MECHANIZATION OF RICE GROWING AND IT'S PROBLEMS IN IRAN

by

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INTRODUCTION

Mechanization of agriculture has been studied for many different purposes. The important purpose is to find out how it affects agricultural production. To figure out these effects considerable research has been carried out at agricultural research centers over the world. Field experiences have proven that mechanization is a major factor in agricultural production. It has significant effects if all the related aspects are studied completely. Shortage of agricultural production may be solved in two general ways:

1 - Increasing the agricultural crop acreage.

2 - Improving the agricultural production per land unit.

To increase agricultural crop land we may face many new difficulties and constraints. Improving the production per land unit seems to have more potential. Proper use of soil and water resources, mechanization and field management will be required to improve the crop production yields. Mechanization as a principle has a very important role in improving the agricultural production output.

To introduce technology for agricultural production some requirements seem to be necessary. Financial, technical and educational programs are three major requirements to introduce mechanized techniques in agricultural production fields. The above mentioned items may be more important for developing nations rather than western industrialized countries. Introduction of tractors and equipment is not effective unless special attention is paid to the above factors.

Machine replacement for manual operations in the rice growing areas of Iran was started twenty five years ago. This replacement still is continuing but more effort is needed to solve new problems. The main problems encountered in the northern rice growing region of Iran are as follows:

1 - Lack of a complete irrigation and drainage systems - Drainage systems make it possible to improve soil trafficability conditions and provide more rational use of mechanization. Top priority should hence be given to soil drainage research.

2 - Introduction of machinery without testing and determining their performance under local field conditions - some farm machinery research and testing centers should be established to test tractors and equipments. These centers should have up-to-date regulations and equipment for testing tractors and their associated implements to give correct and complete information to rice growers.

3 - Existence of traditional agricultural practices - Traditional agricultural practices cause improper application of manpower, soil and water resources. These practices must be changed into more productive methods to increase the production output.

4 - Small scale farm holding - small farms have prevented use of suitable irrigation and drainage systems and hence impeded the appropriate application of machinery. An extensive re-allocation of land program must be carried out to improve land use. This makes it possible to progress as far as mechanization of rice growing is concerned.

5 - Insufficient machinery service from dealers and expanded extension services - Increased attention must be paid to the extension services. Government and private sectors must provide more

services to farmers so that they can use their machinery efficiently.

The first purpose of this report is to analyze some of these problems. Second purpose is to give some suggestions which may solve some of the difficultires that deal with rice growing in northern part of Iran.

MECHANIZATION OF RICE PRODUCTION IN TROPICAL COUNTRIES

Mechanization of rice production in the tropics has many problems which still remain unsolved. Attempts to transfer the highly advanced western and Japanese mechanization technologies have not produced effective results for the small farm holdings in the tropical regions. The overwhelming need today is to develop an intermediate mechanization technology to suit the prevailing set of agricultural, socio-economic and industrial conditions of the tropical regions.

More than half of the world's population depends on rice for their basic food supply. Rice is grown on 1290 million hectares with an estimated annual production of 2760 million tons per year. Table 1 includes some basic information on the major rice-producing countries of the world. Approximately 90% of rice production is concentrated in south, southeast and far east Asia, where population density is high and rice is primarily produced with traditional non-mechanized methods (6). The mechanization of rice cultivation with power equipment is therefore a vital subject which will affect millions of people who depend on this crop for food and for their livelihood (6). Mechanization of rice production in the tropics not only presents the usual non-technological dryland farming problems related to equipment size, economics of use and ownership, but also many technological problems which still remain unsolved.

The changing agri-economic climate in the tropical regions is making it increasingly difficult to follow traditional rice production practices. Agricultural mechanization is therefore becoming an important issue in many

Table 1. Area, Production and Yield of Paddy in Various Continents and Selected Countries of the World

Region/country	1963			1967		
	Area	Production	Yield	Area	Production	Yield
	Thousand hectares	Thousand tons	100 kilogrammes per hectare	Thousand hectares	Thousand tons	100 kilogrammes per hectare
Total world	122 277	253 220	20.7	128 842	275 942	21.4
CONTINENTS						
Asia	114 825	237 697	20.70	118 093	252 049	21.34
North America	1 325	4 181	31.6	1 408	5 207	37.0
South America	4 499	7 528	16.8	5 250	9 199	17.5
Europe (including USSR)	466	1 873	40.19	371	1 943	52.37
Africa	3 137	5 783	18.4	3 425	5 595	19.6
Australia-Oceania	35	158	45.1	40	284	58.5
SELECTED RICE - GROWING COUNTRIES						
Japan	3 272	16 639	50.9	3 263	18 770	57.5
China	31 500	85 000	27.0	32 000	92 000	38.75
India	35 809	55 497	15.5	30 722	56 787	15.5
Pakistan	10 294	17 724	17.2	11 309	19 005	16.8
Indonesia	6 731	11 915	17.7	7 523	13 932	18.5
Burma	4 877	7 783	16.0	4 800	7 714	16.1
Ceylon	525	1 026	19.5	546	1 169	21.4
Philippines	3 089	3 843	12.4	3 304	4 561	13.8
Thailand	5 354	10 029	15.9	5 601	9 595	17.1
Viet-Nam Dem. Rep. of	1 959	4 296	21.9	2 550	4 700	18.4
Viet-Nam, Rep. of	2 538	5 327	21.0	2 296	4 688	20.4
Egypt	403	2 219	55.1	464	2 318	49.9
Brazil	3 722	5 740	15.4	4 291	6 792	15.8
Taiwan	749	2 763	30.9	787	3 162	40.2

Source: FAO. Production yearbook 1964, 1968. Rome.

countries. Questions pertaining to mechanization are being vigorously debated by various authorities, but there is no clear-cut agreement on either the necessity or the type of mechanization that should be promoted in the developing regions.

Two somewhat opposed premises are often put forward for the mechanization of agriculture in the tropical world: (a) that mechanization of agriculture would displace labor and create adverse socioeconomic problems, hence, mechanization is both unnecessary and harmful; (b) that mechanization of agriculture with large tractors and equipment is desirable, since shortage of power is the essence of the mechanization problem and large equipment can provide this power in the most economical manner. Proponents of these two points of view have often argued strongly and have seemingly put forward substantially convincing data to support their hypotheses (6).

An unusual characteristic of the first hypothesis is that it is invariably based on the amount of direct agricultural labor that may be displaced by the machines and does not take into consideration the employment generation and labor intensification aspects of agricultural mechanization. Past experience indicates that seed and fertilizer technologies have generally preceded the mechanization of agriculture in the agriculturally mechanized countries. There is no reason to believe that it would be otherwise in the tropical regions. Recent studies in the Philippines indicate that the progressive farmers who adopt the new rice seed-fertilizer technology are more inclined toward mechanization. Tables 2 & 3 are the results of two studies in the Philippines which show increased labor utilization in rice production on more mechanized farms. The case of Japan is perhaps a classical example that indicates a very high labor

Table 2.

Man-Days of Labour Per Hectare, for Specific Operations on 42 Farms Planting High-Yielding Varieties in 1969, Laguna 1966 Versus 1969 Wet Season

	1966	1969	1970[1]
	Local Varieties	High - Yielding	
Number of farms	42	42	32
Average area, in hectares	2.4	2.3	2.2
	Man-days, by operation		
	. . . . Total		
Land preparation	22	16	13
Transplanting	10	10	10
Weeding	14	14	17
Other preharvest operations	10	11	15
Harvesting and threshing	23	34	36
Total	79	85	91
Percent using tractors	31	52	75
Yield (per hectare)	2.5	4.3	3.5
Kilogrammes per man-day	32	51	38

Source: Barker, R. and Cordova, V. The impact of new technology on rice Production: a study of change in three Philippine municipalities from 1966 to 1969. Paper presented at IRRI Saturday Seminar, December 12, 1970.

[1]Latest available data from continuing survey for the 1970 wet season.

Table 3. Man, Animal and Tractor Utilization per Hectare of 100 Lowland Rice Farms in Rizal Province, by Variety and Season, 1967/68.

	Man	Animal	Tractor	Man	Animal	Tractor
	. . . . Days per hectare					
WET SEASON						
Land Preparation	28.45	19.73	0.53	27.60	15.89	1.35
Transplanting	12.95			17.37		
Weeding and replanting	13.65			29.38		
Other preharvest operations	2.95			5.83		
Harvesting, threshing, hauling	25.86			30.72		
Total	83.86	19.73	0.53	110.90	15.89	1.35
DRY SEASON						
Land preparation	28.84	28.08	1.13	24.48	11.24	3.02
Transplanting	18.49			18.76		
Weeding and replanting	22.71			46.28		
Other preharvest operatoins	5.52			6.67		
Harvesting, threshing, hauling	25.10			35.97		
Total	100.66	28.08	1.13	132.16	11.24	3.02

Source: Manuel, P.C. and Lopez, M. P. Productivity of farms using traditional and improved rice varieties in Rizal and Laguna. Paper, Siminar on Economics of Rice Production in the Philippines, IRRI, December 1969.

[1] Average farm size was 1.39 hectares with 23 percent double-cropped; 42 percent of the farmers were owners or part-owners.

utilization (1400 man hours per hectare) in spite of a highly mechanized agriculture (2.664 hp per hectare), shown in Tables 4 and 5. It seems highly doubtful that the mechanization of agriculture in the tropics with smaller machines when coupled with appropriate seed-fertilizer technology would reduce labor utilization.

An unusual aspect of the second hypothesis is the contention that adequate equipment to mechanize rice production is already available from the temperate regions and that the problem lies primarily in the proper selection of equipment. Such a premise is based on a limited knowledge of the requirement of the tropical regions, for there is a wide range of operations which can not be satisfactorily performed with the existing array of equipment available from the temperate regions. Some examples of the unsolved problems of wetland paddy cultivation equipment are concerned with mechanical tillage of soft soils, mobility of tractors, seeding of pregerminated paddy on puddled soils, application of plant nutrients in puddled soils, harvesting and threshing of high-moisture paddy, small-scale rapid drying, parboiling and milling of paddy.

Another unusual aspect of the two hypotheses is that they are primarily concerned with only the utilization aspects of the agricultural machines and do not consider the various implications of manufacture, sales and service of the tools necessary for mechanization. It is taken for granted that agricultural mechanization in the tropical countries will be based on a non-indigenous technology, and that equipment to mechanize will primarily come from the industrialized regions. The history of agricultural mechanization of even the smaller countries of Europe reveals that widespread agricultural mechanization was only possible with the indigenous production of farm equipment (6).

Table 4. Labour (In Hours) Per Hectare, for Rice Cultivation in Some Selected Asian Countries

Country	Land preparation	Trans-planting	Harvesting	Total, including others
Japan	50	240	220	1 400
Taiwan	60	190	220	1 300
India	170	229	227	1 000
Philippines	190	120	170	800
Nepal	240	240	240	n.a.
Korea, Rep. of	160	160	160	830

Source: [Report of] APO Expert Group Meeting on Agricultural Mechanization. Vol. II. Tokyo, October 1968 (APO Project SYP/III/67).

Table 5. **Some Agricultural Mechanization Indicators on 11 Selected Rice-Producing Countries in Asia**

Country	Arable land per holding	Agricultural working population per hectare	Net domestic agricultural production		hp per hectare				hp per agricultural worker	Cost per hp of agricultural tractors	
			Per person	Per hectare	Human	Animal	Mechanical	Total		Small (6-8 hp)	Large (35 hp)
			U.S. dollars							U.S. dollars	
Ceylon	1.59	1.20	293	352	0.120	0.148	0.110	0.378	0.009	133.30	66.70
India	2.62	0.90	148	133	0.090	0.204	0.008	0.249	0.009	179.48	107.69
Iran	6.17	0.37	417	154	0.037	0.048	0.154	0.292	0.418	92.85	66.85
Japan	1.06	2.16	626	1,350	0.216	0.120	2.664	3.000	1.231	77.48	59.12
Pakistan	2.37	1.09	154	169	0.109	0.288	0.013	0.410	0.012	164.29	71.69
Philippines	3.66	0.71	242	186	0.071	0.104	0.023	0.198	0.030	219.25	146.17
Thailand	3.64	1.10	102	112	0.110	0.184	0.054	0.348	0.050	89.14	68.57

Source: [Report of] FAO Expert Group Meeting on Agricultural Mechanization. Vol. II. Tokyo, October 1968. (FAO Project SYP/III/67).

The high cost of imported machinery has always been a serious, limiting factor in the mechanization of tropical agriculture. Farmers in the developing regions pay considerably higher costs for machines than their counterparts in industrialized countries, whereas the returns from agriculture are usually much lower in the less developed regions (Table 5). Most developing countries are undergoing balance of payments problems of varying degree. It is doubtful that these problems will improve enough to permit the large-scale import of farm equipment in the foreseeable future. Figure 1 indicates an estimate of the number of tractors that would be required in three Asian countries to raise their power level to a conservative 2.00 H.P. per hectare in a period of 20 years. The compound rate of tractor population growth necessary to achieve such a level will be 27.5% for Pakistan, 21% for the Philippines, and 15% for Ceylon. The foreign exchange required, if tractors are to be obtained from non-indigenous sources, would be of staggering proportions and is clearly impossible to contemplate in consideration of the present foreign exchange allocations for importation of agricultural machinery (6).

The question of agricultural mechanization is therefore very closely related to the indigenous manufacture of agricultural equipment in most developing countries. It is somewhat unrealistic to look at agricultural mechanization without considering the indigenous production of the tools that are necessary for mechanization. Unfortunately, however, almost all national and international efforts toward agricultural mechanization in the tropical regions are primarily directed toward the utilization aspects of agricultural machines.

