International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

VOL.X,NO.2, SPRING 1979

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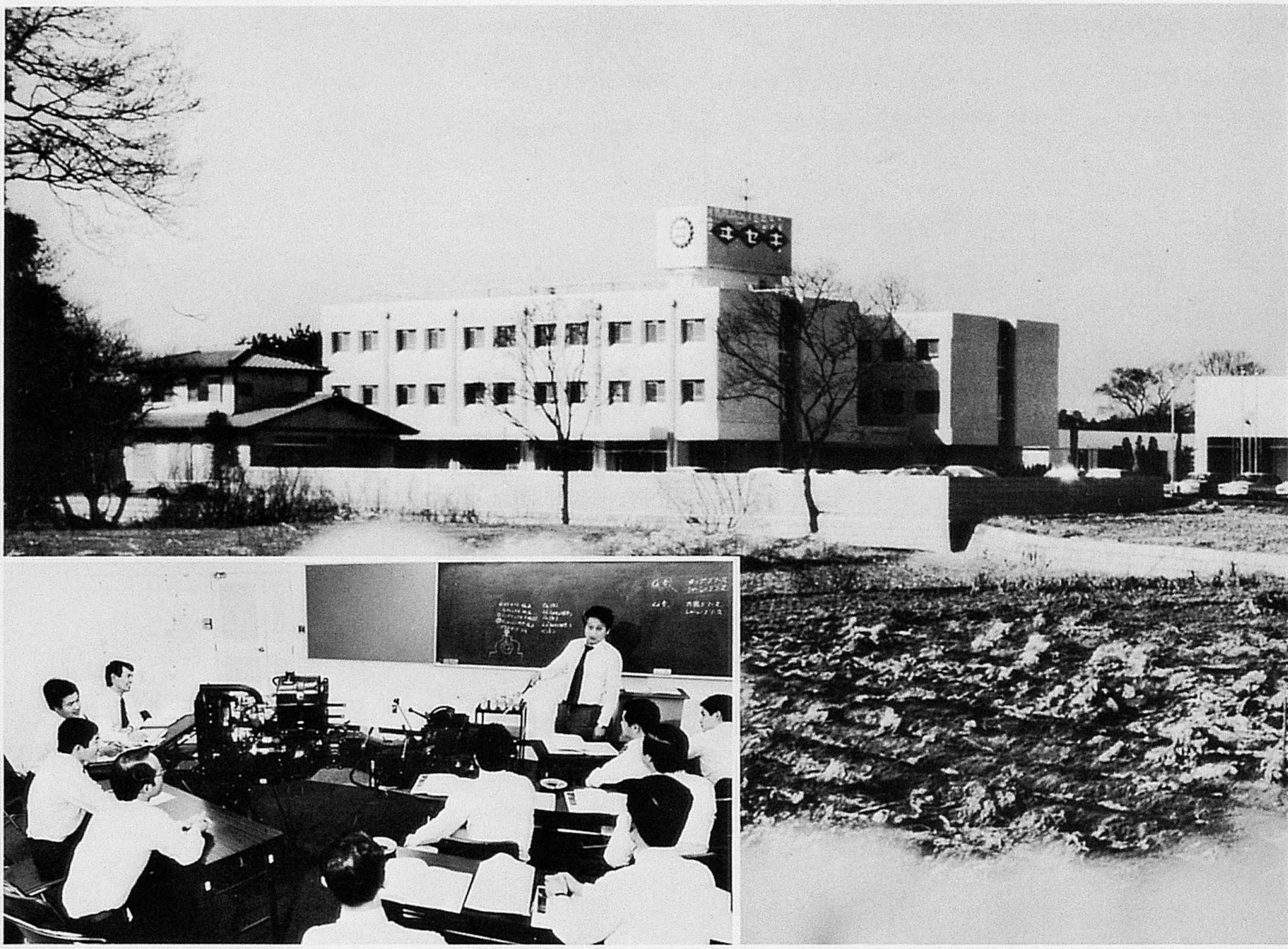

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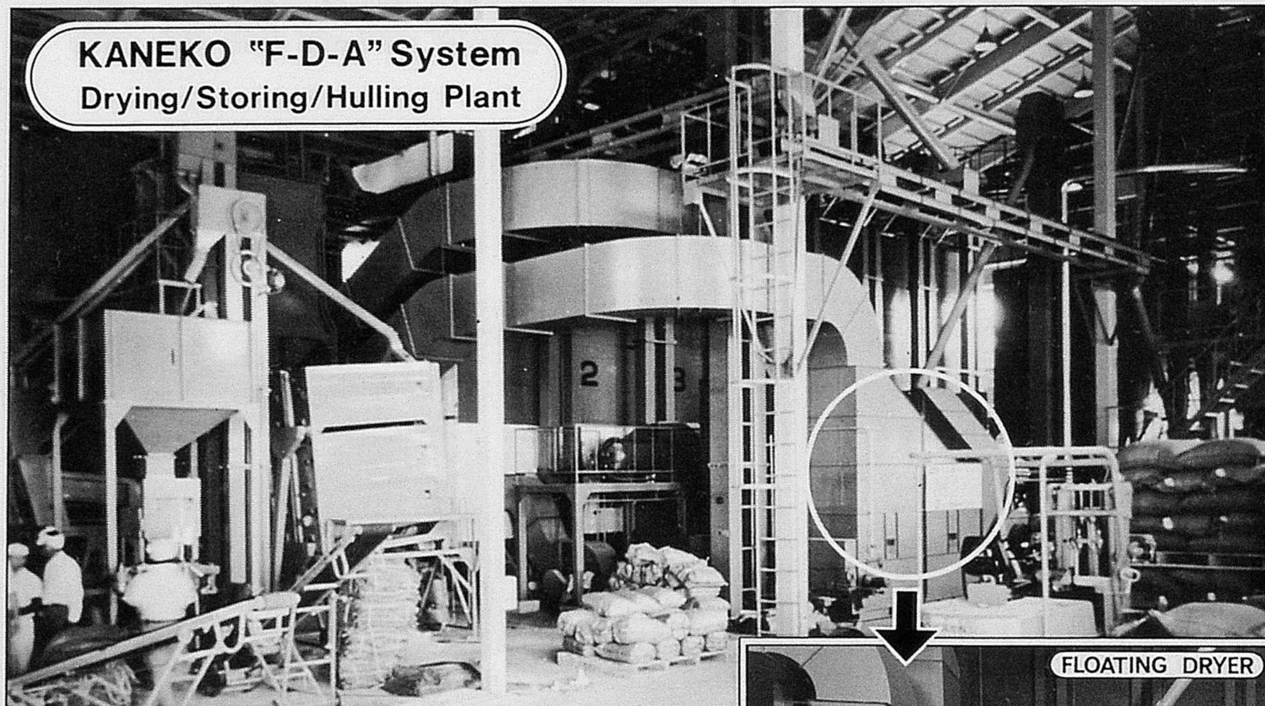

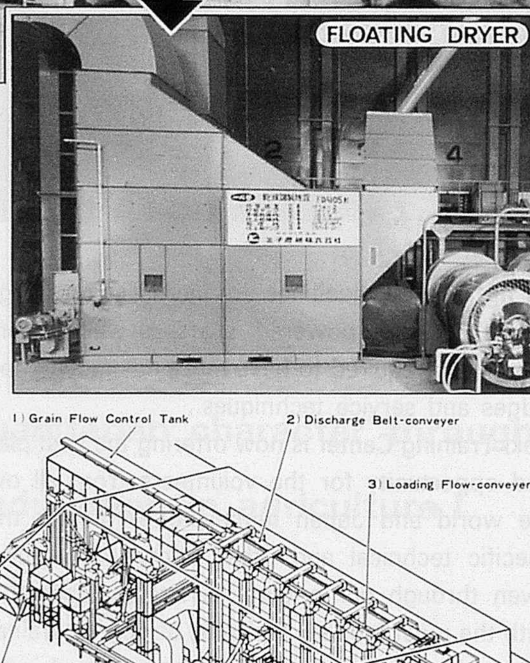

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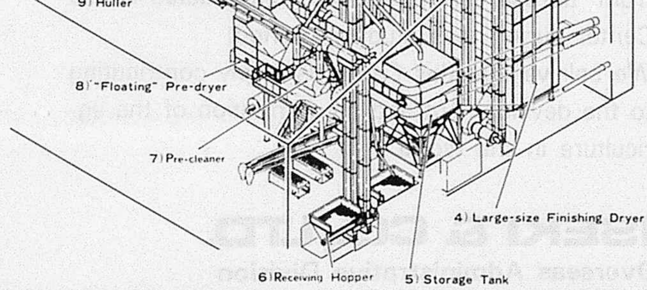

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Edited by

YOSHISUKE KISHIDA

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TOKYO

This is the 23th issue since the issue, Spring of 1971.

EDITORIAL

Dr. C. J. Moss, Head of agricultural Engineering of IRRI, has recently visited Japan. On that occasion, he told us that production and sales of simple and low-priced agricultural machines is indispensable so as to promote agricultural mechanization in Asia. According to him, it is scarcely possible for farmers in south east Asia to buy machines from US$1,000 up. Further, even if the price should be lowered up to about US$500, they will still bear considerable expenses. If it is possible, we must consider such a system that useful machines for farmers can be sold under US$500. But this is very difficult subject.

Japanese agricultural machinery industry has wide experience in producing low-cost agricultural machines. About 14 years ago, I also have an experience in developing light, low-priced and high-performance thresher for rice and wheat, which is operated by a motor of 1KW. But extremely I took pains to let the cost down.

As the easiest way to lower the price of agricultural machines, designers should device the way, considering production method. Observing agricultural machines produced in developing countries, actually they produce and sell heavier machines more than they need. In the long run, farmers are reduced to buy machines that have life but are very expensive. When I have developed a thresher in Japan, I designed it in prospect of life to 25ha so as to produce it at low cost.

Japanese machines are often criticized for they are easy to break and last only short life. One of cause of it is that agricultural machinery industry had to produce low-priced machines for Japanese poor and small farmers. Machines designed for developing countries should be made thorough value analysis and their weight should also be lightened.

Now, from now on in AMA journals I intend to introduce machines produced in developing countries and manufacturers as well as new products presented in developed countries. We highly appreciate your continued cooperation and assistance to AMA journals.

Chief Editor
Yoshisuke Kishida

April, 1979
Tokyo

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AGRICULTURAL MECHANIZATION IN ASIA

Vol.X, No.2 Spring, 1979

Reflection of the Energy Requirements of Small Rice Farmers

by
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The level and pattern of a country's use of energy from different sources often serve as an index of its agro-industrial development and standard of living. Because commercial energy inputs are an indispensable part of transitional and modern agriculture, a slight increase in the energy inflow often results in a significant response in food production.

Self-sufficiency in food production is an understandable goal of developing countries, which often have scarce or underdeveloped natural resources. The attainment of that self-sufficiency should be through prudent use of available energy resources, a steady supply of commercial energy inputs at reasonable prices, and the development of production systems or schemes that will fully utilize all production resources (3).

Six basic agricultural production resources are land, water, man and animal power, energy (commercial and non-commercial), crop technology, and capital.

We deal here with energy use on small rice farms and attempt to put alternative sources of energy into perspective.

Commercial energy inputs arrive on farms in many different forms, e.g. petroleum, irrigation water, chemical fertilizer, machinery, pesticides, and herbicides (**Fig. 1**). Non-commercial energy is available as solar radiation and wind. In a highly mechanized corn production system, around 90% of the total energy input comes from solar energy and 10% (14) comes from commercial energy (**Fig. 2**). Unfortunately, plants do not use solar energy efficiently for photosynthesis ; about 25% of the energy absorbed by a plant is rejected through the process of photorespiration (9). Less than 1% of the total incident solar energy is converted to total plant energy content. For example, a 4 t/ha paddy in Los Baños, Laguna implies a conversion efficiency of 0.74% :

$$\eta sc = \frac{S_A}{S_B \times T} \times 100$$

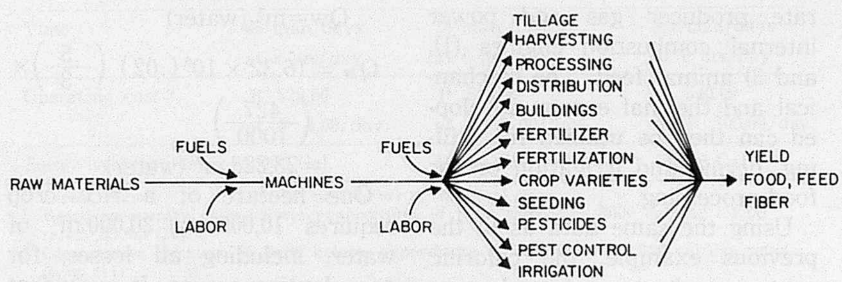

Fig. 1 Flow of energy from fuels and labor during the manufacture, distribution, and culture of food, and feed (Heichel, 1973)

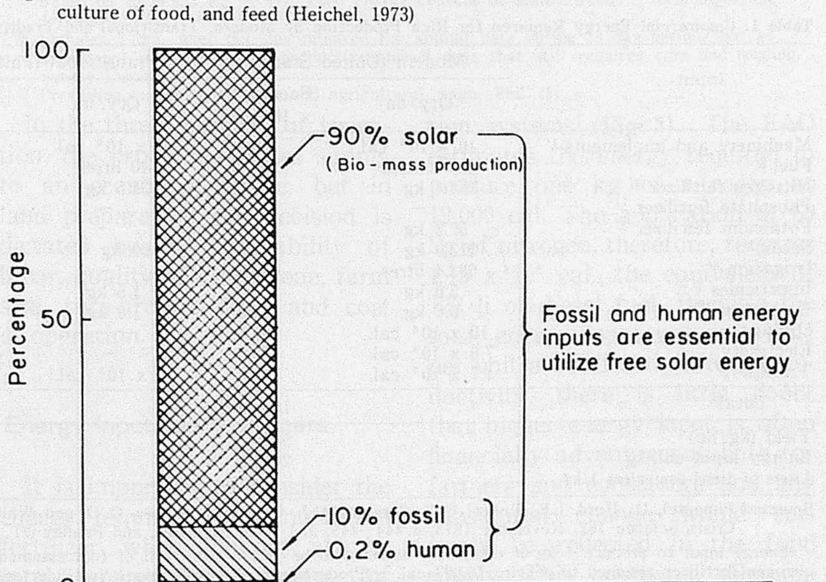

Fig. 2 Energy share in a mechanized corn production system USA. (14)

where :

$S_A = 28 \times 10^6$ cal/ha (calorific content of 3,200 kg rice + 800 kg rice hull + 4,000 kg straw)

$S_B = 37.6 \times 10^6$ cal/ha day (average solar radiation in Los Banos)

T = 100 day crop

ηsc = solar converstion efficiency

$$\therefore \eta sc = \frac{28 \times 10^6}{37.6 \times 10^6 \ (100)} \times 100 = 0.74\%$$

Obviously, any improvement in the solar conversion efficiency would have a tremendous impact on food production.

This 0.74% solar conversion efficiency is not realized unless the potential energy of the rice hull and straw is harnessed. Three obvious methods of using this energy are : 1) combustion in steam boilers to drive prime movers (steam engine or turbine) ; 2) thermal gasification to generate producer gas and power internal combustion engines (1); and 3) animal feed. The mechanical and thermal energy developed can then be utilized for milling, drying and irrigation or for food processing.

Using the same data as in the previous example, the calorific content per hectare of residue is :

$$H_C = (W_{RH} + W_S)\,HV$$

where :

$W_{RH} = 4{,}000$ kg rice hull

$W_S = 800$ kg straw

HV = 3,400 cal/kg (Heating Value)

Hc = calorific content per ha residue

$$\therefore \ Hc = (4{,}000 + 800)\ 3{,}400 = 16.32 \times 10^6 \text{ cal.}$$

Assuming that the over-all thermal efficiency of a steam power plant or producer gas generator is 2% and a water pump efficiency of 50%, the quantity of water pumped at 3m lift per ha of residue is :

$$Q_W = H_C(\eta t)\ (\eta p)\ \frac{1}{h}\left(\frac{427}{1000}\right)$$

where :

Hc = calorific content per ha residue

ηt = thermal efficiency

ηp = pump efficiency

h = lift

1 cal = 427 kg-meter

m^3 = 1000 kg (water)

Qw = m^3 (water)

$$Q_W = 16.32 \times 10^6\,(.02)\left(\frac{.5}{3}\right) \times \left(\frac{427}{1000}\right) = 23{,}228 \text{ m}^3 \text{ (water)}$$

One hectare of a rice crop requires 10,000 to 20,000 m^3 of water, including all losses, for one planting season. It is evident that the potential energy in 1 ha of rice crop residue can irrigate 1 to 2 ha of paddy land and that nonutilization of this residue represents a significant loss of the solar energy and the petroleum, capital, and labor invested in raising the total crop.

Energy Requirements for Rice Farming

Traditional, transitional and modern agriculture practices generally correspond to nations which are underdeveloped, developing and developed. Modern agriculture systems use 10 times more commercial energy per ha than transitional systems and 300 times more than traditional systems. It is interesting to note that the yield per ha from modern agriculture is twice the transitional and four times that of traditional practice **(Table 1)**.

About 42% of the total commercial energy input in modern U. S. rice production goes for irrigation, 20% for the manufacture and operation of farm machinery, 18% for fertilizer and 7% for crop drying. In transitional rainfed Philippine rice farming, 39% is used for fertilizer and 30% for the manufacture

Table 1. Commercial Energy Required for Rice Production by Modern, Transitional and Traditional Farming Methods

Input	Modern (United States)		Transitional (Philippines)		Traditional (Philippines)	
	Qty/ha	Energy/ha x 10^4 cal.	Qty/ha	Energy/ha x 10^4 cal.	Qty/ha	Energy/ha x 10^4 cal.
Machinery and implements [1/]	10 x 10^5 cal.	100.0	8 x 10^4 cal.	8.0	4.13 x 10^4 cal.	4.13
Fuel [2/]	224.7 litres	209.0	40 litres	38.0	—	—
Nitrogen fertilizer [3/]	134.4 kg	260.0	31.5 kg	60.0	—	—
Phosphate fertilizer [4/]	—	—	—		—	—
Potassium fertilizer [5/]	67.2 kg	14.0	—	—	—	—
Seeds [6/]	112.0 kg	82.0	100 kg	39.0	107.5 kg	—
Irrigation [2/]	683.4 litres	640.0	—	—	—	—
Insecticides [7/]	5.6 kg	13.0	1.5 kg	3.6	—	—
Herbicides [7/]	5.6 kg	13.0	1.0 kg	2.4	—	—
Drying	10 x 10^5 cal.	100.0	—	—	—	—
Electricity	7.6 x 10^5 cal.	76.0	—	—	—	—
Transport	1.7 x 10^5 cal.	17.0	7.4 x 10^3 cal.	.74	—	—
Total		1515.0		152.0		4.13
Yield (kg/ha)		5800		2700		1250
Energy input cal/kg		2612		563		33
Liters of diesel equivalent l/kg		.28		.06		.0035

Sources : Pimentel, D., Hurd, L.E., Belloti, A.C., Sorster, M. J., Oka, I. N., Sholes, O. D. and Whitman, R. J., Food Production and the Energy Crisis, Science 182, November 1973, p. 444−445, and FAO estimates, and Faidley (7).

