International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL. VI, NO. 2, AUTUMN 1975

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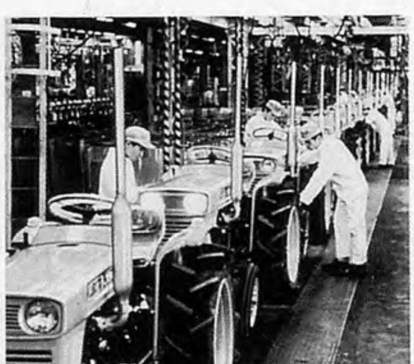

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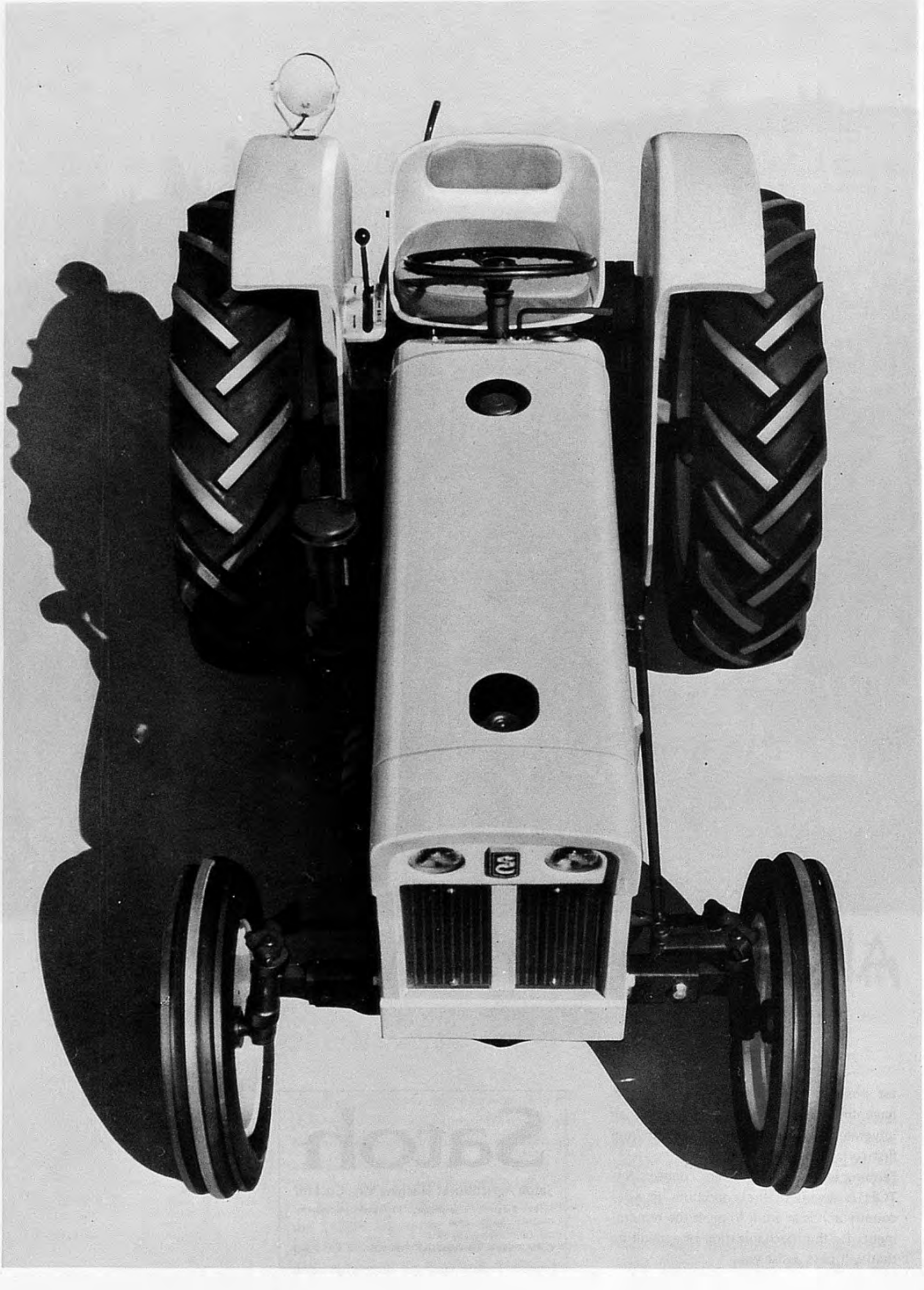

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The basic feature of the System consists of a predrying process and finish drying one. Former process is provided with the Floating Dryer which drys row paddy as fluidizing and mixing it on the perforated plate in the drying chamber with forced drying air passed through the plate. A large amount of row paddy of high moisture content is continuously pre-dryed for short period by the Dryer. Pre-dryed paddy is transfered to the Finishing Dryer with big holding capacity in later process and is gradually finished to predetermined moisture content.

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Explanation of main equipments

This System includes two transporting lines. Each of them is provided with a hoper scale and a Floating Dryer which can treat 7.5t/hr of paddy. The total receiving capacity of both lines is 15t/hr. Pre-dryed paddy is transfered to the five storage tanks and cooled by suction air of low pressure turbo-fan. Each of the tanks has 15t of receiving capacity. After cooling, high moisture content paddy can be return to the Floating Dryer in order to dry again. Four recirculation type dryers with the automatic moisture control are used for finish drying. Each of them has 15t of receiving capacity. The holding capacity of discharge control tank is 3t and finished paddy tank is 0.6t. The capacity of rice huller is 4t/hr.

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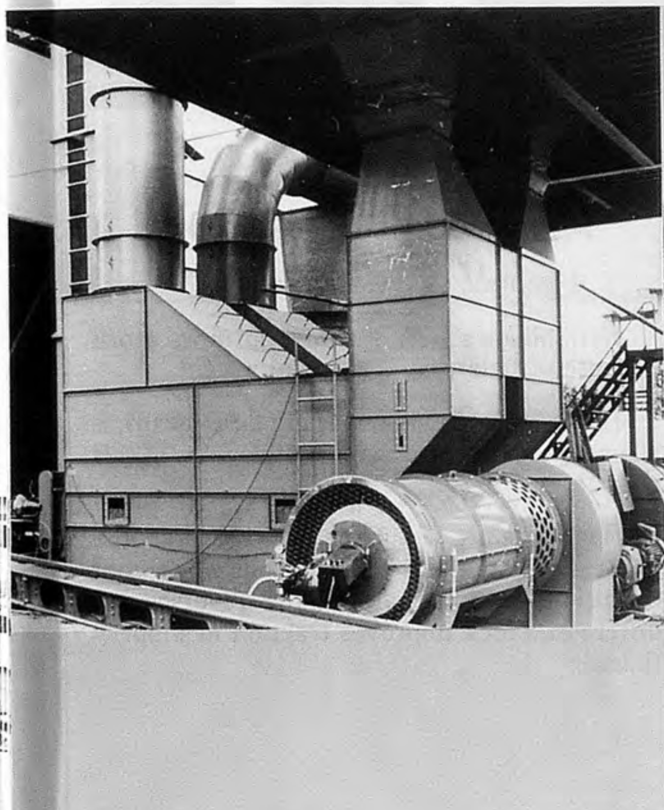

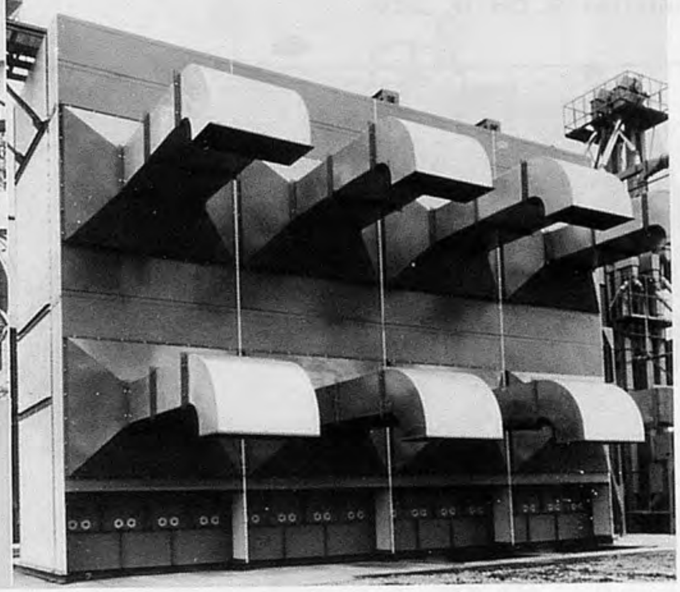

Features of Floating Dryer.

- Pre-brying and pre-cleaning is carried out at the same time.
- It is easy to keep paddy in the storage tank for short term. because the Dryer can make row paddy to half-dryed one.
- It has high capacity with even drying for small scale equipment.
- It is very compact type. There are two types of mobile type and fixed one.
- The operating ratio of small Co-operative Rice-Drying Facility "Rice Center" is very improved.
- All sorts of granular materials can be dryed.

Features of Large Type Finishing Dryer.

- The holding capacity is so big that the power of Finishing Dryer is most demonstrated in handling large volume of paddy.
- The dryer is most suitable for drying row paddy because of adopting triangular perforated pipe in draft system.
- The kracked or over-dryed rice is never occurred due to warm, not hot temperature air (35°C).
- There are two types of non-recirculation type with a moisture control equipment and a recirculation one.
- Facility cost is cheaper because of being installed in the out of door.

Outline of FDA System-120

Harvested Area··························300ha
Volume of Harvested Paddy·········8t/ha
Harvesting Term·························20days
Volume of Drying Paddy/day·······300ha × 8t/20days = 120t
Initial moisture Content············· 25% (Average)
Final moisture Content···············15%

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Preface

It has passed more than four years since we published the magazine, entitled "Agricultural Mechanization in South East Asia", on the problems of agricultural mechanization in the developing countries in the spring of 1971. During the time, we changed the name to AMA (Agricultural Mechanization in Asia) from the second issue and we have published up eight special editions.

1971 was the just next year when FAO announced the optimistic prospect on the problem of population and food in the developing countries. However, when we watched the development of the world, the condition does not get better at all, though the great efforts of various peoples. In those four years, the interests of the whole world concentrated in the need of agricultural mechanization. And the argument seriously rose.

Up to passed five years, many economists persisted that if agriculture would have been mechanized, the unemployment problem would come to us. But such a opinion has almost disappeared.

In 1973, the oil-shock, buying a large amount of food and the rapid rising price of the primary products came into existence. After all, these caused the world-inflation and recession.

The life of people in the developing countries has become worse. The problem of South and North and primary products hold many difficulties in the present world system.

At this time, every person related to agricultural mechanization should have a long-view on agricultural mechanization in the developing countries. We think the article of Dr. G. W. Giles is very significant from this point of view.

We would greatly appreciate your kind cooperation to enrich AMA in contents.

Yoshisuke Kishida

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA

Vol. VI, No. 2, Autumn, 1975

The Reorientation of Agricultural Mechanization for the Developing Countries

Part 1. Policies and attitudes for action programs

by G.W. Giles
professor Emeritus,
North Carolina State University
and consultant in Agricultultural Engineering,
Raleigh, North Carolina, U.S.A.

No longer should the western world's objectives and patterns of agricultural mechanization be adopted per se by all of the developing countries. The emphasis on increased production per worker and convenience in the industrialized contries is simply not applicable. In place must go selectively mechanized systems that maximize crop production and optimize labor utilization per unit area per year. This paper will present the justification and the guidelines for the change. The focus will be on the hard-core approaches and actions for a sound technical program, pushing aside, temporarily, the less tangible social and political aspects. It goes without saying that successful machine systems must, in the final analysis, be suited to the technological, social and economic conditions of an area.

Despite measurable progress in many instances a large number of the developing countries most pressing problems remain : too many people, and too little food and/or poor distribution. What has mechanization to do with these problems? A lot! It is now recognized in limited circles that machines, selectively and wisely used, in conjunction with multiple cropping will contribute markedly to :

increased yields and production of food crops;
better utilization of labor.**

However, our policies, attitudes and action programs have not been sharply tuned to meet these needs. Specifically we need facts on the relationship of machine systems to yield, multiple cropping and labor utilization. We need to eliminate the unessentials in talks, plans and programs and concentrate on getting tangible measureable facts. Only then can the technical and economic validity of machine systems be determined.

The Mechanization Dilemma

Mechanization is the one segment of a total agricultural program in the developing nations that remains to be well thought out. In contrast one can cite the improved crop variety programs, the vast majority of which are aimed at achieving higher yields. Too many of the mechanization projects are haphazardly selected and not coordinated with the work of other scientists, nor fit securely into the hard core objectives of agriculture. Some examples are : a piece of steel added to an indigenous plow; a puddler made of steel; harness

**More man hours per cultivated hectare and per year, more days worked and uniformly distributed per year, and more food produced per worker.

for bullocks; universal frame with wheels for animal drawn improved equipment; steel moldboard plow; low-power tractors of various configurations. Much of the work has been on single machines and operations. Also, in so many instances their value to agriculture has been measured in western terms of draft, time, convenience, etc. True, these and other accomplishments have made contributions. Many a machine has relieved drudgery, improved human productivity and provided an opportunity to develop mechanical skills. Nevertheless, a relatively untouched void remains—the pressing need for *systems* that *produce more food and put more people to work productively.*

Past studies and rhetoric regarding agricultural mechanization in developing countries have been voluminous but quite worthwhile. Noteable among the published comprehensive reviews of accomplishments and situations are C. Voss (1), H. von Hülst (11) and A. Moens (13). Still, facts that unite machines with other inputs as a forceful contributor to agriculture's primary objectives are woefully inadequate. We do not have a clear and explicit path of action for achieving technological greatness in the context of the developing countries' needs and resources.

It is not surprising to find that national and local planners in both developing and developed countries, lacking facts on the more meaningful role of machine-systems, have vacillated somewhat in establishing firm contitnuing policies in mechanization for the developing countries. There has always been an uneasiness about promoting machines, largely because of the growing population and unemployment. As a consequence a middle ground is usually hewed—some tractors, improved hand and animal powered tools, and local industries. Still, there is something amiss in this rationale. Relatively undiscovered and unpromoted is the fact that machines and machine-systems wisely selected and used will contribute to higher crop yields and labor utilization. Outside technical consultants have not been sharply tuned to these values, either in their understanding or obligated leadership.

It is time to move away from the rhetoric stage and to untangle ourselves from the distracting and secondary aspects that always seem to engulf a sincere debate on mechanization. Stout and Downing said, "National mechanization policies are desperately needed in every country" (2). True, providing they lead to sound action programs based on facts regarding machine —yield —crop intensity—labor utilization relationships.

Indicator of Progress

If we are to redirect and give added emphasis to mechanization, we need a better indicator of the changes. This is needed for a historical perspective as well as for meaningful future planning. The fertilizer input expressed in tons utilized has real meaning. But, in the case of mechanization, the number and kinds of machines on farms, or other existing criteria, are inadequate.

An indicator of "horsepower per cultivated hectare" is proposed and illustrated herein. The horsepower figure suggested is the effective capacity* of three power sources: human, animal and mechanical. It is important to use the three sources because all have been, are and will be in the foreseeable future important to agricultural operations in the developing countries. Furthermore, as von Hülst summarized (11), most engineers now recognize three main levels of mechanization: hand tools, animal draught and mechanical power.

A program of mechanization should be built upon the power available and that which is planned. Power is the foundation of agrlcultural operations. A systematic supply, therefore, in the kinds and amounts of power, within economically available limits consistent with maximizing crop production and labor utilization is one of the basic ingredients in effective planning.

We should also have some sense or feeling as to how the horsepower indicator associates with Agriculture's highest priority objectives. The author has studied some 23 regions, countries, districts and farms covering a time span of more than six years. And in doing so the power indicator has been visually compared with yields per hectare, agriculture's highest objective. There is a correlation (statistician's definition) between power and yield, but this does not mean that one causes the other or that one is dependent on the other. It is extremely helpful to have both values on the same chart. Fertilizer consumption has been correlated with crop production for decades.

The results of the author's study are presented in **Figure 1** "Chart of Agricultural Mechanization." First, we shall discuss some conclusions relative to past progress that **Figure 1** seems to point up. Agricultural areas generally have developed initially along line A—B, later along C—D. Apparently, along line A—B crop yields and economic returns are greater when other inputs such as fertilizer are used. The rate of increase of all areas studied, that are in early stages of development, averages about

* Effective capacity is defined as the horsepower that the source is able to exert continuously during a normal work day, day after day without abnormal deterioration. In the case of animals and humans this means without losing bodyweight and vigor. In the case of new tractors it is the measured, rated drawbar h.p. (Not engine hp or advertising claims).

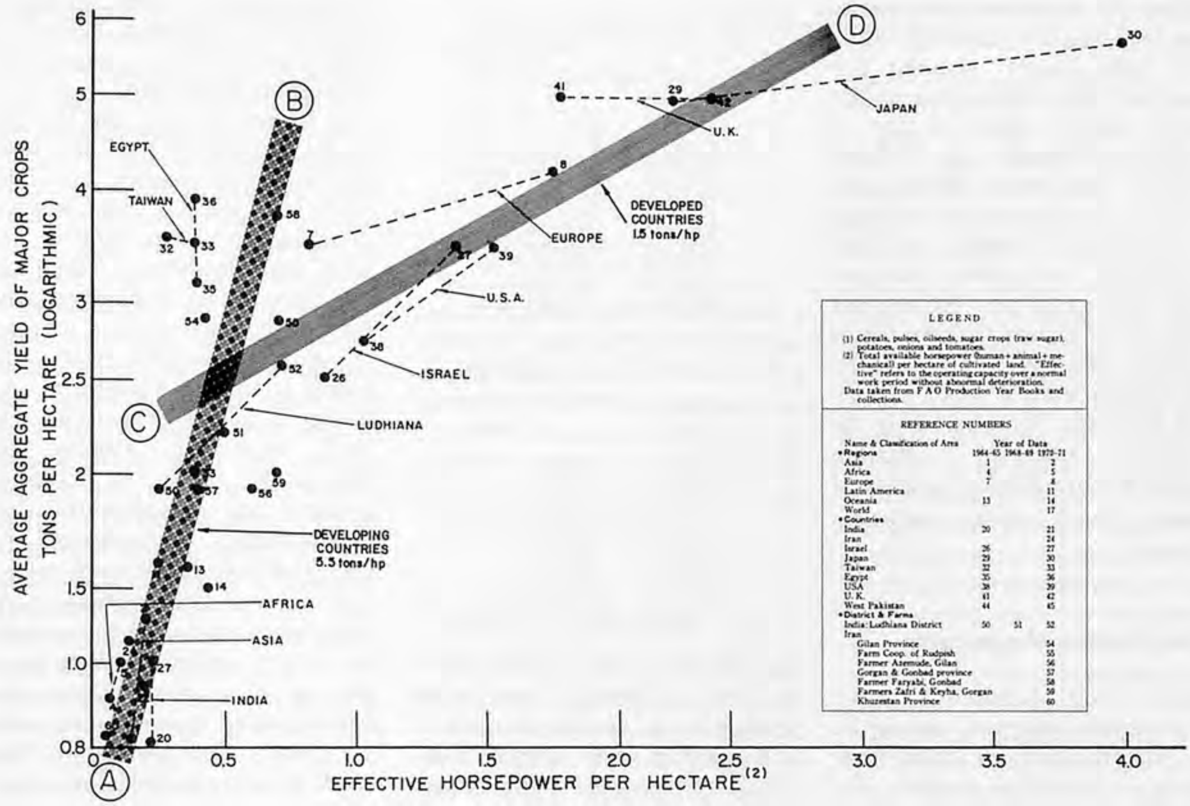


Fig.1. Chart of agricultural mechanization (Crop yield associated with power-1964—1971)

5.5 tons of crop/hp. At around 2.5 tons per hectare mechanization seems to compete economically with other inputs and is increased rapidly along line C—D. The author has observed that along A—B the power is usually increased by adding tractors and tillers, and not without good reason. Along C—D, however, tractors, as well as animal power, are accompanied by more precision type of equipment such as a grain drill.

Much depends upon the unique characteristics of an area. von Hülst (15) rightly points out that advancement along A—B is particularly true for areas of high population density. In contrast he says that newly opened areas benefit from tractor prepared seed beds and plantings, and therefore cannot wait for increased yields to occur first. Also, in some dry areas, soil and water conservation practices made practical by mechanization are more important to increased yields and production than say fertilizer and fertilizer responsive varieties.

Note that India, as a country, during the period 1964—65 to 1970—71 moved generally along A—B (points 20 to 21) whereas Ludhiana District in India has achieved the hypothetical 2.5 ton turning point and is now advancing swiftly along C—D (points 50 to 51 to 52).

Interestingly, during the period 1964—65 to 1970—71 Japan increased its farm power from 2.3 hp per ha to 4, and USA from 1.02 to 1.55 hp per ha. This occurred during a period of relatively inexpensive fuel. On the other hand Africa, Asia and India have made relatively modest increases in this regard. The chart points out rather dramatically the ever widening gap between developed and less developed countries on the basis of hp and yields only.

We come back to our first premise that the chart is a visual aid to record and understand how an area has progressed, and to plan the future. For example, an area might progress more rapidly along an intermediate line somewhere between A—B and C—D providing their mechanization is properly orientated as suggested in this paper. The problem of the developing countries is really one of determining the kinds and types of machines that are vitally needed, or more appropriately "selective mechanization". Each area must maximize labor and yields, and optimize energy input in its own way, and to record and compare its advances using its own chart—a reorientation of mechanization, if you please, in the total scheme of agricultural development.

Looking to the future we need to sharpen and improve the power indicator tool and how it is used. Most countries are collecting more reliable figures on the number and use of laborers, tractors and draft animals on farms. The engineers now need to improve effective capacity values for each power source. For example, the tractor capability values should reflect in part at least, age, number out of commission and break down time. Also, with an anticipated increase in multiple cropping, a chart correlating the power indicator with production per hectare per year would appear to have visual aptness. The same applies to an association with a labor utilization indicator. Most certainly the worlds energy situation compells more detailed studies of energy input—output relationships.

Yield Intensive Mechanization

First and foremost, in a reorientation program, should be the identification of those machines and machine systems that will contribute to an increase in crop yields, and the determination of how much increase. The developing nations lack these kinds of data, and therefore cannot plan effective mechanization programs.

There are a few experimental and field trial observations to support the claim of yield intensive mechanization. Four will be presented. The first two are machines which in their own right gave greater yields. The second two pertain to systems in which the machine(s) play a predominate role.

A combination seed and fertilizer drill was compared with a

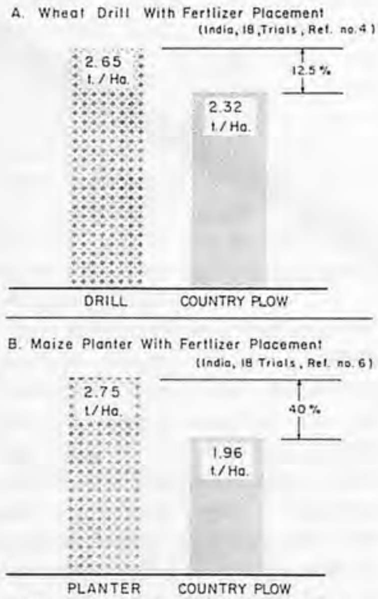


Fig.2. Two yield-intensive machines

country plow for seeding wheat in India in 1964(4). A total of 60 trials gave an average increase of 12.5 percent. See **Figure 2—A.** The resullts varied from District to District and, of course, among farmers. Some farmers who managed well their bullock drawn 3-row drill, got as high as 70 percent increase over their conventional country plow method. These observations gave rise to the use of the term "selective mechanization". It simply means that the achievement of higher yields depends greatly on the type of machines used, the farming situation, and the manager and/or operator. Therefore, machines should be selectively applied depending upon these values. At the time of the drill trials, a Punjabi farmer could pay for his machine through the yield increase achieved by using it to seed a total of 6 hectares—quite an economical investment.

It is important to note that the above cited trials compared modern wheat seeding principles such as precise and uniform metering and placement of the seed, side placement of fertilizer and good seed-soil contact, with the conventional farmer practice of using a wooden plow. The power source is immaterial. Although a bullock drawn unit was used, equivalent results are achieveable with a tractor powered unit providing the drilling principles, management, and operational skills are identical.

In India in 1965, eighteen field trials were conducted to compare the yield of maize resulting from the use of a modern one row bullock-pulled maize planter with the country plow method (6). The resulting average yields presented in **Figure 2—B** were 40% higher for the planter, but were so variable as to lack significance. Nevertheless, the author's experience in India leaves no doubt about achieving substantially higher yields from mechanical planting.

Unlike the two previous examples, the machines in the following two examples do not stand alone. Rather they are some of the necessary inputs to a more complex and improved farming system that does result in increased yields.

One example is a system for growing maize in India under experimetation by Y.C. Arya (9).

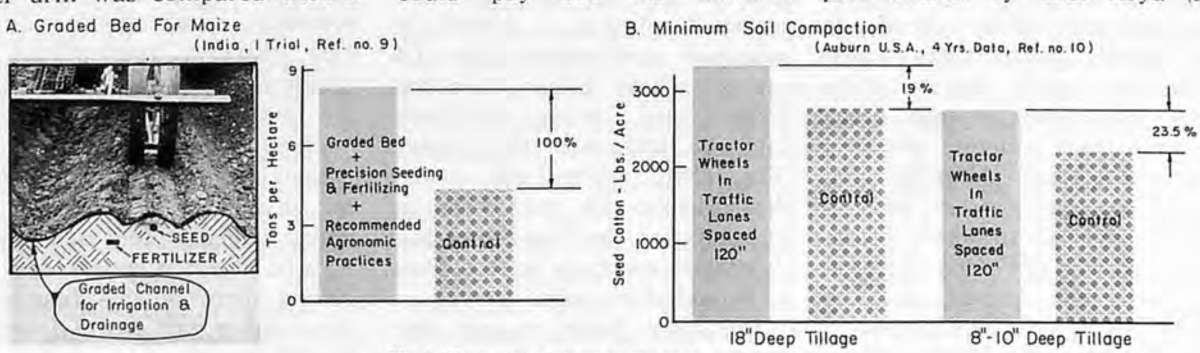


Fig.3. Two yield-intensive mechanized systems

The system involved bedding on a grade so channels serve both for irrigation and surface drainage (water control), and precision seeding and side placement of the fertilizer simultaneously on the firmed bed. Most importantly was a trial by Arya on a farm with heavy, poorly drained soil. This new system was compared with the conventional seedbed preparation and using all recommended agronomic practices in both cases. The new system gave 8.28 tons of maize grain yield per hectare against 4.25 tons for the conventional. The nearly 100% increase (**Figure 3—A**) is indicative only since replication was not possible. However, there is still no question about achieving an increase with the new system. The "trial demonstration" to be covered in Part III at a later date would be the means for firming up the amount of the increase.

The second example of yield-intensive mechanized systems is an experiment by Dumas *et al* at Auburn, Alabama, USA (10). The system minimizes soil compaction by using permanent root beds on which no wheel traffic passed, and permanent tracts to accommodate specially designed, wide-spaced, four wheel tractors. The yields of the most important treatments appear in **Figure 3—B.** Four years data show increases of 19% and 23.5%, depending on the depth of tillage, over the control. The control was a tricycle tractor with rear wheels space 80″ plus a tricycle high clearance sprayer with rear wheels spaced 80″. Because the experimental system is only practical with tractors and not with human or animal power, one must attribute the increase solely to tractor mechanization.

The reader is cautioned that the above cited experiment may have limited applications and that it requires specially designed equipment and additional management skills. It would be prudent, therefore, to make a careful analysis of conditions before duplicating elsewhere. It is presented herein because it is an excellent example of the kind of systems work widely needed. Such examples are sparse in the developing countries.

Table 1. Kilocalories and Percentage Distribution of Fossil Energy Inputs for Producing Corn in USA (adapted from Pimentel et al. (3)).

Type of Input	1945		1970	
	Kcal	%	Kcal	%
Labor	12,500	1.4−	4,900	0.2−
Field operation (machinery + fuel)	723,400	78.0	1,217,000	42.0
Fertilizer	74,600	8.1−	1,055,900	36.4+
Seed	34,000	3.7−	63,000	2.2
Pesticides	000	0	22,000	0.7+
Irrigation	19,000	2.1−	34,000	1.2−
Off-field operations (drying, electricity & transportation)	62,000	6.7	500,000	17.3

Energy and Green Crops

Before moving on to the next thesis involving labor utilization and multiple cropping, one should first have some understanding of the energy problem and how it relates to our goals.

Most helpful is a study by Pimentel et al. (3) of the energy requirements in the USA for producing corn in 1945 and in 1970. The results are summarized in **Table 1.** Note that in 1970 the field operations account for, 1,217,000 kilocalories or around 42% and the off-field operations 500,000 kilocalories or about 17% of the total fossil energy input (solar energy excluded). The total amount of kilocalories for operations, particularly field, are quite substantial. The increase in the use of fertilizer, etc., and of off-field operations during the 25 year period from 1945 to 1970 is also substantial and clearly reflects the adoption of fossil energy intensive technologies that have characterized the progress of developed nations. The increase in energy input for these countries is also apparent in **Figure 1.** The horsepower in **Figure 1** represents the capacity for carrying out, largely, the field and off-field operations.

Our reorientated agricultural objectives, in contrast to those of the developed countries in times past, do not necessarily require a greater input of fossil fuel. Rather, our goal, for efficiency only, is to maximize the ratio of food energy output to fossil energy input per unit area. This paper presses the point that the greatest contribution that mechanization can make to the energy efficiency objective lies in machine and power selectivity and in systems design.

The type of power source, as well as the total power available, varies widely from one area (district, country or region) to another. This is well illustrated in **Table 2.**

Note that Asia derives 51% of its power for agricultural operations from animals, whereas Latin America gets 71% from tractors and only 20% from animals. One must be careful, however, in looking at large areas. Ludhiana District in India, for example, obtains around 74% of its power from tractors compared to 12% for India as a whole.

The type of power and the fossil energy requirements for carrying out agricultural operations will in all likelihood change slowly. Asia, for example, will be tied to animal power for some time even under the most optimistic tractor production and/or import program. The reason is that the restraints for increasing mechanical power rapidly are complex and overwhelming, defying a quick solution.

In our studies and plans we should ever be appreciative of

Table 2. Distribution of Agricultural Power.

Region	Total HP per Ha	Percentage of available power per ha. Human	Animal	Mechanical
Asia (exc. Red China)	.22	26%	51%	23%
Africa	.10	35%	7%	58%
Latin America	.25	9%	20%	71%
Aggregate percentages		24%	26%	50%
India	.23	26%	62%	12%
Ludhiana Distr., India	.82	4%	22%	74%
West Godavari Distr., India	.40	20%	60%	20%

the fact that the biological system remains the world's most effective converter of the sun's free and limitless energy. Of the total energy input in producing and processing corn in the USA under a highly mechanized system, around 90% comes from the solar source (3). Of the remainder, around 10% comes from fossil fuel and an insignificant amount, perhaps 0.2% comes from labor. See **Figure 4—A**. Under more intensive labor and animal power farming, however, labor would be greater and fossil fuel less.

We should also be remindful of the fact that the product of the biological factory, food and fiber, is also energy. It is used to fuel the man and animal power. In this sense, it is reusable.

Energy considerations, therefore, support an emphasis on continuous cropping of productive land wherever possible. And that this be done with the least expenditure, or within the limits, of available fossil energy. We should not arbitrarily reduce the fossil fuel input to agriculture. Rather we must find ways of insuring sufficient fossil fuels for every promising agricultural area of the world. If conservation is necessary, let it be in less essential uses such as processing food for convenience only.

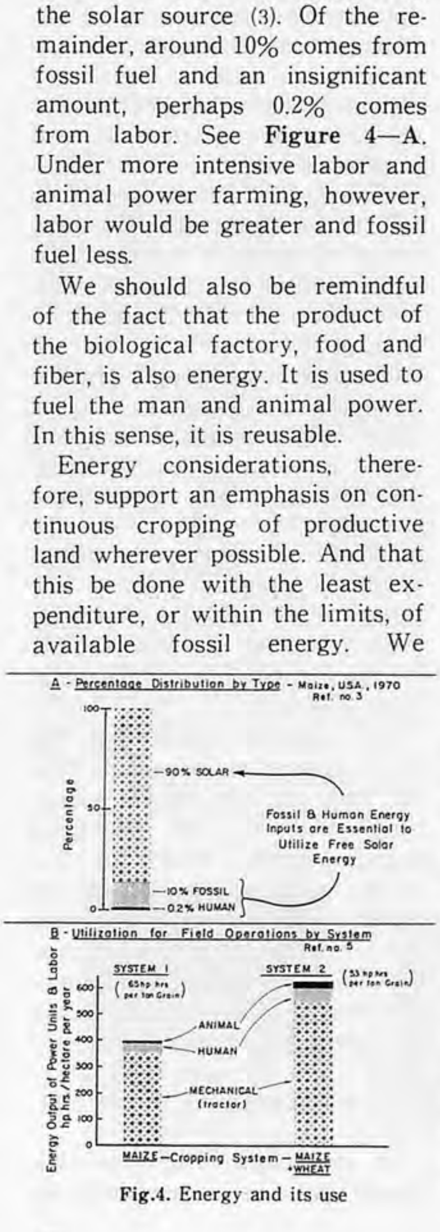


Fig.4. Energy and its use

Labor Utilization and Production Intensive Mechanization

The second main thrust of reorientation is to help maximize the crop production and labor utilization per unit area per year. A lesser objective is to minimize fossil energy requirements for farming operations. Land is the more precious of resources.

By far the greatest opportunity to accomplish the afore stated objectives is by way of multiple cropping. In fact, it is contended that some machines are necessary to make multiple cropping practical and acceptable to farmers.

One piece of indicative evidence is a study of two hypothetical 12 hectare farms in Ludhiana District, India (5). See **Figure 5**. The selectively mechanized and multiple cropped farm (upper graph) had a greater labor requirement per hectare per year compared with a typical bullock powered farm (lower graph) growing only one crop per year. These graphs apply only to the field operations. The model multicrop farm required a labor input of nearly 0.6 of a man year per cultivated hectare. As a comparison, the district, as a whole has available only about 0.5 year per hectare. Despite this large labor input in our model, a high degree of mechanization, including the use of tractors, was used.

Most importantly the selected machines leveled off the peak labor dembnd periods and helped keep people gainfully employed throughout the year (**Figure 5**). Multiple cropping and the diversification from field to field seemed the best means of filling in the valleys of the labor distribution chart. Keep in mind that the off-field operations will contribute measureably to an even higher labor input as well as more uniform distribution throughout the year.

The above study of two hypothetical farms provide data to compare energy requirements for field operations of one crop (maize) with two crops (maize--wheat) per year. The energy figures in hp hours of output per hectare per year are presented in **Figure 4—B**. These figures exclude off-field operations and the amount required to manufacture the machinery. Twelve hp hours of energy is saved for every ton of food grains produced by the two crop system (No. 2) compared with the one crop system (No. 1). The imdicated savings come in the land leveling and major seedbed preparation opera-

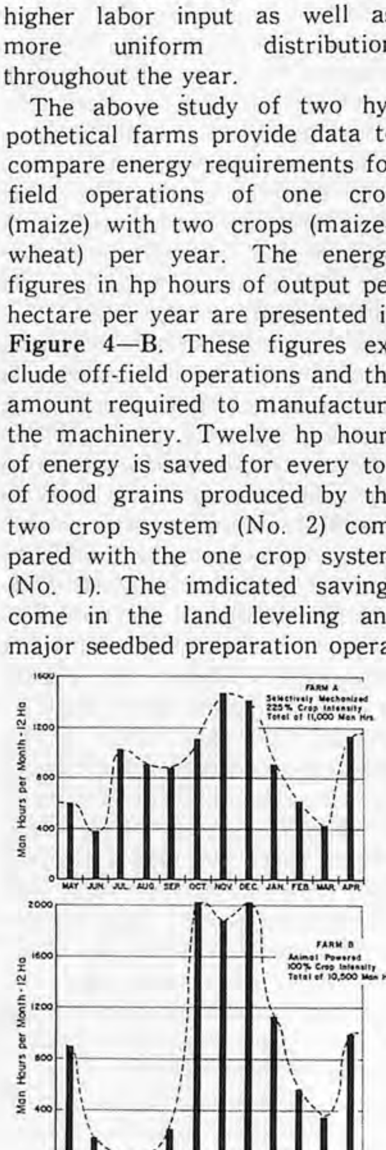


Fig.5. Monthly distribution of labor for field operatians (Man hours for 12ha farm. Source: Ref. no. 5)

tions.

While 12 hp hours of energy is small compared with the total of 635 required, the possible returns and benefits certainly are not: around two times more grain, greater and more productive use of labor, and some animal power utilization.

It is also worth noting that system 2 has improved balance of labor, draft animals and motorized mechanization. C.M. Downing has pointed out the importance of countries with limited foreign exchange to utilize local energy and other resources in developing optimum systems. He said "its not a matter of arbitrarily reducing fossil fuel input but deciding what to limit (fuel, fertilizer, machines, etc.)" (14).

An interesting intensive cropping system has been developed by Dr. Richard Bradfield at IRRI (7). His objectives were to produce a diversity of food for a balanced diet and to increase production and income. Five crops per year with remarkably high yields and income were accomplished with a six horsepower rototiller and attachments. The labor input would be unquestionably higher, more uniform and certainly more effective and appealing by using the power tiller, although these values were not measured.

Apparently missing in this project to date is a critical analysis and adaptation of equipment to improve the operations. Precision, timeliness, practicality, effectiveness and ease of performance should be the objectives of the missing segment.

It is highly questionable whether many farmers in the developing countries are able or willing to put forth the managerial and concentrated effort required to produce five crops per year. Much will depend on the equipment used and its ease of operation. Nevertheless, the project provides a goal and represents in part the kind of "operational system" project mechanization experts should be actively enaged in as a top priority. Even one additional crop per year makes significant increase in the farmer's income, nation's food supply and the use of limitless solar energy.

The next step following Bradfield's experiments should be to get the project off of the experiment station and in a "trial demonstration" on the farm. There, such performance factors as labor input and economics as well as yield and production under the operational and managerial skill of the farmer can be meaningfully determined.

I.A.R.I. at New Delhi, India has done some admirable work on relay cropping (8). A four crop (moong-maize-potato-wheat),single year rotation gave a consistent annual yield for four years of 13 to 14 tons/ha/year. Here again the problem is one of developing a farm level operational system. It is one thing to interplant small station plots, but quite another to make the system operationally acceptable to a farmer. Reported also in reference 8 on multiple cropping in India are the cost benefits and employment potentials. Both resultant values are extraordinarily good.

Multiple cropping is not absolutely necessary to increase labor utilization along with mechanization. Faidley and Esmay (12) found that in Bangladesh power mechnization increased the demand for hired labor. Nevertheless, based upon the evidence available, the combination of selective machines and multiple cropping appears to be an unbeatable combination to best achieve the top priority objectived—maximum production, and greater and more uniform labor input and productivity. The real trick is to adapt machines that will make multiple cropping practical to manage and exciting to labor. If we don't, labor will still migrate to the cities. Downing (14) rightly put it, "The amenities of mechanization are far more important to a modern society than they are given credit for."

The Machine Element in a System

One cannot always validate a claim that the use of a machine in the production, harvesting and processing of field crops is a sole contributor to a demonstrated yield increase or to an effective increase resulting from a reduction of losses. The reason is that the machine usually is only one of many exceedingly complex interacting inputs within a system.

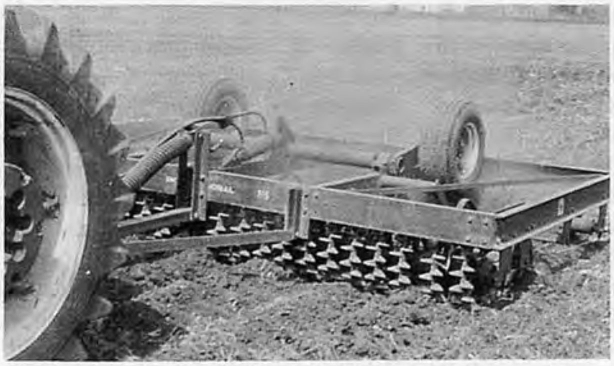
This complexity and interdependence of influencing elements within a system can be illustrated in the case of a planting system for maize in rotation with wheat being tried out in Egypt by Ahmed Bahgat and G.W. McLean. The seed bed is prepared by chisel plowing, cultipacking, harrowing, and landshaping or planing. Irrigation furrows are formed by the use of a country plow. Two rows are planted by a specially designed planter working astride this channel. Fertilizer is simultaneously placed between the seed and irrigation water (below the seed and to the side). The conventional system involves seed bed preparation with a country plow and no field surface shaping or planing to a grade. The furrows are formed by the country plow, basal application of the fertilizer broadcast by hand, and the seed planted by hand. The system is illustrated in **Figure 6**.