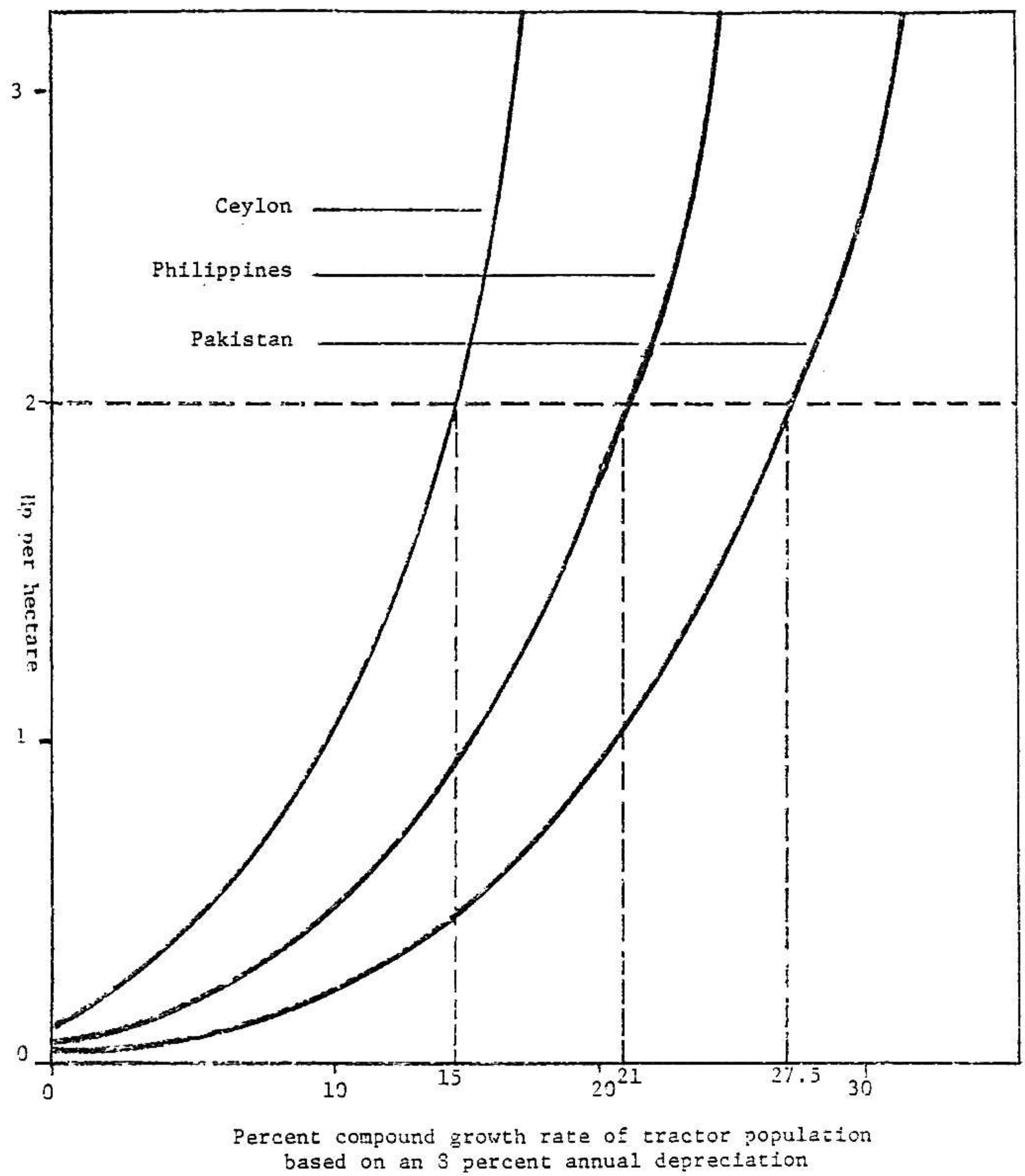

Figure 1.--Tractor population growth rate for three countries in Asia, to achieve a 2-hp per hectare level in a 20-year period (1966 to 1985).

Source: [Report of] FAO Expert Group Meeting on Agricultural Mechanization. Vol. II. Tokyo, October 1968.

Quite often the argument is put forward that economical manufacture is only possible when there is a mass demand for it. There is no doubt that economies of scale in manufacturing are extremely important in the industrialized countries where the cost of labor is very high. Understandably, farm machinery manufacturers from the industrialized countries have tended to overemphasize this aspect when considering the feasibility of manufacture in the developing regions. It is often unrealistic to apply the highly capital-intensive manufacturing techniques in regions where labor costs are only a fraction of those in the industrialized countries.

Many interesting examples of economic short-run production industries are found today in Asia. These examples indicate that it is possible to manufacture relatively complex products provided such products are suitably modified and adapted for low-volume production. An interesting example is the local manufacture by small fabricators of the old McCormick type threshers in the Philippines. These machines are sold at economical prices and are very popular for custom threshing of paddy in the Central Luzon region of the Philippines. In Iran, some fabricators are manufacturing small walking tractors of relatively simple but indigenous design in moderate volume for paddy cultivation. These machines are quite economical and can adequately meet most of the requirements of the Iranian farmers. Similarly, many modest machine shops are successfully fabricating small power tillers and farm trucks in Iran in limited quantity with simple production techniques.

A closer examination of past achievements in agricultural mechanization in the tropical regions indicates that the real and overwhelming need is not just to transfer the highly advanced mechanization technologies from the developed countries but rather to create an intermediate level of mechanization technology tailored specifically to the developing countries.(1). This new technology must fit well into the prevailing set of agricultural, socioeconomic and industrial conditions of the tropical regions.(1).

There are two distinct agricultural mechanization technologies which have evolved in the industrialized regions of the world. The western approach emphasizes dry land farming, using large, high-powered equipment with greater emphasis on labor saving. The use of large machines either on large-sized farms or in custom operation has but limited application for paddy cultivation. In certain countries, such as Thailand, Malaysia, the Philippines, and Ceylon, custom operation with large equipment has gained some degree of acceptance for either land preparation or for threshing. It is doubtful, however, that in the long run, the tropical farmer would accept only a selective mechanization of his operations. The other crop production operations, along with the transport of farm produce and personnel, will continue to favor individual ownership of smaller equipment.(1).

A study in Malaysia indicates a rapid increase in the sales of two-wheel tractors even inthe face of the availability of economical large tractor hire services (1). The introduction of custom operation services for every operation of rice production may also have some serious economic limitations. A survey of ten special projects in Ceylon indicated that up to 50% of the cost of rice production consisted of the two custom operations of tillage and threshing (2).

Recent trends reflect a widening gap between the available mechanization technologies from the industrialized countries and the requirements of the less developed regions. Mechanization in the western countries is decidedly moving toward larger and larger sized equipment. To some extent, developments in Japan indicate a similar trend. Along with an increasing complexity in their farm equipment, these developments will no doubt further hamper the introduction of these agricultural machines in the developing regions. The inadequacy of the available mechanization technologies and the lack of an appropriate alternative to satisfactorily meet the overall requirements of the tropical regions has been the most important reason for the slow and spotty progress in the mechanization of tropical agriculture. Mechanization of tropical agriculture at the present time is primarily limited to the larger farm holdings which constitute an insignificantly small segment of the total agricultural land.

Table 6 shows that about 95% of the farm holdings in the ten rice-growing Asian countries are below ten hectares. If mechanization is to be a reality in the tropical regions, it must be considered in this particular frame of reference. Just after the war, numerous small shops mushroomed all over Japan and started producing simple mechanized farm equipment. At that stage, Japanese farm equipment was primarily designed as a replacement for animal power and usually matched the working capacity of animal-drawn implements. Japan was in effect developing an intermediate technology into the highly advanced agricultural mechanization technology which we see today in Japan. The initial steps toward the development of an intermediate mechanized technology for the less developed regions involve the design and development of relatively labor-intensive but simple, mechanically powered equipment which can be produced with the production methods that are currently available in the developing regions. Fortunately, some encouraging signs are occurring in development of such a technology in a few Asian countries.

Table 6.

Percentage of Farm Households, by Size of Holding

Country	Year	Number of holdings	Percentage of total holdings		
			0-1 hectare	1-10 hectares	0-10 hectares
			.....	Percentage	.....
Ceylon	1961	1 119.8	65.40	33.4	98.80
India	1954/55	---	19.42	62.39	81.81
Japan	1965	5 465.8	70.70	29.3	100.00
Pakistan	1960	10 999.5	43.40	52.8	96.20
Philippines	1960	2 166.2	11.5	82.9	94.40
Thailand	1963	3 214.4	18.60	76.1	94.70

Source: [Report of] FAO Expert Group Meeting on Agricultural Mechanization. Vol. II. Tokyo, October 1968. (FAO Project SYP/III/67)

Some production of farm implements, pumps, stationary farm machines and in some cases, diesel engines and walking tractors, has been started by small machine shops in Iran, India and the Philippines.

This indigenously-produced agricultural equipment is either adapted from imported equipment, or developed locally by machine shop operators who usually have had no formal engineering training.

FACTORS TO BE CONSIDERED FOR INTRODUCING MACHINES TO SMALL FARMERS

Changing Traditions

Tradition plays a large part in the day-to-day life of most people, whether sophisticated or primative. It is natural to play safe and employ practices whose outcome is foreseeable from experience. The inventor and innovator is looked at askance and with fear, until he can show that the changes he wants to introduce can be sure of producing the results he claims for them. Nothing is more damaging to the introduction of new methods or machines than demonstrations which fail to convince.

When an improved method of growing a crop is worked out in detail, it will consist of a number of operations which have to be carried out in the correct sequence and with considerable accuracy, i.e., row sowing as compared with broadcasting may necessitate accurate control of the soil texture to allow the seeder to work properly and give accurate spacing of the rows to permit the following weeding operations with rotary weeders to be effective.

The innovator must be able to explain the reasons behind each operation and to demonstrate how to carry it out. The man who is only prepared to shout instructions from the bounds of a paddy field is not likely to gain the support for his methods which could easily be gottin if he took off his shoes and plunged into the mud to do the job himself.

Communication between the cultivator and the scientist or engineer is always difficult unless the latter has a sufficient understanding of the background of the small farmer's culture and can explain new ideas in terms of his everyday experience.

Assessment of Needs

A first step in analyzing the problem is to make a detailed survey of each operation carried out in growing each crop. This might be called a "crop calendar," which should include:

(1) the number of days during which each operation should be completed;

(2) the number of man/days per hectare required to do the work.

If this information is tabulated against the weeks of the calendar year in which each operation takes place, it is easy to determine the peak labor requirement period. An example of such a crop calendar is given in Fig. 2. It is a generalized form to illustrate the methods used in building it up. The two-week periods for each operation are assumed to be optimal and the spread and actual dates may vary from season to season, but the relative position of labor peaks is likely to remain unchanged.

Possible variations, from year to year, in the timing of the operations dependent on seasonal weather should be noted. For example, in areas of well-defined wet and dry seasons, it may not be possible to begin work until after the break of the seasonal rains. Where work is dependent on draught animals' power, some weeks of delay from the onset of the rains may be necessary, while the animals, in a semi-starved condition at the end of the dry season, regain their strength as new forage becomes available to them.

In the dry zone of Ceylon, the introduction of a hire service of tractors and plows to carry out the primary cultivations on dry paddies, before the onset of the rains, resulted in rice planting being done a month earlier than the traditional methods allowed, and it was estimated

CROP	AREA (hectares)	OPERATION	LABOR REQUIREMENTS (man/days)																							
			JAN.		FEB.		MAR.		APR.		MAY		JUN.		JUL.		AUG.		SEP.		OCT.		NOV.		DEC.	
RICE	$\frac{1}{2}$	Nursery							1/8M																	
		Sow								1/8E																
		Plough							½A																	
		Cultivate								½B																
		Irrigate								1/8P	5/8P	½P	½P	½P	½P	½P	½P	½P								
		Puddle									½Q															
		Levelling									½D															
		Transplant										½F														
		Weeding										½H		½H					½I							
		Harvesting								1/8H																
COTTON	1	Plough																								
		Cultivate	1B																							
		Ridge				1E																				
		Sow				1E																				
		Single					1G																			
		Weeding							1I		1I															
		Irrigate				1P	1P	1P	1P	1P	1P	1P	1P	1P	1P	1P	1P	1P	1P	1P	1P					
		Harvest																				1K	1K			
		Cut Stalks																							1S	
WHEAT	2	Plough																	2A							
		Cultivate																		2B						
		Bund form																			2R					
		Levelling																				2D				
		Sow																					2E			
		Irrigate	2P	2P	2P	2P	2P																2P	2P	2P	2P
		Harvest							2I																	
TOTALS	$3\frac{1}{2}$		1B			R + E + P	G + P	P	1/8M + ½A + I + P	1/6N + ½B + 1½P + 1/3H	1 5/8 P + ½Q + ½D + I	1½P + ½H + ½F	1½P	1½P + ½H	1½P	1½P	1½P	1½P	½J + P + 2A	P + 2B	P + 2R	K + 2D	K + 2D + 2P	2P	S + 2P	2P

Fig. 2. A Sample Crop Calendar. Source: Coleman, Francis. Problem of introducting machines to small cultivators. Mechanization and the world's rice. Massey-Ferguson, Warwickshire, England 1966.

KEY: (Man/hours/Hectare)

A. Plow
B. Cultivate
D. Levelling
E. Sow
F. Transplant Rice
G. Single Cotton
H. Weed Rice
I. Weed Cotton
J. Harvest Rice
K. Pick Cotton
L. Harvest Wheat
M. Prepare Rice Nursery
P. Irrigate
Q. Puddle for Rice
R. Ridge or Make Bunds
S. Cut Cotton Stalks

that an additional 30 hectare-centimeters of water were available to the crop. This allowed longer maturing varieties of paddy to be grown, with consequent increases in yield.

Once the periods of maximum labor demand have been determined, we must find out if the local population can satisfy the demand or whether it is customary to bring in hired labor from other districts. If this is so, then a prima facie case can be determined for introducing machinery to ease the burden. If reduction in labor requirement results in underemployment, then ways and means of profitably using the man-hours now available should be sought, e.g. can production become more intensive or can a profitable rural craft be developed?

The crop calendar will also pinpoint those operations which are dependent on wetter conditions. If it can be shown that this limits production, then alternative ways of doing the work should be sought.

When introducing machines to do work now carried out by animal power, consideration must be given to the overall position of animals in the local culture. Where ownership of animals confers social status or where animals are used for transport purposes at other seasons, it is unlikely that machines will displace them. In this case, the animal becomes underemployed and yet continues to consume food and require the attention of herd boys to control their grazing. If, however, the draught animal is also a milk cow or buffalo, then the reduction in physical work is largely compensated by the increase in milk production. Sometimes machine ownership replaces animal ownership as a status symbol. Tempany and Grist noted that in Guyana, mechanization of the rice production led to the machine's being regarded as a social asset rather than an economic factor in production (4).

Tillage operations require much more power than any other work in rice production. Handwork and animal power limit the depth of cultivation and the timing of such work. The introduction of engine-driven machines allows work to be done on hard soils and assist in the more thorough incorporation of green manures.

The crop calendar also shows the sequence of operations in the existing methods of growing the crops. Each operation should be carefully scrutinized in the light of up-to-date knowledge and the following questions answered:

(1) What is the object of the operation?

(2) Does it achieve the desired end?

(3) Is it put in the right place in the sequence?

(4) Is it necessary?

(5) Are better ways of doing it possible?

Care must be used in establishing the criteria by which to judge the relative merits of different ways of growing the crop. Are yields to be the sole criterion? When a small-holding is worked entirely by a family, it is difficult to assess the cost of their labor. Perhaps their total effort should be compared with yield in order to bring about more efficient use of man-power.

Sometimes field inspectors are too prone to compare cultural methods by estimating yield in the standing crop or by careful hand sampling and counting grains or weighing the yield from their samples. This assumes 100% recovery of the grain grown and can be very misleading. It is the grain that is available as food that counts.

Choice of Machines

At one time it was thought that once the needs of a peasant cultivator had been determined, it was possible to select equipment already in production somewhere in the world to satisfy them. In practice, such machines are often too expensive or too complicated and new designs have to be developed to fill the requirements.

