International specialized media for agricultural mechanization in Asian developing countries.

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AGRICULTURAL MECHANIZATION IN ASIA

VOL. VIII, NO. 4, AUTUMN 1977

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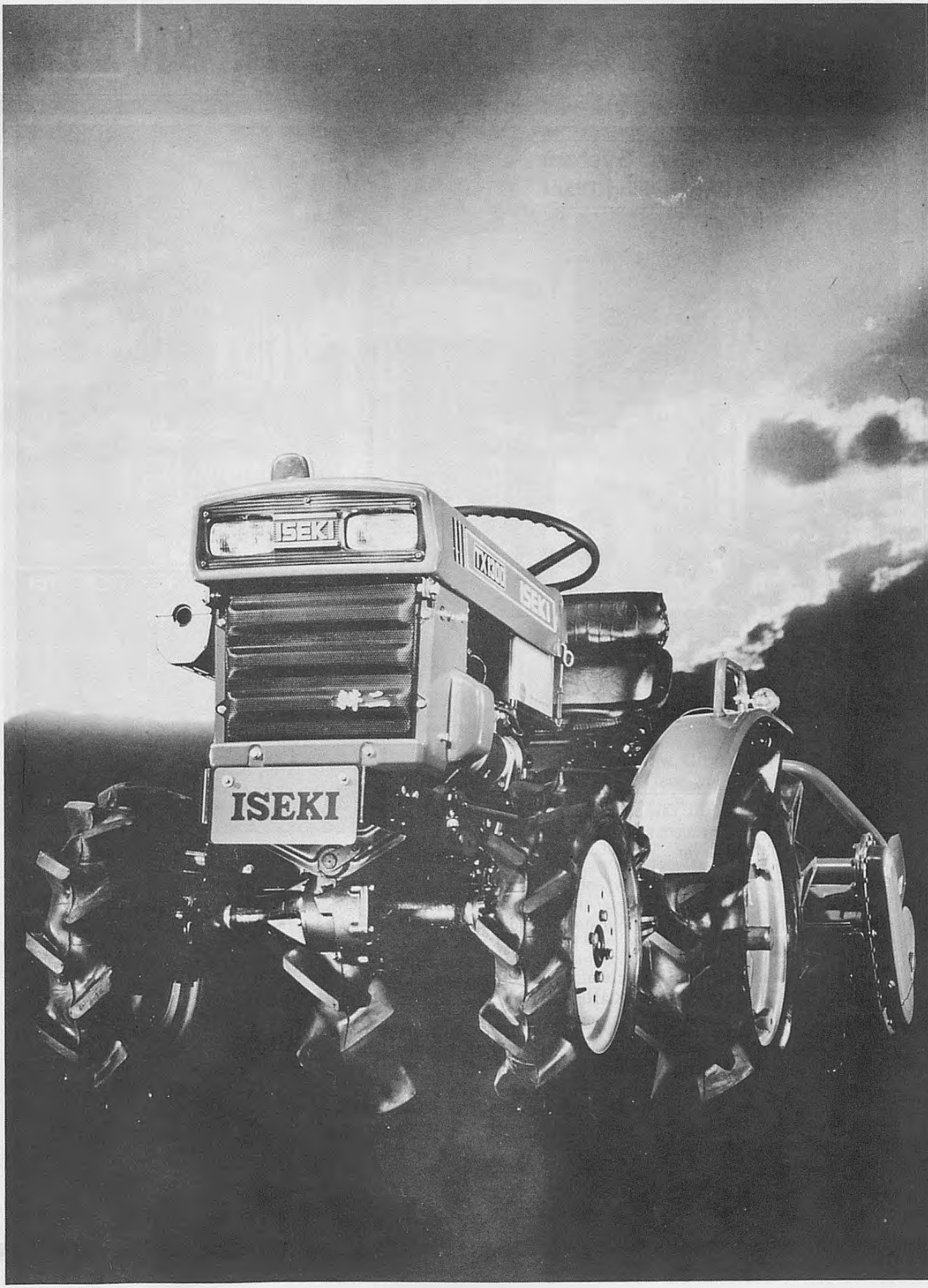

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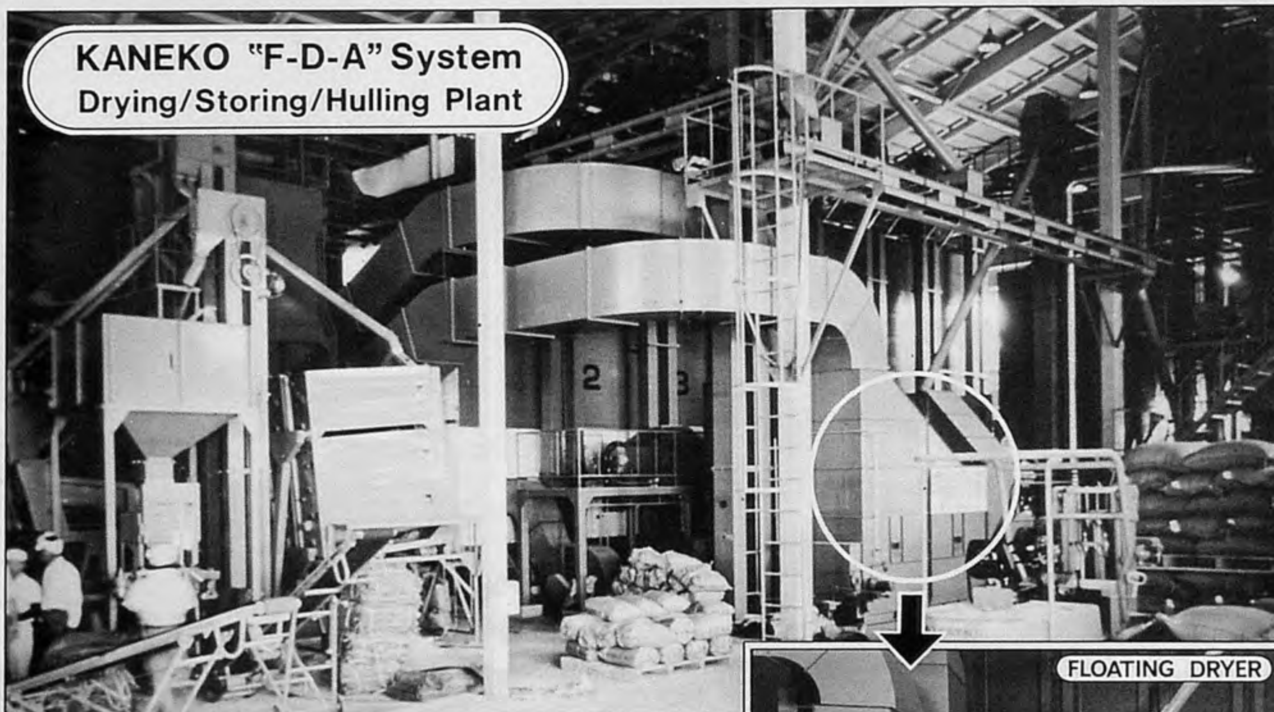

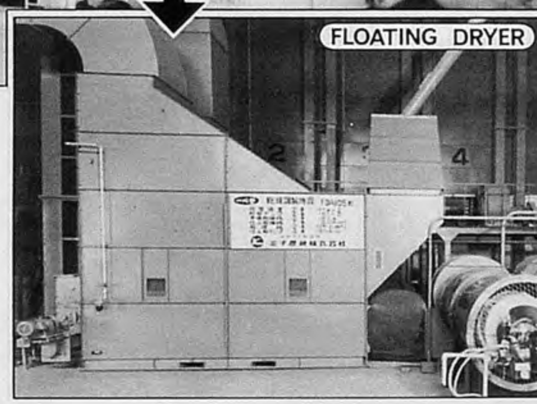

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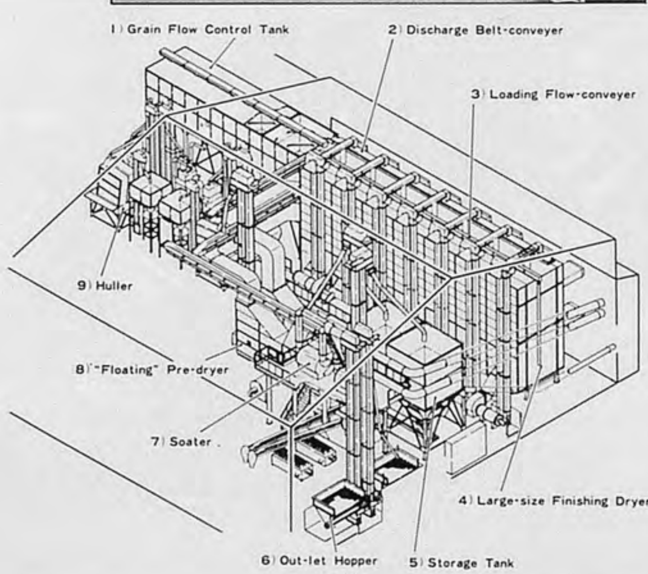

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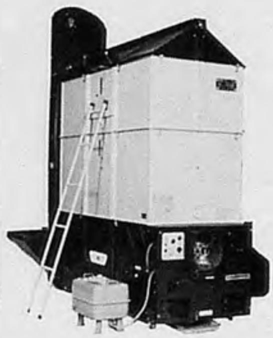
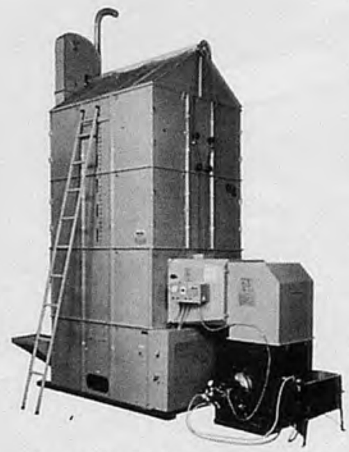


* Model SL-155R

* Model SH-285SR



* Model SG-451S

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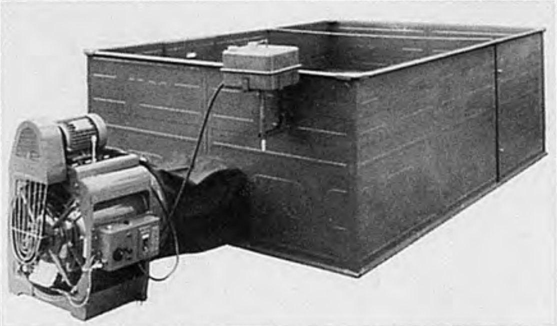

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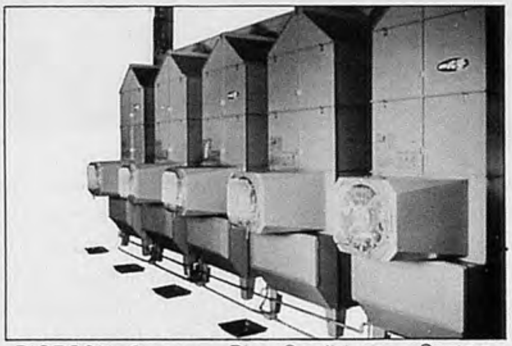

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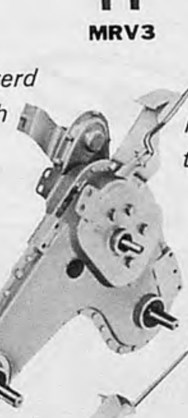
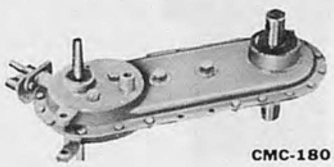
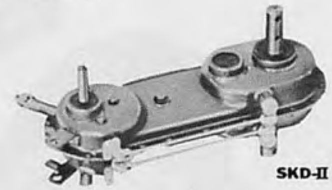


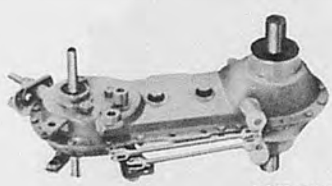
MRV3



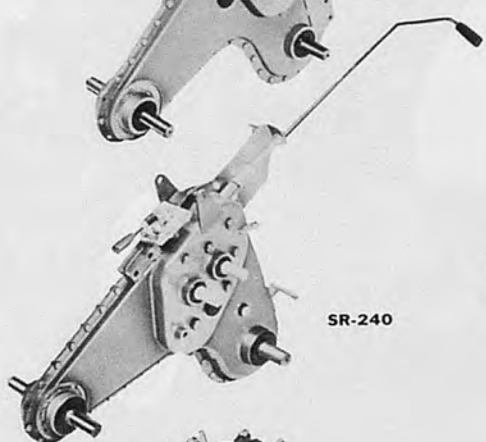
CMC-180



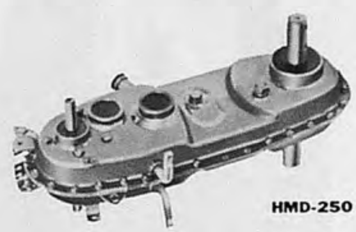
SKD-II



DMC-180

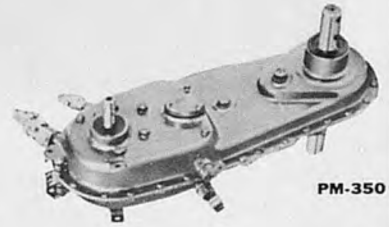


SR-240

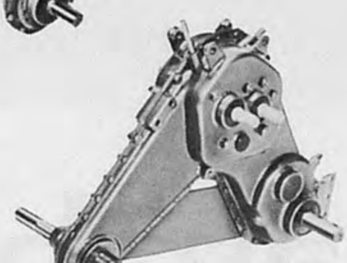


HMD-250

UK-13



PM-350



JAN-800

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

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AMA

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This is the 17th issue from the first issue, Spring 1971.

Preface

We are going to have Tokyo Farm Machinery Show '77 in Tokyo for one week from November 22. Visitors will be able to see almost all of Japanese farm machinery, there. There are various kinds of farm machinery shows for farmers in Japan. This coming national show is going be held after a long interval and Tokyo is very convenient for visitors from foreign countries. In this AMA issue, we introduce several products from the ones displayed at Tokyo Farm Machinery Show '77.

In November, EIMA Farm Machinery Show is going to be held at Bologna, Italy, and Orange Show, in Australia. We are going to put a calender of farm machinery shows of the world in the next issue.

Recently, I visited the People's Republic of China for two weeks as a leader of the Japanese Farm Machinery Inspecting Group. I was able to find a lot of interesting things, there. I am going to put the report on the recent situation of China in the next issue.

We are very happy that AMA can gain many readers year by year. We have to make every effort to improve this AMA more than ever in order to meet the reader's requests.

We would appreciate for sending us your articles opinions, and problems and also appreciate your various kinds of cooperation.

October, 1977

Chief Editor

Yoshisuke Kishida

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AGRICULTURAL MECHANIZATION IN ASIA

Vol. VIII, No. 4 Autumn, 1977

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Simulation and Modeling Techniques of Agricultural Systems

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

The thceniques of Simulation are widely used (a) in engineering analysis, design and research, and (b) in business, industry and defence as a standard research and management techniques. Relatively few research projects in agriculture so far have been conducted using Simulation techniques. Recently it is gaining popularity as a research and management technique. Because the general solution which is always preferred is beyond the reach of to days' mathematics for complex agricultural systems irrecpective of engineering analysis, design and research or managerial decision making. The essential steps to be followed in analysing a system are illustrated in Fig.1. The system is defined precisely on the basis of some assumptions and the new system is referred to as idealized system. The model is fully based on the idealized system.

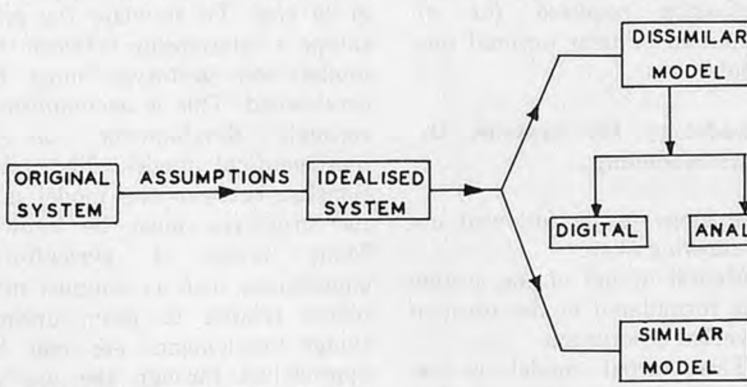

Fig.1. Flow chart for problem analysis

Simulation and Model

Naylor, Balintfy, Burdick and chu (6)[※] define the term simulation as a technique 'that involves setting up a model of a real situation (system), and then performming experiments on the model'. Simulation is thus a two phase operation namely (a) Modelling and (b) experimentation. Systems dynamics is a methodology developed by Prof. Forrester for approaching dynamic system problems and from systems dynamics view point Prof. Drew (3) defines Dynamic Simulation as a technique for constructing and operating dynamic models. The type of simulation to be used largely depends on the type of model.

Systems research is based on the use of models. Forrester (4) defines model as a substitute for an object or system. It may be physical models that represent objects or it may be abstract model.

Ackoff, Gupta and Minas (1) classifies the models into three : Iconic models, Analog models and Symbolic models. Iconic models are similar to real system. Iconic models are widely used in agricultural research and the plot of the agronomist is an example. analog models are used on the basis of the property that it can represent another as in situation where water flow is represented by electric currents.

※Numbers in parentheses refer to the appended references

There are many references on the subject such as (8). Symbolic models are represented by symbols as mathematical model i.e. the most abstract models. The systems research is primarily concerned with quantitative mathematical models. Young (11) distinguishes the models into two broad classes : (a) Similar Models and (b) Dissimilar Models. Similar models represent physical system and Dissimilar models are abstract models. In **Fig.1.** the models have been classified on the basis of Young's classification.

Dissimilar Model

Dissimilar models are not similar in appearance or identical to original system. If the problem is to be solved numerically, mathematical model must be developed. It can be solved either by Analog computer or by Digital computer. Computers are used because it is impracticable to solve the problem manually. The systems simulation consists of developing a mathematical model suitable for computer operation and the general purpose language FORTRAN is most frequently used. The special type of systems model is known as Systems Dynamics model. The systems dynamics model is based on the methodology developed by Prof. Forrester of MIT. and systems dynamics is a way of analysing the behaviour of complex systems possessing technological, social and political elements. DYNAMO is the special purpose computer language for systems dynamics simulation.

Methodology for Developing and Using Systems Simulation Model

The following Steps to be followed (2):

1. Modelling :

This phase of simulation consists of developing a mathematical model suitable for computer use. To develop a mathematical model the problem is represented by a diagramatic model. This provides information regarding the type and form of data required. The starting point should be a simple input output model which can be extended in details by successive indentification of :

(i) major sub-systems.
(ii) important components and relationship within each sub-systems.
(iii) link between sub-systems.
(iv) important environmental variables and
(v) control points.

2. Validation :

The process of determining how well the model relates the real system is known as validation. Where real system may not exist, validation of the model is based on subjective judgement.

3. Experimentation :

It shows the behaviour of the system to the changes in structure or managerial policies. The objectives of experimentation are the following : —

(i) to compare the courses of action.
(ii) to estimate the response of the system to changes in the level of a single input.
(iii) to explore the response surface, generated for different combination of input levels, and
(iv) to estimate the input combination required for an optimal or near optimal output.

Methodology for Systems Dynamics Modelling

The steps to be followed are the following (3,4) :

1 Mental Model of the system is formulated in the form of verbal description.

2 This verbal model is expressed in the form of flow diagrams. In converting the verbal description into flow diagram, the system is considered as consisting of two basic components-levels and flow rates. Levels represent accumulation of flow in the system such as population, arable land etc. The rates of flow represent the activities and decision functions in the system such as movement of goods, the bringing of land into production through irrigation etc. The levels are represented by rectangle and the rates by symbolic valve. Information flows are represented by dashed line and other flows such as materials, capital etc. by solid line.

3 This flow diagram is converted into a set of simulaneous difference equations. Thses equations are solved by computer. The special purpose computer language DYNAMO is used for this purpose.

Then the model is tested for its validity. The usefulness of a mathematical Simulation model should be judged in comparison with other abstract model which would be used instead.

Similar Model

A similar model is defind as a system which is similar in appearance to prototype, but not identical to it. It is usually smaller in size. To simulate the prototype a relationship between the model and prototype must be established. This is accomplished through development of a mathematical model. The relationship between the model and the prototype must be known. Many areas of agricultural engineering such as complex problems related to grain drying, tillage implements etc can be approached through the use of similar models. Although mathematical models can be built, the problems of this type would require many simplifying assumption.

There are two well known methods for establishing similarity relationships between a model and a prototype. These are:

(a) by analysis of characteristic equations of the system and

(b) by dimensional analysis.

If the method of analysis by characteristic equations is used, the system is described by a mathematical model and scaling laws or similarity requirements are determined.

The second method for establishing similarity requirements is dimensional analysis (11) and it is the simplest to use. The three basic steps to be followed are:

(i) selection of variables.
(ii) application of Pi theorem and
(iii) the establishment of similarity requirements.

Conclusion

Simulation techique possesses sufficient potentiality that it can be applied in engineering analysis, design and research. This includes simulation of grain drying (9), Simulation of corn drying (10), etc. This can also be applied as a research and management technique to increase the efficiency of agricultural production. Simulation of crop-irrigation (2), Simulation of farm machinery selection (2), Simulation of commodity production systems (5, 7) etc fall in this category. The artistry required in developing and experimenting a simulation model can come from (i) thorough knowledge of the system, (ii) thorough knowledge of different types of simulation techniques i.e. methodologies for simulation and their irrespecive computer languages. These can be gained through experience. Finally it is concluded that techniques of simulation and modelling can play vital role in agricultural mechanization.

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National Problem of Agricultural Engineering for Rural Development

—Present Status of Small Scale Industry and Small Farm Holding Holds Key—

by
Sharad L. Patel
Technical Director
American Spring & Pressing Works Ltd.
Malad, Bombay 400064, India

Views expressed by Dr. Swaminathan at The 63rd Session of The Indian Science Society

The education system should be integrated with other development inputs. The country's well organised infrastructure of formal education should be re-oriented to new needs and objectives. Non-formal education should be developed in a variety of ways to suit the local needs. Every institution of higher education including university departments, colleges and training institutes should incorporate some form of development activities into their regular teaching programmes and students should be made to work on projects as a part of their practical work and the staff should be involved in operational research. Such a participation can be ensured by conditioning the Government financial grants to the institution subject to its fulfilling the qualiflying criteria.

The country should not give undue attention to the problem of brain drain. Instead it should pay serious attention to utilization of brains within the country. Once this is done the brain drain would automatically be stopped. Nay, it would be reversed as surely a number of Indian scientists abroad would return to the Motherland as what has compelled them to seek job satisfaction abroad is not the financial remuneration but the absence of such satisfaction at home.

———·———·———

From the beginning of time man has wrested his food from the soil. Thousands of years have made no basic change in the external quest, he continues to do so. The earth is at once his larder and his adversary.

But over the centuries, man has found that he needs more food. No longer can he glean enough for his family and rest content. The farmer must buy many things with money which can only come from the fruits of his land. And conversely, the course of civilization has brought to the world's table more and more millions who make their living apart from the soil, but who still require food from it. The farmer has therefore tried to raise larger crops.

His own hands soon were not enough for the task, and he began to develop tools to aid him. The post-war period has shown a great growth of interest in solving the problems of food production.

Our Basic Need

During this decade, and part or perhaps all of the 1980's, it is very likely that there will be need for food aid from other countries, especially in times of unusual weather or other natural calamities. But food aid from abroad is unlikely to be available in the quantum that existed in

Paper presented at G.B. Pant, University of Agriculture & Technology, Pantnagar (U.P.)

the past. In the absence of food aid, the only alternative is to increase local production.

India has to build-up self reliance in the food situation, on which rests the economic, social and political stability of the country. As a matter of fact, besides food crops, we have also to step up the production of cash crops like sugarcane, jute, tea, coffee, cotton and nuts, which are playing a vital role in improving the overall health of our economy by earning valuable foreign exchange.

The Green Revolution has brought the Agricultural Revolution, which calls for considerable changes in the agricultural production technology. The so called Green Revolution, however, invited an illusion to some people that the problem of Agricultural Production will be solved in no time by the introduction of "MIRACLE SEED". There is a danger in looking upon the "MIRACLE SEED", as the solution of Agricultural Production. The new hybrid strains are but a single ingredient in a production technolgy. There are so many essential components such as water management, land reform, and improvement, fertilizers, pesticides, harvesting and threshing facility, transportation, storage, marketing facilities, credit sources and above all Agricultural Mechanization, if the hopes for the Green Revolution are to remain green.

At present in Agricultural Development, intense-land-utilization, intensive-fertilizer-input and multicropping methods are used with the new strain. However, success cannot be achieved without the rationalization of farming operation-using the right kind of machinery—at the right time and at the right place. In this respect Agricultural Mechanization is the most important and indispensable component among various essentials stated above.

Agricultural Engineeing & Farm Machanization

Many persons often think that Farm Mechanization is limited to the introduction and use of tractors only. Also mechanization is not solely a matter of internal combustion engines and all that accompanies them, although the term is generally understood to mean that. Power is needed to wield tools, pull implements and drive machines and it is these contrivances that ultimately perform the work desired, whether they are operated by muscles, wind, water, steam, hydro-carbon fuels or electricity. In considering improvements in farming practices the tool or machine and the power that propels it must be kept separate if confused planning is to be avoided.

A stone grasped in the hand will drive a nail, but a steel hammer will do the job better. Similarly an ox-drawn indigenous plough will scratch the ground in strips, leaving some soil untouched, but a modern implement will till it all at a time and perhaps give better results. In both cases the source of power remains unchanged. Yet, a measure of what can be called improved mechanization has been achieved. The substitution of a tractor for a team of bullocks, each pulling a similar implement, is also mechanization; here the power has been modernized while leaving the tools as it was.

Human beings and animals undoubtedly supply the power needs of large numbers of farmers and will do so for many years to come. But when labour and draft animals are inadequate for the work to be done, internal combustion engines should be considered. However, the more change over to mechanical power for the sake of mechanization might not be sound.

Defination

The term farm mechanization has much wider sense. The F.A.O. has adopted the defination for agricultural Engineering and Farm Mechanization as:

> "Agricultural Engineering is a field of Engineering in which physical and biolgical sciences are utilized to find and apply better ways for the production, handling, processing and storing food, fibre and fodder to improve rural life and living conditions".

Farm mechanization also refers to design, developments, testing, manufacturing, marketing, operation and repairs of all machines and equipment.

Our Present Position

India,is, from the point of view a surface area, the seventh largest country in the world with a population of 560 million (in 1971-1972). Seventy percent of the population are employed in agriculture. Agriculture is our biggest industry.

Agriculture is influenced by the monsoon. The climate is divided in two distinct seasons dry and cold with the rain in between. The periodity of rain controls farming operations. It is difficult to plough sunbaked hard soil without rain, with plough drawn by a pair of bullocks. Farmer has to do agricultural operations fast, as the period between ploughing and seeding is frequently short. It is not possible to coltivate all land and sow crops in time. Plough drawn by a pair of bullocks do not work sufficiently and efficiently as the animal power is too weak for the soil. Deep ploughing and quick operations require some kind of mechanical power, due to such natural conditions. Tractors and suitable implements can do such hard jobs at faster rate.

The methods of agricultural management vary. In irrigation areas, consisting of 20% of the entire agricultural surface, which in future will be expanded to 40%, two yearly harvests are possible. Crop rotation takes place with wheat rice and millet, beans, maize, oilseeds. potatoes, fodder and fibrous plants. The geographical situation of the cultivated areas for the main crops, wheat and rice is influenced to a large extent by the climate, mainly rainfall and the irrigation possibillity.

Cultivable land in our country is scarce and farmers are plenty. Farms by western standard, are exceptionally small, as little as a hectare. There are endless number of farmers cultivating tiny plots. In United states there are two farmers per 100 hectares of cultivated land. In India 96 farmers per 100 hectares of land. In Taiwan about 250 farmers per 100 hectares of land.

Level of Farm Mechanization

We can differentiate three levels of technology, which are existing in our country.

1. Hand Tool Technology.
   Human labour main source of power.
2. Animal Draft Technology.
   Animal Power Main Source of Power.
3. Mechanical Power Technology.
   Internal Combustion Engines or Electrical Power.

The three levels exist side by side in our country. However, the problem remains which technology is to be adapted to mechanize. For every given situation there is a justified level of technology which if properly introduced would increase food production and provide better living conditions for the rural population.

Agricultural advances have been concentrated on large and medium size farms. Productivity on these farms is rising steadily, while tens of millions of small farmers having small size holdings have been left out. Their productivity is very low. The combination of small number of high productivity farmers and many low productivity farmers, equals national performance.

It is ironic that with all our technological advances and farm machinery developments, large groups of farmers have little access to appropriate farm equipment. If mechanization is to be successful in our country, it must be introduced on the small farm only.

Farming Technology

Two distinct Agricultural Mechanization technologies have been evolved to suit different sets of agricultural and socio-economical conditions in the world.

The western approach in advanced countries such as United States emphasized dry-land farming with large high powered equipment. American style large farms-tractor mechanized agriculture has been designed for multi hundred hectare farms. The capital cost in this technology is very high and number of jobs involved is too low. This capital intensive technology has evolved from a primary emphasis on replacing human labour with machine.

There is another approach in countries like Japan and Taiwan, where small farm holdings under wet land conditions exist with high farm incomes due to high support prices. Here mechanization of agriculture is done with low-powered sophesticated farm equipment to meet the requirements of Japanese farmers.

Both the nations are using advanced technology. Both make full use of mechanization to increase farmer's production. Both provide farmers with full technical and economic information. Both are mechanized but differently. In the United States large equipment are used to enable farmers to cultivate and harvest hundreds of hectares of land, whereas in Japan, small equipment are used to enable many men to intercrop and multicrop small holdings. In both technologies the farmers are provided with credit and other services through an institute of farmers' cooperatives and marketing organizations.

It is sometimes said that U.S. Agriculture is the most highly mechanized in the world and this is the principal reason for U.S. Farm efficiency. But U.S. style large farms with highly capitalized agriculture is not a guide to raise productivity in over-crowded country like ours. The U.S. method of measurements, mechanization per worker cannot be feasible in our country. The Japanese farming is more mechanized than U.S. The Japanese method of measurement, mechanization per hectare can be applied in our case to a certain extent. Such equipment, as used in Japan, are uneconomic eventhough they are suitable for our farms at certain places in our country.

Both these technologies in toto are not suitable for our country as different agro-economic conditions are prevailing. Introduction of such a technology in our country will make labour surplus which is not at all desirable.

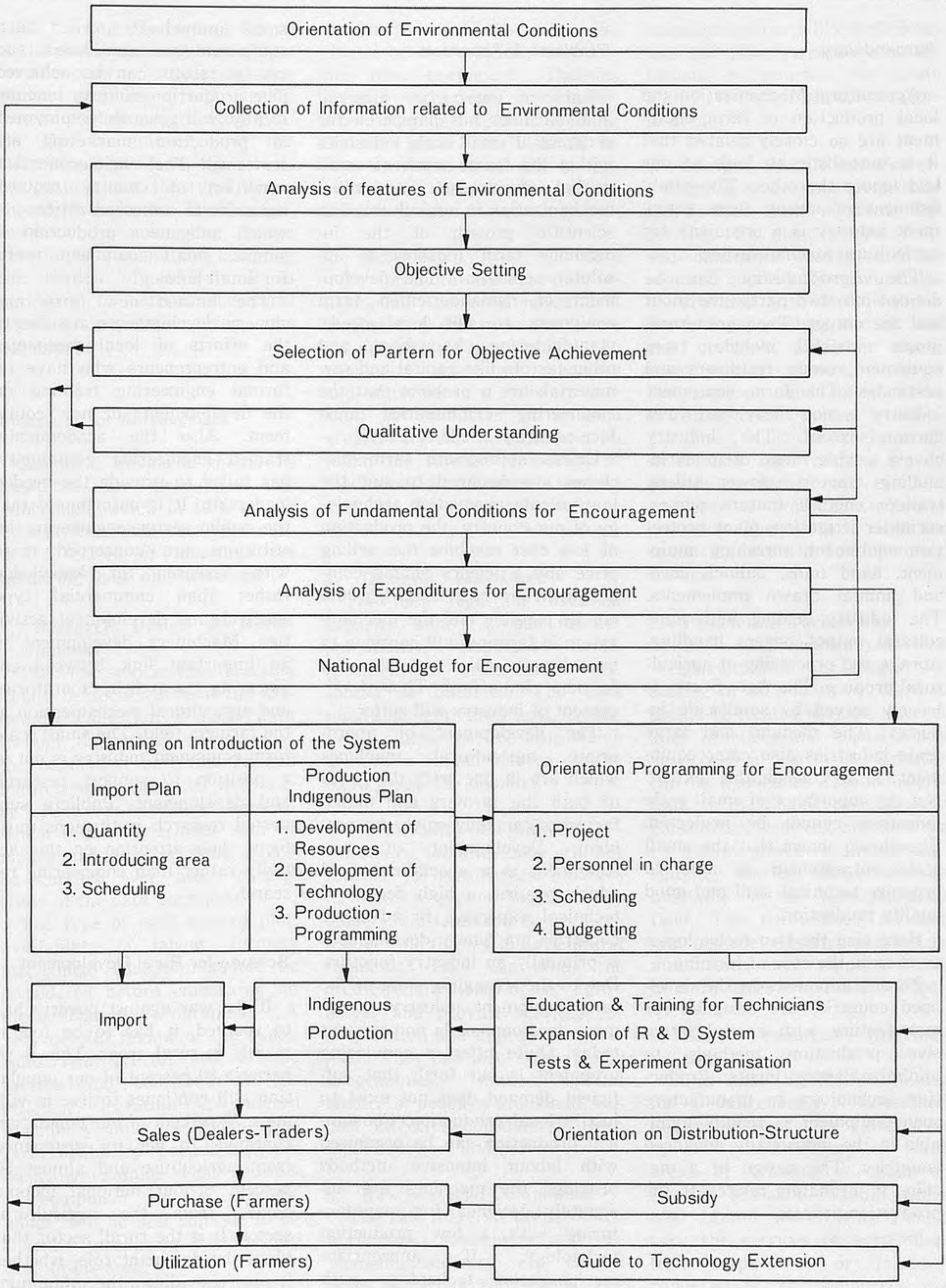

Fig. Promotional System Chart

Agro-Industry

Agricultural Mechanization and local production of farm equipment are so closely related that it is unrealistic to look at one and ignore the other. The establishment of strong farm equipment industry is a prequisite for agricultural mechanization.

The Agro-Industry can be divided into two parts—the input and the output. The agricultural inputs mainly include farm equipment, seeds, fertilizers and pesticides. The farm equipment industry is now developed to a certain extent. The Industry covers a wide range of items including tractors, power tillers, trailers, engines, motors, pumps, sprinkler irrigation, plant protection equipment, threshing equipment, hand tools, bullock carts and animal drawn implements. The industry dealing with agricultural output covers handling, storage and processing of agricultural produce. The Agro-Sector is largely served by smallscale industry. The medium and large scale industries also cater equipment to a considerable extent. But the importance of small scale industries cannot be neglected. Experience shows that the small scale entrepreneur is able to organize technical skill and good quality production.

Here also the two technologies exist as in the case of farming.

Farm equipments in the developed countries are designed for manufacture with capital intensive production methods to minimize labour inputs. Production technology to manufacture such equipment is readily available in the industrially advanced countries. The design of a machine is intimately related to the production process.

Problems & Approach

Lack of appropriate material and machines has hampered the progress of small scale industries within the frame work of small capital investments and limited mechanization in agriculture. The scientific growth of the indigenous farm industry is absolutely essential. The development of demandoriented farm equipment to suit local needs, manufacturing know-how and other factors like capital and raw material, are a problem that the engineering communities must face squarely in our country.

Unless appropriate farm machines are designed to suit the low volume production technology of our country, the production of low cost machine (i.e. selling price and efficiency should compete with low cost labour), would not be possible and the mechanization in farming will continue to be a luxary which only the rich farmers can afford. Thus development of industry will suffer.

The development of appropriate agricultural machines which are in line with the needs of both the farmers and manufacturers can only solve the problem. Development of new equipment is a specialized field which requires a high degree of technical expertise. In advanced countries machinery development is primarily an industry function. Due to the struggling state of the farm equipment industry, equipment development is non-existent today. Quite often a convincing argument is put forth that sufficient demand does not exist to justify local production. Economical production can be organised with labour intensive methods provided the machines are adequately designed for manufacturing with a low production technology. If appropriate mechanization technology with small individually owned farm equipment are considered, successful results can be achieved. The production of farm machine locally, will generate employment in production, marketing and servicing. The socio-economical condition of country requires agricultural mechanization in which indigenous production of simple, small equipment useful for small holding.

The limited new farm machinery developments are due to the efforts of local mechanics and entrepreneurs who have no formal engineering training on the developments of new equipment. Also the academically trained engineering community, has failed to provide the needed leadership. It is unfortunate that the public sector engineering institutions are concerned more with research for knowledge rather than commercial type research and development activities. Machinery development is an important link between engineering research in laboratories and agricultural mechanization in the farmers field. The small scale farm equipment industry is not in a position to support research and development. Publicly supported research institutions must focus their attention on this activity rather than engineering research.

Science for Rural Development

If the war against poverty has to succeed, it has to be fought mainly in rural areas. This is so because 80 percent of our population still continues to live in villages, 70 percent of our population continues to get its sustenance from agriculture and almost 50 percent of our national income comes from the agricultural sector. It is the rurall sector that plays the dominant role, whether it is providing the minimum needs, raising consumption levels of the poor, supplying food grains for the growing population, producing surpluses for earning foreign exchage, or creating jobs for the unemployed and the under-employed. It is, the refore, but natural that the rural sector should be the centre of all activity—both for achieving faster growth as well as for lessening the burden of poverty. It is necessary to activise the rural segment population for our economy.

Measures for Achievement

Scientific advances should be exploited for production advancement which in turn should be converted into rural prosperity. A series of measures for achieving these objectives are:

1. Research, Desigh & Development

The first step in this direction should be focussed upon the systematic collection of basic data through theoretical evaluation of the capability, performance and features of commercial machinery. Research and development which require enormous sum of money and a lot of time should be carried over after careful study of the data obtained.

The type of soil, size of plot, availability of labour, farmers mechanical education should be considered before embarking on mechanization programme. A very careful review of the conditions that prevail and of the factors that contribute to the efficient operation of modern machinery must be made. The farm machinery specialists should basically examine what addition of equipment to the farmers' hands, will be best suitable in efficiently producing his desired crop in his area.

A careful study of the present equipment which are under use, should be made before introducing new equipment. Theories based on experience gained elsewhere may be helpful in framing tentative plans, but it should be also seen that it should be applicable in the prevailing conditions.

2. Extension

To promote the use of indigenously developed agricultural machines there must be some encouraging national policy. To popularize developed machines and implements a pilot project shall be conducted in selected areas to try out the machines. To make the farmers conscious of machines a minimum support price for his produce should be fixed.

3. Demand Assessment

The data regarding installed capacity, annual output, market potentiality, imported items, specifications, price ranges, etc. should be obtained. The data regarding cultivated land, irrigation facilities and the crop which are grown should also be obtained to assess the demand.

4. Availability of Finance

Banking facilities have still not reached the rural areas. Farmers have still to depend on the money lenders. Nationalized Banks have a wide role to play in agricultural financing. They can study the credit requirements of the agrosector and provide services for preparation and appraisal of projects. They can also evaluate the programmes, make special studies in problem areas and suggest effective coordination with input suppliers and borrowers.

5. Raw Material Componens

The raw material needs of the agricultural machinery and implements industry are special types of carbon alloy steels. The standardized parts like Ball Bearings and Hardwares are also important components, the availability of which should be considered.

6. Energy—Farm Fuel—Power

Much is to be done to provide the farmer with efficient fuel services. He must receive fuels and lubricants unadulterated in required quantity. He should also be provided with technical guidance for providing storage and use of fuels. Different equipment/engines require different fuel/lubricant and as such lubrication charts/guides on these equipment must be freely available. The fuel centres should provide the farmer with efficient services as well as technical guidance. There is also need for organzing a farm fuel advisory service.