More than a 50% yield increase resulting from using this system is anticipated by the author. None of this expected increase can be attributed directly to any one or all of the machines. The placement of the fertilizer will unquestionably increase the yields, as will the uniformity of the irrigation from one end of the row to the other, made possible by surface planing and furrowing to a grade. But are these specifications dependably achieveable on relatively flat land without machines? No! Humans simply will not and cannot compete with some machines in the kind of precision and repetitiveness required. In small plots, perhaps, but the developing countries' food and labor problems require a workable system on a large area basis. Millions of farmers must be enthusiatic participants. The above is only a trial. It may turn out to be unworkable. The important point is that it represents the kind of research and development we need to pursue more vigorously than here-to-fore.

Another important point pertains to multiple cropping. The time available to harvest one crop, prepare the seed bed, and plant the next is very short, if the yields are to be maximized. In many instances machines and power will be necessary. It is simply impractical to assemble and manage the necessary hand labor. On isolated, special farms, Yes! Of course, irrigation is usually a requisite. But, world wide, the cropping intensity of irrigated land is only slightly over 100%.

The important point is that some machines are absolutely necessary to make the system work, especially under irrigated situations. If this be so, why should one attempt to segregate out the contribution of those


1. Chisel plowing


2. Cultipacking and harrawing


3. Land shaping and planing


4. Forming irrigation furrow


5. Planting two rows astraddle furrow

Fig.6. Experimental planting system for maize (Egypt,—Yield intensive and a judicious blend of mechanical, animal and human pawer)

components that are essential? Admittedly, the system can be made to work by using only hand operations on relatively small plots on agricultural experiment station farms. But it is not a rational plan for farm usage in the future. The problem is one of supplying those machines that are needed to make the system practical and acceptable at the farm level.

The Action Program

We have pointed out that the scientific facts with respect to mechanization are woefully inadequate. We also said that the scientific facts needed as a top priority are those pertaining to a system. To acquire such requires hard work over many years involving "field plot experiments" at experiment station level and "field trial demonstrations" at the farm level. These will be covered in subsequent papers. Following are some general policies and attitudes pertaining thereto.

The Multiple Discipline Approach - a Must

If we are to have an integrated system, it follows that we must have an interdisciplinarian effort to "develop" the system. There is no good alternative to this principle. Involved in the initial development work of the maize system described in the previous section and illustrated in **Figure 6** should be the following specialists in addition to the Agricultural Engineer:

- *Irrigation* and *Soil Scientists* on furrow lengths, sizes, absorption rates and fertilizer placement;
- *Agronomists and Plant Breeders* on varieties, planting rates, seed spacing and depths, and cultural practices;
- *Plant Protectionists* on treatment of the seed and the use of pest control measures;
- *Agricultural Economist* on planning systems that best fit future economic situations of an area (availability of labor, type of fertilizer, pricing of energy etc.).

The Agricultural Engineer is usually involved in all of the development studies by the above Specialists because they must, (1) integrate the system, (2) make it operative on a practical farm basis, and (3) adapt or develop the machines necessary to make the latter possible.

In developing new systems the cost/benefit analysis and related economic calculations must be postponed until after a workable system has been devised and evaluated. Scientists must be free to try new systems and elements thereof that may not appear to be economic. Valid analysis requires both yield and labor utilization results first. After these values are known and one is ready to try the system, operationally on larger plots usually at the farm level, an economic analysis then becomes important.

Make no mistake the crop production and labor utilization problems of the developing countries are overwhelming and need new and imaginative technological approaches. One must have a sense of future requirements and opportunities unclouded by cost figures of today. We simply must do this to avoid mediocrity and insignificant progress.

The real challenge in a multidisciplinary approach is to make it possible for each specialist to achieve identity and credit for individual accomplishment. Competent administrators and responsive leaders will create and insure the kind of organizational structure and working environment in which this will be truly possible.

Mechanization Institutes

There are many centers throughout the world whose function is to develop and test agricultural equipment. Many of these are concerned, as a top priority, with only one part of a system, as for example, a puddler. Although such objectives are important, the developing countries need a few exceptional centers that are geared, as a top priority, to the development of new systems designed to increase yields, production and labor utilization per hectare. It is suggested that a few be established at existing research and development centers where the required specialists are presently at work. To make such a Center succeed, three points seem important. First, there must be room to recognize the accomplishments of each Specialist. Work on operational systems should occupy only a portion of the scientist's time—the remainder being for the pursuit of more individualistic professional challenges. Sesond; the name must carry the connotation of being as it really is, interdisciplinary. "Operational Systems Institute" is suggested. Thirdly, we must recognize that it takes time to develop a machine as a part of a system. Basically the development of a machine is similar to the development of say a new crop variety. Elements and characteristics are put together to achieve desired effects. Each promising resultant must be adequately field tested and evaluated relative to widely used equipment on farms.

A complimentary requirement to development centers, conventional as well as "operational systems institutes", is a coordinating agency. In this regard the international FAO rice mechanization studies in collaboration with coordinator Professor A. Moens of/and with Wageningen University, the Netherlands, is noteworthy. In operation since 1971, it is concerned with exchange of information on designs, field tests, systems analysis, etc. Its duties might well be expanded to promote with greater strength the top priority objectives called for herein (16).

Local Planning Is the Foundation

Up to this point the discussion has been directed to policies and attitudes at the national level, and well they should be. Agriculture, however, is very diverse within a nation. Crops, soil, rainfall, labor availability, drainage, irrigation, management competence, and the will to accomplish change varies widely, even from one farm to another. Therefore, imporved cropping systems must be evaluated and applicable to a manageable area—preferably a farm*

This principle is no different than what is used in the case of the other major inputs. For example, recommended fertilizer rates and grades are made on a wide area basis. However, in the final analysis, an individual farmer, usually with the aid of the Extension Specialist, must adjust his applications to his crops and fields based upon crop response. As in the case of fertilizer, mechanization must also be selective with respect to the local area. For example, the graded bed system illustrated previously in **Figure 3—A** for maize is particularly effective on heavy, poorly drained soils.

Ludhiana District, India has .61 hp. per ha. of mechanical power (74% of its total available power), whereas the average for India as a whole is only .028 (12%). The tractor has been developed, however, as a successful universal power unit applicable to very wide usage. This is not necessarily so with some other machines. The two row maize planter, for example, shown in **Figure** 6 may work only with the system shown. At this stage in "reorientation" it is sufficient to recognize that systems must be workable at the individual farm level and not necessarily applicable to the entire nation. National leadership must recognize this principle in planning mechanization programs.

Lastly, local farmers will make mechanization work if they have the incentives. Leaders must remove insignificant factors, such as poor roads, small farms, low mechanical aptitudes, from their planning. They should concentrate instead on offering the farmer a number of mechanized systems, and components thereof, that will make a significant impact. Aranda Heredia of Spain speaking at the 1974 CIGR meeting put it aptly, "Mechanization can introduce itself if the right alternatives are offered." It is for the local people to help pinpoint the alternatives.

Summary and Recommendations

This paper has suggested that the world, particularly many of the underdeveloped countries, must reorient their agricultural mechanization programs to help

- —increase yields and yearly production of food crops, and
- —increase the utilization of labor.**

Why? Because the most pressing and urgent problems are too many people and too little food. Some machines and machine systems will increase yields. Some machines are necessary to make multiple cropping systems work, and a greater intensity of cropping increases production and labor utilization per unit area per year.

It follows that machines are one of the main influencing elements in systems designed to increase crop production and the labor utilization. All of the major inputs—fertilizer, seed, pesticides, water and machines—interreact and are very interdependent. If one can segregate out the contribution of each, fine! Still, more importantly the top priority goal must be the development of systems that produce more food and put more people to work productively.

The agricultural operations, primarily field, consume the bulk of the total fossil energy required for food production. Our goal should be, therefore, to maximize the above benefits at the lowest possible fossil energy input at the best or within the limit of availability at the worst.

The reorientation of the role of machines in agricultural development should be accompanied by a better measure of their status and progress. Furthermore, this indicator should be associated with the primary objectives of agriculture. "Effective capacity" *** of the power units per cultivated hectare correlated with (1) yields, (2) production and (3) labor utilization is suggested.

Action programs at both the experiment station and farm levels are urgently needed. These programs should seek facts on machine-yield-production-crop intensity-labor utilization relationships, and aim at developing improved systems. An attack by concerned agricultural specialists working together will be more productive than separate efforts.

Our most challenging opportunity is to establish at least a few Institutes to develop new systems by a truly workable multiple discipline approach. In

*Expounded by Dr. D.M. Leeuwriik, Agronomist, The Ford Foundation, Beirut.

**More man hours per cultivated hectare and per year, more days worked and uniformly distributed per year, and more food produced per worker.

***Horsepower that the source is able to exert continuously during a normal work day, day after day, without abnormal deterioration.

line with its objectives and professional content such an Institute might appropriately be called· "Operational Systems Institute".

National leaders must be cognizant of the fact that mechanization programs must start with and be implemented at the local level. In the final analysis, machines and the systems they make practical will be accepted and used by individual farmers. National programs can best coordinate, promote and make possible the local ones.

The top priority principles, then, for establishing rational, effective national policies and attitudes are restated in itemized form as follows:

1. Judicious use of yield-increasing and multiple-cropping machines. Some machines will, in fact, help to increase yields. Some machines, necessary to and in combination with multiple-cropping, will help to increase production and the utilization of labor per unit area per year. Therefore, selective mechanization must be recognized as an essential component of systems that produce more food and put more people to work productively.
2. Determine and allocate the optimum amount of fossil energies required to maximize green crops and food production per unit area per year to those areas having the potential.
3. Action programs to develop and evaluate machine systems at the field-plot (Experiment Station) and field-trial demonstration (farm) levels are urgently needed. The development of new systems must be by a team of specialists whose efforts are coordinated by a strong, competent Administrative Leader.
4. A few nations or regions should establish "Operational Systems Institutes", interdisciplinarian in their approach and action. Establish an international coordinating agency for these centers.
5. National planning for the manufacture/importation, distribution, demonstration and service of farm machines must start at the local level, such as a District.

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Systems Analysis as a Guide Technology Transfer

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Introduction

Food shortages and famine now face countries in Asia and Africa. The situation has become so critical in the Sahelian area of Africa that the United Nations and FAO have called for emergency aid to these drought-stricken areas (CERES, 1974).

Purchase prices for imported agricultural equipment, fuels, and fertilizer have increased dramatically. Freight rates tripled in 1973. Öil prices quadrupled from $2.48 a barrel in January, 1973 to $11.65 in December (Flores, 1974). International prices for essential foodstuffs have recently doubled (Brown, 1974). The developing countries which do not export oil will need to pay $15 billion more for essential imports of pertroleum products, foodstuffs, and fertilizer in 1974. The combined price increases for these commodities are equivalent in amount to nearly five times the total of net U.S. development assistance in 1972 and well above the $9 billion total for all development assistance from industrial countries that year (Grant, 1974). Developing countries which in recent years embarked on modernizing their agricultural production methods now find that with increased prices they have insufficient foreign exchange to sustain their present level of agricultural development.

Traditional methods of developing and evaluating agricultural modernization programs in developing countries now appear to be inadequate in light of the rapidly changing economic and environmental conditions. An effective method for evaluating development programs is required which incorporates a comprehensive analysis of all relevant factors and parameters and which provides for iterative redesign of the development program as changes occur in its operating environment. Systems analysis including abstract modeling and computer simulation have a potential for meeting these requirements.

Systems Analysis

The systems approach consists of five major phases (Manetsch and Park, 1972):

1. Feasibility Evaluation
2. Abstract Modeling
3. Implementation Design
4. Implementation
5. Operation

The feasibility evaluation generates a set of viable alternative solutions (systems concepts) capable of satisfying the needs of the people for whom a development program is being designed. The first step of the feasibility analysis is the needs analysis. Distinguishing between the real need and the expressed needs is important (Asimow, 1962). An individual person or group can often state their expressed needs. Combining the expressed needs of the large number of individuals and groups affected by change into the real needs of the society is much more difficult, but is the goal of the needs analysis.

Having established the real needs, the next step is system identification. This step identifies the systems concepts which are capable of satisfying the real needs. Systems identification includes recognition and consideration of all input and output variables as well as system parameters. Controlled and environmental inputs and both desired and undesired outputs should be identified for consideration.

After the real needs have been stated and the system has been identified, an explicit statement of the problem (problem formulation) can be made. Included in the problem formulation is a statement of the criteria for evaluating alternative solutions.

The fourth step of the feasibility evaluation is the generation of a broad range of alternative solutions. These alternative solutions should then be screened for physical, social and political realizability. System concepts passing the above tests should further be evaluated for economic and financial feasibility. Some alternatives will be eliminated because they are not economicaj, others because they are too costly to finance or because they are physically unrealizable. The existing political or social conditions may eliminate others. The set of feasible solutions remaining requires a more careful analysis and for this abstract modeling is desirable.

Abstract Modeling

Abstract modeling has two major applications. The first is in developing and implementing new development programs and the second is in analyzing and controlling existing systems already in operation which may or may not have been developed using a systems approach.

The first application has been well developed by Mantesch and Park (1972), as well as others. In this application, abstract modeling starts with the viable concepts from the feasibility analysis and ends with an optimized model of one or more of these concepts. Concept selection, the first step in abstract modeling, must be based on a value judgment of all people to be connected with the proposed system-administrators, operators, users, designers, financers, etc. Compromise will invariably be required. The criteria for evaluating alternative solutions developed in the feasibility study is used here to assist in the concept selection.

Actual modeling of the concept is the next ptep. Models can be either static or dynamic in time. Dynamic models are more complex and difficult to construct, but can more nearly represent the real world. One simulation technique which is applicable to a variety of situations is a simulation procedure whereby a model is developed which approaches a one-to-one correspondence of systems components with the real world (Fridley and Holtman, 1973). Validation is required once the modeling is completed to determine whether the model represents the real world satisfactorily. This is followed by a sensitivity analysis to determine which parameters and controllable inputs most significantly influence system performance and by a stability analysis to if there are combinations of parameters and inputs which render the system unstable. The final step is system optimization. Optimization results in the specification of the best combinations of system parameters and controllable inputs which satisfy the needs given the constraints placed upon the system.

The second application, that of simulating an existing system, follows the same steps of model development, except that concept selection is deleted. The objective of modeling an existing system is to provide a method of evaluating alternative management decisions and thus develop an optimum strategy for operating or altering the system in a rapidly changing economic and physical environment.

The final three phases of the system approach, implementation design, implementation, and operation, are always required when a new system is being developed. When an existing system is being modeled, the implementation design and implementation phases may or may not be required. This depends upon the extent of changes the model indicates will be required in the system to adequately respond to the changes in the environment.

Implementation design specifies the details of the system created by abstract modeling. The feasibility determination and mathematical modeling results are successively reapplied to the various related subsystems. This involves the design and development of all organizational structures and supporting institutions, and the determination of manpower and technical expertise required to make the total system function. Technical projects will fail if all subsystems have not been adequately developed.

Implementation provides physical existence to the system design. Physical facilities and equipment are acquired, personnel are hired, and the organizational structure established. The physical adequacy of implementation design is tested and necessary corrections made.

Operation is the final phase of the system development and provides the real valid test of its adequacy. Modifications may be found necessary, but should be few and slight. A system failure should rarely occur if the five phases of the system approach have been properly and rigorously followed.

Example: Tractor Mechanization for Land Preparation

The hypothesis of the authors is that no segment of the rural population should be excluded from participation in agricultural development programs. It is possible and desirable to design agricultural development programs which provide an equitable distribution of benefits, regardless of farm size, and labor-generative mechanization can be an important aspect of these programs. Research by a number of investigators has found that mechanization for land preparation is oftem critically needed and much demanded by farmers (Faidley and Esmay, Chancellor, Cervinkia). Chancellor, for example, found that in 1968, customhired tractor tillage was being applied to an area equivalent in size to 55 and 48 percent respectively of the total land planted to annual crops in Thailand and Malaysia (Chancellor, 1968). In Comilla, Bangladesh, it was found that tractor tillage through a central cooperative association was an important source of power for tilling the land of small farmers. In 1969, about 30% of the winter season crop acreage was tilled with tractors. In Comilla, 15% of the farmers with less than two acres (.8 hectares) owned bullocks. In 1969, half of the farmers who did not own bullocks used the tractors for land preparation of their winter season rice crop (Esmay and Faidley, 1972). Not all ownership patterns for tractor mechanization are applicable, however. Donaldson found in West Pakistan that with private ownership, tractors tended to be owned by large farmers, and these farmers tended to increase their farm size. These farmers both purchased new land began farming land they had previously rented to tenants (Donaldson, 1973). Similar results were indicated in Bangladesh with the ownership of two-wheeled power tillers (Donaldson, 1970). In both of these countries, private ownership of mechanization tended to displace human labor in crop production and was of no benefit to small farmers. Thus, some type of nonprivate ownership appears to be a more appropriate form of tractor mechanization for developing countries.

Computer Simulation Model

Based upon the conclusion that some type of hire service is an appropriate form of tractor mechanization for many developing countries, a generalized computer simulation model was designed to simulate the operation of cooperative tractor station programs, contract hire services, and government tractor hire services. Tractor operation and repair data of the Comilla cooperative tractor station were used as the main source of information for developing the model.

Figure 1 gives a schematic of the major interrelationships of components of the cooperative tractor station at Comilla. Tractors at Comilla were hired out for both haulage and tillage. Tillage, however, was the only major operation performed for farmers. Similarly, in other tractor mechanization programs, demand for tractor services has been mainly limited to tillage (Chancellor, 1970, Stout, 1971). Therefore, demand for tractor services in the model has been limited to tillage. In Comilla, demand for tillage comes to the tractor station from primary cooperative organizations located in the small villages spread throughout the agricultural area surrounding Comilla. Tillage work is performed by the tractor station in the order in which requests are received. As long as the number of tractors and equipment exceed the demand, the tractors and equipment are randomly assigned to perform the work. When demand exceeds the capacity to perform the work, the unfilled requests enter a delay. The model provides for the withdrawal of demand if delays in performing the work become excessive.

In Comilla, two tillage implements are employed. The disc harrow is used for dry land tillage and the rotovator for flooded fields. The model allows implements to be changed on the tractors as the demand for different types of tillage changes throughout each season.

Breakdowns to the tractors and equipment are of two types: one type is field breakdowns which occur randomly and require one day for repair; and the second is major breakdowns which usually require more than one day to repair. Both occur randomly but the probability of the major breakdown is more related to the accumulated work performed by the tractor. The time required to complete major repairs and repair costs are also randomly determined, based upon an expected repair duration and cost. As with the probability of repair, the repair duration and

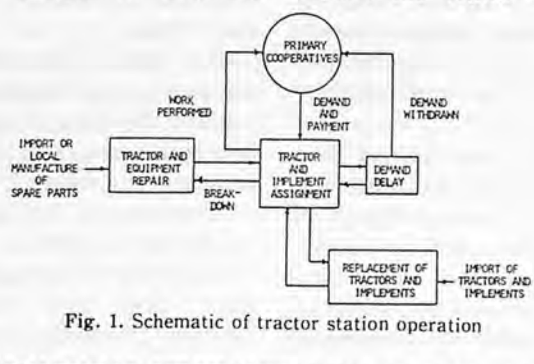

Fig. 1. Schematic of tractor station operation

cost are related to the accumulated work which a tractor has performed.

Expected life is used as the basis for equipment replacement. The experienced life of tractors and equipment in Comilla, Bmngladesh, which was about one-half of that expected in the U.S. has been used in the model. Disc harrows and rotovators are assumed to have no salvage value at the end of their life. Tractors are replaced according to the accumulated amount of work they have performed but with consideration given to reliability and accumulated average cost of operation. The model allows for the specification of an appropriate delay in delivery of imported equipment.

Results of the Simulation

The amount and distribution of demand for tillage services is an important consideration in evaluating any mechanization program. For purposes of this paper, a 15-year sequence of demand for tillage, based upon the tillage demand in Comilla, Bangladesh in 1969, but including a random variation in demand from one year to the next, has been selected. The amount and distribution of tillage each season over the 15 years is retained from one run of the model to the next. This allows each change in the mechanization program to be evaluated based upon the same quantity and distribution of seasonal demand. The expected demand each season as predicted by 100 iterations of the model is shown in **Figure 2.** There are four main demand periods. The first demand period, which corresponds to the irrigated winter season at Comilla has a demand for both disc harrow tillage and rotovator tillage. Disc harrow tillage is the only type of tillage demanded in the second demand period while only rotovators are demanded during the third and fourth demand periods.

The major value in simulation modeling is the ability to evaluate the effect of changes in management or operation of mechanization systems without having to make these changes in the real world and then observe their effects over a period of time. For example, an important consideration for cooperative tractor stations and government tractor hire centers is the number of tractors and equipment which they need in order to provide a timely and economic tillage service to farmers. The simulation model provides insight into this question. **Figures** 3 through 7 show the percent of demand delayed each season when the model was run with from 0 to 16 tractors in the tractor station. Delays in performing demand of 1, 3, 7, and 10 days are included in each figure. The model indicates, as shown by **Figures** 3 and 4, that over a narrow range small changes in tractor numbers result in large changes in the percent of farmers who have their demand delayed for the various lengths of time. The demand for rotary tillage during the first demand period (**Figure** 4) shows, for example, that if the tractor station owned eight tractors, 75 percent of the farmers would have at least a three-day delay in having their request for tillage filled and 30 percent would have in excess of ten days delay. If the tractor station increased the number of tractors from eight to ten, the number of farmers with a delay of three or more days would decrease to 35% and less than 5% would have delays over ten days. Similar narrow ranges are indicated for the other seasons. However, the number of tractors which effect these changes are different (see **Figures 5** and **6**). In the third demand period (**Figure** 6) the largest decreases in delay occurred when going from four to six tractors and in the fourth demand period (**Figure** 7) when going from three to five tractors.

If there are delays in performing tillage for farmers, it must be assumed that some farmers will withdraw their requests. The model has been used to evaluate the effect of demand withdrawal for different numbers of tractors in the tractor station (**Figure** 8). The model indicates only a small change in the percent of total demand lost when demand is withdrawn after either two days delay or after 11 days delay. Substantial amounts of tillage are lost in either case, however, as the number of tractors in the station are reduced. If a tractor station owned eight tractors, 91% of the demand would be performed if withdrawal occurred after two days delay and 96% if demand was withdrawn after 11 days delay. If the tractor station contained four tractors, only 63% of the tillage demand would be

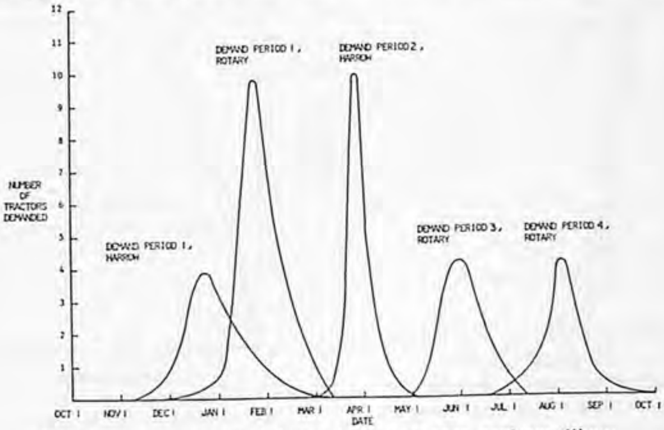

Fig.2. Expected seasonal demand for tractor to perform tillage

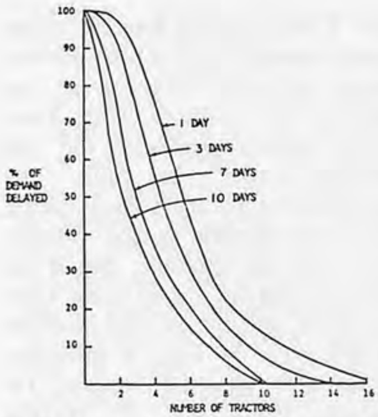

Fig.3. Delay in forming demand for harrow tillage during demand period 1.

performed if demand was withdrawn after two days increasing to 74% with withdrawal after 11 days.

Since more tractors are needed in some seasons in order to provide a timely tillage service, it is desirable to investigate the tillage costs when various numbers of tractors are owned by a tractor station. The costs per acre of tillage as predicted by the model based upon the labor wage rate, fuel, and equipment prices in Bangladesh in 1969 are shown in **Figure 9.** Under these pricing conditions, costs would range from \$3.65/acre (\$9/hectare) with four tractors in the tractor station to \$6/acre (\$14.80/hectare) with 16 tractors. This figure also indicates that costs per acre increase at an increasing rate with additional tractors.

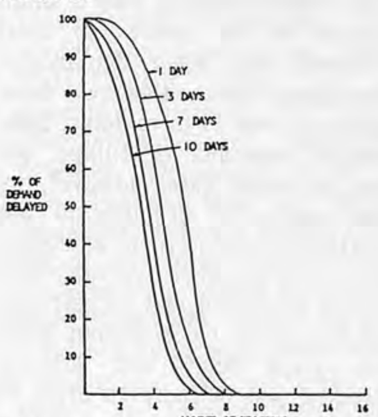

Fig.6. Delay in performing demand for rotary tillage during demand period 3.

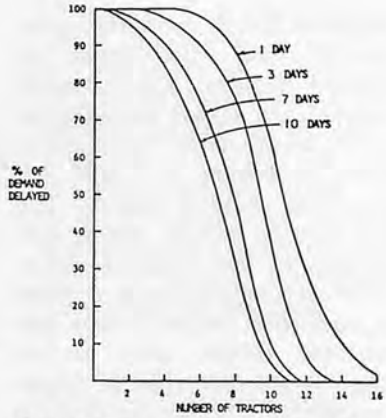

Fig.4. Delay in performing demand for rotary tillage during demand period 1.

The lower cost with fewer tractors is the result of increased tractor utilization. With four tractors each tractor would till an average of 870 acres/year (350 hectare/year). With ten tractors this yearly rate would be reduced to 478 acres/tractor (197 hectare/tractor). As can be seen in **Figure 8,** however, only 63 to 74% of the work demanded could be performed with four tractors, while ten tractors could perform 96 to 100% of the tillage demanded. It should also be emphasized that over several years the foreign exchange requirement of a tractor station would be approximately the same irregardless of the number of tractors. This is because in most developing countries depreciation of equipment is usually directly related to usage and equipment most often does not become obsolete before it has worn out. In **Figure 9,** increased costs with larger numbers of tractors are mainly due to increased personnel hired to operate and maintain the machines. In Comilla there were two drivers for each tractor and one maintenance person for every four tractors. These persons were paid a fixed salary whether the tractors worked or not. Since it is socially unacceptable to lay off personnel during slack periods labor costs continue whether the tractors work or not. Thus, a reduction in the cost per unit of operation is possible only by increasing tractor utilization. This is often done by using the tractors for non-agricultural purposes during the periods of the year when tractors are not fully utilized for tillage. Since this means that the tractors depreciate more quickly because of the additional

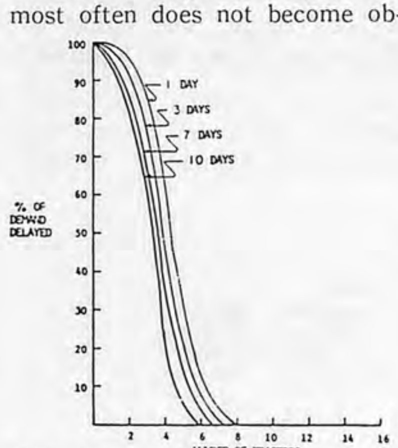

Fig.7. Delay fn performing demand for rotary tillage during demand period 4.

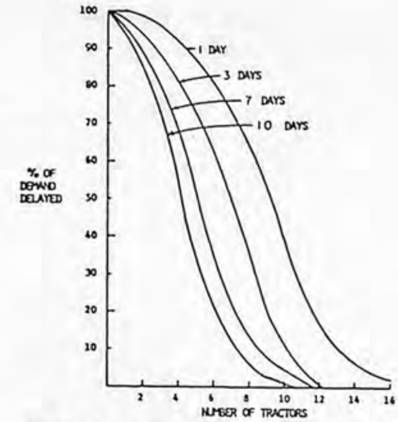

Fig.5. Delay in performing demand for harrow tillage during demand period 2.

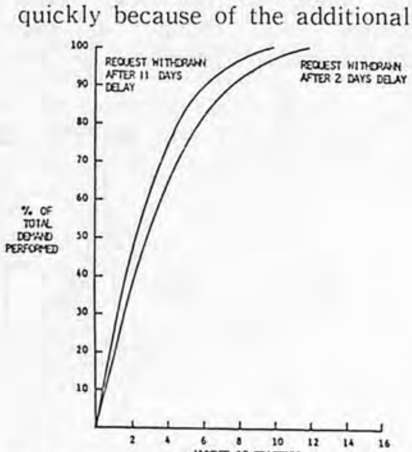

Fig.8. Demand performed when requests are withdrawn due to delays.

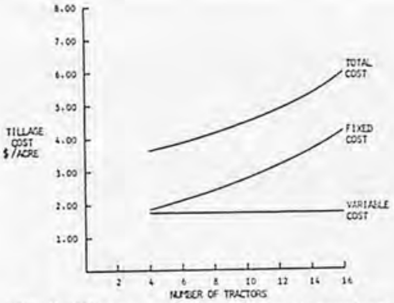

Fig.9. Tillage cost for different numbers of tractors.

work they must be replaced more often and this requires foreign exchange. With increased international prices for fuels, machines and spare parts the use of tractors for non-essential agricultural purposes should be carefully evaluated.

The model has been used to predict the effects of price changes on the costs of operation for a tractor station with ten tractors (**Table 1**). The model indicates that for each 10% increase in fuel prices, variable costs/acre increase 4.6% and total costs/acre increases 1.8%. Thus with the two to three fold increase in international prices of pertroleum, the costs of tillage/acre could be increased from 36 to 54%. Purchase price for tractors, equipment, and repair parts was also predicted. For each 10% increase in purchase price, total cost will increase 3.1%. With a 30 to 50% increase in imported equipment and the increased fuel cost, it does not seem unreasonable that the foreign exchange requirements for agricultural mechanization programs could easily increase between 50 and 70%. Combined with domestic inflation, the cost of tractor services could rise even higher. Price rises such as these would appear to put agricultural mechanization programs in jeopardy. However, would food prices have increased even faster. Thus, selective mechanization which increases agricultural production may still be justified.

Table 1. Cost increases for tractor tillage due to increases in fuel prices, purchase prices, interest rates, and labor costs

For each 10% increase in	% Increase in		
	Fixed cost	Variable cost	Total cost
Fuel price	0	4.6	1.8
Purchase price	1.9	4.8	3.1
Interest rate	1.8	0	1.1
Wage rate	7.1	0	4.3

Summary

Systems analysis can provide insight into the critical and rapidly changing problems facing agriculture in developing countries and can help guide engineers, planners, and government officials in the selection and transfer of appropriate technology essential for the current survival and future advancement of the developing countries. This paper has presented systems application to selective mechanization of the tillage operation. This, however, is only one of the problems facing farmers in developing countries. To effect change in the broad range of problems facing agricultural development, an interdisciplinary approach involving agricultural economists, social scientists, systems analysts and agricultural engineers is necessary. Systems analysis provides the means for incorporating the efforts of all of these individuals into a unified program to meet the needs of agricultural development.

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Progress on the Establishment of the ACAM

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Background

Present situation in agriculture

Various studies of the agricultural conditions in the region have indicated that around 80% of the total population of the developing countries is dependent on agriculture, and agricultural products contribute 50-85 per cent of the GNP, and the average size of farm holdings is only 1-4 hectares and around 90% of the farms are less than 5 hectares in area (**see Table 1**).

It is very clear that there is no way without improvement of productivity in small farms which are occupied more than 90% in Asian farm household. Dr. R. McNamara, president of the International Bank for Reconstruction and Development (IBRD), also has emphasized in this point at its session held in Nairobi, September 1973 that the most important problems in our future plans are technical development, policies and projects for improvement of productivities in small scale farming in the developing countries.

Most countries in the region which have problems of insufficient food production in the midst of increasing population, are in the process of converting into a more intensive type of agriculture, by introducing new crop varieties, fertilizers, pesticides, improved water management, crop diversification and multi-cropping. The cultivation and processing of products within the prescribed short period of time by intensive methods are generally beyond the capacities of traditional monocultural practice of farming. Apart from the consideration of the population pressure in the countries, exports of agricultural products being one of the main resources to get foreign exchange both the quantity and quality of farm production has to be increased and losses to be decreased by adoption of suitable bquipment machines and selective mechanization system in each farming operations.

The cultivation of the crops is done almost entirely by hand and by the use of draft animals, except in some developed areas and estate farming. According to a study of agricultural power and equipment, more than 0.5 hp per hectare is used in the developed countries as compared with 0.19 hp per hectare in the developing countries in Asia. It is thus clear that more power including full utilization of animal power and suitable equipment would contribute substantially to increasing

ACAM : The Asian Centre for Agricultural Machinery

The views expressed in this paper are those of the author and do not necessarily reflect those of the ESCAP secretariat and other UN organizations.

Table 1. Some figures estimated on agricultural situations in the selected ESCAP countries in the region

Prepared November 1973 by : K. Kobayashi
Revised June 1975

	Farm household		Farm household by size (%)				Population			Per capita income ($)
	Total (1,000)	Average size (ha)	Less than 1.0(ha)	1.0-2.0 (ha)	2.0-5.0 (ha)	Less than 5.0(ha)	Total (Million)	Growth ratio (%)	Agriculture (%)	
Afghanistan	---	---	---	---	---	---	17.5	2.84	82	83
Bangladesh	6,139	1.4	51.7	26.3	18.6	96.6	75.0	---	85	
Burma	12,148	---	---	---	---	---	27.6	2.33	64	68
India	61,780	2.30	19.4	43.5	22.7	85.6	563.5	2.35	68	88
Indonesia	12,148	1.1	62.0		24.5	86.5	124.9	3.09	70	100
Iran	1,877	4.3	---	---	---	---	30.5	3.42	46	341
Japan	5,419	1.03	70.0	24.7	4.6	100.0	100.2	1.14	21	1,900
Khmer (Rep. of)	840	3.5	30.7	22.3	32.6	85.6	5.7	2.51	76	---
Korea (Rep. of)	2,488	0.91	67.0	26.0	7.0	100.0	31.9	2.47	58	258
Laos	---	---	---	---	---	---	2.9	2.63	78	---
Malaysia	577	4.4	---	---	---	---	10.7	3.50	56	296 1/
Nepal	1,496	1.22	4.9	45.0	31.5	91.4	11.5	1.98	92	74
Pakistan	12,155	2.3	49.0		28.0	77.0	60.0	---	70	116 2/
Philippines	2,168	2.58	11.5	29.6	39.9	81.0	39.0	3.40	70	246
Sri Lanka	1,174	1.5	65.3	18.9	12.3	96.5	12.8	2.78	52	164
Thailand	3,214	2.95	18.6	20.3	37.6	76.5	35.3	2.89	76	174
Viet-Nam (Rep. of)	1,893	1.35	43.0	27.7	22.2	92.9	18.6	2.85	78	232

Source: Compiled and estimated from the following references.

1. Report of the expert group meeting on agricultural mechanization, Vol, 1, APO, 1968
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* Yearbook of National Account Statistics 1972, Vol. 111.

1/ West Malaysia only

2/ Include former East Pakistan

farm production in all the developing countries in the region.

The small size of farm holdings, low farm income, and unemployment are often cited as factors which hinder mechanization in Asia. However, the experience of Japan indicates that mechanization with small types of agricultural machines is possible within the framework of small farm holdings, and labour utilization for paddy cultivation is among the highest in Asia (1,400 man-hr/ha) even though it has very highly mechanized agriculture (2.7 hp/ha). Recent studies in the Philippines indicate that the progressive farmers who adopt new seed-fertilizer technology are more inclined towards mechanization. No significant changes have been observed in labour inputs on such farms in spits of increasing mechanization during the last six years. It is reported that the mechanization at the peoples communes in China has resulted in a change of the traditional cropping pattern and farming practices, and has accelerated agricultural development and intensive cultivation, even causing labour shortage at times.

In the countries of the region with conditions such as: abundant man-power, low farm income, scarce power resources and manufacturing capaity, a modest selective farm mechanization has to be introduced gradually at progressive levels in the region, and not, as is done in the developed countries, by introducing costly equipment to replace or raduce man-power. Moreover, the selective mechanization must not only increase production, stabilize or increase labour per unit of area but finally must be cost reducing, and last but not least mechanization should improve the working conditions, make the hard field work, often done by women or children.

The term 'agricultural machinery' for the purpose of this paper covers the full range of tools, implements and machinery utilized by the farmers for agricultural work, in clearing land and forest areas, land preparation, irrigation, seeding, planting, fertilizing, crop protection, harvesting, threshing, drying, storage, conveying, transport, etc. It includes hand tools, hand-operated machines and animal-drawn implements, power-operated equipment and engine-driven machines with their related implements. Therefore, agricultural mechanization does not mean the 'tractorization'. Over 100 million of the small-scale farmers in the region, as the first step of their farm mechanization, are interested in low-cost farm machinery, equipment and tools of simple design which are durable, easy to operate and maintain.

Present situation in manufacturing and design development

Some of the simple machines and equipments are manufactured on a modest scale in some developing countries in the region, but are not being manufactured in many countries primarily due to lack of access to appropriate technology and adaptation of techniques suited to their own needs. Although leading farm machinery producers have in many instances collaborated with local manufacturers in supplying some modern types of agricultural machinery, it is well-known that these tractors and power-operated machines are suitable for large-scale farming with high-volume market and meet the requirements of the rich farmers which are a very small percentage of Asian farmers, because the agricultural machinery and its production technology in the developed countries is geared to meet the domestic farming and economic conditions. Such machinery is generally of imported origin. This requires scarce foreign exchange for its purchase as well as securring import of spare parts. It is usually expensive when compared to farmer's income in the developing countries of the region.

There is a gap with respect to the development and local manufacture of appropriate agricultural machinery, equipment and tools needed by the small farmers which could be produced by rural-based small and medium-scale industries with locally available raw materials. In other words, there still exists a great need for developing types and sizes of agricultural machinery and equipment that are suited to the majority of Asian small farmers with low farm incomes, because most of the land-holdings in ESCAP region are too small for modern high-powered machines of imported design, and moreover, the small existing fabricators in developing countries cannot afford research and development work, and the established machinery manufacturers in the developed countries are not interested in developing designs for a limited market with low margins of profits.

Many institues operating at the national or international level in the region are dealing with similar problems. It is recognized that their activities are insufficient because of lack of funds and facilities, and under-utilization of skills. Owing to inadequate co-ordination in their programmes and in exchange of information, there is at time, duplication of work.

Conclusion

"Appropriate technology" of the farm mechanization and industries manufacturing farm machinery should be identified and introduced to developing countries in the region. The technology in a given socio-economic situation will take into account adaptation of sophisticated technologies or development of intermediate technologies suited to a particular situation; but, in general, in the context of the adoption of technology for both small scale farm mechanization and farm machinery industries, they should be essentially labour-intensive and capital-saving.

The need for a regional centre is apparent for many reasons mentioned above. The Centre should be undertaken as a nucleus or a co-ordinating centre of the activities concerning farm machinery in corporation with national institutions in member countries and related international organizations to develop selective mechanization systems and to improve many types of farm machines, equipment, implements and tools which are suited to the physical, social, economic and technical conditions prevailing in Asia.

The implementation of such a project would not duplicate but would strengthen the functions of national institutes in this field, where they exist. Its resources would be utilized to supplement the capabilities and efforts of the national institutes. The centre could undertake development work which would not generally be done elsewhere. It would function as a clearing house for information and for exchange of experience with regard to adaptation, development and utilization related to agricultural machinery and equipment. Moreover, it will concentrate its activities upon the implements needed by the small and medium scale farms in the Asian region and which can increase and facilitate the agricultural products without creating excessive displacement of human labour.

Expectable objectives of the proposed centre would be as follows:

A. Long-range objectives

(i)To initiate a systematic approach in evaluating different methods of mechanization of cropping systems on the one hand and an integrated programme of improvement and adaptation of existing designs, development and manufacture of farm tools, implements, equipment and machines that are suited to Asian farms on the other, through co-operation with national institutes local manufactures and international organizations.

(ii)To achieve a high level of agricultural productivity and labour-intensive production techniques with amphasis on the utilization of domestic materials or resources and more particularly on the development of small and medium-scale industries, with a view to promoting rural industrialization in the developing countries of the region, especially in the least developed and land-locked countries.

B. Immediate objectives

(i)To identify bottle-necks in farm mechanization and manufacturing of agricultural machinery and equipment and, to this end, to develop guidelines for selective mechanization in different agro-climatic and socio-economic conditions;

(ii)To select tools, implements, equipment and small power-operated machines suitable for small farms by engineering, testing and product performance analysis, including field testing.

(iii)To promote adaptation of existing farm tools, equipment and machinery to the specific conditions of a given area;

(iv)To develop, through design development, the prototype fabrication of simple equipment and machinery;

(v)To assist and promote local manufacture of appropriate machinery through consultancy services and training in co-operation with national institutes and manufacturers in the developing as well as industrialized countries;

(vi)To introduce appropriate techniques, bring about technology transfer and organize extension services at the national level through dissemination of information and consultancy services in co-operation with national institues;

(vii)To strengthen national institutes in both farm mechanization, and small and medium industry promotion through regional co-operation.