[1]Energy input to produce 1 kg of equipment assumed to be 16,396 cal. [2]1 li of fuel assumed to contain 9,321 cal. −[3]Production of 1 kg of nitrogen fertilizer assumed to require 19,093 cal. −[4]Production of 1 kg phosphate fertilizer assumed to require 3,341 cal. −[5]Production of 1 kg of potassium fertilizer assumed to require 2,148 cal. −[6]Production of 1 kg of high-quality seed assumed to require U. S. 7,159 cal and Phil. 3,579 cal. −[7]Production of 1 kg of pesticide assumed to require 23,866 cal.

and operation of farm machinery.

It is evident that irrigation, fertilizer and farm machinery constitute the main use of commercial energy on modern U. S. rice farms. An energy equivalent of from 0.1 to 0.28 liter of petroleum fuel is required per kg of rice produced. For the developing countries to meet such an energy requirement will require very gradual and prudent handling in order to minimize undesirable economic and social consequences.

In the primary operation of agriculture, land preparation and lift irrigation are major consumers of on-farm energy. The energy used varies in amount and source. To understand how energy use is affected by power source, energy expenditures of three prime movers currently used on rice farms in developing countries were studied : human, animal, and mechanical **(Table 2, 3).**

Analysis reveals that the energy input per man-day for a given area in a mechanical irrigation system is 4 times more than an animal driven system, and 20 times more than with manual operation. Manually powered irrigation does not appear to be economically viable at wage rates in the Philippines because it would cost more than the total expected income. In land preparation, there is a minimal difference in operating cost of the three methods. Obviously, the amount of energy used per unit time per unit area is proportional to productivity and inversely proportional to the operating time. From the above, it is apparent that before farmers and farm operators will use labor intensively for irrigation, the price of oil must be raised 20 times or the minimum agricultural salary must be reduced to about US $. 10 per day. Intensifying animal use would reduce crop land by as much as 15% because animals require a year-round feeding ground (9).

Table 2. Energy Source and Expenditure for Irrigation (1 ha-m, 1.5 m head, Q=10 x 10^6 li)

Energy Source	Human	Animal	Mechanical 1/
Energy input	1.86 x 10^6 Cal. 2/	1.116 – x 10^6 Cal. 2,3/	.732 x 10^6 Cal.
	503 kg. of rice 4/	465 kg animal feed 5/	1.3 kg of rice
		50 kg of rice	77 liters diesel
Time	619 man days at 8 hrs/day	62 man days 6/ at 6 hrs/day	12 man days at 8 hrs/day
Operating cost 7/	₱ 4,952.00/ha	₱ 1,550.00/ha	₱ 480.00/ha or 15% yield
	at ₱ 8.00/day	at ₱ 25.00/day	at ₱ 40.00/day
Energy input/man day	3,000 Cal.	18,000 Cal.	61,000 Cal.

1/ Diesel engine – 3–5 hp (.7 to 1 li/hr) at 9321 cal./li
2/ Based on average daily calorie expenditures of farm worker – 3000 cal/day rated .05 hp (16) (2) (3)
3/ Conservative estimate of daily caloric expenditure of carabao – 15,00 cal/day rated .6 hp (11)
4/ Based on 3700 cal/kg – food energy content of rice (13) (3)
5/ Based on 2,000 cal/kg – ave. food energy content of animal feed – total digestible dry matter (15)
6/ Includes 3 hrs. ave. per day required for animal care during 62 day period, but no adjustment is made for non-productive animal days that still requires care and feeding. Survey/Laguna.
7/ Prevailing custom hire rates and agricultural wage. Phil. (5)

Table 3. Energy Source and Expenditure for Land Preparation (1 ha)

Energy Source	Human	Animal	Mechanical Power tiller 1/
Energy input	.195 x 10^6 Cal. 2/	.36 x 10^6 Cal. 2,3/	.348 x 10^6 Cal.
	53 kg of rice 4/	150 kg animal-feed 5/	4.4 kg of rice
		16 kg of rice	35 liter of diesel
Time	65 man days at 8 hrs/day	20 man days 6/ at 6 hrs/day	5.4 man days at 8 hrs/day
Operating cost 7/	₱ 520.00 at ₱ 8.00/day	₱ 520.00 at ₱ 25.00/day	₱ 540.00 at ₱ 100.00/day
Energy input/man day	3,000 Cal.	18,000 Cal.	64,506 Cal.

1/ Diesel engine – 3 – 5 hp (.7 to 1 li/hr) at 9321 cal./li
2/ Based on average daily calorie expenditures of farm worker – 3000 cal/day (2) (3) rated .05 hp (16)
3/ Conservative estimate of daily calorie expenditure of carabao – 15,000 cal/day rated. .6 hp (11)
4/ Based on 37000 cal/kg – food energy content of rice (13) (3)
5/ Based on 2,000 cal/kg – ave. food energy content of animal feed – total digestible dry matter (15)
6/ Includes 3 hrs. ave. per day required for animal care during 20 day period, but no adjustment is made for non-productive animal days that still requires care and feeding. Survey/Laguna.
7/ Prevailing custom hire rates and agricultural wage. Phil. (5)

In the three methods of irrigation, the problem reduces simply to an economic choice, but in land preparation the decision is dictated by the availability of labor, quality of work done, farm size, turn-around time, and cost of operation.

Energy Inputs as Fertilizers

It is important to consider the energy required to manufacture fertilizer when looking at the total energy requirement of alternate irrigated rice production systems **(Fig. 3).** The FAO estimates the energy required to produce one kg of nitrogen as 19,000 cal. The application of 60 kg of nitrogen, therefore, requires 1.15 x 10^6 cal., the equivalent of 122 li of diesel fuel. Because the total energy input per unit time per unit area directly affects productivity, there is little doubt that higher energy input is often financially advantageous both for farmers and consumers and any substantial change would certainly be reflected in the food supply. This creates a dilemma for policy makers in the develop-

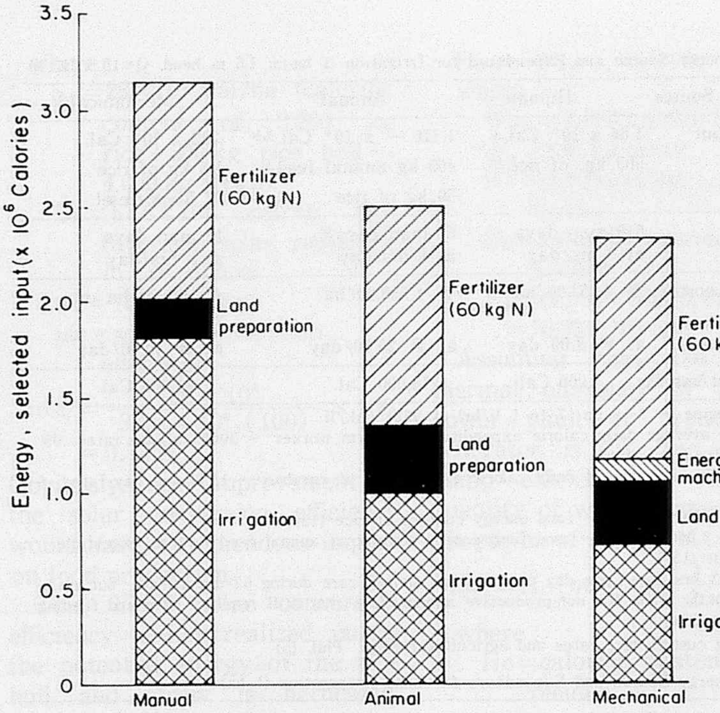

Fig. 3 Energy systems practice in LDC's (1 ha rice field)

ing to the FAO estimates about 4 to 6 percent of the total energy is used in agriculture. The present annual energy consumption per capita is about 1.6 barrels and will increase to about 5 barrels by the year 2000. Meeting this huge energy demand totally by petroleum has caused serious concern in light of the recent oil embargo. **Fig. 4b** shows the Philippine's vulnerability by deriving 95% of its energy from imported oil (6). Attempts are being made to broaden the energy infrastructure by accelerating the tapping of indigenous natural energy resources. As indicated in Figure 5b, the projected energy consumption of 165.5 million barrels for 1985 will come increasingly from hydro-

ing countries who want to maintain certain levels of commercial energy, animal, and labor utilization while at the same time maximizing food production (8). In a free enterprise society, drawing a national master plan for energy allocation to the production system is difficult becasse farmers and farm operators make choices based on convenience and maximization of personal financial gain (9).

Meeting the Need

An adequate and stable supply of commercial energy is one of the fundamental needs of farmers wanting to break away from a subsistence agriculture. Although man has acquired the knowledge required to provide adequate energy for the world community, unfortunately that knowledge has not benefited man equally. Some acquire more than enough energy, while others have a shortage.

Providing sufficient energy for a nation demands total political and economic commitment. **Fig.4a** show the energy consumption of a typical developing country, the Philippines. Accord-

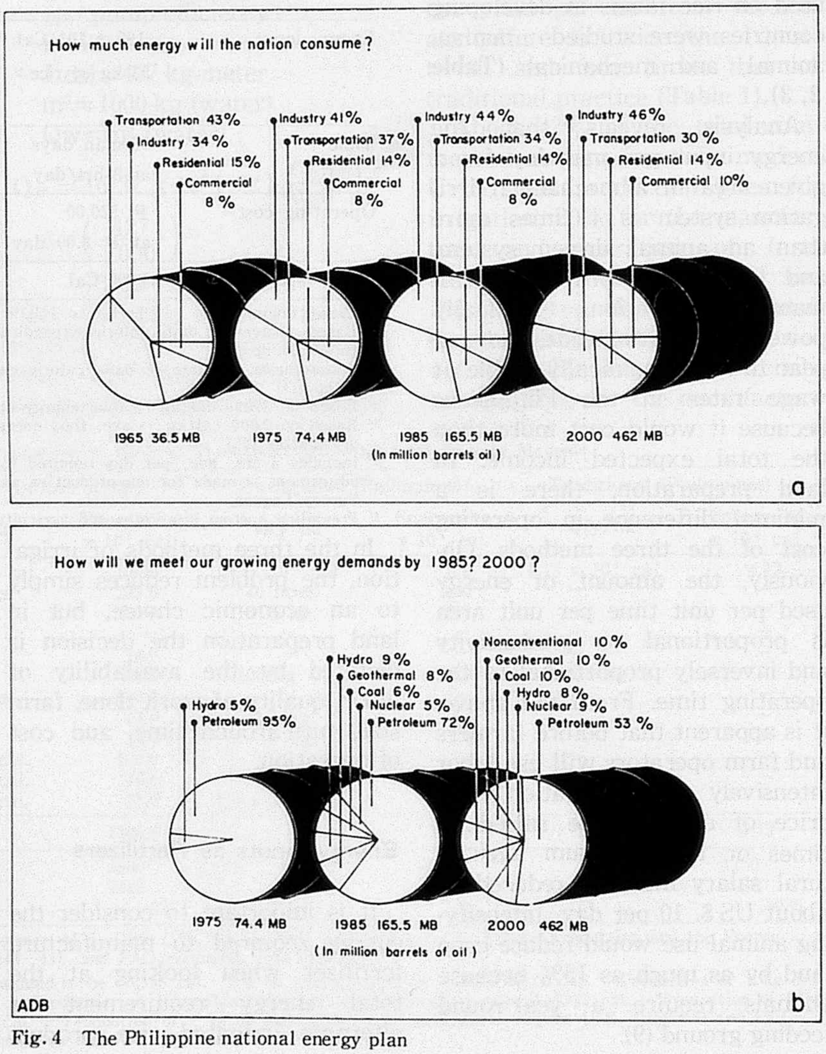

Fig. 4 The Philippine national energy plan

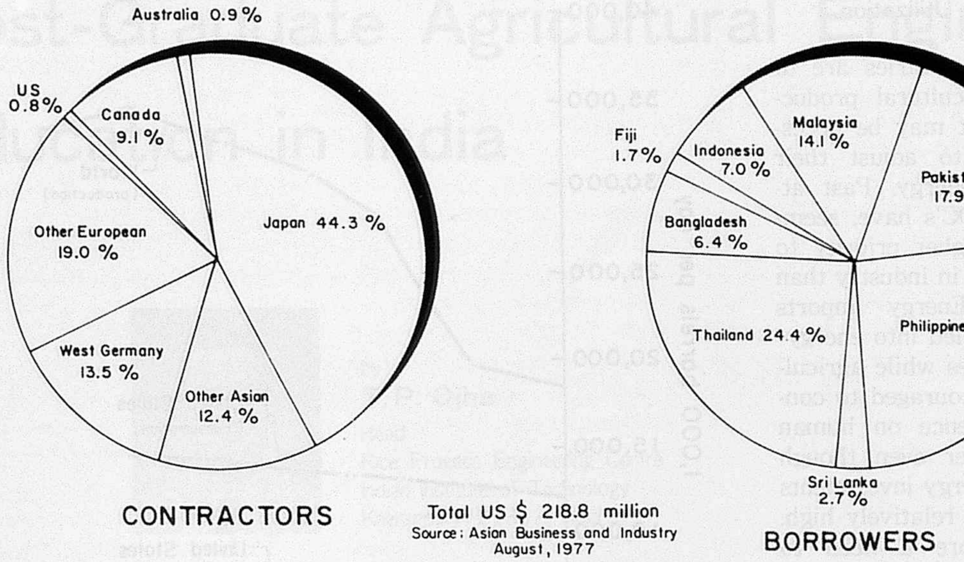

Fig. 5 Asian Development Bank Power Loans

electic, geothermal, coal, nuclear --- leaving 72% for petroleum. Hopefully, by the year 2000, the total potential of these indigenous resources will be fully realized thereby reducing the share from petroleum to 53% but still requiring an added 126 MB of oil! Non-convetional energy resources (solar, wind, bio-gas, agricultural field residue) are projected to supply 10% of the total energy requirement at that time.

The energy development programs of underdeveloped and developing countries cannot often be realized by depending totally on their own financial resources. They normally rely on large foreign loans for development projects **(Fig. 5)**. This financial commitment underscores the importance of developing a better understanding of energy requirements and the potential of energy sources.

Reflection of Energy Requirements

Most farm workers in the industrially advanced countries use twice as much energy as nonfarm workers where as nonfarm workers in the less developed countries (LDC's) consume more energy than farm workers. Industrially advanced countries have fewer agricultural workers but utilized energy at a high level. In the UK and US, one day's work by a farm worker provides enough food for himself and 50 to 60 nonfarm workers (9). Although these production systems are rather energy-intensive, only about 3% of the industrialized countries' energy use is for agricultural production **(Table 4)**.

In the LDC's there are more agricultural workers but the per capita level of energy utilization is much lower ; 1 to 3 barrels of oil per year against 17 to 50 barrels of oil in the advanced countries **(Fig. 6)**. Often farm workers in the LDC's only support themselves and additional food must be imported to feed the urban population.

Table 4. Total Use of Commercial Energy and Commercial Energy Used in Agricultural Production, 1972/73

Region	Total Energy	Energy used in Agricultural Production		Total Energy per Caput	Energy in Agricultural Production per Agricultural worker
	.. x 10^{14}	Cal. ..	%	.. x 10^{6}	Cal. ..
Developed Market Economies	323.9	11	3.4	44	26
North America	183.5	5	2.8	79	133
Western Europe	102.4	5	4.9	28	20
Oceania	5.73	.24	5.6	37	59
Eastern Europe and the U. S. S. R.	118.8	3.8	3.3	34	17
Total developed countries	443.0	15.0	3.4	41	15
Developing Market Economies	46	2	4.3	2.6	.5
Africa	3.8	.24	6.5	1.2	.2
Latin America	19	.7	3.7	6.7	2
Far East	17	.95	5.3	1.4	.33
Near East	6.2	.5	8.4	5.7	1.0
Asian Centrally Planned Economies	34	.95	2.8	4	.4
Total developing countries	80	3	3.75	3	.47
World	523	18	3.5	14	2.4

Sources : United Nations, Statistical Office, World energy supplies 1950−1974, New York, 1976, p. 18−123, 707−762 ; FAO Foundation yearbook 1974, Room, 1975, p. 11−13 ; later tables, by L. V. Faidley, Ag. Engr. FAO.

[1]Including countries in other regions not specified.

Balanced Energy Utilization

If developing countries are to attain their agricultural production objectives, it may be necessary for them to adjust their thinking about energy. Past attitudes in the LDC's have, seemingly, given a higher priority to the use of energy in industry than in agriculture. Energy imports have been channeled into energy-intensive industries while agriculture has been encouraged to continue its dependence on human and animal power even though the returns on energy investments in this sector are relatively high. There is therefore a need to develop rational energy programs and policies based on a comprehensive understanding of the alternatives that will balance industrial and agricultural growth.

