as soon as local demand for a machine has been fully met. We came across many cases where production of threshers and other agricultural machines was discontinued because of the saturation of the local markets. While the low-volume decentralized production approach may not seem very efficient, it has, nevertheless, helped to meet the local demand for agricultural machines which would have been difficult to do otherwise.

The limited size of the local markets and the consequent intermittent production, however, has been a constraint in improving the designs of the locally developed machines. Most machines are improved gradually in the process of commercialization through years of steady production and modification. Intermittent production hampers with such an evolutionary process. This is particularly true of the simpler farm machines that are produced at the commune and brigade level plants in China.

In our visits to county and commune level plants, we were impressed by the judicious mixing of rather modern mass production and simple manual production methods. For example, it was not uncommon to see large pneumatic power hammers being used along with manual forging operations (**fig. 8**) Most county and lower-level plants do not use special production equipment but depend on standard machine tools for production. Production of farm machines at the county and commune level plants is quite labor-intensive and offers considerable potential for improvement in labor productivity.

Almost all county and commune level plants have a small foundry. The foundry is an important part in most manufacturing units, for castings are liberally used in the production of agricultural machines. The operations of sand conditioning, mould preparation, and metal-pouring are mostly done manually at the county and lower-level plants. In a few larger county plants we did see the overhead traveling cranes for transporting molten metal and the use of portable vibrators for tamping sand in the mould boxes. The national managed machine tool plant in Shanghai and the Internal Combustion Eigine Plant at Peking, however, have the most modern and automatic equipment for sand conditioning, mould and core preparation, and other foundry practices (fig. 9).

The use of sheet metal, both stamped and formed, is not popular in the production of agricultural machinery. Fabrication of sheet metal parts requires large investments in stamping presses and dies and is often justified only for larger-volume production. Because of lower production volumes at the local plants, sheet metal is sparingly used in the production process. In our opinion, sheet metal fabrication was the least developed section in most farm machinery manufacturing plants that we saw. At the Shanghai tractor plant, sheet metal tractor fenders were being fabricated by manually pounding with hammers. Since sheet metal components are often meant to enhance machine appearance, relatively less attention is paid on improving the sheet metal components in the Chinese agricultural machines.

On the other hand, considerable emphasis has been placed on the development of machining capabilities at the small plants located in the rural areas. Most small plants are well equipped with lathes, milling machines, shapers and other standard machine tools. We were repeatedly told of the many self-made machines that were fabricated by each manufacturing unit and we saw many of these machines in operation. The self-made machine approach is still being followed at many plants although they are no longer the cobbled-up versions that we had envisioned. Most of these plants produce rather modern machine tools for their own use, which are comparable to factory-built machine tools. Machine tool designs are obtained from the larger machine tool plants and from national research institutes, and since castings and machining are the two major operations in machine tool production, small plants can produce some excellent machines for their own use. It was our impression, however, that the self-made machine tools approach is beginning to decline as more factory-built machines become available and as production efficiencies dictate the use of more specialized production machines.

Conclusion

China has undoubtedly made impressive progress in mechanizing its agriculture and in decentralizing the production of tractors and other agricultural machines. Available mechanization technologies from many parts of the world have been successfully transferred and adapted to suit local farming and manufacturing conditions. The progress achieved in irrigation and land development in the dryland areas has assisted in the mechanization of agriculture; we see no major technical bottlenecks to the mechanization of these agroclimatic zones of China.

In the wetland paddy cultivation area, however, some technical problems still remain and will require greater research and development efforts. Considerable progress has been achieved in recent years in the development of power-operated paddy transplanters; the new Chinese transplanters have potential for application in almost all developing countries. Development of machines to solve some of the problems that are indigenous Chinese agriculture, however, has not made as much progress. This area needs further attention.

In agricultural mechanization, China is decidedly moving towards the eventual use of larger tractors and other farm equipment. With greater land consolidation, the larger machines will undoubtedly gain substantial popularity in the dryland areas of China. However, the diversity of equipment sizes being made available in the early stages of the country's development is noteworthy. Power tillers, small threshers, and other low-powered machines will continue to be popular in the wetland paddy areas for quite some time.

Production of large tractors and other complex agricultural machines is well established and is of fairly high quality at the national and provincial level. The production of machines of medium complexity, such as the 10 hp to 20 hp riding tractors, power tillers, and small diesel engines, is being expanded and rapidly decentralized to the county and, in some cases, the commune level plants. It seems that in the interest of greater production efficiency and technological development, production of such machines will probably stabilize at the county and city levels. In the long run, the commune-level plants will probably specialize in machine rebuilding and the production of simpler farm machines and implements.

It appears that in the immediate future small-scale industuies at the county and commune levels will continue to grow at a rasid pace. Traveling through the countryside, one cannot help but feel that the rural areas of China will not only be the suppliers of food but will also make a major contribution in the industrial sector. The achievements of agriculture and related industry that we saw during our trip no doubt indicate that China will have a highly mechanized agriculture in the not-too-distant future. ■ ■

NEW PUBLICATIONS

New IRRI Publications

Research Highlights for 1974 is a 90-page publication that summarizes IRRI's major research accomplishments and collaborative rice improvement programs.

Changes in Rice Farming in Selected Areas of Asia is a 373-page report on the changes in production and farming practices that have followed the modern rice varieties. Twenty-five social scientists in India, Indonesia, Malaysia, Pakistan, Philippines, and Thailand collaborated in the regional study and wrote respective chapters. IRRI and the International Development Research Centre (IDRC) of Canada supported and coordinated the project.