Progress in the Form of the Project

Since 1968, ECAFE through AIDC projects and in co-operation with member countries and other UN organizations, has placed significant stress in its activities in the field of agricultural machinery in the region. The institutional development and promotion of the farm mechanization and agricultural machinery industry in the region in the form of a regional agency for agricultural machinery was recommended at its fourth session of the Asian Industrial Development Council (AIDC) held in 1969, based on the existing situations mentioned before by the ECAFE/UNIDO Fact-Finding Team which visited twelve countries in the ECAFE region in 1968-69, and was subsequently supported by the Expert Team on Transfers and Power Tillers, also organized by ECAFE in 1971.

Pursuant to the decision of the AIDC at its seventh session held in 1972, an Expert Working Group on the establishment of an Asian Agricultural Machinery Institute was held at Bangkok in October 1972 and was attended by the representatives from Australia, India, Indonesia, Iran, Japan, the Republic of Korea, Laos, Malaysia, Papua New Guinea, the Philippines and Republic of Viet-Nam. Representatives from UNDP, UNIDO, ILO and FAO as well as from other organizations such as the Asian Institute of Technology (AIT) and the International Rice Research Institute (IRRI) also attended the meeting. The Expert Working Group drew up the broad guidelines and functions of the Institute.

The AIDC at its eighth session held in 1973 gave strong and enthusiastic support to the proposal for the setting up of the Institute. The Council noted with appreciation the offers of Indonesia, Iran, the Philippines and India to provide host facilities, and of Japan to consider providing experts in the preparatory stage and operation of the proposed institute; and of Australia and UNIDO to give their full co-operation and support.

At the twenty-ninth session of the Commission which took place in Tokyo, April 1973, the Government of Japan expressed its willingness to give full support to the project for establishing the Institute and to consider providing not only technical assistance but also substantial financial contribution. The Governments of India and the Philippines renewed their offers to provide host facilities for such an institute.

The AIDC at its ninth session held in January 1974 expressed "the unanimous view that the need for the institute has been well established and action should be initiated for the implementation of the project without further loss of time". The Counci felt that, in the initial stages, the centre should confine itself to a limited scope of work. For the present, it should concentrate its attention on (i) machine design development, adaptation and improvement of existing machines, equipment and tools, (ii) development of guidelines for selective mechanization, (iii) information collection and dissemination. Reference was also made to the need for organizing activities in the existing national institutes of the member countries with emphasis on adaptation of the agricultural machineries, equipment and tools to meet the actual requirements of the farm conditions, especially for small farmers, in the Asian countries. The activities of the institute should also be geared to the utilization of the under-utilized capacities and also for development of light engineering industries in rural areas to meet the specific requirements of individual countries.

It heard with interest the reiteration of host facilities by the Governments of Philippines and India. The representative of Japan expressed full support to this project and stated that for the fiscal year 1974 Japan would contribute US$300,000 subject to the approval of the Parliament and on the understanding that suitable arrangements for the

Centre could be finalized within 1974. The representative of Australia stated that his government would consider offering assistance after further examination of the requirements. The UNIDO representative stated that UNIDO would work jointly with ECAFE for the centre. The FAO representative also expressed his organization's interest in and support for the proposal. FAO suggested emphasis should be placed on the selection and adaptation of existing design and mechanical principles. The Council urged the Secretariat to continue to work closely with the FAO, as well as with UNIDO. The Council decided to designate the proposed institute Asian Cntre for Agricultural Machinery (ACAM)".

In March 1974 interagency consultation resulted in the setting up of a working group to prepare a project ideas taking into account, inter alia the strengthening of the existing national institutes through a redional centre to be established in one of the institutes in the region.

The ECAFE Commission at its 30th session in Colombo (27 March to 6 April 1974 reported that "there was a broad consensus that the establishment of the proposed Asian centre for agricultural machinery should be regarded as a mattar of urgency. The secretariat was requested to take appropriate action for the immediate implementation of the project. As a first step, an ECAFE/UNDP/FAO/UNIDO joint mission should be sent to interested countries to adopt the Terms of Reference and to finalize related matters for the establishment of the Centre. In particular the problem of financing the Institute on a long term basis should be seriously considered to ensure the smooth operation of the Institute. It is suggested that the financing of the Institute should not cause undue financial burden to participating developing countries.

As regards the location of the Centre, it was recalled that the Governments of India, the Philippines and Pakistan had offered host facilities. The delegates of India and Pakistan very graciously withdrew their governments' offers to hose the proposed Institute, in a spirit of compromise and with a view to achieve an unanimous decision on this matter in conformity with the ECAFE tradition. The Commission decided to establish the Centre in the Philippines. The Commission warmly commended India and Pakistan for this very generous gesture. The Commission also warmly thanked the Government of Japan for their reiterated offer of a cash contribution of US$300,000/=for fiscal year 1974, subject to preliamentary approval."

The Commission session also adopted a resolution 145 (XXX) as follows:

Recognizing that agriculture is a vital sector of most countries of the ECAFE region and that industrial development, particulerly, the development of agro-related industry is also very important to their economic development,

Aware that most countries in the region, confronted by grave problems resulting from insufficient food production coupled with rapid population increases, are introducing crop diversification and multicropping,

Recognizing furthermore that there is an urgent need to maximise the benefits of the green revolution and to extend them to the majority of Asian small farmers who have been left behind by the green revolution,

Considering that, to achieve this end, small-scale farmers of the region must increasingly be equipped with more suitable tools and machinery,

Noting with gratification the activities of AIDC and the secretariat in the fields of agricultural machinery industry,

1. Endorses the decision of the ninth session of AIDC to establish an Asian Centre for agricultural machinery and decides that it be set up in the Philippines as soon as possible;
2. Expresses gratitude to the Government of the Philippines for its offer of host facilities;
3. Requests the Executive Secretary to take all necessary steps for the prompt establishment of the centre in the Philippines, including the dispatch of an ECAFE /UNDP/FAO/UNIDO joint mission to interested countries, to finalize the project document, and the convening of a meeting of the Governments of those countries to adopt the terms of reference and to decide upon matters relating to the centre's establishment;
4. Urges UNDP to give the most favourable consideration to providing assistance to this project;
5. Urges the international organizations and the institutions concerned with the development and adaptation of suitable agricultural machinery, such as United Nations Industrial Development Organization, the Food and Agriculture Organization of the United Nations and the International Rice Research Institute, to extend all possible assistance to the establishment of the Centre'.

On the other hand, the FAO Regional Conference for Asia and the Far East, at its twelfth session held in Tokyo (23-29 September 1974) urged that the Asian Centre for Agricultural

Machinery should be put into operation as soon as possible.

The UNDP Administrator mindful of the injunctions of the UNDP Governing Council that inter-country projects should strengthen existing national Institutions to make their facilities suitable for regional purposes rather than helping to create wholly new centres or institutes, agreed to field an inter-agency exploratory mission with a draft 'Project Ideas' to ascertain the current precise needs and desires of a number of the possible participants. The exploratory mission was also charged with ascertaining the preparedness of recepient countries to contribute cash counterpart support.

A joint preparatory mission for this purposes through the UNDP preparatory technical assistance in co-operation with ECAFE, FAO and UNIDO visited between 20 October and 3 December 1974 thirteen interested countries in the region, namely, Philippines, Korea (Rep. of), Japan, Australia, Indonesia, Malaysia, Srilanka, India, Iran, Pakistan, Nepal, Bangladesh and Thailand, and prepared a report for the project including various recommendations and draft project document.

The final report and draft project document prepared by the UNDP/UNIDO/FAO/ESCAP preparatory mission on technical assistance for the development of agricultural machinery suitable for use and production in Asian countries was submitted to the ESCAP Commission at its 31st session in New Delhi (26 February to 7 March 1975). The Commission adopted the annual report which mentioned that "the Commission noted with appreciation the progress made towards the setting up of a regional organization for the development and adaptation of agricultural machinery and endorsed in principle the proposals relating thereto that were contained in the report of the joint mission. The Commission agreed that the proposed regional centre should be located in the Philippines. It welcomed the decision of the United Nations Development Programme to have designated the Commission as the executing agency for the preparatory assistance phase of the project. Further it requested the United Nations Development Programme in accordance with Economic and Social Council resolution 1896 (LVII) to designate the Commission as the executing agency for the project. The Commission also noted with appreciation the support extended by UNDP for the preliminary work on the project which was expected to commence by the end of March 1975."

The Commission session also adopted following resolution 156 (XXXI) which reads:

Recalling its resolution 145 (XXX) on the establishment of the Asian Centre for Agricultural Machinery in the Philippines,

Noting with appreciation the progress made in implementing the said resolution,

Taking cognizance of the recommendations of the UNDP/UNIDO/FAO/ESCAP Preparatory Mission on Technical Assistance for the Development of Agricultural Machinery Suitable for Use and Production in Asian Countries,

Requests the Executive Secretary to take immediate appropriate measures to implement the recommendations of the UNDP/UNIDO/FAO/ESCAP Preparatory Mission and to locate the regional centre in the Philippines;

Welcomes the decision of the United Nations Development Programme to have designated the Commission as the executing agency for the preparatory assistance phase of the Project;

Requests the United Nations Development Programme in accordance with Economic and Social Council resolution 1896 (LVII) to designate the Commission as the executing agency for the project,

Urges the international organizations and institutions concerned with the development and adaptation of suitable agricultural machinery and all member countries to extend their fullest assistance in order to ensure the successful implementation of the Project.

According to the previous procedures and resolution of the 31st Commission session, UNDP has approved preparatory assistance phase of the project for six months and designated the Commission as the executing agency of the phase. A project manager has been appointed by ESCAP in July 1975 and all necessary preparations are under way. ■ ■

Agriculture and Mechanization in West Africa and South-East Asia : A Comparison

by
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While farming in West Africa is still predominantly of the shifting cultivation type and most farmers are subsistence farmers, developments in most parts of South-East Asia are steadily moving towards intensive continuous cropping and increased technological inputs.

An attempt is made in this paper to explain some of these different developmeuts and relate them to present and future mechanization trends.

In this respect, a few characteristics will be discussed in so far as they have affected the application of technological inputs in agriculture.

The "Green Revolution"

The green revolution, which has been showing its effects in South-East Asia for some years, has not yet started in West Africa.

Hanson (1971) lists five factors of food production which are aifferent between Asia and Africa and which represent constraints to a green revolution in Africa:

1. Africa is not generally hungry at its present level of population and feels no food crisis.
2. The farming system for food crops in Africa is very complex, involving shifting cultivation and mixed cropping, for which improved technology is needed.
3. Lack of irrigation.
4. Lack of animal power or mechanization, at least, for periods of peak labour requirements.
5. Inadequate marketing arrangements.

Fig. 1. Traditional farm with shifting cultivation and mixed cropping

Population Density

The population density in West Africa has not to any extent reched that of most parts of South-East Asia, not forcing farmers to confine themselves to a limited piece of land. Because of an abundance of land, shifting cultivation has been able to persist in West Africa. The higher population pressure and the need for more production and more intensive land use has reduced the shifting cultivation type agriculture to low levels in South-East Asia. This need has not yet occurred in such an extent in West Africa, thus not necessitating farmers to adopt and apply higher production practices and techniques.

Agro-ecological Conditions

For centuries, the main farming activities in South-East have centered around lowland areas. Two inherent characteristics have been, that continuous cropping could be maintained without a too serious reduction in yield levels, and that the principal single crop was rice. Only as land became scarce more intensive use was made of upland soils for food production.

On the other hand, in West Africa, extensive farming has been continued on upland soils mainly. All types of prevailing diseases have kept people away from the lowland areas.

Continuous cropping was not feasible on the upland soils, because of a rapid decline in soil fertility, soil erosion and increased weed problems. Only recently, with better health services, has the potential of the lowland areas been valued and have Governments and farmers started exploring and farming the vast areas of lowland soils in West Africa.

As a consequence of these differences in land use, the population density in the lowland areas in West Africa, in general, is low, while the population densities in these areas are by far the highest in South-East Asia. Another consequence is that while farmers in South-East Asia did not have to change their farming system drastically for adoption and application of new inputs and techniques, the West-African farmer and his farming system need considerable change and intensification before new practices and techniques can be applied successfully.

Another condition, which has been to the advantage of the South-East Asian farmers is the fact that animals and animal power have been an integral part of farming life to many of the farmers for a long time, thus introducing them to animal power to augment human power. On the other hand, in West Africa, no animals can be kept in the humid parts, because of diseases. In the drier savanna areas, traditionally, animals have been herded by nomadic tribes and the farming tribes have only accepted animal power gradually and to a limited extent.

Fig. 2. Traditional farm with rice

Socio-economic Condtions

To change, traditional farmers need an incentive, either by accepting high yield increases through improved varieties, continuous consistent improved farming systems, or by credit facilities, adequate marketing channels, improved (perhaps initially subsidized) sales and after sales services or by some other sociological reasons, such as population pressure, status, or the desire to keep children in farming and thus having to change.

Not many of these factors are at the moment in West Africa real or sufficiently in the foreground to bring about any substantial change in shifting cultivation/subsistence farming, except at a very slow rate.

The soaring prices of materials and equipment with relatively lower increase in produce prices at the farmers level are also not favourable to start technological change at the present yield levels.

It can be expected that the level of sociological and psychological change farmers in West Africa have to make to achieve

Fig. 3. Lowland rice cultivation offers best opportunities for mechanization

Fig. 4. Irrigation an important factor successful mechanization

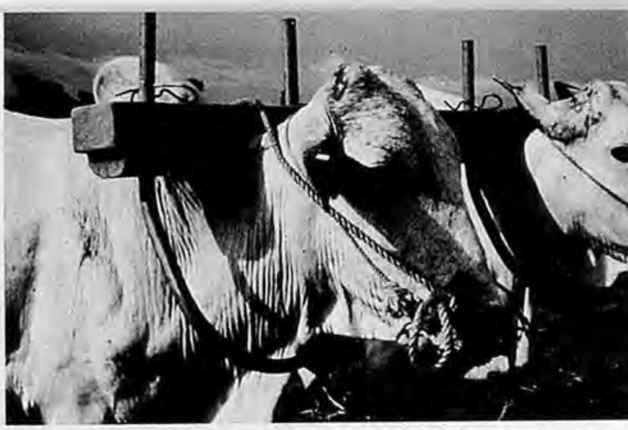

Fig. 5. Animal traction cannot be applied in the humid parts of West Africa

continuous, higher management input farming, will be considerably greater than was necessary for the majority of farmers in South-East Asia, at, for instance, the start of the Green Revolution. Governments in this respect could help a great deal by improved and focussed extension services, subsidies, credit facilities, marketing co-operations, etc. and so provide an additional incentive for farmers to change.

At any rate, it is quite clear that higher levels of additional inputs will be required from the Governments in West Africa than from those in South-East Asia, particularly because of special problems of land clearing and land development, the inputs which farmers in West Africa cannot afford.

Most Government in West Africa have embarked upon large-scale mechanized farms to improve food production. However, it is inevitable, as indicated by several authors (FAO, 1970; de Boer, 1974; Robinson, 1974) that the major increase in food production in the foreseable future will have to come from the small farmers through increased yield per unit area rather than by expansion of new land through large-scale mechanized projects.

Technical Background

It is quite clear that the general level of technical know-how in South-East Asia is very much further developed than that of West Africa. This is illustrated by the prominence of agricultural and other workshops and skilled personnel in large numbers in rural areas in South-East Asia.

Whatever skill is available in West Africa is invariably only to be found in the urban areas partly because of a lack of demand for such skills and services in rural areas and partly because of the reluctance of people generally to remain in the rural areas.

Conclusions

In South-East Asia, the higher yield levels and double cropping brought about by the Green Revolution, has had the ultimate effect of making mechanization economically feasible. In West Africa, on the other hand, low and fluctuating yield levels, inadequate marketing arrangements and the absence of a developed farming system to enable continuous cropping whilst maintaining soil fertility, have restricted the scope for mechanization.

There are strong indications that the eventuacl break-through in West Africa would be associated with the use of four-wheeled tractors (Anon 1971; Gordon 1971; Downing 1972; Cervinka 1971; Kolawole 1974 and Purvis 1968).

At some stage these may have to be shared, but owned and operated by private individuals, as distinct from government hiring services.

The lowland areas in West Africa are likely to offer the best opportunities for successful and economical mechanization, as indeed has been the case in South-East Asia.

Many sociological adjustments will inevitably be necessary, such as adoption of new diets, intensified continuous cropping systems and so on. Above all, the attraction of skills and services to rural areas would appear to be feasible only in West Africa after farming as business becomes sufficiently attractive to compete with job opportunities in urban areas.

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Agricultural Engineering and Productivity

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Farm mechanization is the specific area of agricultural engineering which will be discussed. Food production is the main source of income for farmers. To receive optimum returns, farmers must wisely manage their inputs of land, labor and capital. The best mix of resources varies by geographic location. The use of the capital inputs of fertilizer and mechanization will be examined for their influence where land or labor inputs are scarce. His particular set of economics determines whether the farmer will adopt mechanization primarily to improve the productivity of his labor or the productivity of his land.

Resource Use Among Major Grain Traders

Four major grain trading nations are of interest, **Figure 1**. The U. S. exports at least twice as much grain as its nearest competitor and for the period 1964-72 averged 38.4 million metric tons annually.(1) West Germany ranks behind Japan, United Kingdom and Italy in grain imports at an average of 5.5 million tons per year but is of interest because it is the most mechanized nation. Japan is the largest grain importer with an average of 12.3 million tons per year for 1964-72. During the past few years, Japan has depended on imports for half of her grain needs.(2) India is included because it is the largest recipient of food aid. During the period 1964-72, an average of 5.2 million tons were imported annually. Food grain imports peaked at 10.4 million tons in 1966 following two drouth years.(3)

Among these four countries, the U. S. is the distinct leader in cereal production with 1.049 tons per capita. While we take pride in normally exporting about 20 percent of our grain production, our high consumption of grain-fed meat makes our diets look extravagant by world standards.(4) If the U. S. in 1972 had consumed grain only at world levels of consumption, we could have exported as much grain as was produced that year by Africa and India combined. Our high standard of food consumption is possible because our annual per capita income is $4,274.(9)

West Germany has an annual cereal production per capita of .34 tons which is equal to the average for the world. However, their high income per capita permits them to import a significant percentage of their food needs. Japan's cereal production of only .15 tons per capita is insufficient by standard and through import they bring it up to about world levels. This is possible because of large industrial exports. India almost met her minimum food needs in 1972 with .19 tons of cereal produced per capita. By the time it reaches the consumer this results in an average consumption of less than .5 kg per day. However, with an annual average per capita income of only $88 this still means that food takes about three-fourths of their budget.(9)

The average U. S. farm at 150 hectares is distinctly larger than any of the other three countries considered. Directly related to this is the use of only .017 farm workers per hectare. Although world averages are not known, West German farm sizes of 12.1 hectares and .32 farm workers per hectare are probably about average. India's farm size is low and labor use is high. However,

The author was on a leave of absence from Deere & Company from 1966-71 working in India with The Ford Foundation in the Intensive Agricultural District Program.

Figure 1. Resource use in food production

	World	U.S.A.	West Germany	Japan	India
Food production and demand					
1972 Cereal production, 1000t	1,275,138	228,093	20,240	16,185	107,278
1972 Population, 1000	3,760,745	209,170	59,200	107,055	562,995
1972 Cereal production per capita, t	.34	1.09	.34	.15	.19
1970 Annual income per capita, $	---	4,274	2,698	1,658	88
Land					
1968-71 Total area, 1000ha	13,393,000	936,335	24,728	37,208	326,809
1960-70 Farm land, 1000 ha	4,444,000	444,071	21,370	7,124	123,047
1968-71 Cropland, 1000 ha	1,457,000	192,318	8,083	5,446	164,610
1972 Land in cereals, 1000 ha	698,398	58,503	5,302	2,944	95,795
1960-70 Number of farms, 1000	---	2,954	1,761	6,057	48,882
1960-70 Average farm size, ha	---	150	12.1	1.18	2.52
Labor					
1970 Farm workers, 1000	---	3,243	2,558	10,864	146,491
1970 Farm workers/all workers	51%	4.0%	9.6%	20.7%	67.7%
1970 Farm workers/ha cropland	---	.017	.32	1.99	1.04
Capital					
1971-72 Fertilizer use N+P+K, 1000t	72,146	15,623	3,300	1,913	2,628
1971-72 Fertilizer use t/ha cropland	.050	.081	.41	.35	.016
1971-72 Farm tractors in use, 1000	15,578	4,469	1,394	267	170
1971-72 Garden tractors in use, 1000	---	830	100	3,201	9
1971-72 Total tractor power, 1000 hp	---	209,000	42,000	27,000	5,000
1971-72 Total tractor hp/ha cropland	---	1.1	5.2	5.0	.031
Land productivity					
1972 Cereal yields, t/ha	1.826	3.899	3.817	5.497	1.120
1972 Rice yields, t/ha	2.251	5.250	---	5.847	1.616
1972 Wheat yields, t/ha	1.628	2.196	4.064	2.309	1.382
1972 Wheat price on farm, $/t	---	49	112	206	100
Labor productivity					
1970-72 Cereal production per worker, t	---	70.3	7.91	1.49	.732
1971 Farm wages, $/day	---	12.20	9.76	5.13	.50

References 2, 4, 5, 6, 7, 8, 9

Japan must rank near the ultimate for the world on both counts. Their average farm size is only 1.18 hectares and they use 1.99 workers per hectare.

The U. S. is intermediate among these four nations in its use of capital for fertilizer per hectare and tractor power per hectare West Germany cannot raise as much food as is demanded and therefore uses high capital investments to provide .41 tons of fertilizer per hectare and 5.2 horsepower per hectare. This latter figure makes it the most mechanized country in the world. Japan follows closely behind, based on her high food imports rather than on an above average food demand per capita. Japanese farmers invest the capital required to obtain .35 tons of fertilizer per hectare and 5.0 horsepower per hectare. Unlike the remainder of the world, Japan obtains their power primarily through low horsepower two--wheel walking garden tractors. These tractors are well suited to the country's major crop of flooded rice and to its extremely small farms. However, during the last few years there has been rapid growth of four-wheel riding farm tractors in Japan. India's use of fertilizer and power is distinctly below the other three countries.

In 1972, U. S. farmers received $49 per ton of wheat sold. This is about half the price received by farmers in India and West Germany. Japanese farmers received four times this amount which provides them a distinct incentive to invest capital in any means that will raise the productivity of the land. Wages for farm workers in the four countries generally parallel average per capita income with Indian farm workers typically receiving about $.50 per day.

Japan's land productivity at 5.5 tons of cereal per hectare is ditinctly the highest of the four countries. This high yield coupled with high farm prices paid for their high use of labor, fertilizer and power. Germany's wheat yields were almost double those of the U. S. and helped pay for her high investments in labor, fertilizer and power. India's overall cereal yields were less than one third of any of the other three countries, resulting in little income to invest in any form of purchased input.

The U. S. farm worker produced 70.3 tons of cereals in 1972. Beyond this he also produced the meat, fruit and vegetables so important to the American diet. The West German farm worker produced about one tenth this amount. Although Japan is extremely labor intensive, each farm worker produced 1.5 tons of grain in 1972. Indian farm workers averaged only .73 tons of cereal produced in 1972.

U. S. Food Production per Hectare

Cropland used for crops in the U. S. has generally held about steady since the 1920's and at most accounts for 20 percent of all land in the 48 states.(10) Harvested cropland peaked out in 1930 an has declined somewhat since then.(11) Many changes have

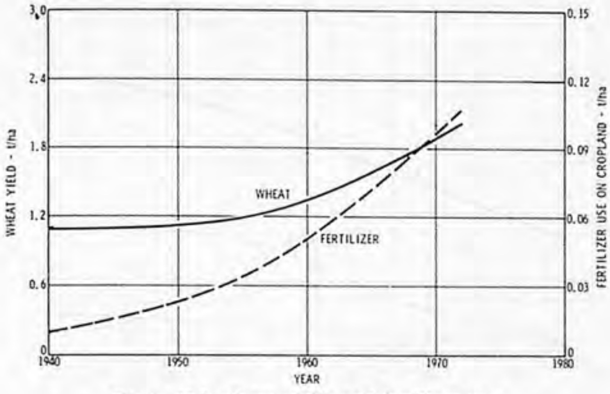

Fig.2. U.S. wheat yields and fertilizer use.

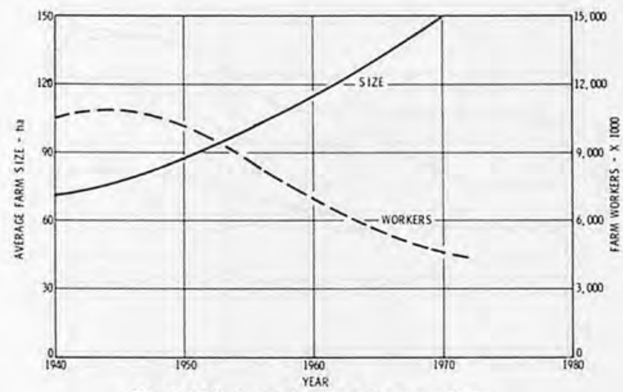

Fig.3. U.S. farm size and farm workers.

taken place on U. S. farms since 1940. **Figure 2** shows U. S. wheat yields increased 113 percent from 1.03 tons per hectare in 1940 to 2.20 tons per hectare in 1972.(10, 11) This increase in wheat yield generally parallels that of all crops wiich increased 86 percent during this same period.(4, 12) Major contributors to these yield increases were fertilizer, better varieties and improved cultural practices. Fertilizer consumption per hectare of cropland increased from .011 tons to .116 tons during this period.(13, 14) Specialization on farms has increased since 1940 to gain comparative economic advantage of location, economies of scale and better management.

U . S. Food production per Farm Worker

The number of farms in the U. S. peaked out in the depression year of 1935.(15) Since 1940, the average farm size has increased from 70 hectares to 154 hectares, **Figure 3**.(10, 11) The number of farm workers per farm has consistently remained between 1.5 and 1.8 during this period, resulting in the number of farm workers being reduced from almost 11 million in 1940 to just over 4 million in 1972.(10, 11) Larger farms became practical to manage with only two workers with the advent of increasing tractor power, **Figure 4**. Tractors on farms grew to a maximum of 4,787,000 units in 1965 and have declined about 8 percent since then as they now exceed the total number of farm workers.(4, 12) Average power for tractors on farms remained steady at below 30 horsepower until most farms had switched to tractor power. It has essentially doubled since then and stood at 48 in 1973. The average power per tractor on farms will continue to rise because the average tractor sold by industry today is about 80 horsepower.

Total tractor power on U. S. farms continues to rise, **Figure 5**. Power on farms increased 398 percent from 42 million horsepower in 1940 to 209 million horsepower in 1972. This increased power available to the farm worker allowed him to increase his productivity an even greater amount during this period. Productivity in wheat production increased from 54 kg per man-hour in 1940 to 302 kg 1972 or about 460 percent increase. Labor productivity for all food grains increased 493 percent during this period. Stated in more human terms, the U. S. farm worker now supplies 42 people here at home and 10.4 abroad.(10)

The majority of farm equipment in the U. S. is designed and used to increase the productivity of the farm worker while maintaining the productivity of the land. Hay conditioners and subsoilers are specific machines that were designed to improve yields while lowering labor productivity. However, the farm manager is the ultimate decision maker in what he will use and how he will use it. Precision planters have

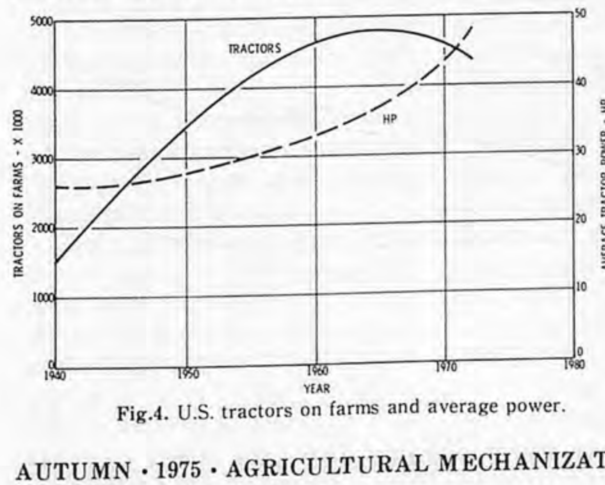

Fig.4. U.S. tractors on farms and average power.

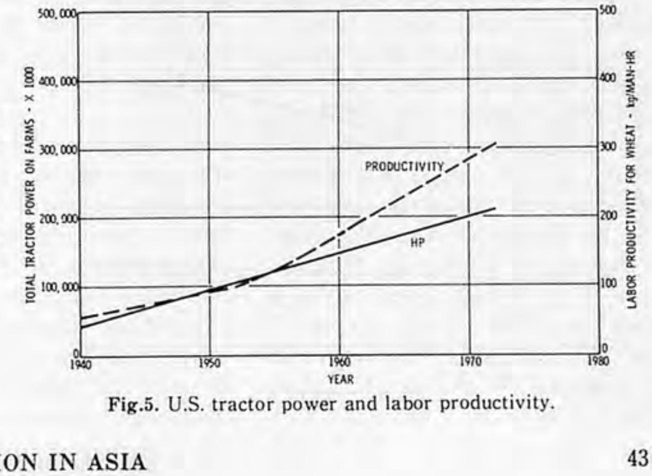

Fig.5. U.S. tractor power and labor productivity.

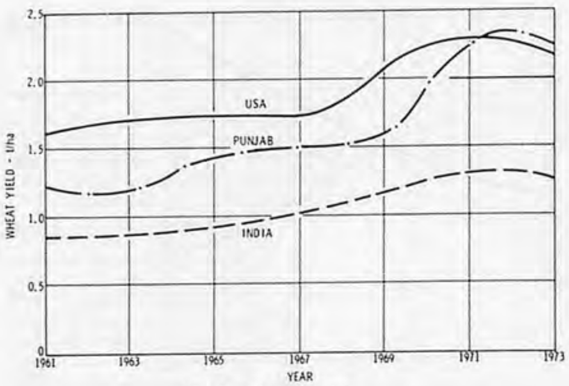

Fig.6. Wheat yields.

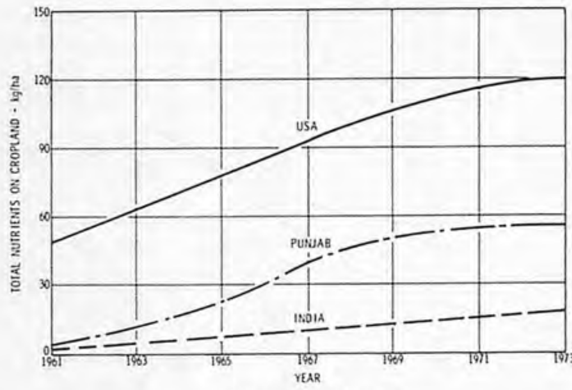

Fig.7. Fertilizer use.

been designed to provide better crop stands when used at current travel speeds. Soybean harvesters have also been designed which provide reduced losses at current speeds. However, even with these machines, the farmer may choose to drive faster and retain only his previous yield levels to take his gain in labor productivity rather than land productivity.

Indian Food Production per Hectare

Among the developing nations, India has imported the greatest amount of food, especially wheat. Land, and more particularly land with an adequate water supply, is a major limiting factor in total food production. India had 43 percent of its land sown to crops in 1970.(3)

Much of this land is so marginal it would not be used for crops in other countries. Punjab, the state that supplies the most food for the remainder of the country, had 81 percent of its land sown to crops in 1972.(16) Punjab, in recent years, has made the most progress in food production so will be compared to India as an example that the remainder of the country might consider following.(17)

Wheat will continue to be used in these comparisons. Wheat is the largest agricultural commodity in world trade, the largest agricultural export item for the U. S., the largest import for India, the largest crop for Punjab and the second most important crop for India. Wheat and other crop yields remained essentially stagnant in India prior to 1961. Wheat yields in Punjab essentially doubled between 1961 and 1973 and now exceed those of the U. S., **Figure 6**.(16) The large yield increases in Punjab helped the nation as a whole to reach similar yield levels in 1973 to what Punjab had in 1961.(3, 18)

The stage was set for Punjab's drajatic yield increases by the introduction of Mexican Dwarf Wheat. These wheat varieties were capable of fully utilizing considerably larger amounts of fertilizer, **Figure** 7. Average fertilizer consumption in Punjab increased tenfold during this period and stood at 56 kg of actual nutrients for each hectare of cropland in 1973.(5, 16, 19)

Irrigation is extremely important to wheat production in India because the monsoon rains fall entirely outside the wheat growing season with little rainfall coming durind wheat production. Punjab increased its crops receiving irrigation from 56 to 77 percent during this period, **Figure** 8.(16) The nation as a whole increased their percentage from 18 to 24 percent.(3) Indian farmers have endorsed the increased production potential of assured water by investing more moner in irrigation pumpsets than all other forms of mechanization combined. More than $600 million are estimated to have been spent on pumpsets by 1971. These pumpsets contribute about 4 percent of

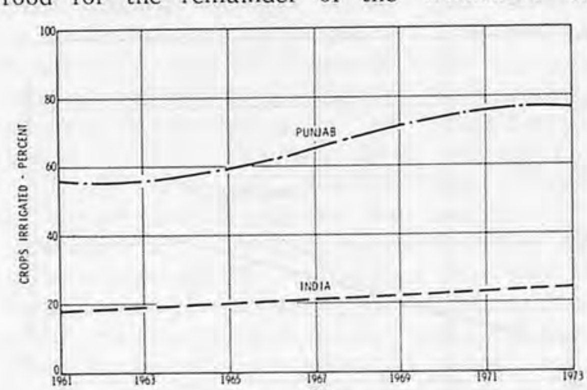

Fig.8. Irrigation.

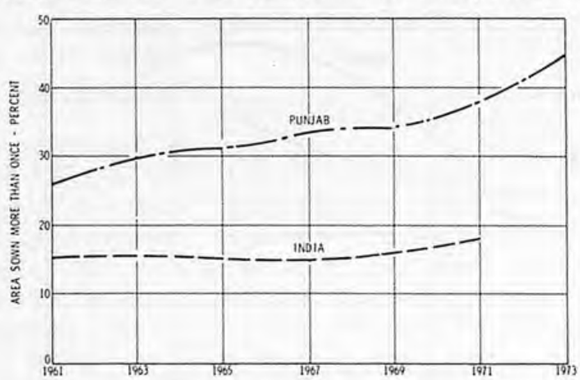

Fig.9. Multiple cropping.

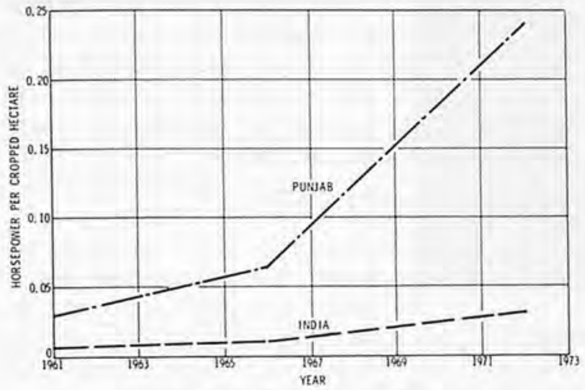

Fig.10. Tractor power.

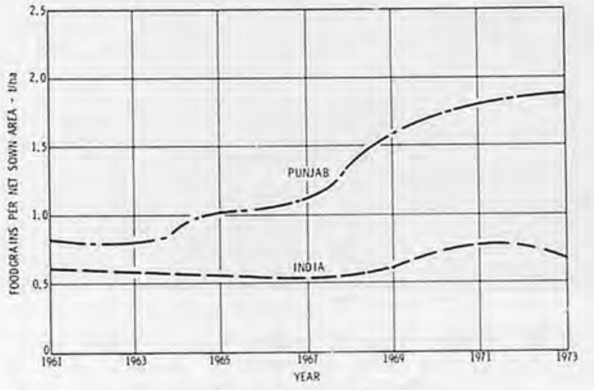

Fig.11. Land productivity.

India's food grain production througe increased yields and an additional 2 percent through growing a second crop each year.[20] The additional food produced by the use of pumpsets in India each year exceeds the average food imports for the past 10 years. The contribution that pumpsets have made to Punjab's food production has been even more dramatic. Tubewells with pumpsets grew from 26,000 in 1966 to over 180.000 in 1973 and now supply over half Punjab's irrigated acres.[16] Pumpset mechanization has truly concentrated on increasing food production per unit land.

Irrigation makes it practical to grow a second crop each year in India during the season of inadequate rainfall, **Figure** 9. Punjab increased its area that is sown more than once from 26 to 45 percent during the period while the nation as a whole made only a minor increase even though it has been a major agricultural goal.[3, 16] Althouge India's sunlight supply is adequate for crop growth around the year, the production of two or even three crops places high demands on the rapid harvest of one crop followed by tillage and planting of the succeeding crop.

This has led Punjabi farmers to buy tractors rapidly, especially since 1966, **Figure 10**. One farmer in 15 in Punjab now owns a tractor while for the country as a whole, it is only one farmer in 300.[13, 16] Most farmers in Punjab with tractors have the following three implements: a field cultivator or offset disk for tillage, a Drummy or Ludhiana thresher and a two-wheel trailer. Punjabi farmers own about half of the tractor-mounted 1.5-meter-cut combines that have been made and sold in India. Four-meter-cut, self-propelled combines are being imported by government organizations and generally used for custom work in Punjab and elsewhere.

Tractor power has provided the Punjabi farmer with more rapid tillage and permitted him to plant his second crop on time. Tractors and implements can improve the quality of work as well as the quantity. In some instances yields have been increased by better seedbed preparation. A variety of tests has shown that the use of grain drills has increased wheat yields 10 to 15 percent over traditional hand seeding. More limited tests have shown 40 percent corn yeild increases with the use of row-crop planters.[20] For both machines, yield increases come from more uniform stands and better fertilizer placement.

Threshers and combines have reduced losses of the crops already grown. Properly adjusted threshers and combines have lower losses in the threshing process than traditional bullock trampling. Mechancal threshing is aoso more timely and has resulted in peak market arrivals of wheat coming three weeks earlier than previously.[20] Further adoption of threshers and combines will reduce grain losses from exposure to rain, fire, rats birds, cattle and pilferage.

The real payoff to the farmer and to the nation for the adoption of the new technology package including high yielding varieties, fertilizer, irrigation, multiple cropping and mechanization is best seen in food grain prodnction per net sown area, **Figure 11**. In Punjab this increased by 124 percent from .84 tons per hectare in 1961 to a total of 1.88 tons per hectare in 1973.[16] During this same period the nation as a whole vacillated up and down with only a minor net improvement.[3] Prmpsets were a major factor and tractors an important factor in Punjab's successful increase in land productivity.

Indian Food Production per Farm Worker

Labor productivity may at first glance seem unimportant in a land of overpopulation, unemployment and underemployment. With over two thirds of all of India's workers being farm workers, each of them is still responsible for producing all the food for 4.35 people if the nation is to be self-sufficient in food.[3] Thus, the productivity of each farm worker determines the important yardstick for standard of living in India, that of food avail-

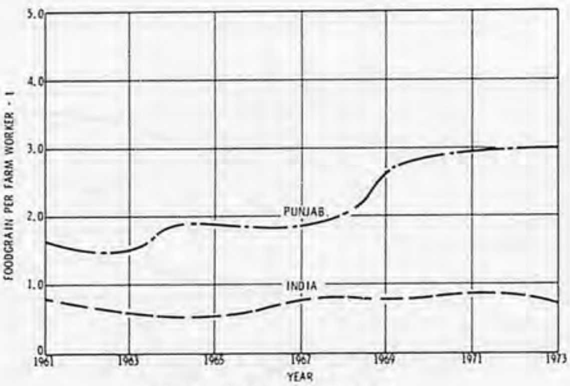

Fig.12. Labor productivity.

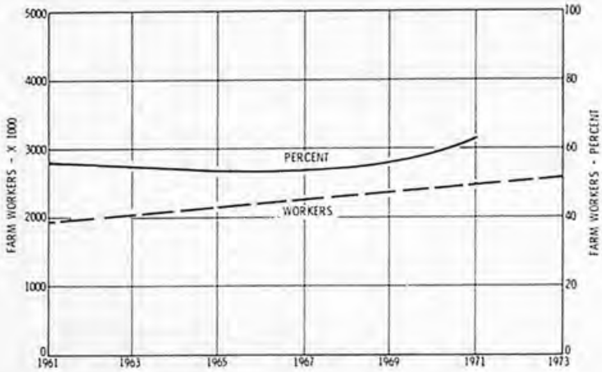

Fig.13. Farm workers in Punjab.

ability. Farm worker productivity in India peaked in 1971 at .862 tons of food grain per farm worker.(3) With a bad momsoon in 1973, labor productivity actually showed a decrease for the total period covered, **Figure 12**. Farm workers in Punjab increased their productivity 83 percent during this period from 1.63 tons of food grain to 2.99 tons of food grain.(16, 21) Malnutrition will continue to haunt India and any other developing nation whose labor productivity remains below one ton of food grain farm worker per year.