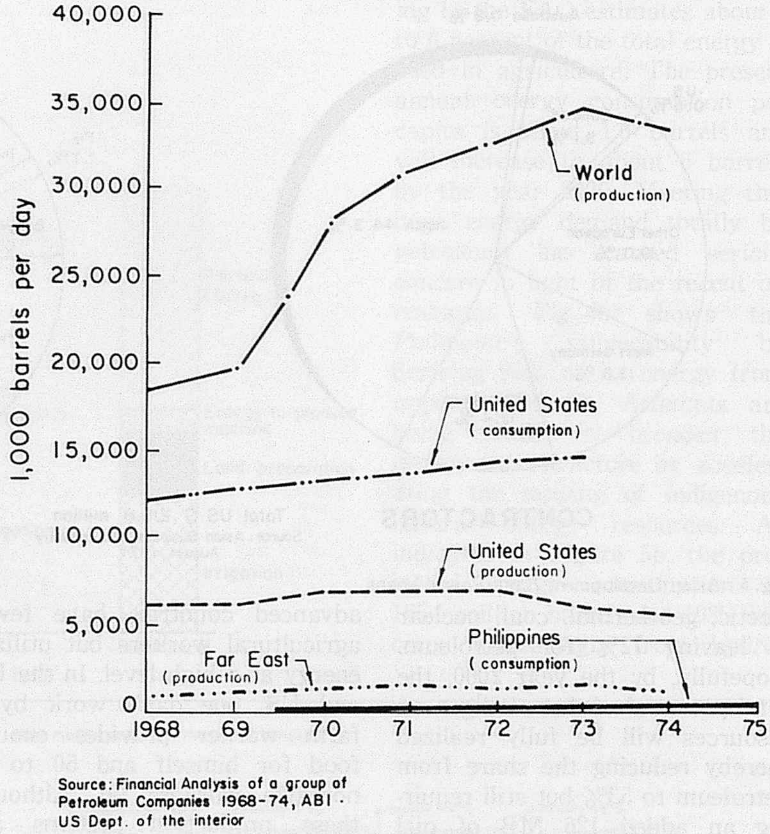

Fig. 6 Gross crude oil production and consumption 1968–74

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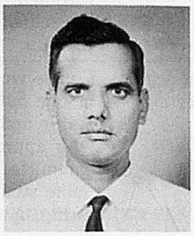
Post-Graduate Agricultural Engineering Education in India



by
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Kharagpur 721302, India

The first programme of post-graduate education in agricultural engineering leading to Master of Technology (M. tech.) degree was initated at the Indian Institute of Technology (IIT), Kharagpur in 1956. The first batch of students with specialization in farm machinery and power was admitted in the same year. The first batch of M.Tech. students with specialization in soil water conservation engineeing was admitted in 1958. The IIT remained the only institute training M.Tech. students until 1965, when the Indian Agricultural Research Institute (IARI), New Delhi commenced its post-graduate programme in agricultural engineering. The post-graduate courses at the Punjab Agricultural University (PAU), Ludhiana and G.B.Pant University, Pantnagar were organized in late 60s. Around the same time, an M.Sc. in agricultural engineering course at Allahabad Agricultural Institute (AAT), Allahabad was also started. The Master Degree programmes at Udaipur and Coimbatore commenced in the academic year 1978-79 only. Thus at present there are seven institutes/universities offering post-graduate programmes in agricultural engineering (**Table 1** and **Fig. 1**). In some of the institutes, there is provision to depute the

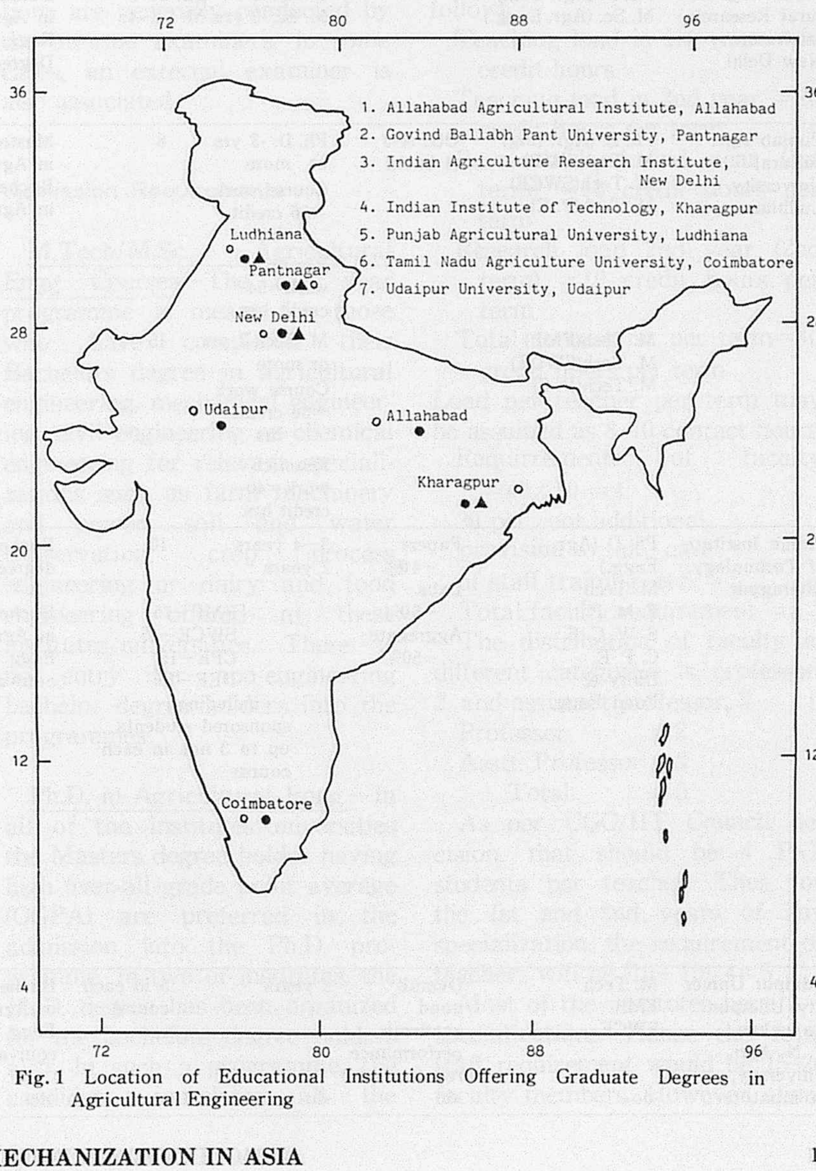

Fig. 1 Location of Educational Institutions Offering Graduate Degrees in Agricultural Engineering

Table 1. Agricultural Engineering Post-Graduate Programmes

Name of Institution	Degrees Offered	Minimum Pass Mark (%)	Duration of Course	Annual Admission Capacity	Admission Requirement	Special Features
Allahabad Agricultural Institute, Allahabad	M. Sc. Agr. Engg.	Papers —40% Aggregate —50%	2 years	10	Bachelors degree in Agr. Engg., Civil Engg. or Mech, Engg.	Students have to undergo common courses of studies. Only the thesis work distinguishes their field nf specialization No scholarships given by the Institute
G. B. Pant University of Agriculture & Technology, Pantnagar, Nanital	i) Farm Machinery & Power (FMP) ii) Soil Water Conservation Engg. (SWCE) iii) Process Engg. iv) Irrigation & Drainage Engg. (Irrig. & Drge) Ph. D.	OGPA=3 out of 4 OGPA=3	2 yrs or more, i. e., 65 trimester credit hrs, including 15 to 25 credits for research & thesis work 3—4 years	FMP-10 SWCE-6 P. E-10 Irrig & Drge -10 3	Bachelors degree in Engineering	Course work is covered either in one major field or in a major and one minor field with approval of advisory committee. Some students are offered scholarship up to Rs. 250/-p. m.
Indian Agricultural Research Institute, New Delhi	Ph. D. (Agr. Engg) M. Sc. (Agr. Engg.)		Ph. D. -3 yrs M. Sc. -2 yrs	Ph. D. -2 M. Sc. -4	Bachelors degree in Agr. Engg./ Engg or Masters Degree in Engg.	Ph. D. & M. Sc. students are offered Rs. 400/- and Rs 300/- P. m. scholarships, respec tively. internal and external evaluation system are followed for both courses
Punjab Agricultural University, Ludhiana	Ph. D. (Agr. Eng) M. Tech(FMP) M. Tech(SWCE) M. Tech(P. E)	OGPA=3 (4 basis)	Ph. D. -3 yrs or more Course work =36 credit hrs. Research work=54 credit hrs.	8	Masters degree in Agr. Engg. or Bachelors degree in Agr. Engg.	A fellowship of Rs. 400/- p. m. is provided for every candidate admitted to the Ph. D. Programme
	M. Tech(FMP) M. Tech(SWCE) M. Tech(P. E)		M. Tech-2 yrs or more Course work =50 credit hrs Research work=40 credit hrs.	15		Students are awarded fellowship of Rs. 300/- p. m.
Indian Institute of Technology, Kharagpur	Ph. D. (Agr. Engg.) M. Tech F. M. P. S. W. C. E. C. P. E. Dairy & Food Engg.	Papers —40% Labs —50% Aggregate —50%	3—4 years 2 years	10 FMP—15 SWCE—15 CPE—15 DEF—15 including sponsored students up to 3 nos. in each course	Bachelors/Master degree in Engg. Bachelors degree in Agr. Engg/ Engg or equivalent	Students are required to complete minimum of 18 semester credit hours plus a foreign language as course requirement. Research work constitutes the major part of work. Students are required to complete 45—56 semester credit hours as course requirement. Research work is complete in 1½ semesters. A fellowship of Rs. 500/- p. m. and Rs. 400/- p. m. are awarded to all candidates for Ph. D. and M. Tech programme respectively. However, the Ph. D. scholar receives Rs. 600/- p. m. after 2 yrs of good Performance
Udaipur University, Udaipur, Rajasthan	M. Tech FMP SWCE	Overall good academic performance requirement	2 years	5 in each course	Bachelors degree in Agr. Engg./ Engg. or equivalent	Fellowship of Rs. 300/- p. m. is awarded to selected candidates.
T. N. Agri. University, Coimbatore	-do-	-do-	-do-	-do-	-do-	-do-

Ph.G./M.Tech. candidates to the industry field for completion of research work after completing the minimum residential requirement of one or two years as the case may be. However, there are proposals to organise similar courses in other agricultural universities currently offering undergraduate courses in agricultural engineering only.

Ph. D. Programme in Agricultural Engineering

Due to fast expansion programmes in agricultural engineering education in various agricultural universities in India, a serious shortage of highly qualified teachers was felt in these Universities. Part of the demand could be met from the trained Ph.D. degree holders from USA, Canada and some Europen countries. However, there still appeared to be a major gap between the demand by the universities and the supplies from abroad. The demand of post-graduate students also increased due to the fast expansion of researh activities in India. It was, therefore, felt necessary to train Ph.D. degree holders in the field of agricultural engineering in India. To bridge this gap the IIT organized the First Ph.D. programme in 1960. However, only by 1964 could the first candidate successfully complete the Ph.D. degree programme.

The Ph. D. courses and research programmes at IARI, New Delhi, PAU, Ludhiana and G.B.Pant University, Pantnagar were initiated in the years 1970, 1971 and 1978, respectively.

The Ph.D. programme offered at Kharagpur revolves around research work mainly. A research candidate is required to take few courses of post-graduate level in his major as well as in allied fields. Of course, the candidate has to complete the foreign language requirement as one of the essential requirements for his Ph.D. degree. It has been observed in the past that a Ph.D. candidate requires 3-4 years to complete all requirement, including submission of theses. The Ph.D. programmes at Ludhiana, New Delhi and Pantnagar include the course work up to 60 credit hours besides the research work as essential requirement of the programme. The pattern has been derived mainly from the U.S. pattern of agricultural engineering post-graduate education.

The evaluation of the Ph.D. thesis in all the institutes/universities is done by external examiners. But the course work and the comprehensive exdminations are generally conducted by the internal examiners. In some cases, an external examiner is also associated.

Admission Requirements

<u>M.Tech/M.Sc. Agricultural Engg. Courses</u>—The two year programme is meant for those who have completed their Bachelors degree in agricultural engineering, mechanical engineering, civil engineering or chemical engineering for relevant specializations such as farm machinery and power, soil and water conservation, crop process engineering or dairy and food engineering offered at these institutes/universities. There is no entry for non-engineering bachelor degree holders into the programmes.

<u>Ph.D. in Agricultural Engg.</u>—In all of the institutes/universities the Masters degree holder having high over-all grade point average (OGPA) are preferred in the admission into the Ph.D. programme. In two of institutes, the Ph.D. degree has been organized for the bachelors degree holders also. In such a programme, the candidate completes all the courses of M.Tech. level but skips the thesis work. He then moves over to the Ph.D. programme and completes the same for his final degree. The past experiences indicate that only Master degree holders should be admitted to the Ph.D. programm. However some exceptions are shown in the case of candidates possessing uniformly good acadmic background and long field experience.

Faculty Requirements

Considering each M.Tech. course having intake capacity of 10 students every year, the total load (teaching and research) is as follows :

Teaching load in 1st year = 40 credit hours

Teaching load in 2nd year = 20 credit hours per term

Research load 2nd year (1st term) = 10 credit hours per term

Research load 2nd year (2nd term) = 10 credit hours per term

Total contact hr. per term = 40 credit hours per term

Load per teacher per term may be assumed as 8-10 contact hours

Requirrements of faculty = 40/10 = 4

20 per cent additional provision to take care of staff training, etc. = 1

Total faculty requirement = 5

The distribution of faculty in different categories is professor, 2, and assistant professor, 3

Professor = 2
Asstt. Professor = 3
Total.. = 5

As per UGC/IIT Council decision, that should be 4 P.G. students per teacher. Thus for the 1st and 2nd years of any specialization, the requirement of teachers will be (10+10)/4=5

Most of the institutes have 3-4 specializations. Hence the total staff requirement would be 15-20 faculty members. However, there are few common core courses offered to the students of all specialization. In such an event, the faculty strength may be reduced by about 2-3 members. Many agricultural engineering colleges do not have separate departments of mechanical engineering, civil engineering, chemical engineering, mathematics and statistics. In such cases the staff distribution should be as follows :

Specialization		No. of Faculty Member
FMP	4	Agricultural Engg.
SWC	4	Agricultural Engg.
CPE	4	Agricultural Engg.
DFE	4	Agricultural Engg.
General	1	Mechanical Engg.
	1	Civil Engg.
	2	Mathematics and Statistics

The ratio of professor to assistant professor may be kept at 1 : 2 or 2 : 3 approximately.

It would be desirable to have the faculty of the following educational qualifications :

Professor, a) Essential: Master's degree in the concerned specialization, b) At least 10 years experience in teaching/research/design and development in an institute of university standard, and c) Evidence of having published research papers in reputable journals, and d) Desirably a Ph.D. degree holder.

Assistant Professor, All other requirements being the same as those in case of professor, except the experience which may not be less than 5 years.

Teaching and research loads for Ph.D. scholars can be calculated and the faculty strength can be determined. As a rule, for every 4 scholars, one faculty member should be appointed. As far as possible, the total faculty strength should be divided equally among the Professors and assistant professors.

Physical Facilities

The physical facilities required for an effieient operation of the post-graduate programme may be grouped into 8 items : laboratory facilities, research project space, class rooms/drawing room, seminar-cum-conference room, experimental farm, library -cum-reading room, instrumentation-cum-data processing, and graduate student's rooms.

Laboratory facilities—For each specialised post-graduate course and in addition to undergraduate laboratories, specific laboratories are desirable for each subject in the following departments.

Farm Machinery and Power
a) Agricultural machine dynamics and fludids
b) agricultural machine testing.
c) Soil dynamics.
d) Energy conversion.

Soil Water Conservation
a) Pumping machinery.
b) Field testing of irrigation methods
c) Lysimeter and evapotranspiration (field lab.)

Crop Process Engineering
a) Physical properties.
b) By-product utilization
c) Grading and quality control
d) Crop drying
e) Grain storage
f) Heat treatment
g) Bio-Chemistry

Dairy and Food Engineering
a) Heat processing
b) Unit operations
c) Food technology
d) Food engineering

In planning for the size of the laboratories a space requirement of 20 m^2 per student with a minium of 150m^2 of floor area should be provided.

Research Project Space—Each student should preferably be assigned a research-cum-testing project as essential requirement for his thesis work. It is important to provide a covered area where the projects can be set up. For each student, 8—10m^2 floor area would be required for such a job. The minimum size of such a hall may be 80m^2.

Class Rooms—For each post-graduate class there should be a separate class room. The size of rooms may be determined on the basis of space requirement of about 2.8m^2 per student. However, the minimum size should not be less than 15m^2 of floor area under a class room.

It is desirable to have a drawing class room where the design-cum-drafting work may be done by all the classes in a staggered manner.

Seminar-cum-Conference Room—Seminars have been accepted as an essential means of preparing post-graduate (PG) students for their future career as teachers/research worker/executives and so on. It is essential for each P.G. student to present 3—4 seminar talks in an academic year. A well equipped seminar room with modern projection facilities having a floor area of about 50m^2 should be provided. The same seminar room can be utilized by all P.G. classes at different intervals. In fact, one seminar room can hold about 10 seminar classes in a week.

Experimental Farm—There should be a farm of at least 8 ha for laving out field experiments of machine testing, soil water management, etc.

Library-cum-Reading Room—In addition to the main university/institute library, it is desirable to have a college/departmental library where students can borrow specialized books, periodicals and departmental theses. Such a library should remain open during working hours having provision of an open rack system.

A floor area of about $80m^2$ with adequate reading room facilities would be considered essential.

Instrumentation-cum-Data Processing—An adequate number of electronic instruments, such as recorders, calculators, data processing aids, etc. Under the supervision of well trained technicians is considered an essential facility for P.G. students. Such a laboratory is meant for training the students, housing and repairing the instrument.
Periodically the instruments can be loaned to be used in different labs by the students in their research projects. Keeping in view all the requirements, a floor area of about $60m^2$ may be considered as minimum size of the laboratory.

Graduate Students' Room—At the rate of $5m^2$ of floor area per student, adequate number of rooms may be arranged for all the 2nd year P.G. students as well as the Ph.D. scholars. Such a facility has been found to be satisfactory in making the students work effectively.

Additional Recommendations

Industrial training programme—It is considered essential to provide industrial/field training to the P.G. students at the end of the first year. These students must be asked to work for period of 10—12 weeks in a industry or research institute concerning their research project in the field of their specializations. Such a traninig makes them to realize the problem and challenges of industry/field where these students would be required to work in the latter part of their career. After completing their training programmes, the students have been observed to be more realistic in their approach to the practical problems. Such a training should be arranged during the summer months between the two academic years.

Research Projects—If possible, the P.G. students may be encouraged to take up their thesis problems in relation to the present day needs of the country. In such a case, they may be required to work part of the time in an industry/field for the collection of data. Problem solving topics of research have been appreciated by all in all the fields of specialization.

Short Study Tours—under many circumstances it is not possible to provide all facilities required for organizing few specialized laboratory classes. Such a situation arises either due to the demand of heavy investment for equipment or non-availability of a few instruments. Such a problem can be very well overcome by organizing short study tours of 1—2 days in a months in the neighbouring industrial/field project areas. ■■

Agricultural Mechanization Strategies in Bangladesh

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Introduction

Bangladesh is a fertile, alluvial floodplains with an extensive network of more than 15,000 miles of rivers, streams and canals formed by the river systems of Ganges, Brahmaputra and Surma. Out of the total population of 71 million in 1974 it was estimated that about 91 percent lived in the rural areas and that of a total labor force of about 25 million, agricultural labor accounted for about 14 million or 56 percent of labor force (5). About 75 percent of its entire population is either directly of indirectly dependent on agriculture for their livelihool.