The modification of existing equipment or the design of simple tools that can be made locally with the additional resource of materials brought in from elsewhere stimulates farmers to fresh thinking and the step-by-step advance which results is often more acceptable and longer lasting in its effect.

In choosing machines, emphasis should be placed on those features of design which will produce the required result without adjustments and manipulation that depend a great deal on the skill of the operator.

Under irrigated farming conditions, a truly level soil surface is of prime importance to ensure economy of water use and evenness of maturation of the crop.

If cultivations are carried out on dry land, then chisel plows and cultivators are to be preferred to disc or moldboard plows. With wet work, rotary cultivators or gang-discs will do little to disturb the surface of the soil.

Traditional levelling tools such as the single, towed beam; the Egyptian kassabia or earth scoop; or the comb-harrow of the Far East require much skill from the operator to produce a true level surface. A rectangular, 3-bar scrubber, whose cutting edges are in one plane, will ultimately give a plane surface without any adjustment or special skill from the operator.

The accessibility and size of the paddies determine the size of machine which can be used. In terraced paddies, the machine must be carried to the site by men; otherwise, damage is done to the water-retaining bunds.

When introducing tractors and other machines to peasant farmers, simplicity of operation is most improtant. For example, the sophisticated hydraulic controls of implements, which allow finger-tip control of depth, draught and speed of reaction are seldom utilized to obtain the best performance from the tractor. A single level control, based on draught reaction, is likely to get better use out of the tractor.

The small plots imposed by irrigation requirements (i.e., the necessity for water control bunds and the difficulty of leveling large areas) do not allow high speeds over the ground. This combined with good maneuverability and mounted implements makes the smaller-wheeled tractor a better investment than larger, higher-powered ones.

Some years ago, a study showed that tractor size ranged from 25 hp for wheeled tractors to 50 hp for crawlers; all were used for pulling tined cultivators in the heavy soils of the Nile Delta. In no case was output of 17 draw-bar horsepower reached. The best utilization of available engine power was obtained with the 20-30 hp wheeled tractor (4).

Maintenance

The introduction of the more sophisticated machines to peasants presents special difficulties.

In highly developed societies, many purchasers of equipment can not be bothered to read instruction books and seldom carry out accurately the maker's instructions on maintenance. When troubles occur, they call upon the local agent to correct the problem and blame the maker and not themselves for the faults that occurred.

In the more remote parts of the world, where there is an urgent need for the application of increased power to the land, the difficulties of servicing machines are much greater, especially with the smaller, walk-behind machines, which are often seriously overloaded.

Reliability of machines is a first necessity, and unless this can be achieved in the conditions of use, there is strong resistance on the part of the peasant to break away from traditional equipment. Delays resulting from breakdowns in countries far from the factory that produced the machine can be disastrous. Even when manufacturers insist on their agent's carrying good stocks of spares, such delays may be on the order of weeks rather than days, owing to poor communications over long distances. If spares have to be ordered from the factory, delays of six months to a year are common.

Instruction books in the local language are very helpful, but are expensive to produce, since the demand is small. If they are so printed, the words must be those of the village and not the language expert, whose etymology may be academically correct, but whose vocabulary is not understood in the village. Where possible, leaflets showing maintenance methods and routines should be in the form of clear line drawings (photographs are too confusing) which tell their own story without the use of words. Such strip cartoons can be used in many different countries without alteration.

Implements made in the traditional way from local materials are often held together by wedges, and where iron is used, pinning and riveting is the usual method of fastening. The nut and bolt are not often used, owing to their high cost. Much patience is required in teaching the use of accurately fitting spanners and the degree of force needed for the proper tightening of nuts. It is not easy to see when the nut on a bolt is loose, hence many are lost. This is serious where replacements are not easily available. Increased use of self-locking nuts is helpful. Machines with a minimum of nut sizes are more likely to be maintained, especially if only one or two spanner sizes are required for the work.

People who do little or no reading usually have well-developed memories and if they strip and re-assemble their machines under the tutelege of well trained and conscientious mechanics, they will be able to do it on their own in the future.

Robustness and simplicity of design are much more important than fine adjustments and controls. The latter are seldom used to promote the increased production, and they add appreciably to the first cost of the machine.

Energy costs

Whether man, animal, or engine powered machines are used, the work done is derived from the conversion of the food consumed by the first two or the fuel burnt by the last respectively. Man and animals are much less efficient convertors of food into mechanical work than internal combustion engines; they have the advantage that their food is available locally, while petroleum products have to be purchased, and frequently, imported from abroad.

The substitution of engine-powered equipment for animals will release the land used for growing fodder crops, to increase the output of food and cash crops. A good deal of the income from these additional crops will be used in buying the fuel. Amortization costs are also high where the life of a machine is short.

Land Availability and Tenure

The introduction of machines to peasant farming can either promote more intensive use of existing holdings or can be used to extend the area worked by one family. In heavily populated areas, the former will be obtained, but in countries with areas of shifting cultivation or virgin forest, government agencies can clear new land and allocate tenancies of sufficient size to allow the economic use of tractor-power equipment.

The small size of the holding worked by a family, or its fragmentation into a large number of small plots at some distance from each other, as a result of the implementation of tribal or religious laws of inheritance makes the introduction of machines still more difficult.

Many governments have already enacted laws to promote the consolidation of holdings into larger units, so that production can be increased by the efficient use of machines.

In countries where land reform measures have been implemented, the allocation of tenancies or free-hold ownership is often conditional on there being no fragmentation on inheritance.

Holdings, in the rice-growing areas of the world, vary greatly in size, from the 0.2 hectare plots of parts of India; 0.8 to 2.0 hectares in Japan; 2.5 to 4.0 hectares in Iran, and Italy; and more than 4.0 hectares in Pakistan (4).

In general, the larger holdings give higher yields, but this is not true always. High yields are obtained in Japan, Spain and Italy, while much lower yields apply to Burma, where cultivation methods are less effective.

FACTORS TO BE CONSIDERED FOR EFFICIENT MECHANIZATION OF RICE PRODUCTION

Physical Factors

Water. Every project for irrigated rice growing should have an ample supply of water of good quality. The quantities needed are greater than for other crops. At some time during the early growing period, the supply may be critical for getting a good stand. It should be possible to apply water freely especially during the first few weeks after sowing, for weed and pest control. The quantity needed depends on rainfall, evaporation, and soil type.

Soil. A heavy soil that has low permeability and a low percolation rate is preferred. To permit working with heavy equipment under wet conditions, the soil should not become bottomless. Big tractors and plows need large fields for economical operation; therefore, the terrain has to be level. In the fields the differences in elevation should not exceed 5 centimeters. Larger differences have to be eliminated with scrapers or other leveling devices. Field size will then be determined by water requirements and drainage and perhaps by the capacity of the bulk tanks of the combine harvesters.

Climate. Long periods of sunshine during growing periods, dry weather during field preparation and harvest are important for rice growing. Dry cultivations mean higher yields and lower costs for machinery and equipment. If the water supply is sufficient, low rainfall will be an advantage.

Site. When looking for a site for a new scheme, connecting roads with the neighborhood or the possibilities of building them have to be considered. They are essential for the supply of labor and for transportation of all the goods needed and of the products to be sold. Poor or non-existent roads will be a heavy burden every year. If the products are to be exported, the distance to the loading place should be short. Rice is a vulnerable product and it should be handled with care and as little as possible (4).

Personnel

Farm Labor. An estate with highly mechanized production, and aircraft for dusting, needs only one hand for every 40 to 50 hectares. The men should be well trained to work with a tractor, a combine harvester, a motor grader, or with a hydraulic backhoe. They should not be put on these expensive machines without proper training because these are the people who will determine the performance of the machines and, to a great extent, the costs of production.

Technical Labor. The machines used not only need good operators but also highly skilled mechanics to repair them or to prepare them for the next season. These people should be trained extensively. Both the operators and the mechanics should know everything about the machines used, and be thoroughly familiar with the factory manuals for operation and maintenance.

The need for qualified personnel is seldom overestimated, since the cost and performance of the machines and installations are important inputs to the cost of production (4).

Machines and Installations

Selection. A great number of types and makes is available and, undoubtedly, most of them would be suitable. After-sale service and availability of spare parts are very important to minimize down time.

Standardization. An optimal standardization, whereever possible, is very important since it greatly simplifies service and supply of spare parts. There will be greater possibility of getting spares on consignment or to make use of an exchange-parts service. All this will mean less time lost for repairs or waiting for spare parts.

Workshop and storage of spares. A well-equipped workshop for servicing, maintenance and repairs is needed. Careful attention should be paid to the maintenance of performance records and repairs in order to have correct data in case of replacements or for buying new machinery. A proper register of the flow and storage of spare parts is essential for keeping the supply adequate and dead stock to a minimum.

Water Management

Without good water management, mechanized rice production can not be considered. It is important that any field can be irrigated or drained at any time. Whole fields could otherwise be lost, especially during the first weeks after sowing, when pests should be controlled by flooding or draining. Reuse of water should be prevented not only for health reasons but also because most of the time, this water is muddy. Silt deposits will create higher costs for maintaining the canals.

Layout

The layout should be as efficient as possible. Good all-weather roads to reach the main points of the estate will be a considerable advantage, especially during the rainy season. Short distances for transportation of personnel, machinery and equipment, seed and fertilizers and products are important just as they are for water supply. In some cases, waterways may be used for transportation of products and goods. When aircraft is used, houses and buildings should be windward, and fields layout should facilitate long runs for efficient aerial applications.

System Management

Paddy is harvested with a moisture content of about 20%. For safe storage, it has to be dried down to 14% or less (4). The quality of the product is to a great extent determined by the correct time of harvesting and by the proper handling, drying and storage.

For optimal efficiency, the capacity of the drying facilities, combine harvesters, water supply, aircraft and of other machinery should be properly sized. To calculate capacity, one should start with the time available for harvesting. Using this figure, the number of machines needed and the area to be planted weekly can be calculated. Of course, there should be some allowance made at each stage of the operations, to account for bad weather or other calamities. On the other hand, seeding should be done at a definite time even if the weather permits speeding things up or if land preparation is ahead of schedule.

IRANIAN LAND

Iranian National Land

Iran is a large country with a total area of 1,648,000 square kilometers. It is about four times the size of Japan, and equals the total areas of England, France, Germany, Italy, Belgium, Holland and Denmark. The Iranian plateau is a triangle set between two depressions: the Caspian Sea to the north and Gulf to the south. Iran is at 26 - 40 north latitude and at 44 -6630 east longitude. It is bounded on the north by the Soviet Union and the Caspian Sea, on the east by Afghanistan and Pakistan, on the south by the Gulf and the Sea of Oman, and on the west by Irak and Turkey. In Fig. 2, the administrative division in Iran is shown (17). This country has twenty-one administrative divisions. The population growth is 2.6% per year. The population percentages of urban and rural are 39.9% and 61.1%, respectively. Tehran, E. Azerbaijan and Khorasan are the states with big populations. E. Azerbaijan, Khorasan, Tehran, Mazandaran, Gilan and Fars states have high population growth rates (5). These states are in the northern Iran area. In urban areas, the population of Tehran (the capital city) is 3,000,000; the population of Meshed, 410,000; and the population of Tabriz is 400,000. The nomads live in the states of Khorasan, Baluchistan and Sistan, in eastern Iran (5).

Condition of Nature

1-Geographical condition. The triangle of the Iranian plateau is bounded by mountains around a central depression and a desert region formed by the bed of a dried-up ocean. The western mountains, of Zagros Range, run

Fig. 3. Administrative Divisions in Iran.

from northwest to southeast, and are over 620 miles in length and 120 miles in width. The range rises to a height of 5,570 feet and consists of numerous parallel folds, enclosing valleys 30 to 60 miles long and 6 to 12 miles wide. The northern part of the triangle is formed by the mighty Alborz Range, of which the highest peak, Mt. Damavand, rises to over 19,000 feet. Two great deserts, the Dasht-e-Lut and the Dasht-e-Kavir, occupy a large part of the central plateau and together account for one-half of the desert area and one-sixth of the total area of Iran. These deserts are the most arid in the world, and while an occasional oasis may be found in the Kavir, the Lut is totally barren, supporting no life whatsoever.

2-Meterological condition. Iran is a mountainous country that extends between 25 and 40 degrees north latitude and is, therefore, entirely in the temperate belt of the northern hemisphere. Geographically seen, it occupies the major portion of the Iranian plateau. The country is rimmed by ranges of mountains on all sides, circling a central plateau which ranges in altitude from 1,000 to 2,000 mts.

The two major mountain systems of Iran are the Alborz in the north, and almost continuous range from the Turkish frontier in the northwest to the Afghan border in the northeast, and the Zagros chains which extend from the northwest to the southeast portion of the country. In addition, there are northeastern mountains which, although neither as continuous nor as high as the two major systems cited above, are important from a climatic point of view, as they complete the circle of higher elevations that girdle the interior tableland. Generally speaking, Iran is a country of scant rainfall. The annual amount of precipitation for the country as a whole averages from 300 to 350 mm of rain and snow. The average amount of precipitation ranges from less than 10 mm in the desert interior to more than 2,000 mm in the southwestern corners of the Caspian (Rasht). Since rainfall varies greatly from year to year, agri-economic prosperity depends almost directly on the actual annual precipitation (15).

Utilization of Agricultural Land

The total agricultural land is about 22,500,000 ha. and this is about thirteen percent of the total land. The total land under cultivation is 11,356,254 ha. and this is only 50.5 percent of total agricultural land. The cultivated area under irrigation is 41% of the cultivated area. The irrigated area is located mostly in the dry area from central Iran to Oman port; a small amount of irrigated acreage is found in the Alburz and Zagros mountainous areas (16).

Gross National Product (GNP), Gross Marketable Product (GMP) Per Farm and Per Worker Wages.

Agriculture contributed 21 percent to the G.M.P. in 1967 and 16.6 percent in 1972. It is forecasted that it will contribute 12.5 percent in 1978 at constant money value. The gross marketable product per worker has been 55,000 Rials ($890.00) per labor unit in 1972 and should be 78,000 Rians ($1260.00) per labor unit in 1978.

As far as rice growing in particular is concerned, the production in 1971 was about 877,000 tons of paddy. Considering as an average a paddy production of 2.6 tons per hectare (including straw product) and an average selling price of 25 Rials per kg, we can estimate output per hectare of cultivated land at around 65,000 Rials. To this value should be added that of the straw and we can estimate a value of 1,600 - 2,000 Rials per hectare. Adding this to the above mentioned 65,000 Rials, an output of 67,000 Rials per hectare is obtained. In order to obtain this production, farmers have, on an average, expenses of between 65 and 70 percent of the GMP (Table 8 and Figs. 3 and 4).

From the above it is possible to determine GMP per worker on an average of 75,000 Rials based on 1972 prices and the Land/Work ratio of 1.2 hectares per worker.