Social Considerations in Farm Mechanization

The social consequnces of farm mechanization must be evaluated in a country where the average person has an inadequate diet and the unemployed are prone to diseases from malnutrition. Agriculture contributes over two-thirds of all jobs in India.(3) Agriculture must continue to productively employ as many or more laborers per cultivated hectare in the foreseeable future. India's increased food requirements must be met through increased productivity of the land from higher yields and more multiple cropping while maintaining at least current levels of farm worker numbers and productivity.

The consequences of irrigation pumpset adoption are rather easy to predict on the productivity of both land and labor. Irrigated land requires additional productive labor to level the land, build channels and borders as well as divert and control the water during the growing season. Increased yields require additional labor for harvesting and threshing. Seasonal distribution of farm work is greatly improved from multiple cropping which becomes practical only when the land is irrigated.

Most of the questions and concern about the influence of farm mechanization on farm employment relate to the adoption of farm tractors. They do offer the opportunity to reduce the number of farm workers per hectare. However, there is little incentive in India to substitute tractors for farm workers because about 25 man-years of labor can be purchased for the price of a typical 35 horsepower farm tractor. In the U. S., on the other hand, less than 2 man-years of farm labor can be obtained for the price of a similar tractor. It should be remembered that the good farm manager the world around attempts to use that mix of inputs which results in the greatest net income.

Punjab hav the highest concentration of tractors of any state and has over half of the nation's total threshers and combines. During this period of rapid mechanization the number of farm workers in Punjab increased considerably, **Figure 13**. Between the 1961 census and the 1971 census, farm operators increased by 4 percent indicating that farm size held steady. However, the important component, hired laborers, increased 135 percent from 335,000 in 1961 to 787,000 in 1971.(16, 21) Between these two census dates the cultivable area per farm worker decreased from 2.23 to 1.75 hectares in Punjab. Agriculture actually increased its percent of workers in Punjab from 55.89 percent in 1961 to 62.67 in 1971.(16, 21) For the same census period, the nation as a whole went from 69.5 percent to 69.6 percent workers in agriculture. (3) The number, percentage and productivity of farm workers increased in Punjab during its decade of rapid mechanization.

Seasonal distribution of income is also important in a land of chronic underemployment. A farm account study shows that workdays per year for the Punjab farm worker have increased from 196.1 in 1955 to 295.5 in 1967. A specific study on progressive tractorized farms shows more than a 50 percent increase in labor use.(20)

Labor wages are also an important indicator of the economic impact of farm mechanization. The most tractorized operation in Punjab is tillage. Wages in Punjab for plowing increased from \$.33 per day in 1961 to \$ .95 per day in 1973.(16) Both plowing and harvesting wages are now about double the all-India average. Factory wages in Punjab continue to be below the all-India average so are not the cause for high farm wages.[16]

Pimentel and others have questioned the adoption of modern crop technology practices by developing nations because of energy consumption.[22] Energy for mechanization in developing countries will not be examined in depth, partially because of inadequate availability of data. However, Heichel and others have estimated that the production of agricultural raw products requires 2.6 percent of U. S. energy.[23, 24] Since the U.S. produces over one-sixth of the entire world's production of cereals, it follows that the world food supply could grown by U. S. technology for 15 percent of current U. S. energy consumption. On a world energy consumption basis this would amount to about 5 percent devoted to food production on farms. This seems rational amount to allocate to food in a country where we spend one-sixth of our personal income on food and it seems even more rational in countries where diets are consistently inadequate.

The above suggests that developing nations are justified in adopting some of our food production technology. However, they should not nor can they economically afford to adopt our current food consumption practies.

Matching Mechanization to Needs and Resources

Proper farm mechanization provides functional equipment to meet the farmers' needs at a cost that permits an increase in farm income. While 80 horsepower is the average size of tractor being sold in the U. S. today, the 80 horsepower tractor class is not a popular seller. Two distinctly best selling sizes are the 35-39 horsepower class and the 120-129 horsepower class. In 16 states, the 35-39 horsepower tractor is the best selling of all classes while in another 16 states the best selling class is 120-129 horsepower.[25] In the seiection of these widely different power level tractors, farmers have wisely wisely chosen the equipment which helps them optimize the return on their investment.


Rice harvesting by combine (Japan)

India has six states which may be designated Rainfed because of their low natural rainfall and low availability of irrigation. Farmers in these Rainfed states have wisely adopted irrigation pumpsets at a distinctly higher rate than the nation as a whole because of their pressing need and high return on investment. Although tractors work well functionally in this area, their adoption rate is at about the national average. The need is there for tractors but low and variable rainfall results in yields which are too undependable to pay for the tractor.

Power sprayer adopition rates in India's eight rice growing states are distinctly higher than the national average because the benefits of plant protection chemicals are greatest in rice production. Although there is a need for farm tractors, their adoption rate is less than half the national average. Traction and flotation are serious problems for tractors in the best income rice growing areas because their rice is grown flooded.

Parts of India, the Philippines, Guatemala and other developing countries currently grow grain on mountain slopes too steep for the practical use of animal power. It is obvious then that tractor power will aoso not be practical for such farming conditions.

Summary

The relation of farm mechanization to food production was examined for various geographic and economic settings. The wise use of available land, labor and capital inputs determines whether the farmer will use mechanization primarily to improve the productivity of his labor or the productivity of his land.

Germany and Japan are under extreme pressure to maximize the productivity of their land because they are dependent on imports for much of their food needs. Therefore, both countries use high inputs of labor, fertilizer and tractor to compensate for lack of land. West Germany is the most mechanized country in the world with 5.2 tractor horse power available for each hectare of cropland. Japan uses almost as mrch power per hectare but it is primarily in the form of two-wheel walking garden tractors. Their labor input is one of the highest in the world at two farm workers per hectare of cropland.

The U. S. is distinctly the largest food exporting nation and typically provides 20 percent of its production to other nations. Wheat yields have more than doubled since 1940, primarily due to a tenfold increase in fertilizer use. Farm sizes have more than doubled since 1940 while workers per farm have remained rather constant at slightly more than

one and a half. There is about five times as mrch total tractor power on U. S. farms today as there was in 1940. This has permitted labor productivity to become six time as great today as it was in 1940 in terms of wheat production per man-hour. These increases in productivity of both our land and labor have allowed the U. S. to continue producing food at very competitive world prices.

Indian farmers have invested more money in irrigation pumpsets than all other forms of mechanization combined. The use of these pumpsets has contributed more to India's annual food grain production than the amount of their average food imports. Punjab is the most mechanized state with one farmer in 15 now owning a tractor. Since 1961, the Punjabi farmer has rapidly adopted high yielding varieties, fertilizer, irrigation, multiple cropping and tractor power. As a result of these modern inputs, the productivity of his land has more than doubled since 1961 from .84 tons to 1.88 ton of food grains per hectare of net sown area. During the same period of time, the productivity of his labor has almost doubled while the nation as a whole remained stagnant.

As Punjab rapidly mechanized, the number of farm workers continued to increase. Between the 1961 census and the 1971 census, the percent of all workers employed on farms increased from 55.9 percent to 62.7 percent. During this same period, farm labor wages in Punjab about tripled and are now double the all-India average.

Farmers in the U. S. have used farm equiment primarily to increase the productivity of their labor while maintaining the productivity of their land. With completely different social and economic variables, farmers in India primarily use farm equipment to increase the productivity of their land while maintaining the productivity of their labor. Farmers in these countries and others are making sound decisions on the best use of the resources available to them.

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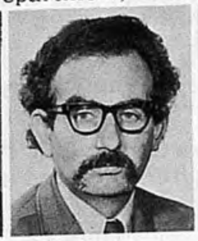
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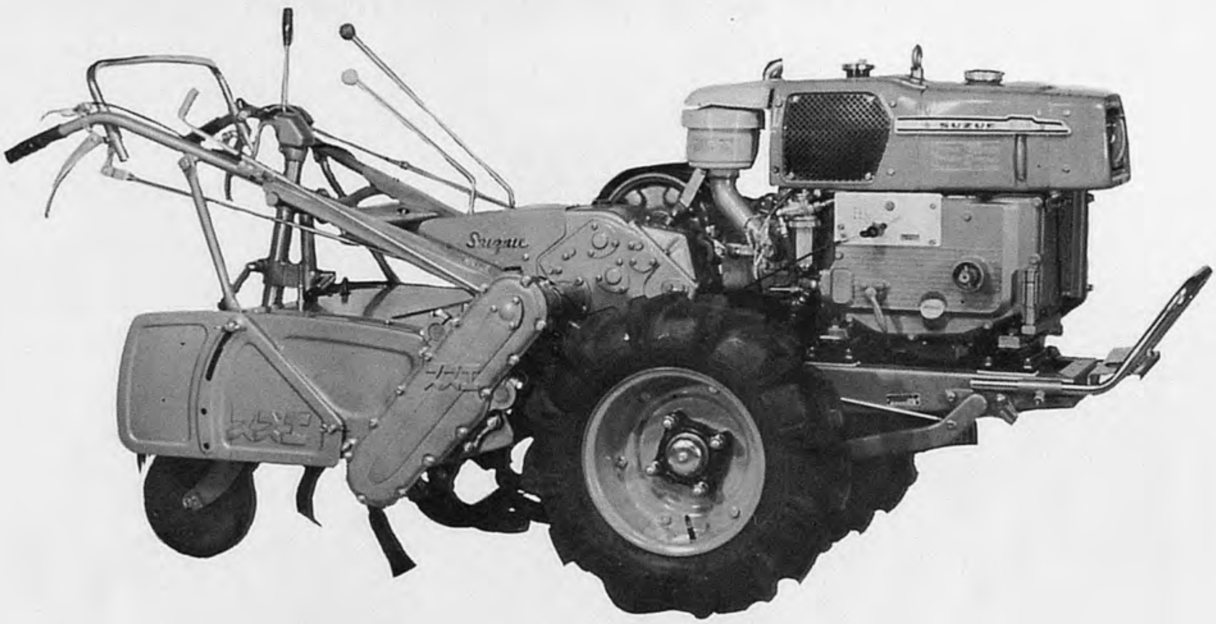

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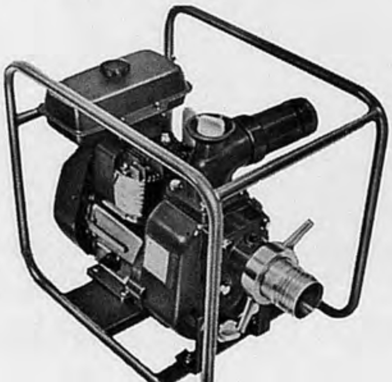

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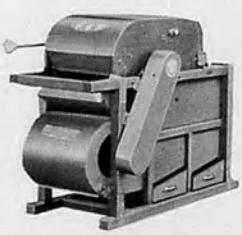

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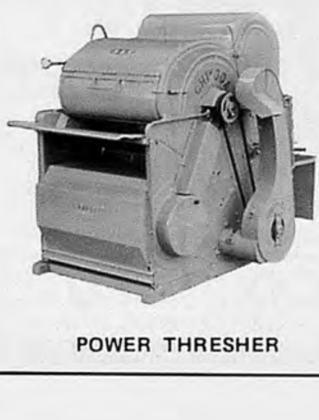

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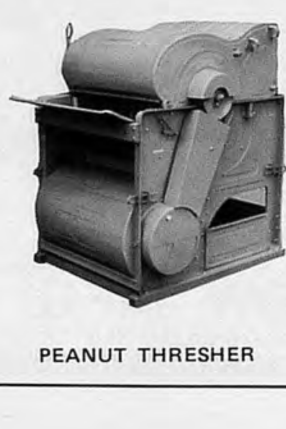

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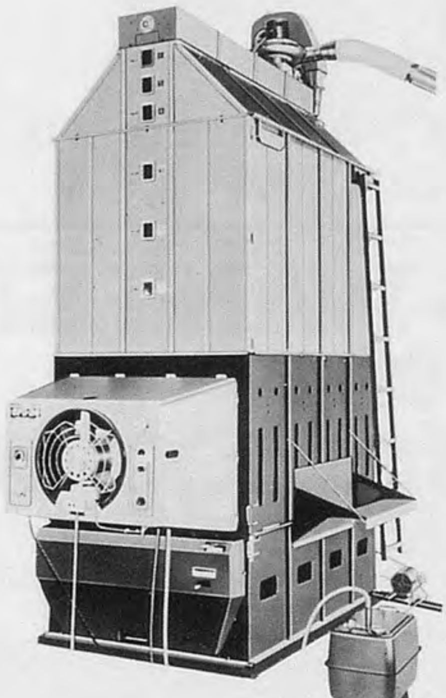

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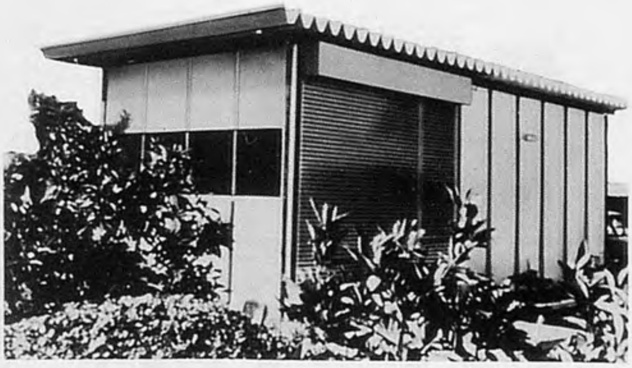

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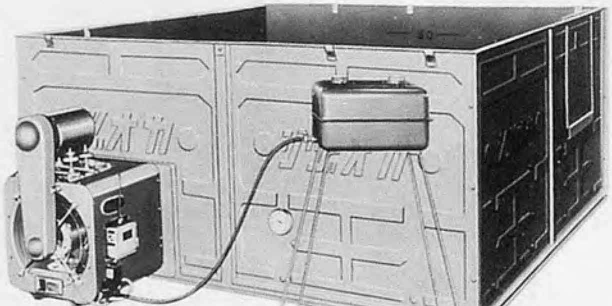

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Resource Productivity on Selected Farming Areas on Punjab

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The modern farm technology comprising new seeds of high yielding varieties of crops, chemical fertilizers, pesticides and farm machinery has been widely accepted by the virile and imaginative farming community of the Punjab state. As a result the productivity of land has increased manifold & the approach to farming has undergone slmost a radical change.(1)

The rapid diffusion of new technology is clear from the fact that between 1951 and 1969 i.e. from the beginning of the First Five Year Plan to the beginning of the Fourth Five Year Plan, Punjab was the only state in the country where there were more than one tractor per 1,000 hactares of land, and as many as nine states were below the national average in this respect(2).

Adoption of new technology follows a time path. The adoption process for agricultural technology has received considerable study. The adoption is a very uneven process. The rate of acceptance varies geographically—farmer to farmer, region to region, and country to country—as well as among crops. But. in general the adoption process follows the S-shaped growth curve. The rate of adoption of new technology will be influenced by the nature of the economy: the nature of the infrastructure, the demand for agricultural commodities, off farm employment, and government policies. Infrastructure includes the availability of inputs necessary for the change, the availability of credit, and the nature of the marketing system.(3)

Depending upon the adoption of new technology the Prnjab farms could be classified into mechanized and non-mechanized ones. Mechanized ones are those who employ tractor and allied machinery for their operations and non-mechanized ones are those which employ bullocks and bullock driven implements of their farms. Naturally the productivity of different input factors would be different on these two types of farms.

Comparative analysis of mechanized and non-mechanized farming is a complex problem, & is not the point on which this study concentrates. The aim of this study is limited to a comparison of the economic performance of those without tractors. It has been suggested that in order to exploit the full possibilities for multiple cropping made possible by the use of H.Y.Vs., tractorization in Punjab is necessary to overcome the constraints of labour & animal power shortages during the peak farming activity. There are apprehensions in some quarters that mechnization of the farms would render a part of the labour force surplus, thereby, accentuating unemployment problem. This view point obviously assumes an advanced stage of mechanization. In practice, mechanization follows a time path. In the initial stages, generally speaking, there is complementarity between technologycal innovations and labour use(4). It is also argued that tractorlzation with multiple cropping results in the use of more labour altogether.

Keeping these facts in view, the present study was undertaken to:

a) estimate the marginal value productivities of different resources for tractorized and non-tractorized farms in the selected area, and
b) compare the marginal value productivities of different resources between different study zones.

Methodology

District Gurdaspur of Punjab State was selected purposively for this inquiry. It has shown a remarkable growth rate in terms of production and productivity of major foodgrains and also in terms of adoption of new technology in the form of H.Y.Vs., tractors, tubewells/pumping sets, etc:. Between 1950-51 and 1969-70, there was a significant (1 per cent level) compound growth-rate of production in terms of wheat (5.66%), paddy (4.11%) and sugarcane (4.61%) in the district. The compound growth rate of productivity, for the same period, in the district was 3.89%, 0.26%, and 1.46% for wheat, paddy and sugarcane respectively(1).

Multistage stratified random sampling technique was used with vIllage as the primary unit of sampling and operational holding as the ultimate unit. The selection of the sample involved the following steps:

Demarcation of District into zones

The district was divided into two zones depending on the major source of irrigation:

Zone A: Canal and tubewell-/pumping set irrigated area.

Zone B: Tubewell/pumping set irrigated area.

Selection of Villages

The villages in each zone were selected with probability proportional to the area under cultivation. Five and three villages were selected from zones A&B, respectively. This gave a total of eight villages for the study.

Selection of Cultivators

The ultimate unit of study is a sample of 15 per cent cultivators from each of the selected villages. This provided a sample size of 115holdings for this study.

These selected holdings were divided into mechanized (tractorized) & nonmechanized (bullock-operated) holdings by pooling the data. This gave a total of 24, & 11 mechanized and 51 & 29 non-mechanized farms, in zone A and B, respectively.

Test of Homogeneity of variance

The hypothesis that the samples of each farm-firm classification from different zones were not hetrogeneous for variation in the dependent variable & tested by applying the Bartlett's test of homogeneity of variance(5). The X^2 was not significant even at 5 per cent level. This showed that samples of each firm classification from different zones were homogeneous for variation in the dependent variables.

The Production Function

The postulated production relation ship in agriculture is reflected in the algebraic form of the function. "The function estimated from farm samples ordinarily have been of power form because of the smaller number of degrees of freedom involved in estimating the parameters, & partly because a multiplicative model seemed logically appropriate."(6) Therefore, the production function considered in this study was as below:

$$Y = a\ A^{b_1}\ L^{b_2}\ C^{b_3}\ I^{b_4}$$

where, Y is gross returns and was dependent variable.

A is value of land

L is total human labour cost

C is operating expenses

I is expenditure on irrigation

All the variables were expressed in current rupees. The procedure followed for standardizing and aggregating the different variables was as follows;

Y—Gross Returns

Because of the variation in the crop pattern and more than one and different products produced from farm to farm, the physical production could not be used as a dependent variable. Thus, in order to quantify the production in a variable which could be compared from farm to farm, gross returns per acre were calculated and included as the dependent variable.

A—Value of Land

The land input measured as simple acreage would not yield authentic results because of the wide variations in the fertility status & productivity of different fields from area to area, farm to farm and even on the same farm. To overcome all these difficulties, the farmers were asked about the value of different pieces of their operational holdings. This value was rationalized in consultation with the Sarpanch, & other leading farmers of the village.

While assigning value of land, irrigation status was taken in to consideration. The un-irrigated land gets automatically adjusted for and hence has not been considered as a separate variable.

L—Total Labour Cost

It included operators' labour charged at the representative wage rate for area, actual wages paid to the hired labour & family labour which was used at any time on any operation in farming at the market wage rate for the area.

I—Expenditure on Irrigation

It consisted of depreciation of irrigation structure (of electric motor, diesel engine, building, fittings etc.:), the annual repairs, the fuel charges of engine, electric charges of electric motor, canal water charges and hiring or irrigation water.

C—Operating Expenses

This variable included the sum of annual expenses for manures, fertilizers, pesti-cides and seeds. For the purpose of comparison all farms were charged for all seed costs.

Table 1. Geometric mean, Elasticity of production, Marginal value product and Marginal factor share, Mechanized & non-mechanized farms, zone-wise, Study area, 1972-73.

Category	Geometric mean	Elasticity of production (b_i)	Marginal value product	Marginal factor share (x_i) (mvpi)
1	2	3	4	5
Zone A				
Mechanized		N=24		R^2=0.877059
	Y=24339.00	—	—	—
	L= 1580.10	−.012731 (.007951)	−.196101	−309.86
	I= 906.77	.002339 (.001356)	.062782	56.93
	C= 326.67	.207961 (.048802)***	15.494422	5061.56
	A= 4789.60	.974314 (.253262)***	4.951108	23713.83
	Sum	1.171883		28522.46
Non-mechanized		N=51		R^2=0.717403
	Y= 8760.00	—	—	—
	L= 99.59	.027036 (.008048)***	2.378104	236.84
	I= 299.09	.281433 (.101275)***	8.242847	2465.35
	C= 1127.70	.380139 (.097377)***	2.952929	3330.02
	A= 2204.90	.104612 (.078309)	.415620	916.40
	Sum	0.793220		6948.61
Peeled		N=75		R^2=0.838201
	Y=12148.00	—	—	—
	L= 241.16	.030746 (.013626)**	1.548774	373.50
	I= 426.58	.332567 (.075135)***	9.400730	4040.02
	C= 1584.90	.335523 (.075390)***	2.571729	4075.93
	A= 2826.20	.175473 (.074601)**	0.754245	2131.65
	Sum	.874309		10621.10
ZoneB				
Mechanized		N=11		R^2=949395
	Y=23083.00	—	—	—
	L= 802.24	.020569 (.048663)	.591836	474.79
	I= 29.89	−.023274 (.046245)	17.973695	−537.23
	C= 3486.60	.475270 (.126842)***	3.146520	10970.66
	A= 3600.80	.393491 (.440474)	2.522482	9082.95
	Sum	0.866056		19991.17
Non-mechanized		N=29		R^2=.787103
	Y= 6620.80	—	—	—
	L= 13.66	−.018739 (.022259)	−9.082516	−124.07
	I= 14.31	−.036086 (.041285)	−16.695890	−238.92
	C= 509.80	.177107 (.104231)***	5.676732	2894.00
	A= 15.86	1.044664 (.704560)	436.097818	6916.51
	Sum	1.426946		9447.52
Peeled		N=40		R^2=.935472
	Y= 9332.50	—	—	—
	L= 41.87	−.014560 (.011140)	−3.747318	−135.97
	I= 2.70	−.022752 (.007566)**	−78.641865	−212.33
	C= 865.17	.494514 (.086140)**	5.334272	4615.05
	A= 1987.50	.620934 (.189039)**	2.915656	5794.87
	Sum	1.078127		10061.62

*** Significant at 1 per cent level of significance.
** Significant at 5 per cent level of significance.

Results and Discussion

Table 1 provides the results of least square regressions for separate tractor and non-tractor functions as well as function with pooled data.

In zone A, the expected mean gross farm income, on mechanized farms, was Rs. 24,339.00. The coefficient of output with respect to operating express (C) & value of land (A) were highly significant at 1 per cent level, whereas, the coefficient of output with respect to irrigation cost (I) was not significant even at 5 per cent level. The coefficient of A had relatively higher value, suggesting that more use of this input would help in increasing the gross farm income more on mechanized farms of zone A.

In zone B, the coefficient of output with respect to operating expenses (C) turned out to be highly significant at 1 per cent level. The coefficient of irrigation statistically. The marginal value productivity of operating expenses (C) was higher in relation to the marginal value productivity of other factors. Thus indicating an increased gross farm income, if more of C was used.

On the other hand, in case of non-mechanized farms of zone A all the variables, except value of land (A) turned out to be highly significant at 1 per cent level. One of the reasons of this variable not turning out to be significant might be that the classification of sample was based on draft power, and the main and only draft power being bullocks in non-mechanized sample, the agronomic operations become delayed, thereby decreasing productivity of land. The marginal value productivity of irrigation cost (I) was higher than other variables, thereby indicating that more irrigation would increase the gross farm income of non-mechanized bullock operated farms.

In zone B, the coefficient of operating expenses (C) was highly significants at 1 per cent level. The coefficient of (L) was negative (though not significant). The plausible reason for this negative sign is that the number of family members in this zone was large and labour was excessively used because of the heavy proportion and fixity of family labour on these farms.

The pooled function for zone A (mechanized plus non-mechanized) showed that the coefficients of output with respect to all the variables were significantly different from zero at 5 per cent level, but the coefficients of I and C were significant even at 1 per cent level. This indicates that with the increased use of irrigation (I) and operational expenditure (C), they are sure to increase the gross farm income. The marginal value productivity of I was higher indicating that more use of this variable world surely increase the gross farm income.

The pooled tunction for zone B showed that the coefficients of output with respect to irrigation (I) was significant at 1 per cent level and the coefficients of output with respect to operating cost (C) and Value of land (A) were significant at 5 per cent level. The coefficient of I (irrigation cost) and L (human labour) had negative sings. This showed that the increased use of irrigation would decrease the gross farm income. One of the explanations might be that the soils of this zone are more suitable for raising paddy than any other enterprise. Moreover, there are pockets in this area which experience water logging conditions. Thus, with increased use of irrigation water logging conditions are formed which might prove fatal to the crop roots thus decreasing crop output and hence gross farm income. The human labour input was also negative, but it was not statistically proved. As was discussed earlier for non-mechanized forms of this zone, the main reason was that the size of farm family labour was large, inducing the farmers to use more and more of labour (although economically it it not profitable).

The marginal factor share i.e. contribution of each factor towards gross farm income was worked out. In case of mechanized farms of zone A, the marginal factor share of all the variables was Rs. 28,552.46, whereas the amount actually received by the farms was Rs. 24,339.00. This higher marginal factor share was the result of the increasing returns to scale. The marginal factor share of human labour (L) had negative sign, indication that the lower use of this factor would increase gross farm income. In zone B the marginal factor share of all the variables was Rs. 19,991.17, whereas, the actual returns were Rs. 23,083.00, which were higher as a result of decreasing returns to scale. In this case, a decreased use of irrigation (I) would increase the total marginal factor share.

Non-mechanized situation of zone A indicated higher realized returns than were shown by the marginal factor share. This, again, was true as there were decreasing returns to scale. All the factors had positive sign suggesting that more would be added to the gross farm income by more use of the variables. But, as the operating costs (C) had a relatively higher marginal factor share, indicating that more use of this factor surely add relatively more towards the gross farm income. But in case of zone B, human labour (L) & irrigation cost (I) had negative sings (not significant). This indicated that lower use of these variables would help increase the gross farm income. The marginal factor share was more than what was realized, as the returns to scale were more than one.

The marginal factor schare of pooled data in zone A indicated that gross returns could be enchanced by employing proportionately more of operating expenses (C) & irrigation (I). In zone B, the land (A) & operating expenses (C) were responsible for the overall increase in gross farm income.

The regression analysis did not reveal a recognizable difference between the two technologies. To study whether there is really a difference between productivities on tractor & non-tractor farms a comparison of resource productivities of different resources was made and 't' test applied to prove the statistical validity of this comparison.

The marginal value productivities of resources in different situations could be compared by estimating the elasticity coefficient necessary for each resource, which would result in a marginal product equal to the marginal product in situation under comparison (K) with the resources (X_{ij}) & output (Y_j) *of the former situation j" elasticity coefficients* 'b'_{ij}), & the one estimated from the sample (b_{ij}) as follows:

$$\frac{b'_{ij} \cdot \bar{Y}_j}{\bar{X}_{ij}} = \frac{b_{ik}\, \bar{Y}_k}{\bar{X}_{ik}}; \quad \text{or} \quad b'_{ij} = b_{ik} = b_{ik}\frac{\bar{Y}_k \cdot \bar{X}_{ij}}{\bar{Y}_j\, \bar{X}_{ik}}$$

The positive difference between the actual elasticity of resource X_i, in situation j, (b_{ij}) & the estimated elasticity (b_{ij}) required to equate its marginal productivity of resource X_i would be higher in situation j, for which the estimate was made. Likewise, a negative difference would indicate that the marginal productivity of the resource was higher in situation 'k', against which the test was made.(7) The value of t-then was computed as follows(8):

Table 2. Comparison of resource productivities of different resources under different technologies, Zone-wise, Study area, 1972-73.

Zone	Labour			Irrigation			Operating expenses			Value of Land		
	b_i	b'_i	b_i-b'_i	b_i	b'_i	b_i-b'_i	b_i	b'_i	b_i-b'_i	b_i	b'_i	b_i-b'_i
A	.020704	-.002234	.209270 (.000532)***	.281433	.001230	.280203 (.214682)	.380139	.199464	.180675 (.001164)***	.104612	1.246198	-1.141586 (.000325)***
B	-.018739	.012211	-.030950 (.002662)***	-.036086	-.038848	.002762 (.014006)	.437107	.242281	.194826 (.744952)**	1.044664	.006043	1.038621 (.001455)***
A&B	-.014569	.066110	-.020679 (.028321)	-.022752	2.739991	-2.762743 (.00350)*	.494514	.238412	.256102 (.110249)**	.620934	.095762	.525172 (.182321)**

Note: b_i=Elasticity coefficient on non-mechanized farms.
b'_i=Elasticity coefficient necessary to yield marginal employment of resource equal to that of tractorized farms.
b_i-b'_i=When positive indicated that factor employment was higher on non-tractor farms. The reverse is true far negative sign.
Figures in parentheses are standard errors.
*** Significant at 1 per cent level of significance.
** Significant at 5 per cent level of significance.

$$t = \frac{bij - b'ij}{S^2bij + \left[\frac{Yk\,Xij}{Yj\,Xik}\right]^2 \cdot S^2bik}$$

Table 2 shows that the significance of difference in the marginal productivities of input factors when compared on the different types of farms.

The difference (b_i—b'_i) revealed that productivity of labour was higher on tractor operated farms. The difference was significant at 1 per cent level in both zones A&B. The productivity of irrigation was not significant, though the positive sign indicated a higher employment of irrigation cost on non-tractor farms. The productivity of operating expenses in zone A was highly significant on tractorised farms. Similarly, the productivity of land revealed that it was higher on tractorised farms. The differnce was significant at 1 per cent level on both zones A&B.

On the whole, it could be concluded that productivity of resources especially of labour & land was significantly higher on tractorised farms. This is a fact which indicated that introduction of tractors in agriculture would make the factors of production more productive.

From the above discussion, it is clear that there were differences in overall economic efficiency between mechanized and non-mechanized farms in Punjab*.

It is interesting that during a period of rapidly changing agricultural technology & governmental policy, the economic performance on tractor-operated farm was more than on non-tractor farms. This helps advocating the introduction of tractors on farms without reservation provided they are sure to get the work the year-round.

The results which emerge from this inquiry is that the policy makers should encourage adoption of tractors in the study area. But, they should keep an eye on social justice & concern for labour employment opportunities for the rapidly growing labour force. Thus, such policy measures are desirous which neither encourage nor discourage tractorisation & which might not cause displacement of labour in the near future, if it is desired that unemployment is to be reduced.

*In his thesis for Ph. D., S.S. Sidhu (1972) has observed that there are no differences in overall economic efficiency between tractorised & non-tractorized farms. In this study under reference, he has worked out the efficiency on wheat farms only. He has not considered all the activities (enterprises) of the farm. It is an obvious fact that if a tractor is used only for one enterprise on a farm & kept idle for the remaining period of the year, it cannot be an economically efficient introduction. The adoption of a machine is efficient only if it is used to its full and maximum capacity, i.e. the year round. And it is only then plausible and sensible to examine if this introduction is economically worth while.

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Recent Advances in Application Techniques

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"In agricultuce, if one Thing is late everything is late" said the famous Greek philospher Cato.

The origin of insects coincided with the origin of land plants.

The origin of insect pests coincided with the origin of agriculture.

The orgin of agricultural development coincided with the origin of pest problems.

The origin of Green Revolution coincided with the origin of pest control technology.

FORTIES:—

* Discovery of the insecticidal properties of DDT.

* Paul Muller got the Nobel Prize 1948.

* Chemical revolution in pest control technology brought "pesticide umbrella".

* Pesticide umbrella helped the breeder in detecting and selecting the high yielding varieties and it also helped the agronomists in obtaining remunerative response by higher dose of fertilizers and ultimately paved the way for green revolution of the sixties with a time lag of about two decades.

* Dr. Borlaug got the Nobel prize 1970.

The importance of plant protection

The use of pesticides has increased very considerably throughout the world since the forties especially in the United States, Japan and Europe. Apart from large scale programmes usually sponsored by Government for control of mosquitoes, Iocusts and other pests, the high cost of pesticides had limited their use by individual farmers in countries like India until the '50 s. But when farmers felt the need for an increased output within the limitation of land under cultivation, they turned to hybrid seeds. These high yielding varieties of seeds necessitated the increased use of fortilizers and irrigation. The increased use of fertilizers and irrigation facilities, resulted in higher incidence of pests, weeds and diseases, making these high yielding varieties less remunerative to the farmers. This necessitated Plant Protection measures.

Mean Percent Crop Losses due to Pests & Diseases in India.

Crop	Kharif, 1967	Rabi, 1968-69
Rice	43.95	20.73
Wheat	—	3.58
Jowar	31.85	41.84
Maize	16.24	—
Bajra	29.41	—

Annual crop losses under field and storage conditions in India are estimated to be 1000 crore rupees. A study of the Planning Commission has shown that the magnitude of losses varies from season to season and from one area to another. Some representative figures taken from the Planning Commission report show that more attention should be paid to prevent these losses.

The third line of defence

In moden farm technology farmers are using high yielding varieties of seeds which can resist or tolerate pests and diseases in place of susceptible ones. They also try to take good husbandry measures, such as varying the dates of sowing and harvesting a crop, providing optimal seed bed conditions and supplying adequate plant nutrition. Eventhough the farmers have taken full advantage of natural control and have applied cultural measures as described above, they may still find pest control an uphill task. Thus they have to depend on the third line of defence, i.e. to resort to chemicals—pesticides. The high yield made possible by applying nutrients—fertilizers is saved from possible losses by appropriate chemicals—pesticides application, which also PROTECT the investment inputs such as high yielding varieties of seeds, fertilizers and water.

The slight upward trend in yield since the fifties, is the result of a slight impact of the insecticides era, emerging from the pest control revolution of the forties. Actually, three main claiman's of credit for this slight upward trend, are improved varieties, fertilizers and pesticides, and each has contributed its share to the yield. However, as regards the comparative claims of the first two, it may be stated that

(i) Improved varieties contributed in its own way.
(ii) One kg. of fertilizer is known to produce about 10 kgs. of additional grain,
while
(iii) One kg. of pesticide produces 1 or 2 quintals of additional yield.

There is now ample data to prove that in the absence of proper pest control, the improved varieties, often not only do not yield higher outputs but they also act as channels for higher wastage of costly imputs like factory produced fertilizers which ultimately find their way to the stomach of the insect instead of man.

Maximum efficiency with minimum effort

The aim of applying pesticides for pest control is to cover a target with maximum efficiency and minimum effort. In insect control, the taget is the nerve-centre of the insects.

While controlling flying instects, the best way of reaching them is by using extremely small droplets (20 to 40 micron), which will only impact on small surfaces and not on large ones. The insect itself contributes very efficiently in the collection of such droplets by its own velocity through air and its very rapid wing movements. As such droplets aare in practice air-borne, they remain stationery for a long time in air, which also supports and moves with the flying insects, ensuring an extended period during which droplets can be picked by the insects. This type of spraying leaves minimum residual deposit on the habitat of such insects. This method is extremely usecul when a large number of insects are present such as in desert locust control.

In fungus control the aim is complete coverage of plant to prevent germination of the fungal spores. This does not necessarily mean a continuous film, but it does mean that the active chemical should be present on all surfaces of the plant whether they are large or small so that no fungus will germinate without making contact with a nearby fungicide particle. Ideally, this coverage should be achieved through direct deposition during spray operation. but might be perfected by re-distribution caused by natural forces such as rain and dew.

In many instances, this direct way of depositing the pesticides on the target self is either impossible or impracticable. Therefore, it is necessary to use the indirect route, i.e. contamination of the habitat or food supply of the pests by pesticides.

Application technique is important

The application technique of pesticides is equally important as pesticides formulation and correct timing of application. Best use should be made of expensive pesticides to obtain maximum returns. It is, therefroe, important to give careful consideration to the best way of placing insecticides—application technique, just where they are needed.

In order to distribute the present day pesticides which are generally very effective, evenly over the biological target, we have a number of application techniques at our disposal. Because of the fact that the ammount of active material per unit area is very small, in most cases ranging from hunderds of grams to at most a few kilograms per hectare, we generally use carriers and diluents to obtain the even distribution required for good biological activity.

The three basic ways of transporting pesticides to the target in the field are by water, air or granules—pellets powder.

The most important carrier material has hitherto been water, and in most of the applications it still is. To render the active material suitable for application with water we have to add formulation aides, such as solvents, emulsifiers, dispersants, wetting agents and stickers. It is, therefoe, obvious that each of these formulation aides, as well as the water, can influence the behaviour of the pestcides.

In principle the carrier material is only used for carrying the pesticides to the target. When water is used as a pesticide carrier, it could be applied with different volumes and pressures according to the method of application.

The spraying techniques are often classified according to the spray volume used in the application. The following classification can be made but is by no means the only one that might be generally acceptable.

(a) high volume:
all techniques in which more than 400 litres of spray liquid per hectare is used.

(b) low volume:
tecnhiques in which the spray volume ranges from 5 to 400 1/ha.

The lower dosages, 15-75 1/ha are commonlv encountered on aerial applications, whereas with ground equipment the volumes are generally within the range of 100 to 200 1/ha.

(c)ultra-low volume:

all techniques in which less than 5 1/ha (0.5 gallon/acre) is applied.

Whicn one of these techniques is the most appropriate for a particular application depends upon many factors, such as type of vegetation, kind of pest to be controlled, availability of water, accessibility of the field, and the experience of the applicator. In many cases, however, the choice of the application technique is mainly determined by the more or less fortuitious preference of the applicator.

Pesticide dose

In the normal course, application rates are prescribed in terms of concentration, i.e. so many kilograms of chemical per so many litres of water. e.g. Suppose an acre of land requires 600 litres of spray material for uniform coverage and the strength of solution is 4% in such a case 24 kilograms of total chemical will be required to cover one acre of land in dilute form (high volume spraying). But in case of concentrated spraying the same one acre of land can be sprayed with 24 kilograms oc chemicals mixed with less amount of water, say 60 litres. This is possible because the particle size which is obtained in low volume spraying is much finer and more uniform.

The wetting surface of a particle varies as a cube of the diameter. In other words, for a given particle if the diamerter is cut in half, then the wetting surface of the same amount of fluid will increase 8 times. Thus the particle size becomes extremly important when different methods of application are used.

Successful pest control by low volume spraying (concentrated dose of pesticide) has been attributed to the maintenance of the PESTICIDE DOSE originally applied by high volume spraying. It should be noted that any form of spraying, i.e. either high volume or low volume, is adequate provided the dose is maintained. DOSE of pesticides per acre or hectare of land is not a valid standard in agriculture due to the wide variation in height and width of plants and the planting distance. A standard using the crop area (target area) has been suggested as a better basis instead of the land area.

It has been found experimentally that effective pest control does not depend solely on either the quantity of pesticide or the volume of liquid used per acre, but more on the placement of the spray liquid upon the required target surface and distribution of active material.

For spray application, especially where the target is foliage, some air movement is essential, but no spraying should be done under strong or turbulent wind conditions, as they magnify the problem of drift considerably. In general, crop spraying should be avoided in the heat of the day when wind conditions are often more turbulent and air convection tends to carry small droplets upward and restrict their penetration of foliage. Anoher factor which is of extreme importance, is the effect of evaporation on droplet size.

Forces used for pesticide application

Natura force

1) Gravity Force

Nature has provided this force free of cost which remains constant and is ever present in all types of particles. A droplet will settle out on a horizontal surface a certain time; this time is determied by the height of its release from the source as well as its size and weight.

2) Air Movement Force

This is also always available but is constantly varying in its movement, either horizontally or vertically.

Artificial force

Man-made force applied to the spray particle. This is done by operating the sprayer by human power or by an engine.

Forms of application equipment

Different types of sprayers are used throughout the world. In these sprayers five different forms of energy are employed to break-up the liquid into drops and project the resultant spray. Sprayers can be classified according to these forms of energy as under:

Hydraulic energy

a) Hyduaulic Pump

A reciprocating pump is used to develop hydraulic pressure. The pump is mounted inside or outside the container and operated by a lever arrangement. The spray Iiquid is drawn by suction stroke from the container through a non-return valve, then forced through a delivery valve into the Pressure Chamber by return stroke. In the Pressure Chamber a pocket of air is present which is compressed due to the liquid charge pump. When the cut-off valve or trigger valve is operated the air which is pressurized in the Pressure Chamber forces out the liquid through the discharge hose and the nozzle. In this type sprayer continuous pumping is essential.

b) Air Pump

An air pump is utilized to develop pressure in the sprayer. The air pump is mounted in or outside a closed container. The container is partially filled with spray liquid and air is charged in to develop pressure on the liquid. The stored air pressure will force the liquid through the discharge hose and the nozzle when the cut-off cock or tuigger valve is open.

c) Nozzles for Hydraulic Application

In the hydraulic spuayer, the distance over which the spray is projected as well as the droplet size, will be determined by the pressure, the orifice size and the type of nozzle. The liquid under pressure is forced throgh a small opening so that the liquid has sufficient velocity energy to spread out, usually into a thin sheet which disintegrates into droplets. Owing to the disorderly nature of the break-up droplets vary considerably in size. The average size of the droplet decreases with increase in pressure or decrease in the orifice nozzle, and vice-versa, i.e. droplet size increases with decrease in pressure and increase in orific nozzle. Thus to get fine droplets, higher pressure should be utilized with nozzles having small orifice. To reduce droplet drift low pressure should be utilized with nozzles having larger orifice. Normally, nozzles require a minimum 10 to 15 psi., pressure to obtain a spray pattern. To get good spray pattern for field crop spraying, a pressure of about 40 to 60 psi.