The agricultural sector of the country suffered a gross neglect in the past. The farm people of the country consider the practice as the means of subsistence and not as dependable business in. Most of the farmers lead their lives under subsistence level. The land holding structure of the country is shown in **Table 1, 2 and 3.**

As noted by Choudhury (6) the total number of holdings in the country was 6.5 million and 43.6 percent of holdings had farm size of 2.5 acres or less. Based on the Pilot Agricultural Census of 1976(1), 46.4 percent of the holdings had farms of 2.5 acres or less. The Summary Report of the 1977 Land Occupancy Survey of

Table 1. Farm Size Pattern (6)

Size of Farms (acre)	No. of Farms (Million)	Percentage
Under 1.00	1.10	17.00
1.00 – 2.50	1.75	26.60
2.51 – 5.00	1.76	26.80
5.01 – 7.50	0.83	12.60
7.51 – 12.50	0.64	9.70
12.51 – 25.00	0.31	5.60
25.01 – 50.00	0.09	1.40
Over – 50.00	0.02	0.30
Total	6.50	100.00

Table 2. Distribution of Farm holdings 1976 (1)

Type of Holding	Size of Holding (acre)	Percentage of Farm Holding	Sub-total of percentages	Percentage of Farm Area(acre)	Sub-total of percentages
Small	0.0 to under 0.5	4.4	46.4	0.4	17.4
	0.5 〃 〃 1.0	10.0		2.0	
	1.0 〃 〃 2.5	32.0		15.0	
Medium	2.5 〃 〃 5.0	32.0	43.6	32.0	53.0
	5.0 〃 〃 7.5	12.6		21.0	
Large	7.5 〃 〃 10.0	4.0	8.5	10.0	29.2
	10.0 〃 〃 12.5	2.0		6.0	
	12.5 〃 〃 25.0	2.2		10.2	
	25.0 & above	0.3		3.0	
Total		100.00	100.0	100.0	100.0

Table 3. Size Distribution of Total Owned Land in Rural Bangladesh 1977 (9)

Farm Size (acres)	No. of Holdings (Millions)	Percent of Total	No. of Persons (Million)	Percent of Total	Area(Million acre)	Percent of Total
Zero	1.31	11.07	5.71	8.28	–	–
0.01 – 1.00	5.62	47.44	29.22	42.33	1.30	9.30
1.01 – 2.00	1.95	16.43	11.52	16.78	2.79	14.43
2.01 – 3.00	1.06	8.91	6.80	9.86	2.55	13.18
3.01 – 4.00	0.62	5.27	4.47	6.48	2.15	11.13
4.01 – 5.00	0.39	3.29	2.93	4.25	1.74	9.00
5.01 – 6.00	0.25	2.09	2.04	2.96	1.33	6.90
6.01 – 7.00	0.17	1.43	1.44	2.09	1.10	5.69
7.01 – 8.00	0.12	1.02	1.08	1.57	0.90	4.65
8.01 – 9.00	0.08	0.69	0.74	1.07	0.70	3.60
9.01 – 10.00	0.05	0.42	0.47	1.68	0.48	2.46
10.01 – 11.00	0.04	0.34	0.37	0.54	0.42	2.15
11.01 – 12.00	0.03	0.29	0.36	0.52	0.39	2.03
12.01 – 13.00	0.02	0.16	0.18	0.26	0.23	1.18
13.01 – 14.00	0.03	0.22	0.27	0.39	0.35	1.82
14.01 – 15.00	0.02	0.13	0.20	0.28	0.23	1.19
Over 15.00	0.10	0.80	1.15	1.66	2.18	11.29
Total	11.85	100.00	69.03	100.00	19.35	100.00

Rural Bangladesh, (9), states that over 75 percent of the holdings had farm size of equal to 2 acre or less only. The total number of holdings rose to an alarming figure of 11.85 million. **The tables** above show the incremental tendency of the number of holdings due to fragmentation from within almost the constant size of total land area, indicating the fact that the condition of the majority of the farm people continues to be alarming.

The poorer farmers are becoming the victims of ill health with less or no capacity of using any improved production inputs. This leads to low land productivity as well as law labor productivity to the bigger fraction of the whole of the country. The condition of this poor farmers, as well as the condition of the country, could not be raised until and unless an effctive and appropriate measure for the production strategy suitable for the farmers could be undertaken.

Present Status of Mechanization

Technological change in agriculture

Agricultural activities in Bangladesh are mostly traditional. The introduction of high yielding paddy varieties, in the late sixties, evolved from the International Rice Research Institute (IRRI), Philippines. The BRRI, Joydevpur, Bangladesh established a new era for the rural people of the country and increased the land and labour productivity as well. The introduction of these high yielding paddy varieties pushed the farmers mostly to act on co-operative basis, specially for the management of water, which necessitated better land preparation within a short time, to meet the group demand for the next action, which created seasonal shortage of draft animals. The new varieties, in addition, necessitated the application of other inputs, such as fertilizer, insecticides, etc. Moreover, the increased grain yields necessitated some post-harvest development in threshing, drying and storage. As a result, the agricultural activities have accelerated to a large extent.

Tractor tillage

Virtually all activities for land preparation in the country are carried out by bullocks, including milking cows in drawing farm implements.

In 1970, the total number of tractors and power tillers in the country were 2,072 and 2571(4). After the cyclone of 1970 the Bangladesh Agricultural Development Corporation (BADC) procured 125 tractors and 569 power tillers under an emergency agricultural rehabilitation programme in the cyclone affected area. A pilot project was drawn up by the same organization after liberation to assess the feasibility of mechanization in selected areas of the country and 17 tractors and 79 power tillers were distributed in units of 4 to 5 each. So far, however, these were scattered efforts and none of these programmes have yet been able to maintain working equipment in the field for a significant period, and cannot, as yet, form the basis for major policy decisions in the area (12).

The latest mechanized cultivation (MC) programme by BADC was initiated after 1973 and 300 tractors were distributed of which 50 were allocated to the Comilla district for custom services (12).

The Bangladesh Academy for Rural Development (BARD) initiated tractor mechanization with two 35-hp tractor in 1960 (8). For the expansion of experiment to cover the entire Comilla Thana, a five-year scheme entitiled, "Mechanized Farming on Co-operative Basis in Comilla", was approved in January, 1962 and made possible the development of the Kotwali Thana Central Co-operative Association (KTCCA) (2, 3). From then onward the tractor station has been providing custom services to the farmers of the Kotwali Thana and others whenever possible. The tractors and implements situation of the BADC (MC) in the Comilla district and that of the KTCCA Tractor station in 1976-77 are given in **Table 4, 5.**

None of the 40 tractores found in Comilla town, during a survey work from September, 1977 to December, 1977 (12), had any tillage implements and all were engaged in haulage of construction and other materials. A very

Table 4. Tractor and Implement Situation in Comilla 1976–77 (12)

Thana *	Tractor		Implements					Area (hectare)	
	Running	Minor Repair Required **	Running			Repairable			
			H	R	DP	H	R	H	R
Kotwali	4	1	2	4	1	–	1	96.10	42.36
Choudhagram	2	–	2	4	–	–	–	–	354.94
Chandina	4	1	–	6	–	1	1	–	369.73
Daudkandi	2	–	2	2	–	–	–	7.85	17.00
Muradnagar	1	–	1	–	–	–	–	–	–
Debidwar	1	–	1	1	–	–	–	8.90	62.93
Laksam	2	1	3	3	–	–	–	129.05	69.66
Barura	4	–	–	4	–	–	1	–	152.19
Kachua	2	2	3	3	–	–	1	–	127.73
Total	22	5	14	27	1	1	4	394.09	944.33

Note : H–Harrow
R–Rotavator
DP–Disc plow
* –Total number of Thanas in the district is 21.
** –23 other tractors require major repair.

Table 5. Tractor and Implement Situation, KTCCA Tractor Station, 1976–77 (12).

Items	Running	Repairable	Total
Tractor	15*	1	16
Disc plow	1	–	1
Moldboard plow	1	1	2
Harrow	8	9	17
Rotavator	2	5	7
Combined polydisc	3	–	3

*10 tractors were engaged in tillage only on an area of 1330 ha.

recent news states that only 5 tractors out of 118 were in working condition during the last cropping season in the Bhula sub-division of Patuakhali district (7). It could be concluded that in no case were 50 percent of the tractors existing in the country are engaged in tillage even though these were imported primarily for land preparation with the hope that tractor cultivation could establish a new era in the increased crop production strategy of the country.

Irrigation

Most of the planning efforts in agricultural mechanization have been focussed on irrigation in order to provide the farmers with water they need to grow additional crops during the dry season. Irrigation in Bangladesh has been expanding gradually over the past few years. In 1950–51, there were only 5 low-lift pumps in the country. By 1975–76 it was estimated that about 1 million ha was being irrigated. The number of low-lift pumps, shallow tube-wells and deep tube–wells operated in 1976–77 and the target for 1977–78 are given in **Table 6.** The area irrigated along with deep tube-wells in 1976–77 was 164,198 acres.

The dependability of irrigation system is often poor and the efficiency of water use is low. Opten ditches, canals and field channels lose an estimated 50% of the water before it reaches the field to be irrigated. Of the water

Table 6. Distribution of Irrigation Facilities

Year	Low-lift pumps	Shallow tube-wells	Deep-tube-wells
1976–77	28,257	6,747	4,464
1977–78 (Target)	39,000	NA	11,159

Source : BADC Bangladesh (1977), by personall communication.

that actually reaches the field only about 50% is used by the crop. In some of the projects managed by the Government organizations like the G. K. Projects and the Thakurgaon Deep Tube-well Project the total efficiency of water use is as low as 25% or less. There are also evidences that excess water is used in some areas which, in turn, reduces the crop yield.

The net area irrigated in 1960 was 7 percent and in 1975–76 the net area irrigated was estimated to be 8.4 percent and the gross area irrigated estimated to be 5.42 percent. The net area irrigated with small holdings, medium holdings, and large holdings were 13.87, 8.43 and 5.15 percent, respectivily. Surprishingly, the percentages of areas irrigated decreased as the size of holding increased. Seventy-two percent area of total high yielding paddy varieties was under irrigation, and for "boro" paddy and wheat, 39% and 6%, respectively, in 1975–76. Irrigation was almost non-existent in the case of most other crops (1).

Use of chemical fertilizer

With the introduction of high yielding crop varieties, the farmers have been motivated to use more irrigation water and chemical fertilizer. In 1960 only 4 precent of farm holdings used chemical fertilizer whereas in 1975–76, 51 percent of the farm holdings used chemical fertilizer. The precentages of net area fertilized by small, medium and large holdings were estimated to be 35, 25 and 18 percent, respectively, the overall percentage being about 25 percent (1).

Plant protection

Pests are the worst competitor of man in available food in that they have an astonishing bio-tic potential and are causing injury to food, fodder, fibre and forest crops, beneficial plants and animals. Pest control is, therefore, vital for man's peaceful and healthy existence. According to the most conservative estimate, 10–15% of the crop is lost annually to pests in Bangladesh equivalent to about Tk. 500 crores (10).

During the crop year 1975–76, about 13% of holdings reported using plant protection materials. The paddy area sprayed was 4.5% of the total under paddy and 90% of the total sprayed area. As regards wheat areas it was observed that 2% of the total area was sprayed (1).

Agricultural power & implements

Based on the Pilot Agricultural Census of 1976, 89 percent of the farmers did not use mechanical power in agriculture. Tube-well irrigation was used by 10% of the farmers and 6 percent used power pump 96 percent of which was provided by the Government and the balance owned by holders individually or jointly.

In Bangladesh, draft animals contribute 73% the total power required in agriculture. The contribution of human power is approximately 20%. The share of machine power is approximately 7 percent (12). This indicates almost a total dependence on draft animals for agricultural operations. Most of the draft animals are very small, underfed and in poor state of health. It is reported that a pair of bullocks would need 100 days for five ploughing and other preceding operations for 2 hectares of land. Recent estimates have indicated that only 0.356 kw/ha is available for crop land in Bangladesh (13) which is below the minimum threshold of power requirement (about 0.373 kw/ha (11)). Due to this acute shortage of power, land preparations are delayed past the optimum time resulting in poor yields.

Need for farm mechanization

The need for technological change to induce an overall improvement in the farming conditions in Bangladesh is than imperative. The Government and the people are fully aware of the situation and have been attaching top priority to the matter. The cropping intensity/easily can be raised to 200% from the present level of 150% by introducing selective mechanization in land preparation and threshing. During the past few years, there has been an increase in the demand for all types of farm equipment. Farmers, more than ever before, are eager to use agricultural machineries for maximizing productivity, within their capacity to invest. With the rise in wages for human labour and cost of maintenance of bullocks, together with non-availability of labour during peak seasons, especially in intensively farmed and newly developed areas (such as G. K. Project, Chandpur Irrigation Project, etc), use of tractors/tillers and other equipment have become necessary and more economical. With the introduction of high yielding varieties and multiple cropping, lack of power on farms for performing the different agricultural operations has become a major bottleneck in further increasing the area under multiple cropping. If 0.373 kw/ha of crop producing area is the minimum requirement for any reasonably efficient agriculture, about 4 million hp is required as against 3.5 million hp currently available in Bangladesh (13). This gap will have to be filled in by tractors and power tillers, etc. as further increase in animal population will create competition for food with human beings. The country is already facing a problem of migration of the rural youth to the city because of the combination of long hours of work and unattractive working conditions that exist with the traditional methods of farming.

Present Situation and Future Aspects of Research Activities on Development, Improvement and Utilization of Farm Machinery

Extent of mechanization

As pointed out earlier, farm mechanization in Bangladesh is limited almost exclusively to rice. Even here, it is further limited to tillage and irrigation purposes only. This is because these operations require too much raw power to be sufficiently met by human labour. Although draft animals have, for a long time, been the main power source for tillage operation, it is much too slow, especially for a double cropping programme.

Multiple cropping demand reduced operating time in the farm for a specific crop so that the next crop can be sown in proper time. The possible operations of doing this are land preparation and harvesting where mechanization are urgently needed. Timeliness in operation helps to increase the yield. It is equally important in multiple cropping practices. Mechanization of certain activities, as mentioned above, is vitally important to maintain timeliness in operation.

The other operations, like transplanting, interculture, etc. are time consuming, but yet, at present, the necessity of using mechanical means in those areas of operations are not as acute as in land preparation, harvesting, threshing and drying of the grains.

Drying of paddy is getting priority in the mechanization programs of the Government. "Boro" and "Aus" paddy are harvested in the middle of the rainy season, and sun drying, which is the only way of drying paddy at the farmers' disposal, becomes difficult and results in substantial post-harvest losses.

As crop diversification programs are becoming popular in Bangladesh, many specialized machineries, such as, seeders, planters, etc., are now making their appearances on many farms. It is expected that in a few years' time these machineries will be widely used throughout the country.

Research facilities

In the past advanced technologies, machineries, equipment and cultural practices were imported from developed countries to improve the agricultural sector. Such technologies did not bring any spectacular economic change in agricultural development. This was because the agricultural technologies of the developed countires were not appropriate for adaptation in the socio-economic and climatic environments of Bangladesh. Bangladesh needs to adopt technologies which will not significantly displace labour force from the farms but will provide rural employment and satisfy the peak period shortage. This calls for undertaking research activities to develop and improve machineries locally to suit local environment. Very little research has been carried out in this field. Available facilities are rather limited. The faculty of agricultural engineering at the Bangladesh Agricultural University has carried out some research work in this field within their limited facilities. Few research schemes were undertaken in recent years to develop dryers, huller, neck-harness, cleaners, seed drills etc., suitable to the country's demand. But for the lack of suitably qualified and experienced personnel more extensive research could not be possible. Other organizations, such as Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural Research Institute (BARI), Jute Research Institute, etc. have undertaken research within their limited facilities. In fact, there are only a handful of agricultural engineers in the country who are engaged in research.

Future approach

In the past, few attempts were made to develop small machines and equipment suitable for small holdings in the department of Farm Power & Machinery at the Bangladesh Agricultural University and at BARI. This approach has been further intensified. The present and future trend should be focussed on (i) modifying and testing of available machineries to suit local conditions ; and, (ii) to find the best methods of utilizing these machineries, either through new farming methods or through better organizations of farm management.

This approach will particularly be suitable because Bangladesh does not manufacture its own farm machines of the sophiscated type. Developmental research would not thus be able to find an outlet in the near future. Bangladesh would do well in adopting machineries developed in advance countries after necessary modifications are made. This does not mean developmental research will be completely ignored at present. Some amount of development work must be done and continued to solve problems which are peculiar to the country.

Utilization

It has been pointed out earlier that in Bangladesh tractors are owned mainly by Government agents and co-operatives. Co-operative ownership had an early start at Comilla but has not yet been fully established. The bulk of the large tractors in the country is owned by Government and semi-government organizations and these tractors operate on large estates owned by these organizations.

Contract-service has not developed yet. Efforts are being made to improve the co-operative systems so as to enable farmers to own their machines. Organizing farmers to form co-operative systems will enable the Government to provide essential services such as credit and marketing facilities. It is hoped that the Comilla type co-operative system will be introduced all over the country in the near future and these when organized will help to spread the mechanization programs.

Socio-Economic Problems

The introduction of farm machinery in Bangladesh has not met with any great opposition as the farmers have long accepted the idea of using machineries. Inspite of this, mechanization has gone at a very slow rate. Some of the difficulties are technical but many others are socio-economic problems like small farm size, lack of skill, high cost of machinery, lack of capital, etc.

Social acceptability to change

For successful mechanization, it is quite often desirable to change farming methods or techniques. But when changes to specialized new techniques are involved, farmers become sceptical, unless the advatages of the new method is glaringly obvious. As the changes can only be affected one at a time, the advantages gained are very often obscure. It requires vigorous and persuasive extension work to persuade the farmers. But due to the shortage of qualified personnel, Bangladesh does not yet have satisfactory extension services specializing in farm machinery. Furthermore, the capital required to bring about a complete change would be too much.

Small farm size

Rice farming is the main occupation of most farmers but not the sole occupation in many cases. Other sources of income include jute cultivation, odd jobs and petty trading. Such small farm size makes it almost impossible for most farmers to have their own machines. Even when the machines are owned by co-operative or contractor, the small size plots are still a hindrance as the machineries have to complete one plot at a time thus making many more turns and stops than are necessary. This results in great reduction in field efficiency of the machines. Therefore, land consolidation is a must for successful mechanization.

High cost of machinery

As most of the farm machineries are imported from developed countries, the initial cost is very high by any standard. This is aggravated recently due to high inflation rate and low exchange value of the Bangladesh currency abroad. On top of that there is the cost of insurance, freight, handling and local taxation. The investment on farm machinery depends on a number of considerations they are used only for a few months of the year. Lack of capital and investment capacity of the farmers and the high cost of machinery retard the mechanization programs. The possible ways would be to manufacture small machineries locally. This will reduce the initial cost by offsetting the other cost-adding factors.

Lack of skill and education

Machineries of any kind need trained operators and mechanics to maintain them. In a society where great majority of the rural people are iliterate, it will take a long time and a great deal of effort to train the people for these mechanical jobs. In many cases, it is very difficult to find people with the right inclination. Lots of people need to be trained to be operators, mechanics, welders, etc. to enhance the mechanization programs. To develop these skills additional vocational and informal training facilities should be established in different regions of the country. Instructors have to be trained to acquire sufficient professional qualifications and experiences. People must be encouraged to get trained in different technical training centers. Co-operative societies can send their members to these centers for training.

Labour problem

Bangladesh has huge surplus labour. It is reported that every year 0.6 to 0.7 million labour force needs to be employed in the rural areas. These are the members out of farm family who helps around the farms and many of them are underemployed. Selective mechanization in agriculture will add some new activities like maintainance, repair, and management of the machineries. These would require skilled labour and the school leavers will feel some attraction towards the improved type of jobs in the field and will help provide the local less qualified youths who would otherwise hesitate to work with the totally illiterate farmers. Hence selective mechanization programs can overcome the labor problem to some extent.