In the industrial section unskilled workers received between 120 - 180 Rials per day; semi-skilled workers between 200 and 300 Rials per day and the skilled ones between 350 - 450 Rials per day. In agricultural section, however, wages vary according to the season and to the different types of work, for example, for the setting up of bounds and the soil preparation wages are about 160 - 180 Rials per day. On the contrary, tractor drivers receive about 300 Rials per day. For transplanting and weeding, women receive around 200 Rials per day (12 hours). In the teagardens, wages reach 150 - 160 Rials per day. During harvesting, wages increase to 400 Rials per day (for 14 - 15 working hours per day).

Rice Growing Paddy Area in Iran

The rice growing area in IRAN covers 330 - 350,000 ha, mainly grouped (Approx. 80 percent) in the Northern region adjacent to the Caspian sea, the rest of rice growing area is in the Khuzistan Region.

I have concentrated on the Northern region in this report. Two large areas are important in the Northern region: Gilan and Mazandaran. Gilan, has rainfalls between 1,500 - 2,000 mm per year and Mazandaran has rainfalls ranging from 500 - 1500 mm annually (Fig. 5 & 6). For these areas the amount of the rice growing area is approximately 180,000 ha for the Gilan province and 120,000 ha for the Mazandaran province (16).

TABLE 7 Costs per hectare of the paddy production following different sources.

Specification	Nippon Koei Co. (Gilan) 1970	Extension Service (Gilan) 1973	Farmer (Mazandaran)	R.R.C. (Mazandaran)
Nursery preparation (Rls/ha)	925	-	-	3,000
Seed bed preparation (Rls/ha)	7,000	5,000	4,000	7,000
Transplanting and weeding (Rls/ha)	4,600	13,000	18,000(*)	13,000
Water management (Rls/)	1,000	-	1,500	3,000
Harvesting and handling (Rls/ha)	1,300	-	5,000	8,000
Threshing (Rls/ha)	750	3,000	5,850	5,000
Irrigation water (Rls/ha)	1,500	900	300	300
Seeds (Rls/ha)	1,600	4,500	3,800	3,800
Fertilizers (Rls/ha)	-	4,000	2,000	2,000
Drying (Rls/ha)	-	750	2,400	900
Miscellaneous (Rls/ha)	500	3,850	-	500
Subtotal (Rls/ha)	19,175	35,000	42,850	46,500
Rental charge (Rls/ha)	12,400	15,000	20,000	20,000
Total	31,575	50,000	62,850	66,500
Average yield production (t/ha)	1.8	2.5	6.0	3.5
Average paddy price (Rls/t)	20,000	35,000	17,500	25,000
Gross output (Rls/ha)	36,000	87,500	105,000	87,500

(*) Nursery preparation is included.

Source: Nippon Koei Company, Rasht Rice Research Center, Rasht, Iran, 1972.

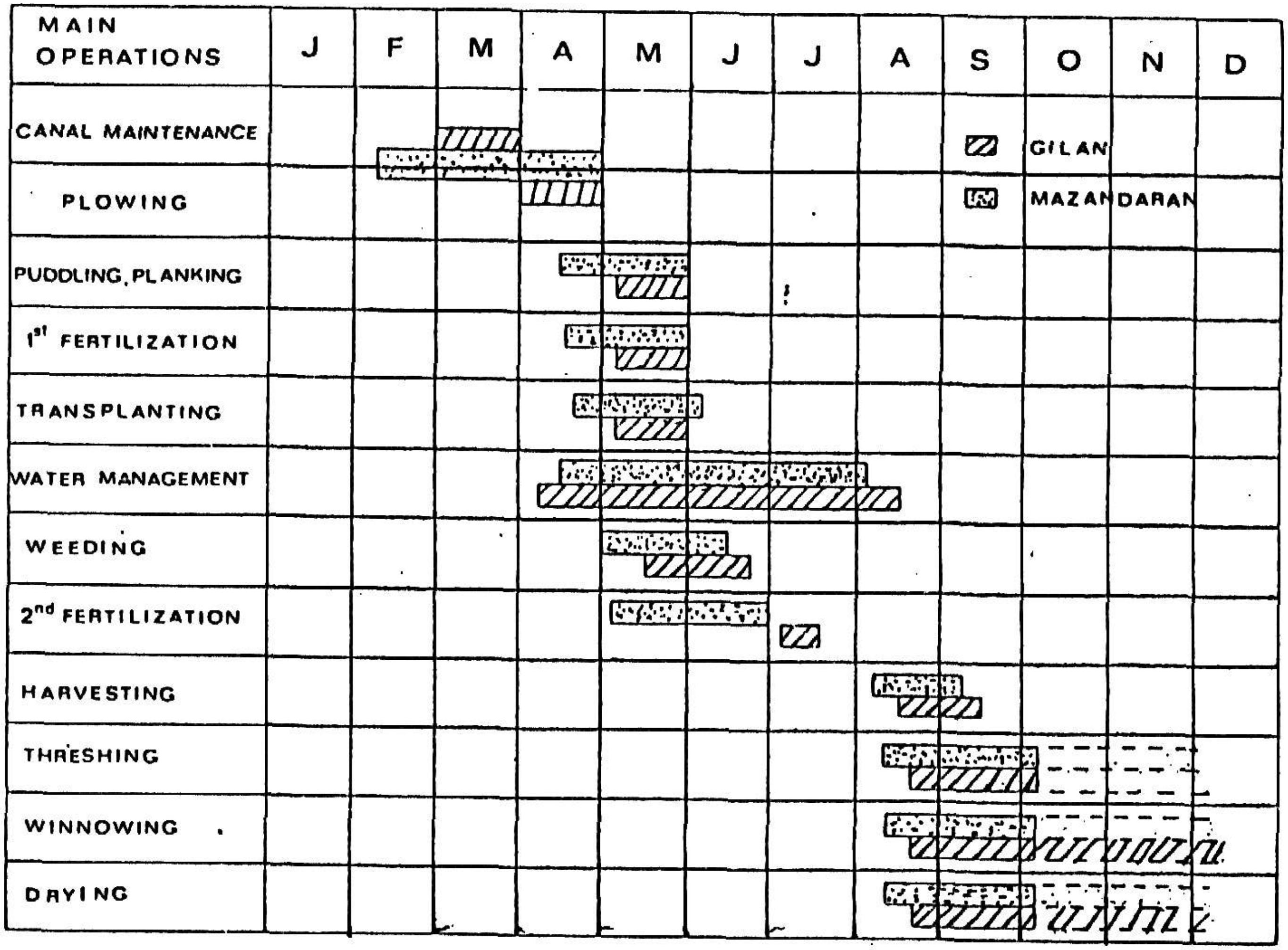

Fig. 4. Useful working periods for different operations.

Source: Nippon Koei Company, Rasht Rice Research Center, Rasht, Iran, 1972.

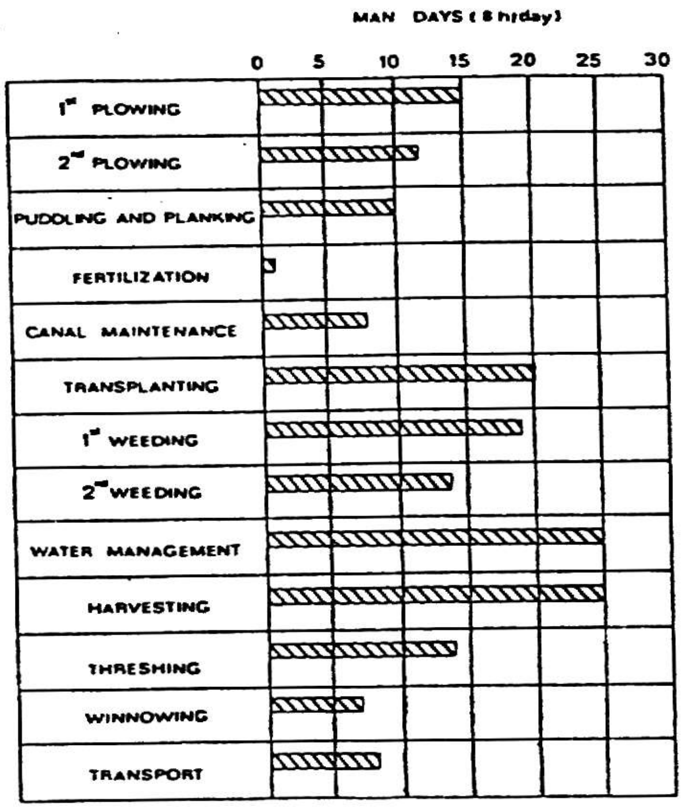

Fig. 5. Labour productivity for rice production operations (Gilan and Mazandaran).

Source: Nippon Koei Company, Rasht Rice Research, Center, Rasht, Iran, 1972.

These two regions represent nearly 90 percent of the area with average slopes of 1 percent in the plains and 10 percent on hilly land. This includes all areas in Gilan and Mazandaran.

Paddy Farms and Agro-Pedological Conditions

The farms in the region are of a small size, generally about 1 - 3 hectares. In practice, 30.2 percent of the farms have less than 1 hectare, 33.5 percent are between 1 and 2 hectare, 21.3 percent are between 2 and 3 hectares and 7.6 percent have an area of more than 3 hectares and only 1.2 percent have more than 10 hectares. Nine percent of these farms are operated on a crop sharing basis, 30 percent are operated by owners and 61 percent are operated by tenants (15).

It appears that for the next 10 to 15 years, there will be a small decrease in the number of agricultural workers (15). The actual rate of industrial development is sufficient to absorb the equivalent annual rate of labor units. Obviously, the enodus from the rural area could be reached by other means such as the institution of retirement age for the farmers. However, this solution does not produce effective results, as will be pointed out in following paragraphs. The population consists mainly of young people.

The majority of the farms are of a limited size and their areas are fragmented into several plots. It appears necessary to improve the irrigation and drainage system with the re-allocation of the farms and the levelling of the soil in both regions of the northern part. Plots have irregular perimeters due to existing counter lines.

In the Gilan province the soil is a heavy clay. It may be more or less calcareous depending on the greater or lesser influence of the Sephid

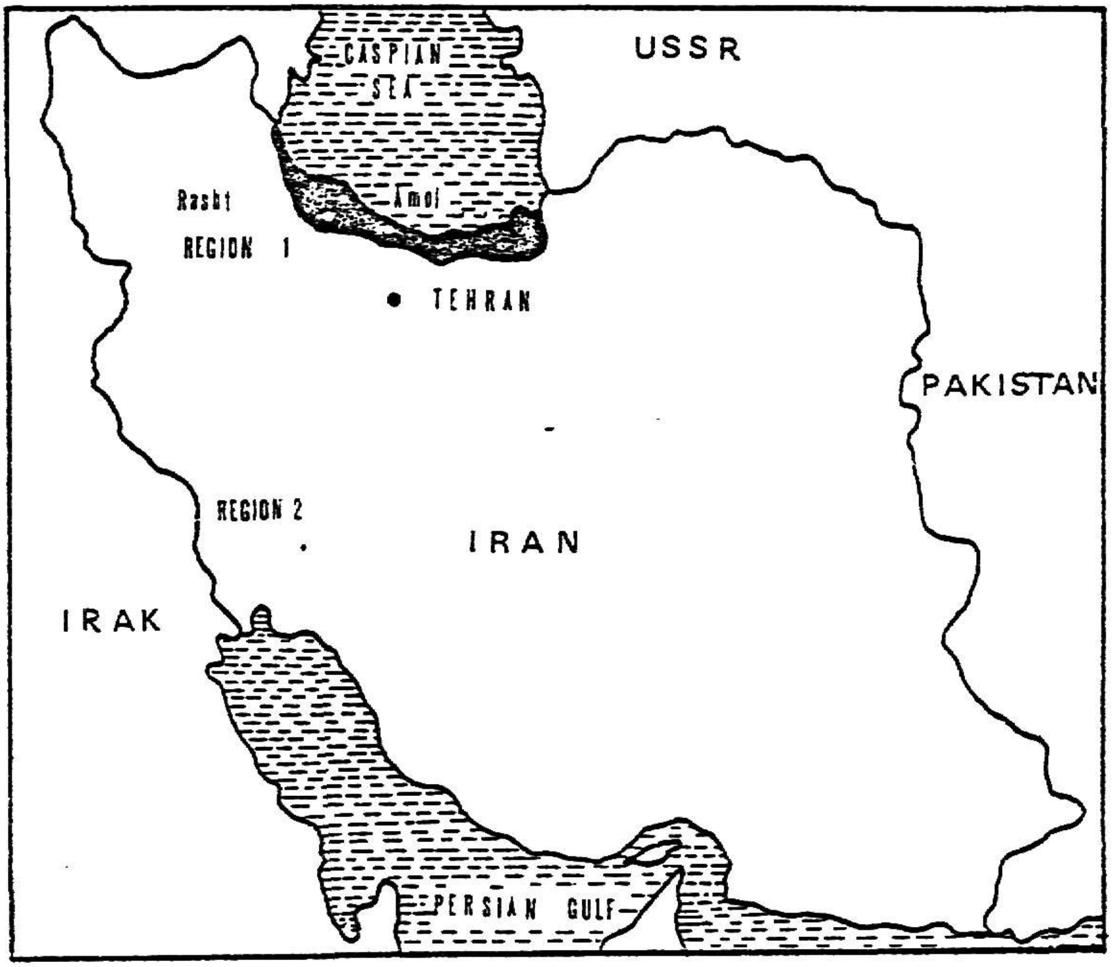

Fig. 6. Region 1 (upperpart of the map) with the two cities of Rasht and Amol where the experimental stations for rice research are located.