Hydraulic Nozzles consist of body, cap, tip or disc and core. In some cases the nozzle body is incorporated with a lance or boom. A strainer or filter can be incorporated in the nozzle. To spray without blockage in tropical conditions where spray liquid is contaminated with dust or other foreign particles which block the nozzle orifice, suitable filter should be used with the Nozzle. The Nozzle Body and Cap are usually made from Brass or Plastic. The Nozzle Tip or Disc and Core are made from Stainless Steel. Non-drip Devices such as Diaphragm, Check Valve or Spring Loaded Non-return Ball Valve in Filter are usually incorporated with the Nozzle. The former is fitted with the Nozzle on the Aircraft Spray Boom, while the latter is fitted with a Hand Sprayer or a Tractor-mounted Sprayer.

i) Cone Nozzles

In this type of Nozzle the liquid is forced through one or more tangential or helical passages into a swirl chamber through which the liquid passes to a circular orifice at a high rotational velocity to form an air core within the orifice and swirl chamber. The liquid emerges from the orifice as a hollow-cone. In the case of a solid cone nozzle the liquid also passes contrally through the Nozzle to fill the air core. The orifice disc and core or swirl place are sometimes combined as a single tip or are available separately. By changing the disc and core different types of discharge rates and cone angles can be obtained. Cone Nozzles give better coverage of fojiage because droplets approach the leaves from more directions than in the single plane produced by a flat fan. Good coverage can be achieved by the placement of nozzles on special booms to suit a particular crop profile.

ii) Fan Nozzle

The tip of this nozzle has a lenticular or rectangular orifice behind which two streams of liquid meet because of the shape of the bore. A very wide range of fan nozzles are produced to provide different outputs and spray patterns with different angles. Very wide-angle fan nozzles are available. Series of slightly overlapping fan nozzels are frequently used on booms for both tractor and aerial application but care must be taken to ensure that the overlap is correct to obtain even coverage. Fan Nozzles are ideal for spraying flat surfaces and have been widely used for spraying residential places to control mosquitoes. 'Even-spray' fan nozzles are available for more accurate band spraying on row crops, e.g. for herbicide spraying.

iii) Impact Nozzles

These Nozzles, sometimes referred to as flooding, anvil or deflector nozzles, normally operate at low pressure. A jet of liquid passes through a relatively large orifice and strikes a smooth surface at a high angle of incidence to form a fan-shaped spray pattern. There is usually more spray at the edges of the fan and droplets are large. Impact nozzles can be manufactured to provide different out puts and swaths at low pressure. This type is beind widely used for herbicide application.

Gaseous energy

When Gaseous Energy is used to spray pesticides, air is generally used as a gaseous medium. A fan driven by motor or engine produces the gaseous energy e.g. the motorised knapsack mistblower is the most commonly used type of sprayer utilising gareous energy produced by an engine driven fan. Air is drawn into the fan casing at high speed and discharged through a flexibe tube in which a liquid flow nozzle is mounted. The action of the high velocity air stream passing over the nozzle shears the emerging liquid into droplets which are then entrained in the air stream and projected into the target. The droples are produced in a fairly narrow beam of air projected at high velocity and there is a considerable variation in the droplet size. Droplet size increases with the flow rate and reduction in air velocity, i.e. bigger droplets are formed if the liquid flow rate is high or air velocity is low and vice-versa droplet size decreases if the liquid flow rate is low or air velocity is high. Normally air velocity is not adjustable with the motor or engine. The average mistblower can discharge 20 to 100 litres per hour and can project the spray about 6 to 8 metres horizontally and 4 to 6 metres vertically. with a suitable restrictor, ultra-low volume applications are possible. Normally herbicides are not applied with mistblowers. On some sprayers with an air-blast to carry droplets towards the target, initial break-up of the liquid is achived with hydraulic nozzles.

Centrifugal energy

In this type of application equipment, centrifugal energy is derived from the rotation of a device such as flat, concave or convex disc, woven wire mesh cage or perforated sleeve or cylinder. The spray liquid is fed onto or from the centre of the rotating surface to spray as evenly as possible over the whole area until the surface tension of the liquid becomes unstable and finally shatters into filaments and droplets. These droplets, flung-off the periphery, are then picked by an air stream mechanically generated by the sprayer or in some cases by the prevailing wind.

Kinetic energy

The application system based on this design is usually used to spray herbicides close to susceptible crops without fear of drift damage.

In this type of equipment, the nozzle is radically different from conventional nozzles, in that it does not atomize the spray fluid. An electrically driven oscillator produces a fan shaped pattern of large. drift free droplets which are evenly distributed over the sprayed area. This type of nozzle is most useful in multi-row spraying machines designed for inter-row treatment with herbicides. It consists of a vibrating unit on which is fitted a special spraying nozzle. The vibrating unit provides a high frequncy oscillation of its shaft which is driven by a D.G. electric motor through a vibrating mechanism. The special nozzle is made of two parts:

1. The nozzle body which is push-fitled onto the shaft of the vibrating unit.
2. The sleeve which fits over the nozzie body and is pierced by a number of small holes through which the spray emerges in separate strcams. Oscillating at high speed, the Nozzle disperses the emerging liquid into an evenly distributed spray.

The supply of liquid is connected to the inlet of the Nozzle Unit. The pressure must be accurately controlled at low vaues since it works at pressures between 1 to 6 lbs. psi.

The electric cable of the Nozzle Unit is connected to a D.C. supply, e.g. a tractor battery or ary cells.

There is a range of sleeves which are slid over the Nozzle Body to get different output (Application) rates.

Thermal energy

In the equipment disigned on the principle thermal energy produced by combustion of petrol and air vapour either by conventional internal combustion engines or a small pulse-jet engine. In either method the perol-air mixture is burnt in a chamber where a high volume of air at low pressure is applied by a blower or fan. The pesticide is formulated in light flash point oil, which is injected and vaporized by hot exhaust gases. When the vapour enters the atmosphere which has a much lower temperature. condensation takes place, resulting in a pesticidal fog being discharged towards the target. The main problem with this type of equipment is the possibility of thermal decomposition of the pesticieds and the risk of fire while operating the equipment. Due to the difficuities in maintenance and noise during operation this type of machine has not become popular. Thermal fogging is used for applying pesticides in warehousts and glasshouses to control fling insects.

High volume spraying

Initially commercial spraying started in plantations. In those days most effective plantation spraying technique for the complex pest and diseases situation under a wide range condition, was high volume spraying. This was done by handdirected lances and dilute spraying liquids (high volume spraying) having adequate wetting properties, were used. In high volume spraying, the dilute solutions are used and applied by hydraulic machines. These techniques were carried out by skilled operators to ensure the contact of active chemicals required dose with the pest organism and to get good control. Although this technique, was biologically highly effective, it was economically imprafticable, being too expensive in time and labour. This resulted in the development of mechanical spraying tractor-mounted and drawn machines. In doing so the labour requirements, were reduced to 1/3rd and operating speed increased by 3 to 4 times.

Low volume spraying

At a later stage mistblowing techniques, low volume or concentrated spraying using air stream from a fan as a pesticide carrier with small quatities of liquid have been developed to reduce the cost.

Low Volume Spraying—an application of a concentrated dose of pesticides in a reduced quantity of water-carrier, is a popular method of applying pesticides. This is not an improved pest control method, but it is an economical method of application. By this method farmers obtain the same results with 25% less spray materials per acre. In addition to the saving in material they can also achieve labour efficiency. In this method the rates of application, are based on the amount of material per acre, rather than the amount per gallon of water.

Ultra-low volume spraying

Ultra-Low Volume (ULV) Spraying can be defined as protection operations in which the total volume of liquid applied amounts to a few millilitre/acre, in contrast to the use of large volumes, tens or hundreds of litres/acre in conventional spraying. The chemical is usually either undiluted or formulated in oil and ULV applications have so far been made mainly in a aircraft spraying where the small volumes and the less volatile liquids offer obvious operational advantages.

The recent introduction of the hand-held spinning disc sprayer, based on the principle of centrifugal energy, employing a droplet generating and dispersing system similar to the used on some aircraft, has revived interest in the ULV technique for ground application. This technique has also been adopted in knapsack sprayers.

Aerial spraying

After World War II a large number of light aircraft became cheaply available and with them a flood of ex-airforce pilots, with the result that there was a flood of young men and old aircraft available for aerial spraying. The first aerial spraycrs simply took the standard spraying attachments used on Tractors and adapted them to the aircraft and the aerial spraying technique used was a copy of that of tractor spraying. The boom and nozzle equipment which spans nearly the full width of the main plane and which determined the swath width, was flown as near as possible to the position of the tractor spray gear, that is as near to the top of the crop as possible.

Transfer of technique and standard spraying attachment from the tractor to the aircraft, had certainly accelerated the rate of work because of the increased speed of the airborne sprayer which is roughly 30 times faster than its ground borne counterpart and in addition there are fewer weather limitations on its availability for spraying.

The advantages of high rate of work and high availability were undoubtedly the main advantages of aerial spraying, over ground spraying and consequently it was these factors which had to be exploited to the utmost if there were to be any great economic advantages in aerial spraying over ground spraying. Increasing the swath width immediately appeared attractive and the only hope of increasing the swath cheaply was by either increasing the length of the boom or drift spraying.

For a long time the only development achieved in aerial spraying was to reduce the dosage rate to about 25 litres per hectare.

The earliest large scale attempts of drift spraying were carried out shortly after the last War, the spray being a diesoline solution of DNOO. These ULV techniques were first used for crop spraying by Joyce, who used a 25 per cent DDT concentrate at 0.25 gallon per acre to control cotton flea-beetle and cotton jassid by ground operated micronair sprayers. During the following years ULV techniques for aerial application were developed.

The simultaneous development of a simple ground sprayer working from the exhaust of vehicles during the years 1952—1957 led to the present day highly efficient drift sparying technique. Measurements of the performance characteristics of the boom and nozzle spray gear fitted as standard equipment to the spray aircraft and the subsequent analysis of the effect of the spray on locusts by a graphical method developed by Sawyer (1950) led to the conclusion that the most effective droplets were the smallest sizes of the spectrum produced. Consequently a new type of aircraft spray gear was conceived in 1953 based on a rotary multi-disc system. Soon after this, experimental spray gear was finished and a commercially produced rotary cage atomizer, the Micronair, became available.

Thus by 1957/58 the spray aircraft had a capability of easily producing a small droplet size down to 70 microns MMD with a much narrower droplet spectrum over the infinitely variable range of droplet sizes, which this equipment was able to produce. This new spray gear made it possible to adapt for aircraft the method of spraying which had been developed for ground spraying by the exhaust nozzle and which had opened up new possibilities in ULV spraying.

Foam spraying

A new pepticide application system was introduced in the early 70's called foam spraying. In this type of application system a special foaming agent—adjuvant (chemical additive) is added to the spraying solution. The spray solution mixed with adjuvant is passed through a special nozzle called Air-Aspirating Nozzle consisting of foam genhrator and nozzle tip to convert the solution into foam.

The nozzle controls the rate of flow and draws air in the foam generator and mixes it with spray solution and adjuvant to create a spray mix resembling a milkly foam called—Foam Spray or an Air Emulsion.

Drift control is one of the main advantages of the adjuvant. The white spray is highly visible and the applicator can see the volume of the spray and see where the spray is falling and make necessary adjustments thereby minimising skipe and reducing excessive spray usage. The adjuvant also reduces the spray run-off by causing the chemicals to stick to the target and topenetrate the waxy surface of the target. In this type of spraying technique less water is required with the adjuvant because the air emulsion—foam expands in the spray solution and reduces the water requirements for good coverage. Thus time for spraying is reduced.

This system of spraying gives better coverage, reduces evaporation, cuts labour and material cost and visibly indicates sprayed area.

Dusting

The use of dust, in which the active component is diluted with a suitable finely-divided 'Garrier' has potential advantages over spraying. The factor of water supply vanishes; the dust may be purchased ready for use and is more easy to hanale than the spray concentrate; the dusting appliances, consisting essentially of fan or turbine blower, are lighter and more easily moved in difficult terrain than sprayers; finally, dusting is less costing in time and labour than spraying. But in practice several less obvious dilliculties emerge : the dust must flow freely; it must not 'cake' (prbsumably through the absorption of atmospheric moisture); it must not 'ball' in the hopper or collect in the duster (prbsumably through static electrification), it must be so mixed that the dust retains a uniform content of active component throughout its range of particle sizes and its distribution.

The general experience is that dusting is practicable only in the calmest weateer and that a better protective action is obtained if the dust is applied when the plant is wet with dew or rain.

Dusting machines are more simply constructed than sparyers and consist of a hopper with some form of agitator that delivers the dust into a fastmoving airstream which carries it to one or more delivery points. Since the feed mechanism may be simply motivated by gravity, an external energy source is only necessary to drive the fan.

Wet dusting (liquiduster)

This is a new type of pesticide application technique which has been developed very recently for trepting crops in arid or drought hit areas. This tehnique can be used as a substitute for spraying and dry dusting. In this method, dust and water are discharged simultaneously from the machine, which ultimately get mixed before depositing on the target, i.e. wetting the dust particles with the liquid before they leave the nozzle. In this method of pesticide application, higher deposition of pesticides is obtained on the target due to the adhesion property of the liquid which is sprayed along with the dust. There is less drift of pesticides and as such pollution of atmosphere can be controlled. This technique can significantly reduce the amount of pesticides required for specific pest control.

Granules

Insecticides formulated as granules were first used experimentaiiy in the 1960's. Today several well known insecticides are availaele in granular form. Granular formulations of systemic insecticides have many advantages over liquid or wett aboe powder formulations.

Granule formulation allows a precise placement of granules in the developing root zones. Concentration pesticides is retained in the soil after placemet. Persistence of the pesticieds is increased since it is released gradually from the granule. The release of active ingredient by vapour pressure from the granule surface give an immediate knockdown effect to the aphids which infect the plant. The beneficial insects escape the effect of pesticides by moving out of the immediate vicinity. The granule pesticides are premixed and available as ready for use. Thus no mixing measuring pesticides is required. The toxic hazards of pesticides to the operator, animal and beneficial insects is reduced. There is less drift of granules during placement operation. Thus dranules can easily be applied from the air.

〔Application Method〕

The granule application equipment are less costlier to maniantain than the spraying equipment. The applicator can be attached to the planting machine, seed drill or cultivating machinery, thus a separate operation can be saved. Some granules may be applied into the plating furrow or into the seed furrow. In some cases they are broadcast over the foliage. The correst positioning of the granules is very essential because the planting roots shorld be easier to access to the nesticides. In the case of foliar application of granules two types of actions have to be considered, viz. fumigant and systemic. In fumigant activity granules have dirict contact action on the insects and in systemic activity the granules have indirect action.

〔Fine Granules〕

In the interest of preventing environmental pollution by drifting dusts, fine granular formulations of pesticides, have been developed recently. These fine granules have less drift than dust and a higher deposit ratio on the plants than the larger granules. The fine granules may be applied by hand, helicopter oc knapsack type power applicator. The materials like diazinon, phenthoate, chlorphenamidine and fenitrothion, have been found to be as effective in fine dranules fcrmulation as they are in other formulations of pesticieds.

Integrated control

Although pesticides are the most powerful tool in the control of pests, they too have their disadvantages, viz.

1. development of resistance,
2. pollution of enviroments.
3. outbreaks of seconday pests resulting from the destruction of their natural

enemies.

This has brought home the thought of integrated contuol which means a method of employing all of the disciplines of agricuitural science to improve crops. While reducing both cost and chemical usage. It can be defined as a pest control which combines chemical and biological control. It also controls all suitable techniques such as the use of attractants, sterilized insects and cultural practices. The aim is to obtain maximum control of pest with minimum disruption of the eco-system to which it belongs.

The economic threshold, viz. that pollution level of the pest which makes an insecticide application economically justifiable, is often a factor limlting integrated control. This threshold can be so low that pesticides have to be applied even when biolgical control organisms are abundant.

The board toxic action of most insecticides is also in opposition to the principle of integrated control. Since selective chemicals are in short supply insecticides with a restricted residual action are preferred for the time being.

Although integrated control involves no new concept it does deliberately abandon the excessive use of pesticides. Its more complicated control system fully opposes the chemical control system that relies solely on the practice, "if it does not do any good, it does not do any harm" Here lies a big task for entomologists and extension officers in supersising pest management.

It is said that "Well begun is half done"

WE ACHIEVED IN FORTIES:—

First revolution on pest control technology provided "pesticide umbrella" under which breeder & agrinomist worked to get high yield on experimental farms visualisation of green revolution.

OUR GOAL IN SEVENTIES:—

Required second revolution in pest control technology to provide integrated plan protection unbrella under which suitable integretion of various methods of pest control should be used to get the optimum out of the use of psticides to realise the green revolution (A reproduction for information from the "Farm chemicals" of October 1972).

Economic Valrue of pesticides - Japan

The benefits of pesticides are nowhere more apparent than in Japan, where they have played a large part in agricultural self-sufficiency and in economic growth in general. Through the use of organically synqhesized agrichemicals, Japanese agriculturists have overcome a dangerous post-war food crisis and now producing enough to feed the entire population of more than 100 million. Moreover, based on 1965 figures, Japan's Ministry of Agriculture and Forestry estimates that pesticides have added eight times their own value to the Gross National Product.

In 1945, at the end of World War II, the economic specialists of the Occupation Forces were seriously concerned over Japan's food shortage. World history has proved that the Japanese were re-sourceful, hard-working people but the hardships suffered from the war, the limited land area of which only 17% is fit for cultivation, and the disproportionate population all seemed nearly insumountable obstacles. Today, as Japan Agricultural Chemicals Overseas Development Commission (JACODEC) reports, Japan is self-sufficient in foodsstuffs and produces more than 14 million tons of rice annually. Policies for the surplus of rice. in fact have developed into a political issue, one that no one could have forseen in 1945.

Japan's tremendous gains in agricultural production are directly attributable to its widespread use of pesticides. Figures reported in JACODEC's publication, Agrochemical Industry in Japan, show that without plant protection against insect pests, the average annual yield of rice would be reduced by more than one-fourth. In monetary terms, this means that the value of plant protection is 69 times the expenditure involved in agrochemicals, agricultural machinery and labour.

The actual figures, compiled by the Japanse Ministry of Agriculture and Forestry in 1965, are as follows :

> Savings achieved through use of pecticides in rice, wheat, vegetable and the cultivation—\$1,589,000,000; value of pesticides used—\$193,333,000; total economic value of pesticides—\$1,395,667,000.Obviously, pesticides have made a significant contribution to Japan's economic growth.

Inaddition to increased crop production and dollar savings, pesticide use has created a labour surplus in Japan, the use of herbicides has released farmers, both men and women, from the diffcult and time-consuming task of weed control and made them available for other jobs in which they can earn additional income. The rural level of living as subsequently been raised.

Farfetched as it was first seems, agrochemicals have even played a part in the rise of the cultural level of Japan. The Japanese consider the family to be one of the most important improvements of their nation, and they credit pesticides with releasing farm women from field labour and thus enabling them to concentrate morb time on raising their children.

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Level of Tractor Power Utilization on Different Operations

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With increasing farm mechanization the number and size of tractors have also been increasing in India for last 2 decades. There are farm sizes varying from a fraction of a hectare of family farms to a few thousand hectares of Government and private farms. The tractors available on some of these farms vary from 20 H.P. range to 75 H.P. range. In lower H.P. ranges i.e. upto 50 H.P. majority of tractors are of indigenous make whereas in higher H.P. range most of them are imported from various countries. On the large size farms usually tractors are maintained in higher as well as lower H.P. ranges. For all tillage and heavy earth moving operations higher H.P. range tractors are used and for light duty work mostly low H.P. range tractors are used.

Every tractor has certain capacity of doing the work. The maximum drawbar horse power available from the tractor is seldom put to continuous use. The usable horse power of tractor is arbitrarily defined as 60 percent of a tractor's maximum PTO horse power as determined by Nebraska Tractor, Tests or any other standard test(2). In actual practice the level of power utilization is much different. Tractors in Czechoslovak agriculture are exploited upto some 50% of their draught capacity during the whole year[3] and an average tractor of 34 H.P. works about 800 hours a year. An average tractor is also reported to consume 4,800 litres of fuel oil per year.

Acharya performed a study on relative economic efficiency and performance of different makes of tractors on traditional farms in Satara district of Maharashtra. He took 35 H.P. and 50 H.P. tractors of different makes and found that the use of both types of tractors was relatively more during the month of November and May. For 51—67% of total hours the tractors were used for transportation work. Ploughing was the next important operation. The output of 50 H.P. tractors was found to be more than that of 35 H.P. ones. For field operations like harrowing and ridging and transportation 50 H.P. tractors

Table 1. Average monthly use of 35 H.P. range tractors

Tractor No.	Average hours of work of 35 H.P. range tractors											
	1		2		3		4		5		Average	
S.No.	Working	Idle	Working	Idle	Working	Idle	Working	Idle	Working	Idle	Working	Idle
Jan.	156	14	133	19	164	22	60	15	87	4	120	15
Feb.	53	7	55	7	125	24	77	15	100	2	82	11
March	103	14	55	6	76	22	93	9	59	—	77	10
April	40	11	84	13	175	26	65	7	82	2	89	12
May	76	19	54	11	178	16	56	14	175	13	107	15
June	52	14	134	13	28	2	54	14	104	10	73	11
July	157	44	64	21	97	26	64	25	75	20	91	27
August	30	6	104	28	101	29	47	11	36	8	64	16
Sept.	53	10	21	3	45	10	48	12	73	15	48	10
Oct.	107	22	32	11	199	25	82	14	105	12	105	17
Nov.	146	24	189	30	180	33	46	17	129	—	138	22
Dec.	176	39	145	13	123	24	56	10	107	—	121	17
Total	1149	228	1073	185	1491	261	748	163	1132	86	1113	183

were observed to be more efficient than 35 H.P. tractors.

The objective of this study is to evaluate the level of utilization of tractor power on Indian farms and also to study the various factors related to tractor use on these farms.

The variation in the power requirement during different months in the same year is usually determined by estimating the operational requirements of various crops being grown under a particular agroclimatic and crop rotational condition. This estimate can be verified by knowing the average use of power during a particular month of the year. Such an information is useful for the planning of tractor purchase as well as its repair and maintenance.

Under this study a detailed analysis of tractor utilization on a 4'500 hectare mechanized farm has been made. This farm maintains tractors in 75 HP range for tillage and other heavy operations and 35 HP range for light duty works like operations with a seed drill, fertilizer distributor, trailor, sprayer etc. Taking 5 tractors in 75 HP range, their use on various farm operations over a period of 7 years have been calculated using the figures from the log books of these tractors. Similarly by taking 5 tractors in 35 HP range the various figures of use over a period of 3 years have been estimated.

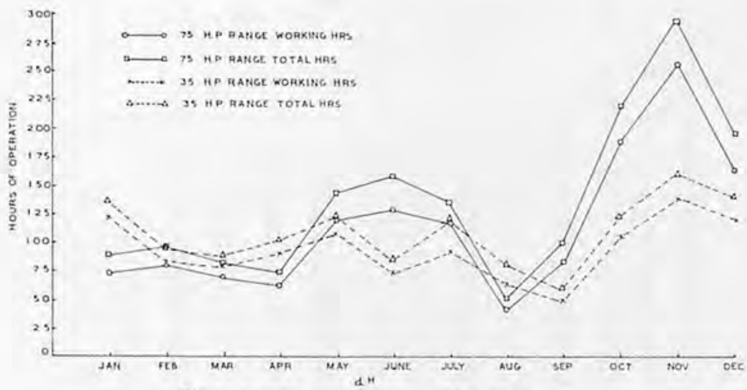

Fig.1. Average monthly use of tractors

Average Monthly Use of Tractors

The use of tractors is not uniform over the entire year. It varies according to operational requirements of crops being grown. **Table 1 and** 2 give the details of average monthly use of 35 HP and 75 HP range tractors. The average results are plotted in **Fig. 1** It may be observed from Fig.1 that there is maximum use of both types of tractors during the month of November and the minimum use is there in the month of August for 75 HP range tractor and in September for 35 HP range tractor. November and part December timings coincide with wheat sowing and August and September are the slack months of rainy season when minimum of operational activities are there. The second peak of utilization comes during the month of May, June and July for the 75 HP range tractor and January for 35 HP range tractors. During the months of May and June most of the tillage operations are conducted for Kharif sowing with 75 HP tractors mostly. The 35 HP tractors appear to be more busy during the month of January due to heavy engagement on transportation of sugarcane and also some spraying and other light operations on the farm.

The total use of 75 H.P. range tractors is more than that of 35 HP range tractors. It is mainly due to the reason that tillage operations are more time consuming and since mostly big size tractors are used for this purpose, their use hours increase. There is appreciable variation in the use of one tractor from the other even in the same H.P. range. This is due to the variation in the physical condition of the tractor. Relatively new tractors are also put to more use due to less down time for repairs.

In the case of all tractors the idle time amounts to 10 to 15 percent of working time. This idling is mostly in taking the tractor from the tractor shed to the field and back. The time is also lost in this way if the implements are not kept at the tractor shed or the field where the tractor has to work the next day.

Level of Power Utilization on the Farm:

The average use of 35 H.P. tractors for various farm operations in a year is given in Table 3. The percentage annual use figures indicate that there is maximum use of these tractors

Table 2. Average monthly use of 75 H.P. range tractors

Tractor No	Average hours of work									
	1		2		3		4		Average	
S.No.	Working	Idle	Working	Idle	Working	Idle	Working	Idle	Working	Idle
1. January	60	11	85	15	78	17	66	12	72	14
2. February	59	15	102	19	117	19	40	9	80	15
3. March	91	12	72	16	70	11	58	13	68	13
4. April	42	9	53	10	53	12	96	19	61	12
5. May	100	16	109	21	138	17	133	34	120	22
6. June	126	25	105	33	139	24	142	17	128	29
7. July	129	6	92	21	119	23	123	25	116	19
8. August	28	6	44	14	44	11	48	11	41	10
9. September	68	15	91	17	77	17	90	20	82	17
10. October	174	35	162	27	221	29	148	32	188	30
11. November	244	43	237	42	306	34	237	35	256	38
12. December	178	45	165	34	211	33	99	18	163	32
Total	1296	238	1317	269	1573	217	1280	245	1375	251

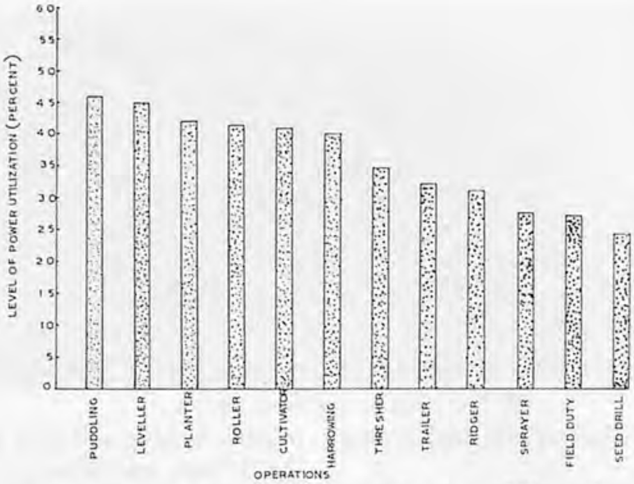

Fig.2. Level of 35 H.P. tractor power utilization on Different farm operations

for transportation jobs. For tillage and cultivation operations they are being used to the extent of about 30% only. About 10% of the total time they are used on stationary operations like threshing. The field duty takes about 30% time of these tractors because the field repairs and maintenance involve long distance travel on the farm.

The average fuel consumption figures indicate the level of tractor power utilization on various operations. For some category of operations these values are plotted in **Fig. 2.** The maximum level of utilization is achieved in tillage operations. Seed drill, fertilizer distributor and thresher operations require the lowest power and the level of power utilization on these operations is quite low. Transportation also has low level of power utilization.

Assuming 150 gm/bhp. hr as the specific fuel consumption at part loads, a tractors with 35 B.H.P. engine should have a fuel consumption of about 6.176 litres/hr. Taking this figure for 100 percent load condition the level of power utilization is calculated in **Table 3.** These values indicate that the range of tractor power utilization is only 24.2 to 45.7 under various operations. For secondary tillage operations the level is only about 40—42 percent.

The average use of 75 H.P. range tractors for various farm operations are given in **Table 4.** The use of these tractors on tillage operations comes to about 58 percent. The utilization on earth moving and levelling operations comes to about 13 percent of total time.This seems quite reasonable as these tractors are used primarily for tillage and other heavy operations.

There is wide variation in the fuel consumption figures for this tractor on various operations. For some selected operations these values are plotted in **Fig. 3.** The maximum fuel consumption comes on disc ploughing and minimum fuel consumpotion comes on transportation.

Assuming 150 gm/bhp.hr as the specific fuel consumption on part load the total consumption for a 70 HP tractor comes to 12.35 lit/hr. Taking this value for 100 percent load condition the level of power utilization on this tractor for various operations has been computed in **table 4.** Although the level of power utilization in this case is a little higher than in the case of 35 H.P. range tractors, it is still on low side. On an average the level varies from 30.0 percent to 59.9 percent. However, in this case for about 80% of time the level of power utilization is about 50 percent. This is relatively good utilization. It is mainly due to more use on tillage and other heavy operations.

The degree of power utilization in the case of 75 hp tractors is similar to that observed by Oubrecht for tractors in Czechoslovakia, although yearly use hours are about 1300 hours for 35 HP tractors and 1625 hours for 75 HP tractors in India whereas in Czechoslovakia yearly use hours are only 800. This is due to the double cropping system in India.

Table 3. Average annual use of 35 H.P.tractor for various farm operation.

S.No.	Operation	Working hrs.	Idle hrs.	Total hrs.	Total fuel cons.	Total oil cons. (lit)	Average fuel cons. (lit/hr)	Level of power utilization (%)	Average oil cons.(lit/hr)	Annual use (per cent)
1.	Harrowing	69.1	19.8	88.9	232.0	10.8	2.60	39.8	0.122	5.00
2.	Cultivator	88.8	21.1	109.9	280.3	13.8	2.55	41.2	0.125	6.35
3.	Roller	78.2	14.5	92.7	238.9	8.4	2.58	41.7	0.090	5.36
4.	Planter	61.8	16.0	77.8	204.2	5.8	2.62	42.3	0.074	4.49
5.	Puddling	134.9	40.6	175.5	496.5	27.7	2.83	45.7	0.157	10.13
6.	Leveller	28.0	3.2	31.2	88.0	5.8	2.78	44.9	0.184	1.80
7.	Field duty	295.1	—	295.1	490.1	22.5	1.66	26.8	0.076	17.05
8.	Sprayer	50.2	33.1	92.3	157.0	7.7	1.70	27.5	0.083	5.33
9.	Fertilizer distributor and seed drill	92.3	16.0	108.3	275.7	11.3	1.55	24.2	0.063	6.26
10.	Ridger	37.0	25.0	62.0	119.0	4.5	1.92	31.0	0.072	3.58
11.	Thresher	145.9	29.1	175.0	378.3	15.6	2.14	34.6	0.089	10.11
12.	Trailer	341.9	80.5	422.4	845.0	45.2	2.00	32.3	0.107	24.33
Total oil and fuel (lit)					3805.0	179.1				
Average oil and fuel Consumption lit/hr.					2.02	.103				

Fuel and Oil Consumption

The total yearly consumption per tractor for 35 HP tractors (Table 3) comes to about 3805 litres of diesel and 179 litres of litres of lubricating oil. From these figures the oil consumption of these tractors may be taken as 4.7 percent of fuel consumption on an average. The average fuel consumption for these tractors varies from 1.55 litres/hour on light operations like seed drill to 2.83 litres/hour on puddling operation.

For 75 HP tractors **(Table 4)** the fuel consumption per year per tractor on an average comes to 15,430 litres whereas oil consumption comes to 372 litres. Thus the oil consumption in these tractors comes to about 2.4 percent of fuel consumption on volume basis. The average fuel consumption varies from 3.7 litres per hour on operations like threshing and transport to 7.4 litres per hour on operations like ploughing, harrowing etc. For other opbrations the consumption comes in the above range.

Table 4. Average annual use of 75 H.P. range tractors for various farm operations.

Operations	Working hrs.	Idle hrs.	Total hrs.	Fuel consumption (lit)	Average fuel consumption lit/hr	Total oil	Average oil consumption lit/hr	Level of power utilization %	% Annual use
Harrowing & one way	1002.0	193.0	1195.0	8786.0	7.35	169.7	0.141	59.5	51.3
Plough	93.0	20.0	113.0	837.0	7.4	12.5	0.114	59.9	4.8
Cultivation	47.0	10.0	57.7	281.3	4.94	8.0	0.140	40.0	2.4
Roller	33.0	7.0	40.0	284.0	7.0	10.0	0.25	56.6	1.7
Seed-drilling	22.0	5.0	27.0	164.0	6.0	3.3	0.016	48.5	1.1
Planter	36.5	8.0	44.5	265.8	6.0	6.5	0.147	48.5	1.8
Trailor	183.0	44.0	227.0	856.3	3.77	31.3	0.137	30.5	9.7
Thresher	39.0	7.7	46.4	173.0	3.7	6.7	0.144	30.0	2.0
Combining	126.3	80.0	206.3	1282.6	6.2	66.2	0.320	50.2	8.9
Ridger	78.6	14.9	93.5	800.3	7.4	9.8	0.104	59.9	4.0
Ditcher	32.0	8.6	40.6	191.8	4.72	6.3	0.156	38.2	1.8
Leveller Planter	125.0	22.0	147.0	966.0	6.58	29.5	0.208	53.2	6.3
Scraper	68.5	18.0	86.5	544.0	6.17	12.7	0.146	49.9	3.7
Total oil & Fuel cons.				15,432.6	372.5				
Average oil & Fuel consumption lit/hr.			6.6	0.16					

Conclusions

The following conclusions may be drawn on the basis of above study:

1. Maximum use of 35 HP and 75 HP tractors is in the month of November at the time of wheat seeding. There is minimum use of tractors in the month of August to September. The second peak of utilization comes in the months of June & July.
2. The idle time amounts to 10 to 15 percent of working time for all tractors. This idle time is taken mostly in taking the tractors from shed to the field and back.
3. The range of 35 HP tractors power utilization varies from 24.2 to 45.7 percent on various operations. For tillage operation level of utilization is maximum.
4. The range of 75 HP tractor power utilization varies from 30.0 to 59.9 percent on operations like threshing and transport to ploughing and harrowing respectively.
5. The total yearly consumption of fuel oil comes to about 3,800 litres for 35 HP tractors and 15.400 litres for 75 HP tractors. The average oil consumption comes to 4.7 percent and 2.4 percent of fuel consumption for 35 HP and 75 HP tractors respectively. For 75 HP tractor oil consumption is approximately half of the oil consumption of 35 HP tractor.

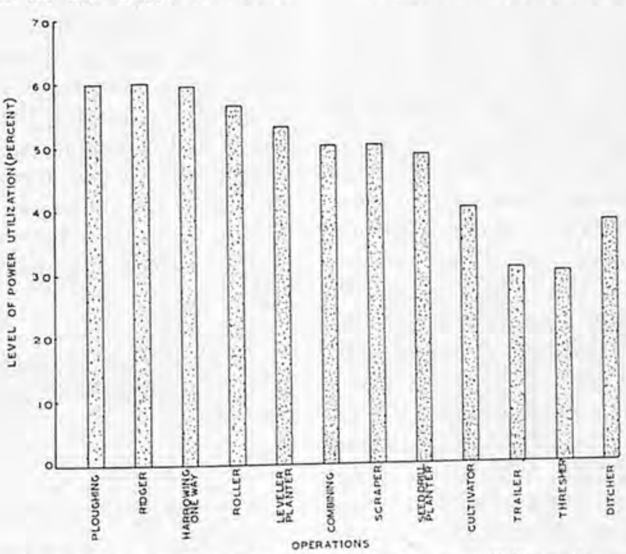

Fig.3. Level of 75 H.P. tractor power utilization on Different farm operations

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Agricultural Technique in India as example of a Development

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The mechanization of farming in India is just beginning. It is marked by considerable shortage of energy. The first step of the development with the transition from autarcy of energy supply of the individual enterprises using manual labour and animal power to energy from outside sources with tractors and electricity has only taken place in a limited number of enterprises. Further progress is dependent on the development of the agricultural technical sciences, artisan training, the establishment of India's own agricultural machinery industry and a general raise in the level of income of the population, which can only be expected in connection with the simultaneous industrialisation of the whole county. As guideline for the development of an agricultural technology adjusted to the Indian conditions, mechanization taking into consideration the energy input, is recommended.

Fig.1. Condition of location on India.

General and economic conditiones

India is, from the point of view of surface area, the 7th largest country in the world with a population of 560 million in 1971/72. It stretches over a length of 3,200 km from north to south and 3,000 km from east to west. It is difficult to make a general classification of the country because of the differences in political, cultural and climatical conditions. There are more than 800 languages and dialects, of which the Indian constitution only recognises 14. Educated Indians speak English. 80% of the population are Hindus with a vegetarian way of life. This has an influence on the agricultural and food economy. 40% of the population live on the border of the existence minimum. India is separated from the industrial centres of the world by long distances (**Fig. 1**). The climate is tropical and subtropical and is considered to be unbearably hot with noon temperatures of 37°C in the shade in New Dehli and up to 50°C in the Northwest of the country (**Fig. 2**).

After being freed from the infamous English colonial rule in 1947, the country needed many years to recover from the aftermath of the fateful British personnel and economic policy. This contributed to the formation of national consciousness, which became a decisive factor leading to the introduction of the eco-

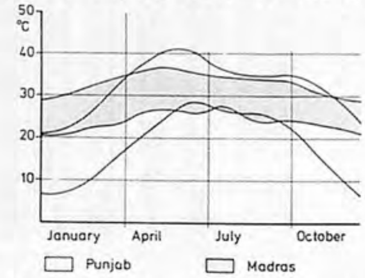

Fig.2. Maximum and miniman daily temperatus.

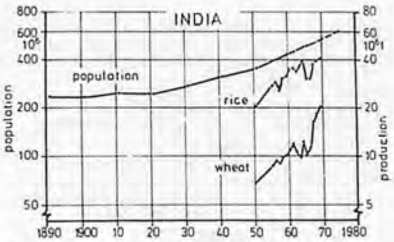

Fig.3. Average yield of rice and wheat in India.

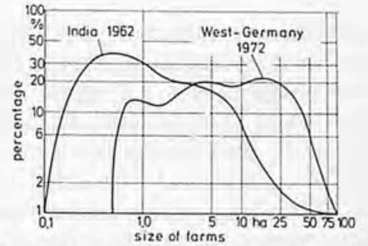

Fig.4. Comparison of farm size between India and West-Germany.

nomic plan covering the whole contry, which led since 1951 to the well-known five-year-plans.

These plan increase of agricultural and industrial production with the help of state investment. India is internationally free of debts and possesses foreign exchange reserves of 4 milliards Deutsch-Mark. As developing country India has need of aids and promotion from industrial nations within the frame of international aid organisations. Because of its geographical situation it is gaining importance in the political and economic region of Asia.

Agriculture

The Indian agriculture has made great efforts to satisfy the foods deficit-partly with astonishing results. Inspite of the resulting increase, the average surface yield still remains low compared with that of Europe, which is due to lack of fertilliser, water, pest control, and sufficient cultivation of soil. This is for example in case of wheat 1,30, rice 1,13, maize 1,27, barley 1,10 and potatoes 8,0 t/ hectare and lies in the lowest group of would statistics.

The highest yields achieved in India in individual cases permit expectations that on the long run the production of sufficient food for the population will be possible. The average yield increase since 1949 was in 1971 for wheat 188%, rice 138%, maize 145%, oilseeds 120%, fibrous material 109%, sugar cane 118%, potatoes 111% [1] (**Fig. 3**).

There is no shortage of labour. 70% of the population are employed in agriculture, mostly in small and very small enterprises (**Fig. 4**) as proprietors, leaseholders, administrators and labourers, very often in a condition of humiliating dependence. The government tries to support the small farmers and protect the leaseholders. Large scale state owned properties and plantations, partly taken over from the colonial period, are exceptions.