Labour shortage during the peak period is met mainly from migrant labour. The local unemployed labour force made up mainly of school leavers who are not interested in farming jobs and prefer to go into the towns and wait for the better paying jobs. This is damaging in one sense because the farming sector is not able to tap this source of labour properly. Some amount of mechanical power supply is needed for some farm jobs if productivity of land is to be increased.

Future Agricultural Mechanization Policies

Since liberation the Government has been persuing a policy of self-sufficiency in rice. In its endevour to achieve these objctive the approach is towards greater production from existing rice production areas. This means that besides increasing yield, the farming system and practices have to be more intensive. For this purpose, the Government is encouraging the greater use of machinery in the farms. This encouragement may come in the form of setting up centres for training of farm operators and mechanics, setting up of agricultural and vocational training centres in each thana, sending instructor in farm mechanics for training overseas and having agricultural credit schemes for the purchase of inputs and for taking other measures. Spreading co-operative system all over the country is another programme under active consideration of the Government. Irrigation pumps are being installed in large numbers for increasing agricultural productivity. The Government is planning to provide all sorts of facilities to the intending farmer going for mechanization in the near future. Several committees have been formed to recommend to the Government measures for the implementation of a practical mechanization program as soon as possible.

It is also under the government's active consideration to create more jobs in the country and the Government has embarked on an industrialization program which will include the assembly of tractors and other farm machineries. It is hoped that in the future the Government will provide more funds for agricultural mechanization programs and for the agricultural engineering fields.

Conclusion and Suggestions

The agricultural mechanization program in Bangladesh has not found a momentum yet as the problems like small holdings, low farm income, low labour productivity, lack of skill and other constraints still exist. The authors believe that agricultural mechanization in Bangladesh will only be possible if the following important services are developed simultaneously.

a) Establishment of service centers with adequate repair facilities and skilled mechanics in the rural areas.
b) Establishment of training and vocational centers imparting training to agricultural engineers, extension workers, technicians, operators, mechanics and farm workers.
c) Providing educational facilities for the rural masses and R & D facilities in the universities & colleges.
d) Creating job opportunities for the displaced labour by establishing more manufacturing industries and agro-based factories.

Systems and techniques developed in the industrialized countries should not be adopted in Bangladesh without testing and necessary modification. Redesign of old implements and hand tools and improvement of local techniques and methods without fundamental change of local infrastructure seem appropriate to Bangladesh condition. Selective mechanization of certain operations such as land preparation, levelling, harvesting and few post-harvest operations should be undertaken at this stage. Mechanizing these operations will increase land and labour productivity. Manufacture of multi-purpose small implements and machinery should be encouraged within the country. The Government must provide service facilities mentioned earlier for successful implementation of mechanization programmes in the country. The Government can play an important role (1) to introduce labour-intensive techonology, (2) to lower the prices of agricultural machinery, (3) to provide loans for purchase of farm machinery with reasonable interest rate, (4) to assist local manufacture of farm machinery and equipment, (5) to establish mechanization promotion centres, (6) to strengthen research, experimentation and training, (7) to consolidate lands, (8) to improve repair and maintenance facilities, and, (9) to encourage the formation of co-operative societies.

The problems mentioned in this paper cannot be resolved overnight with the present socio-economic condition in Bangladesh but the process must be orderly if the benefits of mechanization are to be realized. It is also suggested that the experiences of other countries may be utilized in developing future agricultural mechanization policies of Bangladesh.

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Rural Development : Scope for Voluntary Service Organizations

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The Government is now laying a lot of emphasis on rural development. This has created a favour able environment for voluntary service organisations to participate in rural development activities more actively and vigorously.

Voluntary service organisations like the Lions and Rotary have an important role to play. While official agencies are concerned with planning and long term projects, the service organisations can undertake short-term projects with quick yielding results, with a more favourable cost benefit ratio.

Rural development is not a new field for the service organizations. They have been involved in this activity for a long time. One of the earliest organised rural development activities was perhaps in the form of Trusts and Charitable organisations for the cow—Goshalas, Gopalan Samitis, Pinjrapoles, etc. Some of these Trusts have vast tracts of land running in thousands of acres, for example Nathdwara in Rajastan and Patan Gujarat. Though these trusts were expected to undertake rural development projects, they concentrated on agricultural operations on a minimum scale, just to grow enough fodder for the cattle they had. There is lot of scope in improving the operations of these trusts with the object of raising production and productivity and utilising these centres as bese of operations for rural development work.

Village adoption : Many rural development programmes begin with adoption of a village. This has to be very carefully done. Factors like proximity and communications have to be taken into account. Local contacts in the village is very important. It is advisable that those associated with the rural development projects in the village should keep off politics. There is lot of suspicion among the rural folk and one of their immediate reactions to social service volunteers is that the persons concerned may sooner or later solicit their votes and support for a political cause. In fact mixing up of politics with rural development wok has been a demotivating factor.

When the village or a group of villages have been identified for an intensive work, we must develop a profile of the village—data and statistics and all relevant information which would help in preparation of rural development plans. There should also be a survey of needs and the priorities should be determined.

Having selected the site of operation, we should then go on to identfy the projects. Criteria of selection of a project include (1) quick yielding results ; (2) low cost and high benefits—a favourable cost-benefit ratio : (3) local participation by the rural community ; (4) there should be no doles ; (5) some of the projects should be land mark projects, which can be easily identified as evidence of beneficial work done.

We are listing below a number of possible projects which can be taken up by voluntary organizations. The list is only indicative and not exhaustive. The projects are all practical projects and have been identified on the basis of experience gained by various organizations in the field, particularly the Lions

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Drinking Water

It includes development and maintenance of wells, ponds, and other sources. Potable, hygienic drinking water will ensure better health. Poor quality of drinking water is responsible for most of the diseases. Projects on drinking water supply call for high priority.

During a meeting with the Lions, Mr. Sharad Pawar, the Maharashtra Chief Minister, appealed to them to concentrate on drinking water supply projects in rural areas. The Maharashtra Minister of State for Rural Development, Mr. Prataprao Bhosle, convened a meeting of all concerned government agencies such as Public Health Engineering Department, Ground Water Surveys & Development Agency, Collectors and Chief Executive Officers of Zilla Parishads. A tesk force has been set up to expedite the implementation of projects, particularly in the districts of Thane and Kulaba.

There are government schemes, where local community must raise 10% of the cost. This has not been possible and in some deserving cases, this contribution can come from voluntary service organisations. In some cases, they can also meet the difference in actual cost and that permissible under government norms, which were laid down years ago and have not been updated. Under certain conditions, the local contribution of 10% of the cost can be reduced to 2%, at the govern-men's discretion. Regular treatment of water in existing wells is an important social service. We can use with advantage the Chlorination Pot System developed by the National Environmental Engineering Research Institute. (NEERI) . Nagpur. The following is an extract from an official write-up on this system : "Epidemiological studies have amply proved the role of water in the spread of enteric diseases. Effective utilisation of water treatment practices. has contributed a significant reduction in these diseases. Wells form a major source of water supply to most villages in India. Surveys carried out by this Institute and by others have shown that open dug wells are invariably polluted.

"Well waters can be treated by the addition of bleaching powder or any other disinfectant every day but it is impractical. A method or device that will give effective chlorination of rural wells for a longer period would be of immense use. With this object in mind, NEERI has developed a chlorination pot for open dug wells which will effectively chlorinate water upto 21 days.

"An earthen pot (**Fig. 1**) of 7 to 8 litre capacity is used in this system. Holes of 0.5 cm diameter are made at the bottom. The holes are covered with stones or pebbles of 2 to 4 cm. size. A dry mixture of 1.5 kg. of bleaching powder and 3 kg. of coarse sand is placed over the pea gravel. The pot is then filled with pebbles or stones upto the neck to facilitate its immersion in the water. It is lowered in a well 0.9-1.2m. below water level with the help of a rope. which is then tied to a suitable hold (like the beam holding the pulley used for drawing water). Addition of sodium hexametaphosphate (5% by weight of bleaching powder) helps in prolonging the chlorination period by keeping the mixture soft.

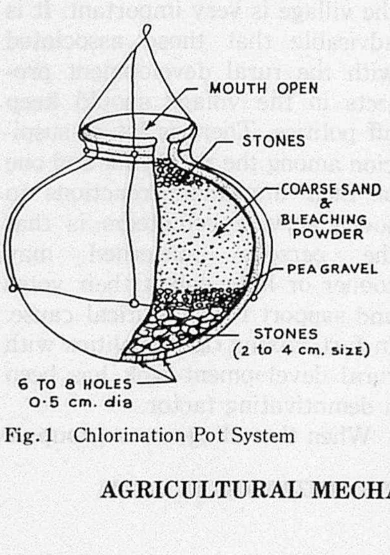


Fig. 1 Chlorination Pot System

"With community wells of 9,000 to 15,000 litres content and daily draw off of 900 to 5300 litres (40-60 people per day), one pot is enough to give adequate chlorination (0.2 to 1.0 ppm) for 10 to 15 days. With higher drawoff rates, two pots are necessary per well."

We suggest using a coir jacket (cage) around the pot to facilitate its frequent re-charging. Chlorination pots ready to use condition can be had from the Lions Club of Bombay.

As an alternative to the earthen pot, NEERI advocates use of a plastic pot—20cm. diameter at the top, 16 cm. diameter at the bottom and 21cm. height, kept in an expanded metal cage, suspended by jute or nylon rope. The pot costs about Rs. 25.

Marketing support: Liberal assistance is available from Khadi Village & Industries Commission in setting up cottage/village industries. Items like matches, agarbattis and soaps can be manufactured. A survey should be made of raw materials locally available so that they can be processed. For regeneration economy, it is important to set up industries in rural areas only. Grants/loans are available to encourage artisans — carpenter, blacksmith, cobbler, potter and others.

Educational

(a) Balwadis for children. (b) Distribution of books, stationery, uniform, toys, sweets and food items. (c) Adult literacy classes. (d) Library, School equipment, Laboratories and other facilities. (e) Educational documentaries and films. (f) Student prizes for best perfomance. (g) Sports tournament. (h) National Service Scheme (NSS) Camps—We have had some good experience in taking young boys and girls to villages for rural development work under the National Service Scheme. Before these camps are organised, it is important to play the activities and cleary identify as to what are the priorities and what do we expect the volunteers to do during their stay in the village. Some useful services rendered by the volunteers include cleaning and treating the wells, desilting of tanks, construction of roads, building and electrification of cottages, etc. Students can also do useful work through concurrent Study Service Projects (CSSP).

(i) Visits and lectures on social subjects like prohibition, family welfare, hygiene, civic affairs and vocational topics in agriculture and industry.

(j) In schools covered by the 'Sukhadi' scheme of distributing meals, 'sukhadi' is delivered generally once a month. It is important that airtight containers, as per the designs of grain storage bins developed by Indian Grain Storage Institute. Nagpur and Punjab Agricultural University, Ludhiana, are donated so that school children do not become victims of spoilt/infested food. A one-tonne containers costs about Rs. 300.

Medical : (a) Dispensary for poor and deserving persons, particularly the weaker sections of the society.

(b) Camps for eye operations. T. B. tests, immunisation against Polio and other diseases among children and general health check up.

(c) Visits of specialists, keeping in view agricultural occupational hazards.

(d) Medicines and injections particularly against snake and dog bites and Tetanus.

(e) Provision of certain free beds and treatment in some nearby hospitals for serious patients and urgent cases for poor persons.

(f) Cottage hospital (with a few beds)

(g) Mobile dispensary.

The health of the natjon's food producers should be our concern.

Agricultural

(a) Providing agricultural inputs like fertilizers, seeds, pesticides, pesticides, tools and agricultural implements—particularty items which may be in short supply. An improved sickle for harvesting paddy cuts the stalk close to the ground and minimises the carriage of stem borer disease from one crop to another. This hand tool is lighter in weight and has better ergonomics.

(b) Guidance and training in improved agricultural and animal husbandry practices.

(c) Getting grants and other aids available with various Government and non-Government agencies. Lions Club of Trombay recently got sanctioned a grant of Rs. 26,000 from the Central Social Welfare Board for purchase of 10 buffaloes, which now provide vital economic support to 10 poor families in the Padghavli village (District Kulaba, Maharashtra).

(d) Activities like soil testing, providing grain bins and fitting reflectors (cat's eyes) on bullock carts to make night plying safe on the roads.

(e) Veterinary camps.

(f) Planting fruit bearing trees like coconut, mango etc.

General

(a) Inducing villagers in repairs and maintenance of roads and maintaining better surroundings; ecological improvement.

(b) Providing occasional entertainment like cinema shows, magic shows and other variety programmes.

(c) Housing for the homeless.

(d) Adoption of children and families from among the poorest and weakest in the village and providing them with nceessary support—on the lines of the now famous 'Antyodaya' programme developed in Rajasthan.

(e) Providing utility and community structures, after a survey of the local pressing needs.

(f) Guidance on how to improve the village economy and the economic condition of the weaker sections of the society by providing them with gainful employment.

(g) Getting expedited the community welfare development projects by follow up with the concerned Government authorities, financing institutions and other agencies.

(h) Installation of hygienic lavatories of designs developed by Maharashtra Gandhi Smarak Nidhi and bio-gas plants.

(i) Other projects to suit the village needs and the resources of the Club.

There are several agencies active in Rural Development. Some of them we have worked with and which could be mentioned are : (1) Lions, (2) Rotary, (3) Yusuf Meherally Centre, (4) National Institute of Rural Integrated Development (NIRID), (5) People's Action for Development (PAD), (6) Sevitavya Sangh, (7) Bharatiya Agro Industries Foundation, (8) Shri Sadguru Seva Sang Trust, (9) Companies in the private sector like Mafatlals, A.C.C., WIMCO, Glaxo, Usha Martin Black and Telco.

There are incentives for the donors in the form of a rural development allowance. The Finance (No. 2) Act 1977 has introduced a new section 35 CC in the Income Tax 1961 under which companies and co-operative societies will be entitled (by prior approval) to deduction in the computation of their taxable profits, of the expenditure incurred by them during the previous year on any programme of rural development. The following is an illustrative list of rural development projects which can be considered for approval under this provision :

(1) Assistance in the setting up of rural industries in selected areas by the rural weak to provide them self-employment.

(2) Establishmhnt and running of dispensaries, maternity and child welfare centres and family welfare centres.

(3) Nutrition programmes for school children.

(4) Establishment and running of educational and vocational training centres.

(5) Construction and maintenance of rural link roads, village streets, pavements and drainage.

(6) Construction and maintenance of drinking water projects, such as wells, tubewells, etc. and cleaning of wells and ponds.

(7) Rural electrification, i.e. provision of street lighting in villages and electrification of Harijan Tribal homes.

(8) Assistance to the weaker sections in constructing houses on sites provided in rural areas by Government, village panchayats, etc.

(9) Minor irrigation schemes, including boring of tubewells and installation of pumping sets for the benefit of groups of small marginal farmers.

(10) Supply of improved varieties of seeds and provision of facilities for seed testing to groups of small marginal farmers and assistance to such farmers for establishing seed farms.

(11) Supply of fertilisers and insecticides to groups of small marginal farmers and giving guidance and training to such farmers in the use of fertilizers, insecticides, etc.

(12) Supply of plant protection equipment, sprayers, farm machinery, implements, etc. to the village panchayat for the use of groups of small marginal farmers.

(13) Animal husbandry —— assisting the farmers in cattle improvement through establishment of veterinary dispensaries, artificial insemination centres etc., dairy products processing and marketing.

(14) Assistance to groups of small marginal farmers, landless labourers, etc., in poultry farming, horticulture, pisciculture, etc.

(15) Establishment of workshops for servicing and repair of farm machinery and traning of artisans, mechanics, etc.

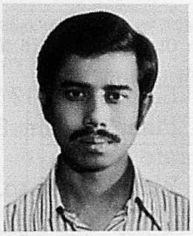
The provision of Rural Development Allowance has so far not attracted the industry/business organisations to the extent expected. There is need for motivation at all levels —— the industry, the trade, the voluntary service organisations and even the beneficiaries. Social workers in rural areas know that it is not easy to get the villager to accept help-financial or otherwise.

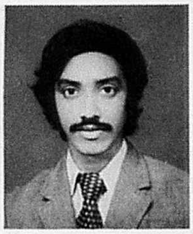
Sir Norman Kipping (of the Kipping Loan fame), during one of his visits to India said : "If I were to deliver any message to the companies, I should say get off your backsides and go out into the country and be enterprising and you will find you can create new markets on which, of course, India will be able to stage, on which it will be able to base, economic recovery."

The message to the service organizations is to go out into the countryside and serve the rural community. Development of rural areas is a greater challenge. The rural community represents a separate and distinct category ; separate, because of its isolation and remoteness calling for special services and communication techniques ; distinct, because of appalling conditions, specific needs, habits and literacy level which in most respects are different from those of the urban community.

Let us be the villagers' friend in need and the rural community's needs are really great. ■■

Design and Construction of Multi-Row Seed Drill for Jute Cultivation





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Abstract

A three-row manually operated seed drill was designed and constructed in the workshop of Farm Power & Machinery department, Bangladesh Agricultural University, Mymensingh.

The main part of the machine was the measuring device which consisted of a wooden block and measuring plates (alluminium alloy) with 10 semi-circular cells in each plate. The cells of each plate were so made that two or three seeds of jute can be accmodated and released easily without any damage or breakage.

The speed of the machine was 1 to 1.5 mph. Hence the circumferential speed of the measuring plate was 42 to 63 fpm. When the machine was pulled forward, the measuring device was powered by the drivewheel through chain and sproket wheel. The seeds discharge from the tube after covering a linear distance of 2 inches.

The effective width of the machine was 2.62 ft. The test result of the machine showed that the seed rates per acre for C. capsularis was 4.2 1b/acre. But the theoretical seed rate was 6.2 1b/acre. The test result of the machine also showed that the seed spacing was 2.125 inches, but the theoretical consideration was two inches.

Introduction

Bangldesh is an agro-based, non-industrialized country. About 85 percent of the total population completely depends upon agriculture (1). Bangladesh earns a major portion of her foreign currency from agricultural products and their by-products. It is necessary to develop agricultural technology for self-sufficiency.

It is true that about 60 percent (2) of the people of Bangladesh earn their liveehood directly through the cultivation of jute. Bangladesh grows two species of jute, viz., Tossa jute (Corchorus olitorius) and Desi jute (Corchorus capsularis). Tossa jute is generally of light golden colour and is also known as Bagipat. It is sown April-May and harvested in August-September. White jute is known as Desipat and is sown in March-April and harvested in July and August.

Temperature ranging between 70°F to 100°F and relative humidity of about 90 percent are favourable for jute cultivation. Two or three inches of rainfall during the growing period and weekly interval thereafter is sufficient for the growth of plants. During the growth period alternate heavy rain and sunshine causes vigorous growth while draught causes reterded growth and early flowering (3).

The Bangladesh farmers still practice their age-old broadcast method of seeding, They prepare their land by 4 to 5 ploughing and laddering. But improved practice of seeding by mechanical means revealed that both quality and quantity per acre can be increased (4).