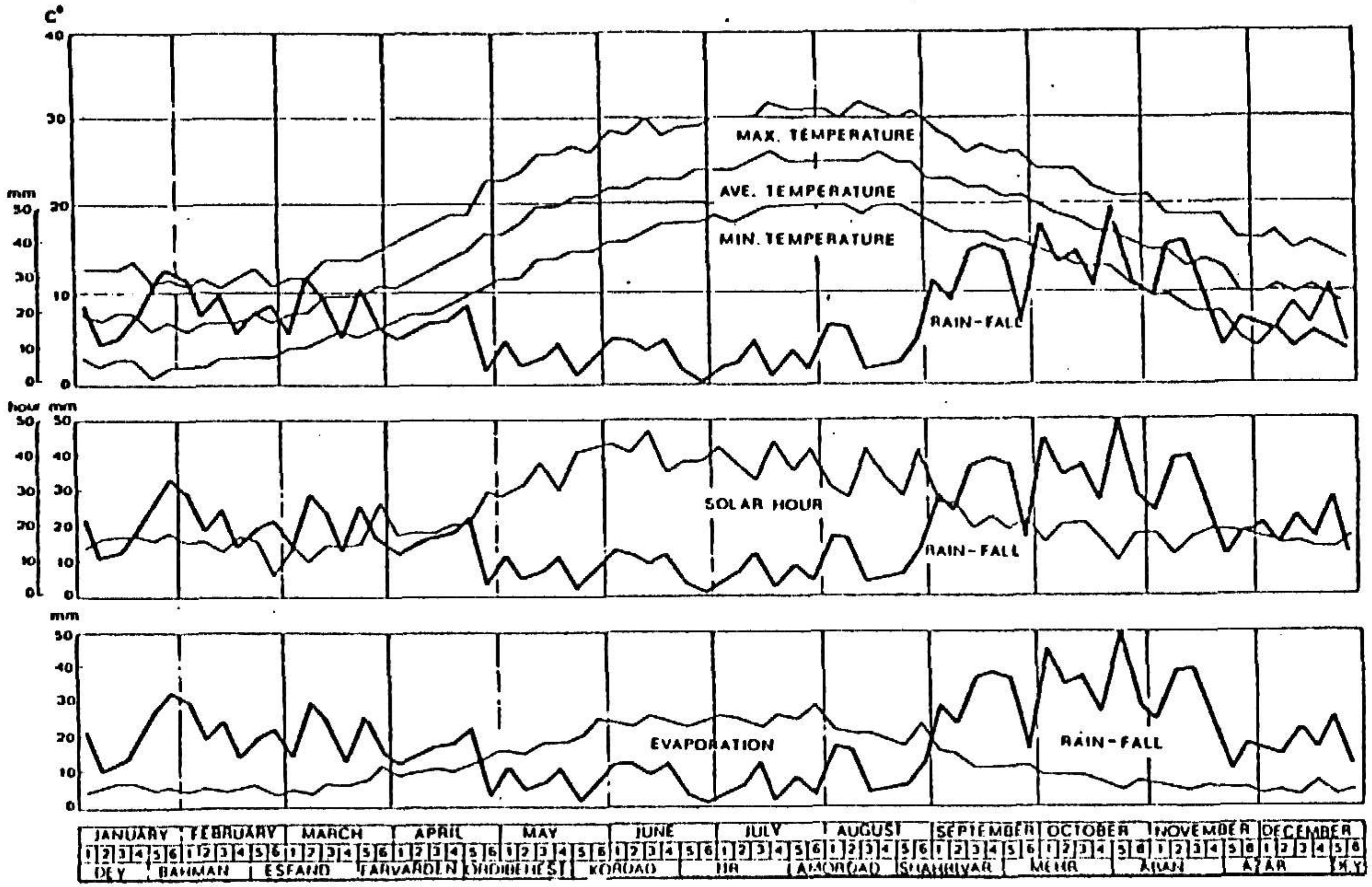

Fig. 7. Fluctuation curves of climatic conditions in Rasht.

Source: Nippon Koei Company, Rasht Rice Research Center, Rasht, Iran, 1972.

Road river. In delta area of the river, soil is of alluvial origin (sandy) with adequate drainage, while in the areas further away from the delta the soil is a clay soil with a PH of 5.2. The irrigation water requirements change due to the type of soils from 0.9 liter per second per hectare for the clay soils to 1.6 liter per second per hectare for the sandy soils. Moreover, in the Mazandaran province, the soil has P.H of 7.7 and is similar to that of the delta area of the Sephid Road river. From the tests carried out in Rasht Research Center (Gilan) plowing resistance was between 80 and 130 kg/cm^2 when in Mazandaran plowing resistance was about 20 to 25 percent less. (15).

Yield Production.

The total paddy production in 1971 was approximately 887,000 tons, 444,000 tons in Gilan and 285,000 tons in Mazandaran. The yield production of paddy was estimated to be around 2.2 - 3.0 tons per hectare in Gilan and around 2.5 - 5.0 tons per hectare in Mazandaran. If it is possible to remove restrictions like labor deficiency, lack of management, inefficient drainage system etc., we may get 4.0 tons per hectare in Gilan.

Sixty percent of the paddy production consists of the so-called Tchampa varieties, of medium and short grain; forty percent is from the so-called Sasdri varieties, of long grain. Saadri usually produce more yield per hectare than Tchampa. On the market, the Saadri varieties represent 60 percent of the total. The Tchampa varieties are used for domestic needs. (15).

The efficiency of drainage of the soil is one of the most important factors limiting the increase of yield per hectare. In Iran the development of efficient drainage systems and field leveling should have top priority as far as engineering concepts are concerned. (15).

PRESENT AGRICULTURAL PRACTICES IN IRAN

In Gilan and Mazandaran provinces there are some differences as far as production and processing are concerned. This causes some differences in the quality of rice. A rice produced in Gilan is more valued and expensive than that in Mazandaran. Cultivation practices are practically the same in both provinces (App. A) even if the execution of the different practices is slightly ahead in Mazandaran due to better climatic conditions. In Gillan, workers are mainly female, whereas in Mazandaran males predominate. This causes a slight modification in weeding technique which in Gilan is carried out by hand while in Mazandaran it is done with feet.

From the two provinces forming part of region 1, Mazandaran has the better possibilities for the introduction of mechanization. Approximately 75 percent of the soil is easily drainable and is dry in the springtime.(15).

The main operations involved in rice growing are as follows: soil preparation (including canal maintenance, plowing, puddling, and planking) fertilizer application, nursery preparation, transplanting, water management, weeding, harvesting, threshing, winnowing and milling. Part of these operations overlap in time.

As a result of the overlapping and different labour productivity at the times the operations are performed, there are notable peak periods especially during transplanting and harvesting.

Soil Preparation.

The tillage is carried out in spring. Work is usually done on flooded land, due in part to the lack of efficient drainage and the need for reducing the tillage resistance of the soil. Seed-bed preparation is always carried out on flooded land; at the same time, farmers prepare the nursery. For soil preparation, animals or 4 - 7 HP power tillers are generally used. Canal maintenance is carried out simultaneously with the plowing in Mazandaran province, while in Gilan this practice is carried out one month earlier than primary tillage. Approximately 15 days are allowed for plowing as far as weather is concerned (normally concentrated in the period from the 10th to the 20th or 25th of April).(15). In Gilan plowing is performed in March and in Mazandaran it is according to the water availability. For the first plowing the average labor productivity is around 100 square meter per hour (1 man + 1 bull). For the second plowing labor productivity reaches 120 square meters per man-hour.(15). Puddling and planking are carried out at a rate of 150 sqr m/man-hour (1 man + 1 bull). Using animals, however it is impossible to work more than 5 - 6 hours per day. On the contrary, with the use of power tillers in Mazandaran approximately 10 days per hectare are required for the seed-bed preparation, the levelling and the boundary maintenance.(15).

Using rotary tillers connected to tractors increases labor productivity notably (5 - 6 times that of the 4 - 7 HP power tillers). In practice this means being able to work an average of 0.2 - 0.3 hectares per hour in comparison with a maximum of 0.035 hectares per hour with power tillers.(15).

Fertilizer Application

The use of chemical fertilizer, although not yet wide spread throughout the region, is developing rapidly. Granular fertilizers are used at an application rate of 0.1 ton per hectare of nitrogen and 0.1 ton per hectare of phosphorous. Fertilizer application is carried out by hand; the labor productivity is approximately 1000 - 1100 sqr. m per hour. The first fertilization takes place on flooded land immediately before transplanting (April - May) and the second one approximately one month later (15).

Nursery Preparation

The preparation of the nursery usually takes place during February and March: sowing begins about April 10. There are, at present, two methods of sowing:

1-Traditional, which consists of using small areas (70 - 80 sqr m per hectare to be transplanted) with a rate of seeding of about 150 - 200 grams seeds per sqr m).

2-The other method (of Japanese origin) is for a lower rate of seeding (approximately 130 grams per sqr m) and requires more area. The preparation of the seed and the subsequent sowing in the nursery requires an average of 4 working days per hectare of cultivated land.

Transplanting

Transplanting is carried out manually by women in Gilan and men in Mazandaran with the random choice of young plants from the nursery (having reached a vegetation stage of 3 leaves). This work takes approximately one month and is normally carried out in May. Labor productivity for this practice is about 50 - 60 sqr m per hour.

Recently interest for using self-propelled transplanting machines has increased amongst farmers; these transplanting machines can work at a rate equivalent to that of 10-15 workers (600-900 sqr m per hour). However, it should be noted that for the correct operation of the transplanting machines, accurate soil preparation (levelling) is necessary. Also special beds suitable for use with this kind of machine must be used; obviously this requires that farmers are skilled in the technique.

Water Management

Water management consists basically of a plot by plot irrigation system. Usually the water level is kept at around 4 - 5 cm. If water level is more than 5 cm, small machines can not work efficiently (16). Time and cost are influenced by the area managed by each worker and depend on the dimensions of the plots and on the slope of the land. During the three week period for water application in Mazandaran, one worker can manage 4 or more hectares. In Gilan, however, the times are more restricted than Mazandaran province. It is possible to count on a uniform availability of water over the whole area besides the possibility of draining it. The capacities have been established at 25 liters per hectare per second. This corresponds to a total requirement of approximately 10,000 - 12,000 cubic meters per hectare. On the basis of water availability, the calculations have shown that in the Gilan province no more than 175,000.00 hectares of land can be irrigated. A complete water supply to the irrigable land could take place within a period of 5-6 weeks starting in the last week of April (16).

Such an irrigation and drainage system is of primary importance for the development of rice growing in the future and for the possible diffusion of a rational mechanization.

Weeding.

Weeding is at present, carried out manually with the use of simple hand operated tools, some experiments are being carried out in the use of chemical herbicides. Manual weeding is usually repeated twice, the first immediately after transplanting and the second approximately one month later. For the first manual weeding, 18 - 20 man-days per hectare are required; approximately 12 man-days per hectare are required for the second one. For the first weeding, in terms of labor productivity, it is done at 60 - 65 sqr m per hour and the second weeding at 80 sqr m per hour (16).

Harvesting.

The harvesting of the short and medium grain varieties (Tchampa) begins in the third week of August, while for the long grain variety this starts in September. The operation is carried out with a sickle; the plant is cut at 30 - 40 cm above the soil surface. Sheaves are then formed. They remain in the field for two or three days, after which they are transported to the farm center and left in the open air for drying. To harvest one hectare (with sickles and to sheave the product) 20 to 35 working man-days are required. In terms of labor productivity, 80 - 110 sq m per hour are required for cutting and 60 - 65 sq m per hour for tyeing and transportation (16). These figures are reduced by up to 70% if the work is done by women instead of men.(15).

At the present, grainlosses due to hand harvesting can be evaluated at around 4 - 6 percent. The use of the self-propelled combine equipped with a 360 cm cutter bar on plots of 0.5 hectares showed a work productivity of around 2.5 hectares per day increasing to a maximum of 5 hectares per day on plots of 1 hectare. Such figures decrease by a factor of as much as 20 when small Japanese combines with 50 cm cutterbar are used (16).

Threshing.

Threshing is generally carried out manually with special wooden or leather flails or in some cases using animals. Several thousand Japanese type stationary threshers are already in use in the region. These machines are generally utilized at cooperative or at village levels. They are usually hired together with an operator, and their productivity is about 75 - 100 kgs per man-hour. Hand threshing is at a rate of productivity ranging from 20 - 40 kgs per man-hour (16).

Drying.

In the Gilan province, paddy is generally dried in special sheds at the farm center. A oil burner or more frequently a burner that utilizes the chaff is used for heating the air. This is a fairly long process that can be postponed since the moisture content of the paddy at harvest time is quite low (23 percent). A better quality of rice is obtained from slow drying for the Tchampa varieties which are more delicate; the operation requires 7 - 10 days on an average. Thirty five to forty five hundred kgs of paddy can be dried per batch. The use of small static type stationary dryers (up to 10 tons capacity) is becoming more widespread; drying capability varies from 100 - 1,300 kgs per hour. The power requirement for the dryer air flow system is between 15 - 25 H.P. (16).

The drying problem is presently of relatively little importance. It will however be quite a different matter once rational mechanization for harvesting takes place (be it either with reaper-binders or combines) due to the necessity of harvesting paddy at a higher moisture content to reduce grain losses.

Milling.

This operation is carried out throughout the year since the farmers market their rice at rather random times.

However, due to the lack of money, farmers tend to sell their rice during the first month after the harvest. Milling is not usually done at the farm level although some machines have recently been sold for this purpose. Milling is usually done at the village level or at large processing centers equipped with modern mill plants. The widespread small plants have an efficiency of between 60 to 75 percent.

The farmers pay, in general, 3 percent of the product weight for milling. There are large capacity plants with capacities ranging between 2.5 - 5.4 tons per hour. In fact, farmers having only a few tons prefer to utilize small mills at village level.

The Second Crop.

The introduction of the second crop (forage) in rice growing areas, is considered as one of the most promising means of providing winter work and increasing the farmer's income.

However its introduction is necessarily linked to the adaption of improved soil drainage. The soil, is usually flooded in the winter due to the overlapping of the rainy season.

ADAPTATION OF FARM MACHINERY FOR LOCAL CONDITIONS IN IRAN

Seventy-five years of development of farm tractors and implements have resulted in a range of sizes, types and designs to meet most of the soil and climatic conditions encountered in the world's agriculture (12).

Yet a serious deficiency exists in the selection and adaptation of agricultural machinery for developing countries. The tendency has been simply to transpose and apply a limited range of equipment manufactured and designed for, and in, the industrialized countries to all other parts of the world. This has been done on a purely commercial basis with little or no effort to test and demonstrate agricultural machinery under local conditions. Most of the local farm equipment agents are conglomerate importers which do not have good knowledge of the products, their limitations, use or application (3).

From my experience, this always has been true of the farm machinery market in Iran. In recent years, the Iranian government has started a new policy to remove this kind of deficiency and overcome the problem through the establishment of testing laboratories and the promotion of local manufacturing.

In the world, efforts for improvements in efficiency will continue. Continued efforts will also be made to accomodate new cultural practices, and to meet the requirements of specific local conditions. Many of the problems of adaptation of farm machinery to local conditions have been overcome by manufacturing implements in Iran. Japanese factories during recent years have done a lot of surveying, and year by year introduced new implements and tractors to rice-growing farmers in Iran.

Local Manufacturing.

The majority of Iranian local manufacturies has developed and grown by duplicating existing designs or old designs. A few years ago, the Iranian government considered investing in the manufacture of sophisticated agricultural machinery, such as tractors and large specialized equipment. Manufacturing is now being done in different ways and levels, it includes hand tools and animal draught equipment, single-axle tractors, two-axle tractors, and associated implements, according to farmer's demand for different types of machines and equipment. In areas where agriculture must continue to rely on hand and animal power, significant increases in production and efficiency can be achieved through the development, introduction and promotion of improved tools and implements utilized with traditional sources of power.

Principles of Design and Selection.

It is apparent that few revolutionary farm machinery designs have emerged in recent decades. Even if major emphasis were placed on the design of implements to meet implied special soil and climatic conditions in developing countries, it is unlikely that major design changes would arise (3).

Reviewing the development of mechanization realistically reveals that although many countries have undergone a revolution in agricultrual machinery production and mechanization, the changes involved in the revolution however have primarily been modifications rather than of major design changes. The tractor evolved as a mechanical replacement for animal power. Animal draught implements evolved as modifications and adaptations of hand implements, and, in turn, tractor implements evolved as modifications and adaptations of animal draught implements (3).