The methods of agricultural management vary. In irrigation areas, which consists of 20% of the entire agricultural surface, and in future will be expended to 40%, two yearly harvests are possible. Crop rotation takes place with wheat, rice and millet, beans, maize, oilseeds, potatoes, fodder and fibrous plants [3, 4]. The geographical situation of the cultivated areas for the main crops, wheat and rice (**Fig. 5**) is influenced to a large extent by the climate, mainly rainfall (**Fig. 6**) and the irrigation possibility.

The animal production consists mainly of milk, which is largely processed into powder milk. The supply of the population with animal products is insufficient, as compared with industrial contries. Great efforts are therefore being made to establish, for milk production, large scale animal farming, supplying daily quantities of 50,000 to 150,000 liters. In addition, there are 500 million holy cows living in free possession, which are milked and used as work animal, but-according to Hindu belief-may not be slaushtered. Cow-dung is an indispensable fuel material, supply of organic fertiliser for the soil is therefore lacking. In addition, organic substances deteriorate quickly due to high temperatures and the good tilth is therefore destroyed.

The state agricultural promotion grogramme plants the following: [3] Exploitation of raw material resources, with optimal use of soil, water, improvement of product quality and production methods and development of the agricultural market, promotion of export of plant and animal products, development of a price policy and price structures, inprovement of rural economic living conditions, research in the field of plant and animal production, expansion of the advisory and testing field, membership in world-wide organisations and maintenance of international relationships.

Fig. 5. Geographical Situation of cultivated areas for the main crops.

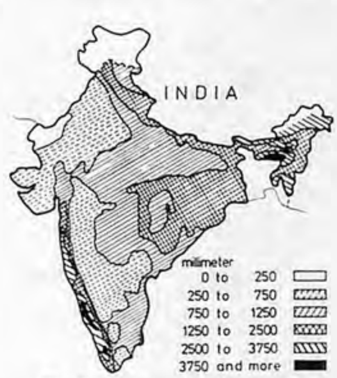

Fig.6. Average annual rainfall.

Agricultural Sciences

Agricultural sciences are in India in prelimimary development

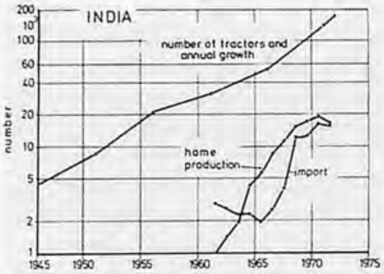

Fig.7. Number of tractors and annual growth.

stages. In 1960 the first agricultural university was founded in Patnagar with the support of the U.S.A., and later, others were founded. Whereas formerly only two institutes at university level existed for agricultural studies, in the meantime others have been established with the help of the Ford and Rockefeller Foundations in Ludhiana, Patnagar, Udaipur, Phubnesawar and Jabalbore.〔3〕. One of the largest institutes is in Ludhiana and is directed by Professor Dr. Pathak, who took his doctor's degree in 1962 at the university of Hohenheim (Fed. Rep. of Germany). The institutes train graduate engineers in agricultural technique. These engineers are employed in research, in industry and in the testing fields and in large scale agricultural enterprises. The training has a high level, comparable with American and German standards.

Emphasis is placed on research work like improvement of sowing and planting equipments, harvesting machines for grains, potatoes and peanuts and ranges from devices for boring deep wells to irrigation devices; from drying and storing plants for perishable grains to equipment for the transport of milk and plants for the production of milk powder.

These institutes are employed by the ministry for agriculture for carrying out tests. Combine harvester tests were done during recent years at the University of Ludhiana, in the centre of the corn chamber of India.

A national institute for agricultural machine research is at present being established, and there are further central institutes for rice production in Karagpur, and for water technology in New Dehli. In 1960 the Indian society for agricultural technology (ISAE) holding yearly conferences with themes on mechinisation and basic research, was founded, and in January 1973 in Coimbatore in Southern India. In 1962 Prof. Pathak founded the Indian Periodical for Agricultural Technical Research.

State of Machanisation

The mechanisation of the Indian agriculture is in its preliminary stage. Manual labour predominates, even when it can be substituted by animal power and hoes. The main supply of energy is the modest water buffalo, which cannot work more than 5 hours daily in tropical climate for about 75 days a year〔2〕. Animals draw the ploughs and are used for transport, they drive sugar cane presses and the bucket elevator. In the meantime numerous combustion engines and electric motors have been used for driving the sugar presses and water pumps for irrigation. The number of electrically driven pumps has been increased from 160,000 in 1961 to 580,000 in 1966, the number of mechanically driven sugar presses during the same period from 33,000 to 50,000. The change to the use of electric power in agriculture involves about 600,000 communities and there is a yearly increase of some thousands of communites.

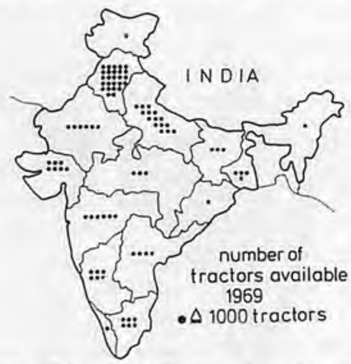

Fig.8. Geographical Situation of number of tractors available.

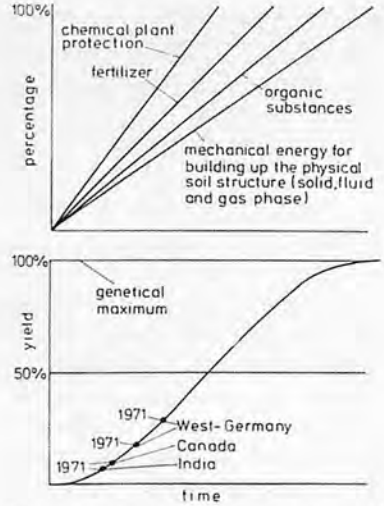

Fig.9. Factors responsible for the yield of the biological reactor soil.

The first large tractors were taken over after the war from the military stocks and used in the cooperation enterprises and hire stations and plantations, mainly in the cultivation of barren land. In 1956 a stock of 200,000 tractors and in 1965 of more than 50,000 tractors has been reached〔3, 5〕. In 1972 (**Fig. 7**) there were 173,000 units with engine performance of 20 to 37 kw. Half of the tractors are produced within the country by 6 companies, and the rest is imported (see **Fig. 7**). The future demand for tractors for the period 1978 to 1979 has been estimated by the industry as 40,000 to 60,000 units per year, by the Indian society for agricultural technique as 60,000 units per year, whereas the national development institute estimated the demand for 1979/1980 to be 80,000 units and for 1983/84 to be 135,000 units, with a share of 15 to 20% in the class 11 kw, 50 to 60%from 19 to 30 kw and 25 to 30% with more than 30kw. The companies Eicher, Escorts (Ford licensee) AMT (Zetor licensee), Hindustan, International (IHC) and Massey Ferguson participate in the production of tractors.

stage	energy: power kW/furrow [1]	cost [2] DM/kWh	ploughing: furrow depth cm	furrow width cm	speed km/h	field productivity m^2/h	comparison
B_1	0.07	5.0	7	9	1.0	100	0.2
B_2	2×0.4	1.2	14	20	2.5	500	1.0
B_3	5.0	0.1	25	32	3.0	920	1.8
B_4	8.0	0.1	30	34	3.6	1220	2.4
B_5	16.0	0.1	30	34	6.5	2200	4.4

1) 1 kW = 1.341 horsepower
2) wages 0.30 Deutsch Mark p hour

Fig.10. Energy lines for ploughing.

Other works producing smaller tractors of Indian design are still in their stage of development. The tractors are mainly used for grain cultivation (**Fig. 8**).

The importance of tractors lies mainly in the improvement of soil cultivation and transport in the field of agriculture. With increasing intensity of soil cultivation and increasing use of organic masses there is a possibility of bringing the soil to better yield and thus achieving larger harvests. With the existing nature of the soil, soil texture, and taking into consideration the climatic conditions and water supply for the soil, and considering those factors influencing plant yield like, for example, suppiying the soil with inorganic fertiliser and organic substances, and pest control, an optimal physical structure of the soil is of great importance. S.R. Verma draws attention to the fact that there is obviously a relation between the use of tractors and plant yield. Comparing the world hectare yield, those countries having a high level of tractor stock with more than 0.6 kw/hectare show the best result, and those with the lowest level of tractor stock--less than 0.4 kw/hectare-the most unfavourable result. India is in the lowest group. Unfortunately there is a lack of comprehensive tests results up to now, except in few cases, which could serve to estimate quantitively the natural yeild, so that the relationship can be determined only on a general basis. (**Fig. 9**). The efforts in introducing suitable soil cultivation in rain and irrigation regions as well as in dry areas is faced with inadequate equipment with traction power. The low performance of the existing draft animals is not sufficient for supplying the pre-conditions of high-yield plant cultivation, as is offered by tractor (**Fig. 10**). The change over to tractors and to higher engine performance results in a gradual increase, according to the energy input, of the possible cultivated depth and surface performance [7, 8]

The transition to a stage of higher energy input, like the present European level, required careful economic consideration, less from the point of view of the relation between input and yield, but more from the point of view of the high capital investment required for the procurement of large tractors. In the field of soil cultivation it seems to be justified the historical development sequence of European agricultural technique. This would mean in developing countries the transition from draft animals to small tractors with 9 to 11 kw for one furrow or to the larger tractors for multi-bottom ploughs with 9 kw for each furrow. Fig. 10 shows the development stage 4-B or 3-B for the still smaller single-axle tractor, a development stage, which has been pssed in the European agricultural technique only by very farms.

A decision on the choice of the appropriate development stage is becoming more and more important, ont only in the field of soil cultivation but also from the point of view of the desired state of mechanisation of harvesting work and the necessary machines, as the performance of the driving foree must be adjusted accordingly.

energy line: energy stage	supply of energy: power kW [3]	processing: cutting	collecting: swath	collecting: bunker or wagon	handling [2]
E_1	0.047	○	○	—	—
E_2	0.4	○	○	—	—
E_3	5.0	○	○	—	—
E_4	8...15	○	○	—	—
E_5	15...150	○	○	○	○
E_6	[1] 30...200	○	○	○	○

1) selfpropelled harvesting machine
2) cutting, compacting or sorting
3) 1 kW = 1.341 horsepower

Fig.11. Energy lines for grain harvest.

energy			processing		productivity		
stage	kind	power kW[1]	cutting	threshing	field: cutting only ha/h	field: combining ha/h	labour: cuttinga threshing men/hour/ha
G_1		0047	sickle	flail	0.05	——	240
G_2		0.4	reaper	horse-capstan thresher	03	——	240
G_3		0.5	binder	motor thresher	0.4	——	100
G_4		8 15	binder	motor thresher	05	——	60
G_5		40 60	pulled combine		——	02 04	50 25
G_6		40 200	selfpropelled combine		——	04 20	25 10

[1] 1kW = 1 341horsepower

Fig.12. Energy lines and productivity.

Thus the development stages for the harsesting processes go the same way from manual labour to animal power to small tractors and larger tractors and finally to self-driven harvesting machines. With increasing use of energy this makes possible the transition from collecting the harvested goods in swath or small containers, involving a lot of work, to fully mechanised interrupted or continuous loading on to the means of transport (**Fig.11**). Where there is sufficient labour available, lihe in the case of developing countries for the mechanisation of harvesting work at first the development state 4-E would be suitable, similar to 4-B in soil cultivation. (compare with **Fig.10**). In conjunction with the efforts towards autarcy in the foods industry mechanisation of grain harvesting is gaining priority India. Grains are an important staple food and are thus an important harvest product. Because of climatic conditions they muse be stored often under pressure of time before the starting of the monsoons and with primitive harvesting processes there is a danger of high harvest and storing losses. Here the demands for mechanisation takes priority and thus an increasing input of energy in the form of the increasing use of tractor-mow-binder and motor threshers and finally combine harvestes (**Fig.12**). This explains the sudden transition in large scale enterprises and in case of collective use of machines, from development stage 2-G skipping the transitional staget to combine harvester stage 5-G or 6-G. In most of the enterprises, however, efforts are being made to find solutions corresponding to stage 4-G, with tractor driven mow--binders and motor driven small threshers, like those being produced already in large numbers. The high level of productivity offered by large threshers is not a primary development target in countries with a surplus offer of manual labour.

Tractor and agricultural machine requirement

The future requirement for tractors and agricultural machines is very large in India. The tractor has a key position in the urgently required increase of natural yield. For the individual enterprises procuring means apparently exorbitant expenses in view of the high purchase tax involved. Nevertheless, the yearly turnover increases. It is difficult to make an estimate of the total requirement for tractors. Judging from the present stock in West Germany of about 1 million units, this would mean for a ten times larger surface area like India about 10 million units. A lower and realistic figure of about 4 to 5 million tractors is estimated when taking into consideration only those surface areas about 10 hectare (**Fig.13**).This figure is, however, hardly to be achieved in the foreseeable future. In addition, there are the singleaxle tractors for rice cultivation, for intensive culture and in irrigation farming for planting, grinding, hoeing spraying, pumping and for transport.

The stock of single axle tractors is it present 10,000 units, the future requirement is estimated by the institute for economic research to be 20,000 units. For production under licensee agreement exclusively Japaneses makes of 40,000 unites per year approval has been given. There are two performances classes of 4 to 5.5kw and 6 to 9kw. Of the six participating Japanese import companies two have begun with assembly works and one with production. The co-operation with the Japanese agricutural machine industry is promoted with the help of a state credit plan [9, 10].

Machines for the preparation seed-bed, seed and plant care, fertilising and sparying are produced to a large extent within the country. For grain harvesting grass mowers with stacking facilities and mow-binders are to be considered, for threshing small tractor-driven stationary threshing machines. Only recently the production of such small threshing machines with only a straw separation or straw shaker, has been started. The annual requirement is estimated to be

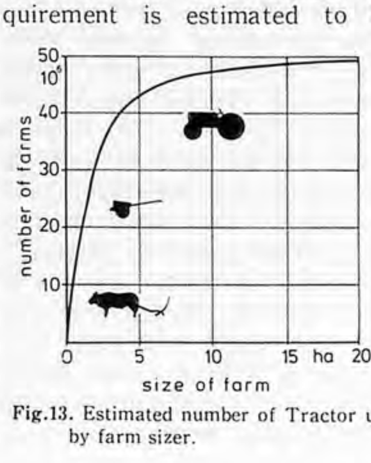

Fig.13. Estimated number of Tractor use by farm sizer.

50,000 unts.

The use of combine harvester is still a mater for dispute. Up to now 500 units are in operation, of which 300 are detachable units built in Bangalore according to a Danish licence and 200 self-driven, comprising only few traction driven machines. The production of detachable threshers will be discontinued in future in fabour of a self-driven combine harvester. Production licences are owned up to now by 4 European firms, 8 licence applications from other companies have been made from Italy, Japan, West Germany and the Democratic Republic of Germany. The importance of combine harvesters in India lies mainly in the need to clear the fields before the beginning of the rainy seasons and to avoid harvest losses. If the fields are cleared in time they can be ploughed before the rain starts and a new crop sown, so that one can count with two harvests yearly. In large enterprises the use of combing harvesters eliminates the need of employing large groups of labours.

The official combine harvester testing carryed out and the results of the first use of these machines were positive [11]. Important for the choice of the kind of combine harvester used is their suitability for working with different grains, these are, apart from wheat and barley, above all rice, mais, beans and millet. The introduction has, however, led to social economic difficulties as a result of polarisation between those benefiting from technology and the underprivileged, and to new dependence from combines and tractor lords, the new lords in the opening of the technical age, resulting in a new dependent society, organised in casts. How much the opening of the technical age pre-occupies the people was shown by a hunger strike on the campus of the agricultural faculty of the University of Dehli. This was directed agrainst the economic privilege of combine harvester owners and not against the saving of labourers.

Mechanisation in Machine Lines in the same Performance Requirement taking into Consideration the Energy Requirement

The steps towards development of an appropriate agricultural technique in India is not working with the motto of saving labour, but of improving and increasing agricultural production [12, 13]. Tow attitudes stand against each other in the development policy[14]. The one fears that the mechanisation of agriculture will increase to number of unemployed, whereas the other is in favour of mechanisation, because it is suitable for increasing the surface productivity. In the first case one would like to keep to the use of hand devices and animal traction machines, the other believes that with the use of highly technical apparatus the target can be reached, and approves the use of over-dimensional technique with the highest degree of comfort, regarding capacity and energy input. Both ways have led to a dead end when they have been practised. They have either missed the target of increased agricultural productivity or the global interests of the country with excessive mechanisation and over-investment.

Indian experts agree that only a careful selective meceanisation adjusted to the existing conditions could be justified by the social and economic conditions. When developing the respective agricultural technology not always the development sequences of Europe and the U.S.A. will be followed, and machines which have stood the tests in one country need not to be used in the other. This has in the past led already to disappiontments in European agricultural technique, in cases where examples of progressive American techniques have been taken over without critic in Europe. If we want to take advantage of this experience, the first step Would be for developing countries to increase the scientific capacity and promote the critic ability of the responsible special institutions.

A very important point of view taken into consideration up to now in planning is mechanistion taking into account the energy input. One can also talk of mechanisation according enery lines. In countries in which mechanisation is in the stage of transition from energy independent individual enterprises with manual labor and animal traction to energy from outside sources with tractor and electricity a progressive plan can become the guideline of an agricultural technology adjusted to the conditions and economic power of the country. The energy input is considered here not so much as a costs factor, but more as being representative for the mechanisation stage to be chosen. The guide-machine deciding the input factor is the tractor (**Fig.14**). The Indian agriculture is in the transition from stage 1 (manual labour) and 2 (traction stage) to stage 3 and 4 (single-axle tractor or fourwheel tractor with low performance).

The progressive plan of development can also be seen as an aid for the establishment plan of a country's own agricultural

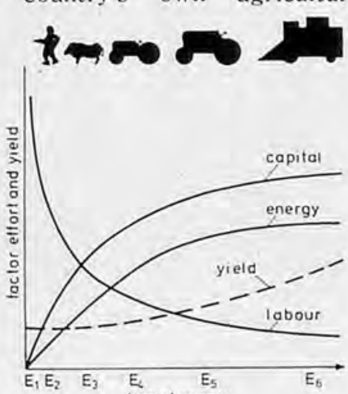

Fig.14. Factor effort and yield of mechanized plant production.

machine production.

The establishment of a country's own tractor and agricultural machine industry is in keeping with the interest of the country in a general industrialisation. Independent product development, particularly adjusted to conditions existing in India could up to now only be done in the case of the most simple devices. One is in need first of taking over licences from Europe, U.S.A. and Japan, where by attempt is being made to adjust these licensee agreements which must be approved by the state to the needs of the country. This procedure must lead inevitably to over licensing resulting in bottle-necks in case of raw material and energy supply. The establishment of the agricultural machine industry takes place either exclusively with private capital or with state majority share. Supply difficulties in case of raw material involves particularly various steel sorts and also finished parts, like pistons, piston rings special parts, transmission units and tyres. Taxes up to 23 and 30% are imposed on production of tractors, inport taxes being 7.5 to 10%. Supply of spare-parts is impeded by inadequate transport facilities. Inspite of great efforts being made there is a lack of education for qualified personnel.

But in the long run the agricultural machine and tractor market in India, like in the rest of Asia, could be, after overcoming a certain unforseable development period, one of the largest in the world.

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Visiting Industry

Parts Supply System with Computor in Kubota

by Farm Mechinery Industrial Research Corp.

Service

We, Kubota Ltd. think that the after-sales service of agricultural machines should be done by the retailers who are nearest to their users. That is, retailing companies or retailers should serve their customers directly and voluntarily within their limit.

So, the manufacturer should help and instruct them how to contrl and serve machine parts. For the purpose, Kubota makes the following maunals.

(i) Standard of Setting up Service Workshp

This shows how many service shops should be necessary according to the numbers of each machine used on farm. Also, this show which layout is suitable to each size of workshop and what kind of accomodation is necessary. Service are to be classified to three classes, according to their accomodation.

(ii) Manual for Service Shops

The content is as follows.

(a) Organization
(b) How to get license
(c) Flow of daily work
(d) Kinds of advice slip
(e) Balance control
(f) Safety control

These are announced and well received at the meetings of dealers and retailers every year.

(iii) Standard of Service

Routines and points of service to be taken care of are shown.

(iv) Standard Time of Service

The list of atandard time of service helps to show the charge of each service by multiplying the number into the labor wages.

(v) Developing the Tools for Service

Kubota's educational system is as follows.

(1) The data for each service engineers of all the dealers and retailing companies are put in the computor.

(2) The disposition of engineers is standardised and they are trained to satisfy the standard. It may be said that among the service system of Kubota, the educational system is most progressing.

On-Line System of Part Supply

It is the duty of the manufacturer and retailers to the farmers to help their machines be in good conditions to run. To provide better and more careful service, the quick supply of machine parts is important. As farm machines become more efficient, the number of parts necessary to one machine become greater. Modern tractors, combined harvesters, bined harvesters, binders, rice-transplanters, efficient dusters and sprayers are consisted of thousands of parts. The number

Photo.1. Computor center in head office.

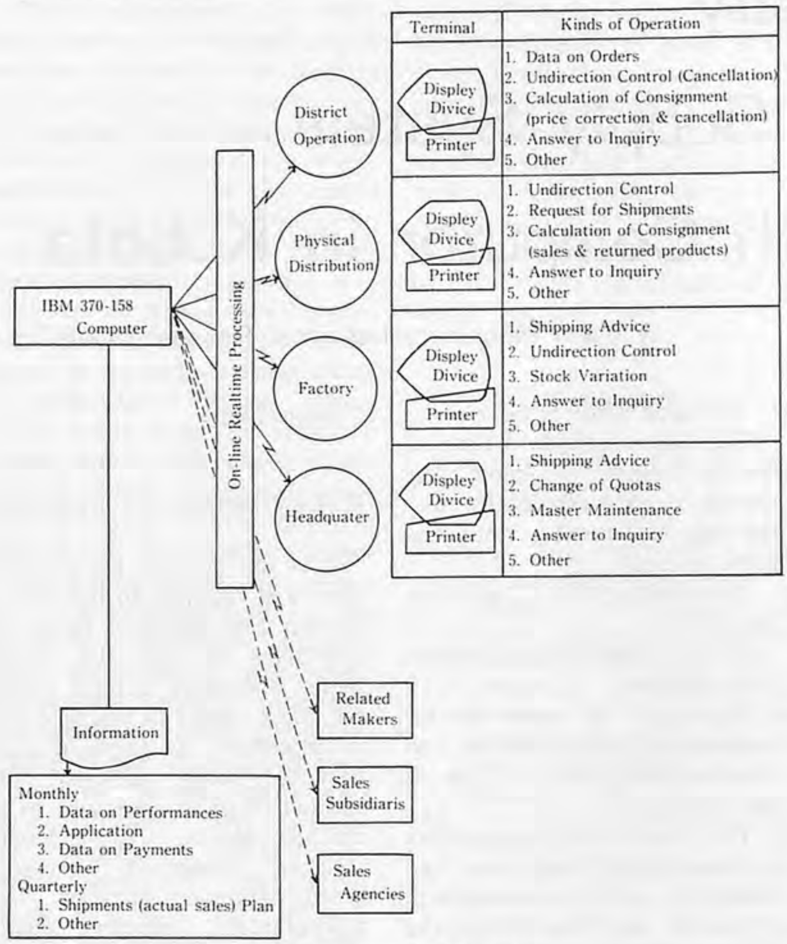

Fig.1. Structure of The System.

of those parts are so many that men can not control and supply them easily. The clerical work for giving and receiving order and shipping of them has become so complicated and needs so long time—— and labor that we can not supply parts of the farmers' machines so as to be in time for farm work, when it has some trouble.

Therefore, Kubota, had studied and developped the on-line system of "Route-retailing information system" using the large computors, and after one and a half year preparation, the part supply runs smoothly since Feb.-16, 1974. (**Fig.1**)

The computor center with the large computors (**Photo.1**) is connected with parts center, 17 service stations in different districts with line, and when a dealer or retailer consults or gives order, the center responses instantly, as shown with the catch phrase "Within 60 seconds from receiving order to shipping".

The on-line system is consisted of two large computors, IBM 3701158 and 71 terminals, IBM 3227 in 17 spots——— this is only in department of agr. machinery, while 130 terminals in 37 spots are connected in all the departments of Kubota——— and more than 140,000 articles are on line (**Photo.2**).

About 100,000 data are dealt each month, and average 10 machine parts are concerned with each data——— therefore about one million parts are dealt every month.

With this on—line system, the following items are covered,-——— *receiving order→ directing shipping *shipping→suming up *collective stock control of 17 spots in different districts *answering inquiries about the full account of shipping, the articles not yet shipped, stock, and the time for delivery *stocktaking (**Fig.2**)

Except special articles, if an order is given and shipping direction is made in the morning, the article is ready to ship in the same day, and sent by the private car, direct mail, or air mail, so it gets to the service station mostly next day, and to the retailer within 1 or 2 days, or 3 or 4 days at the latest after the order.

With this system parts supply, is not only accelerated in the nation-wide scale, but the unnecessary stock of parts between intermediate dealers and retailers are eliminated and better service with less stock is achieved. Before using computors, 3 or 4 days are necessary from receiving order to shipping and now it is dealt on the day to receiving order, and the efficiency of the clerical work is much increased and better service is supplied.

Service System

The service that Kubota wants to supply in the future is the one

Photo.2. Terminals in parts center.

that customers are to be satisfied with, through management for the customers and the society. Therefore, substantial service system is to be established very soon, in order to supply sincere and timely service by dealers or retailers. In order to establish the service system for the customers, the following four elements are to be established; (1) Management (2) Parts supply (3) Machine service (4) education

So, Kubota helps and teached dealers and retailer to establish the above mentioned four system.

(1) Management System
  (i) Establishment of the orgarization of service depertment.
  (ii) Mental innovation through introduction of scientific methods.
  (iii) Safety training and remedying grievance of the basis of humanism.

(2) Parts Supply
  (i) Improvement of efficiency of instant supply of parts to customers.
  (ii) Efficient stock control.

(3) Service System
  (i) Substantial service system.
  (ii) A large number of competent service engineers.
  (iii) Quick, assured and kind service work.

(4) Training System
  (i) Educating employees to be trusted by customers.
  (ii) Training parts clerk with modern feeling.
  (iii) Training competent sales engineers.

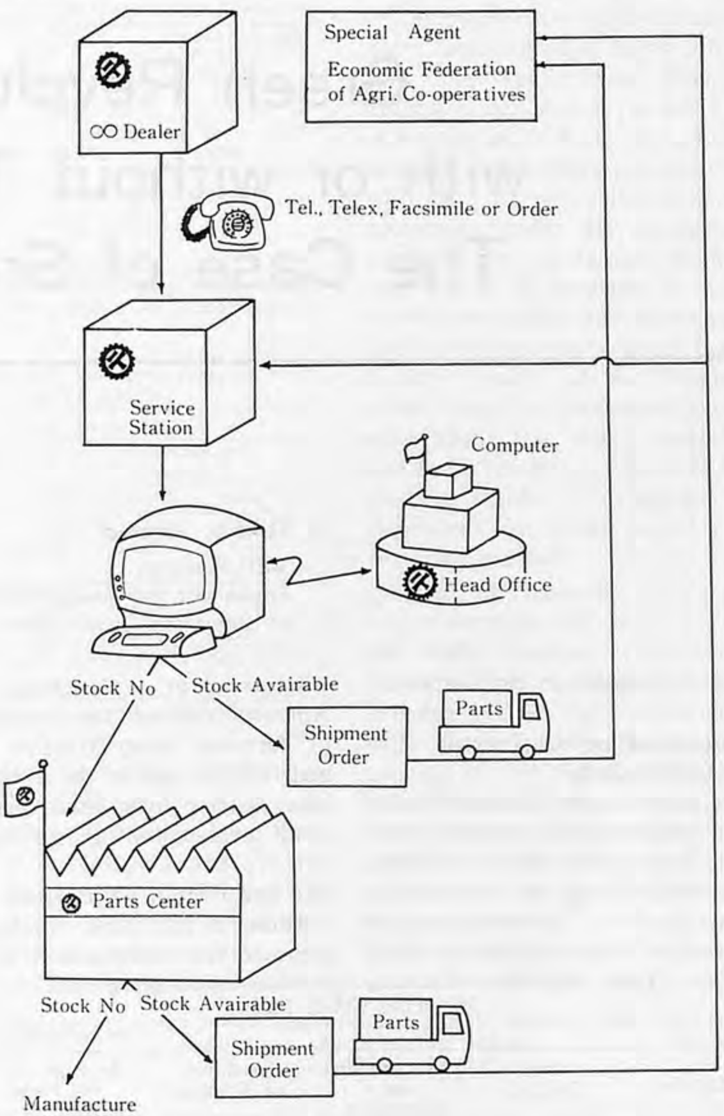

Fig.2. Relation of orders and Shipments.

Value and Future of After-Sales Service of Agr. Machines

Before, the phrase "management that consumers Want" was very popular, and to develop the products which satisfy consumers' need was regarded very important. Today, however, average consumers care not only about the quality or the price of the products of a manufacturer, but also how they manufacture and sell their products and also what role they play in the districts. That is, consumers entertain many expectations other than products, to manufacturers. It is same about agricultural machines ——— Consumers pay attention to the way a manufacturer sell their products and their after-sales service, as well as the quality of machines. The quality of after-sales service is a great factor when consumers choose a produt to buy.

Agr. machines are getting more and more effecient and complicated yeare after year, and on the other hand their users———farmers are becoming older and older. So, the gap between them are getting larger. And also better service is wanted more and more from the viewpoint of saving resources.

Therefore kubota has a vision that the service dept. should be the most important part of the company. In this respect, our service system shorld be the one which can be useful thrughout the world, though the instant supply of parts at present is 95% in Japan by the use of on-line system with computors.

Green Revolution with or without Tractors: The Case of Sri Lanka

by Iftikhar Ahmed
WEP/Research
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of International Labour Office

Use of Tractors in Sri Lanka

Concentration of Tractor—Use in the Dry Zone

In most of Dry Zone districts(1), land preparation is done by tractors. During the 1966—67 Maha season(2), 100% of the paddy cultivators in Polonnaruwa and Vavuniya districts have used tractors for ploughing. In Amparai district the proportion of farmers using tractors was nearly 92% and in the Hambantota district over three-quarters of all farmers were tractor-users.

Pre and Post-HYV Periods

Table 2 compares tractor-use prior to the introduction of the new HYV (high yielding varieties) with that following the introduction of new HYV for Hambantota district.

It is apparent that tractor-use has not increased following the adoption of HYV (on the contrary a slightly lower proportion of farmers use tractors now).

It is also apparent from **Table 3** that 80% of the cash cost of hired draught power is spent on tractor hiring. The tractors are more widely used for tillage operations than for threshing operations although a large proportion of farmers reported its use for threshing purposes.

Table 1 Paddy cultivators using tractors for ploughing land: Sri Lanka 1966-67 Maha[a]

(in percentages)

District	Only Tractors	Both tractors and Buffaloes[b]	Total use of Tractors	Average size of Paddy Holding (acres)
Hambantota	73.3	3.1	76.4	1.98
Polonnaruwa	74.0	25.9	99.9	3.55
Amparai	84.4	7.3	91.7	c
Vavuniya	68.7	31.3	100.0	c
Trincomalee	53.2	6.3	59 .5	c
Batticaloa	59.8	1.9	61.7	c

a. Source: The Central Bank of Sri Lanka, Report on the Survey on Cost of Production of Paddy , 1969, p. 20 and pp. 24-34.
b. First ploughing was done by tractors and the second (and third) proughing by buffaloes or by mammoties.
c. Not available.

Table 2 Use of tractors for land preparation during Pre and Post-HYV periods: Hambantota District[a]

(percentage of total cultivators)

	Pre-HYV[b] Maha 1966-67	Post HYV[c] Maha 1971-72
Proportion of farmers ..	76.4%	75.1%
Average size of paddy holding (acres) ..	1.98	4.51

a. Source: Pre-HYV from Table 1 and Post-HYV from K. Izumi and Ranatunga, Environmental and Social Constraints on Paddy production under existing conditions — A Case Study of Hambantota District, Study Seminar paper, p. 30 (153 Hambantota farmers were randomly selected).
b. Pre-HYV here implies prior to the introduction of the new HYV. IR-8 was introduced in 1967. BG 11-11, BG 34-8 and LD-66 were released during 1970-71. They are the dwarf non-lodging varieties.
c. 43.4% of the farmers have adopted New HYV and 48.8% Old HYV which adds up to 92.2% for the two combined.

Impact of Tractor-Use on Employment

Dry Zone vs Wet Zone

In **Table 4** a comparison is made using cross-section data between the districts in the Wet and Dry Zones. The Dry Zone, as we note from Tables 1 and 3, uses the tractor quite extensively for the "ploughing operation. It is therefore not surprising that the number of man-days required to cultivate an acre of paddy is lower for the dry zone districts

Table 3 Use of tractors in Minipe: Sri Lanka 1967-68
(Average of all Farms)[a]

		Proportion of farmers reporting[b]
Tractor Cost as proportion of Cash Cost of Total Hired Draught Power	80%	
Proportion of total tractor cost spent on tillage	68.5%	58%
Proportion of total tractor spent on threshing	31.4%	79%
Farm size in acres	7.2	
Low land (used for paddy)	3.9	
High land (unfit for paddy)	3.3	

a. Source: University of Ceylon, Characteristics of Individual Project Area, Minipe Agricultural Economics Research Unit, Faculty of Agriculture, Peradeniya, June 1969.
b. Survey covered 212 farms.

Table 4 Labour requirements in the Dry Zone and Wet Zone Districts of Sri Lanka: Maha 1966-67[a] and Yala 1972[b]

Region	District	Labour Requirements: Man-days per acre		Man-days per bushel	
Dry Zone		1966-67	1972	1966-67	1972
Bulk of farmers use tractors for ploughing	Hambantota	35.0	40.6	0.79	1.1
	Polonnaruwa	36.7	68.0	0.78	0.9
Wet Zone	Kurunegala	53.3	64.4	1.73	1.3
	Kandy	97.9	93.1	2.66	1.3
	Colombo	53.1	55.3	3.19	1.2

a. Source: The Central Bank of Sri Lanka, Report on Cost of Paddy Production, 1969 pp. 24-34.
b. Source: Izumi, K. and A. S. Ranatunga, Cost of Production Study: Yala Paddy 1972, Agrarian Research & Training Institute. Research Study Series No. 1, Colombo, Sri Lanka, March 1972.

as compared to the wet zone districts. The lower input of labour per bushel of paddy in the dry zone districts may also reflect a greater efficiency in the production process.

Tractor-Use vs Buffalo-Use

By far the clearest evidence of the impact of tractorisation on employment is brought out in **Table** 5. For every additional acre on which the tractor replaces the plough, the labour requirement is reduced by nearly eight man-days. As the vast majority of the farmers in the dry zone districts use tractors for ploughing, it is important to note that this operation alone displaces almost 6 man-days of labour for every acre on which the tractor replaces the buffalo. When a tractor instead of a buffalo is used for threshing, nearly 2 man-days of employment are foregone for every acre of land.

Major Causes of Tractorisation

The use of tractors is concentrated primarily in the Dry Zone area. What we find is an area where farm size is no more than 3 or 4 acres, and yet the vast majority of the farmers use tractors for ploughing and threshing. This phenomenon is mainly attributable to the *agro-climatic conditions* of this region(3).

Generally, the Maha(4)monsoon rains are preceded by a rather long dry spell from May to August which makes the soil very dry and hard. With the type of ploughs the farmers possess, it is difficult to use buffaloes for ploughing under dry conditions. Thus, in most instances, farmers are not in a position to commence cultivation operations until the actual monsoon rains begin. Even in many of the irrigated areas, water is not made available from the tanks until the monsoon rains have commenced as the tanks themselves are dependent for their supplies of water on rainfall.

Lack of assured supply of water even at the beginning of the Maha season, compels the farmers to do hurried field preparation. In Sri Lanka only 31% of the paddy area has an assured supply of water from the major irrigation schemes. Even in these schemes the time available for farmers from the first issue of water to sowing is about 40 to 45 days.

Poor quality of draught animals available is another

Table5 Comparison of labour requirements for HYV farmers[a] using tractors with those using Buffaloes: Minipe, Sri Lanka, Maha 1969-70[b]

(Man-days per acre)[c]

Operation	Farmers Using (1) Buffaloes	(2) Tractors	(2) − (1) Difference	Index Buffaloes = 100
Ploughing 1 st & 2nd	10.53	4.93	− 5.60	47
Bunding & Plastering	3.40	5.87	+ 2.47	173
Puddling & Levelling	6.20	3.27	− 2.93	53
Cleaning drains	1.00	0.86	− 0.14	85
Nursery prep. & uprooting	4.90	5.24	+ 0.34	108
Transplanting	6.50	6.74	+ 0.24	104
Fertilizer Application	1.50	1.45	− 0.05	97
Hand Weeding 1st and 2nd	6.50	4.92	− 1.58	76
Rotary Weeding 1st and 2nd	—	0.51	+ 0.51	—
Pesticide Application	0.30	0.53	+ 0.23	167
Reaping/Collecting/ Stacking	13.50	14.09	+ 0.59	104
Threshing	7.60	5.72	− 1.88	75
Total	61.93	54.13	− 7.80	87

a. 40 farmers were covered in this survey of which 25 use tractors (average farm size 5.5 acres) and 15 use buffaloes (average farm size 3 acres).
b. All 40 farmers grew HYV on approximately 82% of their total area and the varieties grown were I R-8, H-4 and H-8.
c. Source: Yudelman, Montague, Gavan Butler and Ranadev Banerji, Technological Change in Agriculture and Employment in Developing Countries, O.E.C.D. Paris Development Centre Studies, Employment Series: No. 4, 1971, pp. 79, 81, Table V.

Table 6 Four-wheel tractor imports Sri Lanka: 1950-1976

Period:	1950-60[a] (Little OHYV)	1960-65[b] (Post-Old HYV)	1966-70[b]	1960-70[b]	1950-69[c] (Pre-NHYV)	1972-76[d] (Post NHYV)
Number	7,748	2,200	6,000	8,200	15,948	5,000

a. Obtained by subtracting 1960-70 tractor imports from 1950-69 tractor-import figure.
b. Stoutjesdijk, E and P. Richards, Agriculture in Ceylon Until 1975. Stoutjesdijk, E and O. E. C. D. Paris, p. 146.
c. Tractor Committee Report as quoted in Gunatilleke, Godfrey Import Export Policies and High Yielding Varieties – Synopsis Seminar Paper; Table LX.
d. Five Year Pian Technical papers as quoted in Gunatillake, op.cit. Table VIII.
a. Tractor Committee Report, op.cit.
b. Five Year Plan Technical Papers,op.cit.

factor that has compelled farmers to depend more on tractors. In a situation where farmers are faced with uncertainty most of the time, mainly due to lack of an assured supply of water, delayed ploughing, hurried field preparation and late sowing have become common features in the pattern of cultivation that is generally adopted. Late sowing results not only in poor crops but may also expose the crops to damage by rains at harvesting time.

On the other hand, tractor ploughing of paddy land is possible immediately after harvesting of the Yala (dry) season(5) paddy crop. It is not necessary for farmers to wait till the arrival of the monsoon rains to commence tractor ploughing as tractors are equipped with suitable implements for work under dry conditions. Thus the use of tractors results in timely cultivation which generally results in good crops and the speed of cultivation not only enables the farmers to complete their sowing in time but also relieves them of the drudgery of working long hours with buffaloes.

The old high yielding varieties (H_4 in particular) were highly resistant to shedding of grain, making it difficult for the farmers to use buffaloes for threshing. This compelled the farmers to use tractors for threshing purposes. Given the fact that nearly 80% of the acreage in the Dry Zone area was under H_4, the tractors were used on a larger scale displacing the buffaloes.

Government Tractor—Import Policies (Pre and Post-HYV Periods)

Towards the end of the 50's the old high yielding varieties (tall indicas, H-series) came to be introduced. During the 60's the OHYV's had spread to nearly three-quarters of the rice area (H-4, H-7 and H-8 together covered 72.7% of Maha 1968—69 acreage)(6). A comparison of 4-wheel tractor imports during the two decades shows that the number imported during the 60's was not very much higher than that during the 50's (**Table 6**). At the beginning of the 70's the New High Yielding Varieties)dwarf varieties BG 11—11, BG 34—8 and LD—66) were introduced. The table above sets out the tractor imports during the period 1950—1969 and the projected imports for the Plan period 1972-—1976.

Similarly over seven and a half thousand 2-wheel tractors were imported during the last two decades but nearly as many are to be imported during the first half of the present decade.

Thus we can conclude that a policy of tractorisation was followed by the government quite independently of the introduction and adoption of HYV. During the two decades preceding the introduction of NHYV nearly 16,000 four-wheel tractors had already been imported and less than 8,000 two-wheel tractors were imported during the preceding decade. However, the period of the emergence of NHYV coincides with the heavy tractor imports projected during the plan period.

Socio-Economic Consequences of Tractorisation

The increasing emphasis on tractors led the farmer to release almost his entire buffalo holding for consumption. The Government, however, failed to maintain its fair price tractor pools and the possession and control of the use of tractors passed increasingly into the hands of affluent farmers, merchants and middlemen. We have already noted that three-quarters of the farmers in Hambantota district use tractors for land preparation (Maha 1966—67 and Yala 1972). However, very few cultivators own tractors as is observed from **Table 7**. This suggests that tractor owners are noncultivators. Among 32 owner cultivators, only four have tractors but the total number of tractors belonging to them is six.