7. Production Technology —Consultancy Service

Agriculture is our biggest industry. In fact in many ways it should be treated as such. Several good practices and norms which have been in use in the industry can be applied in agro-industrial field. In the Engineering Industry consultancy services are now an established practice. Similar consultancy services should also be available in the agro-industrial field. The consultancy services can provide effective marketing and management support, which in many cases is so much needed.

8. Sales Promotion Distribution

Sales and Distribution Points for indigenously developed Equipment should be established by the manufacturers in rural areas by creating a chain of Dealers. The small manufacturers who cannot afford this should take the services of agro-industrial corporation or farmers' cooperatives to popularize the equipment. These centres should keep sufficient number of equipment and parts and provide guidance and services to the farmers. They can also train the farmers in handling the newly developed equipment, which ultimately develop confidence, to go in for the machines.

9. Production Price—Economy—Financial Return

Whatever is produced must be produced at economical costs and supplied to the customers at stable, fair and reasonable prices. Profits must be earned. There should not be profiteering. There must be fair trade practices followed at all times and with all kinds of customers. It is not with restricted production that profits should be earned. It is with utilizing the optimum capacity and building up increasing turnover that profits should be reaped, giving as much benefit to the customer as possible.

The new philosophy should be that the Customer is Business. Profit is the reward of entrepreneurship; the reward should be deserved; it should not be manoeuvred. So, production as well as distribution should be so managed that the common man is benefited and not fleeced. It should be accepted as the national policy. Prices should be stabilized to the extent possible by increasing production and also instituting all methods which go under the name productivity.

10. Repairs & Maintenance

Agro-Service Centres could play a great role in providing after-sales-service to the farmers. A large number of such centres should be established which can guide and render services to the small farmers in remote areas. The farmers must be provided with essential inputs at the place of use in good time and required quantities. They can also assist the farmer in farm operation as well as post-harvest handling of his produce. These centres can also take the custom hiring job.

11. Education-Technical Literacy Background

Agricultural Mechanization is partly dependent upon education. Farmers need technical education of some kind in order to manage machines effectively. The technicians who advise the farmers need education. Those who design and market the machines must be educated. The government personnel who plan and finance programmes should be educated. Finally, the educators themselves must be educated. Some of the education will be formal as in the university classroom; some will be informal as in the workshop and field. In any case, progress is enhanced by education.

Agriculture and agro-industry are interdependent and for the development of each one we should adopt the maxim :

"The Agriculture supports the Industry and The Industry develops the Agriculture".

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Potential for Mechanization in Developing Country

A Case Study of Orissa State (India)

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Introduction

The State of Orissa with a population of 22.50 million extends over an area of 15.54 million hectares (1). The average density of population of the State works out to be 141 persons per square km. The net area sown per capita is 0.255 ha as compared to 0.258 ha in the country.

The distribution of land in the different sizes of holdings is given in **table 1**. It is seen that 38.51 per cent of holdings are below 2 ha and 29.65 percent are above 2 ha but below 5 ha. Out of the total cultivated area of 6.7 million ha in the State which comprises of upland, medium land and low land are 2.8, 2.2 and 1.6 respectively. Paddy is the stapple crop of the State and covers a gross area of 4.4 million ha which includes, autumn, winter and Summer rice. The field coverage of other crops like wheat 51,000 ha sugarcane 31,000 ha and cotton 7,000 ha are in addition. The additional labour demand for raising maise, wheat and potato are shown in **Fig. 1**. This indicates that the peak occurs during harvesting and planting season. The labour demand was noted to be maximum for potato.

Table 1 Number of Operational Holdings, and Area under Cultivation in Different Class Sizes of Holdings

Size, classes in hectares	Number of operational holdings	Percentage of operational holdings	Area in thousand hectares	Percentage of area
Below 0.5	731,573	21.47	218	3.37
0.5 — 1.0	743,840	21.83	553	8.57
1.0 — 2.0	1,120,700	32.89	1,713	26.57
2.0 — 3.0	236,134	6.93	614	9.52
3.0 — 4.0	216,371	6.35	749	11.61
4.0 — 5.0	124,711	3.66	549	8.52
5.0 —10.0	184,682	5.42	1,247	19.32
10.0 —20.0	40,548	1.19	533	8.27
20.0 —30.0	5,452	0.16	125	1.94
30.0 —40.0	1,363	0.04	44	0.69
40.0 —50.0	1,022	0.03	35	0.55
50 and above	1,022	0.03	69	1.07
Total	3,407,418	100.00	6,449	100.00

Source = Agricultural Census of Orissa, 1971.

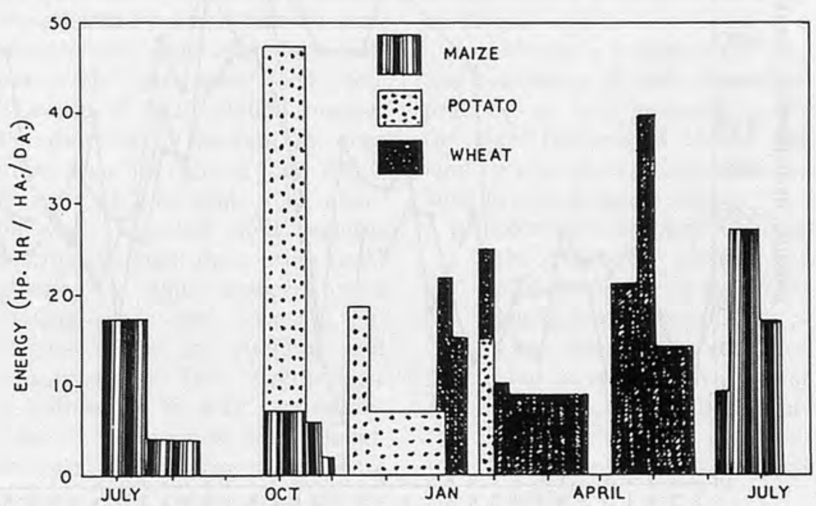

Fig. 1 Seasonal work demand for intensive cultivation (Source: Ag. Inputs Div. USAID, New Delhi, Sept. 1969)

Much of the early benefits from an intensified agricultural extension programme would stem from the adoption of improved cultural practices, particularly technique to achieve more timely planting, increased plant population, better moisture conservation and effective weed control. The use of improved farm implements particularly, replacement of wooden duck footed country plough **Fig. 2(a)** with soil turning iron ploughs **Fig. 2 (b,c)** would help successful adoption of theese practices.

The country plough requires several passes to achieve even partical soil inversion which results not only poor weed control but also inefficient use of man and bullock hours.

While a case can be made for the selective mechanization in Orissa, the vast majority of farmers, 93 percent of holdings are below 5 ha and about 43 percent below 1 ha **(table 1)** will continue to rely on bullock power to bring about any change in cultivation system.

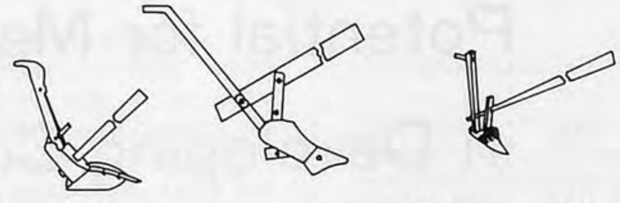

Fig. 2 Deshi and soil turning ploughs

The cumulative weekly break up of the labour demand for raising 250 acres of paddy exclusive of tractor power is shown in **Fig 3**. From the figure it can be visualised that labour demand is noted to be highest during transplanting, harvesting and threshing periods for last six seasons during three years under report for the paddy. The first labour peak was noted during autumn for transplanting and weeding when larger area was under paddy cultivation. A decline in labour peak in the first and 2nd week of August, 1974 and 1975 was due to labour strike. The labour peak demand for autumn paddy during transplanting is more concentrate and causes delay in transplanting resulting in lower yield. This needs maximum consideration of using proper equipments, change in cultural practices and adoption of early varieties of paddy directly sown and or transplanted to stagger the labour peaks.

The second labour peak noted during winter is spread from November to February last weeks as it consists of various cultural practices for winter paddy and other winter crops. This also includes the threshing of autumn paddy in the early stages of the labour peak.

The above noted labour peaks

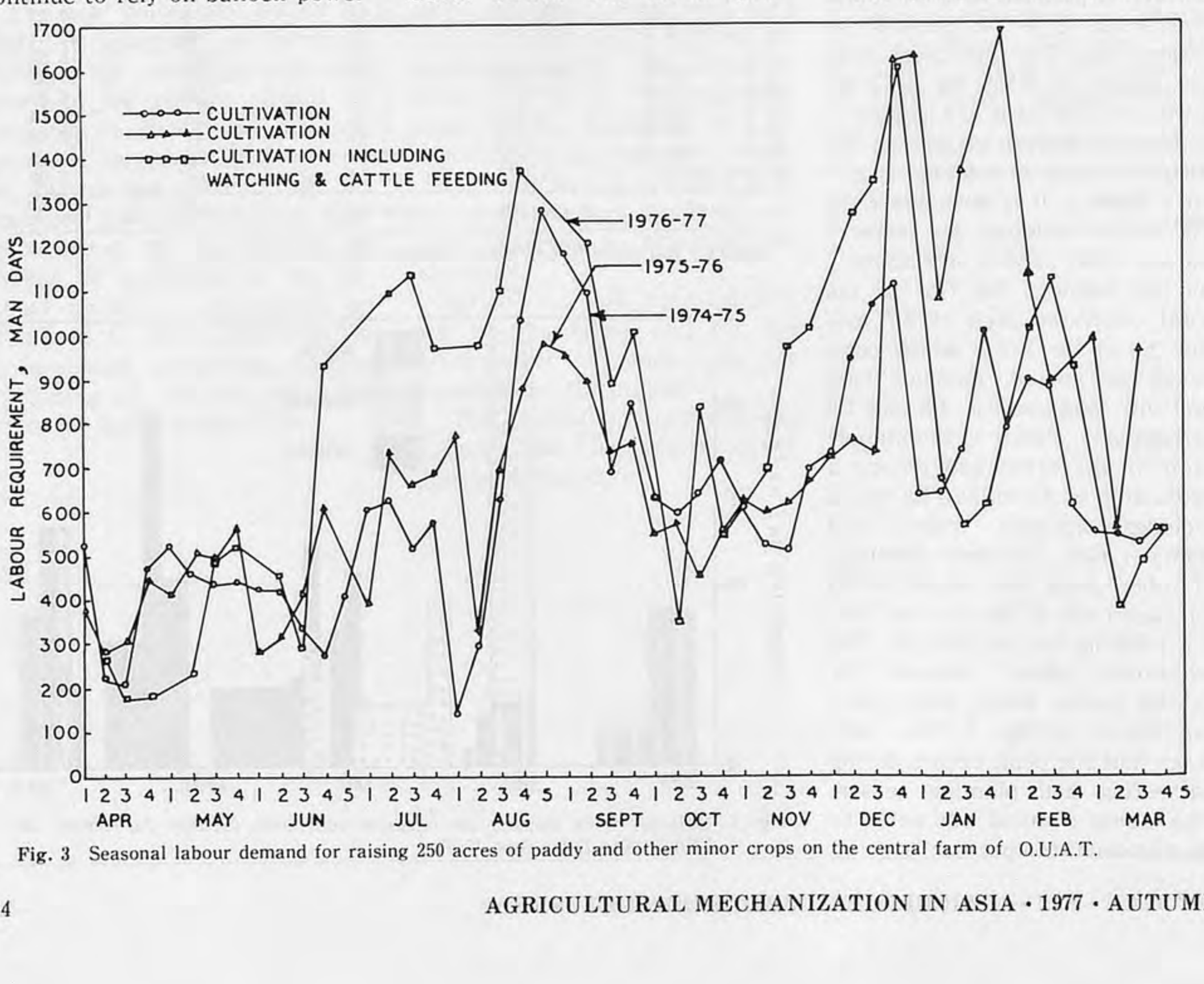

Fig. 3 Seasonal labour demand for raising 250 acres of paddy and other minor crops on the central farm of O.U.A.T.

are less pronounced under the protection of labour employment through out the year on the Governmental or big private farms. This becomes more hazardous in rural areas where the holding sizes are comparatively small and additional labours are employed only during peak days of season.

Role of Farm Implements Improved Agricultural Practices

Improved implements provide more timely land preparation operation, better weed control through soil inversion and simplified line sowing which facilitate weeding. It also reduces the cost of operation per ha as the land preparation consumes maximum energy in raising crops. **Fig.** 4 shows the energy consumption for land preparation with different package of implements for paddy as main crops in various field conditions.

Cultural practices and package of implements in **Fig.** 4 for land preparation and sowing were:

1. Four operations by deshi plough and laddering once exclusive of sowing.
2. Two operations by mould Board plough and laddering once exclusive of sowing.
3. Four operations by deshi plough, laddering and broad cast seeding exclusive of 1 ha puddling and transplanting.
4. Two operations by M.B. plough, laddering and sowing behind 3 tine cultivator with seeding attachment exclusive of one ha low land.
5. One operation by M.B. plough followed by twice disking and sowing behind 3 tine cultivator with seeding attachment exclusive of one ha low land.
6. Four times ploughing by deshi plough and sowing behind 3 tine cultivator with seeding attachment.
7. Two times ploughing by M.B. plough and sowing behind three tine cultivator with seeding attachment exclusive of one ha low land.

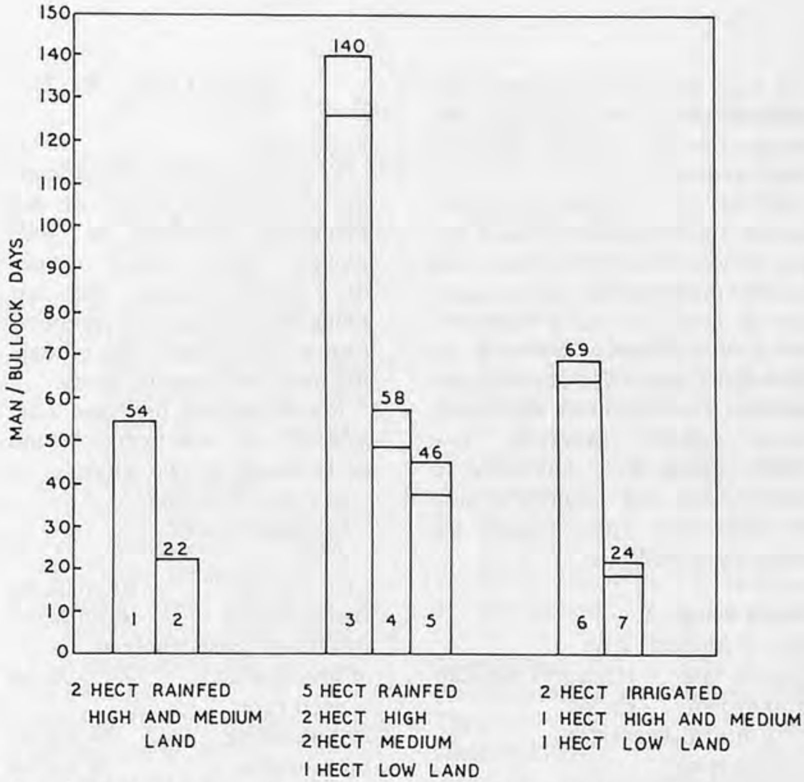

Fig. 4 Energy requirement for land preparation for different package of land

Two ha rainfed consisting high and medium land required 54 man/bullock days (one man with a pair of bullocks) using a duck footed country plough giving four passes and laddering. This time is reduced to 22 when two passes were given by a soil turning steel plough and laddering for comparatively prepared seed bed. The use of M.B. plough reduces the time by 50 percent or even more. Five ha rainfed land which consists of 2 ha high, 2 ha medium and 1 ha low land reguires 140 man/bullock days using deshi plough for four passes, broad casting seeds and covering exclusive of one ha puddling and transplanting. This requirement is reduced to 58 with two operations by soil turning M.B. plough followed by laddering and sowing behind 3 tine cultivator. This energy requirement is reduced further to 46 when one operation was done by M.B. plough followed by two operations of disking and sowing behind 3 tine cultivator in comparision **Fig.** 4 (3,4,5).

Energy requirement for two ha irrigated land is different than that of rainfed. The land preparation by deshi plow in 4 passes and sowing behind 3 tine cultivator requires 69 days where as this requirement is reduced to 24 man/bullock days using a MB plough and 3 tine cultivator for seeding.

Considering a hypothetical case and comparing it with the actual practice of land preparation by the local formers of Orissa, the land preparation work can be done in two different modes.

A. Total land preparation after the mansoon comes; the land is prepared and sowing is done consecutively.

B. Land preparation in part; land is prepared with first mansoon. Immediately after the regular mansoon comes seeds are sown and covered.

In first, due to shortage of time farmers prepare their land much less than desirable and sow. This method some time induces the farmer for late planting and as a result reduces yield.

In 2nd case farmers get sufficient time depending upon the gap between the first shower and regular mansoon for the preparation of land. Taking a hypothetical case of land preparation indicated as above for comparision between the improved and traditional cultural practices, few model studies were conducted to establish the cost benefits in paddy cultivation. These studies are indicated as follows:

Model Study-A

Size of holding- 2 ha
Type of land - High and medium
Crop grown - Paddy

1. Cultural Practices.
   a) Existing
   4 ploughing by deshi plough
   Laddering
   Broadcasting of seeds
   Use of loca 'BIDA'[1]for interculture.
   b) Recommended
   Ploughing by soil turning plough (i.e. mould board)
   Laddering
   Line sowing behind deshi plough
   Interculture with hand weeder
2. Comparison of cost coverage etc. for ploughing with deshi plough and MB plough to attain the same level of soil tilth.
   a) Land preparation:-
   MB plough
   59 hours/ha (10 days/ha)
   Cost. Rs. 240/- for 2 ha
   Deshi plough
   157 hours/ha (26 days/ha)
   Cost : Rs. 624/- for 2 ha
   (Assuming cost of using 1 pair of bullock with implement and labour at the rate of Rs. 12/- per day of 6 hrs.)
   Source: Farm Machinery, Cost and capacity
   Orissa University of Agriculture and Technology-Page 5,1971.
   Laddering: 2 days (1 ha/day) Cost : Rs. 24/- for 2 ha
   b) Sowing:
   Present practice: Broadcasting and covering seed with one ploughing operation by deshi plough. Some times farmer does seeding before the last ploughing during land preparation which reduces the ploughing once for covering seeds.
   Recommended practice: Line sowing is practiced behind deshi plough in two ways:
   a) Hand dropping[2]
   b) Single funnel[3]
   Cost:

Line sowing	Rs.55.00/ha
Broadcasting	Rs.30.00/ha
Additional cost involved in line sowing	Rs.25.00/ha

Seed rate:

Broadcasting	100 kg/ha
Line sowing	75 kg/ha
Saving of seeds	25 kg/ha

The savings in seed compensates the additional cost of sowing in lines as the seed sales at the rate of Rs. 1.00 per kg at a minimum.

c) Interculture and weeding:
Once Bida and twice hand weeding (local method) Rs.325.00-400/ha
Wheel-hoe once and twice hand weeding Rs.210.00/ha
Savings Rs.115.00-190.00/ha
If other hand weeders are used the savings will be in order of Rs.120.00/ha at a minimum.

d) Harvesting and threshing are generally done by manual labours and cost is same in both the cases.

e) Yield:

6

	Normal yield in kg		Difference
	Broad casted	Line sown	
Local varieties	700	1,000	300
High yielding Varieties	2,000	2,800	800

If high yielding varieties are grown, extra benefit will be Rs. 640.00/ha and same will reduce to Rs.240.00/ha with local varieties at a sales value of Rs. 0.80/kg.

Benefit:

1. Advancement in date of sowing:
   The advancement in date of sowing varies in a range from 4 to 32 days.

This will be applicable in case where land preparation is done with premonsoon showers or early monsoon showers and sowing is done after getting second timely monsoon.

Long duration varieties with higher yield potentials can also be grown if the date of sowing can be advanced by using improved implements.

2. Cost saving:
   a) Savings in cost by use of MB plough Rs.-384.00/ha. This saving may be reduced depending upon the land preparation with fall of monsoon.
   On an average Rs.-200.00/ha may be taken as savings as far as land preparation is concerned.
   b) Savings in cost of interculture Rs. 120.00/ha or higher.
   c) Higher yield may be Rs.240.00/ha or even higher.

Model Study-B

Size of holding 5 ha rainfed
type of land 2 ha upland
2 ha medium
and 1 ha low land
crop grown paddy

1. Cultural practices:
   a) Existing.
   4 operations by deshi plough,
   Laddering,
   Puddling of land for transplant-

1. BIDA is straight wooden peg type country made harrow, used for removing the weeds and breaking the hard pan of soil in broadcasted paddy.
2. Seeds are dropped in furrow by hand behind the plough.
3. Seeds are dropped in a funnel attached to the back of plough which releases the seeds in furrow through a seed tube.

Fig. 5 Line sowing by 3 tine cultivator with Seeding attachment

ing,
Broadcasting of seeds (high and medium land),
Manual transplanting (low land),
Use of Bida for interculture in high land.
b) Recommended.
Ploughing by MB plough followed by disc harrow.
Laddering
Line sowing using three tine cultivator with seeding attachment (high land)
Transplanting (low land) puddling with disc harrow
Interculture with hand weeders (upland)
Note: One pair of bullock owned and one pair hired during the land preparation to effect the timely planting for 2 ha high and 2 ha medium lands.

2. Comparision of cost in ploughing using MB and Deshi plough to attain the same level of soil tilth:
a) Land preparation.
i) 59 hours or (10 days/ha) for ploughing the land twice
Cost: Rs.480.00/4 ha.
157 hours or (26 days/ha) for ploughing the land four times
Cost: Rs.1248.00/4 ha
at the working rate as in model study-A (2)
ii) One operation by MB plough followed by two operations by disc harrow.
42 hours or 7 days/ha (3)
Cost: Rs.336.00 for 4 ha.
Four operations by deshi plough, 26 days/ha
Cost: Rs.1248.00 for 4 ha.
Cost benefit Rs.912.00/4 ha.
iii) One ha low land
Once mould Board followed by two operations by disc harrow, 7 days
Cost: Rs.84.00
Puddling: 4 operations by deshi plough, 22 days
Cost: Rs.264.00
Hence cost benefit is Rs.180.00 and advancement in transplanting 3 to 15 days.

b) Sowing:
Seeding by three row seeder as shown in **Fig. 5**
Coverage 10 hours/ha, for 4 ha, 40 hours or 7 days (3)
Cost: Rs.84.00
Broadcasting and covering by ploughing
Broadcasting and covering at the rate of 0.28 ha/6 hours for 4 ha, 86 hours or 14 days.
Cost: Rs.168.00
Days of advancement in sowing 7 days.

c) Interculture:
Once wheel hoe and twice hand weeding
Cost: Rs. 210.00/ha
Once Bida and twice hand weeding
Cost: Rs. 325.00 to 400.00/ha.
Savings-Rs.460.00 to 760.00 for 4 ha taking average Rs.600.00
If other hand weeders are used the savings will be about Rs.480.00 for 4 ha Model study-A (c).

d) Yield:
Extra benefit from the high yielding varieties Rs.2500.00
Extra benefit from the local varieties Rs.960.00

e) Benefits:
1) Land preparation:
Cost of benefit by MB plough only
Rs.768.00 + Rs.180.00
= Rs.948.00
By MB plough and disc harrow
Rs.912.00 + Rs.180.00
= Rs.1092.00
2) Days of advancement:
a) Sowing-5 to 40 days
b) Transplanting-3 to 15 days
3) Early sowing and early transplanting will result with higher yield upto 25 percent to 50 percent extra.
Higher yield of H.Y.V. paddy is about Rs.25.60.00 for 4 ha.
4) Saving in cost of interculture—on an average Rs.600.00 for 4 ha for medium and uplands.

Model Study-C

Size of holding 2 ha Irrigated
Type of land 1 ha-up and medium land
1 ha-low land
Crop grown Paddy

a) Comparision of cost in land preparation
i) 1 ha upland
Land preparation
Two operations by MB plough 10 days/ha
Cost: Rs.129.00/ha
Four operations by deshi plough for came tilth-26 days/ha
Cost: Rs.312.00/ha.
Cost benefit Rs.192.00/ha
ii) 1 ha low land: Same as model study-B (2) land preparation.
Advancement in sowing 3 to 15 days

b) i) Sowing: Same as model study-A (b)
ii) Transplanting:
Paddy transplanting in both the methods require about 65 mandays/ha as there is no suitable machine available for this operation.

c) Interculture: Some as model study-A (c)

d) Yield:
i) Cost benefit in line sowing from high and medium land will be Rs.480.00 to Rs.1280.00 for two

ha respectively when local and high yielding varieties are grown.

ii) Cost benefit from one ha low land will be Rs.-240.00 to Rs.400.00.

Total benefits:

1) In land preparation Rs.384.00

Advancement in days of sowing and transplanting 3 to 16 days.

2) Saving in interculture-Rs.120.00/ha

3) Higher yield—Rs.480.00 to Rs.1280.00 for 2 ha.

The summary of the model studies above indicating the cost benefit and advancement in sowing have been given in **table 2 and** 3 respectively. Based on the data (2) and also from the above model studies taking a hypothtical case for preparation of land in 1/8th ha using improved bullock drawn MB plough in comparision to deshi plough and from improved cultural practices time is reduced by 50 percent or more and at an average cost is reduced by 40 percent and sowing and or transplanting dates can be advanced as much as 20 to 32 days with subsequent improvement in yield.

Weeding

The combination of effective ploughing and timely sowing should lead to the abondonment of the present practice of cross ploughing 'Behushoning'* in broad cast rice, which results in serious reduction in plant population. Hand pulling of weed is presently avoid using simple hand weeders depending upon the availability. If hand weeders are used saving in cost will be in order of Rs.-120.00 per ha as minimum **(table-2).**

*A local practice of ploughing the directly sown paddy field after flooding when plants are about 20-40 days old. A worn deshi plough shown in fig.2 (a) is used. In the process plant population is reduced and weeds are suppressed.

Table 2 Cost Benefit from the Model Farms of Various Sizes with Improved Implements and Cultural Practices

Farm size and type of land	Cost benefit in rupees			Total
	Land preparation	Interculture	Extra yield	
2 ha rainfed, 1 ha high and 1 ha low land	200	240	480	920
5 ha rain fed, 2 ha high 2 ha medium and 1 ha low land	500	610	2,560	3,670
2 ha irrigated, 1 ha high and medium and 1 ha low land	380	270	880	1,530

Table 3 Saving in Time and Advancement in Sowing Dates for the Preparation of Land

No. of plot 1/8th ha each in area	Orissa Deshi Plough		M.B.Plough		Advancement in days
	Land Preparation	Sowing	Land preparation	Sowing	
1	1—6.5	7	1—2.5	3	4
2	7—13.5	14	3—5.5	6	8
3	14—20.5	21	6—8.5	9	12
4	21—27.5	28	9—11.5	12	14
5	28—34.5	35	12—14.5	15	20
6	35—41.5	42	15—17.5	18	24
7	42—48.5	49	18—20.5	21	28
8	49—55.5	56	21—23.5	24	32

1. General practice for the land preparation is in part of an ha and sowing. Some times sowing is defered in a particular condition.

Summery

Though the soil turning ploughs developed by the Agricultural Engineering division of Director of Agriculture and Food Production, Orissa, along with other manufactures have made a good impact as regard to land preparation is concerned in the state but duck footed country plough is still in use. This plough requires several passes to achieve even partial inversion which not only give poor weed control but in-efficient use of man-bullock hours. Considering the larger portion of cultivated land in smaller holdings the mechanization mode was limited to oxen drawn implements and its impact was studied. The following brief conclusions were drawn from the above study.

1. With the use of improved implements and cultural practices saving in time will result.
2. Cost of cultivation will be reduced.
3. Advancement in sowing dates will be achieved. Timely planting will permit multi-croping with high yielding varieties resulting in extra yield benefits.
4. Improved cultural practices in line sown paddy will permit cross cultivation increase aeration and improve the activity of micro-organism which will help the release of nutrients for plant use. It also help in controlling the weeds during plant growth.

ACKNOWLEDGEMENT

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Operating Cost of Rice Harvesting Patterns in Japan

—The Case of Saga Central Plain Area—

by
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Introduction

Because of scarcity of farm workers, relatively high farm wages, the availability of some new machines, and the economic advantage of high quality rice, many farmers have made some changes in their rice cultivation and have increasingly mechanized their harvesting operation. Even though rice production has been declining under the Rice Production Adjustment since 1970, harvesting methods in Japan have kept pace with technical developments in harvesting machinery, and rice harvesting methods and equipment have changed considerable during the past 10 years. Binder and combine were begun to introduce on rice farms in 1970s, substituing for hand reaper or sickel. There has been continuing trend to more mechanization.

This study was made to determine the labor requirments and machinery costs in selected rice harvesting machinery combination in Saga Central Plain Area which is one of the most mechanized in Japan. The data presented may be helpful in making decisions on the purchase of rice harvesting equipment or in calculating production costs for farm planning and enterprise analysis. And also, cost comparisons are presented for machine costs and custom rates. These data are especially useful when evaluating the economic feasibility of owning and operating rice harvesting machines, as compared with hiring performance of specific operation.

The rice harvesting work programs on most farms in this area are made up of reaping, strow-drying, threshing, rice-drying, and hulling. Many different combinations of machines are used to harvest the rice. Of these many combinations 3 important ones were selected and are referred to in this study as rice harvesting patterns.

Information about crops, labor, harvesting machines. power, harvesting practices, and operating cost was obtained from 160 farmers situated in Nishikoga, Yoshimura, Minaminanaku, and Dokyo Villages, Kawasoe-cho, Saga Central Plain Area. All farmers were twice visited to obtain the data, in summers of 1974 and 1975. The data are for the harvest season of 1973, when the harvest was favorable and the weather was fairly good for producing rice.(**Photo 1**)

Mechanization Process of Rice Harvesting

After the power-tiller has spread far and wide, most farmers have introduced gradually, but continuously, several kinds of small machines such as power sprayer, power thresher, power dryer, truck, and so on. This advance in farm mechanization has been caused by a strong demand for labor in other industries that has withdrawn workers from the land and forced wages rates up. Severe labor shortage and high wage rates in the rural area since 1960, together with the simulataneous demands for increased agricultural production, have had a marked influence on the mechanization of various operation. However, the harvesting of rice has been treated with hand sickel on all farms at that time, because the harvesting machine has not been yet developed in Japan.

Hand reaper has been introduced as a first harvesting machine in this area in 1964, and then the number of them has increased gradually from 8 in 1966 to 19 in 1969 on farms surveyed. (**Photo 2 and Fig. 1**) But its spread has been stopped by the appearnce of 2-row self-propelled binder. The work efficiency of binder was so higher than hand sickel or reaper. Both cutting and binding the strow of rice could be done by a binder at the same time. (**photo 3**) Threfore, the number of binders has increased very speedy on farms from 6 in

Photo.1. Landscape of paddy field and rice stocks for strow-drying in Saga Central Plain Area.

Photo.2. Reaping with hand reaper.

Photo.3. Reaping with 2-row binder

Photo.4. Harvesting with combine.

1969 to 64 in 1971, and then 95 in 1973. In comparison with the spread of binder, only 3 reapers were used for rice harvesting in 1974.

Combine was sold in this area around 1972 which has both function of reaping and threshing on paddy field at the same time, and more the sun-drying for strow and rough rice is put out of old work practices by combine in cooperation with the use of new circulated solid type dryer. Therefore, 2-row combine has also increased very sharply on farms from 8 in 1972 to 23 in 1974, while 11 old binders have been replaced with combine. (**Photo 4**)

Most of 91 auto-threshers were owned individually on farms surveyed, but power hullers were used jointly by some groups. Dryer for rice and wheat has spread out in this area since 1960, and most farmers have not used it in all process of rice drying but only in last part for finishing sun-dried rice. The rice combined includes usually about 25 percent of moisture and a farmer has to decrease untill 15 percent for sale during the rush season. Renovation of dryer was so remarkable that some old plane type dryers have been replaced with new circulated solid type ones on the large size farms. About 78 percent of farmers have owned dryer individually in 1974, but the new typed one was only 36 percent of them.

This outstanding advance in mechanization process of rice havesting was due mainly to a shortage of agricultural hired labor, decreasing of family worker on farm, and a rapidly expanding and effective development of farm machinery industries. With this mechanization process, each kind of machines was first introduced under individual ownership into the large size farm group. And then, use of machinery spread under joint ownership into the median size farm group, but did not extend to the small size

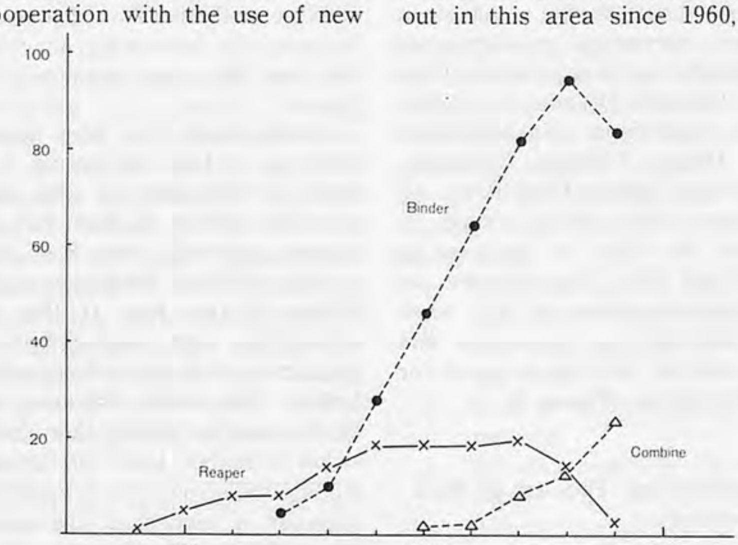

Fig.1. Changes of Number of Rice Harvesting Machines on 160 Farms, 4 Villages, Kawasoe-cho

Phopo.5. Threshing with auto-thresher.

Photo.6. Reaping with hand sickel.

farm group, because of shortage on accommodation funds and unsuitability for machine operation. About 34 percent of farmers have not owned any king of harvesting machines in 1974, but most of them have used at a small portion of rice harvested through a custom work.

Rice Harvesting Pattern

With the introduction of different machines on a farm, obviously these combinations of machines differ from farm to farm. There were 18 rice harvesting patterns on 160 farms surveyed and they were grouped nearly into three typical patterns.

Binder pattern was most popular in 1973, which cosisted of 2-row binder, auto-thresher, small plane type dryer, and power huller. Other typical patterns were distributed according to the size of farm, that is, the reaper pattern with hand reaper, auto-thresher, small plane type dryer, and power huller was mainly on the small farm of 1.0 hectare and less, while the combine pattern based on 2-row combine, large circulated solid type dryer, and power huller was on the large farm of over 1.3 hectares. **(Table 1)**

Combine pattern was most mechanized and of high efficiency compared with others. For instance, reaping and binding with a hand reaper required 154 hours of labor per hectare, compared with 27 hours using a binder. With a combine the labor used for reaping and threshing was only 57 hours per hectare. The work efficiency of combine pattern was about four times that of a reaper pattern.

Field loss or waste results when the combine fails to harvest rice that would normally have been gathered by hand methods. A research of Saga Agricultural Experiment Station has showed field loss from mechanical harvesting to be 3-5 percent of the total yield. There were almost no difference between the rates of three patterns. And also, the relative metabolic rates, showing the degree of fatigue per hour, of farm work with machine are definitly smaller than with hand labor. For instance, in reaping with a combine the rate was 1.6 percent per hour, compared to 2.1 percent with a binder, and 4.4 percent with a hand reaper.

On the basis of these technical effects, the farm system in changed by the use of machines. Not only is there a high degree of commercial farming, but also there is the opportunity to do a custom work with the machine if the owner's farm is not too large. Custom work was harvesting for about 34 percent farmers who have no machines, and they paid a charge for this service to the owner-operator of the machine. Therefore, it helped to increase the annual use of combine or binder and the profit about 15 thousand yen per hectare. But this is limited by the operator's available time, the seasonality of harvesting, and others.

Operating Cost

The total investment in machines was about 890 thousand yen in a combine pattern, while only 150 thousand yen in a reaper one. Gennerally, the purchase price of these machines has shown a sharp increase in the years since 1975. Annual use of combine pattern ranged from 2.13 to 8.22 hectares with a mean of 4.08 hectares, inclused some custom work and harvesting of winter crops, wheat and barley. Reaper pattern was operated between 0.07 and 0.74 hectares because of its low efficiency. **(Table 2)**

Cost of owning and operating machines is comprised of fixed cost and variable cost. Fixed cost results from ownership and will be incurred whether the machines are used or not. It includes depreciation and interest in this study. Annual depreciation was calculated by the straight-line

Table 1. Distribution of Farms with Three Rice Harvesting Patterns in 4 Villages, Kawasoe-Machi, 1973

Kind of pattern	Number of farms	Size of farm				
		−0.5	−1.0	−1.5	−2.0	2.1ha −
Reaper	15(9)	6	6	2	1	—
Binder	137(86)	22	39	30	31	15
Combine	8(5)	—	—	3	4	1
Total	160(100)	28	45	35	36	16
Acreage of rice per farm	1.06ha	0.25	0.68	1.12	1.55	2.19

Average yield of brown rice was about 6,430 kg per hectare.

Table 2. Annual Useage and Operating Cost

Kind of pattern	Total investment in machines	Average annual use (range)	Operating cost per hectare			
			Total	Fixed	Variable	Labor
	(thousand yen)	(ha)	(thousand yen)			
Reaper	150	0.41 (0.07—0.74)	182	56	22	104
Binder	380	2.18 (0.71—4.45)	121	28	24	69
Combine	890	4.08 (2.13—8.22)	88	34	26	28

method as purchase price on farm divided by the standard useful life. The interest on investment was estimated as one-half the purchase price times 7.5 percent. Variable cost is directly related to use and includes such terms as repairs, fuel, lubricants, and labor. The repair costs of machines in this study was calculated as purchase price times 5.0 percent. The cost of the labor required to operate machines and other hand harvesting was an important item of variable cost, and 400 yen per hour was estimated as the labor wage rate.

Since fixed costs per hectare declined as annual use was increased, and variable costs per unit remain more or less costant regardless of level of use, total costs per unit declined as annual use was increased for each three patterns. (**Fig.2**) However, reaper pattern used by owner of 0.41 hectares had an average cost per hectare of 182 thousand yen, while the binder pattern was operated economically by owners of from 1.4 to 2.1 hectares. Its cost was about 121 thousand yen per hectare on usage of 2.18 hectares. When compared with the others with annual usage by owners of over 2.1 hectares, the combime pattern was cheapest. Its operating cost was only 88 thousand yen on the usage of 4.08 hectares.

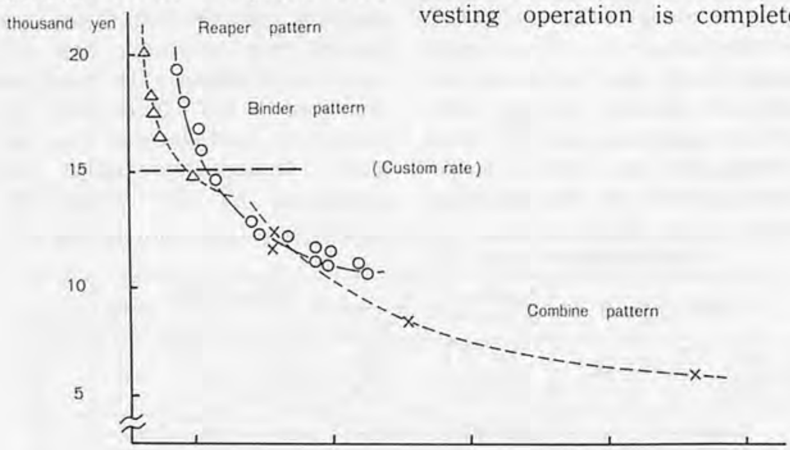

Fig.2. Operating Cost per Hectare

For a custom rate of 150 thousand yen hectare, around 0.8 hectares of rice were needed to justify ownership of reaper pattern. And also, the break-even point was about 1.2 hectares for the binder pattern.