The moldboard plow is a good example of design evolution. The moldboard plow has been used for centuries and although there have been literally hundreds of modifications and improvements, the principle and basic design is still the same, whether it be an animal-powered unit, or a tractor-powered 6 to 8 multiple moldboard implement. It is uncommon for moldboard plows to be branded as unsuitable for local soil conditions when, in fact, only one or two particular body designs have been tried. Many people do not appreciate the fact that a large manufacturer may have ten or more different moldboard configurations available in different materials for varying soil condiitions. In addition, there may be several different share types and shapes, various attachments, such as covering boards, moldboard extensions, coulters, jointers, covering rods, frame combinations, etc., which, in total, may literally make hundreds of different combinations possible (3). Each plow and variation thereof is designed to perform a particular function under a particular set of conditions. A similar but more limited variety of designs and combinations is available for farm tractors, implements, and tools. Unfortunately, only a limited number of types are known or available in Iran. In order to overcome this problem more different types suitable to local conditions of Iran must be introduced. This would give the farmer the opportunity to choose the type of moldboard suitable for his conditions.

There are many poorly designed agricultural machines on the market and there are considerable differences in quality of the farm machinery available. A more rapid and greater impact is likely to occur from critical selection and application of existing farm machinery designs than from a costly effort to design new equipment.

Suitability of Machinery, Crops and Systems

In spite of the fact that most of the essential tractor implements are available in today's world market, the present trend to larger and more sophisticated equipment in the industrialized countries is cause for concern in the developing countries. Many of the styling, comfort, and convenience items found on modern tractors must be considered luxuries which many farmers in developing countries can ill afford (3). In Iran, because of technical, educational, and economical problems, farmers, especially those who have small farm holdings, can not afford large tractors with sophisticated systems and tools. Animal draught implements and hand tools, even in large areas, are still used and have an important role in agri-production of Iran. In some regions, especially in the south where dryland agriculture is practiced, there are some sophisticated tractors and combines used in sugar cane and cotton production, but this is not a dominant sector of mechanization in the agriculture of Iran. In Iran, small scale farming is a reality and increased mechanization at that level seems to be needed. Although large scale farming may contribute to the solution in some countries, in many of them it is necessary to deal with the small scale farming (3).

As far as economic considerations are concerned, tractor mechanization, I think, will require that crop rotations and cropping patterns be altered, and production intensified and extended to achieve sufficient output to compensate for the increased expense of mechanization. The better lands capable of producing high yields will have to be mechanized first. Farms must be laid out to facilitate field operations and, wherever practical, fields will have to be made regular in shape even to the extent of relocating hedges, ditches, fences and roads.

GENERAL PATTERN OF MECHANIZATION IN IRAN

Present Situation of Mechanization.

After agricultural machinery development; agricultural machines and tools were introduced rapidly to the farmers (15).

It is difficult to get statistics in regard to the process of mechanization of agriculture in Iran. The mechanization problems of Iranian agriculture are classified into two groups as follows.

1 - Farm mechanization in rice cultivation area of the Caspian Sea of northern Iran - In the rice cultivation area of Gilan and Mazandaran states, about 85% of farmers have paddy fields of less than 3 ha. Small tractors and other small farm machines are introduced year by year rather than larger sizes due to small size of farms. The Japanese small tractors number has increased to 160,000 units. Small tractors, trailers and power threshers are introduced as a three-set machine to the farmers. About 10,000 power-threshers have been imported so far; 1,400 units are sold annually. Recently, the introduction of farm pumps and sprayers has started (16).

2 - Farm mechanization in the dry area of southwest and western Iran - Another area besides the Caspian Sea which is very dry is the southwestern areas of Iran. The size of farms is large, therefore, large tractors (of more than 60 hp) and combine harvesters are used. There are about 24,387 large tractors in this part of the country. These include many kinds of foreign tractors, especially the Universal tractors made in Romania (wheel type, 45-65 hp) (15).

Present Situation of Mechanization, Local Manufacturing, Distribution, and After Sales Service in Rice Growing Area.

It is difficult to obtain precise data on the existing quantity of machinery in the rice growing area. Power tillers and other agricultural machines were introduced into Iran about 15 years ago. In 1970 the number of 4-8 hp power tillers in Region 1 was about 20,000 units. There were 4500 threshers with 4-5 hp engines and 1500 dryers with a capacity of 1-1.5 tons of paddy per day (16).

Small plows, rotary hoes, puddlers and plankers of suitable sizes are used as attachments for power tillers. Plows and other simple animal drawn machines are now used for seed preparation while transplanters and sprayers are still at the experimental stages of adaptation in Region 1.

Certain aspects of local tractor and agricultural implement production cause problems relating to mechanization progress. Tractor and agricultural machinery industry in Iran is still a limited one (16). There is presently only one wheel tractor factory. It is a cooperative eastern-European factory with a sanctioned production capacity of more than 5000 units per year. This factory has not worked at full production capacity since 1970.(16). Prior to 1978 it produced less than 4000 units per year (65 hp size, both 2 and 4 wheel drive and 45 hp 2 whlle drive); there are also 2 assembly plants for 50-70 hp wheel tractors with a combined sanctioned production capacity of 26,000 units per year. The total production of the 3 factories together was approximately 5000 units in 1975. For power tillers too, there is only one factory (a cooperative Japanese firm); it has a production capacity of 6,000 units per year. It produced 3500 units per year prior to 1978 (16). The manufactured power tillers sizes range between 4 and 12 hp in 4 models. They are equipped with either gasoline or diesel engines. This factory is also assembling several hundreds of threshers, moldboard plows, rotary tillers and trailers per year that can be connected to the power tillers (15).

There are many dealers and agents for selling American, European, and Japanese tractors and implements in Iran. In region 1 there are 4-5 dealers for each of the provinces of the region (15).

Regarding after-sales service of the agricultural machines, it should be noted that these are not supplied with a guarantee. Generally, small repairs are done in the villages while more difficult repairs are carried out by the dealer. Dealers usually have a warehouse well-stocked with spare parts.

As far as price is concerned, a 7 horse power tractor costs 6000 - 7000 rials ($85-$100)per hp equipped with 2 kinds of wheels (rubber and cage). A plow and a leveller are sold for 120,000 Rials ($1700); a thresher (of the Samal type with 200 - 280 kgs per hour paddy capacity) costs 57,000 Rials ($800). A transplanter (Mitsubishi PS-211 type) costs approximately 20,000 Rials ($280) (5).

Preliminary Tests Carried out at the Rice Research Center in Rasht on Existing Machinery

To verify equipment performance researchers at the Rice Research Center Gilan-Iran, have carried out some preliminary tests concerning capacity and work quality (15).

1-Tests on a 7 hp power tiller with cage wheels and a Japanese type reversible plan - The test was carried out on flooded soil over a length of 12 m. The machine weighed between 244 and 258 kgs depending upon the type of engine.

The results obtained were as follows (Table 8).

Average forwarding speed: 0.38 - 0.41 m per second;

Average depth of plowing 10 - 12 cm;

Average cross section area: 2.2 cm^2;

Average power required (based on disel fuel consumption): 3.5 - 3.7 hp;

Idle time for turns and changing of position of the plow: 7 - 8 seconds; practical work capacity (on plots of 12 x 1 m): 0.020 - 0.025 ha/h; work productivity: 50 h/ha; quality of work: The soil was only scratched on the surface and mixed with water. The machine proved unsuitable for work on dry soil due to insufficient drawbar pull capability.

2-Tests on 40 hp tractor with crawler tracks and 40 hp wheel tractor which was equipped with double cage wheels. Both tractors were coupled to a rotavator with a width of 1.80 meters (44 blades) - The test was carried out on soil saturated with water; the machine worked over a continuous run and therefore without idle time.

The following results were obtained (Table 9).

Average forwarding speed: crawler tractor: 0.6 m/S; wheel tractor: 1.0 m/S

Average work width: crawler tractor: 1.35 - 1.75 meter;

wheel tractor: 1.30 - 1.40 m;

Average work depth: could not be maintained constant due to the irregularity of the soil bottom; estimated about 20 cm;

Average power required: Crawler tractor: 35.5 hp; wheel tractor 34.0 hp;

practical work capacity: crawler tractor: 0.40 hectare per hour;

wheel tractor: 0.48 hectare per hour;

Work productivity: crawler tractor 2.5 hour per hectare; wheel tractor 2.1 hour per hectare;

Table 8. Results that were obtained from tests on a 7 hp power tiller with cage wheels and a Japanese type reversible plan.

Average forwarding speed	0.38 - 0.41 m/sec.
Average depth of plowing	10 - 12 cm
Average cross section area	2.2 cm^2
Average power required*	3.5 - 3.7 hp
Idle time for turns and changing of position of the plow	7 - 8 sec.
Work capacity**	0.020 - 0.025 ha/h
Work productivity	50 h/ha

* Based on disel fuel consumption.

** On plots of 12 x 1 meter

Source: Nippon Koei Company, Rasht Rice Research Center, Rasht, Iran, 1972.

Table 9. Results that were obtained from tests on a 40 hp tractor with crawler tracks and double cage wheels.

	40 HP tractor with crawler tracks	40 HP tractor wheel tractor with double cage wheel
Average forwarding speed	0.6 m/s	1.0 m/s
Average work width	1.35 - 1.75 meter	1.30 - 1.40
Average work depth*	20 cm (estimated)	20 cm (estimated)
Average power required	35.5 HP	34.0 hp
Work capacity	0.40 ha/h	0.48 ha/h
Work productivity	2.5 h/ha	2.1 h/ha

* Could not be maintained constant due to the irregularity of the soil bottom.

Resource: Nippon Koei Company, Rasht Rice Research Center, Rasht, Iran, 1972.

Quality of work: The quality of work proved to be inadequate. The depth of the tillage was irregular due to soil conditions. Both tractors tended to sink into the soil. Consequently they used practically all their power to propel themselves thereby leaving little power available for hoeing. When the bearing capacity of the soil was adequate to reduce tractor sinking, engine power still was inadequate and the tendency to stall was noted (15).

3-Tests with a new self propelled transplanter.

This machine requires special preparation of the nursery (small low lying beds [160 trays per hectare] are formed [28 x 54 x 2 cm]).

The distance between the rows was 30 cm and between the plants 15 cm. The machine had a total weight of 70 kgs and was driven by a 2.2 hp engine.

The results of the tests were as follows.

Average forwarding speed: 0.3 - 0.5 meter per second;

Average work capacity: 0.8 - 0.12 hectares per hour;

Average work productivity: 80 - 120 hour per hectare;

Quality of work: The work carried out proved to be of good quality regarding the regularity of distribution and the small degree of mishandling of the plants. Although requiring very well leveled fields and a special preparation of the nursery, the machine proved to be promising (15).

In addition to the above tests the impression on the performance of two additional machines has been reported by Rice Research Center, Rasht, Iran.

1-Plowing with a 40 hp crawler tractor and disc plow (2 discs) on very wet soil. The tractor tended to sink into the soil leaving heavy track marks. It proceeded very slowly with a high slip of the crawler tracks. The disc plow turned the soil over in a very irregular manner (15).

2-Harvesting of the rice with a self-propelled combine equipped with a 3.6 meter cutting bar width. The machine left heavy furrows in the gound when operated on land saturated with water. These furrows were immediately covered with stagnant water. It appeared that it would be difficult to eliminate them with subsequent work. The advancement of the machine proved to be very difficult, also a high loss of grain was reported.

The above tests left doubts about the possibility of a rational mechanization (using the existing farm machinery). The small power tillers do not seem suitable for mechanization development and increased yields. The reason is that they are only able to work on the wet, saturated soils. This soil condition reduces the draw bar pull required. These power tillers offer no real advantages over traditional methods of working with implements drawn by animals as far as improvement in the quality and work productivity is concerned (15).

THE OPTIMAL MECHANIZATION LEVELS OF RICE GROWING IN IRAN

General Aspects.

The previously described situations have made it evident that:
1-Rice growing is still tied to traditional practices based on the use of man and animals (15).
2-The soil is, in the majority of cases, permanently impregnated with water due to lack of drainage. Moreover, it will not be possible to resolve the problem of reducing peak periods with the increased use of power tillers. This is particularly true as far as transplanting and harvesting are concerned (15).
3-An improvement in the condition of the soil can be reached only by creating an efficient drainage network. Such a network should be considered an indispensable step towards the development of mechanization through which the following objectives could be reached: (a) a substantial increase in productivity of the soil and (b) a reduction in effort in performing different operations in terms of timeliness and reduction in passes (15).

As a result of the above, mechanization based on the use of small power tillers is not feasible since they can only be used for small areas, such as those found on small farms of one hectare or less. These small farms would be in a weak competitive position compared with larger ones. Cooperatives formed by rice growers would allow for the introduction of a more advanced and rational mechanization consistent with the socioeconomic development of the country.

The irrigation and drainage systems should be taken into consideration as far as they effect land preparation. This will make it necessary to study a mechanization that is feasible in both economic and technical terms.

The following elements must first be considered when an implement or machine is introduced to accomplish mechanization (15).

1-Proper selection of tractor in terms of work capacity, the size of farms, the pedologicol conditions and the technical knowledge of the technicians. This is to guarantee complete utilization of its work capacity.

2-Consistency in tractor-machinery selection to guarantee maximum performance from them.

3-Maintenance and essential repairs availability.

4-Adequate technical preparation of the drivers and the mechanics in the workshop where repairs will be carried out. This last point is of fundamental importance.

In fact, the introduction of machinery requires trained technicians at all levels. Farmers must have facilities to improve their knowledge in order to obtain the best results offered by mechanization. Along with introduction of the mechanization, the development of the mechanization and technical assistance to farmers must always be considered (4). It is also useful to examine the manufacturing aspects because manufacturing requires a knowledge of market, the presence of basic and ancillary industries apart from well trained personnel and the possibility of supply of satisfactory raw materials. The machinery produced must be properly designed and tested and of good quality in order to overcome the problems of the general lack of awareness on the part of the farmers, the small amount of machinery per land unit, the large distances between manufacturing industries and users and the lack of qualified personnel (7). Cooperation with industries from more technological advanced countries would perhaps be the best solution in the near future. This venture would be done on the basis of thorough investigations of the optimum mechanization levels to be achieved. Therefore the models and the size of machinery would be selected consistent with the economical situation of the country, the existing structures and the foreseen increase in work productivity as a result of mechanization.

The basic problem of defining optimum mechanization levels also must be studied. These levels must be consistent with the density of the active population in the rice growing area and wage levels in order to keep production costs at a minimum level. In order to define the real basis of the problem accurate studies must be carried out. A suitable group of machinery can be introduced to minimize the labor cost (15).

Tractors and Machines Suitable for Local Conditions.