Major Research in Upland Rice is a 255-page report which summarizes the results of research conducted by the International Rice Research Institute on Selected aspects of upland rice between 1962 and 1973. It includes topics such as: upland rice around the world; climates of upland rice regions; characteristics of upland rice; varietal improvement of upland rice; cultural practices of upland rice; studies on insect pests of upland rice; mineral microbial transformations in upland rice soil and future emphasis on upland rice.

Research Highlights for 1974 can be ordered for us $1.50 per copy via surface mail, $3.00 via airmail, and ₱8.00 in the Philippines. Changes in Rice Farming can be ordered for us $2.50 per copy via surface mail, $6.00 via airmail, and ₱12.00 in the Philippines.

Major Research in Upland Rice can be ordered for us $2.00 per copy via surface mail, $5.00 via airmail, and ₱10.00 in the Philippines. Write to: Office of Information Services, International Rice Research Institute, P. O. Box 933, Manila, Philippines.

Report on Drying, Storing and Milling in the Philippines.

The author researched on the matters about palay drying, storing and rice whitening in the Philippines as the agricultural consaltant of the World Bank. The investigation was carried out from the 10th Aug. to 12th Sept. in 1975, to aim at defining the proper method that decreases the rice grain losses in after reaping process in the Philippines. The investigation was focused at whitening loss of rice grain and made the problems at drying or storing processes as general objects.

The report was established with the investigator's results and other matters; experimental data, statistical data and the suggestions of Japanese specialist resident in the spots.

The survey issue about such categories in South East Asian is scarcely circulated. So the report was issued for the information.

Edited by Ritsuya Yamashita Professor, Dr.-Agri., Faculty of Agriculture, Kobe University, Japan.

100 page 18 × 25.6 cm, soft cover.

Request to Shin-Norinsha Co., Ltd. 7, 2—chome, Kanda Nishiki-cho Chiyodaku Tokyo 101 Japan.

Fiber Crops

The content and scope of this volume represent a unique and highly valuable contribution to published information on soft fibers (fibers from the stems of plants). There is no other book that treats the subject in such detail and offers so complete a review of the literature. Also of special value are the numerous photographs that illustrate the taxt.

The nine soft fiber crops that Mr. Dempsey selected for this book—worldwide in scope—are those most important in international trade and those used extensively within the countries where they are produced. For each crop, production, harvesting, processing, and marketing are set forth in detail; and for many of the crops, climatological data and their relationships to production are presented. Producers or would-be producers, as well as businessmen, will find in the volume answers to a wide range of questions. In fact, fibermen may well find it a producer's handbook.

Mr. Dempsey is recognized worldwide as an authority on soft and hard fibers. His work has taken him to both the Eastern and Western Hemispheres. His experience has been both theoretical and practical. He has been involved in commercial production, processing, and marketing of some of the fibers he deals with, and has conducted extensive research on most of them. In Florida, for example, Mr. Dempsey developed and operated the world's first successful mechanized ramie plantation, pioneering in adapting practices and machines to large-scale use on ramie. In Southeast Asia, his research and his advice on kenaf were in wide demand by countries attempting to develop fiber exports or fiber industries.

The present book culminates a lifetime devoted to work on soft fibers.

Edited by James M. Dempsey, (1912-1972).

457 pages-price $ 18.50.

A University of Florida Book.

The University Presses of Florida 15 Northwest 15th Street, Gainesville, Florida 32603 USA.

FOOD:Politics, Economics, Nutrition & Research

Will population growth and rising affluence outrun the world's capacity to feed itself? Will we run out of land, water, energy? Will additional applications of agricultural technology and other inputs yield negligible returns?

These and other questions—some legitimate and rational concerns, others less rational and highly emotional—are addressed in FOOD : Politics, Economics, Nutrition, and Research, a new publication from the American Association for the Advancement of Science. This report is essential reading for everyone concerned with the serious problems we face in meeting the world's need for food. Whether you are interested in the perspectives or politics of the world food situation, the nutritional aspects of world food problems, or the impact of agricultural and biological research on food production and availability—you will find many articles in this compendium of interest and practical use to you.

The thirty-one articles presented in FOOD have been authored by a broad spectrum of scientists specializing in agriculture and nutrition. These articles were published originally in Science, many appearing in a special recent issue devoted entirely to food problems, other selected from earlier issues dating to 1972. Brought together in this compendium, they provide a provocative reassessment of the worldwide food crisis of the last three years and a realistic look at our options for the future. What emerges is a stern indictment of the way governments and private planners have faced the problem of guarding against expected and inevitable crop shortfalls, but with optimism that the world can meet its food needs—IF adequate food reserves are established, IF new and productive crop hybrids are developed, and IF existing agricultural technology is implemented throughout the developing world.

Edited by Philip H. Abelson

v+202 pages, $8\frac{1}{2}\times 11$, available in casebound or vaperbound editions.

Paperbound edition (ISBN 0-87168-226-5)—Retail price $4.95; AAAS member price, prepaid $ 4.45.

American Association for the Advancement of Science. 1515 Massachusetts Avenue, N.W. Washington, D.C. 20005, USA.

Energy, Agriculture and Waste Management

Agriculture requires significant energy resources for food and fiber production. New energy demands have also been created in controlling wastes to improve environmental quality. Recently, these two areas have been linked by studies that emphasize the possibility of converting wastes to energy sources.

This book discusses in detail three main topics: 1) Energy consumed in food production 2) Technology and energy costs of pollution control, and 3) Potential for producing energy from agricultural wastes. An outstanding feature is the large amount of information compiled on anaerobic fermentation, and the discussion of this technology in producing energy from wastes.

To date, few answers have emerged for the engineers, scientists, and policy mahers who must recommend directions for the future of food production, energy use and environmental pollution control—these chapters present one of the first attempts to answer these questions.

This volume will be a valuable reference for civil, agricultural, and environmental engineers, water pollution control officals, microbiologists, wildlife biologists, and professors of environmental engineering.