Table 7 Ownership of tractors and buffaloes: Hambantota District, Sri Lanka 1972[a]

Tenurial Status of Cultivators	No.of farms	No. of farms which have: Tractors Two-wheel	Tractors Four-wheel	Buffaloes	Total No. which belong to each group: Tractors Two-wheel	Tractors Four-wheel	Buffaloes	Average size of paddy holding
Full-Tenant[b]	77	2.5	—	6	3.5	—	38	4.77
Tenant-Owner[c]	18	2	—	1	2	—	24	2.85
Owner-Tenant[d]	16	1	—	2	1	—	33	4.98
Owner[e]	32	3	1	2	5	1	23	2.90
Total	.143	8.5	1	10	11.5	1	118	3.88

a. Source: Izumi, K. and A. S. Ranatunga, Environmental and Social Constraints on Paddy Production Under Existing Conditions - A Case Study of Hambantota district, Seminar paper, pp. 12-14, 30.
b. Entire land is tenant-land and none is rented or leased out.
c. More than 50% land is tenant-land and none is rented or leased out.
d. More than 50% land is owned by the cultivator and none is rented or leased out.
e. Entire land owned by cultivator and none is rented or leased out.

Table 8 Use of hired labour and farm size with tractorisation: Dry Zone Districts: Sri Lanka Maha 1966-67 and Maha 1971-72/Yala 1972

District	Hired Labour as % of Total Labour Use		Tractor-Users as % of Total No. of Cultivators		Average Size of Paddy Holdings	
	Maha 66-67[a]	Yala 72[b]	Maha 66-67[a]	Yala 71-72[c]	Maha 66-67[a]	Yala 72[b]
Hambantota	72	75.6	76.4	75.1	1.98	2.88
Polonnaruwa	73	85.1	99.9	—[d]	3.55	4.09

a. Central Bank of Ceylon, op.cit. pp. 20, 24-34.
b. Izumi, K. and A. S. Ranatunga Cost of Production Study, Yala Paddy 1972 ARTI, Colombo Research Study Series No. 1, March 1972.
c. Izumi, K. and A. S. Ranatunga, Environmental and Social Constraints on Paddy Production under existing conditions, op.cit. p. 30, Table 4-3.
d. Not available.

Those four who have the tractors on their farms obviously hire them out to other farms since the size of their holdings is a meagre 2.90 acres. Similarly out of 77 tenant farmers 2.5 have tractors on their farms but the total number of tractors belonging to this class is 3.5. With farm sizes of 2.85 and 4.98 acres the other two categories of tenants also have three tractors on their farms. It is interesting to note the concentration of buffaloownership. Out of the 111 tenant-farms (all categories combined) only 9 farms have buffaloes. The total number of buffaloes belonging to the tenants is 95.

This pattern of distribution of ownership of both tractors and buffaloes indicates that the vast majority of the cultivators obtain tractors and buffaloes on hire. As mentioned earlier, out of 143 farmers over 75% of the farms use tractors for ploudhing and only 10 of these 143 farmers have tractors on their farms.

When the tractor is hired from affluent farmers, merchants and middlemen, the peasant farmer has to accept the operator and other men engaged by the tractor-owner together with the machine. Men and machines are offerd as a package and imposed on the peasant farmer. It can be seen from Table 9 that it is due to this reason that the percentage of hired labour used for land preparation and threshing has become substantial and is increasing over time. As a direct consequence of the use of such high proportion of hired labour, the cost of cultivation has increased and family labour earnings of the peasant farmers have been reduced.

During the last few years, there has been an acute shortage of tractors and spare parts due to import restrictions placed on account of foreign exchange difficulties being faced by Sri Lanka. One immediate consequence was that owners of tractors raised their charges by 100 per cent(7). The subsistence farmer cannot now return to the use of buffaloes and has become dependent on tractor use for some years. This also resulted in delays in completing cultivation operation. In such situations, farmers have been compelled to go in search of buffaloes for ploughing invariably late in the season(8). The most scathing evaluation of the adverse socio-economic impact of tractorisation has been presented by Jayaweera, "............In the tractor owner, who is invariably an affluent farmer, the subsistence farmer has acquired a new oppressor, more intractable than the feudal-land-owner. A new feudalism of technology has grown up around the tractor owners. The Paddy Lands Act notwithstanding, smallholder subsistence farmers are slowly losing operational control of their paddy lots to the tractor owners."(9) **Table** 8 also gives some indication of increases in the size of operational holdings The newly added landless now available as hired labour,may have been hired on what was their own land.

Conclusins

(1) Tractor-use is concentrated primarily in the Dry Zone area of Sri Lanka and about three-quarters or more of the Dry Zone farmers use them for land preparation and threshing. This is surprising especially in a context in which the average paddy holding is no more than 3 or 4 acres.

(2) Tractor-use was prevalent prior to the adoption and spread of the HYV and appears to have been independent of HYV adoption. It can definitely be said that prior to the introduction of the NHYV (the dwarf varieties) massive tractorisation had already taken place.

(3) The government policies of tractor import appear to be independent of HYV adoption (it can be said so more definitely about the NHYV).

(4) The vast majority of the farmers use tractors for land preparation and threshing because of soil and climatic conditions in the Dry Zone and poor quality of draught animals.

(5) Impact on employment has been abverse. For every acre on which the buffalo is replaced by a tractor, neary 8 man-days of employment are foregone. Almost all this unemployment results from the use of the tractor instead of the buffalo for the ploughing and threshing operations (and this is significant because tractors are used primarily for threshing and ploughing.)

(6) The distribution of ownership of tractors indicate that very few farms have tractors on them. They are owned by a few affluent farmers, merchants and middlemen (non-cultivators).

(7) Personnel engaged by the tractor-owners are offered as a package together with the tractor and is imposed on the peasant farmer. As a result the proportion of hired labour is high (well over three-quarters of total labour used) and is increasing over time. This means the cost of cultivation is higher and that family labour earnings are lower.

(8) Shortage of tractors and spare parts have been caused by

import restrictions imposed on account of foreign exchange difficulties. The consequences have been steep increases in charges for tractor use and delays in obtaining tractor services resulting in delased land preparation.

(9) The door appears to be closed to a return to buffalo-use as an alternative. The large majority of peasant farmers who do not own tractors are dependent on a few tractor owners who are in a position to dictate their terms and are often more exploitative than the feudal land owner.

There is evidence, however, that in the shortage of tractors and the prohibitive hire costs of tractors, there is an increasing demand for buffaloes particularly for ploughing. If this is true, then the old argument that agro-climatic conditions were unfavourable for buffalo ploughing does not appear to be conclusive. It might be possible to find the appropriate technological answers that would make buffalo ploughing efficient.

REFERENCES

(1) The drier part of the Island receiving on an average less than 75 inches of rain per year mainly during October-January.

(2) Extends from September-October to February-March and coincides with the North-East Monsoon which brings rain to the dry zone.

(3) This section draws heavily from Izumi, K and A. S. Ranatunga, *Utilization of Labour under HYV of Paddy in Sri Lanka,* Seminar Paper presented in the I.D.S. Sussex University Seminar on "Economic & Social Consequences of the Improved Seeds", held at Kandy, April 19 to May 20 1973, pp. 8—9.

(4) As indicated earlicr, this season normally extends from about September—October to February—March and coincides with the North-East Monsoon which brings rain to the dry zone.

(5) This season normally extends from April to August and coincides with the South-West monsoon during which time the dry zone gets little or no rain.

(6) The only NHYV introduced during the 60's was IR-8 in 1967. The OHYV includes the H-varieties and were developed in Sri Lanka during the 50's having good fertilizer response and was therefore capable of higher yield compared to prevailing varieties. But these were tall indica varieties of hybrid origin and were susceptible to lodge.
The NHYV were the dwarf indica strains and therefore were not susceptible to lodging and yieded 40 to 50 per cent more compared to OHYV.

(7) Jayaweera, Neville, *Credit Support for HYV in Sri Lanka* in Marge Quarterly Journal, Vol, 2 No.2, 1973, pp. 18—48.

(8) Izumi, K. and A. S. Ranatunga, *Utilization of Labour under HYV paddy in Sri Lanka, op. cit. p. 9.*

(9) Jayaweera, *op.cit.*, p. 43. ■ ■

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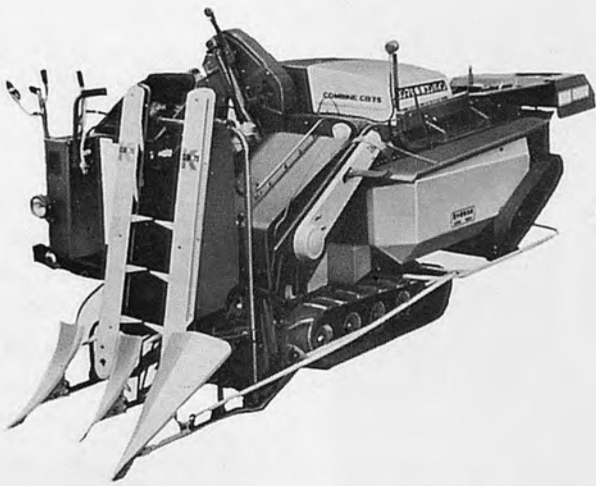

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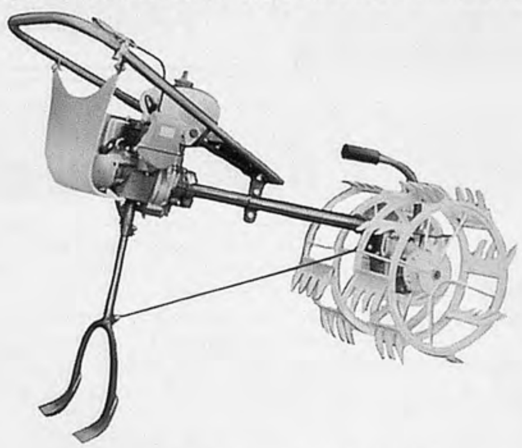

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year	machinery
1928	BEEN OIL CAKE BREAKER
1930	WINNOWER
1932	RICE GRADER
1934	IMPACT HUSKER
1938	HUSKER WITH WINNOWER
1948	STROW ROPE MAKING MACHINE
1950	HAND FEEDING TYPE THRESHER
1952	AUTOMATIC RICE HULLER
1956	FORAGE CUTTER

year	machinery
1957	MECHANICAL FEDING THRESHER
1958	POWER TILLER
1960	BEEN HULLER
1963	WESTERN TYPE THRESHER
1966	SELF-PROPELLED AUTOMATIC THRESHER
1968	PADDY CLEANER
1969	ROTARY POWER WEEDER
1970	HEAD FEED COMBINE HARVESTER
1975	THROWING TYPE THRESHER

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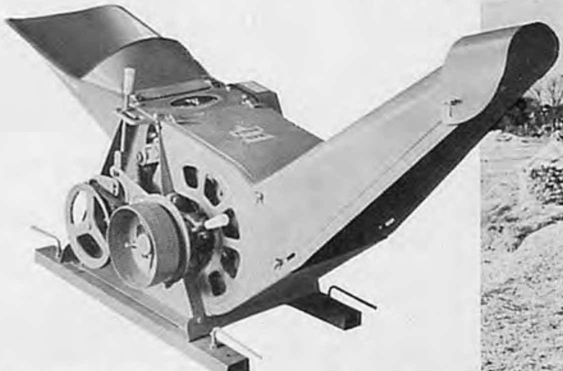

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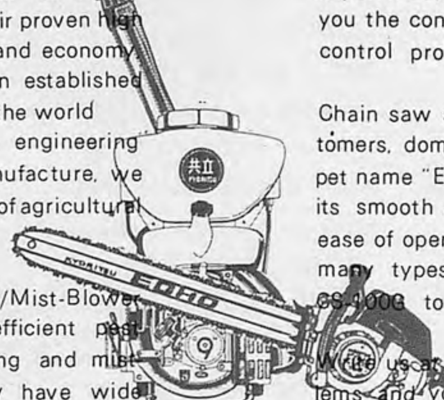

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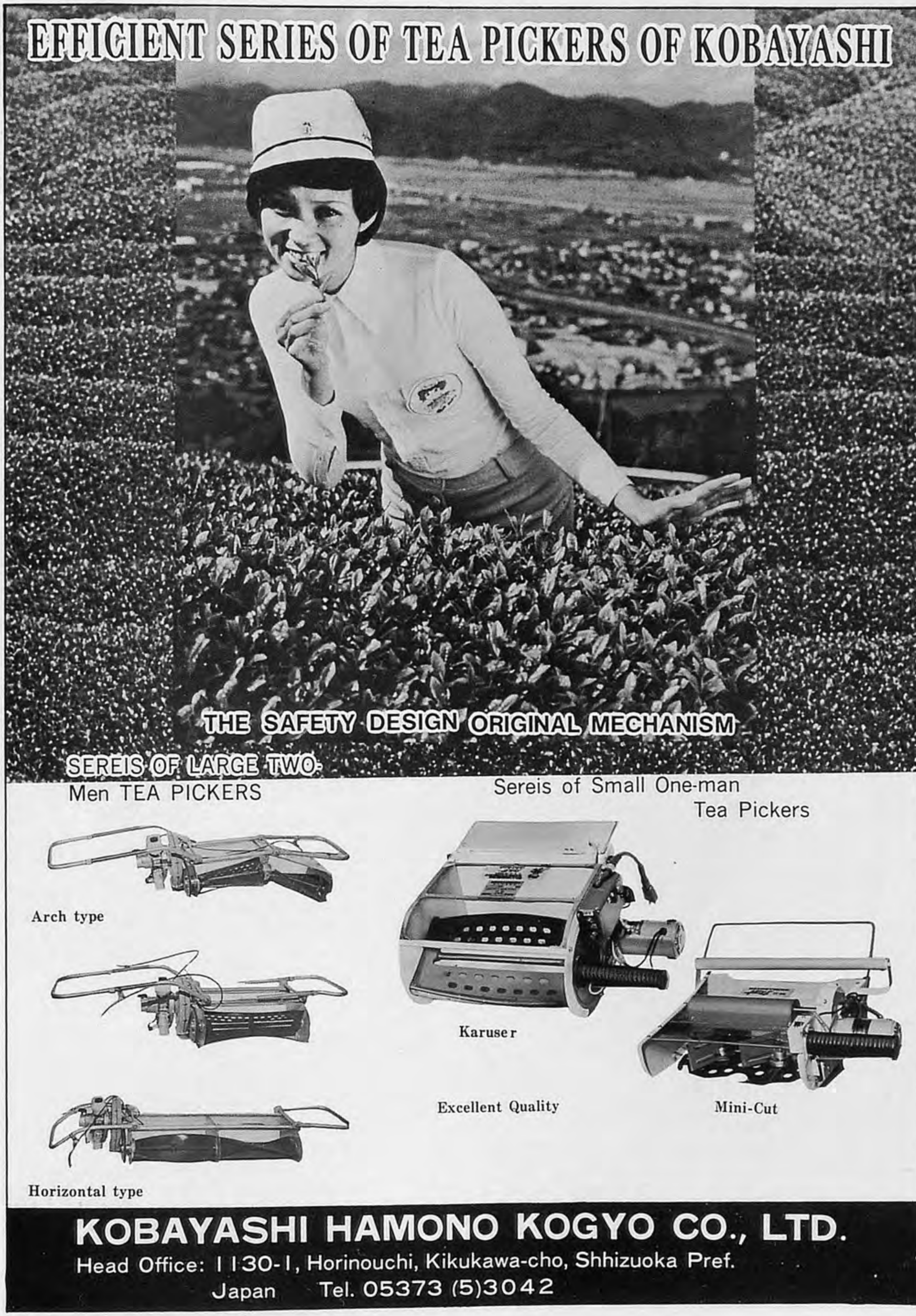
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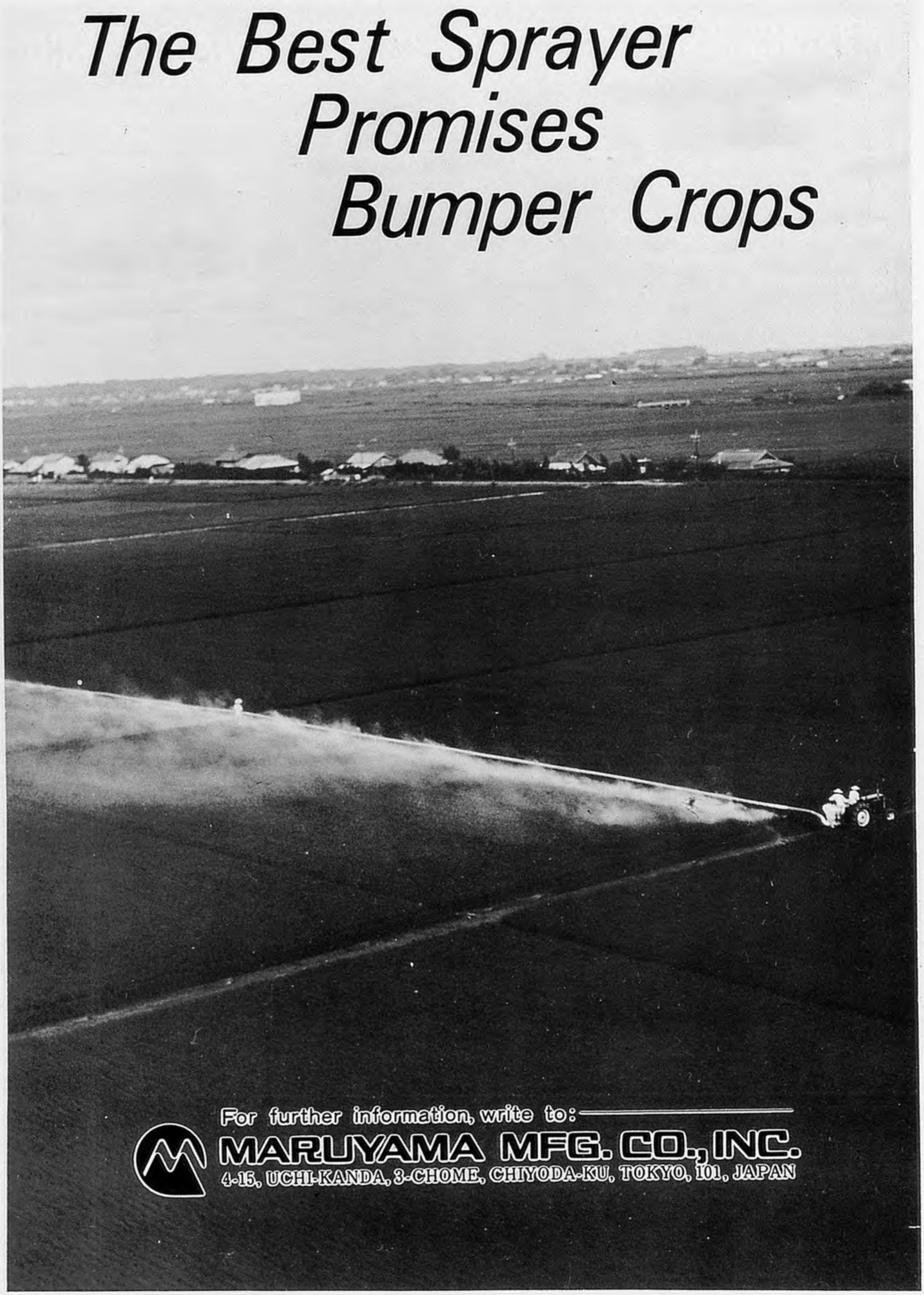
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Summary Report on Agricultural Mechanization and Development in Indigenous Farm Machinery Production in Thailand

by

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Plant production on Thai farms had for centuries been toiled with the use of man labor in form of muscle testers with individual hand tools, eg. big knives, digging hoes, spades, sickles, shoulder bar carriers. Later on, labor saving devices were introduced such as animal drawn plows, rakes or harrows, clot breakers, sledges, winnowers, Chinese dragonwheel pumps attached to wind mills, rice millers. Only a little over half a century ago or after the World War 1, some farm machineries were brought in to Thailand from some European countries. It had been brought to be known to the Thai public only by the late Prince Sithiporn Kridakara who started mixed farming in the southern part of the Kingdom at Bangsapan Yai, the province of Prachuab Kirikhan. During those years, an agricultural school was founded and was known to own few pieces of animal drawn equipment such as gang plows, harrows, planters, drillers, similar to those engaged on Prince Sithiporn's farm. Most of these equipment and machineries were used on upland farms. Some of the well known crops introduced in those days were watermelons, field corn, and some temperate crops of vegetables like cabbages, cauliflowers, celery, beet roots, carrots. Even prior to the Pacific Warfare, not many types of big machineries or equipment were introduced to farming in Thailand, only after the World War II, many types of small, medium and large sizes of machineries were imported for farm use. Hence, the opening of opportunities for talented skilled people came into being. These groups of people were mostly carpenters and metal workers.

Paper prepented at the Workphop on Agricultural Mechanization and Indigenous Production of Agricultural Machines in the LDC. May 6-9, 1975. IRRI Los Banos, Laguna, Philippines.

Development of Small Machineries

The government of Thailand in in 1953 created the Rice Department by the enlargement of the former Rice Section of the Department of Agriculture. The founding of this new department initiated and encouraged a number of research activities under the Engineering Division. Some successful research resulted into low cost water pumps, small 2-wheel tractors mounted with 5 HP stationary engines. Later improvements called for the use of higher power engines of 9 HP. When 4-wheel driven tractors were put out, the power was raised to 12 HP.

Improvements on these machineries came about 10 years ago when the results of these researches were passed over to small factories for commercial production. Thus arose into mass production of small tractors that replaced water buffaloes, when

land preparation was called for in the early part of the rainy season. The shortage of draft animals which resulted from big export of cattle to market like Hong Kong, invited more small tractors on Thai farm, especially in the second plowing or pulvarizing. Of all parts that compose these small tractors only the engines are imported.

Attachments to these small tractors e.g. a set of plow and harrow are normally included in the price of a tractor. Other attachments such as clot brakers, trailers and rubber wheels for transportation and treshing of paddy are also produced locally. Some factories venture to produce attachments for bigger imported tractors of 35-78 HP too.

Commercial Production of Local Made Machine

Truly enough that advancements in the use of modern farm implements lead to the growth in agricultural development as well as the modernization of agricultural techniques. New or modern technique is one of the very important inputs in agricultural produced locally as already mentioned earlier. They are the results of successful researchers. The very first types of implements were centered on the need of wet land farming but do not prevent from making use of such equipment in dry farming, though heavier ones are more suitable. Normally the main farming auxilliaries in use with tractors are disc plows, disc harrows, corn shellers, and trailers. Big tractors are still imported but equipments are locally produced to cope up with approximately 3,000 assembles and imported conventional farm tractors annually during the past 10 years.

At the early stage of production, though with the assistance of research results, manufacturers initiated their production through the modification of imported machines, especially the tillage implements attached to tractors. Experience in the use of these machines by local farmers suggested many modifications to make attachments better adaptable to local problems and needs. Normally, it has been found that local produced machineries and implements cost 30 to 50 percent less than the imported ones.

At present small tractors are more needed by rice farmers, especially in the Central Plain Area which is known to be the Rice Bowl of Thailand. Generally, big imported farm tractors with local attachments are engaged in first plowing that is normally required before or during the first rain. Small tractors follow in the second plowing. The need for small 7-15 HP tractors by individual farmers boosts local manufacturers to increase their output of about 3,000 2-wheel and 800 4-wheel tractors annually. Twenty six plants in the Central Region of the Kingdom are in active production of these tractors.

Type of machine Shops

Appendix 1 Implements among tractor owners studied in Thailand

	Per Cent
Total Tractor Owners Studied	100%
Owners Knowing of :	
Disc ploughs	100%
Mould board ploughs	15%
Disc harrows	58%
Spike tooth harrows	10%
Rotary tillers	32%
Small grain drills	5%
Corn planters check with fertilizer	8%
Rotary hoes or weeders	5%
Cultivators	3%
Corn pickers	3%
Combines	3%
Winnowers	1%
Cotton pickers	1%
Rice threshers	2%
Mowers	2%
Rakes	2%
Balers	3%
Spraying equipment (tractor mounted)	1%
Corn shellers	31%
Trailers	43%
Crop stalk shredders or slashers	4%

Source: Coordinated Industry Study of the Royal Thai Government

Local farm machinery production are of two types.

1. General repair shops

This type of shops generally employs not more than 10 workers. The main function of this shop is to do repairs and maintenance for tractor owners. These shops scattered all over the Central Region with about 6-10 shops in a province. Thus there are no less than 100 shops. Some of these repair shops do assembly job by securing parts and engines for building up tractors according to the orders of their customers in the locallity. Each shop may produce about 10 tractors in a year.

2. Manufacturing firms

Each firm normally employs 10 or more workers. Bigger ones employ up to 60 workers. These firms produce tractors all year round. They do not wait for orders but just keep on putting the machines out to the market. Twenty six of these firms produce no less than 3,000 tractors annually. They produce more than one machine type.

Machine equipment used in tractor production are

1. Lathe machine
2. Electric or acetelene welder
3. Sawing machine
4. Cutting machine

5. Drilling machine
6. Air compressor

These are general for each manufacturing firm. Bigger firms may own Pressing machine, Steel roller and Sprocket wheel cutter.

Each firm trains its own workers through experience and skills from their elders. Thus experience and skill are acquired by long period of apprenticeship.

Materials for manufacturing are mainly mildsteel and iron castings with ball bearings, gears, discs. Other parts are from specialized producers. Only engines are imported.

Manufacturing firms generally produce

1) Two wheel tractors
2) Four wheel tractors
3) Water pumps
4) Disc plows
5) Corn shellers
6) Sorghum threshers
7) Small rice mills
8) Equipment for big tractors such as 6-8 row soil openers, earth moving blades.

Of all the products listed above two wheel tractors, small four wheel tractors and disc plows are most popular. Since the patent laws are not strictly observed, many firms manufacture very similar products that are widely used all over the Kingdom.

Appendix 2 Tractor contractor service in Thailand

Item	Average values
Proportion of labour released by tractor service and subsequently redirected to agricultural intensification	65%
Percent of farmers paying cash for tractor service	64%
Proportion of farmers able to meet tractor charges from new wincome sources	82%
Proportion of tractor contractors that are farmers	90%
Holdings of tractor contractors	130
Average tractor age	3.7
Months of tractor work per year	5.07
Number of tractors per owner	1.71
Drivers per tractor	2.6
Tractor working hours per day	17.2
Field area served per year (single operations)	1,612
Annual operating hours per tractor	1,360
Maximum radius of operation	100
Percent of operating time spent travelling	24%
Percent of working season used for tractor or implement repairs	26%
Annual repair costs per tractor	12,760
Contract charge per rated horsepower hour	0.7
Annual profit per tractor	11,220

Values pertaining to tractors of 45 to 70 horse power.
Source: Agricultural Mechanization in South East Asia P. 59

IRRI-Developed Agricultural machines

IRRI-developed agricultural machines were introduced to Thailand in 1970 but production was put out only 2 years ago. The two outstanding machines are accepted by Thai farmers are power tillers and axial flow rice thresher. Five manufacturers are located in various parts of the Kingdom. They are

1) Anusarn Co., Ltd. 94-120 Chareon Muang Road Chiengmai…Power tiller Axial flow thresher
2) J. Chareonchai 55-57 U thong Road Ayudthaya-…Power tiller
3) Kaset Thai Ltd. Partner-

ship 27 Panutnikom Cholburi···Axial flow thresher

4) Ouppagon 4-4/1 Chaophraya Road Pitsanulok···Axial flow thresher

5) Pramual Kolakij Ltd. Partnership 53 Soi Nugoonton Ngamwongwan Road, Bangkhen Bangkok···Axial flow thresher

Some 300 power tillers have been produced and sold at a cost of $220 per unit without an engine but plow and harrow are included. This is $50 cheaper than a conventional Thai power tiller. Production of Axial flow thresher is being planned by four manufacturers for the next harvest season. Due to the lack of intensive labor during harvesting and threshing season, the six machines that were recently produced made a good performance and impressed many farmers of their high efficiency.

Opportunities for Indigenous Farm Machinery

In addition to problems of credit and capital needs commonly faced by any industries, farm machinery manufacturers need assistance in the field of research and design development. It is neccesary to co-ordinate research and development activities in educational institutions like the relevant government departments and universities with manufacturers, not only for the benefits of any two parties but also the good and reliable machines for farmers.A direct support would be most effective in the form of technical advice that will result in quality improvement of the machine in the long-run. The price of imported equipment is double that of domestic produce. Opportunities have a big openning for the local manufacturing firms to improve their products in competition with imported ones. Any government policy to encourage farm machinery business in Thailand should be directed toward indigenous Thai Manufacturers. ■ ■

Appendix 3 Some farm machinery manufacturers in Thailand

1.	Sing Kru Onsahagum Ltd., Partnership 52—53 Soi Wat Krunai Prapradang, Samutprakarn.	Power tiller
2.	Singha Chai 125 Soi Wat Krunai Prapradang, Samutprakarn.	Power tiller 4-wheel tractor
3.	J. Charernchai 55-57 U-Thong Road Ayudthaya	Power tiller, 4-wheel tractor
4.	Kaset Thai Ltd., Partnership 27 Panutnikom, Cholburi.	Power tiller, 4-wheel tractor, water pump, thresher.
5.	Sahayontra 8/1 Klong 4 Thunyaburi, Patumtani	Power tiller, 4-wheel tractor
6.	Pradityontra Mahajakraphat Road, Chacherngsao	Power tiller
7.	Chaidec Karnchang Mahajakraphat Road Chacherngsao	Power tiller, water pump.
8.	Ayudthaya Tractor 23/4 Near Predeethumrong Bridge Ayudthaya	Power tiller, 4-wheel tractor, Disc plough and Disc harrow.
9.	Chakol Paisal Ltd., Partnership 55/6 Soi Chusunk Bangkae, Bangkok	Power tiller, 4-wheel tractor.
10.	Changkol Thai Suriya 61 Paholyothin Avenue Bangkhen, Bangkok-9	Power tiller, 4-wheel tractor
11.	Cholburi Mungthong Cholburi	Diso plough, disc harrow, trailer
12.	Lert Chai 244/1 Saiku Road. Praputabart, Saraburi	Corn sheller, sorghum thresher, Disc plough, Disc harrow.
13.	Prasert Karnchang 372 Saiku Road, Praputabart, Saraburi	Corn Sheller, Sorghum thresher, Disc plough, Disc harrow, 4-wheel tractor
14.	Prasartporn Praputabart, Saraburi	Corn Sheller, sorghum thresher, Disc-plough Disc harrow, trailer
15.	Nakornsawan Yontarakarn Nakornsawan	Disc plough, Disc harrow. Disc plough, Disc harrow.
16.	C. Manachang Praputabart, Saraburi	Disc plough, Disc harrow Corn sheller, Sorghum thresher.
17.	Limchieng Seng Nakornsawan	Disc plough, Disc harrow.
18.	Anusarn Co., Ltd. 94-120 Charcon Muang Road Chiengmai	Power tiller, water pump, Paddy thresher.
19.	Pramual Kolkij Ltd., Partnership 53 Soi Nugoonton, Ngamwongvan Road, Bangkhen, Bangkok-9	Soybeam thresher, paddy thresher, animal feed mixer.
20.	Ouppakorn 4-4/1 Chaophraya Road, Pitsanuloke	Soybean thresher, paddy thresher.
21.	Siamvitaya 191/12 Satupradit Road. Yanava, Bangkok	Power tiller
22.	Cenglee Karn Kaset 220/1 Sukapibarn Road. Inburi, Singkaburi	4-wheel tractor
23.	Yontrakrumpanich 925/6-8 Praram 1. Road, Bangkok.	Peanut Sheller, Corn sheller, small ricemill.
24.	Aree Karnchang 6 Klongsuan Banpho, Chacherngsao	Power tiller, puddling machine, water pump
25.	Chaithong Motor Hunkha, Chainat.	Power tiller, 4-wheel tractor.
26.	Idea Ltd., Partnership 113/22 Soi chitruam Tivanonda Road. Nontburi.	Soybean thresher, paddy thresher

Outline of the Policy for the Developmenent of Agricultural Machinery in Viet-Nam

by Vo-Sang-Nghiep
Nha Phat Trien Ning Co.
Tan-Dinh-Saigon, Viet-Nam

Besides water and fertilizer, farm machinery must be considered as an important input of agriculture. (Farm machinery is including hand-instrument and equipment, animal draft equipment, facilities for irrigation, plant protection instruments, land clearing equipment harvesting and processing equipment and also 2 and 4 wheels-tractors). In order to accelerate and expand agricultural mechanization activities, the AMD has been reorganized and transformed into Directorate of Agricultural Machinery Development.

Actual situation of farm machinery and its future requirements

(1) Actually, VN has about 3,000.000 ha under cultivation. New objectives of Ministry of Agriculture and Industry aimed at:

-Yield increasing per ha on existing crop land by adoption of high yielding varieties (TN rice).

-Improvement of 500.000 ha of actual local rice by 2 season-crop rice.

-Replacement of 200.000 ha of local rice by TN rice.

On the other hand, the total area of cultivated land will be raised by:

-Bringing about 1.650.000 ha of Ethnic minority people into production.

-Exploiting 500.000 ha of mangrove forest from Ca-Mau to Quang-Tri province.

-Re-exploiting 400.000 ha still not be used because of war.

-Re-exploiting 100.000 ha of forest land.

-Re-exploiting 350.000 ha of virgin land abandoned because of war.

(2) In fact, actually about 1.000.000 HP of farm machinery cannot be enough for urgent need. Besides the vital role of agricultural mechanization will also provide:

-a production low price.

-an exact timing for cultivation.

-a romedy to our shortage labor due to the war.

-a big scale of cultivation for local need and exportation.

(3) Existing farm machinery power cannot meet actual demand:

-Ratio 0.3 hp/ha is too low and ratio 0.004 hp lowest in comparison with other Asian countries.

More than 10 million US dollers spent annually for imported farm machinery from different countries and depending upon the financing system, grant or loan.

-Farm machinery is under-used (maximum 50% of its efficiency and time life).

-Farmer's technical knowledge is low so, they don't use to pay much attention to maintenance and repair problem. Fortunately Vietnamese farmers have ability to accept new technique.

Farm-machinery produced by developed countries did not meet exactly to indigeneous need.

Annual value of imported spare-parts is about 15% of the total amount of imported farm machinery.

Althought, scarcity has been happened from time to time in the local market, specially in provinces.

-Regarding farm industry, local firms meet too many difficulties, shortage of foreign currency, limited consumption and lack of techniques. Netherless, Agricultural mechanization is for GVN a new problem connected with many other consideration (socio-economy, technique, policy and security).

In general, agricultural mechanization has made already some progresses. Now, taking account of these influencing factors: socio-economic, politic, military, technical... and after discussing with many related organization and sectors, Directorate of AMD has studied this new proposal.

Outline of the policy

(1) In response to the urgent need for rural development and under the actual socio economic technical conditions, Directorate of Agricultural machinery development's policy will be based on: Popularity, coordination and self-sufficiency. That means to support farmers, to concentrate all efforts and contribution to exploite intensively the actual national potential and finally to help ourselves by our own facilities. The Directorate of Agricultural Machinery Development will be in charge of the responsability to guide and to support technically and financially private sector.

Its objectives are also:

-To standardize imported and local farm-machinery in coordination with other international institutions for agricultural mechanization.

-To create close relations between government industrialists and farmers in the field of agricultural machinery development.

-To demonstrate and to experiment new farm machinery.

-To promote farmers invention or improvement on imported farm machinery.

-To design, to fabricate, and to promote appropriate prototypes.

-To implement pilot farms for mechanization of agricultural crops.

-To form qualified technicians.

-To train VN farmers on the use of their multipurposed tractor, on maintenance and repair.

(2) In this scope, the Directorate of Agricultural machinery development has studied 6 projects for foreign grant or loan request and 4 for implementation in 1975 with GVN funds:

-Agricultural Machinery Development Center Project.

-National testing and research centre for local and imported farm machinery project.

-Centre for repairing, fabricating and supplying of farm machinery project (first priority of Ministry for Japanese aid request).

-Pilot farm for mechanization of Agricultural crops project.

-Water pump project, financed by Japanese Grant. On the other hand, four other will be realized during 1975:

-Agricultural machinery supporting crop production

-Grain drying and storage project (small scale).

-"Secondary crop Mechanization".

-$VN 10 Billion loan for agricultural mechanization development all the actual potential of the country rather than encouraging importation of sophisticated farm machinery from overseas as before.

Beside, the Directorate of Agricultural Machinery Development has already published and distributed to manufacturers and farmers some primarily projects to promote investement and to provide rural service (water pump, dryer, rice-miller, corn shellers, regional farm machinery repairing center).. In order to carry out these programs, the Directorate of Agricultural machinery development has been strenghtened with 22 qualified farm machinery and mechanical engineers.

Conclusion

With its new policy, the Directorate of AMD will try to set up a solid basis for agricultural mechanization and hope to bring to VN farmers higher income, easier working conditions and higher standard of living in the rural areas. ■ ■

(Continued from page 104)

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"At The IRRI International Conference"

by
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During 6 to 9 of May, 1975, The International Conference on "Agricultural Mechanization and Indigenous Production of Agricultural Machine in the LDC" was held in The Rice Research Institute at Los Banos, Laguna of the Philippines. About sixty specialists on agricultural machinery came from over twenty countries and discussed very eagerly. It was said that if agriculture was machanized, there would be a problem of unemployment because of over-labor. In the developing countries, however, such a opinion has disappeared and the interests in agricultural machinery have increased. People have recoginezed the importance of the agricultural mechanization.

Now, another problem came to us, that is to say, the problem of production of agricultural machinery by the developing countries themselves. In the developed countries, there is no country in which agriculture has successfully developed without a domestic agricultural machinery industry. As agriculture has complicated features according to the difference of countries and regions, it is necessary that the production and the research and development of agricultural machinery should take root to its country.

The agricultural machanization of developing countries has developed by importing machinery from the developed countries or application of imported machinery so far. Although they impelled agriculture toward the agricultural mechization, we have various problems on the supply of the parts, the form of farmers, the agricultural condition, the distribution system and so on. Now we were deadlocked. Meantime, agricultural machinery have begun to be produced in the developing countries. At the beginning the simple farm working machinery were produced and recently even the engines. But various problems still remain.

It is the feature of this conference that not only the engineers who are engaged in the research institute of university but also the manufacturers, importers and other people who work for agricultural mechanization took part in and especially discussed on the various kinds of problem of production in small, middle, and large scale. We saw the demonstration of machinery

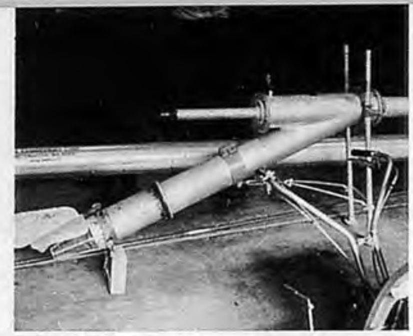
Design room of Agricultural Engineering Dept. of IRRI

IRRI Agricultural Engineering Dept. Workshop

Proto type of IRRI Power tiller with steering clutch

Demonstration of IRRI Power tillers

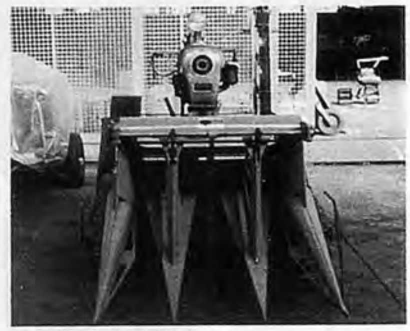
Proto type of 4-wheel tractor which can be locally produced



IRRI jet-flow pump

IRRI liquid fertilizer applicator

Granular fertilizer



Proto type of IRRI rice combine harvester

designed by IRRI and visited its Agricultural Engineering Department in the interval of reporting the papers from every person's standpoint. The Agricultural Engineering Department which is led by Dr. A.U. Khan has studied the new machinery one after another which were able to be produced in the developing countries. Dr. A.U. Khan insists that for developing the agricultural machization, we would rather produce practical machinery and send to farmers as many as possible than any theories. At present, the manufacturers and distributors should be required to produce machinery and send them to farmers as many as possible in the developing countries. As a start for that, we should design machinery which bring profits to the manufacturers at making, the distributors at selling and the farmers at using. In a small market, not the mas production system of developed countries, we sould design proper machinery by using materials, machine tool and technology that they can get in the developing coutries. At IRRI, they have studied the research and development of machinery on the basis of this idea.

As a result of this, there were a few failures, however, in the passed several years, more than

Proto type of IRRI rice combine harvester

Proto type of IRRI Dryer

Demonstration of axial flow thresher designed

New separating unit for IRRI designed thresher

Power unit for transportation and thresher designed by IRRI

IRRI new grain cleaner

to manufacturers which produced the simple tiller by IRRI and the throw in type thresher, were established in the Philippines at least and they are expanding. It is said that the research and development activities of IRRI gave the large impact to the agricultural machinery imdustry of the Philippines. Furthermore, the impact is about to spread over the other Asian developing countries. The research activities of IRRI are neither high-technical nor difficult. They are rather simple. But the staff are choosing the needs which nobody study.