Once these basic outlines have been carried out and before carrying out certain proposals relative to the definition of alternative mechanization levels, it would seem appropriate to produce some details about the machinery which would appear to be suitable for the mechanization of rice growing in the northern part of Iran (15).

If we have sufficient irrigation and drainage systems, it will be possible to work on dry soil and on plots of a rational size and dimension. The modification of some traditional cultivation practices must be considered in order to have a good work efficiency (9).

It must also be remembered that the average present wage level is approximately 250 Rials per day. A gradual reduction in the active population is foreseen. Consequently it is not correct to think of a mechanization level suitable for the small "individually managed" farms. This is due to economic reasons and to the foreseen necessities of having to work on dry soil. It is difficult to provide drainage for a large number of small farms (15).

The machinery must be such that it will not cause too much increase in labor productivity and in production cost of the rice (15). Consequently as far as the tractor selection is concerned, a 35 hp tractor, simple and strong, with a weight power ratio of about 40 kg/hp would be considered adequate for rational use. For heavy and dry soil, however, the drawbar pull required for plowing may be too high for this particular size of tractor, for this reason a 4-wheel drive model with a drawbar pull capacity almost 25 percent more than the 2-wheel drive should be considered (15).

A higher mechanizational level could be considered when agricultural wage levels of 800 Rials/day have been reached. It is then possible to use tractors of approximately 75 hp to an economical advantage. This tractor would offer an increase of about 70 - 80 percent in labor productivity in comparison with 35 hp tractors (15). Implements with suitable capacities are naturally required for use with these tractors (15).

The operations which should be given top priority are seed bed preparation and harvesting as far as implements and reduced peak periods are concerned. For primary tillage we may use a single bottom moldboard plow drawn by 35 hp tractors with 2 or 4-wheel drive, quadrilateral articulated spading machines with a working width of 1.20 meter (connected to a 2-wheel drive tractor) and driven by pto. Both machines have a working depth of up to 30 centimeters. Similar machinery but of a larger size can be considered for the mechanization level based on 75 hp tractors (15).

For secondary tillage the use of the oscillating harrows should be considered in addition to the disk harrow (15). Regarding transplanting, the use of the small self-propelled transplanter is valid even if it requires a particular preparation of the nursery and perfect leveling of the soil (15). If this is not possible, the drawn transplanter for a 35 hp tractor or a 75 hp tractor should be considered. Such machines equipped with special furrowing discs facilitate the laborers' transplanting work rendering it quicker and less tiring.

For weed-control, tractor mounted machinery suitable for the mechanical destruction of weeds and sprayers must be considered (15).

For harvesting, reaper-binders mounted behind 35 hp tractors are useful. Other solutions of the drawn type, p.t.o. drive, also could be considered (15). Self-propelled combines could be considered at a higher level of mechanization. Combines don't seem to be economical to use under present conditions. Mechanical harvesting must be carried out with the moisture content of the paddy 3-5 percent higher than the present moisture content considered for manual harvesting. Flat bed dryers with a capacity of approximately 0.4 ton per hour should be used for this condition (15).

Another group of equipment that could be used consists of: Rotary ditchers coupled to 35 hp tractors for the maintenance of irrigation and drainange canals up to a depth of 60 centimeters, and larger rotary ditchers coupled to 75 hp tractors for canal maintenance up to a depth of 100 centimeters (15).

Tractor drawn rotary scrapers with a capacity of between 1 and 2 cubic meters, and small tractor drawn leveling blades for periodic plot leveling may be used (15).

These operations are very important for obtaining and maintaining an efficient water management program. The program of milling plants is not urgent in terms of priority. In the reorganization of the rice growing sections it will be necessary to plan for a gradual substitution of the existing milling plants with modern plants with a capacity of not less than 1 ton per hour and provided with consistent storing and handling equipment.

Study of alternative levels of mechanization.

Following the general criteria for models of mechanization at the beginning of this chapter, it seems necessary to specify the levels of mechanization that meet present and future requirements.

This is determined by considering Table 10. The mechanization system is based on the use of a 35 hp tractor with 2 or 4 wheel drive, equipped with consistent equipment. Field operation capacities are based on the hypothesis that the field average is 2,000 sqr. meter each (15). The machine, labor and energy values for the various operations are presented in Table 11 which indicates the following values:

Average annual utilization of the 35 hp tractor: 1,450 hours per year, in the case of manual transplanting or of direct sowing; 2,100 hours per year in the case of mechanical transplanting with a transplanter coupled to the tractor itself.

Average specific use of the tractor: 60 hours per hectare in the case of manual transplanting or direct sowing; 85 hours per hectare in the case of mechanical transplanting.

TABLE 10.35 HP tractor 2 wheel-drive - Performance and power requirements for different agricultural machinery working on 2000 sqm plots with time losses of approx. 50%.

	Type of machine	Type of coupling	Work width (m)	Average speed (m/s)	Productivity (ha/h)	Time required work 1 ha (h/ha)	Average power required (HP)	Approx. price of the machines (U.S. $)
1	Ditcher	mounted	0.4([1])	0.2	350([2])	2-3	30-35	1,000
2	Straw chopper	semimounted	2.0	0.3	0.15	6-7	25-30	1,100
3	Spading machine	mounted	1.2	0.5	0.12	8-9	25-30	1,000
4	Rotary scraper (1 m^3)	pulled	1.2	-	- (*)	12-14	25-35	1,200
5	Leveller	mounted	2.0	0.5	0.30	3-4	20-25	1,000
6	Oscillating harrow	mounted	1.2	1.7	0.36	2.5-3.5	20-25	500
7	Puddler	mounted	2.0	1.1	0.40	2-3	15-18	250
8	Planker	mounted	2.5	0.8	0.40	2-3	15-18	250
9	Fertilizer distributor	mounted	8.0	1.7	1.50	0.5-1	15-18	140
10	Transplanter (4 rows)	mounted	1.2	0.5	0.15	6-8	20-25	1,000
11	Broadcaster	mounted	8.0	1.7	1.50	0.5-1	15-18	1,200
12	Weeder	mounted	1.2	0.5	0.15	6-8	18-20	800
13	Herbicide distributor	mounted	8.0	1.7	1.00	1.0-1.5	15-18	500
14	Reaper binder	mounted	1.5	1.1	0.25	3-5	20-25	1,200
15	Trailer	pulled	-	2.0	-	9-11	10-15	1,000

(*) In the hypothesis of an earth movement of 2 cm working capacity 15 m^3/h.

([1]) Canal depth or boundary height.

([2]) Productivity in m/h.

Source: Nippon Koei Company, R.R.C., Rasht, Iran, 1972.

Average power required: 22-23 hp, corresponding to 63 percent of the maximum power.

Labor requirement: 540 man-hours per hectare in the case of manual transplanting; 170 man-hours per hectare in the case of mechanical transplanting; 105 man-hours per hectare in the case of direct sowing (without transplanting). This indicates a low utilization coefficient for the tractor and implements; there is also the possibility of technical obsolescence within 5 years and optimum use of the tractor power.

The power per land unit is approximately 1.3 horsepower per hectare.

It is important to note that, with present methods, the operations shown in Table 7 would require manpower of approximately 900-950 man-hours per hectare. If manual transplanting and weeding is continued as a part of the production system an increase in productivity of about 15 percent would be obtained. On the contrary, with the mechanization of both the planting and weeding operations, productivity would increase by approximately 4-6 times. Taking into consideration all the operations necessary for the production of rice, from the water management to the nursery preparation and the threshing, the work productivity increases by approximately 100 percent thereby providing for a more complete use of the tractor and the implements.

Thus it will be possible only with complete utilization of the irrigation and drainage networks and a consistent land consolidation; planning would also be required for cooperative management of the above mentioned mechanization (15).

However, the organization of mechanization can not be limited to only machinery used in the fields. It must also include the common use of

Table 11. 35 HP tractor 2-wheel drive, workable area 25 hectare, annual utilization of the machine, energy consumption and labour requirements for different levels of mechanization.

Practices	Average utilization of the machines (h)			Energy consumption (HPh)			Labour required (man hours)		
	transplanting by hand	transplanting by machinery	direct sowing	transplanting by hand	transplanting by machinery	direct sowing	transplanting by hand	transplanting by machinery	direct sowing
1-Canal maintenance	60-65	60-65	60-65	1950-2113	1950-2113	1950-2113	120-130	120-130	120-103
2-Straw chopping	160-170	160-170	160-170	4400-4675	4400-4675	4400-4675	160-170	160-170	160-170
3-Spading	210-220	210-220	210-220	5775-6050	5775-6050	5775-6050	210-220	210-220	210-220
4-Earth movement	320-330	320-330	320-330	8800-9075	8800-9075	8800-9075	640-660	640-660	640-660
5-Levelling	85-90	85-90	85-90	1913-2025	1913-2025	1913-2025	85-90	85-90	86-90
6-Boundary maintenance	-	-	-	-	-	-	230-250	230-250	230-250
7-Harrowing	145-155	145-155	145-155	3263-3488	3263-3488	3263-3488	145-155	145-155	145-155
8-Puddling	60-65	60-65	-	990-1073	990-1073	-	60-65	60-65	-
9-Planking	60-65	60-65	60-65	990-1073	990-1073	990-1073	60-65	60-65	60-65
10-Fertilizer distribution	-	18-20	18-20	-	297-330	297-330	220-250	18-20	18-20
11-Transplanting by hand	-	-	-	-	-	-	4800-5000	-	-
12-Transplanting by machinery	-	170-180	-	-	3025-4050	-	-	1200-1250	-
13-Broadcasting	-	-	18-20	-	-	297-330	-	-	36-40
14-Weeding by hand	-	-	-	-	-	-	5800-6000	-	-
15-Weeding by machinery	-	450-500	-	-	8550-9500	-	-	450-500	-
16-Chemical weeding	-	-	35-40	-	-	578-660	-	-	78-80
17-Reaper-binding	100-110	100-110	100-110	2250-2475	2250-2475	2250-2475	300-330	300-330	300-330
18-Handling and transportation	230-250	230-250	230-250	2875-3125	2875-3125	2875-3125	460-500	460-500	460-500
Total	1430-1520	2068-2220	1441-1535	33206-35172	45878-48152	33091-35089	13290-13885	4138-4405	2534-2710
Tractor and labour productivity (h/ha)	57-61	83-89	58-61	-	-	-	532-555	166-176	101-108
Average input of enerngy required per hectare (HPh)	-	-	-	1328-1407	1835-1926	1324-1403	-	-	-
Average power required (HP)	-	-	-	22.9	22.1	22.7	-	-	-

Source: Nippon Koei Company, Rice Research Center, Rasht, Iran, 1972.

machinery and plants for threshing, drying, storing and milling (9). It can thus be hypothesized that the following equipment should be included in the mechanization system:

1. Stationary threshers, with an average working capacity of 0.2 ton per hour, for each 12.5 hectares;
2. Horizontal type dryers with an average working capacity of approximately 0.4 ton per hour for each 50 hectares;
3. Mill plants, with consistent storing and handling equipment and an average working capacity of 1 ton per hour for each 500.00 hectares of rice.

This means that the mill plant (Table 12) would be used for an area consisting of 20 farm cooperatives (25 hectares each) for the common use of the above mentioned machinery. In this case, each dryer could be utilized an average of 220 - 250 hours per year, while every mill plant could work at least 1,200 - 1,400 hours per year.

It is also necessary to plan for the construction of a workshop for the repairs and maintenance of the twenty 35 hp tractors and their implements. Since the problem of the ordinary maintenance of the irrigation and drainage canals at each milling center arises, it will be necessary to have two 75 hp tractors equipped with p.t.o. driven rotary ditchers as well as other digging, earth moving and leveling machinery (15).

Another, more sophisticated and complete mechanization level has been studied, based on the use of a 2-wheel drive 75 hp tractor, with consistent implements (Table 13) which is capable of farming an area of 40 hectares.

Also for this mechanization level, an alternative solution to mechanical transplanting or direct sowing has been included. The results that could

TABLE 13. 75 HP tractor 2 wheel-drive - Performance and power requirements for different agricultural machinery working on 5000 sqm plots with time losses of approx. 20%

Type of machine	Type of coupling	Work width (m)	Average speed (m/s)	Productivity (ha/h)	Time required work 1 ha (h/ha)	Average power required (HP)	Approx. price of the machines (U.S. $)
1 Ditcher	mounted	-	0.5	-	1.8-2.5	60-65	1,500
2 Straw chopper	semimounted	2.0	0.4	0.25	4.0-5.0	40-50	1,500
3 Plow (2 bottoms)	mounted	0.8	1.5	0.3	3.5-4.0	60-65	300
4 Scraper (2 m^3) (*)	pulled	2.0	-	-	7.0-8.0	65-75	2,200
5 Leveller	semimounted	4.0	0.5	0.7	1.5-2.5	40-50	2,200
6 Boundary maintaining machine	mounted	0.4-0.6(1)	0.2	300(2)	1.5-2.0	50-60	500
7 Oscillating harrow	mounted	3.0	1.7	1.0	1.8-2.0	40-50	1,000
8 Puddler	mounted	3.0	1.5	1.0	2.0-2.5	30-35	300
9 Planker	mounted	4.0	0.8	1.0	1.5-2.0	34-40	300
10 Fertilizer distributor	mounted	8.0	1.7	1.0	1.0-1.5	25-30	150
11 Transplanter (6 rows)	mounted	1.8	0.5	0.2	5.0-6.0	45-55	1,500
12 Braodcaster	mounted	8.0	1.7	1.0	1.0-1.5	25-30	1,400
13 Herbicide distributor	mounted	8.0	1.7	1.0	1.2-1.5	30-35	500
14 Trailers (2)	pulled	-	3.0	-	7.0-9.0	20-25	2,800

(*) In the hypothesis of an earth movement of 2 cm working capacity 30 m^3/h.

(1) Canal depth or boundary height.

(2) Productivity in m/h.

Source: Nippon Koei Company, R.R.C., Rasht, Iran, 1972.