Edited by William J.Jewell Environmental Engineer, Associate Professor of Agri. Engineering, Cornell University, New York, USA.

Ann Arbor Science Publishers Inc., P.O. Box 1425 Ann Arbor, Mich. 48106, USA.

Report on the Development of Rice Transplanter and Combine Harvester Suitable for the "Muda Irrigation Scheme", Malaysia

The study on the tropical rice mechanization, which was entrusted by the Tropical Agriculture Research Center, Japan, has been set in since 1973 on a five-year program. It was intended to accomplish a suitable combine harvester and rice transplanter for the paddy region of Malaysia and has been conducted in Malaysia so far in cooperation with the Muda Agricultural Development Authority and the Department of Agriculture from the Malaysian side, and the Institute of Agricultural Machinery, the Central Agricultural Experiment Station and the Tropical Agriculture Research Center from the Japanese side.

The reports are sumarized the data obtained in the field tests. The main themes and studying

NEW PUBLICATIONS

staffs of each report are as follows.

I Development of Rice Transplanter (August 1973)

Contents:

1. Introduction
2. Results obtained in the Field Tests
3. Comparison of 'Mat Seedling type' VS 'Ordinary Seedling" type Transplanter
4. The Determination of the type of Transplanter (Pedestrian, Mounted or Self-Propelled)
5. Conclusion

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Mr. Chew Teck Boon, Department of Agriculture

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Mr. Mustappa Kamal, Department of Agriculture

II-1 Development of Rice Combine Harvester Suitable for Malaysian Condition "Muda Irrigation Scheme"-Studies on the prototype Combine Harvester "SABITA" (September, 1974)

Contents:

1. Introduction
2. Brief Specification on "SABITA"
3. The items and methods of observation and studies on the performance of "SABITA"
4. Result of The Obsevation And Study on SABITA
5. Conclusion

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II-2 Development of Rice Transplanter Suitable for The Muda Irrigation Scheme, Malaysia (September, 1974)

Contents:

1. Introduction
2. Brief Specification of Tested Machines
3. Test Result and Consideration
4. Conclusion

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Mr. Shanmuganathan, Department of Agriculture

II-3 Development of Transplanter And Combine Harvester ---COMBINE HARVESTERS-- "SABITA" & "MUDA" (February, 1975)

Contents:

1. Introduction
2. The Items and Methods of Observation and Studies of the Performance of "SABITA" and "MUDA"
3. The Results of the Second Survey on "SABITA"
4. Studies on the prototype Combine Harvester "MUDA"
5. Conclusion

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Mr. Mustaffa Kamal, Department of Agriculture

III-1 Development of Rice Combine Harvester Suitable for Malaysian Condition "MUDA" Irrigation Scheme"-Study on the prototype Combine Harvester (5th July-23rd August, 1975)

Contents:
1. Introduction
2. The Items Method of Observation and Studies on the Performance of "SABITA" and "MUDA"
3. The Results of Third Survey on "SABITA"
4. The Result of the Second Survey of "MUDA"
5. Conclusion

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III-2 Development of Rice Transplanter-Studies on the prototype Transplanter---"GANTI" (20th August-15th September, 1975)

Contents:
1. Introduction
2. Brief Specification on "GANTI"
3. Test Result and Consideration
4. Conclusion

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Rural development experiment finds frustrations, successes

"The basic problem of poverty and growth in the developing world can be stated very simply. The growth is not equitably reaching the poor. And the poor are not significantly contributing to growth." With this statement, Robert S. McNamara presented to the Board of Governors of the World Bank, meeting in Nairobi, Kenya in the fall of 1973, a strategy for rural development.

Designed not only to increase food production for a hungry world, the strategy is also intended to improve the quality of life for the poorest of the poor. But Mr. McNamara cautioned his audience by saying that no one had "clear answers on how to bring the improved technology and other inputs to over 100 million small farmers, especially to those in dry-land areas.

"Nor," he added, "can we be fully precise about the costs. But we do understand enough to get started. Admittedly, we will have to take some of the risks. We will have to improvise and experiment. And if some of the experiments fail, we will have to learn from it and start anew."

Fig.1. These campesions, paid by PIDER a minimum wage, are building an access road witch will help them export their produce to neighboring markets. Before, the ejido was reachable only by mule.

Among the most interesting of the schemes under way is the Integrated Program of Public Investment in Rural Development (PIDER), initiated in the late 1960s by the Mexican Government.

In a report written for the Bank in September 1975 on the development of public marketing infrastructure in Mexico, James A. Austin of Harvard University and Frank Meissner of the Inter-American Development Bank wrote:

"In the early 1970s, more than 20 million *campesinos* were relatively worse off than ever before: their capita incomes were one-sixth the level of their city cousins ($145 versus $850); a massive exodus from agriculture was triggered off with over 3 million unskilled rural residents migrating to cities (in the decade of the 1960s rural areas had access to only about 15 percent of the public services, schools, hospitals, roads...), creating a serious urban unemplyment and housing problem.

"In short, today there still exist thousands of isolated rural communities where people live under extremely adverse economic and social conditions, where harsh soils and rainfed agriculture yield is so little that most of the output is destined for subsistence. As a result, income is low and employment opportunities scarce.

"Furthermore, illiteracy and disease incidence is high, housing is inadequate, diets are deficient. Most importantly, outlook for improvements of the situation has so far, been bleak."

Past Exploitation

PIDER, an experiment, has had plenty of the frustrations to which Mr. McNamara referred in his Nairobi speech. But now, after only three years of operation, many, in and around PIDER, believe there is hope for the future. Some of the projects associated with PIDER can already be tagged as "success stories"; most of the reasons for PIDER's continuing problems, on the other hand, are to be found in Mexico's history and social situation.