Once Bangladesh was the leading jute growing country. But the position at present has changed. India has boosted her raw jute production whereas other countries like Brazil, Burma, China, and Korea are trying to expand jute cultivation. The area, production per acre yield of different jute growing countries are shown in **Table 1.**

In 1947–48, jute production was 85.34 lac bales and in 1969–70 increased to 200.34 lac bales. The production of jute in Bangladesh remained static with the result that the share of Bangladesh in the world market declined from 80 percent to 36 percent as shown in **Table 2.**

The main objective of this

Table 1. Area, Production and Yield per Acre of Jute (1964−65)

Country	Area in 000 acres	Production in 000 tons.	Yield per acre in Mds.
India	2077	1116	14.6
Bangladesh	1660	951	15.6
Brazil	104	52	13.6
Nepal	79	40	13.8
Thailand	17	8	12.8
Taiwan	−	17	−
Burma	−	11	−
Peru	−	2	−

Source : A. Alim. "Bangladesh Agriculture" Published 1964−65. (−) not available.

Table 2. Juto Production in Bangladesh

Year	Bangladesh Production in lac bales	World Production in lac bales	Share of Bangladesh in world Production percent
1947−48	68.42	85.34	80.17
1950−51	60.07	96.97	61.95
1955−56	55.92	140.60	39.77
1960−61	45.32	139.10	32.58
1968−69	58.81	149.72	39.28
1969−70	73.91	200.34	36.74

Source : Bhattcharjee, D. Jute, Ltd Past, Present and Future, Published in Bangladesh Observer, the 16th March, 1973.

Table 3. Decrease in Yield of Bangladesh Jute.

Year	Area 000 acres	Production 000 bales	Yield(Mds. per acre)
1947−48 1949−50	1832 *	5218 *	13.6 *
1965−66 1969−70	2261 *	6537 *	17.8 *
1969−70	2464	7171	14.1
1970−71	2200	6670	14.7
1971−72	1672	4193	12.2
1972−73	2215	6514	14.4
1973−74	2196	6000	13.2

* = Average.
Source : "Bangladesh Agriculture in Statistics" Ministry of Agriculture, Government of Bangladesh, November 1973, page − 29.

study is to construct and investigate the characteristics of multi-row jute seed drill for sowing jute seeds in line and at uniform distance with a view to :

a) increasing the yield of jute at lower cost ;
b) improving the quality of seed production ;
c) improving the quality of fibre ; and
d) reducing the seed losses.

Past Work on Seed Drill

Galviel Plattle discribed a rough drilling machine and John Worldge, in his "Systema Agricultura", published in 1969 ; advocated the use of this seed drill (6).

Late in 1730-40 Jetbro Tull spent his some time in developing a seed drill. The development of seed drill after Jetbro-Tull was rapid. Early in the 19th century, the firm of Smyth of Peasenhull, started to produce drills that were the forerunners of their Suffolk drill which is widely used in the eastern countries today. In 1838, Hornshy developed a patent for a drop or spacing drill. In 1928, an investigation was carried out at Dacca (5) on seed drill. It was shown that plants grown in lines yielded greater amount of seeds than these grown in broadcast method.

In 1951, a line pushed drill was designed by the Jute Agricultural Research Institute and a local engineering farm, on the model of a Japanese paddy seed drill. The drill was found suitable for small jute fields.

Sanyl (6) pointed out that line sowing increased fibre yield by 12 to 13 percent in C. Capsularis and 11 to 16 percent in C. Olitorius. Weeding cost and seeding rate were reduced by 70 percent and 80 percent, respectively.

Mechanical sowing of jute has been achieved by the use of a converted rice planting machine (7). Kundu (8) showed that line sowing by seed drill increases yield of C. Capsularis by 5 mds/acre and C. Olitorius by 3.5 mds/acre.

The jute plants grown in lines at a distance of 12 inches between row and 3 inches between hills increased fibre yield by 9.72 percent, reduced the cost of weeding and thinning by 29.22 percent and cost of harvesting by 10.69 percent over broadcast method of owing (9).

The Pakistan Central Jute Committee recommended the following for higher yield of jute per acre (10).

Varieties :
a) C. Capsularis D-154, C-6
b) C. Olitorius D-4,

Spacing :
a) Line to line-12 inches
b) Plant to plant-2 inches

Seed rate :
a) White jute-5 to 6 lb/acre.
b) Tossa jute 4 to 5 lb/acre.

Experimental Design

The detail design of the three-row jute drill is shown in **Fig. 1-14.** The total cost involved in constructing the machine is Taka 488.35. Detailed stress analysis on various elements became very difficult due to the lack of information regarding kinds and amount of stresses acting on the various elements. Therefore, the dimensions and suitable materials for the elements were computed by applying a combination of scientific principles and judgement based on anticipated maximum stress condition so that they would perform their task without failure.

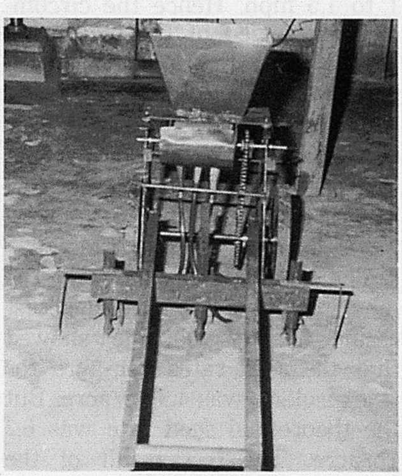

Fig. 1 Front view of three row jute seed drill

Fig. 2 Pictorial view of three row jute seed drill

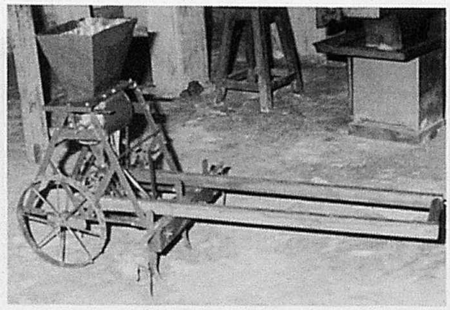

Fig. 3 Side view of three row jute seed drill

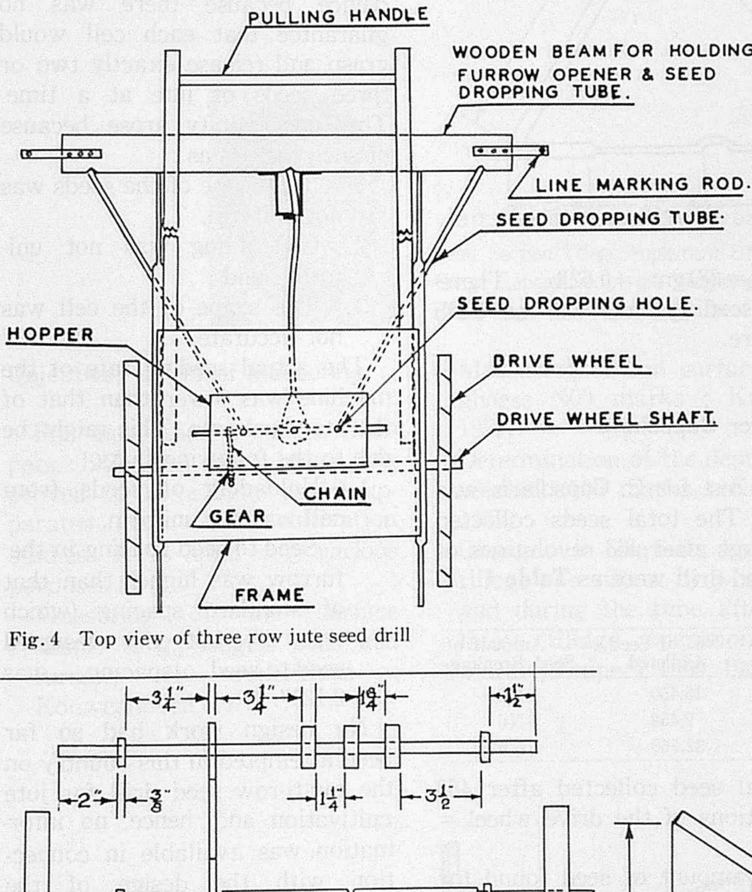

Fig. 4 Top view of three row jute seed drill

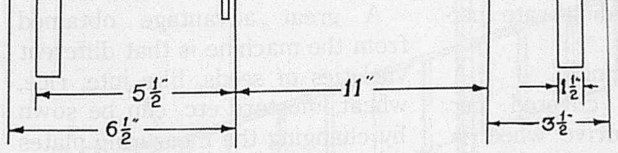

Fig. 5 Power transmission from drive to measuring device

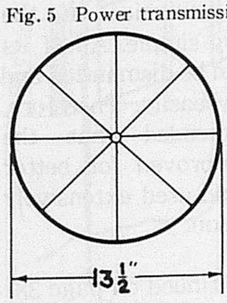

Fig. 6 Drive wheel

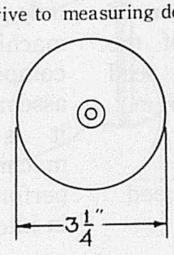

Fig. 7 Measuring plate

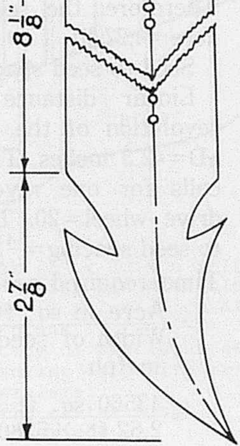

Fig. 8 Furrow opener

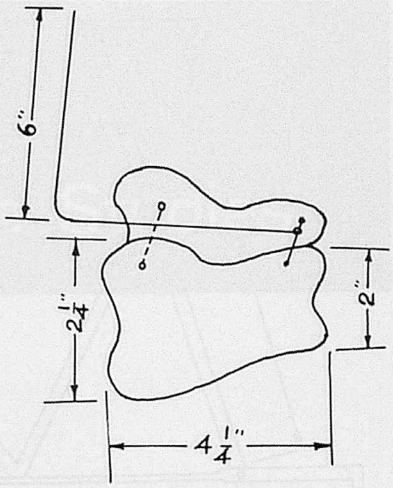

Fig. 9 Covering device

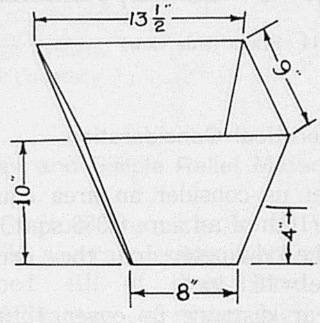

Fig. 10 Hopper

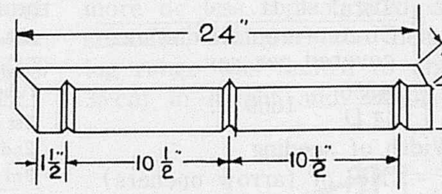

Fig. 11 Wooden beam

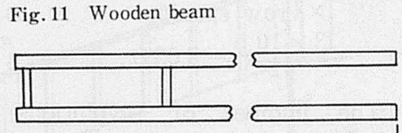

Fig. 12 Drive handle

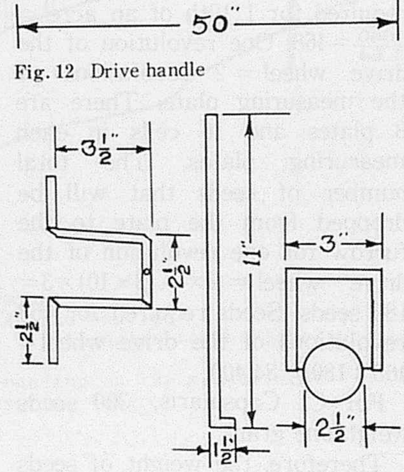

Fig. 13 Parts of gage wheel-arrangements

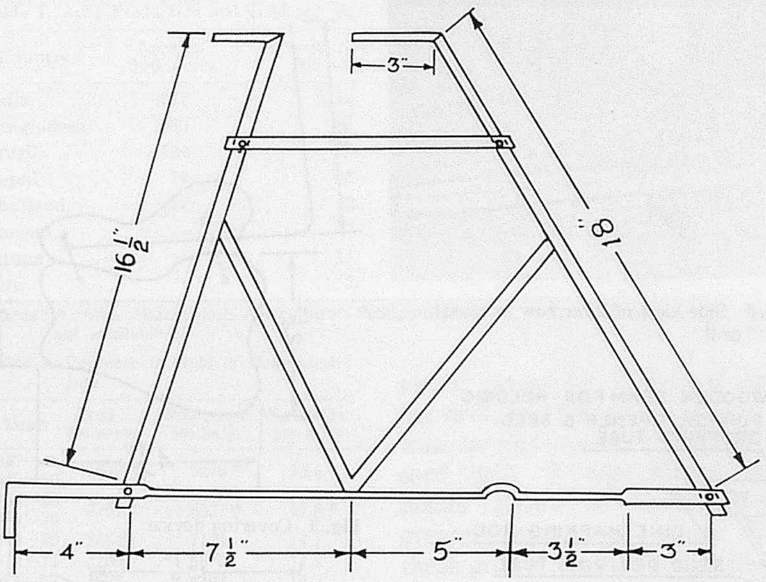

Fig. 14 Frame (side view)

Theoretical Consideration

Let us consider an area equal to 1/10th of an acre (4356 sq.ft.)

The diameter of the drive wheel=13.5 inch.

Linear distance to cover 1/10th of an acre by the drill

$$= \frac{\text{Total sq.ft.}}{\text{Circumferential distance covered per rev.}}$$

$$= \frac{4356}{\pi D} = 1660\,\text{ft}.$$

Width of seeding

$= (\text{No. of farrow openers}) \times (\text{row spacing})$

$$= \frac{3 \times 10.5}{12} = 2.62\,\text{ft}.$$

The number of revolutions required for 1/10th of an acre = $\frac{1660}{3.54}$=468. One revolution of the drive wheel = 2 revolutions of the measuring plate. There are 3 plates and 10 cells in each mearuring plates. The total number of seeds that will be dropped from the plate to the furrow for one revolution of the drive wheel = 2× (3×10)×3= 180 seeds. Seeds required for 468 revolutions of the drive wheel= 468×180= 84,400.

For C. Capsularis, 300 seeds weigh one gram.

Therefore, the weight of seeds to cover 1/10th of an acre= $\frac{84400}{300}$ =281gm. =0.62lb. Therefore, seeding rate will be 6.2lb per acre.

Test for Capsularis

The test for C. Capsularis was made. The total seeds collected in 3 bags after 468 revolutions of the seed drill were as **Table 4** :

Table 4.

Seed Tube	No. of Seed Colleted	Amount of Seed Breakage
1st	15,450	Nil
2nd	9,450	Nil
3rd	32,760	Nil

Total seed collected after 468 revolutions of the drive wheel = 57,660.

The amount of seed found for sowing 1/10th of an acre=0.422lb Therefore, the seeding rate per acre=4.22 lb.

Seed to seed spacing :

Linear distance covered per revolution of the drive wheel = πD=42.5 inches. The Number. of cells for one revolution of the drive wheel=20. Therefore, seed to seed spacing= $\frac{42.5}{20}$=2.125 in.

Time required per acre

$$= \frac{\text{Acre in sq. ft.}}{\text{Width of seeding} \times \text{speed in fph.}}$$

$$= \frac{43560\ \text{sq. ft.} \times \text{hour}}{2.62\ \text{ft.} \times 5280\ \text{ft acre.}}$$

= 3.16 hour/acre.

Theoretical field capacity of seeder

$$= \frac{SW}{8.25} = \frac{1 \times 2.62}{8.25}$$

= 0.318 acre/hour.

Conclusion

Difficulty was experienced in connection with the measuring device because there was no guarantee that each cell would grasp and release exactly two or three seeds of jute at a time. This uncertainity arose because of such factors as :

1. The shape of the seeds was not uniform,
2. Cell filling was not uniform ; and
3. The shape of the cell was not accurate.

The actual seeding rate of the machine was lower than that of the standard rate. This might be due to the following facts.

1. Unloading of seeds from cell was not uniform,
2. Seed-to-seed spacing in the furrow was higher than that of standard spacing (which was 2") but the designed seed-to-seed spacing was 2.125".

No design work had so far been attempted in this country on the multi-row seed drill for jute cultivation and, hence, no information was available in connection with the design of the machine.

A great advantage obtained from the machine is that different varieties of seeds, like jute, rice, wheat, mustard etc. can be sown by changing the measuring plates only. The construction of the machine is very simple. All of its components can be dismantled and assembled very easily. Therefore, it is recommended that the machine be improved for better performance and used extensively in jute cultivation.

(Continued on page 38)

Simple Relief Meter for Soil Cultivation Studies

by
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Objectives of Relief Measuring

For more than 20 years (Kuipers, 1957) the relief meter has proved to be a very useful apparatus for soil cultivation studies. It is used for various purposes :

—Measuring of the surface shape, e. g., ridges, beds and furrows (10 repetitions ; Kouwenhoven, 1970)
—Measuring of soil surface roughness (400 marks ; Kuipers, 1957)
—Determination of the depth of a seedbed (100 marks ; Kuipers, 1957)
—Changes in surface level by tillage operations, by wheelings and during the time after the latest tillage operation (400 marks ; Kuipers, 1960, 1963)

New and Simple Relief Meter

Starting from the same principle several designs were developed. All of them have the disadvantage of rather high production costs connected with a more or less sophisticated construction. Moreover the measuring range was limited to about 35 cm in height and 200 cm in

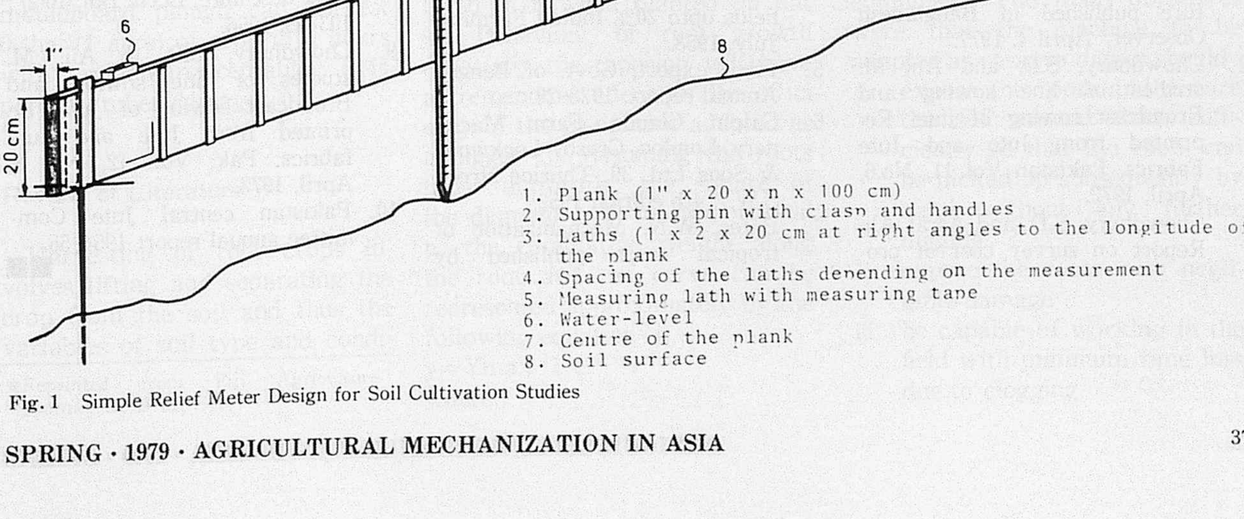

Fig. 1 Simple Relief Meter Design for Soil Cultivation Studies

Fig. 2 Measuring the Width of Potato Beds with Relief Meter

width. To avoid the problems mentioned a new simple relief meter was designed **(Fig. 1)** This apparatus can be easily constructed by a carpenter and blacksmith ; it is cheap and can easily be adapted for measuring high ridges and wide beds **(Fig. 2)**.