TABLE 14. 75 HP tractor 2 wheel-drive - Workable area 40 ha - Annual utilization of the machines, energy consumption and labour requirements for different levels of mechanization

Practices	Average utilization of the machines (h)		Energy consumption (HPh)		Labour required (man. hours)	
	transplanting by machinery	direct sowing	transplanting by machinery	direct sowing	transplanting by machinery	direct sowing
1 - Canal maintenance	72-100	72-100	4500-6250	4500-6250	144-200	144-200
2 - Straw chopping	160-200	160-200	7200-9000	7200-9000	160-200	160-200
3 - Plowing	140-160	140-160	8750-10000	8750-10000	140-160	140-160
4 - Earth movement	280-320	280-320	19600-22400	19600-22400	560-640	560-640
5 - Levelling	60-100	60-100	2700-4500	2700-4500	60-100	60-100
6 - Boundary maintenance by hand	-	-	-	-	350-400	-
7 - Boundary maintenance by machine	-	60-80	-	3300-440	-	120-160
8 - Harrowing	75-85	75-85	3375-3825	3375-3825	3375-3825	75-85
9 - Puddling	80-100	-	2600-3250	-	80-100	-
10 - Planking	60-80	60-80	2250-3000	2250-3000	60-80	60-80
11 - Fertilizer distribution	40-60	40-60	1100-1650	1100-1650	40-60	40-60
12 - Transplanting by machinery	200-240	-	10000-12000	-	1800-2160	-
13 - Broadcasting	-	40-60	-	1100-1650	-	80-120
14 - Chemical weeding	50-60	50-60	1625-1950	1625-1950	100-120	100-120
15 - Handling and transportation	280-360	280-360	6300-8100	6300-8100	560-720	560-720
Total	1497-1865	1317-1665	71900-85925	60700-73725	4129-5025	2099-2645
Tractor and labour productivity (h/ha)	37-47	33-42	-	-	103-126	53-66
Average input of energy required per hectare (HPh)	-	-	1797-2148	1517-1843	-	-
Average power required (HP)	-	-	47,1	45.2		

Source: Nippon Koei Company, R.R.C., Rasht, Iran, 1972.

be expected from such a level mechanization are summarized as follows (Table 14):

1. Average annual use of the 75 hp tractor: 1,650 hours per year in the case of mechanical transplanting, and 1,450 hours per year in the case of direct sowing;

2. Average specific use of the tractor: 42 hours per hectare in the case of transplanting; 37 hours per hectare for direct sowing;

3. Average power required: 45-57 hp corresponding to 62 percent of the maximum power.

Labour requirement: 115 man-hours per hectare, in the case of mechanical transplanting; 60 man-hours per hectare in the case of direct sowing.

Also in this hypothesis one has a high coefficient in the performance of the machinery. The power load per land unit rises to 1.6 - 1.7 hp per hectare. Moreover such a solution involves harvesting with a 3.6 meter (cutting width) self propelled combine on areas of 80 hectares. Dryers with a capacity of not less than 1 ton per hour operating over at least 80 hectares. A mill plant can be used for over 480 to 500 hectares considering the above quoted dimensions (15).

With such a mechanization level, labour productivity increases by approximately 80 - 90 over the level based on the 35 horse power tractor. It is then possible to foresee each labourer handling no less than 7 to 8 hectares. It is obvious that the use of the mechanization could involve cooperative farm management (15).

Economic conditions and credit facilities.

In order to define the economical limits of a certain mechanization level, it is necessary to add operation cost of the machinery to that of the manpower through work productivity values (15). This is done as represented in Fig. 8, with the curves of the costs of three proposed levels of mechanization (the present one, that is based on a 35 hp and a 75 horsepower tractor) and three wage levels: 250 Rials per day (present wage $4/day), 500 Rails/Day ($8/Day) and 1,500 Rials/Day ($24/Day). This corresponds to hourly wages in US dollars of respectively 0.5; 1.0 and 3.0 $/hour.

On the basis of figures in Table 10 and 13. It is possible to calculate the minimum "cost of work" in the hypothesis of different wages. For a 0.5 $/h wage, the minimum cost of work is reached by a mechanization level (B) based on a 35 hp tractor. The more sophisticated level of mechanization (c) related to a 75 hp tractor will become economic when the wage level reaches 1.8 $/h. Point (A) refers to the present situation.

As it is seen in Figure 8, at the present average gross wage it is possible to arrive at the minimum production cost of the paddy with a mechanization level corresponding to that based on 35 horsepower tractors (covering 25 hectares each). Only when the average gross wages have increased to 800 Rials per day (Approximately $1.8/hour) will it be economical to use a mechanization level based on a 75 horse power tractor and on a self-propelled combine harvestor.

In this case, however, it will be necessary to enlarge the plots in order to have combinations consistent with the dimensions and the working capacity of the machinery (15).

For a balanced budget for the farm, it is necessary that the mechanization cost is not more than 15 - 18 percent of the gross production cost. Although it is very difficult to make stipulations, however, it is possible to indicate (purely as an estimate) that the mechanization level based on a 35 Horsepower tractor will have a cost of around 25 - 28 percent of the gross output. Consequently to promote a mechanization development it will be necessary to plan for easy term credit over five years (15).

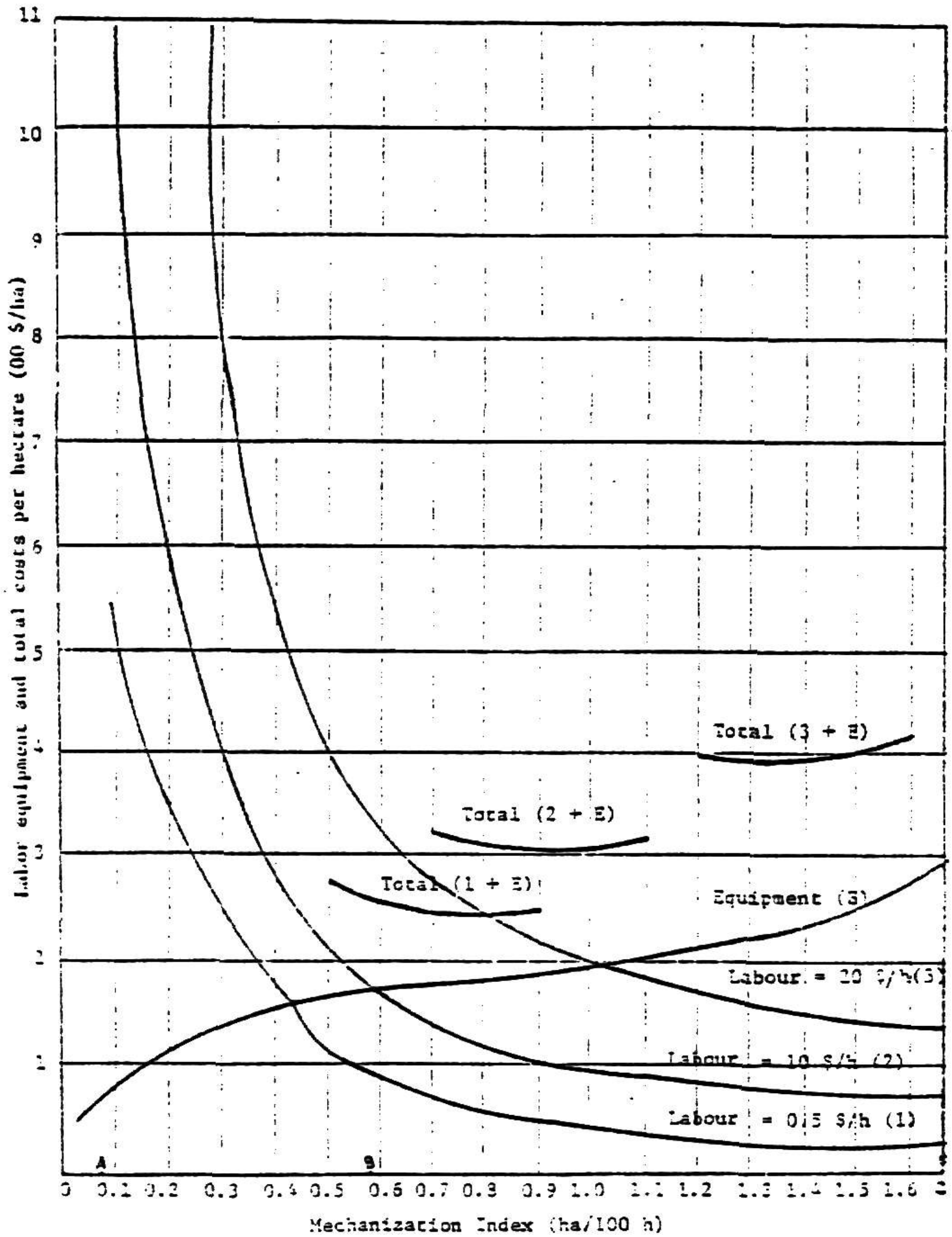

Fig. 3. Relationships between mechanization index and labor equipment and total cost per hectare.

NEW ASPECTS TO BE CONSIDERED FOR NEW PLANNING OF RICE MECHANIZATION IN IRAN

The essential problem which limits introduction of machinery to rice growers is inefficient drainage and also lack of a complete drainage network in region 1. To begin building a drainage system, we should start constructing a drainage network in Mazandaran. The reasons for this selection are as follows:

1 - soil has less clay content than Gilan province;

2 - farms are of larger size than Gilan;

3 - more investment is being made in industrial sections; therefore, labor released from the land could be absorbed in the industrial sections; and

4 - soil leveling requirement in this province is less and easier than in Gilan.

The only drainage system which is suitable for both areas is an underground tile drainage system. This type of drainage system lasts a long time, about 5-10 years, before the first maintenance operation. During this period of time, technical labor would be available to be used for maintenance purposes. Materials for construction of this project are available in the area, and we do not need to import constructional materials from other parts of the country. This decreases the transportation cost and also initial installation cost. Also, by using local materials such as bricks and tiles, the labor employment increases, and in a short time it affects the economical situation of local construction industries. The capital investment for these projects will be too high to be afforded by farmers on cooperatives. Hence, the government with its financial resources must provide assitance for construction of this drainage system and its accessories.

Along with constructing the drainage network, three major tasks must be performed:

1 - re-allocation of land in two provinces;

2 - establishment of complete extension services;

3 - investment in tractor and implement industries to produce locally suitable machinery.

At the present time, 85% of the rice growers have less than 3.0 hectares (6.5 acres). Practicing any type of new technology in these small plots at an economical level seems doubtful. The land must re-allocated such that each rice grower will have at least 12.0 hectares (25 acres) for rice growing. With this quantity of land, farmers can produce enough rice to allow them to pay all their expenses and recover their capital for more future developments.

As far as extension services are concerned, a complete and sufficient extension department must be established. In different ways, these extension centers should give educational and technical services to rice growers. There are about 3,000 agricultural college graduates in Iran, and for purposes of extending new technology at the farm stage, a part of these educated people will be required. These extension service centers must have a close working relationship with the universities to transfer new findings to farmers.

As far as introduction of machinery to rice growers is concerned, two different types of machinery must be considered:

1 - mechanically simple tractors and implements; and

2 - improved tractors and implements.

In some parts of region 1, farmers still use animals as a power source for performing different types of agricultural operations. Introduction of simple machinery to these farmers with little technical knowledge gives farmers an opportunity to increase their land productivity and output. In the long run, they also become familiar with machine operations and related technical problems. After a period of time based on the educational and economical situations of farmers, these types of machinery could be replaced with advanced machinery. At this point, training of farmers is easier than before, since they have obtained knowledge and background of machinery applications for different operations.

For those farmers who are familiar with machinery, small tractors and associated implements with no more than 35 hp and more advanced design features should be introduced. Introduction of 75 hp tractors must be done after the labor wage has increased to $12/day.

To manufacture machinery required for rice growing, local manufacturers must be supported by the government. These factories, based on the farmers need for machinery, should produce those types of machinery which would be used for growing rice efficiently. A complete survey and research must be done by these industries to find new designs and techniques suitable for the local conditions of Iran. As a first step, these factories must understand farm equipment requirements. These factories can contact small shops in the area and establish a continuous dialogue for understanding technical defects and restrictions. Some of these small local shops have good experience in producing locally used machinery, and this experience should be improved for increased machinery production.

CONCLUSIONS

The discussion carried out has made it possible to establish that top priority must be given to experimental research into soil drainage as a basis for obtaining dry soil that has a sufficient bearing up capacity to allow for a rational use of mechanization.

Improvements will have to be made in the research and experiments carried out in the rice growing area. This, in order to have accurate testing of machinery suitable to local conditions in relationship to the development of socio-economic conditions in the region, the obtaining of lower working costs and an appropriate use of manpower. Nothing, however, must digress from the principal problem of the re-allocation and consolidation of the farms and of the rationalization of the plots with both reference to the irrigation and drainage works as far as a correct use of the machinery is concerned. To this end it will be necessary to start through studies and surveys throughout the entire region, also as far as the possibility of soil levelling in development of cooperatives is concerned.

At the same time great attention must be paid to the extension services, in the after-sales service and in the study of the possibility of developing industries for the local manufacturing of the machinery required for rice growing.

App. A, Hand weeding at R-R-C in Rasht

MECHANIZATION OF RICE AND ITS PROBLEMS IN IRAN

by

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ABSTRACT

Mechanization of rice production in the tropics has many problems which still remain unsolved. Mechanization of rice production in the tropics not only presents the usual non-technological dryland farming problems related to equipment size, economics of use and ownership, but also many technological problems which still remain unsolved. The change of agrieconomic conditions in the tropical region is making it increasingly difficult to follow traditional rice practices. Agricultural mechanization is therefore becoming an important issue in many countries.

To introduce machines to small farmers several factors should be considered. Changing of traditions, assessment of needs, machine selection for field operations, machine maintenance, energy cost and land availability are some of these factors which should be taken into account. Also more important factors should be considered for efficient mechanization of rice production. These factors include some physical factors like water availability and its properties, soil conditions, climate, location of the fields and some personnel factors. Machine selection and adaptation, installations, water management, layout and system management are other factors which have an important role in an efficient mechanization program.

Iran has a rice growing area of 330,000 - 350,000 hectares and a production of 900,000 tons. There are two regions where rice is grown. Region 1 in the northern part of the country and Region 2 in the southwest part of Iran. In region 1 agricultural practices for rice production are as follows: soil preparation, fertilizer application, nursery preparation, transplanting, water management, weeding, harvesting, threshing, drying and milling. Each of these operations is presently done by inefficient methods. The tendency to apply a limited range of equipment and machines has been

increased somewhat but it is not widespread in either region. Improvements must be found to increase the efficiency of machines and methods and to develop new cultural practices which meet local requirements.

The mechanization problems of Iranian agriculture are classified into two categories,

1-farm mechanization in rice cultivation area of the Caspian Sea of northern Iran.

2-farm mechanization in the dry area of the southwest and western parts of Iran.

In region 1 three major problems relating to mechanization of rice production were evident.

1-Rice growing is still tied to traditional practices based on the use of man and animals.

2-The soil is, in the majority of cases, permanently impregnated with water due to lack of efficient drainage system. Moreover, it will not be possible to resolve the problem of reducing peak periods by using power tillers, especially as far as transplanting and harvesting are concerned.

3-An improvement in the condition of the soil can be reached only by creating an efficient drainage network.

As a result of the above, mechanization based on the use of small power tillers cannot be considered valid as they could only be used over small areas, such as those found on small farms of one hectare or less.

Two types of alternative levels for rice growing mechanization have been studied:

1-A mechanization system based on the use of a 35 hp tractor with 2 or 4 wheel drive, equipped with consistent equipment.

2-A mechanization system based on the use of a 75 hp tractor with a 2-wheel drive for a more sophisticated and complete mechanization level.

Economic conditions which define the economic limits of a certain mechanization level also have been studied. In this study operation cost of the machinery has been added to that of the manpower through work productivity values. These two alternatives for mechanization of rice growing can be applied but further information and investigations seem to be required.