After the Mexican Revolution (1910-1917), the *ejido* (common ground owned jointly by the villagers) replaced the *hacienda* (large ranch) as the dominant social form in rural Mexico, giving the farmer in a community inalienable rights to land. But the Revolution didn't solve the problem of agricultural credit, the lack of productive land or water resources, or of population growth, and titling problems. And it didn't remove suspicions rooted in past injustices which allowed farmers to be exploited by landlords, traders, and officials.

Tahdziu, a small Maya village in southern Yucatan, exemplifies some of those problems.

"We will hang you if you come back again," the people of Tahdziu tell Jose Xoy. Mr. Xoy is working for one of the agencies associated with the PIDER program, and he is in Tahdziu to help establish rural programs and projects. He grew up in the region, where Spanish is only the second language, and he speaks Maya fluently.

Gonzalo Lopez, PIDER's regional supervisor in the area, explains:

"The people say he is an agent, because he works for the Government. They won't accept anything, neither irrigation nor livestoch, nor cash crop projects. They think the Government will come and take away half their crops."

This harsh rejection doesn't surprise Arturo Diaz Camacho who, as general manager of PIDER, runs its daily operations out of Mexico City.

"There are still places where our people cannot venture without a definite physical threat," he says. "In those cases, we try to find a suitable project nearby and hope that the 'infection process' will take place. In many instances, communities originally opposed to projects watched other communities benefit from our programs. After a while, they became interested, and we were able to start talking business," he adds.

Still in Yucatan, not far away from Tahdziu, is the village of Xcobiacal. There, the 38 members of the ejido have not only accepted PIDER's projects. but they are "already far ahead of us," the regional supervisor says. Xcobiacal now has two agricultural "units." 170 head of cattle, and almost 2,000 acres of pastureland cut from the surrounding jungle. A bilingual teacher comes in daily on the newly built earth road to teach the village children. Most of the labor for the projects has been provided by the villagers who, in only three years, have "evolved" from an isolated, subsistence (corn) community to an *ejido* whose economic and social achievements are quite tangible.

But then, less than two miles away, another *ejido*—Uitzina—has rejected most offers of assistance because of previously frustrating experiences with some of the agencies which used to work separately in the rural development field before PIDER's establishment.

Uitzina is not alone in its reluctance to accept Government help: "Too often have we played guinea pigs for incompetent technicians, ill-advised management methods, and corrupt marketing practices," says Jorge Arroyo, one of the leaders of *ejido* "Justicia Social."

After a fraudulent bankruptcy, the capital assets of one exploitive enterprise were transferred to the newly formed *ejido*. But "Justicia Social" also inherited broken-down water pumps, disabled heavy tractors and bulldozers, inadequate agricultural equipment. One of the most sophisticated fruit and tomato packing plants in the contry is showing signs of delapidation because there are no tomatoes to pack. Planting, fertilizing, and harvesting of crops was initially made according to the advice of technicians; the advice was frequently no good.

The man from PIDER confirms the mistakes made before PIDER's time, and one of his jobs is to keep in touch with the people of the *ejido*. "They know we are here to help if they need it. As a matter of fact, they are considering a couple of projects we proposed not long ago, but there are factions within the *ejido*. Some of the 300 proprietors reject anything new. Some push for outside help. Most don't know what to do. They have to get their priorities straight, first," he says.

Consensus within the *ejido* is essential because the community adopts the main decisions made in the *ejido*. Thus, the elected authorities have to take into account the opinions of their constituents.

Diaz Camacho recognizes this as one of the more sensitive aspects of PIDER's work. "Twelve different agencies are charged with executing our programs. Their aim and our programs are designed not only to increase production and help solve the unemployment problem, but to involve its beneficiaries in decision-making and planning as

Fig.2. A PIDER extension agent (seated in the middle) explains to the ejido farmers a rural development program designed to help them increase their cash earnings by planting citrus trees.

well. It is a question of leadership. If an *ejido* is ready to change, a leader will emerge. Sometimes, it is the other way around," he says.

Near Oaxaca, the capital city of Oazaca Province on the Pacific Ocean, two *ejidos* lie side by side. In one of them, in Ocotlan, where private holdings of no more than half an acre are still the rule, people have been maimed, stabbed, and killed in disputes over a furrow of almost non-productive and overused land. According to Alberto Padilla, one of the *ejido* members, the Olmeca and Zapoteca inhabitants of this *ejido* believe that if they consolidate their land, the Government will come and take it away. Mr. Padillo has three sons, 15 grand-children, and owns three furrows, each about 300 yards long. The three furrows are supposed to provide a livelihood for his entire family. Until now, the *ejido* has refused assistance from PIDER.

Next door is *ejido* "Cinco Senores." Here, despite some initial resistance, the 37 owners have consolidated their land and are working together on the resulting 96-acre farm.

To help this cooperative effort, PIDER has built a small concrete and cement factory where young people earn a living and learn a trade by making water pipes and light poles. Normally, since *ejidos* don't expand, the size of family plots shrink as children grow up. Alternative jobs must thus be created if family plots do not eventually shrink to the vanishing point.

PIDER's experience now comprises 5,400 individual projects ranging from irrigation and livestock to education, rural electrification, and small rural industries in more than 70 small regions throughout Mexico. The World Bank is helping to finance projects in 30 such regions. In total, as many as 9 million of Mexico's poorest people are being reached, either directly or indirectly, by the projects.

PIDER's critics argue that from a budget of more than $1 billion (for PIDER's first stage, 1973-78), drastic changes have not been made in Mexico's rural environment. On a national level, there is still no crop or livestock surplus, nor are the campesinos much better off than before. But PIDER's long-range program is building the infrastructure necessary for a gradual and steady take-off once the motivation has been sown, and the initial risks and improvisations are beginning to show results.