Therefore, a reaper pattern has been rapidly disappeared from farms in this area, and the replacement of obsolated binder into the combine has been made promptyly progress at present time. Harvesting rice with a combine has certain advantages and disadvantages that must be considered. It is impossible to bind the strow of rice after reaping when combine is used. Some farmers have furnished a new attachment on the combine for binding in stead of cutting equipment. However, the strow is not wasted as it has many beneficial effects on the soil to which it is returned. One of the biggest advantages of harvesting rice with a combine is that the harvesting operation is completed early enough to permit the rice to be followed by a winter crop such as wheat or barley.

Under the present circumstances, however, it is difficult to shift entirely from the binder pattern to the combine one, because the paddy field condition is not always so good for its utilization in this area and most of farmers still own a line of obsolate small machines.

Conclusion

The binder pattern for harvesting rice was most common as a substitute for a reaper pattern in Saga Central Plain Area in 1974. Grain combine have become an important item of machinery on some large farms over the past few years, because of high efficiency. The outstanding advance in mechanization process was due mainly to a shortage of agricultural worker on farm, high wage rates, and a rapidly development of farm machinery industries. The distribution of three harvesting patterns has related closely to the size of farm. The average annual use on farms studied was only 0.41 hectares for the reaper pattern, and 2.18 and 4.08 hectares for the binder and combine pattern, respectively. Average operating cost per hectare was lower for the combine pattern than for others in spit of high investment. For each pattern, operating cost per hectare decreased as annual usage was increased. With a custom rate of 150 thousand yen per hectare for harvesting rice, hiring custom harvesting would have a cost advantage over owning a binder pattern if fewer than 1.2 hectares were harvested annually. And also, when the usage was over 2.1 hectares, the ownerphip of combine pattern would have a cost advantage compared with of binder one. This interrelationship between the three rice harvesting patterns would be more emphasized if the wage rates was gone up. ■■

Farm Equipment Standardization for Agricultural Development

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Farm tools and equipment play a vital role in increasing agricultural productivity. These are required not only for carrying out the different agricultural operations, but also for ensuring the efficient application and utilization of other inputs, viz. seeds, fertilizers, pesticides and irrigation water, The production capacity and quality of work of a person depends on the type of tool he uses. This is true for industry as well as agriculture.

In the past, the implement kit of the Indian farmer comprised of simple tools, and equipment mostly manufactured by the village artisans. Inspite of their relatively low cost, these had the constraints of low efficiency to meet the accuracy and thoroughness in operations. Today a wide range of implements and equipment are used by the farmers, and the farm equipment industry in the county is fairly well developed, manufacturing equipment ranging from improved implements to tractors and processing equipment. Investments on farm equipment are steadily increasing. The investments limited to only those items included in the Livestock Census (1972) alone work out to about Rs. 68500 million.

It would suffice to say that the farmers are taking to a wide variety of tools and equipment which are essential for the crop production and related operations, and this process will have to be planned, guided and accelerated to make agricultural operations easier, faster and more economical. It is in this context that standardization should play its vital role to trigger a more rapid modernization of agricultural operations by ensuring to the farmer, supply of quality implements and equipment. The equipment besides meeting the functional requirements should be reasonably priced, enable him to achieve overall economy in operation, reduce human effort and facilitate ease in maintenance and repair. Related to these is safety in handling and operation.

The Agricultural Implements and Machinery Sectional Committee, as compared to other Sectional Committees, though is relatively young, has to its credit formulation of a large number of standards (separately listed), covering different type of tools and implements, components and assemblies of machines, code of practices, testing procedures, terminology etc. For ensuring greater participation of all concerned and for intensifying the activities on formulation of standards, the work handled by the Sectional Committee AFDC -20, has been divided between four Sectional Committees which pays exclusive attention to farm power and machinery, processing equipment, crop protection equipment, and horticultural equipment. While greater effort is being made in the formulation of new standards, I would like to draw attention to a few selected aspects concerning the formulation of standards, their adoption and implementation. These are discussed briefly, mainly with the objective of focussing attention on certain issues as they come to mind.

Priorities

The present situation warrants priority attention to standardization of items that promote use intermediate/appropriate technology, code of practices for improving efficiency in the operation and utilization of farm equipment, and those that would result in reduction in initial cost, problems of maintenance and servicing and ensure operators' safety and comfort.

Standards for Improved Implements

Faster introduction and popularization of appropriate/intermediate technology, which would enable the larger sections of the farming community to modernise their agricultural operations is essential. The progress made in the introduction

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and popularization of improved tools and simple machines which the small and medium farmers can easily own and operate is not commensurate with the agricultural production needs. Though some of the commonly used tools and implements, components of such items as seed-cum-fertilizers, chaff cutters, have been standardized, it is necessary that standards are formulated for a complete range of tools, implements and small equipment that are essential for tillage, intercultivation, irrigation, plant protection, harvesting and post harvest handling, suitable for a general farming situation and wherever necessary with variations in specifications that would permit their adaptation for different agro-climatic conditions. The standards would prove usefull communication media between manufacturers and designers and the extension agencies. An agricultural college in Manarashtra has developed an implement stand for about a dozen tools and implements of approved design for demonstration and use by the students, and the result has been a faster acceptance of these in the area. What is important is the effort in identifying items the farmer needs and the message of quality and availability that facilitates faster adoption.

It would be too ideal a situation, if a farmer can walk into an in-put distribution store and select a set or combination of standardized tools and implements to fully meet his farming requirements or a kit of standardized gardening and horticultural tools. Standardization, besides helping the farmer would be a stimulant for their faster adoption. A more critical examination of the requirements of additional standards, to cover new items of essential implements is necessary. Such a step will have to be followed up with a system of quality marking.

Code of Practices

The more commonly accepted objectives of standardization include interchangeability, choice materials and specifications, functional parameters and so on. Code of practices or recommended practices in the form of standards is a relatively new effort. Reviewing as to how some of the standards have come about, it will be interesting to note that the inability of fire fighting squads to couple together water hoses from fire fighters drawn from the different parts of the city of Baltimore to quench the great fire in 1903, has promoted development of a standard for hoses and couplings. The standard came about because there was a felt need.

In promoting agricultural mechanization and in ensuring proper utilization of costly machinery, code of practices are important, primarily to safeguard the interests of the consumer. When bulk of the requirements of tractors were met out of imports, the price charged to the farmer include dealer expenses for providing on the farm free services during the warranty period. While some of the distributors provided as many as six free services, some others were providing only two on three, and yet, few others even obtaining the free service coupons signed by the farmers at the time of delivery of tractors. Also there was no uniformity between the types of adjustments and maintenance jobs done during the free service visits. The Farm Machinery Sectional Committee, therefore, took up the work of formulation of code of practice for preventive maintenance, and code of practice for installation of agricultural tractors.

While tractors are one of the widely used agriicultural machinery, there are several other items in respect of which code of practices are necessary. These include engine and electric operated pump sets, use of plant protection equipment and several others.

Population of irrigation pumps has increased from about 3.9 lakhs in 1961 to about 32.5 lakhs in 1972. Annual production and sale of these ranges from 2.5 to 2.8 lakhs. A study carried out by the Punjab Agricultural University shows that as against an expected overall efficiency of 50%, the average efficiency obtained varies from 23% to 37%, the major reason for this low efficiency being poor quality and improper selection. Further under-utilization due to improper installation and lack of maintenance and servicing are also considerable. The above study reveals that, if steps are taken for obtaining optimum effciency, for the 1.5 lakhs electrically operated pumps in Punjab, the saving in electric power will be the order of 321 million KW per year and for the 2.77 lakhs engine operated pumps the savings in terms of quantity of fuel would be of the order of 118 million litres. The magnitude of benefits that would accrue by use of good designs, supported by proper selection of pumps and their maintenance and repair would be substantial to justify special efforts. An immediate need is a code of practice for installation and routine and periodical maintenance.

The servicing facilities set-up by farm equipment dealer ranges from ill-equipped and poorly staffed workshops to well-planned ones staffed by factory trained service engineers. Also there is no norm for stocking of spare parts. It is not necessary to amplify the situation as it exists in the interior parts of the country. A norm for servicing facilities, especially the minimum tools and servicing equipment, standard of training and proficiency of mechanics, categorization of workshops based on the facilities and expertise and norms of fast and slow moving parts that every farm equipment dealer should maintain for a given population of machines sold and serviced by him, are an immediate need.

With the extension of area under high yielding varieties and multiple cropping, plant protection has become important. While there are several standards available for pesticides and plant protection equipment, standards on protective accessories the operators should use as a measure of safety requires special attention.

The above are only a selected few, and mention of these have been made to highlight the general need for code of practices for improving the upkeep and utilization of farm equipment.

Interchangeable Components

One of the highly standardized item available to the common man is the cycle in which all the major components such as wheels, frame, handle bar, chain, etc., have a very high percentage of interchangeability which makes it easy for the users to maintain and repair even in the remotest parts of the country. While we are today manufacturing about 15 models of tractors, five makes of power tillers and a wide range of irrigation equipment, no serious effort has been made to standardize some of the interchangeable parts between the different makes of machines. Taking only the example of a tractor, hardware items, hoses instruments and even the wheels of tractors in the same H.P. ranges offer considerable scope for standardization. While mentioning this, I do not overlook the fact that there is certain amount of standardization, as far as some of the proprietory items such as batteries, fuel system parts etc., are concerned. A deliberate and conscious effort for identifying items which can be taken up for standardization is needed. The types and varieties of hardware items used in agricultural machinery and implements are too large. These are used in innumerable sizes, head shapes, lengths, diameters, strength and designs.

An effort worth mentioning in reducing the types and varieties of bolts and nuts used in tractors was attempted by Harry Ferguson in which he developed the Ferguson tractor, in which all the bolts and nuts requiring periodical check-up could be handled with only one double ended spanner. Just imagine the convenience this brings to the farmer in promptly attending to the routine check-ups and maintenace. It is a common practice that hired operators seldom carry a complete set of tools to the field and the result is one of premature failures followed by costly repairs.

It may be worth mentioning that one of the leading automobile manufacturers used an engine oil drain plug which for its opening needed a special spanner. Whatever be the motive behind providing such a special plug, the consequence had been that the users who could not visit the servicing station on the due dates abnormally delayed the oil changes, causing premature failure, which ultimately affected the general repute of the product.

John Deere Co. in USA, conscious of reducing the manufacturing cost took up a study on reduction of variety of parts and hardware items. The result had been that the parts used were reduced from 25,000 to less than 8,000 resulting in a one time saving of 500,000 and a substantial recurring annual benefits. This also resulted in eliminating about 11,000 parts required for service and their stocking by the dealers.

To the manufacturer, every new part included in the machine adds to the cost by way of expenditure for design, testing, manufacture, stocking and handling. The analysis made by John Deere shows that the average cost of adding a new part works out as under:

Engineering	53.42%
Manufacturing	30.54%
Marketing	6.94%
Hardware	9.10%
Total	100%

A wide range of alloy steels are in the market and in many cases the variety of raw-materials that are presently used can be drastically cut down without unduly sacrificing the quality and performance of the product. All that would be necessary is to make marginal changes in the design. This world reduce the inventory on raw-materials and also facilitate ease in availability. Reduction in manufacturing cost resulting from standardization would ultimately make ownership and operation cheaper for the farmer and would stimulate demand which would benefit both the manufacturer and the farmer.

Use of a large number of standardized components could be a good selling point to convince the buyer of the ease with which servicing and parts supply would become available.

How many of our farm equipment manufacturers are using this as a sales promotion tool?

Reduction of variety through standardization for the dealer, would amount to fewer spare parts to be stocked and handled, lower capital employed, faster turn-over of fewer parts, lower write-offs due to absolescene and change of models. All these in turn would also benefit the farmer through improved parts availability and faster service.

Participation and Consultations

To make a standard purposeful and useful, it is necessary that there should be an active participation of the manufacturers, users, testing and research institutions etc. The standards are formulated based on the proposals that are received by the ISI. The draft standards before they are finalized are discussed by the concerned technical committees of the ISI and the drafts are then circulated to all concerned for a period of three months for eliciting comments. Constructive suggestions from manufacturers, research institutions and professional bodies such as the Indian Society of Agricultural Engineers, Institution of Engineers, etc., are necessary for improving the quality of standards. Also it is necessary that the Govt. and private organizations should make their technical officers responsible for perusing the standards and in actively participating in the deliberations on standardization. Not only, the organized industry should have a separate cell to study and propose standards which will be useful to them, but also to the industry in general and the consumer.

Supporting Services and Research

For formulation of technically sound standards, extensive research, testing and follow up survey are necessary. The initial efforts in the formulation of standards were acceptance of design parameters and specifications which have had been common acceptance. In the traffic lights that we come across every day, if red has been taken as a standard to signify danger, or "stop", it is because the red colour was associated with fire or colour of blood to signify danger even from the time immemorial; and the green being a more soothing colour signifies safety. I do not think that lot of research and technical discussions would have gone into in standardizing these colours for traffic signals. This was more of a convention which had been codified. While this could be one of the easy methods that could be followed, a dynamic and purposeful programme of standardization should be backed by extensive research. To cite an example, agricultural disc is one of the extensively used components and which has been standardized as early as 1968, the official testing of which, for the first time was taken up by the Government of India Tractor Training and Testing Station, Budni early in 1965. Based on the experience gained, standard on Agricultural Discs IS-4366 was formulated in 1967. The ISI marking automatically involved a testing procedure by which conformance with the standards could be ensured. While attempts have been made to formulate a standard procedure for testing of agricultural discs, the problem has arisen as to what should be the impact strength of discs. This naturally involves experimentation and field trials for selection of parameter which takes into account what is actually demanded by the field situations.

While specifying design parameters, for agricultural implements, often there is a tendency to specify too close a tolerance, which though in certain cases would be essential, due consideration will have to be given to an additional expenditure that will be involved in maintaining a high precision/tolerance. Unless the technical and functional requirements warrant, it will have to be ensured that the design parameters are not too strict which would unduly inflate the manufacturing cost and the end price to the user. The cost to the end-users on the possible probabilities would have to be carefully studied and analyzed in deciding upon the parameters. This would involve detailed studies and research.

One of the constraints in the faster adoption of mechanization is the relatively high cost of tractors, power tillers, and other farm equipment. Some of the major manufacturers abroad have already standardized components of different models manufactured by them. Use of standardized components between the products manufactured by the same organization is relatively easy. But as far as India is concerned, a special effort is required for use of common assemblies and components between manufacturers engaged in the manufacture of similar products. Stretching this concept a little too far, it is difficult to see any insurmountable problem in using a common gear box and hydraulics, say for tractors, between 20 to 30 HP with a design so selected that it fully meets the requisite performance and design parameters. Volume effects on economies of scale would be substantial. Barring the desire of the different manufacturers to maintain their own identity, use of production facilities already set up by them, or arrangements made with vendors, it is difficult to visualise any major difficulty in adopting this over a period of time. Power tillers and other equipment manufactured in Japan and other countries, make extensive use of inter-changeable assemblies and components. Taking the example of power tiller in India, in view of the present high price of indigenous machines which has dormanted demand, special efforts are needed to ensure that the cost of production is not unduly high due to low volumes of production by the different manufacturing units. What it needed is in-depth study of possibilities of use of common components and assemblies and adaptive research Unless these and similar steps are initiated in the long run, besides the price effects on domestic demand, India made equipment perhaps, may even find it difficult to compete in foreign markets without heavy reliance on export incentives.

Work of the above nature

needs initiative and takes time, patience and considerable effort. Major manufacturers have their own R & D cells. Would it not be appropriate for the manufacturers to join hands to develop facilities for research and investigations which could benefit them and the user?

Implementation

The number of standards formulated, certainly is a measure of performance. But equally important is follow up action to evaluate the use and adoption of standards both by the manufacturers and consumers. It is hoped that the ISI, in its programmes of expansion would consider having its own technical cells for carrying out periodical surveys and investigations; the feed back information serving as an effective tool for updating and implementing the standards.

Formulation of standards should be supported by the necessary infra-structure for carrying out approval tests. While Tractor Training and Testing Station, Bundi, is engaged in testing of tractors and other power equipment, purely from the point of approval tests, quality marking facilities spread over the country, preferably on regional basis will have to be established.

The maximum benefit from standardization would accrue when a standard is adopted both by the manufacturers and the consumers. At present obtaining of quality certification is not obligatory on the part of the manufacturers. While there would be two possibilities; in either making adoption of some of the very essential standards compulsory, the other would be that the user's opinions and preferences influence the manufacturers to produce and market products conforming to the standards. For the latter to happen, quality marked products should offer a definite advantage to the consumer to motivate him to opt for only quality marked products. It is also pertinent, that unlike other consuming sectors of the society, the farming community is widely dispersed and organizationally weak either to express or to influence trends and decisions. Their interests are take care of largely by the Government. The Ministry of Agriculture has already requested the different State Governments that preference should be given to ISI marked products in their programmes of introduction and popularization of agricultural implements and machines.

Safety

With an increase in the use of power machinery in agriculture, safety becomes a very important consideration. A survey carried out by the Punjab Agricultural University showed that accidents due to use of threshers were high. It may, therefore, seem desirable that from the safety point of view, wherever safety requirements are prescribed in the relevant standards, these are made compulsory. Enforcement would naturally involve an infrastructure dispersed atleast at the regional and State levels for inspection of the products and for certification. While in UK and some of the other advanced countries, compliance of safety requirements are obigatory, and Safety Councils exist, action in this direction is yet to be initiated in India.

An Aid to Sound Credit Financing

Credit financing of farm equipment is increasing, and fiancing institutions could take advantage of standardization, not only for ensuring that quality products are made eligible for credit financing, but also for ensuring that such equipment are properly maintained and operated. It is for this latter part, the code of practices for installation, after-sales sevices, norms of spare parts stocking etc., discussed earlier would become useful, as compliance of these practices would prove effective in ensuring efficient utilization of the equipment, and thereby farmer income and consequent prompt recovery.

Participation in Regional and International Activities

Standards could be used as an effective instrument of communication and as an aid for export promotion. Export of pumps alone during 1975-76 was of the order of Rs. 6.0 crores. India has been exporting improved implements and tools for over a decade and tractors and other machinery are also now being exported.

Participation in the deliberations of ISO and other organizations dealing with standards and quality control would not only enable us to make known the progress of our development and expertise, but also to benefit from developmental trends in other countries.

In the field of hand tools and improved implements, the experience and expertise of India is considerable and this experience could be shared by us in the promotion of agricultural development of other developing countries. It would be useful if serious thought is given to the possibilities of India taking up the activity on standardization of improved implements and hand tools on behalf of ISO by offering facilities for organizing the Secretariat for this purpose.

The challenges standardization offers for improvement of agricultural production are many. What is needed is a concerted effort. ■■

Appropriate Rice Production Technology for Bangladesh

by
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The economy of Bangladesh is predominantly agricultural. Of the 74 million people of Bangladesh about 90% live in rural areas and over 75% are engaged in agricultural activities. Agricultural output acounts for over 55% of the Gross Domestic Product (GDP). Rice covers nearly 80% of the total Bangladesh cropped area of about 31 million acres. It is little surprising, therefore, that nearly a third of the GDP is derived from rice alone.[1]

During the 1950s agricultural output in Bangladesh virtually stagnated. Rice production increased at only 0.7 per cent per annum. Agriculture improved during the 1960s when agricultural production grew at 2.5 per cent per annum. This improvement in the pace of growth of agriculture was brought about primarily through an equally improved pace of growth in rice production.[2] This only shows that the growth in Bangladesh agriculture relies heavily on the growth in rice production alone.

Further, Bangladesh has been suffering from chronic food deficits over the past several years. In 1975 alone 2.4 million metric tons of food grains had to be imported into Bangladesh[3] Nearly 83% of the entire Bangladesh 1975 total export earnings of Taka 3595 million was used up in payment for this food import resulting in an enormous gap of Taka 6782 million in the country's trade belance that year.[4]

Over 76% of the 26 million total work force is agricultural. Unemployment and underemplyment is estimated at 37% of the agricultural labour force. Two-thirds of this is estimated to be composed of seasonal underemployment.[5] The number of landless workers in agriculture was 15% (2.5 million in number) of the total agricultural labour force as is seen from the 1961 Census and this represented a 63% increase over the previous census year (1951).[6] In May 1976, over one-quarter of the 625 rural households surveyed in the districts of Bogra, Sylhet and Noakhali were without land. (The description of the survey follows below).

The choice of thchnology for rice cultivation when seen in this perspective would clearly have to be guided by the dual considerations of increased productivity and greater employment.

Purpose of the Paper

The paper begins by evaluating the output and employment implications of the alternative bio-chemical technolgies currently in use in Bangladesh rice cultivation. Secondly, the impact of the alternative sources of draught power on rice production and employment are systematically examined. In the third section, the two alternative bio-chemical technologies and draught power techniques are synthesised in order to determine the optimum combination of the two which is consistent with the maximization of both output and employment. The prospects of reducing seasonal underemployment and providing wage employment to the landless agricuitural workers following the use of the new rice technology is taken up in the end. Finally, the main findings are recapitulated and a conclusion,

※ The views expressed in this paper are those of the author in his personal capacity and do not necessarily represent those of the ILO.

※※ Containing a disclaimer to the ILO is definitely retained.

1 Government of Bangladesh, "The First Five Year Plan : 1973-78", Planning Commission, Dacca, November 1973, p. 83.

2 Bose, S.R., "The strategy of Agricultural Development in Bangladesh", in Robinson, E.A.G, and Keith Griffin (eds.) The Economic Development of Bangladesh, Macmillan 1975.

3 Bangladesh Burear of Statistics, "Economic Indicators of Bangladesh", Ministry of Planning, Dacca, Volume III, No. 9, September 1976, p. 25.

4 Op. cit., pp. 19-21.

5 Government of Bemgladesh, op. cit., pp. 21 and 187.

6 Abdullah, Abu, "Land Reform and Agrarian Change in Bangladesh", Bangladesh Institute of Development Studies, Dacca, November 1973, p. 55.

important for agricultural policy making is reached.

Source of Data

The data has been obtained from a direct survey in April-May 1976 of 459 rice holdings conducted in three selected villages of Bangladesh spread over three widely separated districts of Bogra in northern Bangladesh, Sylhet in the east and Noakhali in the south.[1] The crop statistics obtained related to the 1975 Aman (main rainy season, July-November) and 1974-75 Boro (dry season, December-April).

Without entering into controversies of defining and distinguishing between "technologies" and "thchniques", following William Bartsch[2] the term technology will be used here to mean the application of knowledge involving the use of combinations of material inputs of a bio-chemical nature while techniques would relate to the method of delivery and application of these inputs in association with different sources of power. For our purpose we shall distinguish between two types of technologies. (1) Traditional technology will be used to imply the cultivation of traditional varieties of rice seeds using small doses of chemical fertilizers. (2) High Yielding Variety (HYV) technology will be used to imply the cultivation of high-yield varieties of rice seeds, greater use of chemical fertilizer and irrigation in conjunction with the cultivation practices, such as weeding, for their optimum use. Only two different power techniques are identified. (1) Bullock techniques involving the use of bullocks primarily for land preparation (2) Tractor/Power tiller technique would imply the use of tractor/power primarily for land preparation.

Alternative Bio-Chemical Technologies

The employment and output effects of the two different biochemical technologies currently in use in Bangladesh are examined separately for the two seasons.

Employment: The survey of nearly 400 bullock farms in Aman 1975 helps us to draw the following conclusions about labour utilization (**Table 1**). (a) Per acre labour input increases by 28% when HYV technology replaces the traditional rice technology. (b) This increase in employment is largely the result of near doubling of labour input for fertilization (HYV farms used three times more urea, four times more phosphate and five times more potash compared to the traditional farms, on a per acre basis) more than tripling of labour input for weeding and a substantial increase in labour input for irrigation (through a more intensive use of irrigation water).

However the survey of 60 tractor/power tiller farms during the same season indicates a meagre 8% increase in employment per acre (**Table 2**). Differences in fertilizer use between HYV and traditional farms is smaller under tractor/power tiller technique

Table 1. Labour input per acre on 399 Bullock Farms[a] Under HYV and Traditional Technology: Bogra, Sylhet and Noakhali Districts, Bangladesh, 1975 Aman Season[b]

	Man-hours per acre[c]		
	Traditional technology farms	HYV technology farms[d]	Index for HYV farms (traditional=100)
Number of farms	243	156	—
Operation			
Preparatory tillage	138	159	115
Transplanting	145	143	99
Fartilization	17	33	194
Weeding	34	107	315
Irrigation[e]	2	22	1,100
Harvesting, carrying and threshing	155	165	107
Total operations	492	629	128
Output per acre (maunds)[f]	19	27	142

[a]Average size of farm is 2 acres.
[b]Main rainy season, July-November.
[c]One acre is equal to .4047 hectares.
[d]Area under HYV is 25% of total area.
[e]About 4% of total area under irrigation.
[f]One maund is equal to 82.286 pounds.

Table 2. Labour Input per Acre on 60 Tractor/Power Tiller Farms[a] under HYV and Traditional Technology: Bogra, Sylhet and Noakhali Districts, Bangladesh, 1975 Aman Season[b]

	Man-hours per acre[c]		
	Traditional technology farms	HYV technology farms[d]	Index for HYV farms (traditional=100)
Number of farms	18	42	—
Operation			
Preparatory tillage	95	97	102
Transplanting	104	116	112
Fertilization	29	23	79
Weeding	94	99	105
Irrigation[e]	0	1	—
Harvesting, carrying and threshing	132	154	117
Total operations	454	490	108
Output per acre (maunds)[f]	18	25	139

[a]Average size of farm is 1.5 acres.
[b]Main rainy season, July-November.
[c]One acre is equal to .4047 hectares.
[d]Area under HYV is 84% of total area.
[e]About 5% of total area is under irrigation.
[f] One maund is equal to 82.286 pounds.

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[1] The three villages were Taraf Sartaj in Gabtali Thana of Bogra district, Jangirai under Kulaura Thana of Sylhet district and Chandpur under Feni Thana of Noakhali district. The HYV rice being rifered to are IR-5, IR-20 and Paijam during Aman and IR-8, 532, Paijam and Purbachi (China) during Boro.

[2] Bartsch, William H., "Employment and Technology Choice in Asian Agriculture", ILO WEP study, Praeger Publishers, 1977, pp. 4-5.

Table 3. Labour Input per Acre on 397 Irrigated a/ Bullock Farms b/ under HYV and Traditional Technology: Bogra, Sylhet and Noakhali Districts, Bangladesh, 1974-75 Boro Season c/

	Man-hours per acre d/		
	Traditional technology farms	HYV technology farms e/	Index for HYV farms (traditional = 100)
Number of farms	145	252	—
Operation			
Preparatory tillage	191	189	99
Transplanting	121	169	140
Fertilization	11	24	218
Weeding	93	198	213
Irrigation	32	173	541
Harvesting, carrying and threshing	207	208	101
Total operations	655	961	147
Output per acre (maunds) f/	21	32	152

a/ About 8% of total area is under irrigation.
b/ Average size of farm is 2 acres.
c/ Dry season, December-April.
d/ One acre is equal to .4047 hectare
e/ Area under HYV is 50% of total area.
f/ One maund is equal to 82.286 pounds.

Table 4. Labour Input per Acre on 63 Irrigated a/ Tractor Power/Tiller Farms b/ under HYV and Traditional Technology: Bogra, Sylhet and Hoakhali Districts, Bangladesh, 1974-75 Boro Season c/

	Man-hours per acre d/		
	Traditional technology farms	HYV technology farms e/	Index for HYV farms (traditional = 100)
Number of farms	22	41	—
Operation			
Preparatory tillage	93	99	107
Transplanting	45	144	320
Fertilization	27	39	145
Weeding	105	189	180
Irrigation	2	50	2,500
Harvesting, carrying and threshing	123	183	149
Total operations	396	704	178
Output per acre (maunds) f/	14	32	229

a/ About 77% of total area is under irrigation.
b/ Average size of farm is 1.5 acres.
c/ Dry season, December-April.
d/ One acre is equal to .4047 hectare.
e/ Area under HYV is 77% of total area.
f/ One maund is equal to 82.286 pounds.

Table 5. Labour Input per Acre on 261 Traditional Technology Farms Using Bullock and Tractor/Power Tiller Techniques: Bogra, Sylhet and Noakhali Districts, Bangladesh, 1975 Aman Season a/

	Man-hours per acre b/		
	Bullock technique	Tractor/Power tiller technique	Index (Bullock = 100)
Number of farms	243	18	—
Average farm size (acres)	2	1.5	75
Proportion of area under irrigation (%)	4	5	125
Fertilizer use per acre (seers) c/			
Urea	14	31	221*
Potash	2	3	150
Phosphate	6	24	400
Cropping intensity	170	107	110
Operation			
Preparatory tillage	138	95	69**
Transplanting	145	104	72*
Fertilization	17	29	171
Weeding	34	94	277*
Irrigation	2	0	0
Harvesting, carrying and threshing	155	132	85
Total operations	492	454	92
Output per acre (maunds) d/	19	18	95

a/ Main rainy season, July-November.
b/ One acre is equal to .4047 hectare.
c/ One seer is equal to 2.0572 pounds.
d/ One maund is equal to 82.286 pounds.

Note : One-way analysis of variance test was performed to statistically test the equality of mean values for each row across columns (Ho: $\mu_1 = \mu_2$). One asterisk implies that the difference is significant at the 1% level, two asterisks imply significant difference at the 5% level.

compared to bullock technique above.

Output: HYV rice output was higher than traditional rice output by 39% and 42% in bullock and tractor/power tiller farms respectively.

1974-75 Boro Season

Employment: The survey of nearly 400 bullock farms in Boro 1974-75 showed patterns of labour utilization which were no different from that during the preceding Aman season (**Table 3**). (a) Labour input per acre on HYV farms exceeded that of traditional farms by nearly 50%. (b) This was largely the result of more than doubling of labour input for fertilization on HYV farms (use of urea per acre quadrupled, phosphate use was six times and potash was five times that of traditional farms), labour input for weeding had more than doubled as well as a five-fold increase in labour input for irrigation.

The survey of 63 tractor/power tiller farms during the same season showed virtually similar pattern of labour utilization (**Table 4**). (a) Per acre labour utilization on HYV farms was 80% greater than that of traditional ones. (b) Once again this increase is largely the result of increased labour input for fertilization (per acre application of urea, phosphate and potash on HYV plots were respectively 2.5, 5 and 2.6 times that of the traditional rice plots), for weeding, irrigation (more intensive use of water) and for harvesting and threshing.

Output: HYV rice output per acre was 50% higher than traditional rice output on bullock farms during 1974-75 Boro Season. Per acre HYV rice output was nearly two and a half times that of the traditional rice variety during the same season on tractor/power tiller farms.

Bullock vs. Tractor/Power Tiller

Under this section the relative impact on employment and output of the two alternative power techniques are evaluated frist on traditional rice farms and then on HYV rice farms, again separately for thn two seasons. 1975 Aman

Employment: The survey of 261 traditional rice farms in 1975 Aman helps us to draw the following conclusions regarding labour utilization on bullock and tractor/power tiller farms (**Table 5**). (a) Labour input per acre on tractor/power tiller to grow traditional rice was 8% lower than that of bullock farms. (b) This overall decline in employment per acre is despite larger labour inputs for fertilization and weeding on tractor/power tiller farms. Per acre urea and phosphate application on these farms were respectively two and a quarter and four times that of traditional rice farms.[1] Had adjustments been made on fertilizer inputs, the difference in labour utilization could have been greater. (c) As expected this overall decline was largely due to a significant decline in labour input for preparatory tillage.

The survey of nearly 200 HYV rice farms in 1975 Aman revealed similar labour utilisation patterns when bullock cultivation is compared to cultivation by means of tractor/power tiller (**Table 6**). (a) Per acre labour input to grow HYV rice on tractor/power tiller farms is lower by more than one fifth of that of bullock farms (the difference being statistically significant). (b) This decline in employment in tractor farms occured despite the application of significantly higher does of fertilizer. (c) As before, the decline in labour input for preparatory tillage (by over 40% the difference being statistically significant) primarily explains for the overall decline in employment.

Output: It is interesting to find that output per acre was lower on tractor/power tiller farms compared to the bullock ones irrespective of whether it was in the cultivation of traditional or HYV rice (although the difference was not statistically significant, **Tables 5 and 6**). It is important to note that traditional rice output was lower on tractor/power tiller farms despite their applying two and a quarter times and four times higher doses

Table 6. Labour Input per Acre on 198 HYV Technology Farms Using Bullock and Tractor/Power Tiller Techniques: Bogra, Sylhet and Noakhali Districts, Bangladesh, 1975 Aman Season[a]

	Man-hours per acre[b]		
	Bullock technique	Tractor/Power tiller technique	Index (Bullock=100)
Number of farms	156	42	—
Average farm size (acres)	2	1.5	75
Proportion of area under irrigation (%)	4	5	125
Proportion of area under HYV (%)	25	84	336*
Fertilizer use (seers per acre)[c]			
Urea	43	53	123
Potash	8	2	25**
Phosphate	29	38	131**
Cropping intensity	170	187	110
Operation			
Preparatory tillage	159	97	61*
Transplanting	143	116	81*
Fertilization	33	23	70
Weeding	107	99	93
Irrigation	22	1	5
Harvesting, carrying and threshing	165	154	93
Total operations	629	490	78*
Output per acre (maunds)[d]	27	25	93

[a]Main rainy season, July-November.
[b]One acre is equal to .4047 hectare.
[c]One seer is equal to 2.0572 pounds.
[d]One maund is equal to 82.286 pounds.

Note : One-way analysis of variance test was performed to statistically test the equality of mean values for each row across columns (Ho: $\mu_1=\mu_2$). One asterisk implies that the difference is significant at the 1% level, two asterisks imply significant difference at the 5% level.

Table 7. Labour Input per Acre on 167 Traditional Technology Farms Using Bullock and Tractor/Power Tiller Techniques: Bogra, Sylhet and Noakhali Districts, Bangladesh, 1974-75, Boro Season[a]

	Man-hours per acre[b]		
	Bullock technique	Tractor/Power tiller technique	Index (Bullock=100)
Number of farms	145	22	—
Average farm size (acres)	2	1.5	75
Proportion of area under irrigation (%)	81	77	95
Fertilizer use (seers per acre)[c]			
Urea	10	24	240*
Potash	1.4	.76	54
Phosphate	5	19	380*
Cropping intensity	170	187	110
Operation			
Preparatory tillage	191	93	49*
Transplanting	121	45	37*
Fertilization	11	27	246*
Weeding	93	105	113
Irrigation	32	2.4	8
Harvesting, carrying and threshing	207	123	59*
Total operations	655	396	61*
Output per acre (maunds)[d]	21	14	67*

[a]Dry season, December-April.
[b]One acre is equal to .4047 hectare.
[c]One seer is equal to 2.0572 pounds.
[d]One maund is equal to 82.286 pounds.

Note : One-way analysis of variance test was performed to statistically test the equality of mean values for each row across columns (Ho: $\mu_1=\mu_2$). One asterisk implies that the difference is significant at the 1% level, two asterisks imply significant difference at the 5% level.

[1] It may be noted that while the difference in fertiliser dose between bullock and tractor farms were statistically significant, the difference in labour input was not (Table 5).

respectively of urea and phosphate fertilizers (both the differences being statistically significant). Similar is the case of HYV rice. It is to be noted that there is no significant difference in farm size and in the proportion of area under irrigation between the bullock and tractor/power tiller farms.

1974-75 Boro season

Employment: The survey of 167 traditional rice farms reveals the following difference in labour utilization when the use of bullocks is compared to that of tractors/power tillers during 1974-75 Boro (**Table** 7). (a) Per acre labour input on tractor/power tiller farms is nearly 40% less than that of bullock farms. (b) This difference would have been greater but for the bigger labour input for fertilization (per acre urea and phosphate application tractor/power tiller farms was respectively 2.4 and nearly 4 times that of bullock farms). (c) Again the decline in employment was largely the result of reduced labour requirement by over one half for preparatory tillage (the difference being statistically significant).

The survey of 293 NYV farms confirmed the above findings for 1974-75 Boro season (**Table** 8). (a) Tractor/power tiller farms used nearly a third less labour for the cultivation of an acre of HYV rice compared to the bullock farms (the difference being statistically significant). (b) The overall decline in employment would have been greater had the tractor/power tiller operators not applied significantly higher doses of fertilizer (urea 55% more and phosphate nearly double, both statistically significant) which led to 63% higher labour input for fertilization (also statistically significant).

Output: The comparatively lower output on tractor/power tiller farms is most convincing and glaring during 1974-75 Boro season (**Tables** 7 and 8). (a) Traditional rice output on tractor/power tiller farms was exactly two thirds of that of bullock farms (difference was statistically significant). This was so despite the use of nearly two and a half and 4 times higher application of urea and phosphate fertilizers respectively on tractor/power tiller farms (the difference also being statistically significant). (b) HYV rice output on traotor /power tiller farms was exactly the same as that of bullock farms. This was so despite their applying over one and a half times and double the urea and phosphate fertilizers respectively.

It is important to note that the tractor/power tiller farms do not differ significantly from bullock farms in terms of farm size and proportion of irrigated area.

Table 8. Labour Input per Acre on 293 HYV Technology Farms Using Bullock and Tractor/Power Tiller Techniques: Bogra, Sylhet and Noakhali Districts, Bangladesh, 1974-75 Boro Season[a]

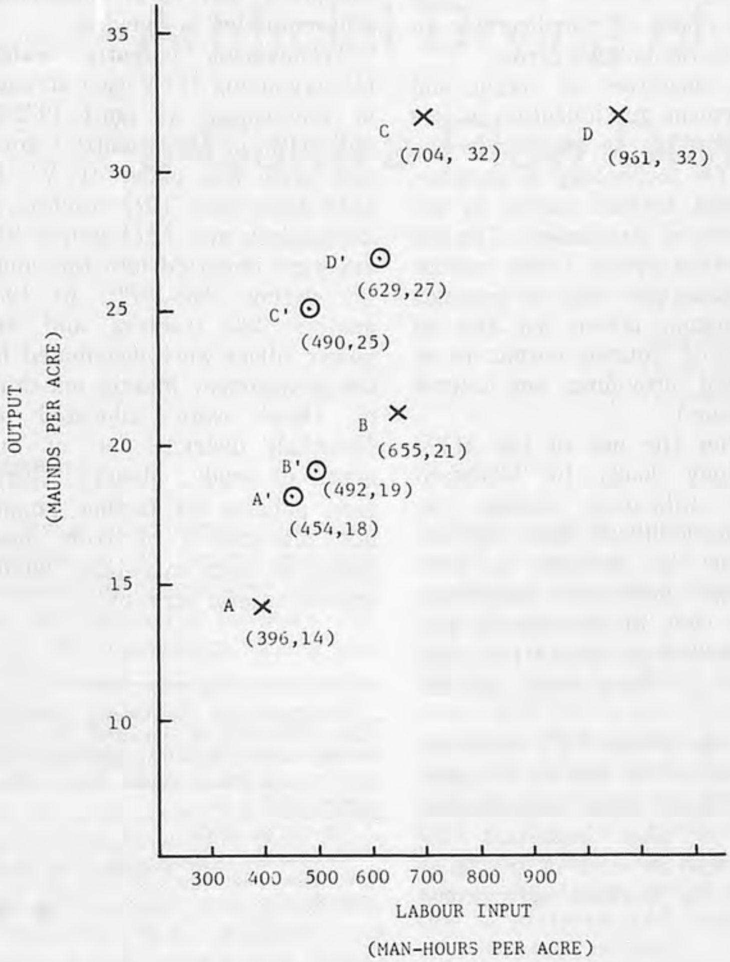
	Man-hours per acre[b]		
	Bullock technique	Tractor/Power tiller technique	Index (Bullock=100)
Number of farms	252	41	—
Average farm size (acres)	2	1.5	75
Proportion of area under irrigation (%)	81	77	95
Proportion of area under HYV (%)	50	77	154*
Fertilizer use (seers per acre)[c]			
Urea	40	62	155*
Potash	8	4	50
Phosphate	25	49	196*
Cropping intensity	170	187	110
Operation			
Preparatory tillage	189	99	52*
Transplanting	169	144	85
Fertilization	24	39	163*
Weeding	198	189	96
Irrigation	173	50	29
Harvesting, carrying and threshing	208	183	88
Total operations	961	704	73*
Output per acre (maunds)[d]	32	32	100

[a] Dry season, December-April.
[b] One acre is equal to .4047 hectare.
[c] One seer is equal to 2.0572 pounds.
[d] One maund is equal to 82.286 pounds.