Some Instructions for Use

—For surface shape measurements the plank should be placed in the same position ; e. g., the centre of the plank at the centre of a ridge.

—The measuring lath (5) must be held tightly to the small laths (3) during measuring ; readings can be done at the upside of the plank

—Generally, readings are done in cm's, as depths of seedbeds are preferably carried out in mm's, this reliefmeter is less suited for (shallow) seedbed measurements,

—The distance between the laths (3) should be 10 cm for surface roughness determinations, 5 cm for surface shape and level measurements and 2.5 cm for depth of seedbed measurements

—Changes of surface level during the season should be measured from a fixed level.

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Design and Construction of Multi-Row Seed Drill for Jute Cultivation

(*Continued from page 36*)

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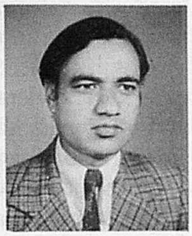
Studies on the Mechanized Harvesting of Cassava in Fiji



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Summary

Cassava is shifting from a peasant crop to a commercial plantation in this country. A scale of production of higher magnitude with minimun input cost is more practicable when supported by suitable mechanical equipments. In this paper some of the results of the studies conducted on the mechanized digging of Cassava roots are reported. Field tests were carried out at Koronivia on the farmers fields to find out a suitable machine from the existing one's for use as Cassava digger with the objective of reducing the cost of cultivation so that the net profit per unit of investment could be enhanced. Results of this study have established that a tractor of medium horse power and above range attached to a single bottom mouldboard plough can harvest 0.4ha. (1 acre) of crop in 6 hours with minimumacceptable (1.44 percent) tuber damage.

Review of Literature

Harvesting of root crops involves lifting and separating the crop from the soil and thus the variables of soil type and conditions are added to the usual crop variables encountered in ground harvesting (6). For this root harvesting or digging, machines are often adapted only to the area where they have been develped. Digging of crop like cassava which is one of the most important crops of this nation, has been a real problem of this crop (2). Under the existing farming methods mostly fork is used as a means of digging this crop which requires a heavy investment of input on labour and leaves a considerable percentage of tubers in the soil both injured and buried (1). Makanjuola suggested the use of a mouldboard ridger and a disc plough as an aid for the lifting of Cassava tubers (4). However, studies on the rooting characteristics of Cassava seem to suggest that the crop planted on the ridge will be more easily lifted than when planted on flat (4). Behaviour of root growth especially the tapering will have a tremendous effect on the efficiency of the equipment adapted as a digger (3). Assuming the roots taper uniformly, the square of the diameter will be proportional to the comulative weight along the root and the curve can be represented approximately by the following equation (4).

$y = Ymax\ (1-e^{-kxn})$

where ;

x = diameter along the root.

y = cumulative square of root diameter at 25mm intervals.

Ymax = Cumulative square of root diameter for the whole root.

Onochie, et al (5) found that the digging of cassava roots alone by traditional method of using a fork accounts for over 40% of the cost of production.

Materials and Methods

Research trials were conducted by using a tractor drawn single disc plough, mouldboard ploughs both tractor and animal drawn to establish and adapt a suitable equipment as a digger out of the existing machines. The existing method of manual digging with a fork was also taken into account for the cost comparison of digging by different methods and equipment. The main objectives were that the machine to be adapted as cassava digger should :

i expose the roots and disturb the soil around them sufficiently so that the roots can be picked up subsequently by hand without any further digging.

ii expose the roots with negligible damage.

iii be capable of working in the field with minimum time loss due to clogging.

※Reprinted from Fiji Agriculture Journal, 40, 59-61, 1978.

iv be of reasonably low cost.
v be of simple design for easy operation and maintenace.

In the process of trials two men were required for the efficient digging of cassava with a tractor drawn mouldboard plough which was found to be best suited for adaption as a digger out of the machines tried. This machine is a simple mouldboard plough of single bottom which is operated on a standard three point linkage system. The equipment is light and can even be used in deeper penetration and offers minimum draft on the tractor under favourable field conditions. Before this equipment is used the cassava stems are cut 10 to. 15cm above the ground level so as to avoid any damage caused by the tractor to the stems which are used as planting materials. The portion of the Cassava stems left above the ground enable easier hand picking after the tubers have been exposed to the ground surface. The permissible speed of the tractor for better efficiency has to be not more than 3km. per hour, and a speed higher than this will cause damage to the tubers. The depth and the angle of the plough has to be adjusted during the digging process accordingly to give a good turnout of marketable tubers. As soon as the tubers are lifted and exposed to the surface they are hand picked and left aside before they are covered by the overturned soil. (Fig. 1)

Fig. 1 Working of the machine is being demonstrated to a group of farmers

Fig 2 Cassava being harvested in one of the experimental fields

Results and Discussion

Data of the various trials conducted by using different methods as described earlier have been recorded in **the table** below. From the table and the performance characteristics explained in this paper on the basis of studies conducted it is clear that a single bottom tractor operated mouldboard plough can be well adapted as a cassava digger. This equipment exposes hundred percent of roots on the surface and the damage to the tubers is quite negligible in comparison to any of the methods studied. The time required to harvest 0.4ha. (1 acre) of cassava crop by this machine is only 6 hours which is minimum as compared to other methods. (Fig. 2)

The results of the field tests suggest that it is necessary to

Table Comparative Performance of Various Methods of Cassava Harvesting

Method	Weight of tubers exposed(kg)	Tuber damage(%)	Wt. of marketable tubers(kg)	Wt. of Unmarketable tubers(kg)	Marketable tubers(%)	Time taken to harvest 0.4ha(Hours)	No. of men required
Tractor drawn single bottom mouldboard plough	115.60	1.44	113.80	1.55	98.50	6	2
Tractor drawn single disc plough	71.10	7.76	65.61	5.57	91.90	5.60	2
Animal drawn mouldboard plough	53.00	25.00	39.80	13.10	74.80	23.30	2
Mannual digging by using fork	59.70	5.20	56.60	3.10	94.70	36.69	1

clear the plant residue in order to ensure uniterrupted movement of the machine. The procedure requires cassava stems and leaves to be cut and carried off the plot. (Fig. 3)

Manual digging of cassva as shown in the table appears to be most expensive for large scale commercial production which not only consumes maximum time but gives maximum tuber damage. During the trial it was observed that the following factors affect the efficiency of digging of cassava tubers by machine.

1. Speed of the machine.
2. Weeds in the field.
3. Moisture in the soil.
4. Method of planting, whether on ridges or flat
5. Physical properties of soil.
6. Growth pattern of tubers.
7. Depth of digging
8. Row spacing
9. Topography.
10. Experience of operator.

With the field studies carried out and results obtained it is evident that a tractor drawn single bottom mouldboard plough can be adapted as cassava digger under local agro-climatic conditions.

Acknowledgement

I am grateful to Dr Satish Chandra, Assistant Director of Agriculture (Research) for the guidance he provided during the experimentation. The assistance extended by Mr. Param Sivan, Senior Research Officer (Root Crops) and the cooperation extended by the farmer, Mr. Dalip Singh on whose farm this study was conducted is thankfully acknowledged.

Fig. 3 It is necessary to cut and remove the cassava stems before using the machine

Acknowledgement of AMA

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ERRATA

Vol. IX, No. 4, Autumn, 1978.
Potential of Bullock Cart Transport in Orissa–A Case Study, It's problems and possible solutions by B.G. Yadav, p. 75.

a. Column 1, equation 2 should read : $F\frac{d}{b} = K\left(\frac{W}{b}\right)^n, \mu$

b. Column 2, bquation 4 should read : $F = \frac{K}{d}\,\frac{W^{3/2}}{b^{\frac{1}{2}}} + \frac{b}{d}c$

c. Column 2, line 18 should read :

$$\frac{dF}{db}\;\frac{K}{d}\,W^{3/2}\,{}_{(-\frac{1}{2})}\,b^{-3/2} + \frac{c}{d} = 0$$

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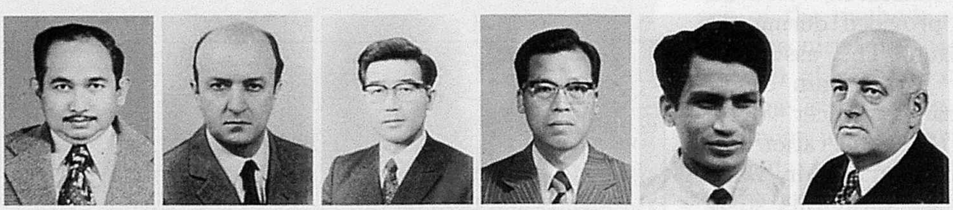

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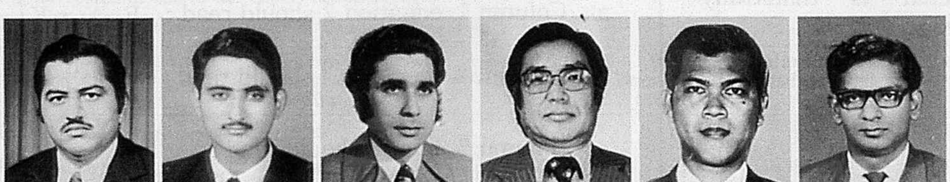

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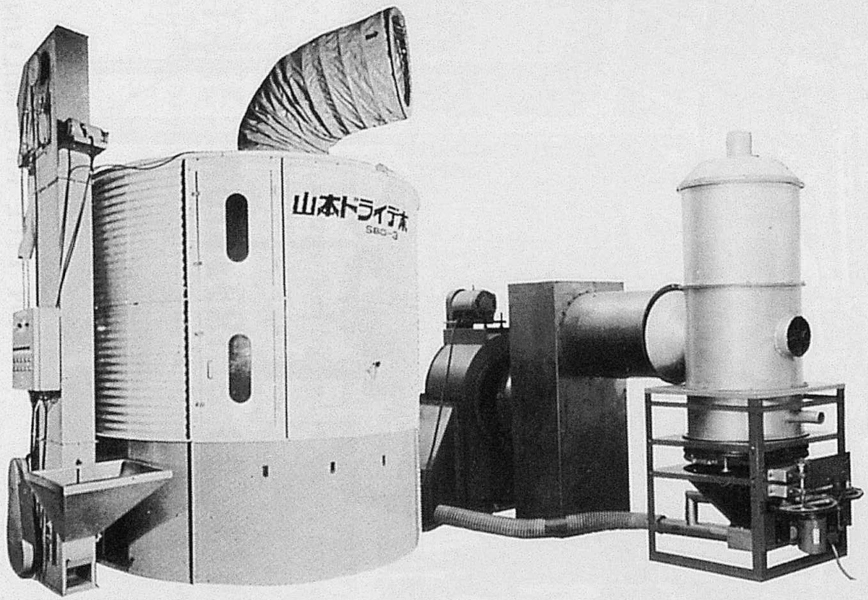

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Overall height (m)	3.5	Combustion capacity (kg/h)	30
Max. loading level (m)	1.8	Calorie generated (kcal/h)	9000
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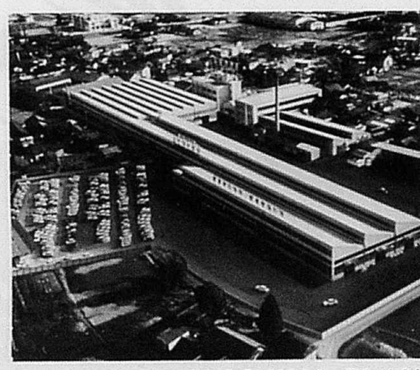

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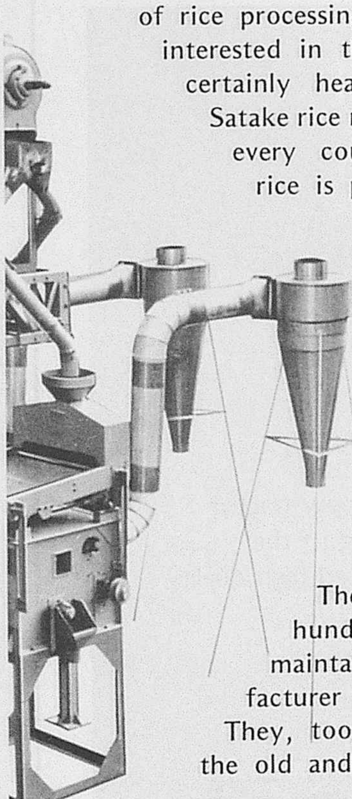

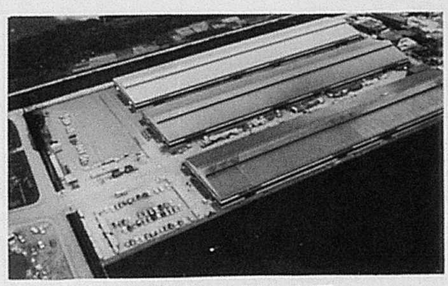

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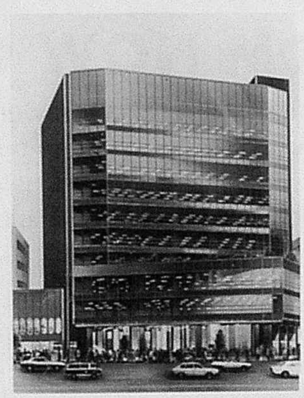

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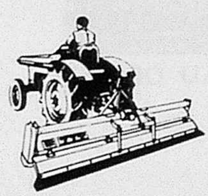

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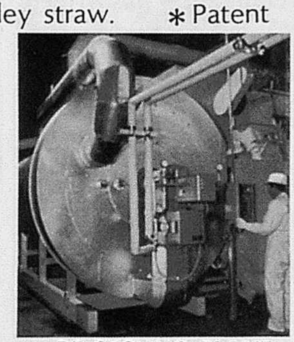

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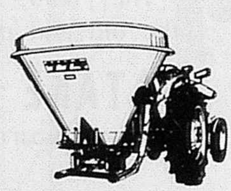

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Theoretical Design of Small Tractors

by
C.P. Crossley
Lecturer in Engineering Design
National College of Agricultural Engineering
Silsoe, Bedford, U.K.

Power Requirement for Agricultural Operations

Considerable differences, typically of the order of 5 : 1, can be observed between the crop yields per unit area obtained on research establishments in developing countries and that obtained in similar conditions by traditional farming methods on small farms. Many factors influence yield and very considerable improvements can follow the balanced introduction of new cultivars, fertilizers and pesticides. A further important factor, however, particularly in areas where the wet growing season is preceded by a sustained dry period, is timeliness of cultivation since delay in soil preparation leads to late sowing and a consequent reduction in crop yields. Cultivation during the dry season would eliminate the timeliness constraint, but this cannot normally be achieved by traditional animal drawn systems because the force required to disturb hard, dry soil to a depth of 150 mm with a single narrow tine is of the order of 4.5kN (1000 lbf). This draught force cannot be provided by a pair of oxen, particularly when in poor condition due to lack of feed during the dry season. Manual labour is subject to similar constraints which, together with the limited output available per person (approximately 0.075 kW) restricts the area under cultivation.

It is observed that the power available per unit area over much of Africa, for example, is about 0.04 kW/ha, while that in most developed countries, with yields per unit area of between 3 and 5 times greater, is in excess of 0.6 kW/ha. **(Fig. 1)**. It is suggested (U.N.I.D.O., 1972) that in order to achieve reasonable productivity in developing areas such as Africa, a tenfold increase in power, to 0.4 kW/ha is necessary.

To increase the available power by the introduction of more people or animals is unlikely to be feasible since in eigher case a rise in productivity could be countered by an increased food demand. Fossil fuelled agricultural machinery offers a technically feasible way of providing additional power. The size of the average family holding in many developing countries is of the order of 2 to 5 hectares, with 3 hectares as an approximate average figure. Such a holding would therefore requires a power input of 1.2 kW to provide the level suggested.

Many problems are associated with the indiscriminate introduction into developing countries of the technology evolved in Europe and North America, since the technical, economic and social conditions are entirely different. For the same reasons, the assumption that an intermediate level of technology is required, leading eventually to the application of the same higher technology, could be regarded as less than ideal. It is felt that a more promising approach is the development of an "appropriate" technology, in which the most suitable aspects of all available expertise is logically applied to produce a satisfactory solution to the problems unique to developing countries.

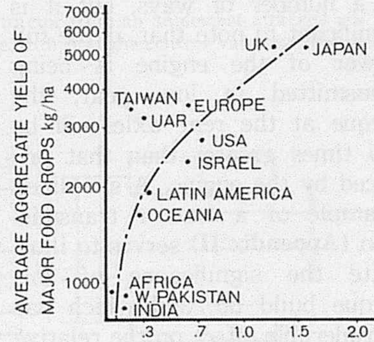


Fig. 1 Relationship between yield and power input (After Verma S.A., AMA, Summer 1972)

※Paper was presented at the Spring National Conference of the Institution of Agricultural Engineers, held at the National College of Agricultural Engineering, Silsoe, Bedford, on 21 March 1978.

Engine

The most commonly used power source is the internal combustion engine, either petrol or diesel. The initial cost of a small petrol engine is usually significantly lower than that of a diesel of similar power, but the petrol engine is unlikely to have a useful life of more than 500-1000 hours when run near full power, compared with a figure normally in excess of 2000 hours for a diesel.

The fuel consumption is also higher than that of a diesel, in which the specific fuel consumption is substantially independent of engine size. Power outputs of all normally aspirated engines will be reduced by approximately 15 percent when operated at 1220 m (4000 ft) and 37°C (100°F) and for the design life to be achieved it is vital that adequate maintenance be carried out.

The fitting of internal combustion engines to small tractors for use in developing countries gives rise to problems in operation. **(Appendix I).**

Transmission

A small tractor fitted with an engine rotating at 3000 RPM and running on 7.50-16 tyres in low gear at 1 m/s (2.2 miles/h) requires a total reduction in speed, between engine and rear axle, of 125 : 1.