We visited several manufacturers making agricultural machinery disigend by IRRI in Manila. We found there that the improvement of orginal design by IRRI have done by the manufacturer itself. For instance, the tiller of MARSTEEL CORP. is a good example. The transmission case have already been made of steel by press and the tiller with sidecluch is going to be sold in this September. From these examples, if they start from the developed technolgy in the passed several tens years and what they can do by themseleves, even if it would be seen very slow, we will notice it will take less time to overtake than the time of developed countries. Because there are examples of the developed countries.

We also visited the factory making three jeepny bodies and two finished jeepnies, the total five jeepnies with three hundreds persons a day. We cannot belive that making five jeepnies with three hundreds persons a day pays well. According to our figuring, however, it is ture such companies get great profits in the Philippines. We should adjust the form of production or the design of machinery according to the process of development of each country. This jeepny factory is just a good example.

Although the conference was very short time, the participants were greatly impressed and learned something. The conference succeeded. We also discussed on the problem of how to transfer the passed informations, technology and talent of the developed countries to the developing countries before losing them.

I think we should have another chance to discuss on these problems.

Power tillers with B&S Engine made by P.I. Industries at Manila. This company produce more than ten units a day. Many power tiller manufacturers are appearing in the Philippines in last few years

Improving of IRRI Desinged Thresher at IGRI Industrial Sales Corp.

Mass production of power tiller at MARSTEEL CORP. in Manila

OHTAKE MINI-CULTI for weeding, which was originally designed by IRRI

Threshability Test for sorghum at KAUNLARAN INDUSTRIAL SHOP. This company started this production only about one and half year ago and growing successfully

Labor intensive automobile (Jeepney) production about 300 workers produce five unit of jeepney per a day. This is really very profitable business.

PROGRAM

May 6, Tuesday
Welcome address N. C. Brady
Slide presentation on IRRI's comprehensive program
Office of Information Services

SESSION I.
Chairman-Dante B. de Padua
Objectives of the workshop
A.U. Khan
The role of mechanization in developing intersectoral linkages
B. Duff
The IRRI machinery development program and its strategy
A. U. Khan

Rice milling machinery development in Asia

C. C. Lee

SESSION II.

Chairman-Loyd Johnson

Corporate farming in the tropics

E.A. Uichanco

Appropriate technology for developing countries

C. Follosco

Tour of IRRI Ag. Engineering Department & Machinery Demonstration

May 7, Wednesday

Full-day field trip to IRRI machinery manufacturers in Manila area

May 8, Thursday

SESSION III.

Chairman- C. Follosco

Commercial credit program for small-and medium-scale industries

S. Rzonka

Programs of assistance to small- and medium-scale manufacturing firms

L. Chico

Technical consultancy for rural industrialization in Ghana

B. Ntim

Local production of aircooled gasoline engines in Sri Lanka

N. Jinasena

Aircooled gasoline engine production in Thiland

A. U. Khan

Small-scale production of diesel engines in Pakistan

S. Ansari

SESSION IV.

(Seminar Room, C. H.)

Chairman- Fred E. Nichols

Rice mechanization developments in Thailand

C. Chakkaphak

Farm machinery market research and product planning

E. Fredriksen

Historical review on development of "Minicultivator" by Ohtake Seisakusho Co., Ltd.

Y. Kishida & T. Matsunaga

Cooperative manufacture of IRRI power tiller in Sri Lanka

M. D. P. Dias

May 9, Friday

SESSION V.

(Seminar Room, C. H.)

Chairman- E. A. Uichanco

Indigenous production of threshers in India

S. Patel

Profiles of the agricultural machinery manufacturing industry production & marketing strategies: large firms

L. G. Bernas

Growth strategy for small farm machinery manufactring

A. E. Dungo

Discussions of IRRI machinery manufacturing problems

S. Patel, B. Ntim, Yuwono, S. Habib, K. Attah, T. Caubang, R. Lahoz, C. Viaplana, N. Jinasena, M. D. P. Dias

SESSION VI.

(Seminar Room, C. H.)

IRRI cooperative industrial liaison program

B. Duff

Future cooperative industrial extension -- discussions

Summary and recommendations

Committee to be appointed

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(Continued to page 104)

PRODUCT NEWS from Various Counties

Show(S.I.M.A.) in Paris

The 46th International Agricultural Machinery Fair (S.I.M.A.) was held in Paris of France for a week during 2—9 of May, 1975. The S.I.M.A. Commitee For The Promotion Of Technical Research was organized for the Fair. Before the opening, the committee selected the most efficient agricultural machine and did honor to it. The he committee held in the 5th of December, 1975.

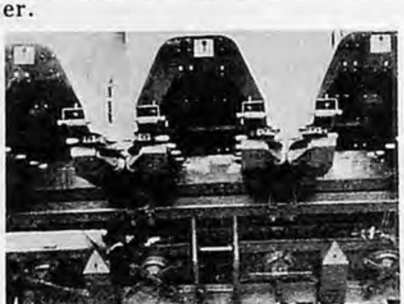
Sprayer with active ingredient dosage proportional to treated area.

When main working features of sprayer have to remain unchanged during treating operations, pressure has to continue constant. Changes are made in the mixture concentration to obtain a constant dosage of active ingredient in case of travel speed variations. For this purpose a variable displacement pump, land wheel operated and liable to be adjusted, takes in superconcentrated spray mixture from a special tank.

Torque is insignificant and none the slippage for the pump output is very low, thus the pump is driven proportionnally to covered distance. Superconcentrated spray mixture is diluted under pressure into a given quantity of water so as to obtain the best possible coverage.

With this system safety surdosage are needless, the use of active ingredients disminished and contamination reduced.

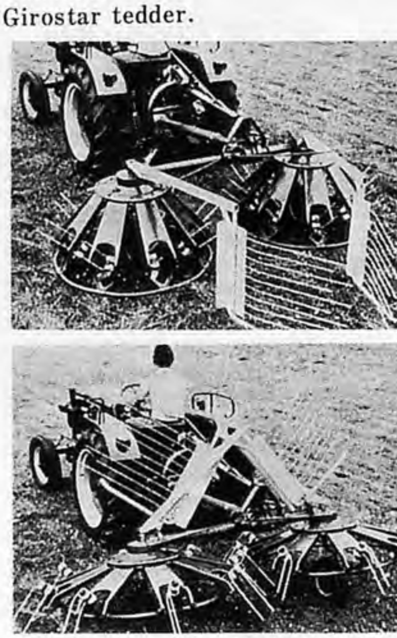
Stalk shredder for maize header.



A vertical axle rotary shredder with 4 articulated bladed arms rotating at 1600 rev./min. is fitted under every row of a maize header attachment. Power requirements for 4 rows is of about 14 metric horsepower.

The adjustment of shredder's height is independent of the one of the maize header attachment and is carried out by means of a quick-coupling flexible suspension and some wire ropes operated by the driver of a tractor. For turning and transport operations both shredder and maize attachment are locked and litted up. The shredder can swing away in front of an obstacle. Better possibillties of adhesion and of holding capacity are obtained with the swath of shredded materials left by the machine.

Girostar tedder.



Double purpose machine designed for turning and windrowing the crop from a conventional 2-rotor tedder:
—for tedding, tine arms are slightly vertical to ground and for swathing, are placed horizontally;
—for windrowing, rotor's dia. becomes smaller to prevent tine intersection;
—for tedding, tine arms are set in fixed position while in swathing tine arms follow ground undulations.

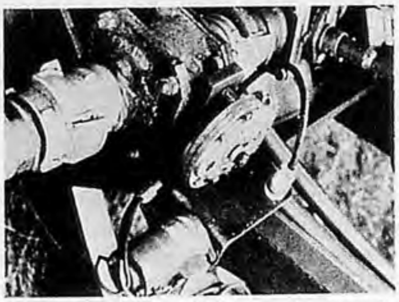
Change is lever made. Tine arms articulate on crakshafts connected to rotor's flaps.

Flaps are disengaged for tedding and they open to set tines in vertical position.

Flaps are closed for swathing to disminish rotor's dia. and, as rotor revolves, tine arms are disengaged in horizontal position by centrifugal force.

The tedder is lever locked for both working positions. Anticipated tilt angle of tine arms avoids any further adjustment of ground wheels.

Electronic adjustment of spraying.



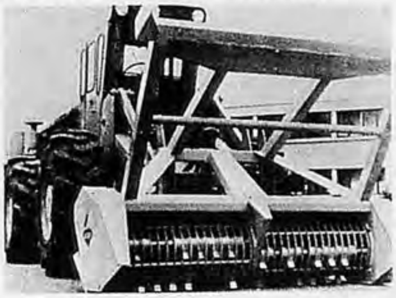
it is question of an electronic computing unit actuated by the pulsations of a non-sliding wheel which automatically controls pressure in terms of travelling speed, nozzle orifice diameter and volume/hectare.

Information obtained from the computing unit are displayed on the dashboard to give messages to tractor's operator to know if he needs to accelerate or slow down for reaching the intended output/hectare when once he has set pressure, nozzle size and eventually viscosity of the liquid.

"Aebi" hillside tractor.

Four-wheel drive tractor, 43 DIN HP, low barycentre and front and rear lift and hichting systems, fitted with a rotary mower liable to work at 12 km/h in 45% to 65% gradients. Other conventional hillside ancillary equipment such as a rear axle driven low trailer can be adjusted. Tractor's seat can be correctly set according to working gradients and cladded with a safety cab.

Self-propelled stalk cutter.



Four-wheel self-propelled implement carrier, 230 metric horsepower, articulated, suitable for forest husbandry operations and equipped with winch and front mounted high speed (up to 2000 rev/min) hammer rotor.

Rotor and travel speed are hydraulically actuated. When the cutting task becomes difficult the machine slows continuously down from 3 to 0 km/h shifting the whole power to the stalk cutter. Movement is reversed by operating a pedal. Work width: 2.40 m and height range: from 0.40 to 1.10 m. Road travelling speed: up to 23 km/h.

England

New 91 hp david brown tractor

David Brown 1412 91 hp tractor with turbo charged diesel engine giving instant controlled power. Equipped with the patented David Brown Hydrashift Semi Automatic Transmission providing full power clutchless gear changes and the single lever-choice of four services selectamatic hydraulic system.

A multi-speed power take off unit is filled to this tractor.

This allows heavy or light PTO operated implements to be driven at precisely the most efficient and economical speeds.

The new model is supplied with 10001b of chassis ballast weight mounted in a carrier frame. The David Brown Weather frame is available in three versions as an unclad safety frame; with metal cladding; or with a combination of medal and soft cladding.

David Brown Tractor Ltd.
Meltham Huddersfield England
HD7 3 AR

The hydra-shift transmission unit

The David brown 1412 91 hp

tractor is fitted with the patented hydra-shift transmission unit. This enables the operator to make gear changes quickly and effortlessly when ever the engine load varies. A single range lever selects the appropriate working range: creep., field., road or reverse. Then the use of the hydra-shift control lever on the instrument panel gives on-the move cutchless changes in any of four ratios.

David Brown Tractor Ltd.
Meltham Huddersfield England
HD7 3 AR

The leyland 2100-100 h.p. tractor

The most important feature of the 2100 is the incorporation of a six-cylinder engine. All well-known characteristics of six-cylinder engines combine to give a quieter, smoother performance than any other power unit currently available in the high horsepower tractor class.

The 2100 is two-wheel-drive tractor and this model has been designed specifically for the big-thinking farmer who wants faster cultivation and a higher PTO output.

The 2100 is capable of handling high-capacity forage harvesters, rotovators and other equipment where the primary need is power.

British Leyland UK Ltd.
Bathgate, West Lothian, Scotland
England

The leyland 154-25 h.p. tractor

The 154, a lightweight tractor with built-in big tractor features, its compact design and high manoeuvrability making it ideal

for agricultural, horticultural and municipal work. As its heart is a 25 h.p. four-cylinder diesel engine, smooth running and easy to start in all weathers. The narrow-track model has been designed specifically for confined width row work, and has an overall width of only 46.5 ins (1181mm). The 154 has powerful two-speed PTO, and implements available include those for ploughing, spraying, loading and mowing. And there is a 28.4 h. p. petrol unit as an option.

British Leyland UK Ltd.
Bathgate, West Lothian, Scotland
England

France

Pneumasen II-fully pneumatic precision seed drill

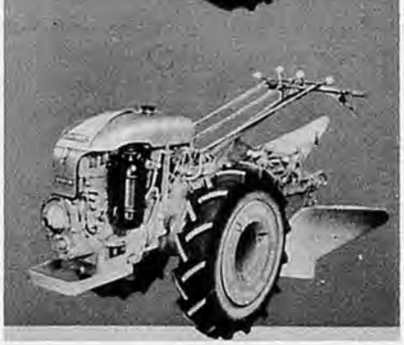
Without any modification, Pneumasen II will sow all categories of seeds, whatever size, whatever variety, with constant accuracy. Lengthy and complicated adjustment are no longer necessary with Pneumasen II.

It takes less than five minules to change from 1 seed to another. The secret of this unequalled performance lies in a new method of pneumatic distribution which necessitates only one disc for all the different sorts of maize.

It is the heart of the drill and the reason for its unbeatable accuracy. For the ability to sow quickly and without wasted time is not everything.

NODET-GOUGIS
77 Montereau- France

Staub walking tractors



The PP 4 B (Photo: Above), 7 metric H. P., petrol and the PP 4 HD (Photo: Below) 8 metric H.P., Diesel. These machines are a perfect subsidiary of agricultural tractors for small-scale farming.

Handiness:

- —Adjustable handlebar to any position
- —Automatic clutch with brake
- —Reverse gear
- —Three forward gears ensuring an exceptionally easy drive
- —The perfect equilibrium obtained with additional weights allows to deal comfortably with any kind of work

Versatility:

- —The most improved general

purpose hitch ensures a quick attachment of a complete range of agricultural implements

- The front hitch for multi-row cultivators allows an accurate tillage between narrow rows
- The fron and rear p.t.o. shafts drive a whole range of implements either for field work or stationary one.
- The wheels of different dimensions adapt the walking tractors to the widest possible range of works and types of ground.

SOCIETE DES TRACTEURS & MOTOCULTEURS "STAUB"
25, boulevard de Verdun
92-Courbevole-France

The staub 2000 motor hoe

The "STAUB 2000" means means more than a simple driven tiller.

With the "STAUB 2000" gardening is a real pleasure. The most difficult operations —digging—are carried out free-and-easy and by no means represent either a weary or an aching duty. After a run of the "STAUB 2000" a soil layer of 30 cm. depth is finely pulverized and ready to be seeded or planted.

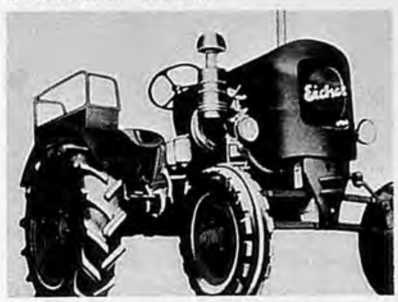
Designed to deal with any gardening tasks, the "STAUB 2000" can be converted in few minutes into a: walking tractor, motor mower, lawn mower, pump, self-propelled wheel barrow, roller, hedge trimmer, fore-carriage with trailer, power saw, etc.

The original feature of the "STAUB 2000" lies in using always the same reduction gear (patented system), therefore the expenses are less. Whatever conversion into two-wheeled tractor or motor mower is carried out the running equilibrium is kept as well as the synchronsing between speeds and work.

SOCIETE DES TRACTEURS & MOTOCULTEURS "STAUB"
25, boulevard de Verdun
92-Courbevole-France

India

The eicher tractor



Eicher tractor manufactured in technical & financial collaboration with Gebr Eicher, West Germany, has a powerful 26.5 h.p. single cylinder air-cooled Eicher diesel engine. Eicher's fuel consumption is the lowest in the world and also maintenance cost is negligible.

Eicher is modern yet simple in design rugged in construction. The tractor has 6 forward speeds and 1 reverse speed with differential lock Foot-brake which are also steering brake operate on rear wheels. Hard brake is provided for parking.

The only Tractor which starts easily with hardle & hence makes self starter optional.

Eicher Tractor India Limited
New Farrdabad 121001 Haryana, India

The escort 335 tractor

Escort 335 is middleweight tractor mounted URSUS C—312 engine, 2 cylinder diesel water-cooled, 35 h.p. at 2200 engine r.p.m.

The features of this model are as follow :

1) Centrifugal oil filter that never needs replacement.
2) Automatic depth and draft control.
3) Separate gear levers for low and high speeds.
4) Electric lights, self starter, horn, hourmeter, all controls within easy reach.

Escorts Limited
Farm Equipment Division
18/4 Mathura Road, Falidabad (Haryana), India

The escort paddy puddler

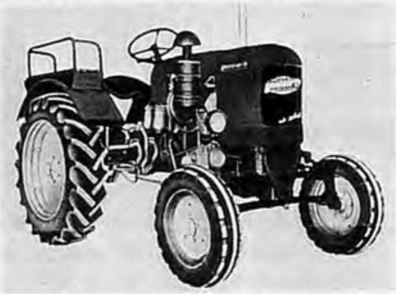
Designed for quick and efficient soil preparation for paddy cultivation in wet land. Especially effective when working in fields deep in water or when in soft, muddy soils. Soils. Special steel cage wheels are provided which help the escort paddy puddler to maintain a high-level balance in relatively deep, wet, swampy fields; the combined effect of buoyancy and traction from the pneumatics with additional support from the extensions allows optimum puddling performance. An even puddle, excellent burial of grass and green stalk result, with maximum economy of operation.

Principal dimensions

Model: EI/34, Length: 705 mm, Width: 2310 mm, Height: 1050 mm, Weight: 191kg, Working Width: 2150 mm

Escorts Limited
Farm Equpment Division
18/ Mathura Road, Falidabad (Haryana), India

Goodearth air-cooled tractor



Goodearth Tractors have conclusively proved to be the most economical and dependable tractors for farmers, municipal and general haulage in mills, mines, factories, and for community development.

Their extremely high pulling power, and reserve power, enabling use of comparatively heavy implements without loading the engine, their exceptionally low fuel consumption and other outstanding features mentioned below, provide a powerful yet economical tractor for all cultivation and haulage jobs.

Outstanding features:

1) Lowest Fuel Consumption in the World.
2) Negligible Cost of Maintenance and Repairs.
3) The Goodearth has a Perfect Air-cooled Engine.
4) Unique starting system.
5) Frameless Design.
6) Rugged, Sturdy Gearbox.
7) Differential Interlock.
8) A most comfortable spring seat.
9) Hydraulic Lift and 3 Point Linkage.

GOODEARTH PVT. LTD.
(EXPORT DIVISION)
Sunderson Court, 16. Asaf Ali Road, Delhi-1 India.

Japan

Robin bush cutter

Model NB03C (Photo: Above) and NB04C (Photo: Below) are the ideal bush cutters designed and manufactured by mobilizing experience accumulated for many years and unique technique by Fuji Robin.

This traditional technique is reflected in cutting force, easiness to use, durability and design of the mowers.

For grass mower, use Model NB03C (30.5cc, 6.5kg) and for powerful high performance in forestry, use Model NB04C (37.7cc, 6.7kg).

Both new models have following features.

1) Compact, light-weight and good balance
2) Adoption of 2-port type carburetter for no place to engine
3) Gears can withstand long use and high speed revolution
4) Adoption of unique automatic centrifugal clutch
5) Hook the shoulder band according to the operation and physique

FUJI ROBIN INDUSTRIES LTD.
Shinjuku Bldg. 1-8-1, Nishi-shinjuku, Shinjuku-Ku, Tokyo, Japan

Kaneko F.D.A. system-120

FDA system adopts the two--step-drying system which divides the process into two steps of Pre--drying and drying.

First of all, the floating dryer system is adopted for the first time in the industry as Pre-drying. Consequently, it deals a large amount of unhulled rice in a moment and in succession, and take away moisture at once. Besides that, the floating dryer has the feature that drying capacity is so large as compared with the size. (EX. The 7.5t floating dryer can take away 280 kg moisture on an average per hour. This is equal to 7-10 dryers of 2t dryer, though the 4m² size dryer. Furthermore, as continuously dealing, it takes grains smoothly, and also discharge straw. The floating dryer has the function of selection.

How about drying?

This is the first, large circulation dryer in our country, which can dry 15t unhulled rice at once. The dryer that is used the most in Japan is the circulation type, which has a lot of features. Since it drys little by little by low temperature and a large quantity of wind, there is no need to worry about uneven-drying, over-

-drying and incom-pleted-drying. It completely drys in quality. This is the big feature of the floating dryer.

In case of drying for long time, stop the circulation. You can use it as the layer type. If you will fit up it with the humidity control devise, it can drys evenly with time, not to over-dry, even if moistre is differnt between the first and the later unhulled rice.

KANEKO AGRICULTURAL MACHINE CO., LTD. 2-21-10, Nishi, Hanyu City, Saitama Pref. Japan

Konma combine-model CB75D

Konma Combine harvester installed revolutionary MCP engine. This is semi-diesel engine which combines the merits of both gasoline and diesel engine. The reliability is extremely high. The fuel cost is low.

The cutter can be seen from the driver's seat, which is on the front part of the machine. Cutting, threshing, moving and any other operations are all easily done, as levers are located within easy reach.

With special crawler it gives outstanding operation even on wet fields, and stable, efficient harvesting is always assured. The crawlers on the right and the left move independently of each other. For rotation, just pull the steering lever. Mobility is excellent.

Cutting is available on any part of field. There's no need to cut by hand.

The Combine with a special design stalk raising device can raises and cuts even plants that are leaning 85°.

The cutting heght (4-20cm) and supply depth (60-140cm) can both be simply adjusted.

Combine performance is greatly enhanced by using a thresher developed especialy for this combine. Can work 8-12 ares per hour.

KONMA SEISAKUSHO CO., LTD. 4-26, Izumicho, Tsuruoka City, Yamagata Pref. 999, Japan

Matsuyama animal Plow-Reversible type "GEM-3"

Matsuyama animal plow has many exclusive features as follow:

1) It is a soil-turning type not to be an old soil-opeining one.

It can be used for both common field and paddy field.

2) It is of wood and steel, so it is very light yet strong.

3) The special steel share lessen the soil resistance in a high degree, so animals are not tired and a deep plowing can also be done.

4) As the dynamic stability of plowing condition is exceedingly tranquil, it is very esay to handle, and so you don't feel tired.

5) It is useful for making better physical and chemical soil texture that furrow slices are entirely turned into wide opened furrow.

Rending and impact which act upon the furrow slices by plowing heighten the harrowing effect and especially physical soil texture better, and moreover the entirely turned furrow slices are effective to retard the growth of weed.

Specifications

Dimensions (Length × Width × Height): 150cm × 30cm × 102cm, Weight: 17.5kg (Steel parts- 13.5kg, per one set), Plowing depth: 9-15cm, Plowing width: 13-16cm, Capacity: 3-4 a/h.

MATSUYAMA PLOW MFG. CO., LTD. 2949, Shiokawa, Marukomachi Nagano Pref, Japan

Star mower—HBK 130D

Star mower is suitable for mowing not only meadow grass on the flat but also weed on the hillside and slope.

The construction of Star mower is very sturdy original mechanizm. The hand tractor is designed to use of mowing, and it is equipped with two wide tires. The cutter bar is guardless, and the knife bar is supported with four needle bearings.

Specifications

Dimensions (Length × Width × Heigh): 2,240mm × 1,370mm × 1,040mm, Net weight: 160kg, Working width: 1,295mm, Nos. of knife: 17 pcs, Working height: 40 to 80mm, Working capacity: 25 to 35 a/h, Mounted engine: Air cooled gasilon engine of 3.5 to 4.5hp

STAR FARM MACHINERY MFG, CO., LTD. 110, 6-chome Toyohira 3-Jo, Toyohira-ku, Sapporo-City Hokkaido, Japan

Hinomoto E23-25hp Tractor

Hinomoto E23 has introduced to meet farmer's middle-sized tractor needs. This model has removed all the drawbacks of conventional middle sized trac-

tors. The result is a machine with every necessary quality created through in spired technology.

Hinomoto E23 has so many exclusive features to do better work, as follow:

1) Powerful diesel engine displaces 1263cc.
2) More-than-adequate speed differentiation with 12 foward speeds and 3 in reverse.
3) PTO speed are independent of tractor speeds.
4) Top in its class, top in maneuverabilhty with a minimum turning radius of 1.7m.
5) One-touch linking for fast attaching/detaching.
6) Raise and lower the attachments in accordance with hydraulic lever.
7) Lifts up to 1500kg.
8) Luxiropis and comfortable suspended seat for fatigue-free operation.

TOYOSHA CO., LTD.
55, Joshoji-16, Kadoma-City, Osaka, 571 Japan

Philippines

Kalayaan productions developed by I.R.R.I.

Manual Weeder is very popular in the Philippines because of high cost of herbicides.

Row Seeder can plant I hectare in 8 hours.

Grain Cleaner can clean as much as 4000 kilograms of rice grains per hour.

Batch Type Grain Dryer has a capacity of 1500 kilograms, 20%-14% moisture removal per 4 hours.

Axial Flow Thresher ready for delivery

KALAYAAN ENGINEERING CO., INC. 4255 Emilia St., Makati, Rizal Philippines

U.S.A.

Allis-chalmers 7080-180 hp tractor

The 180 PTO hp Model 7080 tractor leads the new line of farm tractors introduced by Allis-Chalmers Corp., and is the largest two-wheel drive farm tractor manufactured in the United States. The 7080 is being marketed as part of the company's program of total committment to supply the equipment needs of the large farmer in the field of world agriculture. Powered by a turbocharged 3750 Mark II six cylinder diesel engine, the 7080 is capable of handling the toughest field operations. Some of the tractor features are: a 20 speed Power director transmission; fully independent PTO with safety braking system; 47 gpm hydraulic system consisting of three separate circuits; load sensitive system to match horsepower requirements to demand; "new family" styling making maintenance easier and more convenient; and the Allis-Chalmers quiet, comfortable, safe (QCS) cab as standard equipment.

ALLIS-CHALMERS CORP.
Milwaukee, Wisconsin 53201, USA

Allis-chalmers Air Planter

The new air planter introduced by the Allis-chalmers corp. features the shortest seed drop available on the market, standardized plastic disc which handle a wide variety of seed grades and brands, only one eletric motor /blower for every two or three

planter units, the versatility to plant a variety of row widths and the flexibility to use either conventional, minimum or no-tillage planting methods. The simplicity of design of the new planter will cut operation costs of initial purchase items, maintenance and reduce downtime.

ALLIS-CHALMERS CORP,
Milwaaukee, Wisconsin 5320 I,
USA

The 2670 Case 4-wheel-drive tractor

Case foresaw today's need for faster farming, adaptability and lower operating costs—designed our 4-wheel-drive tractors specifically to meet this need.

With the 2670 4-wheel-drive you have 256 turbocharged horsepower at your command. An engine intercooler condenses air to increase air intake and deliver increased power output. Incidentally, note how few 4-wheel-drive tractors offer the power-boosting benefits of turbocharging.

Case was the first manufacturer offering 4-wheel-drives with 12 speed range power shift. There are 4 easy shift, constant mesh ranges with 3 on-the-go speed choices in each range.

The 2670 have torque-proportioning differentials...a Case feature that improves traction, lengthens tire life. Add to this, independent power takeoff to handle today's big choppers and shredders, and Category III 3-point hitch with 10,000 lb hydraulic lifting capacity.

Tops in comfort and protection, Case air conditioning is standard on the new 2670 as is the security of a Case-built 4-corner protective frame cab. 4-way-steering is a real asset in row. crop country where it handles just like your present 2-wheeler—and on hillsides where crab steering offsets sidehill drift.

J.I. CASE CO.
Racine, Wisconsin 53404, USA

Long 445—41.9 PTO hp. diesel tractor

The Long 445 is precision engineered for outstanding quality, performance and economy.

Heavy-duty three cylinder engine with four main bearings, induction hardened crankshaft, designed to give years of maintenance-free, smooth-running service.

Included at no extra cost are special features such as: Live PTO, 6 forward and 2 reverse speeds, 3-point hitch with draft and position control, automatic depth control, differential lock, hand and foot throttles, parking brake and full lighting. With the Long 445 you get more horse-power and more quality per dollar than any other tractor in its class.

Take a close look at the Long 445 and the other models which round out the line of highest quality products at the lowest possible price.

Long. We're the other Blue Line.

Long Mtg, N.C. INC.
Torboro, N.C, USA.

Long rotary tiller—model 1537

Ideal for pulverizing and mixing soil without plowing.

Cut weeds and turn them under soil.

Mix fertilizer with soil for vegetable gardens, lawns, fields.

Break up clods for smooth soil surface.

Operates with tractors in the 30-50 h.p. range. 48 cutting blades shaped for maximum efficiency. Tills to a depth of 4 ¾ ".

PTO drives telescopic shaft and helical gears give positive performance.

A demonstration of the versatility and efficiency of this rotary tiller will prove that quality is available at a low price.

Specifications:
Working width...63", Working depth...4 ¾ ", Length...55", Width-...63", Height...38", Weight...450 lbs.

Long Mfg. N.C. INC.
Torboro, N.C., USA.

BACK NUMBERS

◇ ◇ ◇

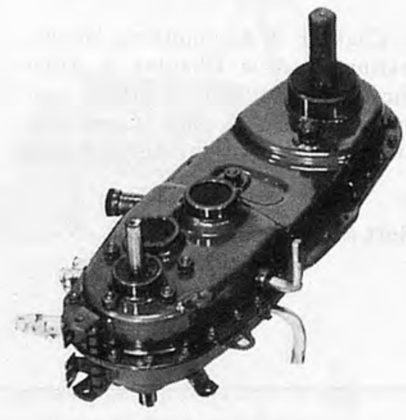
◇ ◇ ◇

INDEX TO ADVERTIZERS

Mametora, get highest appraisal in the world

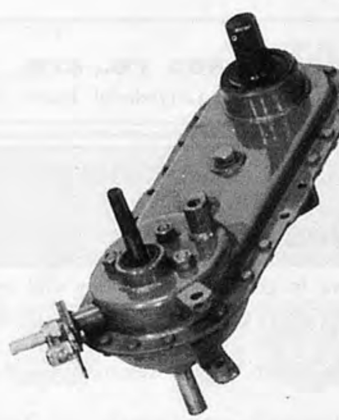
MAMETORA MACHINERY CO., LTD. is one of the biggest manufacuters of small type machines (Power Tillers) in Japan. Power Tillers have been developed so unipue that they perform efficiently. The feature is the efficient transmission in the design.

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

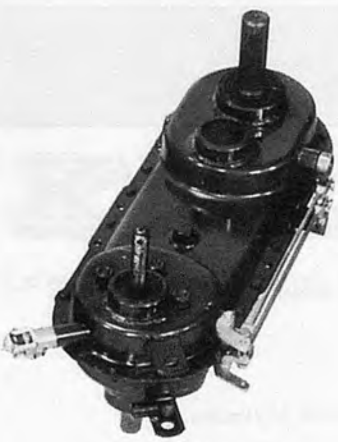


HMD-250

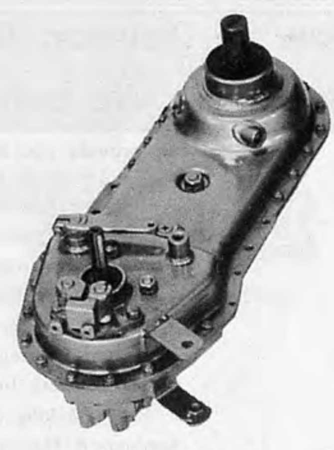
PM-350



CMC-180



SKD-II



PMC-II

TYPE	PS	SIDECLUCH	GEARRATION OF TRANSMISSION								WEIGHT
			FORWARD						REVERSE		
			1 ST	2 ND	3 RD	4 TH	5 TH	6 TH	1 ST	2 ND	
HMD-250	5~7	○	1 : 70.03	1 : 38.73	1 : 15.81	1 : 8.74			1 : 105.04	1 : 23.71	29.5kg
SKD-II	4~5.5	○	1 : 03.22	1 : 08.82					1 : 02.246		17.5kg
PM-350	5~8	○	1 : 01.85	1 : 02.67	1 : 05.40	1 : 05.14	1 : 07.42	1 : 15.01	1 : 01.50	1 : 04.16	30.0kg
DMC-II	3~4.5	○	1 : 41.31	1 : 19.40	1 : 9.35				1 : 50		17.0kg
CMC-180	3~4.5		1 : 03.93	1 : 06.5					1 : 02.81		9.7kg

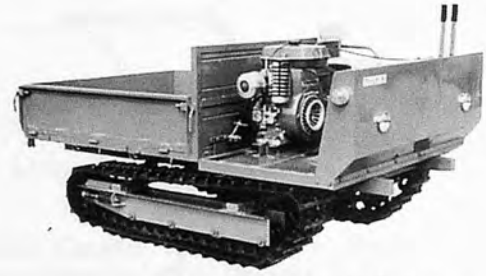
MAMETORA AGRIC. MACHINERY CO., LTD.

9—37, NISHI—2 CHOME, OKEGAWA, SAITAMA, JAPAN Tel : 0487—71—1181

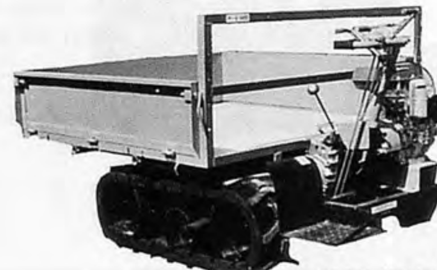
FARM-PORTER

A SERIES OF OUR TRANSPORTERS ARE MOST SUITABLE FOR HAULING OVER BEACHES, SANDY OR DAMP GROUND, SLOPING ROADS, AND SNOWY SURFACES.

- FARM-PORTER runs smoothly.
  The all-rubber caterpillars beat sand, mud, and many other troublesome conditions.
  Slopes up to 40° declination present no problem, even when the FARM-PORTER is fully loaded.
- FARM-PORTER has the largest load carrying capacity in its class. 500kg (1,100 lb)
- FARM-PORTER is very well balanced.
  The low center of gravity (height to platform: 500m/m (1ft 8in)) and wide caterpillars provide great stability.
- FARM-PORTER has multiple gear transmissions.
  (Three forward and 1 reverse)
- FARM-PORTER Pivots on one spot.
  It turns freely and compactly by switching off one of the two clutches to fully disengage one track on which it revolves.



MODEL P6-120



MODEL P5-600

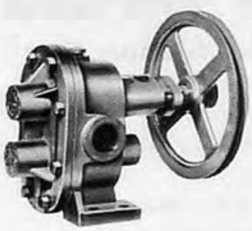
SIROISI KOKI CO., LTD. Nishinosato, Hiroshima-cho, Sapporo-gun, Hokkaido, Japan Telephone: 01137-2-3241

ORIENTAL KOSHIN PUMP

LARGE VOLUME! HIGH DELIVERY HEAD!

WIDE USE FROM DRAINING TO SPRINKLING!

MECHANICAL SEAL PARTS OIL BATH, LONG DRY RUN OK!

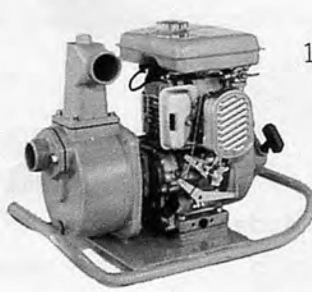


GC, GB
SIREISE
1/2" ~ 1"

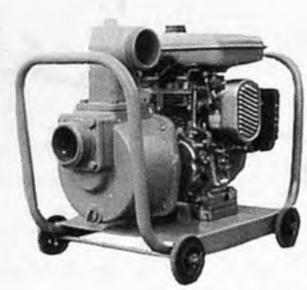
SU-25
1"

SU-40
SU-50
SU-50L
SU-50H
SU-80
1" ~ 3"

SE-25
1"



SE-40
1b SE-50L
1" ~ 1 "



SE-50H
SE-80
2" ~ 3"

KOSHIN LTD. 12-KAMIHACHINOTSUBO, NAGAOKAKYO-CITY KYOTO, JAPAN. 617 TEL 075-932-6111

HINOMOTO®

Strengthening Our Link to Life

People, intricate, living organisms. And their link to life is food-link whose strength is becoming more and more precarious. Crop failures in recent years have made worldwide food shortages a reality.

The aversion of this threat lies in expanded food production great enough to insure every human being with a daily minimum of sustenance.

Advanced agricultural technology is the only realistic means of enlarging the world's food supply. Toyosha's contribution to modern agriculture is the availability of advanced technology at minimal expense. In over one hundred years of existence we have passed through revolutions in the engineering of agricultural machines. Founded by farmers, Toyosha has never lose contact with those who till the soil.

HINOMOTO products are at work all over the world, "Strengthening Our Link to Life".

MB-1100D, 13hp (SAE), diesel

E-23, 25hp (SAE), diesel

MB-1100, 13hp (SAE), gasoline

HB-501, 17hp (SAE), gasoline

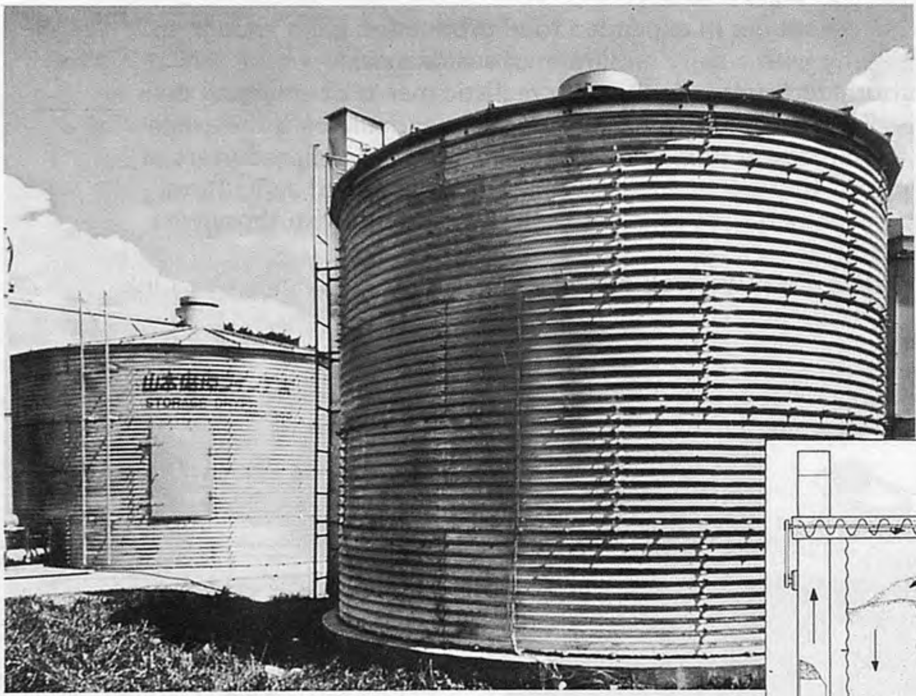
MB-1500, 17hp (SAE), gasoline

TOYOSHA CO.,LTD. 55, Joshoji-16, Kadoma-city, Osaka, 571 Japan
Cable: TOYOSHA NEYAGAWA / Telex: 05347763 MBTRAC J

YAMAMOTO: Our machines are the best helpers to you.

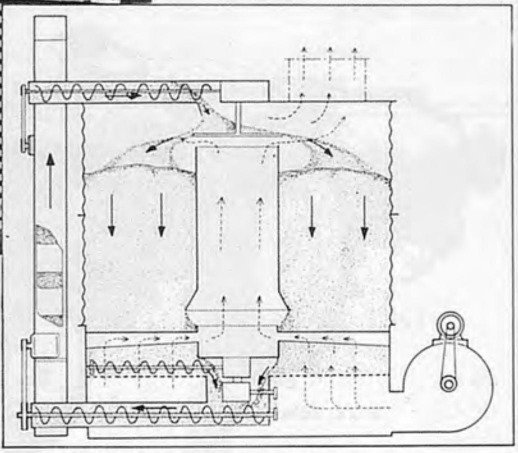
YAMAMOTO RICE DEPOT

Rice harvest depends on right cultivation. As YAMAMOTO RICE DEPOT makes a new dryer system which fits with any regions and enterprises, it perfectly dry and store.



Rice Depot

YAMAMOTO RICE DEPOT can manage any amount up to 8 tons.



Explanation of Circulation Dryer

Specification

Type: SBD-3

Dimention: 4.3m (wibth) × 3.5m (length) × 3.4m (height)
(size of bin: 3m (diameter) × 2.7m (height)

Maximum capacity: 8 ton

YAMAMOTO MFG. CO., LTD.

813-17, TENDO-KU, TENDO-SHI, YAMAGATA-KEN 994, JAPAN
CABLE ADDRESS: YAMAMOTOTENDO, YAMAGATA
ADDRESS: P. O. BOX 3 TENDO, YAMAGATA
TELEPHONE: TENDO (02364) 3-3411