Note : One-way analysis of variance test was performed to statistically test the equality of mean values for each row across columns (Ho: $\mu_1=\mu_2$). One asterisk implies that the difference is significant at the 1% level, two asterisks imply significant difference at the 5% level.

Synthesising Technologies with Techniques

Four alternative combinations of technologies and techniques were in use both during 1975 Aman and 1974-75 Boro (**Figure** 1). (a) During both the Aman and Boro seasons the use of HYV technology in conjunction with bullock technique would lead to the highest levels of output and labour utilization per acre (961 man-hours of labour input to produce 32 maunds of rice on an acre during Boro and 629 man-hours of labour input to produce 27 maunds of rice on an acre during Aman). (b) The path to maximization of employment and output follows the same pattern during both Aman and Boro seasons. Following the impact of combinations during Boro (i) any movement from traditional rice —tractor combination to traditional rice — bullock combination simultaneously increases output by 33% and employment by nearly 40% on a per acre basis during Boro. (ii) Further movement directly to the combination of HYV rice and bullock leads to 52% increase in output accompanied by nearly 50% increase in employment. For illustrative purposes the above sequence of movement was narrated but for policy purposes movement from any one combination to another would certainly



A=Traditional Biochemical Technology and Tractor/Power tiller Technique

B=Traditional Bio-Chemical Technology and Bullock Technique

C=HYV Technology and Tractor/Power tiller technique

D=HYV Technology and Bullock Technique

A', B', C', and D' refer to 1975 Aman season and are shown by circles
A,B,C, and D refer to 1974-75 Boro season and are shown by crosses

Figure. 1. Employment and Output under Alternative Combinations of Biochemical Technllogies and Power Techniques Bogra, Sylhet and Noakhali districts, Bangladesh 1975 Aman and 1974-75 Boro seasons.

Table 9. Proportion of Hired Labour in Total Labour Input under Alternative Technologies and Techniques: Bogra, Sylhet and Noakhali districts, Bangladesh 1975 Aman (% of total labour input per acre)

Bio chemical technology \ Power technique	Bullock	Tractor/ Power tiller
Traditional (N=261)	48	61
HYV (N=198)	55	70

Table 10. Proportion of Hired Labour in Total Labour Input Under Alternative Technologies and Techniques: Bogra, Sylhet and Noakhali districts, Bangladesh 1974-75 Boro Season (% of hired labour in total labour input per acre)

Bio-chemical technology \ Power technique	Bullock	Tractor/ Power tiller
Traditional (N=167)	48	60
HYV (N=293)	53	64

be feasible.

Use of Hired Labour

During 1975 Aman **(Table 9)** HYV rice growers using bullocks used 55% hired labour as compared to 48% for traditional rice growers. Tractor/power tiller farms growing HYV rice used 70% hired labour as opposed to 61% on farms growing traditional rice. However, for any one given level of technology, the per acre labour inbour input on tractor /power tiller farms is composed of a higher proportion of hired labour compared to that on bullock farms. Similar is the picture for 1974-75 Boro **(Table 10)**.

Concluding Remarks

It has been observed that if the national food deficit has to be reduced, agricultural unemployment and underemployment is to be diminished, the gap in the country's trade deficit is to be narrowed and the pace of agricultural growth has to be accelerated then clearly a great deal of emphasis will have to be placed on rice prodcction in Bangladesh. Of course, improvement in any of the above indicators would largely rely on the choice of appropriate rice production technology.

The following broad conclusions emerge from the study.

(1) Labour input per acre on HYV farms is 30% to 50% higher than that of traditional rice farms when both use bullocks. This ranges between 8% to 78% when both these farms use tractors/power tillers. This increase in employment is largely the result of greater labour inputs for fertilization (associated with the application of higher fertilizer doses on HYV plots), for weeding and for irrigation.

(2) Per acre labour utilization on tractor farms is 8% to 40%

lower than/that on bullock farms in the cultivation of traditional rice. In the cultivation of HYV rice the decline on tractor/power tiller farms ranges from 20% to 30%. As expected this decline is largely on account of a substantial reduction in labour input for preparatory tillage. This decline would have been much greater but for the relatively higher labour inputs for fertilization (associated with the application of higher fertilizer doses on tractor/power tiller farms).

(4) During 1975 Aman both the HYV and traditional rice outputs were lower on tractor/power tiller farms as compared to the bullock ones. This was so despite the fact that the former applied significantly higher doses of fertilizers for their crops. During 1974-75 Boro the difference is glaring. HYV rice output on tractor/power tiller farms were only 2/3 of that on bullock farms Traditional rice output was less than 3/4 of that on bullock farms. Rice output on tractor/power tiller farms is lower despite the fact that they apply significantly higher doses of fertilizers compared to the bullock farms.

The objectives of output and employment maximization in rice production can be reached by the use HYV technology in conjunction with bullock power in the rice fields of Bangladesh. The use of tractors/power tillers cannot be justified not only on grounds of displacing labour but also on grounds of reducing output (or at least not providing any output advantage.)

Further the use of the HYV technology leads to increased labour utilization during the usual agricultural slack periods and this is certainly a very important additional consideration in view of the serious seasonal underemployment rate that prevails in Bangladesh agriculture.

The use of the HYV technology leads to the use of a higher proportion of hired wage labour which is also important for Bangladesh in view of the large size of the landless agricultural labourers and rural households whose number is growing.

Tremendous potential exists for expanding HYV rice acreage in Bangladesh as until 1972-73 only 11% of the country's total rice area was under HYV[1]. In 1970 there were 2,072 tractors in Bangladesh and 2,571 power tillers were imported into the country during 1965-1970[2]. In 1972 another 182 tractors and 648 power tillers were distributed by the government (nearly one-third of these were allocated to Noakhali district, one of our areas of study, alone)[3]. Therefore, policies for further import and distribution of both these pieces of farm machinery would require careful scrutiny.

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[1] Government of Bangladesh, "Bangladesh Agriculture in Statistics", Ministry of Agriculture, Agro-Economic Research Section, Statistical Series No. 1, November 1973, p. 23.

[2] Op. cit., pp. 62-63.

[3] Government of Bangladesh, "The First Five Year Plan : 1973-78", op. cit., pp. 178-179.

Artificial Drying of Rice Using a Contra-Flow Dryer

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Abstract

Drying experiments with paddy initially at 30 percent moisture content (dry basis) were conducted the obtain the moisture content (M.C.) gradients, drying rate $\frac{(dm)}{(d\theta)}$ and energy consumption rate of a 15 c.m. deep bed drier employing contraflow drying principles. The results were compared with a bottom ventilated continuous flow batch drier under approximately similar air-flow, air temperature and initial m.c. conditions. M.C. gradients are very low in contra-flow drying compared to static bed. Drying rates in the contra-flow drying runs were greater than those of static bed runs at the same inlet conditions, the water removal from the grain being about $1\frac{1}{2}$ times greater in the contra-flow drying runs. Estimates of energy consumption in terms of Kj/Kg. of water removed show that contra-flow runs consumed much less energy in almost all cases. Drying rate constant (m) drying time (θ) and $\frac{(dm)}{(d\theta)}$ calculated from the thin layer theory agreed quite well with actual values obtained during the study. Properly designed dryers using contra-flow principles will be able to dry even small amount of paddy harvested in any season with minimum loss and comparatively in a short time than conventional driers presently used by the farmers in Bangladesh.

Introduction

Drying usually implies the removal of moisture to a moisture content (m.c.) in equilibrium with normal atmospheric air etc. to such a m.c. that decrease in quality from moulds, enzymic action and insects will be negligible-12 to 14% wet basis (w.b.) for most agricultural materials. The purpose of drying rice is to produce a rice with good keeping qualities without any appreciable loss in substance, any deterioration in nutrients and food value or any change in taste.

According to Muckle and Stirling (1971) current losses of about 30% are apparently occuring throughout large areas of the World particularly in the tropics and sub-tropics. These losses occur due to respiration of grain which produced heat and moisture, insects and moulds. The rate of respiration and consequent heat production depend on m.c. of the grain, the type of crop, its degree of maturity and the ambient storage temperatures.

There are two main methods of drying: Natural and Artificial. The most common practice in Bangladesh and her neighbouring countries is sun drying floor, usually made of beaten earth and sometimes covered with lime mortar a long process. Artificial drying with unheated or heated air not only reduces the time taken for drying but also gives better milling quality, by eliminating the "Sun-checking" or "Sun-Cracking" effect of sun drying.

The need for artificial drying to-day is extremely high due to the second generation problems created by the new technology e.g. rainy season harvest of HYV of IR-8 and triple or multiple cropping in many rice producing areas of Asia. For the above reason it is obvious that wide spread introduction of grain driers cannot be avoided in the near future in many countries including Bangladesh. But to be successful the drier would have to be economical in its capital and running costs and a drier must be designed taking full consideration of local materials and skills available. In this study contra-flow drying method was compared with the static-bed continuous air flow method of drying. It is hoped that the results obtained (see table) can be used as a basis for designing a system whereby to small farmer can dry his harvest safely and economically using contra-flow drier.

Grain Drying Principles and Theories

Like other forms of life, grain gives off heat, carbondioxide (respiration) and water as its store of food is consumed. The rate at which grain lives is governed by its m.c; its temperture and the availability of oxygen. Thus it is possible, by adjusting these conditions, to preserve the properties of grain by reducing its life activity to a very slow rate and this is usually done by reducing the grain m.c. and temperature to a level suitable for safe storage.

Unhusked paddy grain (Caryopsis) is enclosed by lemma and Palea (Hull) forming a relatively tight case which partly prevents interchange between the caryopsis and the ambient air. Therefore, paddy is not dried in the same way as other cereals with uncoated grain such as wheat, maize and barley.

The paddy grain is a porous material which contains a certain amountof water. This water tends to evaporate when the water vapour pressure of the grain is greater than that of the ambient air, and to increase when the air is more humid.

Thus the ambient air-grain moisture equilibrium attaned in drying depens on many factors. The main factors are:—

1) Relative humidity (R.H.) of air,
2) Moisture content of the grain,
3) Air temperature, and
4) Grain temperature.

Usually when crops containing water are exposed to air at a constant relative humidity, there may be movement of water either from the crop to the air or from the air to the crop. In the first case, the m.c. of the crop will decrease and in the second, it will increase. After further exposure to the air, the crop m.c. will reach a constant level. In Bangladesh, the average m.c. of the rice crop after harvesting is 22-24% on wet basis(wb) during the November-December-season. But it may go upto 28% during the rainy season (R.H. approx. 85-90%) when "Aus" crop is harvested. The safe economic level of m.c. of paddy for storage is 14% wet basis. The safe level of m.c. is also the driers' target reduction for m.c.

Theory of Shallow-bed Drying

A drying process can often be regarded as comprising two phases known as the constant rate period and the falling rate period respectively. The constant-rate period is not a characteristic of normal agricultural drying, and is usually very short and may be neglected in the calculation when compared to the complete drying process (Allen, 1960). Practically all agricultural drying takes place in the falling-rate period. Normal agricultural drying follows the pattern of an initial quick decrease in m.c. followed by a progressively decreasing drying rate, and this is termed as "falling-rate drying".

A simple, and convenient expression of drying rate (at falling-rate period) recognising the analogy between the phenomenon of drying and heat temperature is given by

$$\frac{dM}{d\theta} = -2.303m(M - Me) \cdots\cdots (1)$$

Where M = instantanceous moisture content (db).

θ= time, hr.

m= dimensional drying-rate constent, $hr.^{-1}$.

Me = equilibrium m.c., kg. water/kg. drymetter.

$\frac{dM}{d\theta}$= rate of drying.

This is the form of expressions which simmonds, Ward and McEwen (1953) employed in their studies of thin layer drying. General equation (1) can be written after Integration as –

$$\ln \frac{M - Me}{M_1 - M_e} = -m\theta$$

$$\text{or} \quad \frac{M - Me}{M_1 - M_e} = e^{-m\theta} \cdots\cdots\cdots (2)$$

The term M-Me is known as free-moisture. The value of m is dependent on varieties, initial m.c., drying air temperature, R.H. and quantity of drying air supplied and depth of grain.

Contra-flow Grain Drying Principles

In a contra-flow drier the grain and the hot drying air moves opposite to each other. Usually the air is forced to flow through the grain upward and the grains flow downwards very slowly relative to the air. The grains come out of the drier by some means and removed after they have been dried to an expected moisture level. Fresh gresh grains are fed to the drier from the top.

In this study the drier consists of six trays each of which is filled up to 25 mm depth of grain and air is blown up through a small fan from the bottom. When the bottom try dries out to approximately 16% m.c. (dry basis), it is removed and replaced by fresh grains at the top and the process continues until the whole set of trays dry out to nearly the same moisture level.

A drier using the contra-flow principle would have the following advantages:-

a) The hottest air would meet the driest grain,
b) The greatest possible concentration gradient of a mass transfer would be created at every point in the bed of grains,
c) The air leaving the bed could be brought near its saturation value during the whole drying cycle, and
d) The grain leaving the drier would be dried to a uniform value of moisture content.

It has been pointed by Oxley (1953) that the contra-flow principle offers possibility for improved heat economy in the drying of wheat. This study also proves this statement for paddy (see results).

In this study simple methods have been used to calculate Me and m throughout. In the absence of a readily useable theory relating cost of drying (in. Kj/kg. water removed) to air flow and air temperature, a graph (**Fig. 1**) was plotted of cost against air flow.

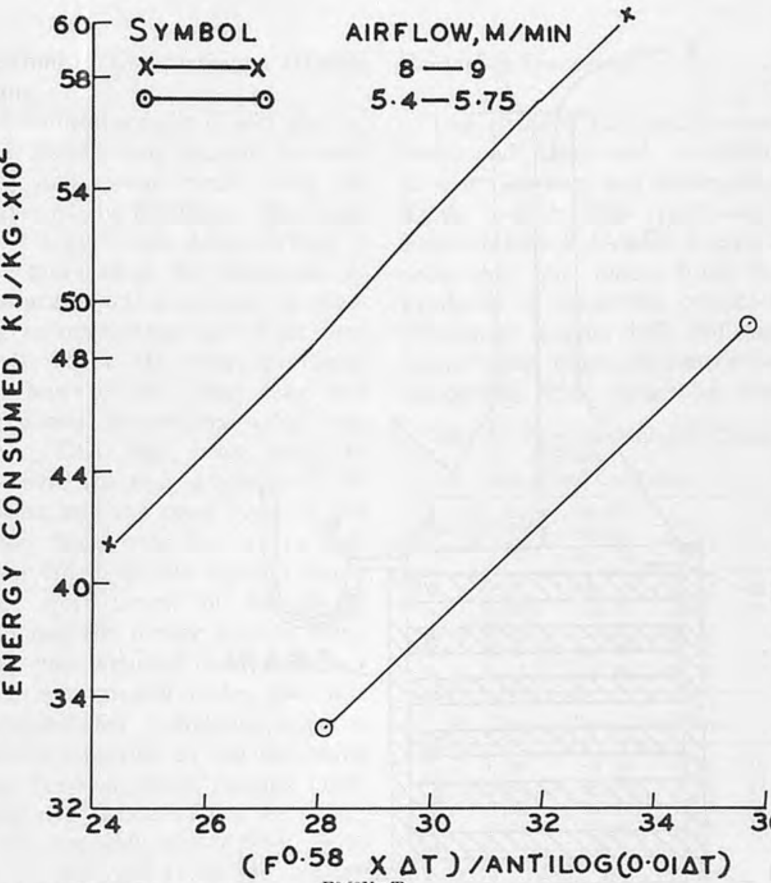

Fig.1. Energy consumed vs. $\frac{F^{0.58}X\Delta T}{\text{ANTILOG } (0.01\Delta T)}$ for static-bed runs

Theory of static bed drying

From the basic equation (1) for constant mass flow rate of air and temperature rise, Morris Thomas (1962) derived an equation relating drying rate and air temperature of the form;

$$R=\frac{\vartheta_n P_s}{2.3}/\text{Log}\frac{(h_1-h_e)}{(h_2-h_e)} \cdots\cdots\cdots(3)$$

where R = drying rate, h_r.[1]

P_s = Saturation varpur pressure,
h_1 = initial F.H., Percent,
h_e = equilibrium R.H., Percent,
h_2 = final R.H., Percent,
n = a constant.

Morris Thomas states that R is proportional to $G^{0.59}$ where G is air flow rate. He then shows that for wheat an empirical relationship embodying log R and log G as a funcion of T of the form

$\text{Log}(R/G^{0.414}) = a\Delta T + b$ holds true ....(4)

where G = rate of air flow, mass/unit time,

ΔT = temperature rise of air above ambinet air, OC a, b are constants.

It is shown in Fig. 2 that an approximate linear relationship of this form is obtained for rice.

$\text{Log } R/F^{0.414} = a\triangle T + b$ ···(5)

Where F = rate of air flow, M/Min.

An expression for the energy consumption during drying can be found for static-bed drier, which is similar to the expression.

$Ha = 0.42G^{0.58}\triangle T/Z_2$ ·········(6)

Where, Ha = air heat, KJ/Kg, and

Z_2 = antilog $0.01\triangle T$.

found by Morris Thomas.

Plots of $\frac{1}{F^{0.414}X\theta}$ against temperature rise $\triangle T$ above 20°C and energy consumed Kj/Kg^{vs} $\frac{F^{0.58}X\Delta T}{Z_2}$ are presented in Fig. 1 & 2.

The efficiency of the method or system performance may be based on two main measures; one, the amount of paddy dried per unit time, and two, the amount of heat energy used to dry a given amount of paddy (Esmay, 1973).

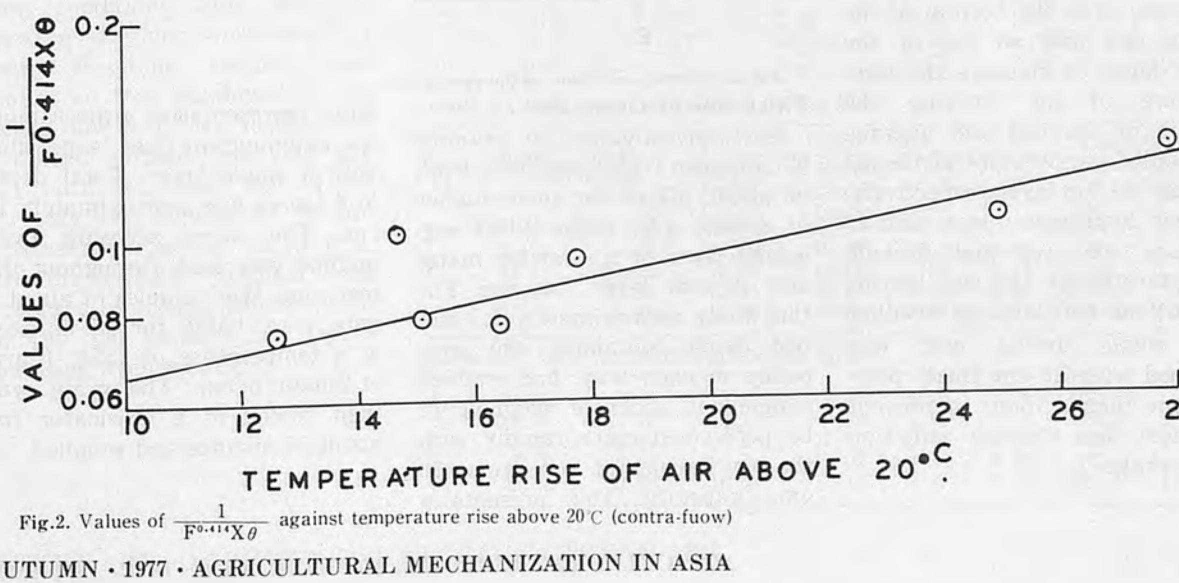

Fig.2. Values of $\frac{1}{F^{0.414}X\theta}$ against temperature rise above 20°C (contra-fuow)

Materials and Methods

This study was carried out in 1974 at the National College of Agricultural Engineering Silsoe, U.K. Since freshly harvested paddy was not available, medium grain variety of paddy from Italy was used throughout the study. The samples for the tests were prepared from this variety by artificial wetting and the m.c. range after wetting was between 29-35% d.b.

The experimental drier used in this study is shown in **Fig. 3.** The paddy to be dried was placed in removable trays of 2 mm thick and 19.8 cm. in diameter on top of the plenum chamber, which is of cylindrical shape and constructed of G.I. sheet, prefabricated aluminium "honey comb" air straightener was put inside the plenum chamber to distribute air from the fan as uniformly as possible throughout the bed. 2.4 mm mesh wire sheet was welded at the bottom of each tray. The range of air flow rates used was between 4-10 m/min. Two 11-watt fans were driven via a variable transformer arrangement which enabled the air to be supplied at various rates. The air flow rates were measured by a cassela air-flow meter. Manometers were used to measure the static pressure as well as the pressure difference within the depth of the bed. Thermocouples were placed at the bottom of the drying bed and on top of the upper layer to measure the temperature of air entering the bottom of the bed and average "dry bulb" temperature of the air leaving the top layer respectively. Assman hygrometer was used to measure the wet and drybulb temperatures of the air leaving the drying before each reading. The whole drying unit was wrapped with 2.5 cm thick polyurethene plastic foam to prevent any heat loss through radiation and leakage.

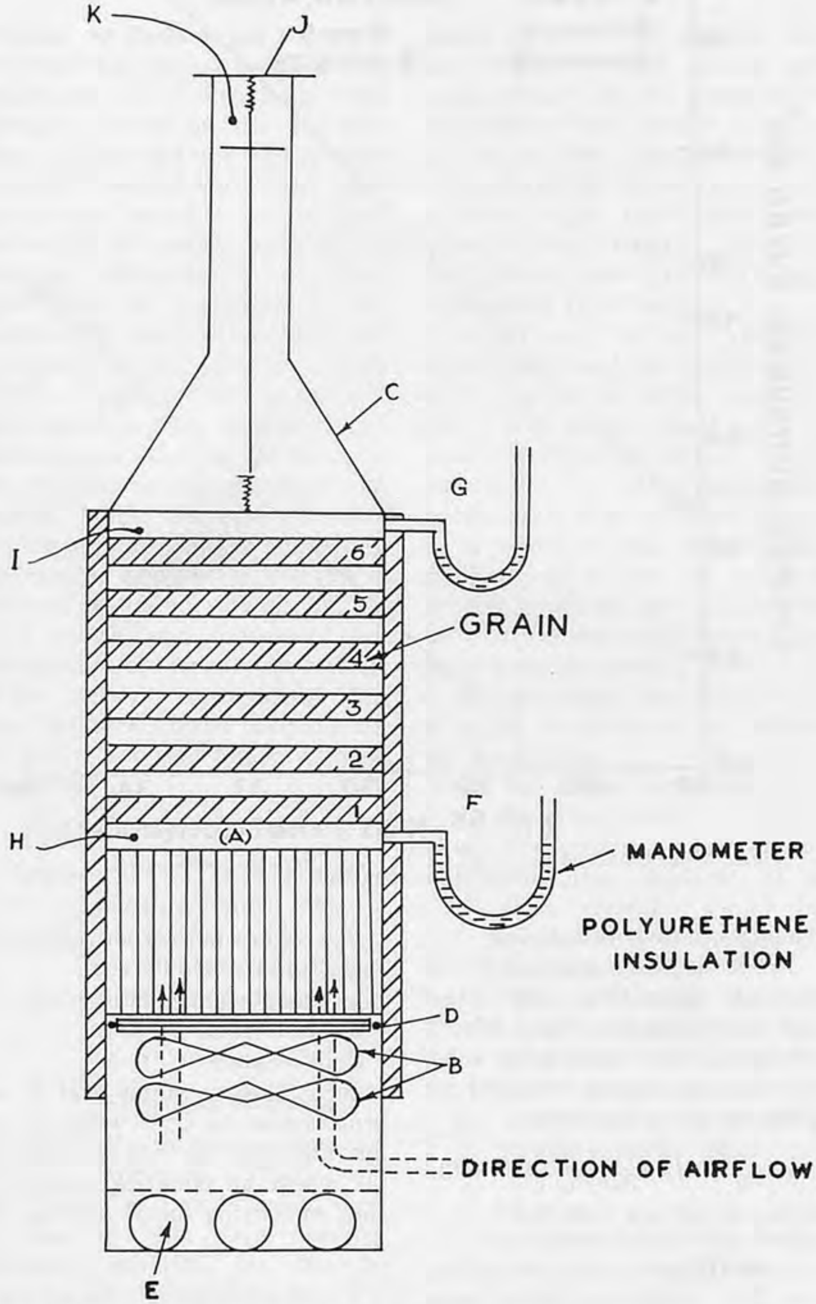

Fig.3. Sectional elevation of the drying unit

Thickness of Grain Bed

Early investigates, for example 0' callaghan (1956) used bed depth of about 1/2 m for their studies of drying. J.R. Allen (1960) suggested layer of 2.5 cm for maize and 20 mm layer for rice. For this study approximately 2.5 mm bed depth containing 400 gms. paddy in each tray, had enabled simple and accurate weighing to be performed more rapidly with the pan balance of maximum 800 gms. capacity. This presents a more representative grain sample for examination than is possible with a single layer. Total depth in 6 layers was approximately 15 cm. The more accurate oven method was used, throughout the test runs. Wet samples of about 5 gms. were hated for 15 minutes at a temperature of 155℃ (Carter-Simon oven). The grain was then cooled in a dessicator for about 15 minutes and weighed.

Method of Conducting a Drying Runs

An initial weight of 400 gms. of wet paddy was placed in each tray and spread evenly over the trays. At the bottom of the lower most tray 3 mm layer, which is not more than the thickness of one grain, was separated by placing nylon netting cut to fit properly inside the tray. Similarly top layer of the upper tray was separated by placing nylon netting. This had been done to measure the m.c. gradient of the lowest and top most layer of the grain bed, once the trays had been filled to the desired depth they were placed on the drying unit and the drying started. Each tray was weighed to an accuracy of± 0.1 gm and water loss was recorded for individual tray at hourly intervals at the beginning and between 30-45 minues intervals after 3 hours from the start.

As for the contra-flow tests, trays removed from the bottom of the bed as the desired dryness was reached were refilled with wet grain and replaced at the top of the bank of remaining trays in order. This process continued until the last try was removed at about 16% m.c. (db). The m.c. of 3 mm top and bottom layers were determined accurately by oven method to find the m.c. gradient of the whole bed depth of 15 cm.

For the static-bed continuous flow conditions time intervals between weighing were nearly 1 hour. Weighing method was similar to that employed in the contra-flow tests, but drying was continued without removing any tray until the water loss in the top tray was equivalent to approximately 15-16% m.c. (db). Moisture content gradient was measured by taking samples from the top and lower 3 mm layers and using oven method.

Results & Discussion

Test results for both contra-flow and static-bed continuous flow drying runs are presented in **Table 1—3 & Figs. 1, 2 and 3.** From **tables 2 (A&B)** it can be seen that the mean final m.c. gradients in static-bed conditions (the range is from 3-5% db) much higher than those of contra-flow conditions (the range is from 0.4-0.7% db). Analysis of final m.c. gradients between the top and bottom 3 mm layers showed greater differences in the case of static-bed as was expected **(Table 1, A&B)**. The effect of air-flow rates on the m.c. gradients is evident from the static-bed runs under nearly similar temperature and initial m.c. regimes e.g. run number S_4 and S_8. Under contra-flow conditions very much small-

Table 1. Average Moisture Content (% d.b.) at Different Positions at the End of Runs

A. Static-Bed Conditions

Run No.	Air-Flow m/min.	Mean Initial m.c. %	Tray Nos. (Top-Bottom) 6	5	4	3	2	1	Gradient % (Top-Botton)
S_1	5.57	30.50	15.74	15.60	13.38	11.61	10.57	10.47	5.27
S_2	5.60	34.70	15.00	13.73	12.98	12.84	12.17	11.60	3.40
S_4	5.74	34.03	16.21	16.37	14.70	13.26	12.55	12.09	4.12
S_7	8.08	29.07	16.32	15.58	14.91	13.87	13.10	12.26	4.06
S_8	9.13	30.98	16.38	15.99	14.87	15.00	14.55	13.79	3.19

B. Contra-Flow Conditions

Run No.	Air-Flow m/min.	Mean Initial m.c. %	6	5	4	3	2	1	Gradient % (Top-Botton)
C_{10}	6.00	55.76	15.50	15.00	15.06	15.06	15.73	15.37	0.13
C_{11}	5.88	34.71	15.75	14.84	15.68	16.83	15.24	15.24	0.51
C_{13}	8.77	29.07	15.94	15.03	16.36	15.52	14.20	16.35	0.41
C_{14}	8.28	34.28	16.39	16.46	15.52	15.05	15.28	15.89	0.50

Table 2. Drying Rate (% m.c./hr.) and Energy Input (Kj/Kg. Water Removed) Calculation at Different Air Temperature

A. Static-Bed Conditions

Run No.	Average Air Temp. oc.	Drying Time from 30% to 15%, hr.	Total Energy Input Kj/Kg. Water Removed	$\frac{1}{F^{0.414} X \theta}$	Drying Rate % m.c./hr.
S_1	34.6	4.70	3,492.15	0.1045	3.19
S_2	48.75	3.62	5,488.83	0.1355	4.14
S_4	32.50	6.40	4,130.56	0.0758	2.34
S_7	37.70	4.45	5,025.32	0.0945	3.37
S_8	32.42	7.00	6,893.03	0.0571	2.14

B. Contra-Flow Conditions

Run No.	Average Air Temp. oc.	Time to 1st Change hr.	Time to 2nd Change hr.	Time to 3rd Change hr.	Kj/Kg. Water Removed	Drying Rate % m.c./hr.
C_{10}	36.36	4.34	5.0	5.0	3,884.41 4,262.10	2.98
C_{11}	44.21	2.50	3.50	3.50	4,665.68	3.58
C_{13}	32.96	3.80	4.50	4.50	4,792.79	2.44
C_{14}	37.48	3.0	3.75	3.75	4,664.15	3.32

Table 3A Data for Contra-Flow Drying Runs

Run No.	Average Air Temp. oc.	Mean Initial m.c. % d.b.	Final m.c. % d.b. at Top 3 mm Layer	at Bottom 3 mm Layer	m.c. Gradient % d.b.	Duration of Run hr.	Loss of wt. gm.	Evaporation Kg. $hr^{-1}m^{-2}$
C_{10}	36.36	35.76	14.39	12.77	1.62	6.83	476.6	2.26
C_{11}	44.21	34.71	14.94	13.18	1.76	5.34	450.8	2.75
C_{13}	32.96	29.07	17.11	15.25	1.86	5.47	341.7	2.03
C_{14}	37.48	34.28	16.30	15.80	0.50	5.62	469.9	2.72

Table 3B Data for Static-Bed Drying Runs

Run No.	Average Air Temp. oc.	Mean Initial m.c. % d.b.	Final m.c. % d.b. at Top 3 mm Layer	at Bottom 3 mm Layer	m.c. Gradient % d.b.	Duration of Run hr.	Loss of wt. gm.	Evaporation Kg. $hr^{-1}m^{-2}$
S_1	34.56	30.5	15.87	9.77	6.10	7.00	332.70	1.54
S_2	48.75	34.70	12.75	7.82	4.93	4.75	376.8	2.58
S_4	32.80	34.03	17.99	12.55	5.94	7.93	355.2	1.50
S_7	37.70	29.07	16.54	12.02	4.52	4.53	273.9	1.96
S_8	32.42	30.98	16.01	13.14	2.87	7.17	291.2	1.32

er gradients were observed as was anticipated, e.g. run nos. C_{10} and C_{14}..

Drying rates in terms of percent moisture per unit time were greater at higher inlet air temperatures test results also showed that time required to dry paddy from 30 to 15% m.c. (db) in static—bed conditions was less at higher temperature rise above ambient (20_{0c} in this case) at the same air flow. Also increased air flow rate at a lower temperature rise (ΔT) above ambient reduces the drying time to the same extent. Mr. Stenning (1962) working on wheat grain at a similar bed depth reached similar conclusions.

Under similar temperature & initial m.c. ranges higher air flow rates gave greater drying rates for both the drying conditions.

Plot of values of $\frac{1}{F^{-0.414}X\theta}$ against temperature rise (ΔT) of air above 20^{oc}(**Fig.2**). Produced an approximately linear relationship which can be compared with the empirical equation (5). Drying rate $\frac{dM}{d\theta'}$, rate constant m and time of drying θ were calculated on the basis of thin layer theory by Simmonds, et al 1953) and showed good agreement with the experimental results presented in table IIA.

Total cost of drying in terms of heat energy (Kj/Kg of water removed) was calculated for individual run from energy input as thermal heat from the fan and heat energy used to raise the ambient air to desird limit. In the absence of any usable relationship relating cost of drying (Kj/Kg) to air flow and temperature, **Fig. 1** was plotted of cost VS. air flow. As expected, the slope of the curve indicated that less efficient drying occured as the air flow increase beyond the critical value (8.5 m/min.). Also test results showed that contra-flow drying used less energy in almost all the drying runs than the static-bed runs (**Table 2, A&B**).

Weight loss is some times used as an indication of drying rate. Contra-flow runs gave about 50% higher values of weight loss than those of static-bed runs. Weight loss with the same position of the trays for both the conditions was found to differ from one another under similar temperatures, initial m.c. and air flow rates.

Conclusions: —From the tests results it can be concluded in general that the energy saved with contra-flow drying is much higher than static-bed drying. About 50% more amount of grain can be dried by utilization of same amout of heat in case of contra—flow drying compared with static-bed drying.

In contra-flow drying air leaves at a lower temperature and high humidity condition where-as high temperature gradient exists in static-bed drying. This implies that higher utilization of heat potential in contra-flow drying. Cost of drying increases enormously as temperature rise or air flow rate exceeds certain critical value. If properly designed and constructed with local material and fuel source, contra-flow types of drier will be able to even dry wet season harvest e.g. (Aus paddy) efficeintly at a minimum cost and comparatively in a short period than conventional driers presently used by the farmers in Banglandesh.

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Farm Use Terrain Vehicle with Hydraulic Articulated Steering

by
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Introduction

The transporting operation in agriculture is still a difficult work, especially in the field. About one hundred and twenty five million trucks are being used now for agriculture in Japan.

Most of them are very small trucks of which the loading capacity is 360 to 500kg. They are very handy in carrying many kinds of things necessary for farming such as harvested agricultural products and fertilizers etc., however they are not useful for the transportation of those things into or out of the field, because of the disadvantage of the trafficability in negotiating the irregular surface ground in addition to the low floatation capacity.

The loading and unloading operations are necessarily accopanied with the transportation, therefore the problems listed below must be preferably desired to solve prior to the purpose improving or reducing the heavy duty work in transportation. They are:

1) Better trafficability in the field.
2) Easy loading and unloading of the load.
3) Small turning radius.
4) Ease of operation.
5) Possible to use for other field operation such as tillage.
6) Low cost.

The purpose of this study is to reduce the heavy duty work in transportation and improving the difficult work in loading and unloading. Most of the conditions considered above can be satisfied with the application of hydraulic power unit (1). Similar vehicle can be seen in military use vehicle (2), (3).

Structure and Function of the Vehicle Constructed

A vehicle based upon these constraints shown in **Fig.1.** was designed and constructed. Two hydraulic cylinders one on either side of the vehicle and the joint located at the connecting point of two parts, front and rear of the vehicle can control the pitching and yawing motions of the vehicle. The pitching control makes the easy loading and obstacle negotiation, and the yawing control facilitates the articulated steering of the vehicle.

In **Fig.1**, the vehicle consists of the following components;

1.	Five horsepower diesel engine.	Front part.
2.	Oil tank for hydraulics.	
3.	Transmission.	
4.	Operator's seat.	
5.	Powered wheels.	
6.	Hydraulic cylinders.	
7.	Hydraulic cylinders.	
8.	Load carrier.	Rear part.
9.	Unpowered wheels.	

Specifications of the Vehicle Constructed

Table 1. shows the specifications of the vehicle constructed in this study.

Hydraulic Circuit

Fig. 2 shows the hydraulic circuit diagram used for the vehicle constructed in this research work. As shown in **Fig. 2**, each manually operated directional valve can control each hydraulic cylinder separately, however for the purpose of controlling the pitching motion and articulated steering of the vehicle, those directional valves are connected with link attached to the steering rod. Therefore the rotative operation of the steering rod can control the articulated

Article is the summary of the "Preproduction of the Farm Use Terrain Vehicle with Hydraulic Articulated Steering and Its Practical Application" and "Development of Farm Use Terrain Vehicle with Hydraulic Articulated Steering". The original paper was first presented at International Conference on Rural Development Technology: An Integrated Approach, AIT, Bangkok, Thailand, June 1977.

(a) Pitching control for easy loading and unloading (Prototype I vehicle)

(b) Yawing control (Hydraulic articulated steering) (Phototype II vehicle)

Fig.1. Whole view of the vehicle constructed

Table 1. Specifications of the vehicle constructed.

Engine	Manufacturer	Mitsubishi SD5H
	Type	Horizontal, one cylinder water cooled
	Fuel	Light oil
	Starting method	Starting handle
	Cylinder	Bore × Stroke, 78 × 85 (mm)
	Capacity	406 (cc)
	Compression ratio	21
	Rated horsepower	5 PS/2,000 rpm.
	Maximum horsepower	7 PS/2,200 rpm.
Vehicle	Total length	4,780(mm)
	width	1,780(mm)
	height	1,100(mm)
	clearence	125(mm)
	Wheel base	3,050(mm)
	Front axle	1,550(mm)
	Rear axle	1,650(mm)
	Front wheel	5-12 (2pr)
	Rear wheel	5-12 (2pr)
	Transmission	Mitsubishi power tiller CT 531
	Total weight	860 kg
	Travelling speed, forward	1 1.08 (at engine 2,000 rpm)
		2 1.77 (same above)
		3 3.03 (same above)
		4 4.68 (same above)
		5 8.14 (same above)
		6 13.59 (same above)
	rearward	1 1.39 (same above)
		2 6.06 (same above)

Table 2. Comparison between the measured and theoretical values of turning radius.

Turning radius	Four wheel vehicle		Six wheel vehicle	
(unit:m)	R_I	R_J	R_I'	R_J'
theoretical value (SC-ON)	6.501	6.231	6.524	6.231
measured value (SC-ON)	7.98	7.79	8.03	7.85
measured value (SC-OFF)	6.59	6.48	6.55	6.40

where R_I' and R_J' are the turning radii of the points I and J in Fig. 3 (in case of six wheel) about the point 0_1.

steering and the push-pull operation of it can control the pitching motion of the vehicle used for negotiating the obstacle and, loading and unloading.

The flow control valves are used to control and adjust the displacing speed of both hydraulic cylinders.

Turning Radius

For determining the turning radius of the vehicle, both of mechanical and geometrical discussions are necessary, however it is actually difficult to determine the turning radius considering both discussions simultaneously because many complex factors such as soil conditions including contact pressure and slippage of the wheel should be involved in mechanical discussion.

In general, geometrical analysis can be used easily for this purpose compared with the mechanical one. Smaller turning radius are needless to say desired for flexible and easy running operation especially in the field like an orchard.