Mr. Schmidt, formerly international editor of El Nacional *in Caracas, Venezuela, is now a Public Affairs Specialist in the Information and Public Affairs Department of the World Bank.*

Table 1. IDA Credits, October-November 1975

Country	Purpose	Amount ($ millions)
Bangladesh	Imports	100.0
Burundi	Coffee improvement	5.2
Chad	Polders	5.0
Malawi	Education	11.6
Mauritania	Ports	8.0
Sudan	DFC	7.0
Total credits, July-November, 1975		427.7

Table 2. World bank loans, October-November 1975

Country	Purpose	Amount ($ millions)
Botswana	Roads	5.8
Brazil	Railways	75.0
Ivory Coast	DFC	8.0
Kenya	Water supply	35.0
Korea(2)	Dairy development DFC	45.0
Mauritius	D F C	7.5
Romania	Flood recovery	60.0
Tanzania	DFC	15.0
Turkey	Power	56.0
Uruguay	Livestock	17.0
Yugoslavia	Oil pipeline	49.0
Total loans, July-November, 1975		976.1

by Report (News of the World Bank, January-February 1976)

World Foodgrain Outlook, 1975-76

Excluding USSR, the world supply of grain for the crop year should be good. Prices are expected to remain stable.

Total foodgrain import bill of the developing countries may be 20 percent less than in 1974-75, but still two and a half-times 1972 levels.

Wheat

Look for supplies to remain in most delicate balance with demand, and for production to remain even with last year's 358 million tons, well below the record 1973-74 crop of 377 tons. Critical production decreases expected in the USSR and, to a lesser extent, in Europe, will almost be compensated for by increases in the US and Canada. Import requirements in the developing countries will remain high because of the need to replenish stocks and because of relatively lower prices. Prices are expected to stay at about present levels, though minor declines may occur if the early 1976-77 crop estimates prove favorable.

Coarse Grains

An increase of 20 million tons in world production (to 666 million tons) is now expected. US production may increase 40 million tons, or 27 percent higher than last year. Production in the USSR, on the other hand, may drop 20 million tons. A further decline in prices may be expected later in the crop year, though much depends on the demand for feed in the industrialized world and on the level of Soviet bloc purchases.

Rice

The outlook is encouraging. The 1975-76 crop is estimated at 227 million tons, up about 5 percent over record 1974-75 levels. The excellent monsoons in Asia will account for most of the increase, and improved production is looked for in almost every Asian country with the possible exception of the Philippines. US production is about 3.8 million tons, a record. China, too, will see another record yield. Prices are expected to continue to decline, and Thai quotation are now at about half their April 1974 ($617 a metric ton) level.

by Report (News of the World Bank, January-February 1976)

New technique saves irrigation water

BEAN FARMERS can reduce by 30 to 50 percent the amount of water they now use each season for irrigation by adopting a new within-row irrigation technique.

Beans grown in semi-arid areas are planted late in the spring to avoid frost. It is necessary to irrigate prior to planting to provide moisture for germination. With conventional irrigation practices it is not uncommon to wet the entire soil profile, applying as much as 12 inches of water.

Much of this water is lost to deep percolation and evaporation. Moreover, the soil in bean-growing areas is usually loose and highly susceptible to erosion. The frequent irrigations and large volume of water used in conventional irrigation practices often cause considerable erosion in bean fields.

According to soil scientist Warren Rasmussen and agricultural engineer Robert Worstell, of the Snake River Conservation Research Center, Kimberly, Idaho, the quantity of water needed to establish satisfactory stands and subsequent growth of beans, can be almost cut in half.

By applying water with a multi-set surface irrigation system to small listertype furrows—which resemble corrugations—the ARR researchers apply only about 1/8 of the water generally used in conventional, pre-plant irrigation.

The use of multi-set surface irrigation systems enable the application of small quantities of water at controlled rates to small areas of soil around the furrows. The average depth of water applied to furrows by the researchers during pre-plant irrigation was a mere 1.5 inches.

The researchers use an ordinary surface planter to seed beans directly into the damp furrows 2 to 3 days following the pre-planting irrigation. After the beans emerge and while the plants are still small, frequent, light irrigations are applied directly around the beans growing in the lister furrows. At the last cultivation, standard irrigation furrows are reformed in the centers between the rows of bean plants and are irrigated in a conventional manner until harvest.

By continuing within-row irrigations while the plants are small, only 0.5 to 1.5 inches of water are applied to the furrows each irrigation. In total, only 14 to 16 inches of water are applied to bean plants each season. Conventional irrigation methods average 22 to 28 inches of irrigation water each season.

Besides reducing the amount of irrigation water used, the researchers also significantly reduced soil losses by furrow erosion and runoff, and to a lesser extent, cut nitrogen losses with their new irrigation technique.

Fig.1. Soil scientist Rasmussen watches as within-row irrigated beans are checked. Soon, the furrows will be reformed and the beens will be conventionally irrigated until harvest (0874 × 1357-11).

by U.S.Department of Agriculture (Agricultural Research, January 1976, Vol.24, No.7)

NEW PRODUCTS

Tractor

Hinomoto E21···Hinomoto Tractor E21 is installed a engine with strong torque and its pulling capacity is very powerful due to the medium speed revolution. The body itself is a unique mechanism. The wide steering angle and well disigned pinion and sector gear allow it to turn around a small round.