As shown in **Fig.1**, the vehicle constructed here has a hydraulic articulated steering, but not a front wheel steering, therefore the width of the vehicle, the ratio of the maximum and minimum lengths of both hydraulic cylinders, and the wheel base of the vehicle are considered in determining the minimum turning radius of the vehicle with hydraulic articulated steering. The minimum turning radius of this vehicle was obtained experimentally and theoretically, then compared. The value of the minimum turning radius was about 6.5m and the difference between the measured and theoretically estimated values was quite small in case of steering clutch off running. The measured values of minimum turning radius were

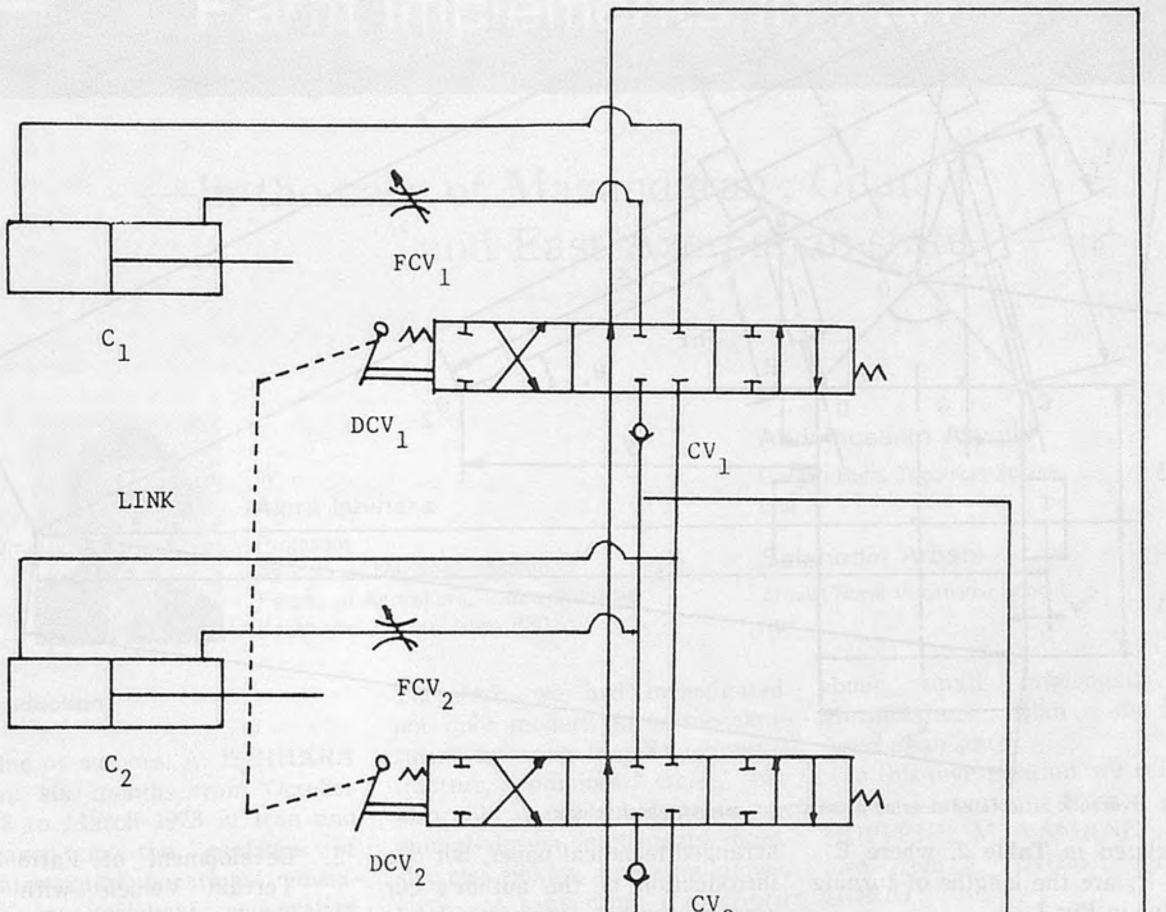

Fig.2. Hydraulic circuit diagram for steering

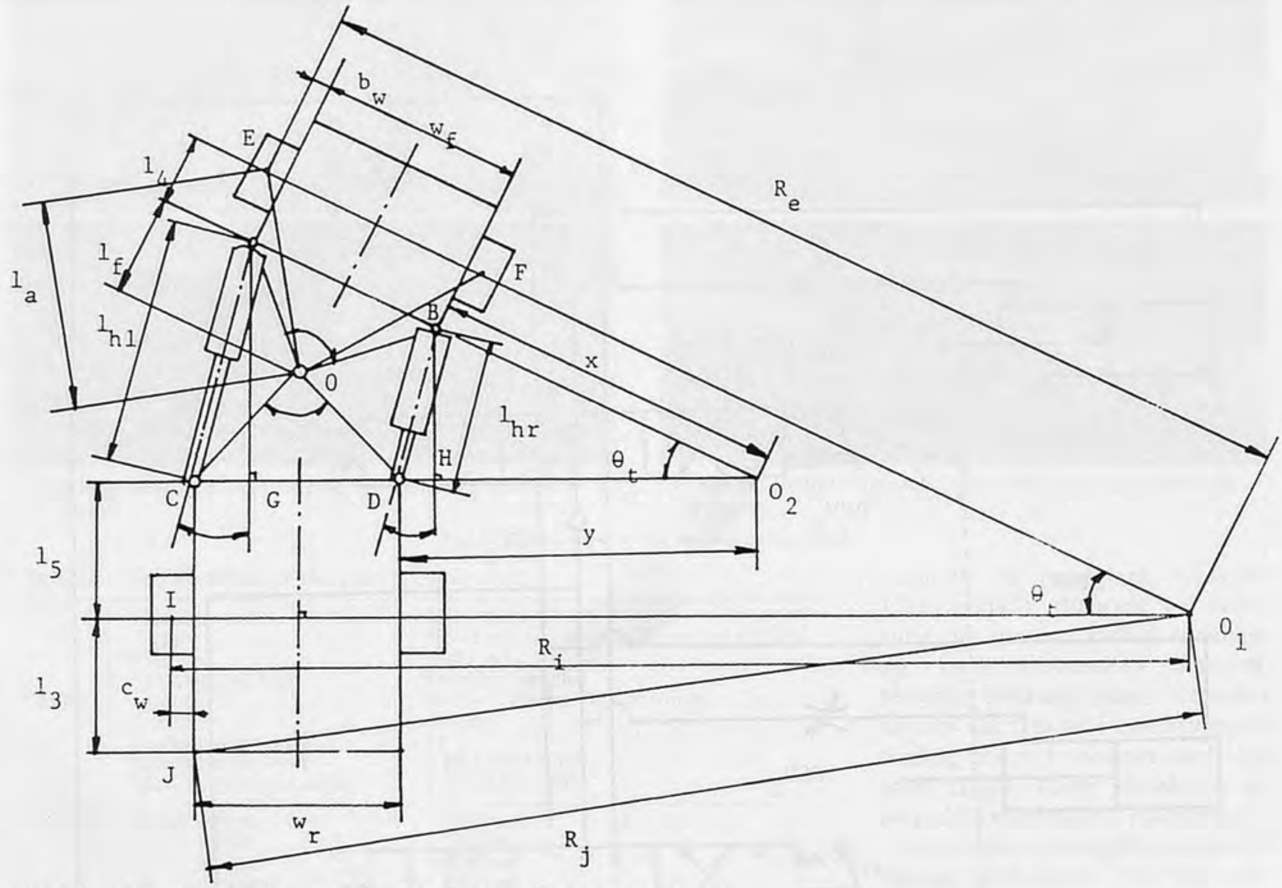

fig.3. Hydraulic articulated steering geometry (in case of wheel vehicle)

tabulated in **Table 2**, where R_i and R_e are the lengths of turning radius in **Fig.3**.

Closure

For practical use of this vehicle, the following improvements should be done. The attachment of differential gear or application of hydraulic motor to all the axles is strongly desired to maintain smooth steering and obstacle negotiation on irregular surface field.

As mentioned already, the author wishes to emphasize the mechanization promoting the reduction of heavy duty labor work in transporting operation in agriculture, especially in agricultural field. The author believes this kind of vehicle will be extremely hopeful for that purpose in the future not only in Japan, but also in developing countries. This article is not a well-arranged technical paper, but one introduction of the author's current researches, therefore he is very happy to distribute the related papers which were already presented or published before. You are always welcome to obtain the following materials from the author.

1. Research on the Development of Farm Use Terrain Vehicle with Hydraulic Articulated Steering. The Bulletin of the Faculty of Agriculture, Mie University, No. 54, pp. 157-185. (in Japanese with English summary)
2. Preproduction of the Farm Use Terrain Vehicle with Hydraulic Articulated Steering and Its Practical Application. Proceedings of International Conference on Rural Development Technology: An Integrated Approach, Asian Institute of Technology, Bangkok, Thailand. June 1977. pp. 259-273.
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■ ■

Farm Implements in Iran

——In the case of Mazandaran-, Gilan- and East Azerbaijan-state——

by
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Introduction

One of authors, A. ISHIHARA spent six months from October 1972 to March 1973 in Iran and engaged in the guidance of Iranian rural vocational education as technical cooperative activity from the Japanese Government under the Colombo Plan. Activities in Iran included staying at the Gorgan Rural Technical School and at the Rasht Rural Vocational school, and visiting to the Sari Rural vocational School and to the Isfahan Rural Vocational School.[1,2] On the other hand, A.ABWALLI worked as counter part for A. ISHIHARA at the Gorgan Rural Technical School, and he received the training of the Agricultural Machinery Education for Iranian Teacher in Tottori University from September to October 1973. S.ARBABI also received the training of the Agricultural Machinery Education for Iranian Teacher in Tottori University.

Recently, we had a chance to made a field investigation about the farm mechanization in Iran. Therefore, we had investigated not only modern farm mechanization by using large machines—tractors, combines, etc.—, but also old hand implements or animal drawn implements—hoes, shovels, sickles, breaking plows, etc.—, at same time from April ty May 1977.

In this paper, we will report about small implements in Mazandaran—, Gilan—, and East Azerbaijan-state.

In this investigation, we refered some reports from H.J. HOPFEN[3], M. YAMANE[4], and also from J. IINUMA and H. HORIO.[5]

Fig. 1 Farm implements in Ardabil area
(1) : Short-handled spade
(2) : Long-handled spade (New type)
(3) : Long-handled spade (Old type)
(4) : Spading fork
(5) : Four-tine grass and manure fork
(6) : Three-tine digging hook
(7) : Scythe

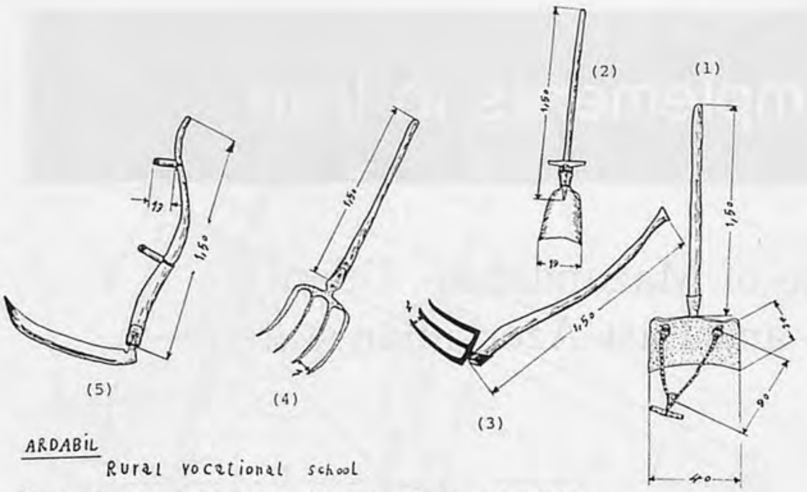

Fig. 2 Sketch and dimension of farm implements in Ardabil area
(1) : Two-man shovel
(2) : Long-handled spade
(3) : Three-tine type digging hook
(4) : Grass or manure fork
(5) : Scythe

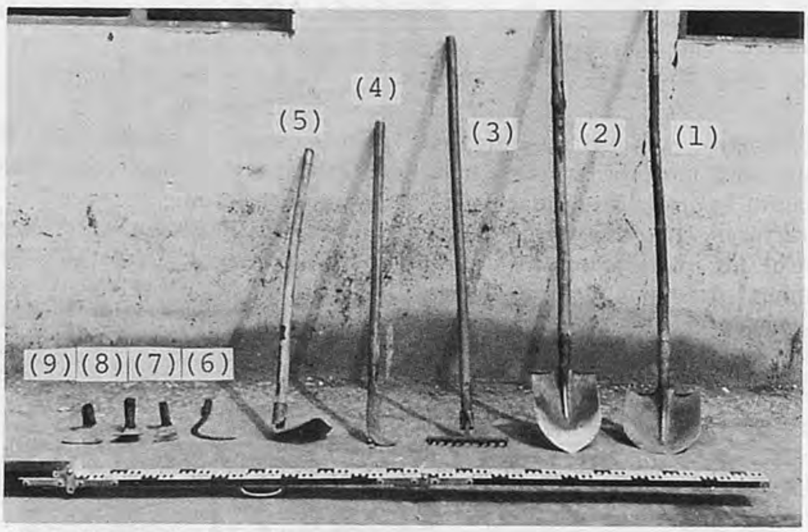

Fig. 3 Farm implements in Gorgan area
(1) : Shovel for use on even ground
(2) : Multipurpose type shovel
(3) : Common hand rake
(4), (5) : Digging hoe
(6) : Sickle with a serrated edge
(7), (8), (9) : Digging and chopping hoe

Tillage Implements

1. Spades

The spades is used to dig, lift and turn soil for the preparation of arable land, to make holes and to dig and clean channels or ther excavations. For work with spades both hands are usually employed as well as one foot which helps to push the blade into the earth. The spade in its original form, consisting of a long stick with or without a metal socket point or with a small blade.

(1) Long-handled spade

This spade has a handle length 150 cm (**Fig. 1 (2) (3), Fig. 2 (2)**), and foot rests. The blade is a lozenge, therefore this form is different from Iraq-type or Afghanistan-type which has triangular blade. One of those is old type (**Fig. 1 (3)**), and another one is new type (**Fig. 1 (2)**).

(2) Short-handled spade

This spade has a rectangular blade and short handle (**Fig. 1 (1)**). This kind blade is used for soft soils or loose soils.

(3) Spade fork

Spading fork with several tines are used for heavy soils (**Fig.1 (4)**).

2. Digging Hoes and Digging Hooks

Digging hoes and hooks are used for tilling and for clod breaking. The digging hoe is a more universal implement as it also serves for ridging, surface cultivation and weeding. Its elements are a steel blade, usually with a hole for a wooden handle. The angle between the working part and the handle varies between 85°and 90°. Blades of digging hoes vary considerably in Size, weight and shape according to the user's physique and soil conditions. They are small for children and women and large for men, long and narrow and heavy for compact soils and short, wide and light for light soils.

(1) Digging hoes

This digging hoes has short handle 100 cm (**Fig.3. (4) (5), Fig.4 (4)**). In **Fig.3 (5)**, shape of blade is quite alike to Japanese digging hoes. In **Fig.3 (4)**, shape of blade is made long and as hooked form.

(2) Digging hooks

Digging hooks kave three strong tines instead of a blade and mainly serve for tilling very hard or strong soil and sometimes for digging out root crop (**Fig.1. (6)**).

(3) Digging and chopping hoes

In **Fig.3 (7) (8) (9)** and **Fig.4 (6) (7) (8)**, three kind shape of blades were shown for digging and chopping hoes. In these Figures, handles are removed. The wide of blade are 6∼15cm.

3. Plows

The plow came into existence when man first succeeded in taming and harnessing animals for draught purpose. The

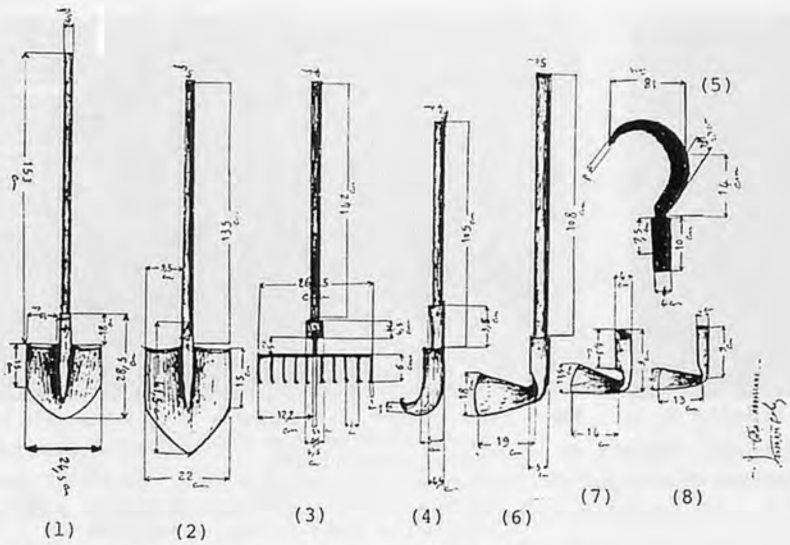

Fig. 4 Sketch and dimension of farm implements in Gorgan area
(1) : Shovel for use on even ground
(2) : Multipurpose type shovel
(3) : Common hand rake
(4) : Digging hoe
(5) : Sickle with a serrated edge
(6), (7), (8) : Digging and chopping hoe

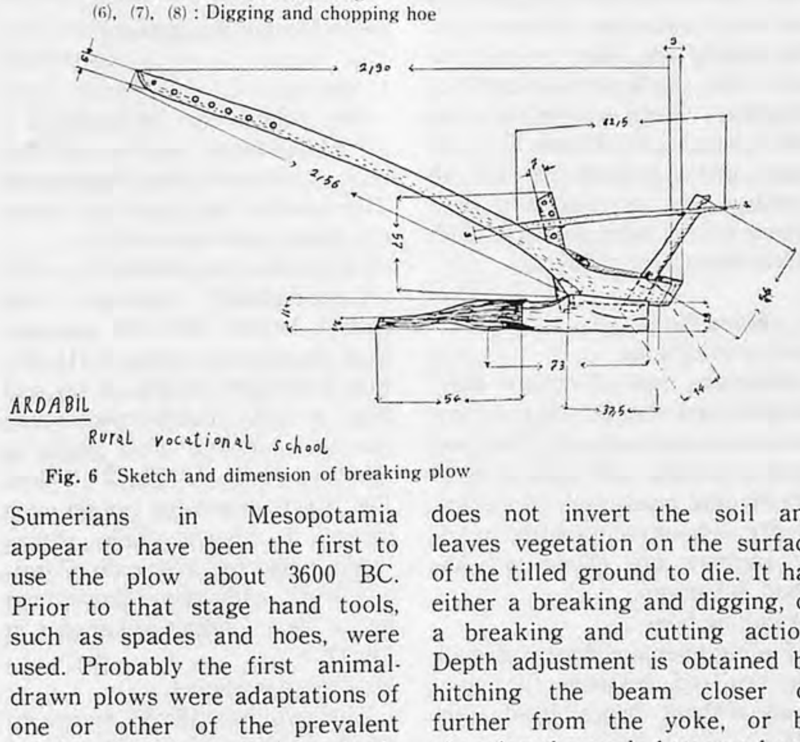

Fig. 6 Sketch and dimension of breaking plow

Fig. 5 Breaking plow

Fig. 7 Mouldboard plow

Sumerians in Mesopotamia appear to have been the first to use the plow about 3600 BC. Prior to that stage hand tools, such as spades and hoes, were used. Probably the first animal-drawn plows were adaptations of one or other of the prevalent hand tools. There are two basic types: the symmetric breaking type and the symmetric turning (mouldboard) type.

(1) Breaking plow

In **Fig.5** and **Fig. 6**, breaking plow is shown. This type plow consist of a beam, body and handle which are commonly made of wood, the share of iron. It produces a slightly ridged tilth, does not invert the soil and leaves vegetation on the surface of the tilled ground to die. It has either a breaking and digging, or a breaking and cutting action. Depth adjustment is obtained by hitching the beam closer or further from the yoke, or by changing the angle between beam and body.

(2) Mouldboard plow

In **Fig. 7**, one of the mouldboard plow is shown. Generally, the mouldboard plow lifts and turns the soil toward one side. Some invert the soil, and others only partially invert it. It differs essentially from the breaking plow by its ability to clear the furrow bottom for the next turn and enables the plowman to till a field in one operation instead of with repeated cross-plowing which is necessary with breaking plows. In **Fig. 7**, all construction —beam, plow body and handle— are made with iron.

4. Multipurpose Implements

The name "Multipurpose implement" has been coined to include implements which have a basic frame or toolbar to which a variety of tools or sets of tools or mechanical devices can be fixed for different work. To fulfil their task efficiently the devices under draught should keep under control unbalanced component forces such as side draught. The weight of the implement combination should not be so high as to make it difficult to handle in small fields or to transport over country without roads.

(1) Multipurpose implement with plow body

This multipurpose implement is used at the Rasht Rural Vocational School (**Fig.8**).

(2) Multipurpose implement with cultivator tines

The tool carrier sets shovel tooth and sweep (**Fig. 9(6)**).

(3) Multipurpose implement with sweep blade

In this case, the tool carrier sets wide blade of sweep (**Fig. 9 (5)**).

Fig. 8 Multipurpose implement with plow body in Rasht area

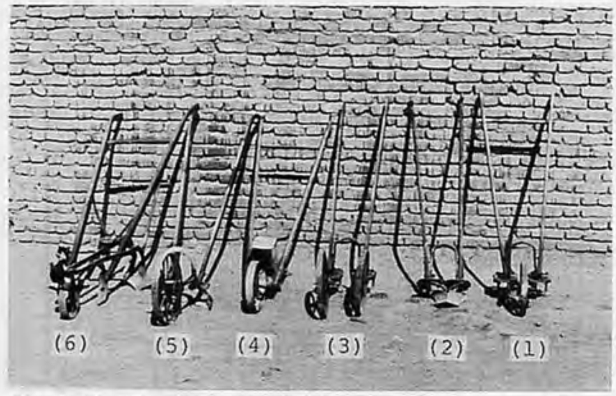

Fig. 9 Farm implements in Ardabil area
(1), (2) : Animal drawn ridger
(3) : Animal drawn cultivator
(4) : Common type one row hand drill
(5) : Multipurpose implement with sweep blade
(6) : Multipurpose implement with cultivator tines

Fig. 10 Work with the chopping hoes and the pulling hoes at Ali-Abad in Gorgan

Fig. 11 Work with the multipurpose type shovel and chopping hoes

Fig. 12 Two-man shovel

Implements for Intercultivation

The main objects of intercultivation are to destroy weeds, aerate the soil, ridge up the plants. Irregularly spaced crops can only be cultivated with chopping hoes or weeding knives with great expenditure of labour and time. Since timeliness is generally decisive for success, a farmer and his family are able to cultivate only very small plots properly in this way. Crops planted in rows with regular, sufficiently wide space and a soil that is not too cloddy, can be cultivated with labour-saving hand tools, or with animal-drawn implements.

1. Hand Tool

(1) Chopping hoes

Chopping hoes of various sizes, weights and shapes are the most common weeding tools. They are normally wide and lighter than the digging hoes used for tillage. In **Fig. 10**, intercultivation work by farmers are shown at Ali-Abad in Gorgan.

(2) Pulling hoes

Pulling hoes are drawn through the top soil between the plant rows without being lifted (**Fig. 12**).

2. Animal-Drawn Implements for Intercultivation

(1) Animal-drawn ridger

In **Fig. 9 (1) (2)**, two kind animal-drawn ridgers are shown.

(2) Animal-drawn cultivator

Also, animal-drawn cultivator is shown in **Fig. 9 (3)**. For single row the horse hoes type cultivator is very common implement for deep row-crop intercultivation and weeding.

Earth-Moving Equipments

1. Shovel

The chief object of a shovel is to move loose soil or similar material over short distances. The essential parts are the blade, the socket and the handle.

(1) Common type shovel

Long-handled shovels with handle length 130—160 cm are used in generals (**Fig. 3 (1) (2), Fig. 4 (1) (2)**). In **Fig. 3 (2)** and **Fig. 4 (2)**, multipurpose type shovel is shown. This blade is standard form. In **Fig.3 (1)** and **Fig. 4 (1)**, shovel for use on even ground is shown. This shovel blade is shorter and wide. Farmer's work with using shovel and hoe at near Gorgan are shown in **Fig.11.**

(2) Two-man shovel

The two-man shovel serves to prepare alternating ridges and furrows, to form bunds for irrigated crops, and for other shovel work. It consists of a large, slightly concave, flat-sided blade with two rings on the inside. The rings hold the ends of a rope. In use one man pushes and direct the shovel with the long handle while a second man, facing the first, pulls on the rope.

This rhythmic action generally results in an output exceeding that of two men with two shovels (**Fig.** 12, **Fig.** 2 (1)).

Sowing and Planting Implements

The drilling operation consists of depositing seeds in shallow furrows cut in the seedbed and then covering them with soil with same implements. The uniformity of seed deposition in the furrows depends mainly on the seed ejecting mechanism with which the drilling implement is equiped.

1. Hand Drill

In **Fig.** 9 (4), common type one-row hand drill is shown. This is consists of a wheelbarrow frame with a front wheel, a seed-box, an adjustable feed mechanism, a furrow opener with depth adjustment, a seed coverer, a press wheel and marker. The feed mechanism is adjustable for spaced drilling in the row.

Harvesting Tools

1. Sickle

The sickle is one of the most ancient harvesting tools and is mainly used for reaping cereals. It exists in a great variety of forms, with two different types of blade edges: those with a serrated edge and those with a smooth edge. The first is of older origin. In **Fig.** 3 (6) and **Fig.** 4 (5), one of Iranian sickle with a serrated edge is shown.

2. Scythe

The scythe is essentially a grass-mowing implement, used with two hands. In **Fig.** 1 (7) and **Fig.** 2 (5), Iranian scythe is shown. The modern scythe for grass mowing consists of a blade jointed to a handle, called the "snath" by a ring connector.

Handling and Transportation Equipments

Much of a farmer's time is spent in handling and transporting the crops he grows.

1. Forks

Forks of many shapes and sizes are used to handle farm produce of various weights and consistancies. The forks are locally made of weed, but the demand for stronger types with steel tines is increasing. Four-tine grass and manure fork in **Fig.** 1 (5) and **Fig.** 2 (4) is used in Ardabil. The tines are somewhat curved, round on cross-section, made of spring steel.

2. Rakes

In **Fig.** 3 (3) and **Fig.** 4 (3), common hand rake is shown. This hand rake has a tubular steel head, 27 cm wide with 10 teeth. The handle must be rather long so that the operator can draw material from a distant point without excessive body movement.

Conclusions

Recently, authors had a chance to made a field investigation about the farm mechanization in Iran, again. Therefore, we had investigated not only modern farm mechanization by using large machines, but also old hand implements or animal drawn implements.

In this paper we reported about small implements in Mazandaran-, Gilan- and East Azerbaijan-state of Iran.

These results will be of value for reference in discussing and making future plan for farm mechanization in Iran.

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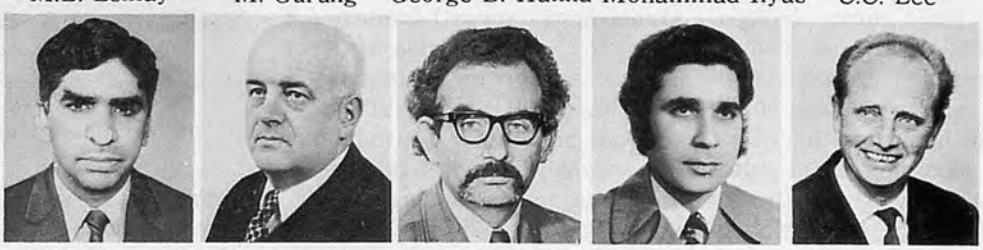

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Development Currents of Agricultural Machinery for Japanese Rice Cultivation and Farming Structure

by
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Abstruct

The well mechanized agriculture of a country could not be successfully established only with the development of the machines adjusted to her traditional farming methods. Although such an attempt is certainly important, it is also necessary that the traditional farming methods should be improved for the convenience of mechanization.

In that case, without understanding the relation of cause and effect of the traditional methods produced by the national social structure and natural conditions thoroughly, we would err from the rational course for the improvement of farming methods and for the development of agricultural machinery.

Japanese traditional method of paddy farming has been influenced exceedingly by a sudden technical reform and the modernization of her social structure since 1945. Accordingly, the agricultural mechines and implements adjusted to the abrupt change of those traditional farming methods have been developed step by step but rapidly, and also those farming methods have been greatly changed by adjusting the rational mechanization.

The development processes of the mechanization in Japan, including some failures, and the farming methods as the background of the necessities to those processes will be explained, using statistical data and many pictures, in order to have the up-to-date machines for paddy cultivation in Japan understood well.

Background of Geographical and Weather Conditions

Japan is a country of islands lying in the subtropical, temperate and sub-frigid zones situated in 46°31′ to 20°25′ N. Lat. Her total area is 377.435 km² (37,743,500 ha). The population is about 110 million, its annual rate of increase is about 1.2%, and population density is 280 persons/km² in 1976. Pupulation growth was about three times within last 100 years.

Four main islands of Japan are, from the north, Hokkaido (78,515 km²), Honshu (230,822 km²), Shikoku (18,782 km²), Kyushu (42,030 km²), as shown in **Fig.1.** Mountain region occupies about 80% of her total area, and there are no wide and extensive flat fields like continental countries.

Japan is located in a part of a monsoon Asian region, in the east of the Asiatic Continent, and greatly affected by a seasonal wind, which causes hot weather in summer by the wind from south and very cold one in winter by the wind from the north continent. The biggest island Honshu is divided into Tohoku (northeast district), Hokuriku (north dis-

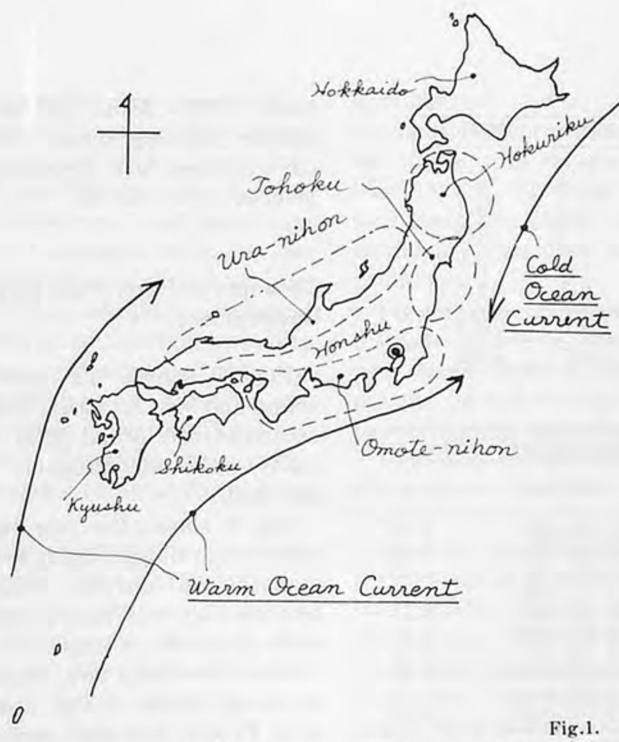


Fig.1.

trict), Ura-nihon (backside Japan) and Omote-nihon (front-side Japan), according to the geographical weather conditions.

As shown in Fig.1, there are two warm ocean currents from south and one cold ocean current from north. Accordingly, Kyushu, Shikoku and Omote-nihon have warm climate but Ura-nihon, Tohoku, Hokuriku and Hokkaido have cold climate of heavy snowfall.

The annual mean amount of rainfall is 1300 to 1400 mm/year. This is about two to three times as high amount as that in Europe or America. This is a characteristic common in the paddy rice cropping region in Asia. **Fig. 2** shows the variation of these rainfall and temperature in Japan[7].

Concepts of Farm Land and Yield Structure

The agricultural land of Japan is 5.6 million ha, about 15 % of the whole country area as shown in **Table 1.**

Japanese had a national custom of not eating animal meat in general till the Meiji era, about 100 years ago, for their proteid was mainly fish meat and beans. Although European culture influenced poeple for eating animal proteid, the pasture land is only 19 % of the entire agricultural land. Accordingly Japan is importing about 70 % of concentrated feeds for livestock industry.[14]

About 80 % of the agricultural land is arable land, about 70 % of which is paddy rice field. Upland rice fields are negligibly small.

Table 1. Land use of Japan, 1973

Agricultural Area (5.647 m. ha)	Arable Land (4.584 m. ha)	Paddy Fields (3.274 m. ha)
		Upland Fields (1.310 m. ha)
	Land under Permanent Crops (0.632 m. ha)	
	Permanent Meadows and Pastures (0.431 m. ha)	

Source : FAO Production Year Book

The agricultural land is owned by actually cultivating farmers, as a rule, depending upon the Land Reform held after World War II, as shown in **Fig. 3.**

As the farmer population to the total population in narrow Japan at that time was not so small percentage, the arable land resulted in small division and family farming has fixed. This means statisically that the number of farm-households is that of farms. The number and size of farms are showed in **Table 2.** 92 % of total number of farms are 2 or less ha. This farm structure became a definite factor to have active R & D on small agricultural machinery in Japan.. The recent average size of agricultural land per one farm-household is about 1.1 ha.

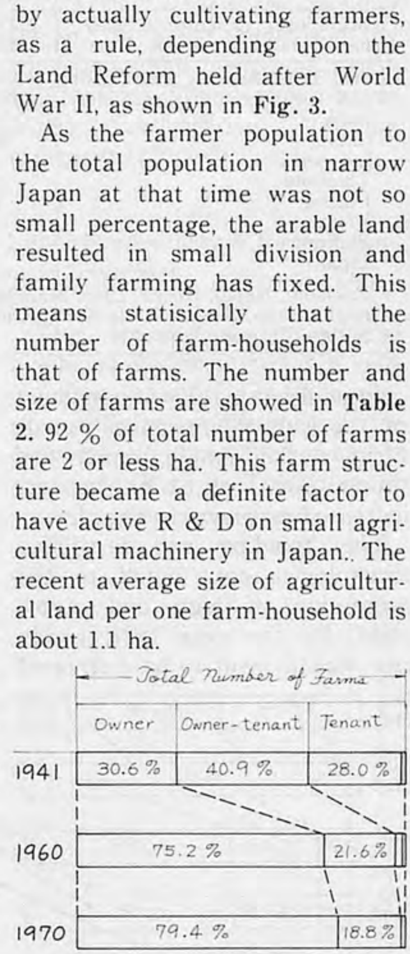
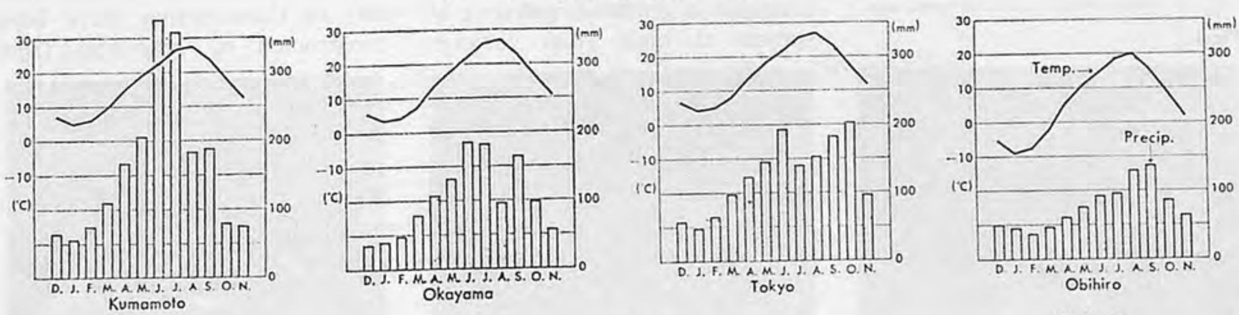


Fig.3.



Kyushu

Honshu

Hokkaido

Fig.2. Temperature and Rain-Fall in Japan

Table 2. (%)

	1941(Aug.)	1950(Feb.)	1960(Feb.)	1970(Feb.)
Under 0.5 ha	32.9	40.8	38.0	37.7
0.5~1.0 ha	30.0	32.0	31.8	30.2
1.0~2.0 ha	27.0	21.7	23.6	24.1
2.0~3.0 ha	6.2	3.4	3.8	4.8
3.0~5.0 ha	2.2	1.2	1.5	3.0
Over 5.0 ha	1.3	0.8	1.0	
Exceptions	0.4	0.1	0.3	0.2
Total	100.0	100.0	100.0	100.0
Number (in thousands)	5,412	6,176	6,057	5,342

Source : Ministry of Agriculture and Forestry

Table 3. Area and Production of Rice (Paddy)[2]

	Area (ha)	Production(ton)	Yield(ton/ha)
World Total Agricultural Area	1,432,000,000		
Asian Total Agricultural Area	461,300,000		
World Total Area of Rice Fields	134,163,000	320,714,000	2.39
Asian Total Area of Rice Fields	121,953,000	293,793,000	2.41
India	37,000,000	67,600,000	1.83
China	34,755,000	111,520,000	3.21
Indonesia	8,568,000	20,321,000	2.37
Thailand	7,392,000	14,650,000	1.98
Burma	4,911,000	8,559,000	1.74
Vietnum	4,900,000	10,600,000	2.14
Philippines	3,589,000	5,532,000	1.54
Japan	3,270,000	15,766,000	6.02
Pakistan, Nepal, Korea, Laos, Malaysia, Iran, Sri Lanka, Iraq, Afghanistan, Brunei, Hong Kong, Khmer, Port Timor, Saudi Arabia, Syrian, Taiwan, Turkey			

by FAO 1973

In addition, as the development of agricultral machines made farm works simple, quick and timely done, part-time farmers increased as shown in **Fig. 4.**

The breeding and fertilizing technologies contributed to the promotion of high and stable yield. By the year 1927, paddy rice was difficult to be cultivated in northern Japan, because of cold weather. A new variety which is hardly affected by cold weather was developed by breeding technology from 1920 to 1930. In addition to it, better cultivation technologies have produced stable yeild since 1960.

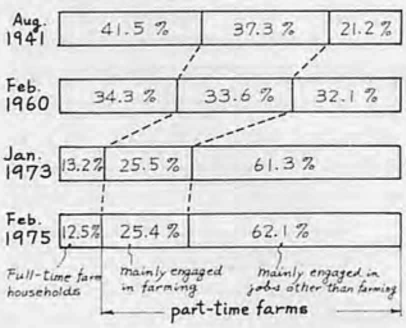


Fig.4.

About 91 % (about 122 million ha) of the whole rice fields in the world (about 134 million ha) is in Asian countries. **Table 3** shows relative situation of Japanese rice cultivation in the world. Japan yeilds 15 to 17 million ton paddy from about 3 million ha paddy field every year.

A paddy cultivated in tropical countries is mainly Indica variety which is different from Japonica variety. The yield in tropical countries is gradually going up by spread of high yield varieties since 1970. Some places with double cropping system in tropical countries are approaching a level of 4 to 6 ton/ha.

Concepts of Farm Field Structure Development

Fig. 5 shows the traditional shape and size of a rice field in a comparatively broad plain, where many fields of irregular shape are seen.

Fig. 6 shows the rice field by contour farming constructed on a mountainous district. The rice terrace like this can be seen in other countries in Asia.

Since the Meiji era, especially in plains, Farm Land Readjustment Project has been performed, in order to improve traditional rice fields to high efficient producing fields. The main objects of this readjustment were to reform size and form of a field and to construct irrigation and drainage systems.

Fig.7 is an example of the district where the readjustment was performed in old time. It shows a plain district where the shape of fields became rectangular and irrigation ponds were constructed. Every district made an estimated count of the rainfall amount and the irrigation water necessary for paddy cultivation (generally 10 to 20 mm/day on the average)[1] and set up irrigation and drainage systems in every village.

Besides many dams were constructed as a national project. Dams for engineering water, which are controled by the Ministry of Construction, have been constructed by graduates from

Fig.5.

Fig.6.

Fig.7.

the civil engineering department.

However, dams for agricultural water are under the direct control of the Ministry of Agriculture and Forestry, and have been built by graduates from the department of agricultural engineering. Accordingly, Japanese agricultural engineering specialty includes the design and construction technology of dams in university level education. This differs from European and American concepts of agricultural engineering.

In case of irrigation dams, the knowledge of agriculture is necessary to the very decision upon the amount of water. Besides, all the irrigation and drainage ditches between dams and paddy fields should be systematically designed with the knowledge of agriculture. Those are why agricultural engineering specialists deal with irrigation dams in Japan.

In 1950s, irrigation dam projects under the Ministry of Agriculture and Forestry were seen in about 1000 places, while about 800 dams were set up under the Ministry of Construction. It is said there are about 30,000 dams including small ones all over the country.[1]

Fig.8 shows an example of the districts where a comparatively new Land Reform was carried out. As the result of advancement to mechanized agriculture, size of a field-plot recommended by the Government became 100m × 30m.

However, as this picture shows, a rice field is often divided again into smaller pieces by farmers themselves. This comes from an inevitable characteristic of irrigation water. The surface level of a paddy field is recommended to be ± 2.5 cm, or within the limits ± 5 cm at most.[9] Japanese farmers know that a paddy field beyond this allowance is difficult to have uniform growth of rice plants because of different soil and water conditions.