Specification

Dimensions : Length 2555 mm, Width 1230 mm, Height 1320 mm

Weight : 830 kg

Ground clearance : 350 mm

Output : 21ps

Revolution : 2400 rpm

Displacement : 1263 cc

Forward : 8 speeds

Reverse : 2 speeds

Turning radium (minimum) : 1700 mm

Rotary type : Side-drive

Tilling width : 1400 mm

(Toyo-sha Co., Ltd.: 16-55, Joshoji-machi, Monma City, Osaka-Fu, Japan)

Tractor

Iseki Tractor TS2510···TS2510 tractor has water-cooled, 4-cycle diesel engines, which produce high power and flat torque. Further, this model has so many exclusive features as follow;

Well balanced weight distribution and low center of gravity with high ground clearance promises stable and safe operation.

Suitable speed operation can be conducted through selection of 9 forward and 3 reverse speed transmission and 4-speed power take-off.

Three spoke type steering wheel and ball-screw type steering system are adopted for safe and secure operation.

Throttle adjustment is either by a hand lever or foot pedal. All instruments are conveniently arranged within easy reach of the driver's seat for efficient and tireless operation.

Revolving sections are covered by the hood, the fan belt and the universal joint by a cover etc., for safe operation.

(Iseki Agricultural Machinery MFG. Co., Ltd. : 1-3, Nihonbashi, 2-chome Chuo-ku, Tokyo, Japan)

Tractor

Kubota Bulltora B5000 ···Kubota Bulltora B5000 is the smallest 9HP farm tractor in the world with a vertical typed 2-cylinder Diesel engine. With 4-wheel drive, its pulling capacity is very strong. Since Kuboto Bulltora B5000 is used high lug tires and the ground clearance is enough, it works easily on paddy fields, turns around a small round and does not slip even on solid alnd and slope.

Specification

Dimensions : Length 1740 mm, Width 840 mm, Height 1067 mm

Ground clearance (minimum) : 270 mm

Weight : 360 kg

Forward : 6 speeds

Reverse : 2 speeds

Tires (high lug) : Front 4.00-10 Rear 7-14

Tilling width : 865 mm

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

Tractor

Satoh Tractor ST1800 ···Compared with 2-wheel driven tractor, the drawing capacity increased approximate 40%. Satoh Tractor ST1800 shows its power in working on a steep slope because of the high climbing capacity and also work well on a paddy field. Since the engine brake works on all 4 wheels, you can safely drive with a trailer on a steep slope.

Specification

Dimensions : Length 2345 mm, Width 1070 mm, Height 1940 mm

Ground clearance : 290 mm

Minumum turning radius : 2100 mm

Tires : Front 6-14 (lug) Rear

8.3/8-22 (high lug)

Travelling Speeds : Forward 9 speeds, Reverse 3 speeds

Weight : 850 kg

(Satoh Agricultural Machine Mfg. Co., Ltd.: Hibiya Kokusai Bldg. 3-2, 2-chome, Uchisaiwai-cho Chiyoda-ku, Tokyo, Japan)

Tractor

Shibaura SD4000 D-O···The IHI-Shibaura Tractor Model SD4000D-O has many superb features and performs every job economically. The SD4000D-O is 4 Wheel drive and will suit every working on road, field and paddy. Hydraulic position and draft control device serve you smoothly for pull-type implement and keep regular working depth. Independent PTO by dual clutch engages smoothly and quietly. When stopping the tractor, there is no interruption of PTO power flow.

Specification

Dimensions : Length 3177 mm, Width 1520 mm, Height 1943 mm & 1550 mm

Minimum ground clearance : 400 mm

Weight : 1510 kg

Travelling Speeds : Forward 12 speeds, Reverse 4 speeds

Minimum turning radius : 3200 mm

(Ishikawajima-Shibaura Machinery Co., Ltd. : Seiwa Bldg., Nishishinjuku 1-6-8, Shinjuku-ku Tokyo, Japan)

Tractor

Yanmar YM1700···It is efficiently desigined for effective operation. You can work in a comfortable position for hours without fatigue. As the revolution radius is 1750 mm, Yanmer Tractor YM 1700 can turn round a small round and proves in cultivating and weeding. Addtion to that, it is applied a hydraulic system. You can set the position of a farm working machinery to every-where as you like with a hydralic control lever.

Specification

Dimensions : Length 2640 mm, Width 1120 mm, Height 1730 mm

Weight : 720 kg

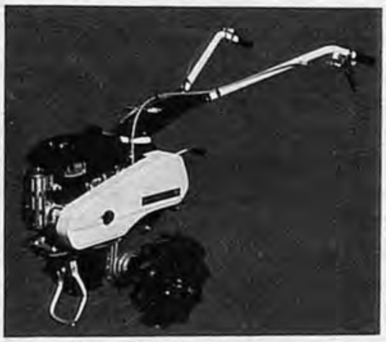
Tilling width : 1300-1500 mm

Foward : 8 speeds

Reverse : 2 speeds

(Yanmer Agricultural Equipment Co., Ltd. : 62 Chaya-machi, Kita-Ku, Osaka City, Japan)

Power tiller



Mametora "Tiller" MC-80···A smart design for multiple purpose makes your work pleasant.

The low center of gravity assures the stability of machine and safety performances provided with belt and geared speed change mechanism with 2 stages for foward makes it possible to obtain an appropriate speed.

Handle can be freely moved vertically, horizontally and turned to 180° by pin and nob operation.

The machine can be easily operated even by a woman's hands. The machine is designed to suit for various performances such as cultivation, weeding, soil breaking, mowing,

Cultivator

Robin cultivator RCO4A···This machine has a Robin Engine Model EC assures superb performance and high dependability.

Its lightweight (13kg) enables applying the Robin Cultivator RC 04A to fields of any geographic condition. Low-centroided, stably balanced cultivator helps facilitate tilling.

By adopting an automatic contrifugal clutch, mere lever manipulation ensures facile operation, eliminating concern over engine suspension while cultivating.

The handle position can be freely adjusted vertically or horizontally to facilitate cultivation in conformity with the operator's stature or job requirements. By detaching the handle, the Robin Cultivator can be mounted in a car trunk or other confined spaces.

(Fuji Robin Industries Ltd. Shinjuku Building 1-8-1, Nishishinjuku, Shinjuku-ku, Tokyo, Japan)

Spraying machine

Spraying machine Casotti…It is a simple and practical means of spraying anti-parastes on grass and trees. Its lightness allows it to be fixed on any type of equipment either to be carried or drawn, at the required height for maximum efficiency. It substitutes favourably all means used up to the present day, allowing good utilization of the antiparasite and a rapid execution of the treatment.

Another inportant factor is the quality of the work. In fact the contionus movement of the jet increases atomization and swirling, making the antiparasite penetrate the less exposed areas of vegetation. Trees and differences in land level are no longer an obstacle. The single nozzle never clogs. The agriculturist need only get off the tractor to fill up.

(Ettore Casotti : 43035 Felino, Parma, Italia.)

Sprayer

Aspee napsak sprayer…Twin Aspee napsak sprayers with spray boom can spray one acre per hour with an application rate of 75 litres/acre approx. at a spraying speed of mile/hour.

Twin Aspee napsak sprayers each having tank capacity of 16 litres, with spray boom having 8 nozzles (each discharging 250 cc/min. at 40 psi.) can be operated by a pair of operators. The operators can maintain working pressure of 40 psi. by operating at a speed of 20 to 25 strokes per minute. The swath width of the spray boom is 13 feet.

(American Spring & Pressing Works Pvt. Ltd. : Malad, Bombay, India)

Grass Cutter

Elta safty grass cutter "uncle Fauchee" AN-22…Revolving at 7,000 r.p.m. "uncle Fauchee" is ideal for parks, cemeteries, gardens, etc., as it can trim effectively around obstacles such as tree trunks, difficult, dangerous work for standard metal-bladed machines.

"uncle Fauchee" Rotary Cutter does the work much faster too, taking care of those "blind spots" and in accessible corners normal cutters cannot reach.

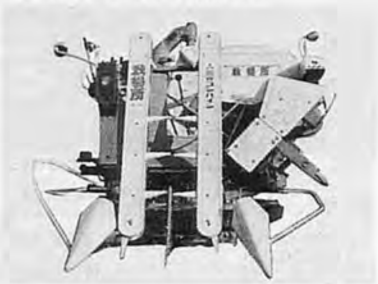
Conventional lawn mowers use revolving metal (usually steel) blades to cut the grass. Thus should the metal blades hit a rock of other hard object there is the fear of pieces of the broken blade flying off and wounding the body.

And the High Strength Cord is harmless ever in the rare event that one's trousers or shoes set caught in it. There's no danger either if the cord hits a stone, fence, etc.

The high strength cord is easily replaceable.

(Elta Machine Industrial. Co., Ltd. 7-22, 4-chome, Asagaya-kita, Suginami-ku, Tokyo, Japan)

Combine Harvester



Mitsubishi Combine MC810 …Mitsubishi Combine MC810 has big features; small, light, lesser vibration and noise and ease and easy in handlings, especially excellent in operation.

With a cell starter, one time for starting is just enough. Furthermore, as it is applied the unique combustion system, NOx and CO is exhausted lesser. Applied the special threshing system for raw threshing, it can thresh completely. A seat is at front.

Specification

Dimensions : Length 2995 mm, Width 1800 mm, Height 1760 mm

Weight : 710 kg

Engine : Mitsubishi Meiki MCP Engine G 11 L-DE

Output : 10ps/1700 rpm (Maximum : 12ps/1800 rpm)

Travelling Speeds : Forward : 6 speeds, Reverse : 2 speeds

Reaping Capacity : 2 rows

Selecting method : Automatic selection and dynamic sieve system

Bagging device : Bagging can be done 4 at one time automatically With a noticing buzzer

(Mitsubishi Kiki Hanbei Ltd. : Hibiya Kokusai Bldg. 3-2, 2-chome, Uchisaiwai-cho, Chiyoda-ku, Tokyo, Japan)

Tea leave picker

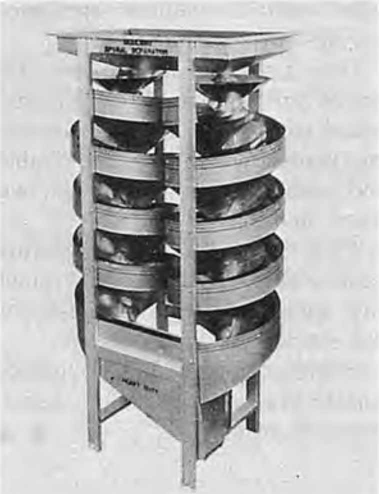
Ochiai EOP A8···Model EOP A8 newly entered the market with a feature of no danger in operation with the safety device. The safety device consists of Main Switch, Left Handle Switch and Right Handle Switch.

The following is the explanation to handle the safety devices.

1) Support the both handles with your hands, and switch on with your left hand, then the blade begins to run.
2) The blade ratation stops if you leave hold of your left hand from the handle.
3) If you leave hold of your right hand, the running blade stops and the buzzer rings.
4) Even if you leave hold of your both hands simultaneously, the blade stops to run, and the buzzer rings.
5) Switch off the main switch if the buzzer rings.