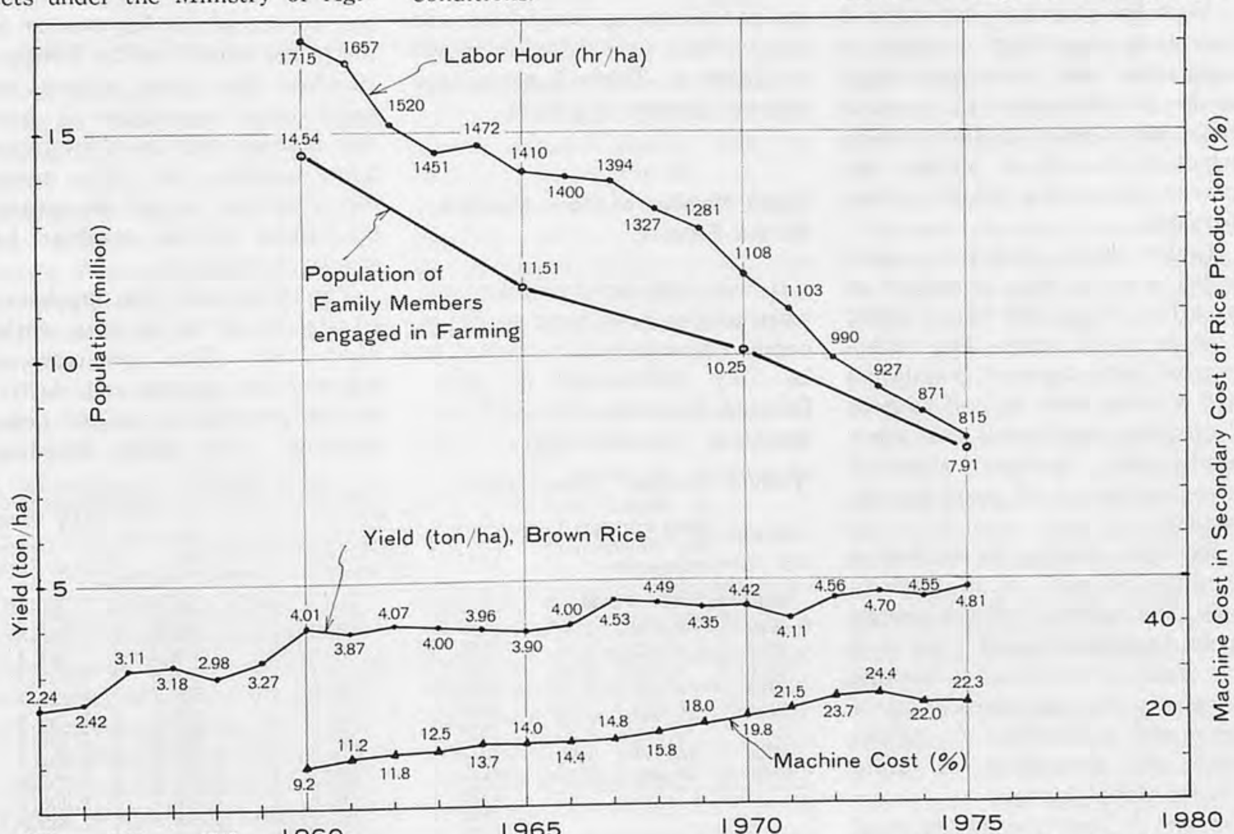
Fig.8.

Through their behavior of having small-scale fields, Japan has the development of small-scale mechanization.

Recently, large-scale farming system is being organized by collecting small farms and working together. There were about 38,000 cooperative farming groups in 1976.[3]

Labor Productivity & Some Economic Situations

The spread of agricultural machines was promoted in a very quick way historically. The progress of labor productivity of rice cropping in the meantime is shown in **Fig. 9.** The yield of



Source : Ministry of Agriculture and Forestry, Japan

Fig.9.

brown rice per hectar became twice as much in 75 years as that in 1900 and it is still increasing gradually. The percentage of agricultural machine and implement cost in the secondary cost of paddy production is going up little by little to be over 20% (about 22%), with the increase of investment in farm machines.

"Secondary cost of production" means all the production cost P as the following equation:

P= (A−B) + (C+D)

where,

A : Total expense of seed and seeding, fertilizers, agrichemicals, fuel and lights, miscellaneous materials, land improvement and water, charge and fees, building and facilities, machinery and implements, labors.

B : Income of by-products

C : Capital interest

D : Land rent expense

(A−B) is called the primary cost of rice production

With the spread of agricultural machines, population engaged in agriculture has been decreasing to be a half in last 15 years, a little less than 6 million (1975), which is 11.4 % of all the employed population (52.23 million persons).

Under those conditions, labor imput hour/ha also decreased to be a half (about 800 hr) of about 1700 hr in 15 years. The reduction of both farmers' population and working hour by half without decreasing yield means that labor productivity became about 4 times as high in 15 years as that in 1960.

Recently, besides the method of thinking of such a productivity only, the learning of the energy input necessary to get 1 kg or 1 cal yield is occurring. It became necessary for the civilization of developed countries to reflect from the standpoint of using limited global energy.

Even if Japanese agricultural structure is changed into the production system by big-scale agricultural machines, it can save mainly labor cost by reduction of working hours but not many other expenses, for example, for seeding, fertilizer, fuel, miscellanious materials, land expense, water, capital interst and so on. In other words, the price of agricultural products depends considerably on the expense items which are influenced by nature and social conditions.

Therefore, under the social and natural conditions like Japan, farmers feel it difficult to change suddenly their farming system by small-scale machinery to European and American system by large-scale machinery. However, as the decrease in farming labor population is still continuing, cooperative farming groups are increasing and the changes from micro to small, and to medium scale farm machinery are occurring recently.

The price of brown rice from farmers to the government in Japan is going up every year, and approaching to 1 $/kg as shown in **Table 4. Table 5** shows the average income of a farm.

Total Number of Farm Machinery in the Farm

It was only several years ago when all the basic farm works of paddy rice cultivation started to be fully mechanized in Japan. Because it is only since 1970 that practical transplanters and harversters started to be popularized. **Fig. 10** shows the histrorical process of them. The details about the development of each equipment will be explained in following chapters. Only conceptional currents will be described in this chapter.

The normal and average method of farming before 1945 was achieved mainly by man and animal power, utilizing an animal plow, rake, harrow, cultivator and so forth. Farming process consisted of animal-powered plowing and puddling, man-powered transplantation and harvesting, weeding with a simple weeder, chemical spray by hand or with a hand sprayer, threshing with a pedal thresher after natural drying process, and paddy cleaning by natural wind or a winnower. Farmers brought sacks of paddy home, and made brown rice with their huller.

When an American thresher was introduced in Japan, the field structure at that time was difficult to accept the big tractor as the prime mover for the thresher. Besides, they used straws for many daily necessities of their own making, such as straw ropes, mats, sandals, etc. This means they could not accept the scratch mechanism of the machine for straws at that time.

Threshing work was mechanized first of all the farming works after 1945. The progress of water-cooled engines and electric motors enabled to replace pedal threshers with power threshers

Table 4. Average Price of Brown Rice from Farmers to the Government in Japan[1]

Year	¥/60kg	$/kg
1969	8,090	0.38
1970	8,152	0.39
1971	8,482	0.46
1972	8,880	0.56
1973	10,218	0.64
1974	13,491	0.80
1975	15,440	0.92
1976	16,432	0.98

Table 5. Average Annual Income/Farm Household in Japan[1] (¥ 1000)

Year	Agricultural Income/farm	Non-Agri. Income/Farm	Total/Farm
1960	225.2	184.3	409.5
1965	365.2	395.6	760.8
1966	413.3	448.1	861.4
1967	510.1	519.6	1,029.7
1968	527.0	598.7	1,125.7
1969	529.3	720.7	1,250.0
1970	508.0	885.2	1,393.2
1971	469.6	1,068.1	1,537.7
1972	585.2	1,267.7	1,852.9
1973	742.0	1,566.7	2,308.7
1974	923.0	2,022.9	2,945.9
1975	1,146.0	2,268.4	3,414.4

¥300≒$1000

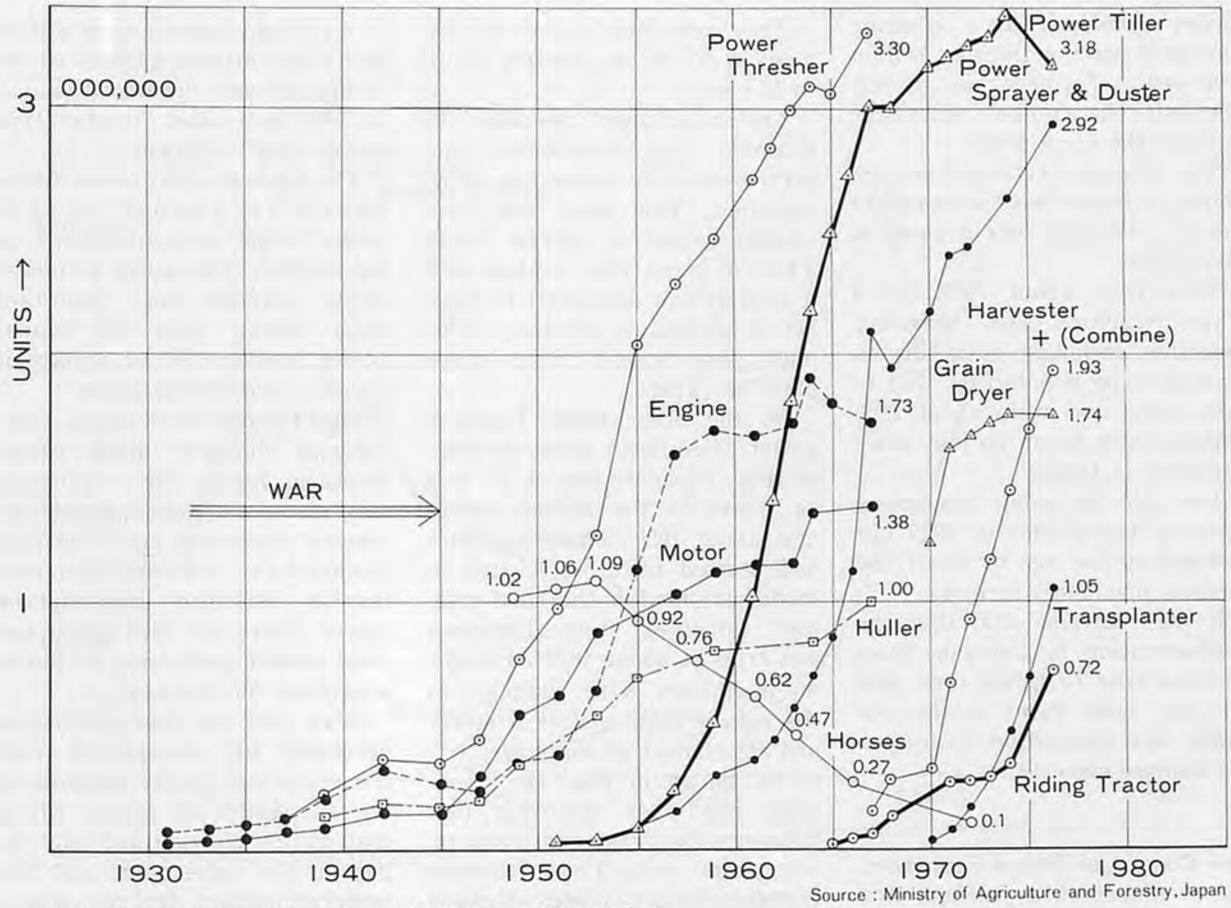


Fig.10. Total Number of Major Farm Equipments on Farms in Japan

driven by the power unit.

During 1950 to 1955, feeding mechanism of a chain belt for paddy bundles was developed and attached to the power thresher. The machine called "Automtic Power Thresher" was the thresher of automatic feeding operation, and rapidly accepted by farmers.

The advancement of farm-use engine led to produce smaller but powerful engines. Thus, mounting a water-cooled engine, practical hand tractors of rotary tillage appeared on the market, and were bought by leading farmers. Some of them used the machine for contract tillage through which they recognized the convenience and higher efficiency than tradititional animal plowing.

Light hand tractors of 3 to 4 ps with air-cooled gasoline engines started to appear in around 1955. This machine could perform most works done by cattles. Those variable power tillers with water- and air-cooled engines were rapidly bought during 1960 to 1970 as shown in **Fig.10.**

Next to power tillers, small engines were coupled with plunger-typed sprayers, and the mist-dusters of knapsack type with tiny engines were developed and quickly replaced hand sprayers in 1965 to 1970.

The age of animal-power farming changed to that of small agricultural machinery farming in 1960 to 1970.

The vital statistics of population at that time showed the movement of labor from farms to other industrial fields as shown in **Fig.9.** The movement caused the diffusion of farm mechanization because of labor shortage in farm area. However, the farmers most of whom were independent family-farmers did not sell their fields and became part-time farmers as explained in **Fig.4.** The increasing number of the part-time farming has promoted the progress of higher efficient farming and better machinery due to limitted working time.

Several manufacturers tried to develop tiny farm-use riding-tactors of 10 and less ps. In about 1965, such tractors of V-belt drive appeared on the market, together with conventional 10 to 20 ps tractors.

There was another strong current of R & D activities for harvester machines and grain dryers at that time. Many trial machines modified to be small and simple from American con-bine-harvesters of reel mechanism were tested to Japanese rice plants.

The reel mechanism was not so adaptable to the rice plants lodged on the field by a typhoon. The binder with a special feeding mechanism of pick-up fingers appeared in 1960 to 1965. This binder developed to a combine harvester with a thresher within five years. Farmers had to buy not only the combine harvester but also the grain dryer.

The transplanter which has the levers of finger-like operations to the rice seedling was devised in about 1965.

Thus from about 1965, the 4 wheel tractors and harvester machines including grain dryers started to be popularized well in farm area, and from about 1970 transplanters began to join other machines in Japan.

The age of small machinery farming during 1960 to 1970 has changed to the age of small and medium machinery farming.

It may be also said that the mechanization is changing from walking type to riding type, and all the main farm works for paddy rice cultivation have been mechanized since 1970.

The Current of Tillage Equipment

The wooden plows with long sole and non-pole were mainly used until about 1910 in Japan. These plows developed to efficient Japanese single plows of short sole metal in about 1900[2] as shown in **Fig. 11** for Japanese paddy rice fields.

Fig.11.

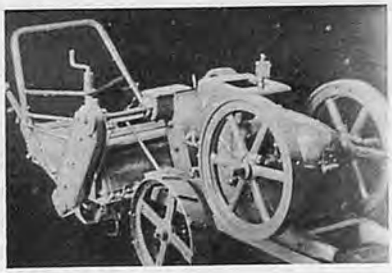


Fig.12.

They were effective to increase about 9 to 10 cm plowing depth to 15 cm.

The mouldboard developed to movable fork mechanism, and turn-wrest plow (reversible plow) appeared. This plow was convenient to use in narrow fields. Then, in about 1945, a plow with a jointer was developed to have better pulverizing efficiency. This plow was called "two stage plow" in Japan.

On the other hand, Japanese power tillers were being developed. **Fig. 12** shows one of 3.5 to 5 ps tillers in the animal power age, about 1950. These machines had started to be developed in modification after the hand tractors imported from European countries in about 1920s. European hook-tines were equipped to the rotary tiller that is a standard attachment of the power tiller as shown in **Fig. 12.** Hook-tines had poor removing performance for grass and straw on soft paddy soils. Thus, Japanese C-shaped rotary blades of good removing effect to grass and straw were developed in about 1950 to 1955.[5] These power tillers of rotary tillage are called "drive-type power tiller", while 3 to 4 ps hand tractors with a plow and many attachments as shown in **Fig. 13** were developed in 1955 to 1960 and called "traction-type power tiller" in Japan.[5]

The medium-sized power tillers between 3 to 4 ps and 7 to 14 ps power tillers were also born on the market. This series of power tillers covered most important farm works done by animal power, and started to replace it rapidly since 1960 in Japan.[5]

Fig.14 shows exchanging technologies through tillage equipments in Japan. The production current of Japanese plows increased depending upon the promotion curve of power tiller production including traction-type power tillers till 1963 when the total annual production of plows was about 260 thausand.

Since 1963, the plow production decreased and disappeared from the statistical report because of the succession of rotary tillers that can do plowing and harrowing at the same time and are more convenient for the preparatory tillage, especially for puddling.

Now, the total production of power tillers is decreasing, and the riding tractor production is

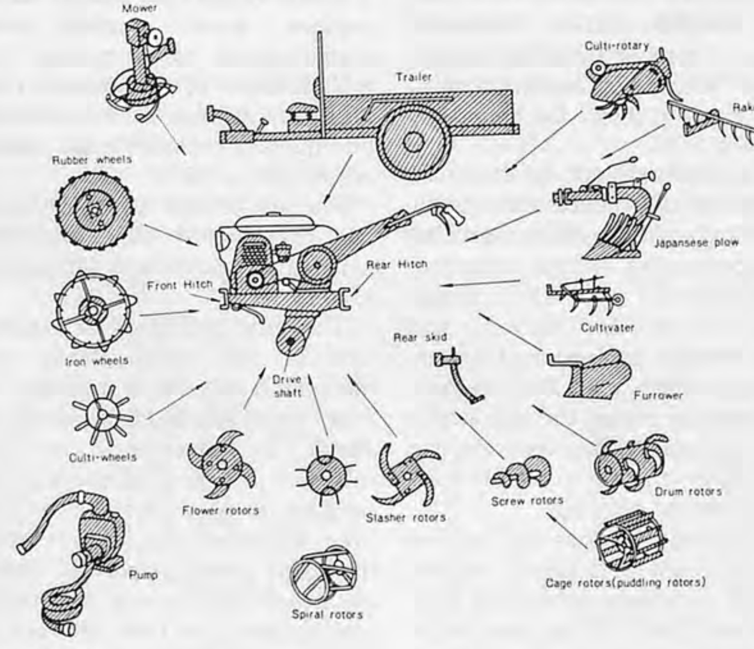
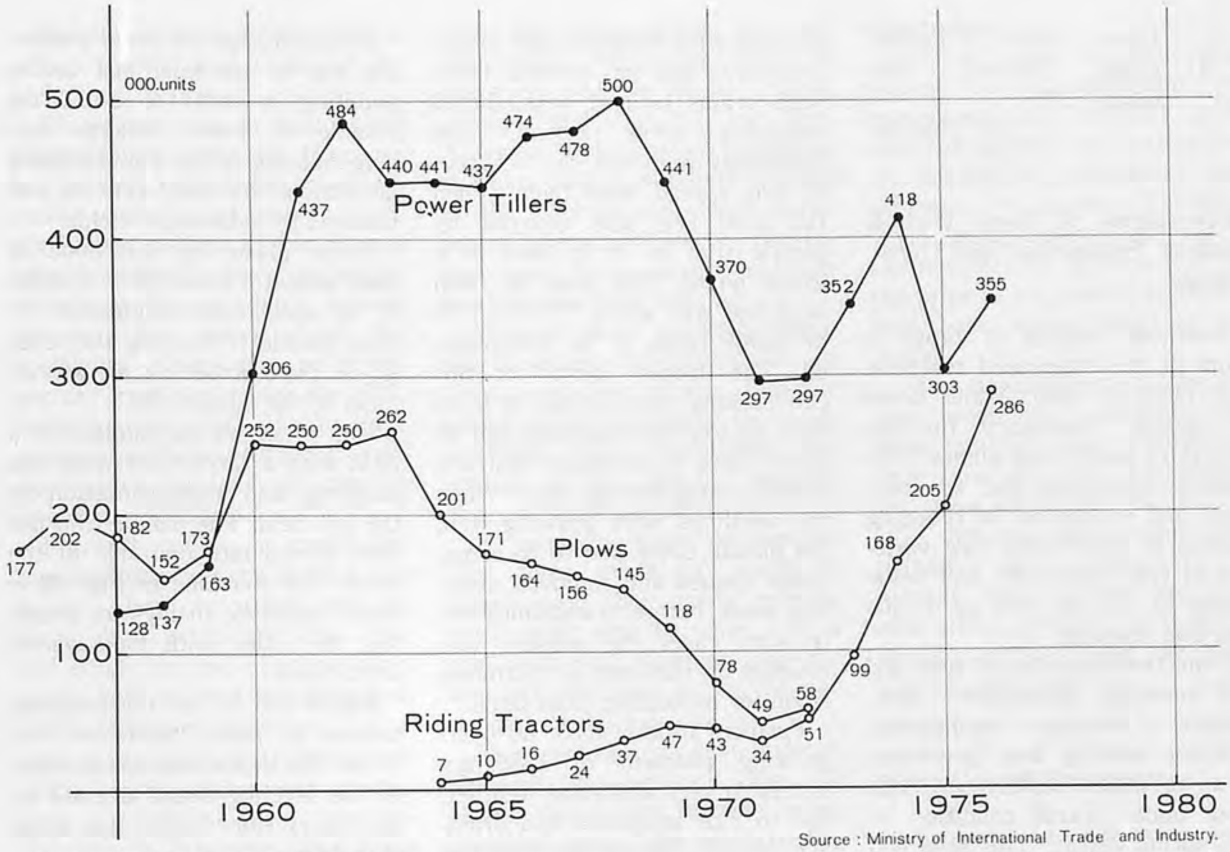


Fig.13.



Source : Ministry of International Trade and Industry.

Fig.14. Annual Production of Farm Machinery

increasing. It is another fact that more than 80 percent of the total tractors are being delivered from the producing factories with the rotary tiller as a standard equipment as shown in **Fig.15.**

After World War II, as deep tillage as about 18 cm and the optimum amount and timing of fertilizer were essential factors to have better yield. Japanese plows were developed with an idea of such 18 cm depth of cut.

Sudden deepening of tilth will destroy the plow-pan under the tilth, and will have the possibilities of much water leakage and lack of fertilizer. Many farmers

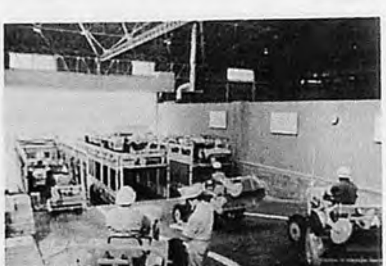


Fig.15.

applied little by little deeper plowing every year, and reformed their shallow tilth to the depth of at least 15 cm, or 18 cm if possible, within four to five years.

In the case of power tillers during 1955 to 1965, such capacity of 15 to 18 cm tillage depth was also a basic design principle for the rotary tiller.

However, the required depth of tillage changed gradually again to shallow tilth of 12 to 14cm, after 1965, on account of the advancement of fertilization technology and application of transplanters. (Although chemical fertilizer is asked to reconsider nowadays) farmers became to promote the yield, applying the technology of three to four times additional fertilizer after base one on and into shallow tilth. The other reason is that better leveling and smooth soil surface of puddling for the transplanter could be obtained easily from shallow tilth.

The author is hardly to say if this tendency is fortunate or not. Anyway, most of recent farmers except orthodox farmers have become to till only 12 to 14 cm depth with machines.

This current of tillage depth problem enabled us to make tiny riding tractors of rotary tillage possible. Namely, excess capacity of tillage depth is utilized to enlargement of tillage width. The Japanese riding tractor of 10 to 15 ps has average tillage width of about 95 to 120 cm[12] which is the dimension to keep the machine stable. Because, the width of the rotary tiller should be equal, or a little wider than the outside dimension of both rear drive-wheels.

The working efficiency of tillage for normal soil condition is as follows:

1) man power with a hoe[13]
0.03 to 0.09 ha/day
2) draft cow power with a plow[1,3]
0.15 to 0.25 ha/day
3) power tiller with rotary

tiller 0.5 to 1.0 ha/day
4) riding tractor with rotary tiller >0.7 ha/day

Technologies of Seed Bed & Seedling Preparation and Trans-Planter

Northeast region in Japan is short of the integrated temperature (3000 to 4000℃)[6] and hours of sunshine necessary for the growth of paddy rice plants. This trouble stimulated the advancement and utilization of breeding science to find better rice varieties of short maturity and resistances to cold as well as to disease and draught.

From the viewpoint of seed bed and seedling preparation technologies in structure engineering, semi-hot seeding was developed so as to make healthy seedlings grow under warm condition in cold spring season. This seed bed is called "ho-on settyu-nawashiro" in Japanese, semi-hot-seeding in English.

These technologies have been applied to establish double cropping of paddy rice in southwest region in Japan.

Fig. 16 shows the traditional basic method of semi-hot seeding in Japan. The seed bed soil was puddled with fertilizer and irrigation water and was leveled. Then, seed grains treated with forced sprouting were spread, and previously prepared chaff-charcoal was spread over them. Then the seed bed was covered by plastic film as if it were in a green house. The area of total seed bed was about 1/20 to 1/30 of paddy fields to be transplanted. The nursery period of this conventional method was 30 to 40 days in southern districts and 40 to 50 days in northern districts before transplanting time.[6] When the seedlings were growing well, the plastic cover had to be sometimes opened and removed about one week before transplantation. In such cases the nursery was covered by thin nets or fluttering ribon for protecting from birds.

Farmers usually have no overgrowing problem of seedlings, except in very abnormal weather, due to rice irrigation and drainage control. During the seed bed farming, farmers have to do preparatory tillage, that is, puddling for transplantation. **Fig. 17** shows a couple of farmers spreading chemical fertilizer after normal rotary tillage without irrigation water. After this work, puddling will be done with enough amount of irrigation water.

However, perfect levee plastering has to be done just before puddling in order to avoid the trouble of water leakage into neighbouring fields. **Fig. 18** shows an almost dry field that is surrounded by submarged fields.

Levee plastering was done by man labor till about 1965. Recently a specialized equipment to bury plastic film along the levee is on the market as an attachment of the power tiller.

Fig. 19 shows the puddling in a field with a small tiller after the puddling and transplantation in the left field. The plastic film has been buried into one side of the levee. The machine in **Fig. 19** is one of standard fittings for puddling, the tiller with cage-wheels and a rake.

Fig.20 and **21** are the puddling method by power tillers of 5 to 10 ps. The driver sometimes rides on the leveling board drafted by the rotary tiller in the last stage of puddling.

Some riding equipments for puddling, such as a riding harrow drafted by the hand tractor and a big rear wheel with a special seat instead of a standard rear wheel, were developed in 1965 to 1970. These were not accepted so much by Japanese farmers, though they are popular in some South East Asian countries and China.

Fig.16.

Fig.17.

Fig.18.

Fig.19.

Fig.20.

Fig.21.

Fig. 22 is the puddling with a riding tractor and standard attachments in Japan.

There are many iron-lugged wheels for puddling use. However in general, Japanese farmers rather prefer to perform the puddling with rubber wheels if possible, not with big iron-lugged wheels or big auxiliary wheels, because they worry about the possibility of any damage of important hard pan under the tilth. Namely, they don't like to have unexpected deeper tilth and leakage water because of digging effect of wheel lugs.

Fig. 23 shows a traditional transplanting scenery at least one to two days, or usualy two to three days after puddling. The soil condition just after puddling is too soft to hold seedlings and apt to have poor rooting.

In 1950s, some trial transplanters for the seedlings with a cubic clod around the roots (tsuchi-tsuki-nae in Japanese) were being developed. The seedlings, pushed out of the machine, could fall down by the weight of the clod itself to the soft field surface. This machine was not successful.

In about 1965, a new lever machanism like finger action to catch and plant seedlings was devised. Agricultural engineers and scholors, who got many ideas from this transplanter, had several years' researches which is the most suitable of the infant, young and aged seedlings. Younger and smaller seedlings are expected their bigger loading on the machine and higher working efficiency. However, too infant ones have weak resistance against weed and weather.

Through these research activities including the development of floats and drive wheels, two-row transplanters for infant to young seedlings were developed and started to be rapidly popular. Fig. 24 shows one of them.

As seedlings grow on regularized pans made of wood or plastic, and their roots entwine each other and becomes like a mat with soil, farmers take the mat-like seedlings out of the pan to load on the machine.

The seedlings can grow indoors as well as outdoors. Fig. 25 shows the recent nursery using seedling pans and covered by plastic films.

Thus, in about 1970, rice transplantation in the field of 1 to 2 ha became possible to be done by one or two farmers.

The quick diffusion of transplanters (and also harvesters) in the whole Japan owes not only to the completion of machine development, but also to the social structure.

At that time in 1970, labor wages to transplantation (and harvesting) was already going over 10$/person/day, besides food and traffic fee, because of labor shortage in Japan. Therefore, when transplanters appeared on the market, all farmers felt that the price of the machine could be paid back within three to four years.

After development of the two-row transplanter, engineers started to multiply the machine, and four- and six-row transplanters had been developed by 1975. In 1977, two models of riding transplanters were already on the market, though these are available after perfect puddling and leveling works under the condition of good hard pan.

Weed Control Equipment

Weeding in summer paddy fields is one of very painful works. Paddy weeders pushed by man power were very popular in the past. From about 1950s, these weeders disappeared on account

Fig.22.

Fig.23.

Fig.24.

Fig.25.

Fig.26.

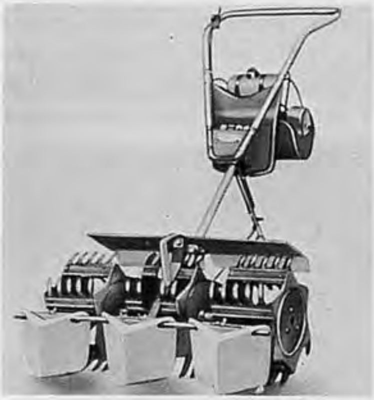


Fig.27.

of diffusion of chemical weeding technology.

At the same time, mechanical weeding of 3 to 4 ps power tillers with 3 to 4 - row weeders were tried in the whole Japan. This device had a trouble of pushing down rice plants by drive wheels when the machine was turning at headlands, and was not accepted so much by farmers.

In about 1965, three-row power weeders of mono wheel as shown in **Fig. 26** was developed and started to be popular, especially in northern Japan.

Another power weeder as shown in **Fig. 27** was also developed in about 1970. This machine was completed in connecting the ideas of IRRI and Japanese industry about the force balancing between the driving-forward force of weeding nails and the backward resistance of a rear skid.

Although the chemical weeding is convenient, it is being reconsidered to use too much chemicals to farm products, and the mechanical weeding basing on blind weeding is being recognized its worth again.

Desease and Insect Control

Hand sprayers were very popular until 1940s. The point of desease and insect control is that even if these controls are done only in a farmer's fields, the effect will be sometimes reduced by invasion of the desease and/or insects from the fields around. The setup of simultaneous protecting system for a whole region or district is a basic necessity as an agricultural policy.

In general, insects have a character of gathering around the light. In 1950s before the popularization of power sprayers, many light traps were set here and there in the fields all over the country. The structure of a light trap is a combination of a standing fluorescent lamp and a pan under it, containing chemical liquid in it. Although a great number of insects were killed easily, the fields of about 50 to 100 meters around each lamp sometimes had serious damage because of increasing insects. There was also another problem of killing useful insects. In 1960s, most of these facilities disappeared.

Portable power sprayers have been diffused all over Japan since 1955. The most standard type is the 2 to 4 ps sprayer of a reciprocating plunger type. Spraying width is about 6 m or so. Two or three persons control the hose, and also two or three persons manage the pump machine and chemicals. In many cases, a spray tank, winding hose device and sprayer machine are set on the trailer drafted by a power tiller, which moves on farm roads, having the working efficiency of about 0.7 ha/hour. There are also bigger sprayers or attachments of riding tractors.

Since about 1965, napsack-typed power mist-dusters of almost plastic make have become popular. As shown in **Fig. 28**, one or two persons can spray in 5 to 20 or 30 m width utilizing the floating force of jet spraying under good weather condition.

Chemical spraying by aircraft (mainly helicopters in Japan) is also being commercialized. This expense is about 7 to 10 $/ha besides chemical fee at present, though about 5 $/ha in 1970.[10]

The utilization of chemicals is also being reconsidered from the standpoint of public population. The biological solution basing on ecology is interested now as a substitute for them.


Fig.28.


Fig.29.

Harvesting and Threshing Machinery including Grain Processing Technology

It is the basic regulation of rice crop farming in Japan that a farmer sells not paddy but "brown rice" of his all yield except self consumption for his family to the government. This small island country has been able to have self-sufficiency of national main food "rice" since 1970s. She was a rice importing country all the time in the past. Accordingly the government enforced controled economy of rice distributing system through which all people could get equally the rice from 1941[11] to several years ago.

Namely, a farmer threshes his paddy and hulls the grains by himself with the thresher and huller. Then, brown rice grains are put into the sacks of 60 kg each and carried and delivered by himself to the government office in his village. He receives the money from the office depending on the quality and quantity of them.

This means that farmers are responsible to the brown rice in Japan, though to the paddy after threshing in many Asian countries.

There is also a big different point in the grain characteristics between Japan and other Asian tropical countries. Japonica rice has difficult shattering and less photosensitive characteristics.

These are why the unique farming system and small equipment for harvesting and processing have developed in this country.

Fig. 29 is a scenery of manual reaping done about 10 years ago. It is common that rice plants will be cut off in about 3 to 5 cm height from the soil surface, except on specially swampy fields of poor drainage function. Because, there was a traditional utilization cycle of straw that some of them were used for fuel and home industrial products such as straw ropes, mats, bags, sandals and so forth and most of them were returned to the fields as manure of cattle waste after the roughage and litter utilization.

After reaped, they were put on the ground in lines and bundled later within the day and left for dry for a few days. Depending on weather conditions or on the wet field, paddy bundles were usually hung on the frames in the field. Fig. 30 is a scenery of naturally drying paddies.

These grains containing about 13 to 14 % moisture were threshed and put in straw sacks.

Manual pedal threshers were used until 1940s, and threshed grains had a lot of dust and straws. After threshed, paddies were cleaned by natural wind or a manual winnower. Japanese farmers prefer to feed clean paddies into the huller.

Mechanical advancement of power threshers, which were developed in 1940s, was to couple a threshing-drum mechanism with high efficient winnower mechanism. They could obtain clean paddies by feeding only pannicle portions of the bundle into the thresher.

Next advancement of the thresher was successfully done in 1950s to couple the power thresher with an automatic feeding mechanism.

The chain belt device in front of the thresher drum hooks and automatically carries the paddy bundles so as to insert the tips of them into the threshing drum, and discharges them after threshing.

This machine is called "automatic power thresher" which enables to perform threshing work by two to four persons. Fig. 31 shows a scenery of the normal case that two persons are carrying bundles, another is feeding the bundle to the chain mechanism and the other is arranging a sack of paddy.

Japanese government established the bounty system for the cultivation of early seasonal rice variety, in southwest districts in Japan. Then, as shown in Fig. 32, the early seasonal variety, which started to grow in semi-hot seed beds in spring, had to be harvested in August. At the same time in August, the late seasonal variety had to be transplanted in the same fields. This put farmers into the busiest situation.

Many trial harvester machines, made with some ideas from European and American harvesters, equipped reel feeding mechanism. This reel mechanism operated well only to the normally growing rice plants.

However, the plants in Japan locating in Asian monsoon district are so easily lodged by a tyhoon that farmers could not be satisfied with the performance of the reel mechanism.

In about 1960, modern reapers and/or binders of pick-up feeding mechanism were accomplished and started to be sold. The plants lodged at an angle of about 30 degrees from the field surface gave no trouble to the machine. Luckily, the difficulty of shattering, an characteristic of Japanese paddy grains, did not cause the trouble of grain loss by the feeding machine.

Fig. 33 shows one of them, a one-row binder. This one-row binder was continuously developed to be multiplied-row binders, as shown in fig. 34. Harvesting

Fig.30.

Fig.31.

Fig.32.

Fig.33.

Fig.34.

Fig.35.

Fig.36.

works became to be done by two or three persons, one for driving the machine and the others for carrying bundles, and farmers started to buy those machines.

In this stage engineers thought to develop a self-propelled thresher in order to save carring labor. Movable threshers appeared in the farm area as shown in **Fig. 35.**

There was also another development current of connecting a reaper and a thresher, which became a rice combine harvester. In about 1965, Japanese rice combine harvesters of pick-up feeding appeared on the market as shown in **Fig. 36.**

The diffusion of these two machines means that the drying process had to be done not before but after the threshing. Accordingly grain dryers had to be diffused as well as self-propelled threshers and combine harvesters.

Mechanical advancement in next stage was focused on increasing the number of paddy rows to be reaped. The working efficiency is 10 to 14 ares/hr for the two-row machine,[10] and 12 to 16 ares/hr for the four-row machine. The efficiency mainly depends upon the capacity of the thresher. Farmers have begun to buy combine harvesters since about 1970, after diffusion of grain dryers.

Then, new mechanism was demanded by farmers. That was to develop a riding combine harvester. In an early stage, the driver's seat was attached to the rear corner of the machine. The driver was diffucult to see the front function of the machine. In 1974 to 1975, the combines with

Fig.37.

the driver's corner in the front part of the machine appeared on the market. **Fig.** 37 and 38 show each of them.

In order to accomplish them, many additional devices had to be developed, because the driver was hard to watch and control the functions of the machine behind his back. For example, the reaping amount of rice plants has to be controlled so as not to feed them over the capacity of the threshing drum. Namely an automatic control device for feeding amount and threshing capacity had to be developed.

Packing process of grains is also requested to be as automatically done as possible. The threshed straw must not be scattered on the field, especially for the following crop. Therefore a chopper machine became available as an attachment to the combine harvester. Now these machines are quickly diffusing in Japanese farming.

Fig.38.

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Present State of Dry Field Farming Mechanization in Japan

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Dry Field Farming in Japan

Besides the fact that a repeated cultivation is harder than that in rice field, fertility is low and various kinds of crops are involved, the dry field farming in Japan features a small-scaled intensive farming, differing from a large-scaled crop rotation which is the skelton of farming in Northen Europe countries, with an importance being placed on increase in land utilization rate as well a improvement of land productivity. Further, its main products generally vary depending upon areas, and most type of agricultural management is a compound one including various vegetables, gardening products, sericulture, fruit-culture and stock farming in addition to ordinary dry field crops.

Further, with the exception of autum-sown wheat, the farming in Hokkaido is a complete single crop with no cultivation during the winter season, while it is almost a semi-annual crop in Kanto area and southward. Such summer crops as dry land rice, soy bean, peanut and sweet potato are sown or transplanted between the rows of wheat as catch-crops. These facts are largely impeding mechanization of dry field farming.

Feature of Dry Field Farming Areas and Present State of Mechanization

Dry field farming area in Japan is broadly divided into Hokkaido area, North-Tohoku area including Aomori and Iwate Prefectures, Kanto Plain area to include Ibaragi, Tochigi and Chiba Prefectures and South Kyushu area including Miyazaki, Kagoshima Prefectures, etc.

Principal dry field crops that can be harvested in these areas are potato, sugar beat, beans and wheat in Hokkaido; soy bean, wheat and potato in the north Tohoku area; wheat, dry land rice, peanut, potato, industrial products and various vegetables in Kanto area; and sweet potato, potato, wheat and vegetables in South Kyushu area.

Dry field farming area in Hokkaido

Total area of farm land in the dry field farming area in Hokkaido is approximately 780,000 ha, of which ordinary form land area, excluding fruit-garden and pasture land, is approximately 420,000 ha, which is the largest farm land in Japan. In this area a mechnized cultivation with large size tractors is being carried out. In other words, three areas of Tokachi, Abashiri and Kamikawa are representative dry field farming areas in Hokkaido, and it is seen that dry field farming is combined with dairy farming in Tokachi area, vegetable cultivation in Abashiri area and rice field cultivation in Kamikawa area. Area of farm land per farm house is 15.4 ha in Tokachi area, 10.6 ha in Abashiri area and 5.7 ha in Kamikawa area. Any of these areas is far more broader than that in other prefectures, which makes it enevitable to utilize agricultural machines.

Accordinly, popularization of agricultural machines is extremely remarkable in these areas. Approximately 80,000 wheel type tractors, which represents 12% of about 650,000 tractors, a total estimated number of wheel type tractors in use in Japan, have been introduced so far, in which large size machines of 30—50 PS class have occupied about 47%.