(Ochiai Cutlery Manufacturing Co., Ltd. : Yatabe Kibugawa-cho, Shizuoka, Japan)

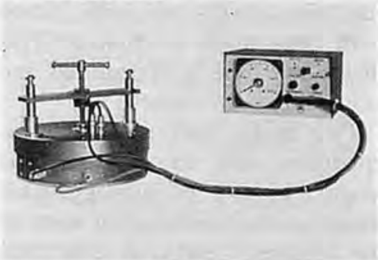
Separator



Cleland double separator···Cleland double separator introduced by Cleland International Inc. The only successful separator for separating corn from soybeans. Separates anything round from anything that is not round, such as soybeans, milo or mastard from wheat, oats, barly, flax or corn. Gravity operated, it requires no power. Ten innerflights in a double unit, separate the round seed into two grades, portions of witch can be controlled by adjusting levers. Can also be used for glass beads and steel ball bearings.

(Cleland International Inc. : 2802 Northway Drive Minneapolis, Minn. 55430, USA)

Forage meter



The RDS Forage meter···The forage meter, as it will be known, employs new electrical and mechanical techniques and is in two parts, a meter unit and a sampling cell. Two readings, nominated X and Y, are taken with the meter unit and the results are converted to a moisture content by means of a simple slide-rule device.

The sampling cell holds approximately one litre of material, being about 6 in. diameter by 3 in. deep. The sample is compressed in the cell by means of a separate piston and screwclamp. The bottom of the cell and the bottom of the piston contain electrodes which take electrical measurements through the sample material. Further electrodes in the perimeter of the cell compensate electronically for variations in the size of the sample.

(RDS (Agricultural) Ltd. : Boundary Court, Woodchester, Stroud, Glos. GL55PN)

Horizontal press

Constructions Chalonnaises ···Two annular ports at each side of the cylindrical through facilitate automatic filling in a high position and draining in a low position.

The ports do not turn during pressurisation (programmed automatic interlocking). During filling, the trough turns; this facilitates profuse drainage, homogeneity of distribution and therefore a more efficient capacity.

Pressurisation is effected in a conventional manner. Draining is effected by the automatic downward rotation of the ports, separation of the covers, crumbling due to spaading and the presence of rubber deflectors. Flow selection can be made and controlled by pressure. Finally, a washing phase is programmed.

This appliance reduces manpower by 2/3 and increases yield by 50%.

(C.M.M.C (Constructions Chalonnaises) : 49290 Chalonnes-sur-loire, France)

Drainer

Poclain SC 150L···Drainers with wheels and especially with chains make very regular profiles at the bottom of the trench.

By placing a gear-tooth of

designed profile with hydraulic floating fixing and controlled by laser, on the turn bable of a conventional POCLAIN shovel we get an identical precision in a more economical way and without any change in the structure of the of the ground. The laying of drains can be effected according to the terrain at nearly 4 km per day.

Systems of hydraulic positioning and of transfer of the weight of the shovel onto the gear-tooth adjusts itself to any change in terrain maintaining an accuracy of 1 mm/m.

This drainer can be quickly transformed into a conventional shovel and endowed with the advantages of control and comfort and reliability which is well known.

(Societe Poclain : 60330LE Plessis-Bellevill, France)

Lifter-Fastener

Gregoire lifter-fastener···Two Archimedes screws driven by a hydraulic motor lift the vine-shoots and lay them on the framework. Two packthreads are unrolled on each side of the plant which is retained in a guide-through.

At intervals, a fastener joins the 2 strips and fastens them together with a metal clip.

The yield of this machine, operated by one man, is hectare in 3 or 4 hours, according to the area and the dimensions of the plot.

(Etablissements Gregoire : 89, avenue de Barbezieux, 16100 Cognac, France)

Framing Machine

Leteux Pneumatic···The machine, which is pneumatically controlled from a compressor driven by a power-take-off, lifts the vine stalks on belts fitted with begs made of rubber. This lifting machine is articulated and adjustable.

Two midly pressurised, blown-up drums hold up the plant and unwind a strip of biodegradable paper on each side of the stem to the required height. A clip joins the two strips together at regular intervals ; the arm carrying the clip is articulated to avoid damage in case in encounters an obstacle such as (stems, pegs, props), etc.

(Etablissements Leteux : B.P. 193, 17100 Saintes, France)

Sprayer

Tecnoma Automatic Sprayer ···In order to achieve high pressure operation this apparatus has the following features :

—a hydrostatic transmission driven from the output of the power-take-off, which quickens the sprayer especially the pumps.

—The velocity of this transmission, regardless of the velocity of the power-take-off is obtained by the action of a tachometric generatrix driven with a minimum is obtained by the action of a tachometric generatrix driven with a minimum of effort by a effort by a carrier wheel ; the velocity is thus proportional to advancement.

Adjustment of the flow is obtained by a potentiometer, the control is by an electrical alarm system, which is triggered off if the characteristics of the material are exceeded.

The F.P.A. system (flow proportional to advancement) therefore has no effect on the nature of the spraying selected by the user.

(Tecnoma : B.P. 195, 51321 Epernay, France)

Stacker

Agram multiblade doublecutting···Boom-stacker chopper-harvesters have been sometimes fitted with a chopper appliance having 3 or 6 cutters.

The present innovation replaces this appliance by a cylindrical rotor with 36 self sharpening blades which are removable and pass in front of one or two fixed blades.

This facilitates a finer cutting (stalks of 20 to 60 mm) without any significant rice in cost for this stacker.

(Societe Agram : 238, boulevard Antole-France, 923000 Saint-Denis, France) ■ ■

BACK NUMBERS

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NewsLetter

INTERNATIONAL FARM MECHANIZATION RESEARCH SERVICE

c/o SHINNORIN-SHA 2−7 KANDA NISHIKI-CHO CHIYODA-KU,
TOKYO, JAPAN., TEL. 03−291−5718, 3674

Dear friends

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

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

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

Whenever you need more informations, pleas write me!

Yours Sincerely
Yoshikuni Kishida
Head of Directors