Taking Tokachi area having a large scale farm land as an example, number of machines per farm is 0.9. Further, utilization rate of implements per farm is 62% for root crop harvesters (potato digger, potato harvester, beat digger and beat harvester) (overall rate in Hokkaido is 30%), and 34% for grain harvesters (beans harvester, combine, etc.) (overall rate in Hokkaido is 14%). Furthermore, various implements for tilling, harrowing, soil preparation, transporting, etc. as well as drying facilities have been extensively utilized. This fact, coupled with a consistent utilization system of mechnical power, has realized the development of highly productive large scale dry field farming in these areas.

Dry field farming areas in Kanto area

Kanto area is a large dry field farming area next to Hokkaido, having a total farm land area of 470,000 ha and ordinary farm land area of 360,000 ha. The feature of this area is that it is a marginal two crop area, located

Table 1. Planted Area of Main Dry Field Crops in Japan (1975) unit : ha

Prefecture	Wheat and Barley		Sweet Potatoes	Spring-planted Potatoes	Autumn-planted Potatoes	Soybeans	Peanuts
	Total	Wheat					
Total	**167,700**	**89,600**	**68,700**	**132,600**	**6,790**	**86,900**	**40,500**
1 Hokkaido	25,900	23,100	—	71,400	—	17,100	—
2 Aomori	214	201	9	2,600	—	4,840	35
3 Iwate	2,290	1,670	105	2,440	—	7,540	8
4 Miyagi	1,950	804	158	2,960	—	4,780	8
5 Akita	23	23	168	1,880	—	3,660	—
6 Yamagata	0	0	222	1,300	—	2,160	0
7 Fukushima	3,660	891	260	4,840	—	5,630	38
8 Ibaragi	14,900	4,650	5,660	1,930	—	2,730	12,000
9 Tochigi	11,800	4,010	367	1,350	—	1,010	2,890
10 Gunma	11,300	9,450	478	2,190	—	920	90
11 Saitama	8,320	6,580	2,080	2,650	—	817	425
12 Chiba	3,710	1,570	5,790	3,390	—	649	18,600
13 Tokyo	215	194	631	745	1	85	19
14 Kanagawa	828	568	886	1,070	—	81	1,030
15 Niigata	30	10	776	3,110	—	3,670	95
16 Toyama	22	5	250	226	—	576	0
17 Ishikawa	12	0	288	527	—	1,180	9
18 Fukui	18	11	96	604	—	539	5
19 Yamanashi	942	636	90	702	—	722	95
20 Nagano	848	458	95	2,930	—	4,060	33
21 Gifu	317	204	494	844	3	1,670	90
22 Shizuoka	764	533	2,730	1,870	29	779	776
23 Aichi	417	294	1,560	1,220	60	1,440	310
24 Mie	391	241	907	380	7	886	172
25 Shiga	170	41	211	386	7	709	14
26 Kyoto	49	22	308	466	—	639	4
27 Osaka	1	1	138	241	—	121	—
28 Hyogo	631	88	446	1,110	36	1,630	1
29 Nara	26	11	185	580	—	442	1
30 Wakayama	21	10	413	272	18	283	12
31 Tottori	50	6	288	382	5	659	11
32 Shimane	406	170	255	490	5	1,000	6
33 Okayama	2,340	394	435	983	307	1,800	2
34 Hiroshima	388	120	351	1,170	960	1,210	10
35 Yamaguchi	858	203	469	452	50	865	6
36 Tokushima	3,890	468	1,350	607	107	1,150	21
37 Kagawa	4,190	480	543	591	194	255	15
38 Ehime	2,830	137	912	996	141	675	18
39 Kochi	141	93	1,600	393	47	285	21
40 Fukuoka	14,800	11,700	467	1,290	139	825	9
41 Saga	13,900	3,590	252	484	372	420	16
42 Nagasaki	4,930	2,510	3,310	4,520	2,900	903	188
43 Kumamoto	11,200	6,690	2,940	1,090	241	1,870	1,000
44 Oita	5,170	3,160	925	489	95	1,520	92
45 Miyazaki	5,970	1,520	5,160	511	223	986	1,260
46 Kagoshima	6,990	1,950	21,800	1,870	636	1,050	1,050
47 Okinawa	23	23	1,850	7	210	38	62
48 Other prefectures	—	—	—	—	—	—	1) 1,510

Remarks : 1) Figures are totals of planded area of the prefectures where production survey is not conducted.
Source: *Crop Statistics,* Statistics and Information Department, Ministry of Agriculture and Forestry. Excluding data of Okinawa Prefecture until 1973.

adjacent to the largest commercial and industrial area in Japan centered on Tokyo. Farm land area per farm in this district is relatively as small as about 1 ha in the suburban district within 50 km from Tokyo and 1—2 ha in rather remote districts ranging in 50—100 km far from Tokyo, which are in addition scattered, although some farm houses have farm land above 3 ha. Further, because of combined cultivation of ordinary dry field crops with various vagetables or industrial products it is hard to efficiently utilize high performance large size machines, even if they are brought into use, and therefore, small size machines have been widely used in this area.

In other words, out of about 3,280,000 hand tractors, number of this type of tractors used in Kanto area has amounted to 860,000, which indicates that 77% of total farm have owned this type of tractors. In addition to this, about 53,000 wheel type tractors have been widely used, of which 31% is 10 PS class or below and 28% is 10-15 PS class. That is, 59% of wheel type tractors is small size tractor of 15 PS class or below and has much contributed in manpower saving in various farm works including seed bed prepartion (rotary tilling, etc.), management, transportation, etc. Although it is not known as to what extent these pervaded tractors are utilized in dry field farming in Japan where rice crop is the core of the farming, approximately 230,000 binders that have been developed in Japan as rice harvesters and brought into this area and other harvesters as well as 41,000 self-threshing type combines are much utilized in wheat cultivation. Furthermore, it cannot be overlooked that desicators also have been extensively used.

Dry field farming area in South Kyushu district

Overall area of farm land in this district is 147,000 ha, of which about 110,000 ha is ordinary farm land and the running scale per house is as small as around 1 ha. This district has various disadvantages as majority of its farm land is covered with volcanic ashes which provide poor land productivity and the area is located in rainy zone and subject to meteorological disasters. The state of utilization of agricultural machines in this district, which is common to other prefectural areas, is that hand tractors are about 137,000, which represents that 46% of total farm own this type of tractors, and wheel type tractors are about 13,000, of which 61% are small size of 15 PS or below. Similar to Kanto area, these tractors are premarilly used in tilling work, and they are also used for such miscellaneous works as management and transportation. In addition, such machines for vegetable cultivation as soil stebilizer, trencher, mulcher, etc. have been recently introduced in this district.

On the other hand, under such systems as a farming machine bank or collective cultivation association, contract farming group, directly managed undertaking by an agricultural cooperative association and tractor utilization association, the systematization of production technique through utilization primarily of medium and large size farming machines is now under progress throughout the country.

State of Mechanization by Dry Field Crop

Principal dry field crops being cultivated in Japan have amount to several ten kinds to include vegetables and industrial products, and their progress state of mechnization is different each other. Now, taking wheats, beans and root crops as examples, present state of mechnization is outlined in the following.

Mechanization of wheat cultivation

Wheat cultivation in Japan consists primarily of wheat and barley which are produced throughout the country. The cultivation is divided into dry field crop and second crop in rice field, and further into intercropping type and non-intercropping type. Farming works in Kanto area, the largest wheat producing district in Japan, have been improved from manual working stage to tillage by means of machines (**Fig. 1**) (ranging from small size to large size) and inter-cultivation (by small size machines). There are some areas where harvesters (principally, binders) have been brought into for use. Wheat and barley, after dired at farm land, are threshed by a power threshing machine and separate by winnor Working hours required per 10 a are 80-100 hours but in a case of a farm whose manhour saving has been greatly improved it is about 50 hours.

Further, in case of dry field farming of wheat in dry field farming areas in Hokkaido, a consistently mechnized system has been setablished with use

Fig. 1 Ploughing

Fig. 2 Wheat harvesting work with an ordinary type Combine

primarily of large size of tractors and ordinary type of combines (**Fig.** 2). In this case, crops are dried and prepared by large size drying and preparation facilities that are available in various places in Hokkaido, and manhour requirements in this area have been thus greatly reduced.

Mechanization of beans

Soy beans had once been produced throughout the country, however, at present self consumption rate of soy beans in Japan is a little less than 4%, and they are much produced in Tohoku area and Hokkaido, in this order. Most of red beans, peas and beans are produced in Hokkido. Therefore, the present state of mechanization of beans cultivation in Hokkaido, a chief producing district of beans, is outlined here.

In the past beans had been cultivated through tillage by domestic animals and manual reaping. With extensive use of agricultural tractors, working system with these machine powers and manpower has been now widely used. This work system includes ploughing with a 40 PS class tractor, seed bed preparation by a disc-harrow, tooth harrow or rotary harrow, and fertilization and planting by a planter (**Fig.** 3). Weeding is made through scattering of weeding agent by a sprayer and cultivation and weeding by a cultivator.

Pest and disease control are made through spreading of agricultural chemicals by a sprayer. When necessary, a soil injector is used. Products are cut down (**Fig.** 4), dried at farm land and threshed by a thresher.

Peanuts are primarily produced in Kanto area, but considerable amount of peanuts are also planted in Kyushu and Tokai districts. Most of peanuts planted is of virginia type. Peanuts are generally planted between the rows of wheat by a manual operated tractor with a mulcher equipped and fertilization and seeding are made manually. Some areas, however, are using a manual seeding machine and soil covering machine. Recently, seeding is increasingly made after a fill is made by utilizing a mulcher in many cases. Weeding is made manually in many cases, and pest and disease control are made by a knapsack type power duster.


Fig. 3 Fertilizing and seeding work


Fig. 4 Reaping work of soy beans

Mechanization of root crops

Principle works that have been mechanized in sweet potato culture in South Kyushu area are ploughing, soil preparation, listing, runner cutting digging (**Fig.** 5) with the use of tractors. Such other works as seeding, transplanting and weeding depend upon manpower. Present state in other areas is almost same as that in this area. Further, the state of mechanization in Hokkaido where more than 60% of total production of potato in Japan is produced is that large size tractors and potato haryesters (**Fig.** 6) are chiefly used throughout the works involved from ploughing to harvesting.

In the foregoing, the present state of mechanization in dry field farming in Japan has been described by taking several kinds of dry field crops in major dry field farming areas as examples.


Fig.5 Lifting work of sweet potatos


Fig. 6 Potato harvesting work with a potato harvester

It is considered that no rapid expansion is expected in the argicultural scale per farm for the time being; however, it can be expected that the technical system of dry field farming centered on agricultural machines will be repleted in the future through further promotion of improvement in such agricultural structures as completeness of foundation, type of ownership and utilization of machines. Toward the realization of this object it is desirable to promote further stabilized mechanization in dry field farming through settlement of matters being left unsolved to include development and improvement of working machines best suited to farming scale in Japan and establishment of their utilization technique, dissolution of labor peak as well as work competition through review of miscellaneous works involved such as cutting and extermination of weeds, and presaration of harvests. ■ ■

The Present Condition of Farm Machinery Industry

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Movement of Farm Machine Manufacturers

There are about 450 Farm Machine Manufacturers in Japan at present. This number is about a half of ten years ago, on the contrary, the scale of industry shows the tendency of enlarging. Especially the monopolistic aspect by big companies is remarkable, and about 80% of the gross sales of farm machine is accounted by the big 5-6 companies.

Looking over distribution of companies in the view point of sales amount, as **Fig. 1** shows, companies which product more than 30 billions yen of sales are only five. Those companies are general farm machine manufacturers dealing in almost all kinds of farm machines. They cooperate with special makers or foreign makers concerning the products not manufacturing in their own factories or the products which against their interests for their own production.

Among all farm machine makers, the backbone makers which sell 5-30 billions yen are about 30 companies, a little less than 7% of all. Those are mainly makers of tiller, cultivator, tractor, pest control machine, binder, combine, threshing machine and drying machine, and those makers are in some way related with big makers providing their products to big makers.

Remaining 92% are small scale companies selling under 5 billions yen, manufacturing working machine of tractors of riding and walking style, food processing machine, machine for dairy farming and machine for fruit culture. Following **Table** shows main brands of farm machine makers in Japan.

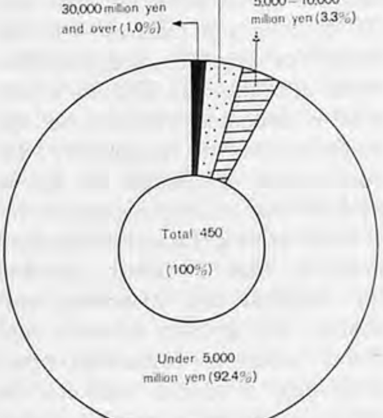


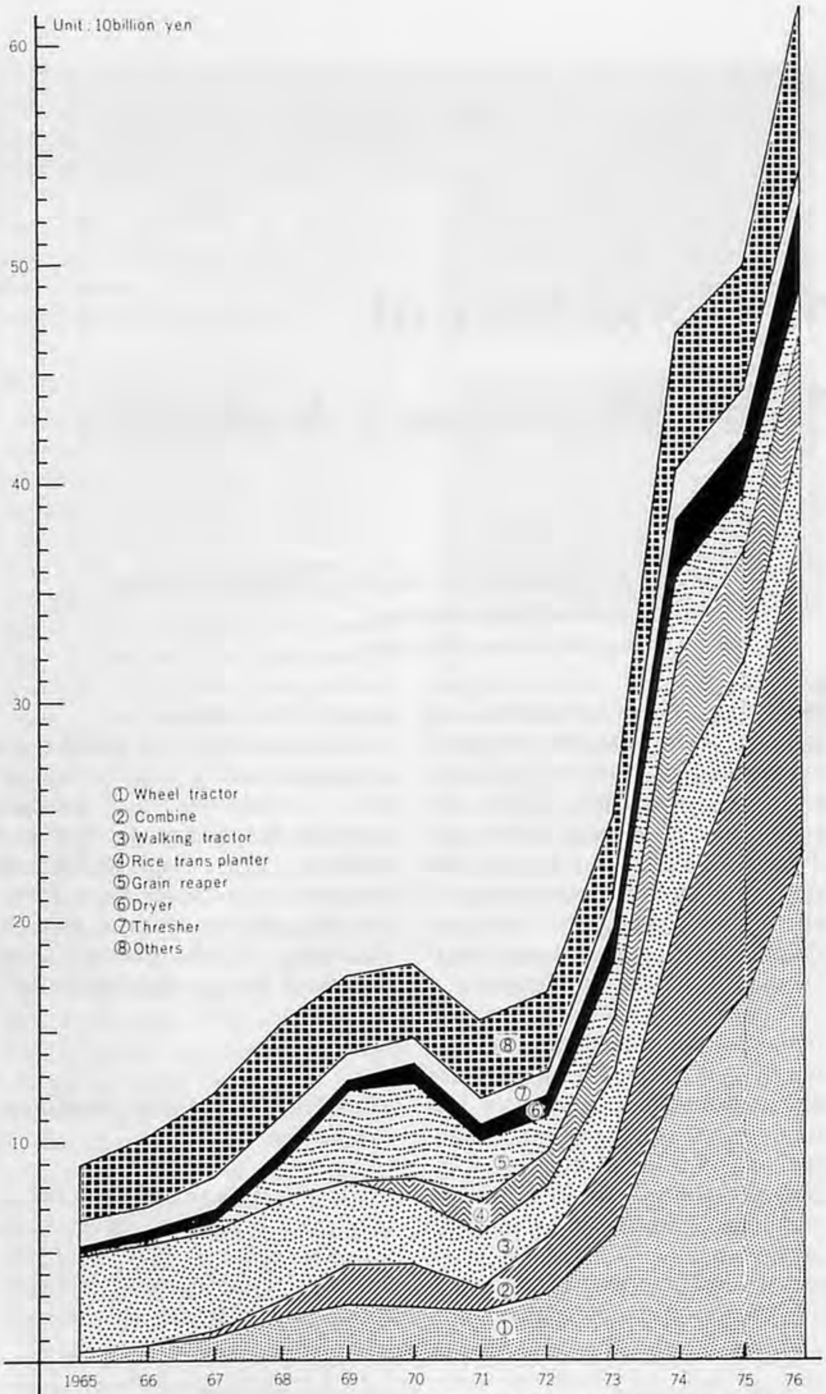
Fig.1. Number of manufacturers by sales

The Trend of Farm Machinery Production

Farm machine manufacturing in Japan began to show large progress around 1955 with the advance of agricultural mechanization mainly by the use of walk-

Table 1. Brand Name by Major Farm Machinery

Kind of machines	Trade and brand names
Engine, diesel	Kubota Mitsubishi Yanmer
〃 , gasoline	Gasden Honda Kawasaki Kyoritz Kubota Mitsubishi Robin Shibaura Tas
Walking tractor	Honda Iseki Kubota Mametora Mitsubishi Robin Satoh Shibaura Suzue Yanmer
Riding tractor	Hinomoto International Iseki Kubota Mitsubishi Sato Shibaura Yanmer
Rice transplanter	Iseki Kubota Minoru Mitsubishi Noda Satoh Suzue Yanmer
Pest control machine	Arimitsu Hatsuta Kyoritz Marunaka Maruyama Robin Shikutani Tokai
Reaper and binder	Hinomoto Iseki Kēo Kubota Mitsubishi Oshima Satoh Suzue Yanmer
Head feed combine	Iseki Kēo Kubota Mitsubishi Oshima Satoh Yanmer
Power thresher	Fujii Iseki Katakura Kēo Kubota Noda Otake Satoh Yanmer
Grain dryer	Kaneko Kanriu Marumasu Oshima Satake Shizuoka Yamamoto
Rice huller	Iseki Kēo Kubota Noda Oshima Satoh Shinomiya Spee



Source: "Survey of Status of Machinery Production" by the Ministry of International Trade and Industry.

Fig.2. Production of farm machinery

ing tractor. Especially a highly advanced economical growth in Japan after 1960 changed adruptly social conditions surrounding Japanese Agriculture and various government policies were worked out aimed at raising agricultural productivity. From that time, large sized farm machinery equipments as riding tractor, combine, public drying equipment have been rapidly introduced into farming village. Furthermore, in recent years, mechanization of rice planting and harvesting in paddy rice crop was realized and consistent systematic technics for mechanization was completed. At present, newly developed machines like rice-planting machine, head feed combine have come to be remarkably popularized.

Fig.3. Production line of head feed combine

With the progress of mechanization, farm machine production in Japan has changed satisfactorily, and in 1966, gross sales was over 100 billions yen. However rapid increase of rice production since 1966 finally caused overproduction of rice. In 1970, with unfavorable factors as restriction of rice production, putting, off raising of rice price, it was enable to reach the initial target 200 billions yen mark.

Since that, after three years hover, the sales got to be over 200 billions yen in 1973, and in 1976, the sales marked 620 billions yen which is about 2.5 times as 200 billions yen. To prospect sales in 1977, although there are some unfavorable factors, damage from cold weather occured mainly in Tohoku-area in previous year, or that raising rate of the producers rice price decided in July, 1977 was very low, only 4.6%, it seems very sure that the gross sales will be over 700 billions yen, because the demand for tractors and combine wiich accounts for 60% of whole yield is expected still to grow. So nowadays farm machinery industry has developed as to be ranked one of the big scale industries among Japanese machine industry. Also in future, demand for tractors and combines will support the growth of farm machine industry. Including other machines, products tend to be generally larger sized and higher performanced, therefore in future

Table 2. Yearly Production of Farm Machinery

Year	Farm machinery total		Wheel tractor		Walking type tractor		Rice transplanter		Power sprayer		Power duster	
	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million
1965	—	88,585	9,685	5,046	436,858	43,344	—	—	114,815	3,245	131,376	3,660
1966	—	102,338	15,897	7,914	474,362	45,743	—	—	135,137	3,585	273,715	6,787
1967	—	121,442	24,090	12,140	477,664	46,471	—	—	159,647	4,016	435,981	10,165
1968	—	153,361	36,615	21,193	500,323	45,799	—	—	141,987	3,844	507,891	10,666
1969	—	175,201	46,753	25,947	440,845	37,875	—	—	130,781	3,265	252,313	4,976
1970	—	181,362	42,611	24,465	370,458	29,803	80,601	8,768	118,076	3,050	182,768	3,721
1971	—	154,932	33,757	22,039	296,839	24,480	129,796	14,679	153,712	3,886	126,191	2,880
1972	—	167,809	51,019	30,678	297,271	23,895	140,894	16,753	198,375	5,136	134,907	2,801
1973	—	247,883	99,394	59,123	351,921	35,753	186,142	25,686	227,708	6,437	221,561	4,881
1974	—	467,565	168,167	129,437	418,446	57,958	345,180	56,045	238,578	8,683	265,015	7,710
1975	—	496,702	207,285	166.277	303,205	41,764	251,437	48,157	147,173	6,333	199,452	7,158
1976	—	618,757	286,349	230,843	354,713	47,546	238,887	45,436	224,138	9,422	235,009	7,900
Year	Blower sprayer		Grain reaper		Power thresher		Combine		Power rice husker		Agricultural dryer	
	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million	Quantity Number	Value ¥ Million
1965	981	529	64,186	1,146	315,441	11,551	17	49	74,844	3,509	238,045	3,732
1966	987	415	86,632	1,467	344,955	11,047	9	28	83,157	3,887	219,660	4,771
1967	3,908	883	68,321	4,773	367,983	14,863	1,269	544	98,256	4,619	208,191	5,581
1968	2,956	1,034	133,192	16,616	372,263	15,547	14,758	6,482	121,767	6,029	233,376	6,168
1969	3,567	1,388	239,102	38,729	273,780	11,927	39,224	16,846	110,771	5,631	206,284	7,305
1970	3,026	979	322,421	43,731	190,121	11,371	44,934	19,605	71,730	3,634	136,963	8,718
1971	2,151	849	245,369	27,404	142,185	11,604	38,159	15,166	53,995	2,593	110,122	7,101
1972	3,285	2,181	164,893	15,389	108,841	10,713	51,414	24,141	47,122	2,701	79,026	9,532
1973	4,189	2,568	222,607	24,195	119,600	13,235	68,279	36,387	59,401	3,960	102,745	14,864
1974	4,803	4,252	244,887	36,668	152,657	22,522	117,381	75,437	72,113	7,240	125,022	26,279
1975	4,024	3,378	152,187	26,607	121,297	21,724	127,271	110,638	73,853	10,146	93,570	25,820
1976	4,463	4,730	141,561	25,903	83,341	18,941	172,351	142,828	62,358	9,751	120,957	35,691

Source: "Survey of Status of Machinery Production" by the Ministry of International Trade and Industry

the sales is expected still to continue to grow even if number of products should decrease.

The Trend of the Distribution of Farm Machinery

The disribution of farm machine in Japan can be classified into two ways, selling through farm machine dealer and selling through organization of Agricultural Cooperatives.

There are about 9,500 farm machine dealers in Japan including both wholesale dealer and retail dealer. 80% of them, about 7.700 dealers, are retail dealers and remaining 20% are wholesale dealers. There is a nation-wide organization of dealers, that is called All Japan of Agricultural Machinery Dealers Cooperative Associations. The organization consists of 47 Prefecture's Dealers Cooperative Associations and 3,500 dealers joining into above cooperative associations. On the other hand, there is a Agricultural Cooperative Purchase Project Organization which is related as, the smallest unit cooperative consists of each Farmers...each Prefecture's Economic Federation...Zenno. The Purchase Project Organization consists of 60 group members and 5000 unit cooperatives and they performing active work to extend their share in market.

However the fact of distribution of farm machine is very intricate as **Fig.4** shows it. The products must pass through some steps to come to the hand user from maker. This condition causes the raising of distribution cost, and consequetly the raising of final user's price. Namely there are two main supplying routes for farm machine, one is, maker—special wholesale agent or affiliated firms※ related with maker, and other is, maker...Zenno. In addition to above two main routes, there are routes in which products pass directly into Pref. Economic Federation or retailer.

In distribution of farm machine, Zenno's share in the step of buying-in is generally a little over 30%, to that adding the amounts Zenno directly buying from Pref. Economic Federation, Zenno handles a little less than 40% in total. Meanwhile dealers including affiliated firm related with maker and wholesaler handle a little over than 60%. While Zenno supplys 100% to Pref. Economic Federation, it is supposed that sales companies related with makers wholesales 60% of all handling amount to retail dealers, and sell a little less than 30% directly farmers, remaining 10% to Pref. Economic Federation and Unit Cooperative. Wholesalers and retail dealers sell over 90% to farmers and wholesale less than 10% to Unit Cooperative.

In above distribution channel, the most remarkable one is affiliated firm related with maker, which is extending their share in market year by year.

There are about 250 affiliated firms related with each marker at present in Japan putting to-

※Affiliated firm related with maker is established by maker which invests 100 % or a part of capital, for the purpose of that maker insure its own sales route.

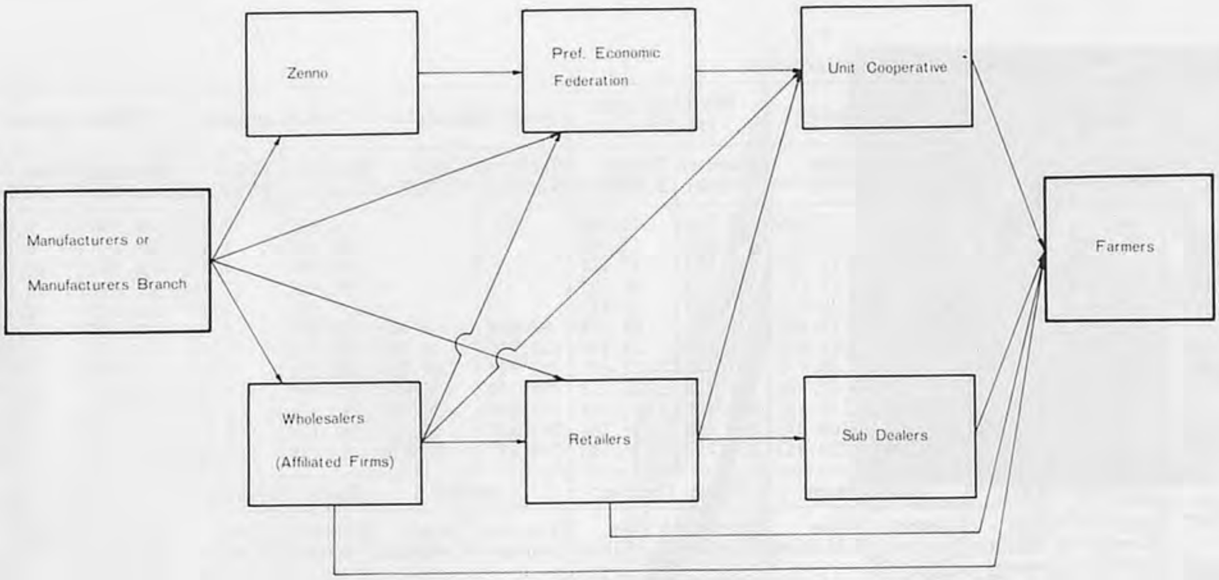
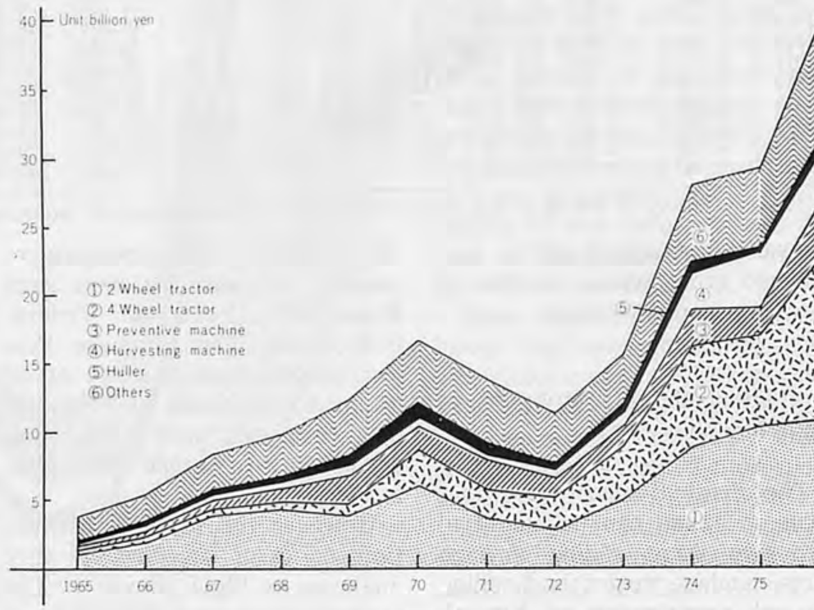


Fig.4. Distribution channel of farm machinery

gether four main affiliated firms (Kubota, Yanmer, Iseki, Mitsubishi) and other affiliated firms. Those affiliated firms insure 38% of gross sales in total and that share will surely increase still more along with expansion and arrangements of business in maker will be proceeded under maker's active policy to promote the sales through their affiliated firms.



Source : Passed the Customhouse of Ministry of Finance. Totaled by Japan Agr. Machinery Manufacturers' Assn.

Fig.5. Export of farm machinery

The Trend of Import and Export of Farm Machinery

Observing past records of farm machine export from Japan, although total export amount decreased temporarily from 1971 to 1972, it recovered soon after that, finally total export amounted to 43.9 billions yen in 1976. To compare this amount with previous year, total export amount has increased 50%. As one of reason for that high increasing rate, total export amount in 1975 was only 29.3 billions yen and increasing rate compared with 1974 was only 3.6%.

However a ratio of export amount for total production amount is very small compared with other industries or foreign

Observing export records by machine types (**Fig. 5**), riding tractor came to the top in 1976, instead of walking tractor which had been the most leading product so far. Other machines mainly exported from Japan are rice huller, pest control machine, and power thresher. However 55% of total export amount are accounted with two leading machines, riding tractor and walking tractor.

Destination of exported machines has changed largely in recent few years (**Table 3**). Around 1970, export to Asian countries was over 50% of total export amount, but thereafter export to United States and France has increased very rapidly and now 43% of total export amount are exported to above two countries. Namely two main backbones of farm machine export from Japan are riding tractor to United States and walking tractor for Europe. That trend is supposed to be increased hereafter.

However, with export of farm machine, there are many its own problems different from other machines. That is, while extending market in the region where big scale agriculture is carried on to produce crops excepting rice, it is necessary to promote the

Table 3. Yearly Export Value by Markets (unit : million yen)

Year		Rank of Export Value										Total Export	
		1	2	3	4	5	6	7	8	9	10	Value	% of Total Production
1970	Market	Viet-nam	USA	France	Indone-sia	Korea Rep.of	India	Ryukyu	Taiwan	Philip-pines	Malaysia	Total	9.2
	Value	4,378	2,862	1,910	1,165	1,116	537	427	399	287	256	16,694	
	% of Total	26.2	17.1	11.4	7.0	6.7	3.2	2.6	2.4	1.7	1.5	100.0	
1971	Market	Viet-nam	USA	France	Indone-sia	Korea Rep.of	India	Taiwan	Iran	Ryukyu	Philip-pines	Total	8.8
	Value	2,488	2,276	1,489	890	809	468	357	342	323	307	13,700	
	%of Total	18.2	16.6	11.9	6.5	5.9	3.4	2.6	2.5	2.4	2.2	100.0	
1972	Market	USA	France	Iran	Korea Rep.of	Indone-sia	Viet-nam	Taiwan	Philip-pines	Brazil	Germany, Fed.	Total	6.8
	Value	3,100	1,581	624	554	534	469	417	354	282	208	11,436	
	%of Total	27.1	13.8	5.5	4.9	4.7	4.1	3.7	3.1	2.5	1.8	100.0	
1973	Market	USA	France	Iran	Viet-nam	Philip-pines	Indone-sia	Taiwan	Korea Rep.of	Germany, Fed.	Brazil	Total	6.3
	Value	3,916	2,311	1,188	1,152	670	518	490	377	377	315	15,606	
	%of Total	25.1	14.8	7.6	7.4	4.3	3.3	3.1	2.4	2.4	2.0	100.0	
1974	Market	USA	France	Viet-nam	Taiwan	Iran	Philip-pines	Indone-sia	Malaysia	Brazil	Itary	Total	6.0
	Value	6,868	4,524	1,743	1,721	1,649	1,344	945	741	536	435	28,235	
	%of Total	24.3	16.0	6.2	6.1	5.9	4.8	3.4	2.6	1.9	1.6	100.0	
1975	Market	USA	France	Taiwan	Iran	Philip-pines	Malaysia	Indone-sia	Thailand	Germany, Fed.	Brazil	Total	5.9
	Value	6,238	4,842	2,585	2,266	1,470	919	783	758	570	553	29,257	
	%of Total	21.3	16.6	8.8	7.8	5.0	3.2	2.7	2.6	2.0	1.9	100.0	
1976	Market	USA	France	Taiwan	Indone-sia	Philip-pines	Thailand	Portugal	Canada	Malaysia	Germany, Fed.	Total	7.1
	Value	11,370	7,487	2,463	1,738	1,561	1,375	1,323	1,248	1,165	945	43,897	
	%of Total	25.9	17.1	5.6	4.0	3.6	3.1	3.0	2.8	2.7	2.2	100.0	

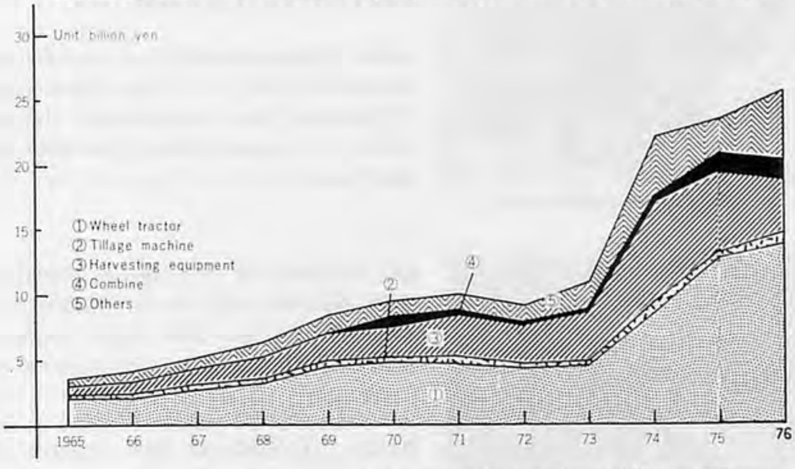
Passed the Customhouse. Totaled by Japan Agr. Machinery Manufacturers' Assn.

export to rice-crop region. Therefor it is very important to grasp how we can help to increase the productivity in each countries and to take counterplans to meet the situation. For instance, to find the method of international division of work corresponding each nation's industrial policy especially in developing countries.

Besides, considering the problem from the aspect of character of destination country, with advanced countries it is wanted to get along with safety countermeasure and consumer protectionism, on the other hand, with developing countries, it is necessary to consider, the problem of foreign money and making the most of each nation's fund, bringing up each country's industry, stability of employment.

Meanwhile import of farm machine has been growing from 1973 and in three years total import amount has increased 2.5 times as 1973's, namely it was 25.67 billions yen at the end of 1976 (**Fig. 6**).

Most of imported machines are from West European countries and North American countries and 97% of total import amount are imported from above region. As to machine type, wheel tractor of high horsepower is top with the amount of over 51% of total import. Also import of machines for harvest adjustment are relatively much weighted as 20.5% of total import, however that rate will shows the tendency of slight decrease hereafter.



Source: Passed the Customhouse of Ministry of Finance. Totaled by Japan Agr. Machinery Manufacturers' Assn.

Fig.6. Import of farm machinery

Home manufacturing of wheel tractor of over 30 h.p. is proceeding now, which affects import and growing rate of import amount tends to decrease. Besides considering the present situation concerning the import of tractor, there are many difficulties as, change of exchange rate of English currency used mainly with import of tractors, a raising of oil price and raising of domestic public price. ■ ■

Feature 3. Tokyo Farm Machinery Show '77

Recent Farm Machinery in Japan

by Farm Machinery Industrial Research Corp.

Tokyo Farm Machinery Show '77 is going to be held sponsored by Japan Agricultural Machinery Manufacturers' Association in the east building of Tokyo International Trade Center, Harumi, Tokyo, for one week from this coming November 23 (Wedn.) to 29 (Tues.). The application of the exhibits of this show was over on August 20, 1977. About 900 exhibits by 62 manufacturers will be displayed at this show. We chose several interesting new products from the exhibits and put them in this article for those who cannot visit this show.

Hinomoto Tractor E14-D

left : Special double universal joints used, the angle of the front wheel turning becomes up to 62°. So, the very small turning is possible.

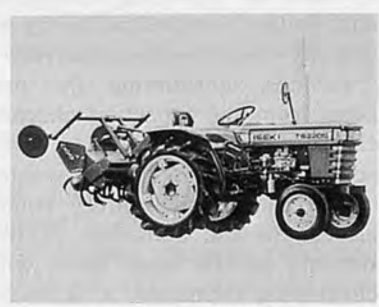
right : Hinomoto E-23 is powered by a powerfull 1,263 cc 26hp diesel engine. This model has removed all the draw backs of conventional middle sized tractors.

Hinomoto Tractor E-23

Hinomoto Tractor E-28

left : The E-28, a light weight tractor with built-in big tractor features, its compact design and high maneuverablity making it ideal for various farm works.

right : TS2205 is new tractor with water cooled 4 cycle 22hp diesel engine. This model has 18 speeds forward and 2 speeds backward in a transmission.



Iseki Tractor TS2205

Iseki Tractor TX1300

left : This compact tractor is light weight and high-powered. The 4 wheel drive unit has 1/ 2 extra traction helpful on slopes or in heavy conditions.

right : HD3100 combine harvester from Iseki Agri. Machinery Mfg. Co., Ltd. has a automatic control system in direction, cuting heigh and Threshing length. Efficiency is 15~20 min per 10a.

Iseki Combine Harvester HD3100

Iseki Combine Harvester HD1000

left : Iseki HD 1000 is small type combine harvester with autmatic paddy supplying unit (aut-hopper) so that operator can be possible to work in field by himself.

right : Iseki HD400 is the smallest walking type combine harvester for small scale farmers. This model mouned 4 cycle 7.5hp gasoline engine.

Iseki Combine Harvester HD400

Iseki Rice Transplanter PF650

left : The PF650 is six rows rice transplanter developed for large scale farmers. This model has planting ability of 20 minutes per 10a.

right : New type rice transplanter for 2 rows is no necessity to adjust wheel heigh by hand as it is equiped with the new system, which make it fluctuate in accordance with unevenness of the clay pan.

Iseki Rice Transplanter PF250

Iseki Reaper Binder RX310

left : Iseki RX310 binder for one row has a cuting width of 350mm and harvests rice plants 1～2hours per 10a. Power is provided by a 4cycle air cooled 3.2hp engine.

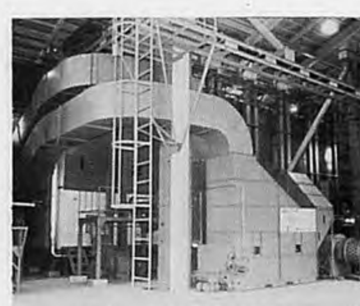
right : There are nine types of SH (4 types), SL (3 types), SM (1 type) and SG (1 type). Then, these dryer are suction type with automatic fire extinguisher, so you can operate the machines safely.

Isshingo "Supering" Grain Dryer

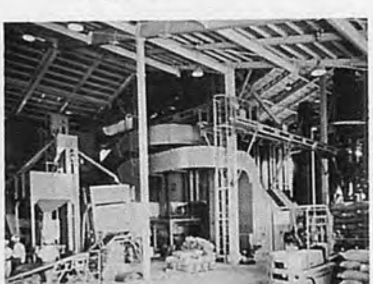
Isshingo "Rice-Con" Grain Drying Plant

left : Issingo "Rice-Con" is grain drying plant with separate management system, which is included various functions of receipt, drying, storage, conveying and hulling.

right : The Floating Dryer pre-dries paddy and corn by floating and mixing them in hot air blown upward through the perforated plate. It is easy to keep paddy in the storage tank for short term.



Isshingo Floating Dryer



Isshingo "FDA" Grain Drying Plant

left : FDA System is a new big scale plant to dry and condition a large amount of newly harvested paddy (wheat) in quick and with keeping good quality and low cost.

right : This system is combined with cage, piggery, sewage disposal system and dung dryer. By the system, you can be produced the pigs of good quality.

Isshingo "Suny" Pig Raising System

Isshingo Cattle Fattening System

left : Issingo Cattle Fattening System is a general beef cattle keeping facilities in fanctional combination with stall, automatic dung carrier, dung dryer and compost making machine.

right : Kubota L1501-AC is 17hp tractor with automatic control system for deep plowing. The model has 16 speeds forward and 4 speeds reverse in a transmission.

Kubota Tractor L1501-AC

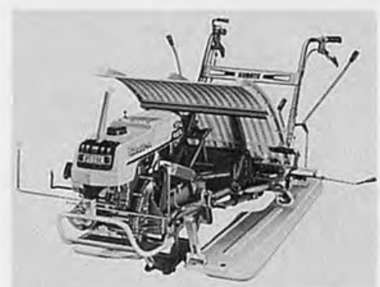
Kubota Tractor 1511

left : L1511 has a new hrdraulic transmission system so that you can control the speeds on running by a lever only. Special low speed is possible. You can use the tractor as a trencher.
right : The engine is very silent and causes little vibration. The strong point of this tractor is to be able to do a heavy work easily such as works in muddy paddy fields.

Kubota Tractor L3001

Kubota Tractor M4000

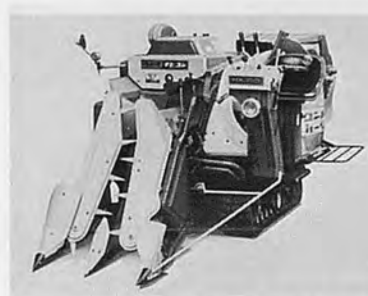
left : Kubota M4000 with a 6 cylinder 45hp engine has 16 speeds forward and 4 speeds reverse so that you can choose a right speed in accordance with working.
right : Kubota S200 is small and lightweight double row rice transplanter so that everybody can be used it easily. Attitude of working is stable because of single wheel and two floats.



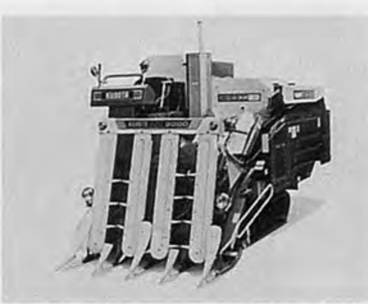
Kubota Rice Transplanter S200

Kubota Rice Transplanter S400

left : The planting work of Kubota S400 is accurate and swift with automatic float, which make the wheels fluctuate according to unevenness of the pan and keep well situation constantly.
right : Kubota HX350 is the smallest "Riding Type Two Row Combine Harvester" in the world. This machine weights 350kg and has a cutting width of 65cm. So, it is very easy to carry it.



Kubota Combine Harvester HX350



Kubota Combine Harvester NX3000

left : The NX3000 is a combine harvester of high performance with automatic speed control system which regulates working speed automatically.
right : Mametora Tiller HMD is a walking tractor with the 4 cycle 7hp gasoline engine. The HMD has 8 speeds forward and 4 speeds reverse, it is easy to speed up and excellent in heavy work at a low speed.

Mametora Tiller HMD

Mametora Return Cultivator V4

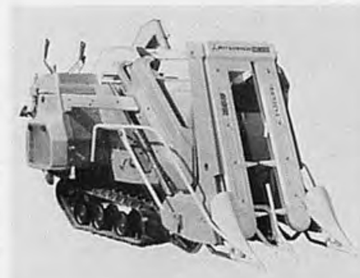
left : The MR-V4 is a cultivator which return the rotary knife. The position of the handle can be changed up and down, according to your work and body.

right : The D1300 Mitsubushi tractor has a water-cooled 13hp diesel engine. This tractor has 6 speeds forward and 2 speeds reverse so that easy to fit the field condition and your work.

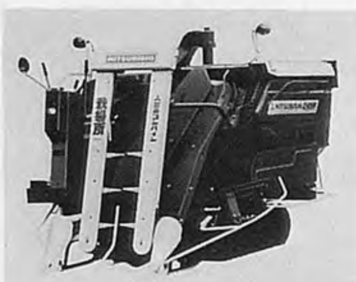
Mitsubishi Tractor D1300

Mitsubishi Tractor R3200

left : Mitsubishi R3200 tractor is powered by a silent 4 cylinder 32hp diesel engine. It has 15 speeds forward and 3 speeds reverse. The lowest gear is 0.22km an hour.
right : The Mitsubishi MC500 weights 350kg and has a cutting width of 650mm. With this small walking type combine harvester, you can make the job of 10 are/ 150-180 minutes.



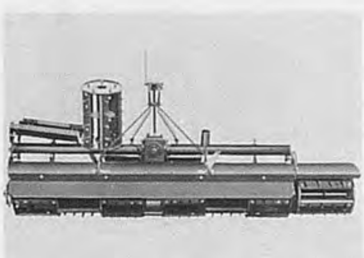
Mitsubishi Combine Harvester MC500



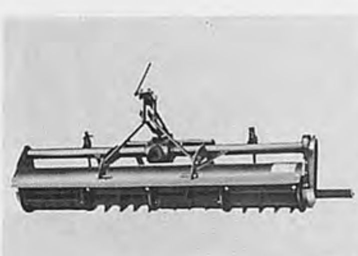
Mitsubishi Combine Harvester MC600

left : The Mitsubishi MC600 is powered by 10hp, gasoline engine. This is high efficient combine harvester and does the work of 10 are/ 60～100 minutes. The cutting width is 700mm.
right : The MP206 is high efficient two row rice transplanter. Plants nursery plants from immatured to matured ones of 15-30cm. Does the job of 10 are/ 45-60 minutes.

Mitsubishi Rice Transplanter MP206



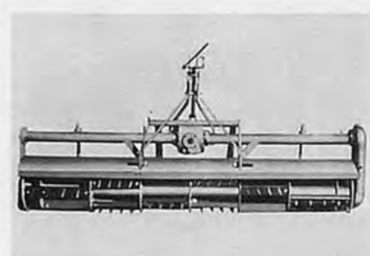
Niplo Drive Harrow HZ-240LA



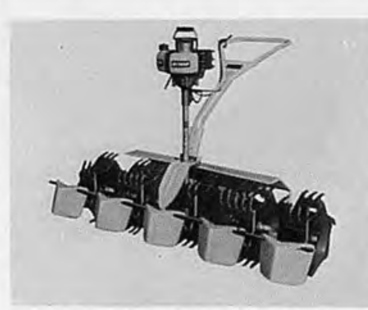
Niplo Drive Harrow HY-201

left, right and left below : There are three models of HY201, HD20A and HZ240LA on Niplo Drive Harrow. These model have so many exclusive features as follows.
① Because of the unique shape of blades, puddling and clod breaking can be completely performed at a time. ② Unique levelling equipment and soil moving system make fields even and smooth. ③ It is light enough to keep balance with a tractor even in muddy paddies and easy to handle. ④ Blade can be easily replaced. ⑤ Model HZ-240LA can be folded both sides by 45cm.

right : Ohtake Paddy Minicultivator is so light as to perform swift and easy cultivating. Working hours is reducted to 1/ 10 as befor. It can be easily water controll and raise a cultivating effect.



Niplo Drive Harrow HD-20A



Ohtake Paddy Mini-Cultivator

Ohtake Auto Thresher

left : Ohtake Auto Thresher is a self-propelled type with special transmission developed by Ohtake. The thresher can be detached instantly from a carrier part.
right : The RD1000 is a 3row combine harvester with an 13hp engine. By a wide rubber crowlers, this machine can be travelling in wet field safely. The RD1000 weights 752kg and has a cutting width of 80cm.

Oshima Combine Harvester RD-1000

Oshima Rice Dryer TY273 · 333

left : Oshima TY273 and TY333 Rice Dryers. Both have a unique high efficient fan designed Oshima, so that the dryer can be finished uniform paddy by a suitable temperature.
right : There are three types in Satake SPS series. SPS44 is one of the series. This model is a paddy husker without screening unit and a four make a set with tempering dryer, rice grader and pack-helper.

Satake Rice Master SPS-44

Satoh Tractor ST3200

left : The Satoh ST3200 tractor is powered by a 4 cylinder 32hp diesel engine. Suitable speed operation can be conducted through selection of 15 forward and 3 reverse speed transmission.
right : The ST2600 is a middle size tractor mounted 26hp diesel engine. This tractor has 15 speeds forward and 3 speeds reverse and drive only 3m an hour with the low speed.
speed.

Satoh Tractor ST2600

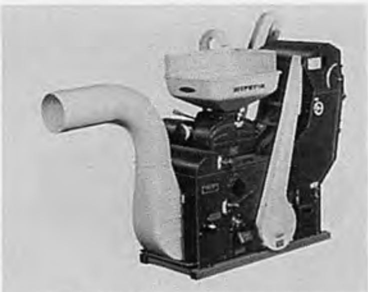
Satoh Combine Harvester H3000

left : The Satoh H3000 has a cutting width of 1.5m and threshing ability of 3.5t/hr. Also, this model is equiped automatic system in various-speed drive, threshing dipth control, etc..
right : The H-500 is a lightweight small type combine harvester. This model is upper feeding type with the threshing drum, 410mm in diameter. There are 6 forward and 2 reverse gears with variable drive within each range.

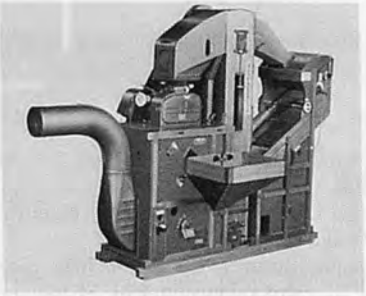
Satoh Combine Harvester H500

Satoh Rice Transplanter PS410

left : The PS410 is a rice transplanter for nursery plant height of 8～10cm. This model transplants nursery plants uniformly, through a hydraulic perceive system which catches unevenness of clay pan by center float.
right : Light, small, easy to operate and does excellent grading work. With a large paddy hopper (capacity-36 ℓ), placed low on this huller, you can pour paddy into it smoothly.

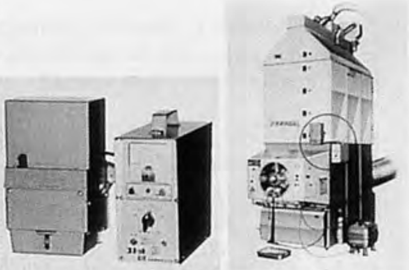


Shinomiya Huller MB-30

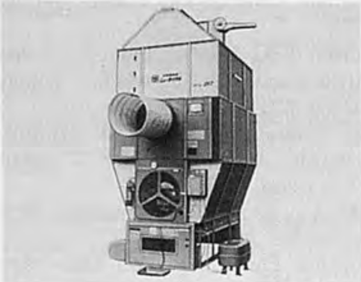


Shinomiya Huller MB-30A

left : New "Huller" of elevator type. By winnowing with a grain screen of absorbing system, the grading capability of this huller gets greater and you can have beautiful hulled rice.
right : With this "Auto Moisture Meter" (COMET S), designed to be attached to a circulation type dryer, there is no need to watch drying work. Also, the meter is available to other paddy rice in addition to the dryer.

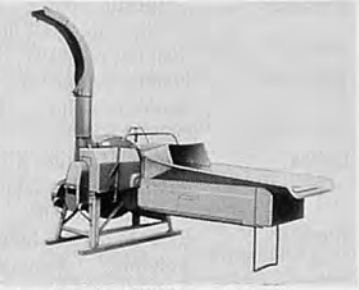


Shizuoka Auto Moisture Meter Comet S



Yamamoto New Cycle Dryer NCD-257

left : The ventilation covers large extent. Possible to send a large quantity of low temperature air. So, you can dry moist crops evenly. The NCD-257 weights 590kg and has a automatic fire extinguisher.
right : With a powerful inertia wheel, it has the high efficiency of blowing up. The weight—259kg, hourse power—5 ~10ps, and working efficiency is 1,000-2,500kg/ hour.



Yamamoto Cutter D-25S

Yanmar Tractor YM2210(D)

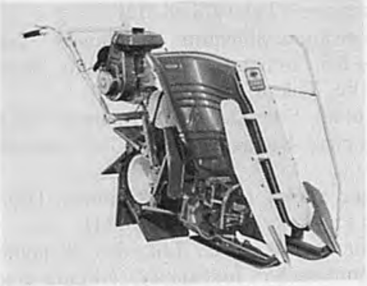
left : New type 22hp tractor, equipped "High Power shift" of new system. 15 forward and 5 reverse gears. While driving, you can change the gear, with one lever. Got more efficient.
right : 7hp tiller with the poweful and economical Yanmar diesel engine. There are six forward and two reverse gears so that the tiller can be worked safely under any condition.

Yanmar Tiller YC70-DG

Yanmar Rice Transplanter YP200

lift : Plants both short and tall nursery plants without any difficulty. The planting claw of this transplanter keeps each piece of nursery bed as it is, prevents the plants from being hurt, and plants carefully and accurately.
right : Harvests all the rice, even lying ones clearly. No clutch of special "W Tension System". Never get tired with a long time work because of the center control system operation.

Yanmar Combine Harvester TC600



Yanmar Binder YB101TS

left : One row binder for both dry and wet fields. You can use this binder not only in general fields but also in muddy ones where you have never used power implements. One row, one wheel. It runs steadity on haulm.

Exhibitor's Brand Name and Address

Aoki	Aoki Mfg. Co., Ltd.…26-5, 2-chome, Taito, Taito-ku, Tokyo. Tel. 03-831-2151
Arimitsu	Arimitsu Industry Co., Ltd.…3-21, 2-chome, Fukaekita, Higashinari-ku, Osaka-city. Tel. 06-976-8181
As-Af	As-Af corporation Ltd.…4-14, Midori 4-chome, Sumida-ku, Tokyo, Tel. 03-634-6381
Chikusui	Chikusui Noki Co., Ltd.…Fukumasu, Yoshii-cho, Ukiha-gun, Fukuoka-pref. Tel. 09437-5-2195
Degoichi	Kanda Tekko Co., Ltd.…4291-1, Nakano, Senokawa-cho, Hiroshima-city. Tel. 08289-3-0361
Delica	Delica Machine Mfg. Co., Ltd.…1618, Idegawa-cho, Matsumoto-city, Nagano-pref. Tel. 0263-25-5665
Elter	Elta Machine Industrial Co., Ltd.…7-22, 4-chome, Asagayakita, Suginami-ku, Tokyo Tel-03-330-2431
Hatsuta	Hatsuta Industrial Co., Ltd.…4-39, 1-chome, Chibune, Nish-yodogawa-ku, Osaka. Tel. 06-471-3354
Hinode	Katayama Seisakusho Co., Ltd.…31-1, Wakitahon-cho, Kawagoe-city, Saitama-pref. Tel. 0492-42-2600
Honda	Honda Motor Co., Ltd.…27-8,6-chome, Jingumae, Shibuya-ku, Tokyo. Tel. 03-499-0111
Hosokawa	Hosokawa Seisakusho Co., Ltd.…Toyoshina-cho, Minamiazumigun, Nagano-pref. Tel. 02637-2-3141
Ide	Ide Industrial Co., Ltd.…638, Takehara-cho, Matsuyama-city, Ehime-pref. Tel. 0899-31-5135
Irino	Otayama-Noeisha Co., Ltd.…4-24, 1-chome, Simadahon-cho, Okayama-city. Tel. 0862-52-5281
Iseki	Iseki Agricultural Machinery Mfg. Co., Ltd.…1-3, 2-chome, Nihonbashi, Cyuo-ku, Tokyo. Tel. 03-271-1271
Isshingo	Kaneko Agricultural Machinery Co., Ltd.…21-10, Nishi-2, Hanyu-city, Saitama-pref. Tel. 0485-61-2111
Kanriu	Kanriu Industry Co., Ltd.…1526, Hirooka, Shioziri-city, Nagano-pref. Tel. 02635-2-1100
Katakura	Katakura Kiki Kogyo Co., Ltd.…7160, Matsumoto-machi, Imai, Matsumoto-city, Nagano-pref. Tel. 0263-58-4711
Keo	Uemori Agricultural Machinery Co., Ltd.…Kanonji-cho, Kanonji-city, Kagawa-pref. Tel. 08752-5-1234
Kioritz	Kioritz Echo Bussan Co., Ltd.…Shinjyuku K-bldg. 11-3, 1-chome, Nishishinjyuku, Shinjyuku-ku, Tokyo. Tel. 03-343-3231
Kobashi	Kobashi Kogyo Co., Ltd.…684, Nakaune, Okayama-city. Tel. 086298-3111
Kowa	Shin Kowa Sangyo Co., Ltd.…163-3, Nagafuse, Mishima-city, Shizuoka-pref. Tel. 0559-77-1830
Kreis	Nippon Kreis Co., Ltd.…4-15, 3-chome, Uchi-kanda, Chiyoda-ku, Tokyo. Tel. 03-252-7631
Kubota	Kubota, Ltd.…2-22. Funade-cho, Naniwa-ku, Osaka-city. Tel. 06-648-2123
Marunaka	Marunaka Sprayer & Duster Mfg. Co., Ltd.…11, Mukaidanishimachi, Kisshoin, Minami-ku, Kyoto. Tel. 075-313-3111
Maruyama	Maruyama Mfg. Co., Inc.…4-15, 3-chome, Uchi-kanda, Chiyoda-ku, Tokyo. Tel. 03-252-2271
Mitsubishi	Mitsubishi Kiki Hanbai Ltd.…2-3, 2-chome, Uchisaiwai-cho, Chiyoda-ku, Tokyo. Tel. 03-502-3771
New-bell	Suzuki Tanko Co., Ltd.…44-3, Hiraide-kogyodanchi, Utsunomiya-city, Tochigi-pref. Tel. 0286-61-5261
Nikkari	Nikkari Co., Ltd.…482-1, Otsutami, Okayama-city. Tel. 0862-79-1291
Niplo	Matsuyama Plow Mfg. Co., Ltd.…2949, Shiokawa, Maruko-machi, Chiisagata-gun, Nagano-pref. Tel. 0268-35-0300
Noda	Noda Industrial Co., Ltd.…3-41, 5-chome, Asahi-cho, Takamatsu-city, Kagawa-pref. Tel. 0878-21-8161
Nozawa	Nozawa Manufacturing, Co., Ltd.…224-1, Naganuma-cho, Isezaki-city, Gunma-pref. Tel. 0270-32-1315
Ohtake	Ohtake Agricultural Machinery Co., Ltd.…Nakajima, Oharu-cho, Ama-gun, Aichi-pref. Tel. 0560-44-2525
Oshma	Oshima Agricultural Machinery Mfg. Co., Ltd.…10-17, 3-chome, Teramachi, Jyo-etsu-city, Niigata-pref. Tel. 0255-23-7211
Sanin	Sanin Sharyo Industrial Co., Ltd.…1-20, Suehiro, Fukuchiyama-city, Kyoto. Tel. 0773-22-5125
Sano	Sano Sharyo Co., Ltd.…39-9, 4-chome, Sugamo, Toshima-ku, Tokyo. Tel. 03-918-6651
Sano	Sano Sharyo Seisakusho Co., Ltd.…1-109, Shikizu-cho, Naniwaku, Osaka-city. Tel. 06-632-0551
Satake	Satake Engineering Co., Ltd.…19-10, 1-chome, Ueno, Taito-ku, Tokyo. Tel. 03-835-3111
Satoh	Satoh Agricultural Machinery Mfg. Co., Ltd.…2-3, 2-chome, Uchisaiwaicho, Chiyoda-ku, Tokyo. Tel. 03-503-7921
Sekiguchi	Sekiguchi Fureimu Seisakusho Co., Ltd.-…2642, Kuragano-cho, Takasaki-city, Gunma-pref. Tel. 0273-46-3131
Shibaura	Ishikawajima-Shibaura Machinery Co., Ltd.…6-8, 1-chome, Nishishinjuku, Shinjuku-ku, Tokyo. Tel. 03-343-3151
Shikutani	Shikutani Co., Ltd.…420, Renjyoji, Odawara-city, Kanagawa-pref. Tel. 0465-36-1122
Shingu	Shingu Shoko Ltd.…4-2, 2-chome, Toyo, Koto-ku, Tokyo. Tel. 03-649-7141
Shinomiya	Shinomiya Mfg. Co., Ltd.…5-8, 2-chome, Minamihoncho, Joetsu-city, Niigata-pref. Tel. 0255-24-2151

Shizuoka	Shizuoka Seiki Co., Ltd.···4-1, Yamanacho Fukuroi-city, Shizuoka-pref. Tel. 05384-2-3111		Nabari-city. Mie-pref. Tel. 05956-3-3111
Shoshin	Shoshin Jidosha Industrial Co., Ltd.-···2156, Ogawara, Suzaka-city, Nagano-pref. Tel. 02624-5-1611	Tanaka	Tanaka Seisakusho Co., Ltd.···Tarohara-cho, Kurume-city. Fukuoka-pref. Tel. 0942-43-1371
Spee	Spee Co., Ltd.···3225-1, Nakasho, Kurashiki-city, Okayama-pref. Tel. 0864-62-2211	Tiger	Kawashima Tekkosho Co., Ltd.···4290, Fujioka-cho, Shimotsuga-gun, Tochigi-pref. Tel. 028262-3001
Star	Star Farm Machinery Mfg. Co., Ltd.-···110, 6-chome Toyohira 3-Jo, Toyohira-ku, Sapporo-city, Hokkaido. Tel. 011-811-5131	Tokai	Takai Industry Co., Ltd.···32, Midorien, Ogaki-city, Gifu-pref. Tel. 0584-78-6131
Sukigara	Sukigara Agr. Machinery Co., Ltd.···38, Sairinji, Okazaki-city. Aichi-pref. Tel. 0564-31-2107	Ueda	Uedanoki Co., Ltd.···Tobu-cho, Chiisagata-gun, Nagano-pref. Tel. 02686-2-1338
Sunwa	Sunwa Sharyo Mfg. Co., Ltd.···21-5, 5-chome, Sendagaya, Shibuya-kn, Tokyo. Tel. 03-354-1721	Watanabe	Watanabe Seisakusho Co., Ltd.···3210-5, Shimokusawa, Sagamihara-city, Kanagawa-pref. Tel. 0427-71-2451
Suzue	Suzue Agricultural Machinery Co., Ltd. ···144-2, Gomen-cho, Nangoku-city, Kochi-pref. Tel. 0886-4-2121	Yamaguchi	Yamaguchi Noki Seisakusho···Yashiro-cho, Kato-gun, Hyogo-pref. Tel. 07954-25-1066
Taisho	Taisho Co., Ltd.···1027, Motoyoshidacho, Mito-city Ibaraki-pref. Tel. 0292-47-5411	Yamamoto	Yamamoto Mfg. Co., Ltd.···Tendo-city, Yamagata-pref. Tel. 02365-3-3411
Takakita	Takakita Noki Co., Ltd.···2828, Natsumi,	Yamapet	Yamasawa Seisakusho Co., Ltd.···1157, Ohashi-cho, Sano-city, Tochigi-pref. Tel. 0283-2-4160
		Yanmar	Yanmar Agricultural Equipment Co., Ltd.···62, Chayamachi, Kita-ku, Osaka-city. Tel. 06-372-1111

NEWS

Kings Instant Dustless Blackboard Chalk Method

Patent Pending

as Broadcast by B.B.C. World Service -New Ideas Programme.. 9/1.. 14/1 /77

The method produces a dustless chalk ready for use in approximately FIFTEEN MINUTES—reduces the cost of chalk by approximately 4/5ths—incredible BUT TRUE! This unique method is a MUST for Schools especially in tropical countries—also a MUST for others who use quantities of chalk. The method produces both white and coloured chalks in minutes! One Cwt. of any type of casting plaster (112lbs.) produces a minimum of 56 gross chalks. Only water and plaster is required for white chalks. Remember! All that is required to have use of this modern unique money saving dustless chalk method—is a 36 impression flexible mould which will last a lifetime (with a little care)—a supply of plaster (obtainable in many countries)—water and my simple instructions. Nothing can go wrong. Just to whink—never again waiting for your supply of dusty, dirty, brittle, indifferent chalks—you process your own—the kind you require—soft, medium or hard—all in a few minutes—all these benefits for a few pounds sterling! To date negotiations are in progress with the Government of India for use of the method.

BW 78—a new variety for the low country wet zone

by International Rice Research Newsletler 4/77, August 1977

The so-called "Miracle rices" of the "green revolution" — or the BG varieties in local parlance —are out of place in some of the ecological situations in Sri Lanka. One such area is the ill-drained belt of about 28,350 ha stretching from Negombo to midway between Matara and Tangalla, where lagoon and river basin systems of rice cultivation prevail (see map). At the mouth of the rivers and lagoons are sandbars. During the rainy season, water builds up behind the sandbars, speads inland, and inundates the paddy fields. Floodwaters hinder cultivation until the force of the bunded waters bursts the sandbars, or until the water is pumped out. These bog soils are usually less than 1 ft below sea level.

Flooding and salinity prevent cultivation of the BG varieties; only traditional types such as Dewareddisi and Pokkali can survive.

Even in higher reaches without continuous flooding and salinity, BG varieties have given disappointng results because of ill-drained conditions due to a surface water table and because of toxic iron deposits. During the rains, iron oxide is washed down from the surrounding red-yellow podzolic highland soils and is converted into the reduced toxic form under the ill-drained conditions. The only way to increase yields without expensive flood-control and drainage schemes is to develop more hardy varieties.

Such a variety, Bombuwela 78 or BW 78, was recently developed and released by research officers at the Bombuwela Research Station near Kalutara. BW 78 is now recommended for cultivation in the half-bogs and mineral soils found above the flood-stricken bog soils. BW 78 is also recommended for the better drained soils of the Colombo district (see map) where it might replace BG II-II in areas where the water supply is unstable and where part-time cultivators cannot give their crops high levels of management.

Paul Peiris, who bred BW 78, described it as "a rugged, rustic, rice. Not only is it resistant to poor drainage and iron toxicity, but it also shows a fair degree of field resistance to the brown planthopper, gall midge, and the leaf-rolling caterpillar, and to the paddy bug, which is the most serious pest in this region."

The paddy bug is probably discouraged from damaging the earheads because of the tough seed coat, which also discourages the paddy moth from destroying stored grain. BW 78 is also tolerant of blast and bacterial blight diseases. Its height (90cm) and spreading growth habit permits a certain degree of flooding while discouraging excessive weed growth.

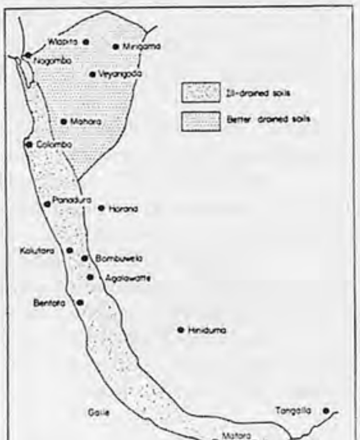


Fig. BG 78, a new rice variety developed at the Bombuwela Research Station in Sri Lanka, is suited to ill--drained soil conditions.

BW 78 is a 4-month variety with a white, round, samba-like grain. It is derived from a cross between H 501 (Podiwi a-8 H 5) and Selection 306, and can be cultivated both in *maha* and *yala* seasons.

A few experimental seed kits were issued to extension officers for demonstration purposes this *yala* season in Colombo, Galle, Kalutara, Matera, and Ratnapura districts. Production kits and larger stocks of seed paddy are expected to be ready for release next *maha* season.

Tubewell Irrigation Project to Benefit 300,000 in Bangladesh

by World Bank (IDA News Release No. 77/68, June 20, 1977)

Bangladesh's efforts to increase food production, improve farm incomes and employment opportunities in the country's dominant rural sector will be assisted by a credit of $16 million from the International Development Association (IDA), an affiliate of the World Bank. The credit will finance the installation of 10,000 shallow tubewells in the country's north-west region where some 2,000,000 farm families, each cultivating an average of 3.5 acres, live. The project will help irrigate 150,000 acres.

At full development, the $25.4 million project will help increase the annual food production by 91,000 tons. The project will increase employment, directly or indirectly by some 11 million man-days and increase the 50,000 farm families (approximately 300,000 people) will directly benefit from the project.

Agriculture is the major part of Bangladesh's economy and accounts for about 60% of the country's Gross Domestic Product, 75% of all employment, and 90% of the exports. Although agricultural production did well in 1975-76 with an overall production increase of over 10%, production is inadequate for the population, which is growing at a rate of 3% a year.

Scarcity of cultivable land is a constraint for agricultural development. Hence Bangladesh is emphasizing better utilization of existing irrigation facilities as well as expansion of irrigation. The Shallow Tube-wells Project has the advantage of extending irrigation to areas where surface water resources have already been exhausted, such as the northwest region. The wells take their names from the tubes, four to six inches in diameter, which are sunk in the ground to convey the water. Tubewells utilize existing groundwater and offer the best solution to agricultural expansion.

Small Farmers to Benefit

The tubewells will be purchased by individual farmers or farmers' groups, mainly with credit from commercial banks. For a farmers' group to be eligible for credit at least 50% of the land to be irrigated must belong to farmers owning a total of three acres or less. This insures that small farmers will benefit from the project.

Increased Rural Employment

The land is now singly cropped under rainfed conditions. The installation of tubewells will enable farmers to increase the number of annual crop harvests. This will create additional farm labor employment opportunities amounting to 7.5 million man-days, an increase of about 60% over the present level. Total employment, including secondary employment, will increase by about 10 to 11 million man-days. Much of the increased employment will be by farmers who are now underemployed since they can now only raise a single crop annually. Two-thirds of the farmers expected to benefit directly from the project presently have incomes below subsistence levels. Landless laborers will also benefit significantly.

Higher agricultural Production

Bangladesh presently imports about 15% of its foodgrain needs. Achieving self-sufficiency in foodgrain production is a major priority. The project will help reduce Bangladesh's foodgrain shortages which have averaged 1.5 million tons annually. The total rice production in the project area will increase by about 40,000 tons and wheat production by about 51,000 tons. The project has a high estimated rate of return of 50%, because of the low cost investment for each tubewell and because farmers will benefit from the wells as soon as they are installed.

Two important features of the project are that about one-third of the total initial investment will come from private savings as downpayments by users or from commercial banks. This means that the project will require little local cost financing from the Government. The project will involve practically no subsidies because the farmers will pay for the capital and most of the operation and maintenance costs.

The IDA credit to Bangladesh is for 50 years, including 10 years' grace. It is interest free, except for a service charge of three-fourths of 1% to meet IDA's administrative costs.

Kishida International Award

The Kishida International Award recognize outstanding contributions to engineering-mechanization-technological related programs of education, research, development, consultation, or technology transfer that have resulted in significant improvement outside the United States.

The Award which will be presented annually at the Summer Meeting of ASAE consists of an engraved diploma and one thousand dollars ($1,000).

The following outline indicates both the kind and order of information that may be submitted to the jury in support of a particular candidate. Unless reasonably complete information is submitted and in the order requested—the sponsors may be asked to revise and/or elaborate their presentations,

1. Conditions of eligibility:

a. The award shall recognize outstanding contributions in engineering-mechanization-technological related programs of education, research, development, consultation, or technology transfer that have resulted in improved food production, living conditions and/or education for people living outside of the United States of America.

b. The recipient must be an ASAE member in good standing. He or she may, however, be a citizen or noncitizen, resident or nonresident of the United States of America. The grade of membership within the Society shall not be a limitation of eligibility.

c. The recipient, at time of election, shall be a living member who is able and willing to be present in person to receive the award at the time and place of the designated summer meeting.

2. Nominations should be prepared in accordance with the instructions listed below and should be delivered to the executive vice-president of ASAE no later than November 1 to be considered in the selection process for the next summer ASAE meeting. Any corporate member of ASAE, including members of the jury, may nominate a candidate for consideration for the award.

3. The jury for the Kishida International Award shall consist of six members of ASAE, as follows: (1) the chairman and three immediate past chairmen of the ASAE International Relations Committee who are eligible and able to serve, and (2) two other ASAE members, to achieve committee balance, serving staggered two-year terms. The chairman of the International Relations Committee shall serve as chairman of the jury.

4. Nominations should be submitted according to the following outline and format so as to provide full information needed by the committee in making its evaluation.

Seven complete copies of each nomination should be submitted to the ASAE executive vice-president by or before November 1 for consideration the following year.

Other Instructions

A. Name of candidate in full (include title, business connection, address).

B. Education, chronologically—schools, dates, degress.

C. Membership in scientific, professional, and honorary societies—grades of membership, offices held, major committee or other activities.

D. Other honors, recognitions, awards accorded the nominee.

E. Professional record (in chronological order)—dates, positions held, and names of employers.

F. List publications, patents, procedures, developments, programs which support the nomination of this candidate for the Kishida International Award.

G. In 500 to 1,000 words describe the noteworthy contributions of the nominee as they relate to the "conditions of eligibility" enumerated above clearly indicating what the nominee has done toward "the improvement of food production, living conditions, and/or education for people in other countries."

H. List any other contributions to international development, not enumerated above, but which indicate the nominee's international service and his suitability for this award.

I. Weight is placed on adequate information and not on the number of sponsors signing the nomination papers. Supporting letters may be solicited to supplement a nomination, but are not a requirement for consideration.

J. Please enclose a photograph of the candidate if at all possible.

K. Mail seven copies of your nomination papers to: Executive Vice-President, American Society of Agricultural Engineers, Post Office Box 410, St. Joseph, MI 49085, USA.

NOTE: Nominees for the Kishida International Award will be kept on the list for active consideration by the jury for a period of three years if not elected or withdrawn.

■ ■

Tractor

Hinomoto Best E-15……(1) You can connect and disconnect a rotary with a lever while sitting on a driver's seat. (2) Complete position control of attachments. (3)Yanmar engine. A large displacement, 1000cc in 18hp class. (4) A new size (8.3/8-20) of high rag tyre. (6) 6 forward and 2 backward gears. You can choose any speed you like. (7) The radius of the smallest turning is 1.6m which is the smallest in this series. (8) The width of this rotary is 1200mm. There is no untilled part in the field by this tractor.

〔Specifications〕

Dimentions : L 2,245(body only) × W 1,050 × H 1,225 mm (up to the handle), Weight : 634 kg, Road clearance : 305 mm, Engine : water cooled 16hp (2,300rpm) 1,000cc, Clutch : diaphragm dry single board, gear : 6 forward 2 backward, The radius of the smallest turning : 1,570mm, Wheel : front 4.00-12 rear 8.3/8-20 high rag, Pump : hydraulic gear pump, Control method : position control, Rotary : side drive, Cutting width : 1,200mm,

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

Tractor

International 455R …… (1) High power engine with large torque. You can start engine easily even in a cold period by a large capacity battery, an inter air heater, and a starter. (2) Without noise by a muffler of high performance, you never get tired after working a long time.

(3) Special dual clutch adopted, you can change clutch or gear easily. (4) Completely controled lining. (5) Large capacity hydraulic system and high speed of operation. (6) Regulation of draft position control is easy.

〔Specifications〕

Dimentions : L 3,340 × W 1,645 × 2,085mm, Weight : 1,810kg, Engine : vertical 4 cycle diesel — 46ps/2,400rpm 2,522cc, Gear : 16 forwrd 8 backward, Radius of the smallest turning : 3,200mm, Brake : wet power steering, Attachment control method : position draft control, Linkage : three point likage,

(Komatsu-International Mfg. Co., Ltd. : Komatsu Bldg., 6-3-2 Akasaka, Minato-ku, Tokyo, Japan)

Disks

John Deere 370 Swinger Disks … A series of wide-working disks that cut 10,5 to 12m swatch, then swing back to half their working width for transport have been introduced by John Deere.

The four sizes in the new 370 Big Swinger TM Level-Action TM doubleoffset disk line are capable of working up to 9 hectares per hour in most conditions, behind John Deere 8430 and 8630 4-wheel-Drive Tractors.

Basically, the 370 is two offset disks joined at the front and rear. Spring-loaded joints provide more fore-and-aft and lateral flexibility than folding disks, and permit the disk to follow rolling ground contours.

The name Big Swinger derives from the manner in which the disks are prepared for transport when one field is finished, then prepared to work again after transport to another field. Preparing for transport, the operator simply pulls a rope to release a hitch member latch, lowers a retractable caster wheel, and drives ahead. The left disk automatically swings behind the right disk. After the operator shortens a diagonal brace on the right-hand disk to center the line of pull, he can drive off to the next field with the left gang trailing behind the right.

Preparing to work again merely requires him to reverse the procedure described above. As the tractor moves backward, the rear gang swings back into position at the left of the front or right gang ; the caster wheel guides the left gang into working position. After the operator raises the caster wheel and lengthens the diagonal brace, he's ready to work again.

(Deere & Company : John Deere Road, Moline, Illinois 61265, USA)

Disk Harrow

Sasaki Combination Harrow …

NEW PRODUCTS

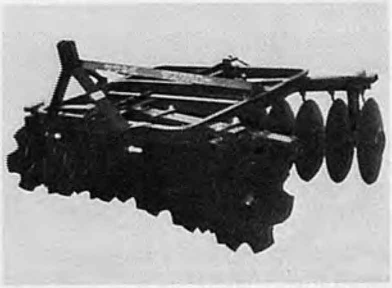
The combination harrow is the versatile tandem type disk harrow. In case of taking out each pin on left and right of center frame, rear disks are set free, so breaking and preparing work can be done at the same time. In case of taking out two pins of the center, front and rear disks are separated, so it can be hitched to a small tractor as a single hallow. In addition, setting tillage implement to the rear, permits preparing work. This is the versatile harrow used from light work to heavy duty.

〔Specifications〕

Dimensions : 1,230 × 2,140 × 1,050mm (L × W × H), Weight : 362kg, Working width : 2,150mm, Tractor output : 40~50ps, Mounting method : 3-point linkage.

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

Loader



New John Deere 143 Loader … John Deere has introduced a new front-end loader engineered exclusively for 40- to 70-hp tractors in the Long Green Line. This loader combines top-of-the-line features with an "economy" price tag. Standard features on the new 143 Loader include :

Double-acting lift cylinders, which provide down-pressure for digging.

Double-acting hydraulic bucket control.

Independent-valve controls, which free the tractor's rear hydraulic outlets for other use, and provide quicker hydraulic response to help get work done faster.

A 152cm materials bucket is also standard. Extra equipment and options include a 183 cm materials bucket, 122cm manure fork with tines, tines for the 152 and 183cm buckets, bottom and side extensions for the 152cm bucket, and a parking stand.

The new John Deere 143 Loader will lift 725kg to a height of 2.87m. Breakout capacity is rated at 1100 kg. (All capacities noted here are based on use of the 143 Loader on a 50-hp John Deere 2240 Tractor equipped with a straight front axle, 7.50-16 front tires, and 13.6-38 rear tires.)

(Deer & Company : John Deere Road, Moline, Illinois 61265, USA) ■ ■

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The Impact of High-Yielding Rice Varieties in Latin America with Special Emphasis on Colombia (Series JE-01, April, 1977)

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Outline of the report are as follows.

Chapter 2 presents an overview of rice production and trade in Latin America and concludes with some observations on trade prospects. **Chapter** 3 is dedicated to measuring the additional output of rice in Latin America due to HYV's, while **Chapter** 4 is intended to provide some economic backgroung to the Colombian rice industry, presenting data which will form the basis of subsequent analyses. In **Chapter** 5 a model is developed to measure the economic benefits of the introdution of HYV's, and the estimation of the parameters required by the model is discussed.

The gross benefits, costs, net benefits and rates of return are given in **Chapter** 6, while the distribution of net benefits by income level is discussed in **Chapter** 7. In **Chapter** 8, an analysis of the farm-retail marketing margin is presented, and a summary of the study is given in **Chapter** 9.

Size: 16.8 × 24.0 cm

Page: 165 page.

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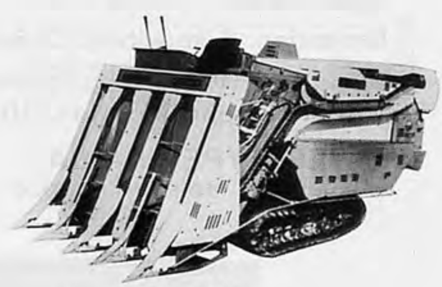

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