This reduction may be achieved in a number of ways, but it is significant to note that, if the full power of the engine is being transmitted in low gear, the torque at the rear axle will be 125 times greater than that produced by the engine. A simplified example of a tractor transmission **(Appendix II)** serves to illustrate the significance of this torque build up, and which has considerable effect on the relative sizes of shafts and transmission components such as chains, couplings, gears and clutches.

Types of transmission

(a) Belts

Vee belts can be used for low power, high speed drives such as the initial reduction from an engine ; a reduction in one step of up to 5 : 1 is feasible. Belts are reasonably tolerant of misalignment and environmental effects but maintaining correct tension can be difficult. Sprung tensioners can be arranged to act as transmission clutches, but will reduce belt life due to the extra bending. Variable speed or torque sensitive drives are available and, if properly matched to the engine and load, can be a useful and cheap primary transmission system. Typical losses in belt drives will be 5-10 percent.

(b) Chains

These high precision components are available in a wide range of pitches and sprocket size, and are generally suitable for higher torque and low speed. Reductions of up to 6 : 1 are possible.

Because of their conservative ratings (usually based on a factor safety of 10 on ultimate tensile stress, and a life of 16000 hours) it can be regarded as acceptable to overload chains by as much as twice their rated power for a design life of up to 5000 hours, but it is important to maintain correct tension, alignment and lubrication and to exclude environmental effects such as dust which can cause serious damage. Losses per chain will be between 2½ percent and 5 percent.

(c) Gears

Stepped gear boxes may be designed or specified. A minimum of two forward and one reverse gear is normally required so that such a gearbox is unlikely to be cheap. The efficiency of a transmission of this type will be around 85 percent.

(d) Hydrostatic

This type of transmission requires a variable displacement pump and a motor for each driven wheel, together with an oil tank and associated pipework and valves. It tends to be expensive and heavy, and is less efficient than mechanical transmissions (typically 65 percent) but possesses considerable advantages for small tractor design in simplicity of operation, infinitely variable gearing in both directions, built in braking and a wide choice of possible tractor configurations.

Tractive Performance

The maximum shear stress at soil failure is given by $\tau = c + \sigma \tan \phi$ and the maximum soil thrust $H = Ac + Q \tan \phi$ corresponding to 100 percent slip. At lower values of slip the soil shear can be described by $\tau = (c + \sigma \tan \phi)(1 - e^{\frac{-j}{k}})$ and for a particular slip value s, where at the end of the contact patch of length 1 j has a maximum value of sl, **(Fig. 2).** Hence, the soil thrust is :

$$Hs = (Ac + Q \tan \phi)\left(1 + \frac{k}{sl} e^{\frac{se}{k}} - \frac{k}{sl}\right) \quad (1)$$

The same thrust value with a shorter contact length (smaller diameter tyres) can only be achieved at a higher slip, resulting in less efficient operation. The maximum draw bar power for an average conventional tractor occurs at a slip value of 15-20 percent **(Fig. 3).**

Lower slip values reduce the pull developed, while higher values lead to reduced field efficiency.

The useful work is further reduced by rolling resistance of

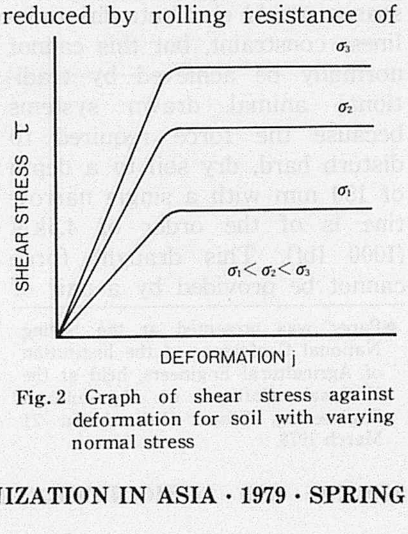


Fig. 2 Graph of shear stress against deformation for soil with varying normal stress

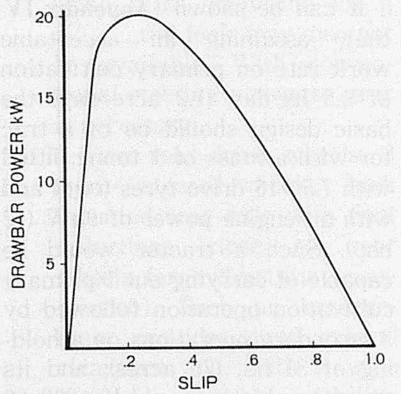


Fig. 3 The relationship between drawbar power and slip

the tyres, typically given by $R=0.15\frac{b}{l}Q$. (2)

Small diameter, wide tyres increase the ratio $\frac{b}{l}$ and hence reduce the useful diameter pull given by $F=H-R$ (Fig. 4).

For a particular tractor, knowing the total weight (including addition and transfer) on the driving wheels, together with the contact patch dimensions, the drawbar pull for a given slip can be calculated from equations (1) and (2). An example is given in **Appendix III**, from which it can be seen that by fitting a light tractor with larger tyres the slip

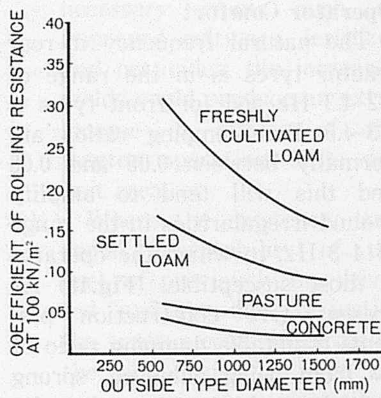


Fig. 4 Effect of wheel diameter on the coefficient of rolling resistance (After Hunt)

for a given (5 kN) drawbar pull can be reduced from 35 percent to 25 percent.

The cost of the larger tyres, however, will be twice that of the smaller ones, and it can be argued that increasing the mass of the tractor by 40 percent so as to load the small tyres fully and obtain the same pull at 15 percent slip is a more effective solution. It should be borne in mind, however, that smaller tyres have reduced flotation and, consequently, more tendency to dig in and spin.

Implement Attachment and Control

The hitch system should control the position of the resultant drawbar load K(Fig.5) thus making effective use of added transferred weight to maximise traction. Control can be by depth wheel, by convensional hydraulic servo system, by adjustable free, 3 point linkage (Fig.6) or by a single pivot free in 2 planes but not in roll (Fig.7). Hydraulic system are expensive and consume power, while mechanical lift systems require high operator effort.

A samll tractor is unlikely to possess the traction capability for more than a single tine or mouldboard, which will generate a drawbar force F offset C from the centre line (Fig.8) and will require a side force $Y=\frac{FC}{W}$ at the front wheels to maintain the direction of travel.

When the tractor is operating at maximum weight transfer the vertical load on the front wheels may be insufficient to allow generation of the side force, and tractor crabbing will result.

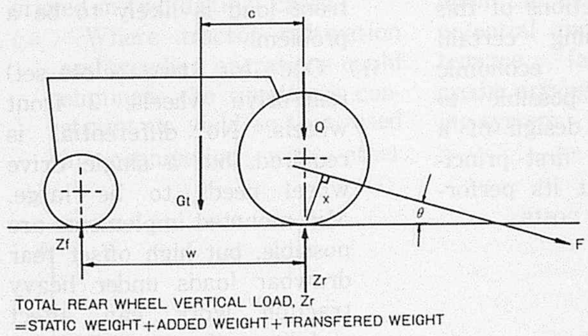


Fig. 5 The external forces on a tractor

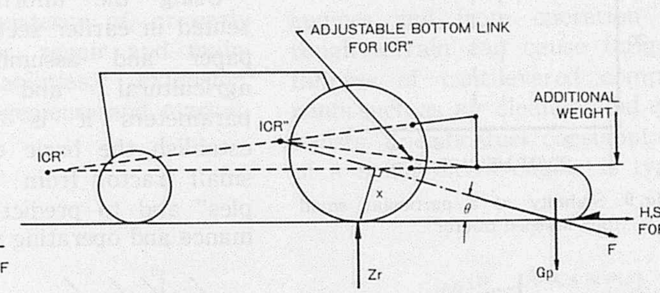


Fig. 6 The forces on the tractor from an implement attached via a three-point linkage with draught control value in neutral or raise

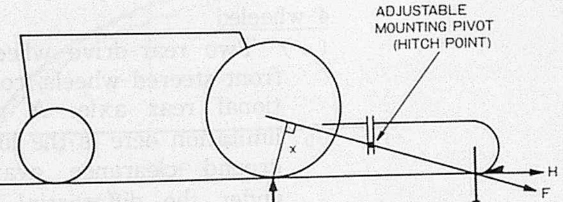


Fig. 7 The forces on a tractor from a simply attached implement

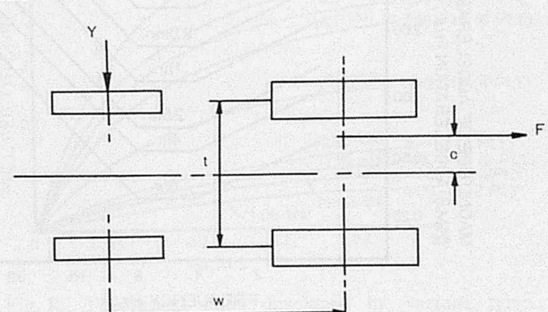


Fig. 8 Steering forces due to an offset drawbar load

Stability

A 4-wheeled tractor having a pivoted front axle will commence lateral overturn if the resultant external force falls outside the line linking a rear wheel contact patch to the front axle pivot point and, on a tractor having front axle stops, will continue if it falls outside a line joining the downslops tyres. Inherent stability will be greater with low centre of mass towards the rear and wide track and can be maximised by designing the height of the front axle pivot to equal that of the centre of mass of the tractor (**Fig.9**).

The stability triangle for a three-wheeled tractor is that of linking the type contact points. Rearward overturn of all tractors can be prevented by careful design of the implement attachment.

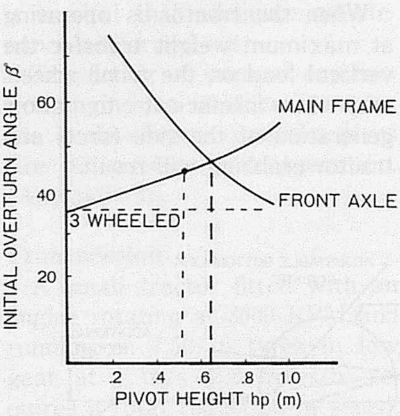


Fig. 9 Stability of a particular small four wheeled tractor

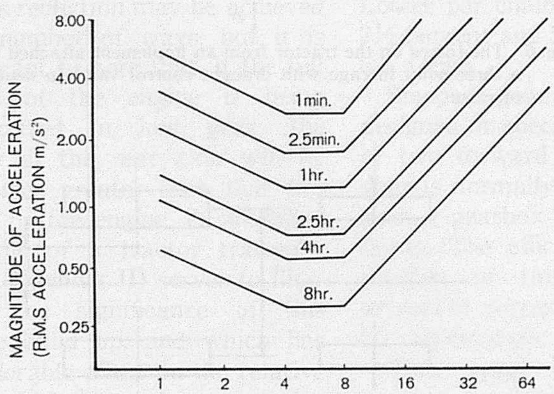


Fig. 10 Fatigue decreased proficiency boundary for vertical vibration of frequency and exposure time

Operator Comfort

The natural frequency it rear tractor tyres is in the range of 2.2-4.3 Hz and for front tyres is 3.3-4.5 Hz. Damping ratios are normally between 0.06 and 0.08 and this will tend to amplify ground irregularities in the range of 4-8 Hz, to which the operator is most susceptible. (**Fig.10**) As present tyre construction prevents a suitable damping ratio of 0.7 from being achieved, sprung and damped seats are usually provided on larger tractors, but these may introduce control problems due to the large deflections involved.

Noise levels in excess of 85 dBA are regarded as unacceptable, but many small units, particularly when the efficiency of engine and silencer has been reduced by wear and misuse, are capable of producing sound pressure levels at the operator's ear of up to 100 dBA.

Fundamental Design of a Small Tractor

Basic Design

Using the information presented in earlier sections of this paper and assuming certain agricultural and economic parameters it is possible to establish the basic design of a small tractor from "first principles" and to predict its performance and operating costs.

It can be shown (**Appendix IV**) that, assuming an acceptable work rate on primary cultivation of 0.5 ha/day (1.2 acre/day) the basic design should be of a tractor with a mass of 1 tonne, fitted with 7.50-16 drive tyres (two) and with an engine power of 9kW (12 bhp). Such a tractor would be capable of carrying out 1 primary cultivation operation followed by 3 secondary operations on a holding of 31 ha, (76 acres), and its operational cost would be £32-60 hectare (£13-20 per acqe).

Configuration

A number of possible layouts exist and can conveniently be categorised as follws :

3-wheeled

(i) Two rear-drive wheels, single front wheel, wheel or tiller steering. This arrangement is relatively cheap and simple and, if fitted with differential and steering brakes (or individually declutchable rear wheels) can turn in its own diagonal length. Spacing of row crops can however give rise to difficulties, and stability in the transport mode with a front load is likely to be a problem.

(ii) One (or two close-set) rear-drive wheels, 2 front wheels. No differential is required, but a single drive wheel needs to be large. Mid-mounted implements are possible, but high offset rear drawbar loads under heavy traction work can affect stability and control. Turning at the headland will be more difficult than with a more conventional layout.

4-wheeled

(i) Two rear-drive wheels, 2 front steered-wheels, conventional rear axle. A major limitation here is the limited ground clearance available under the differential of a conventional (e.g. dump truck) axle fitted with fairly small tyres. Provision for a differential lock may also not be available. With conventional steering a reverse gear is necessary.

(ii) Two rear-drive wheels, 2 front steered-wheels, high mounted rear axle with final reductions close to rear wheels (or hydrostatic transmission). Such an arrangement provides good ground clearance and, with a wide track, acceptable stability. The offset drawbar load problem, however, is likely to be aggravated by the wide track.

Economic Aspects

Assuming that a tractor has been designed, of a suitable configuration and with the ability to carry out the necessary operations throughout its design life in the physical condition to be found in the developing world, it is necessary also to examine the socio-economic conditions which prevail, in order to establish the countries or areas where such a machine could be successful. It is felt that economic justification for a small tractor could be argued in two distinct cases :

(a) Where tractor cultivation and weeding operations could eliminate the timeliness constraint on yield so that, used in conjunction with other necessary inputs such as improved cultivars, fertilizer and pesticides, the increased yields could produce an extra income in excess of the tractor operating costs per unit area, or

(b) Where the existence, (and social acceptability of the use), of previously uncultivated land can directly justify the tractor costs in terms of the yield produced from the extra area under cultivation.

Conclusions

A small tractor designed for use on direct traction in developing countries needs to be robust and heavy, with large tyres, good ground clearance and an engine power of at least 9 kW. The initial and operating costs of such a unit are likely to be high and prior to an application would require careful investigation to establish whether the economic and social environments were suitable. As with all engine powered mechanization devices, the successful introduction of a small tractor would be dependent upon the existence of, or early potential for, repair and maintenance facilities, extension, credit arrangements and marketing system.

Appendix I : Engine Problems

Single or twin cylinder diesel or petrol engines of between 7.5kW (10 bhp) and 15kW (20 bhp) are usually specified for small tractors. Such engines are likely to be operated for long periods dt near their peak power levels at high speeds (between 2500 and 3600 RPM).

Engines are frequently air-cooled, thus eliminating problems due to liquid coolants but giving little or no warning of overheating, which can be caused by dust or trash blocking the cooling ducts. Maintaining clealiness of fuel (particularly diesel) and lubricants can be difficult, and some small oil bath air cleaners require daily oil changing to prevent an accumulation of abrasive dust from entering the engine cylinders. Engine crankcase ventilation can also cause problems due to dust ingress in the absence of reliably maintained filters. Dust causes wear and sticking of components where relative motion occurs, such as in Bowden cables and engine speed control slides.

Vibration from single cylinder engines and from operation in rough terrain can cause fatigue failures of cantilevered components such as air cleaners and exhausts. Specific fuel consumption of a small diesel engine is typi-

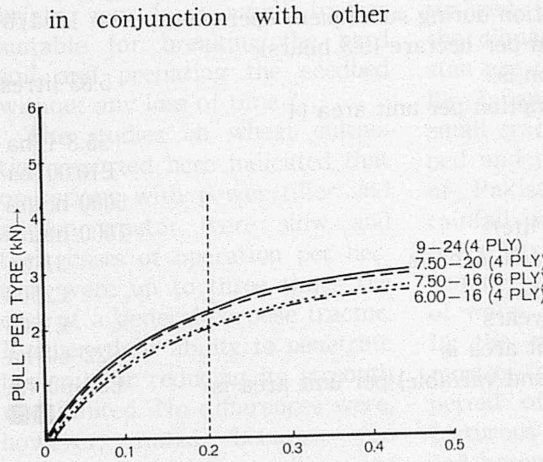


Fig. 11 Theoretical pulls developed by various tyres when loaded to 3.3kN (equivalent to 680kg tractor) in soil : — c =20kN/m², ϕ=35°, k=25mm

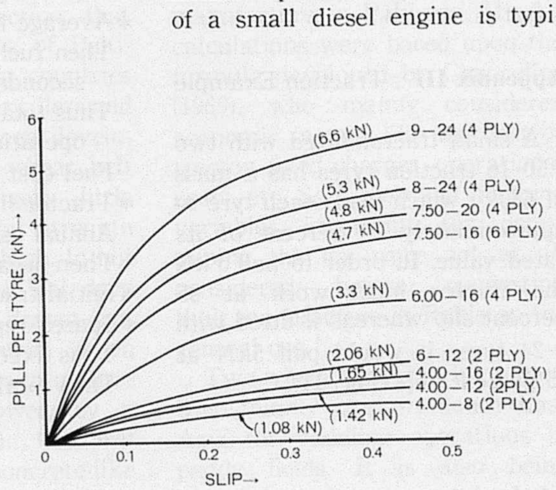


Fig. 12 Theoretical pulls developed by various tyres fully loaded in soil : — c=20kN/m², ϕ=35° k=25mm

cally 0.36 l/kWh (0.5 lb/bhp h) and that of a petrol engine will be 0.49 l/kW (0.62 lb/bhp h).

Appendix II : Transmission Torque Example

It is required to transmit full power from a transversely mounted 10kW (13.4bhp) engine running at 3000 RPM to an axle rotating at 24 RPM. Three chain reductions in series are to be used, each with a ratio of 5 : 1 and in addition to the engine output shaft and the rear axle there will be a requirement for two intermediate shafts.

Limiting each shaft shear stress to 2×10^4 kN/m^2 (30,000 lbf/in^2) due to torsion alone, the engine shaft diameter would need to be 8mm, the first and second intermediate shafts would be 19 and 32mm diameter respectively, and the axle would be 54mm diameter. These figures neglect shaft bending stresses and stress concentrations, which would substantially increase the total stress.

The first of the three chain drives could be $\frac{3}{8}$ in. triplex, the second would be $\frac{5}{8}$ in. triplex and the third would be 1 in. triplex. The shaft diameters and chain sizes required illustrate the build up of torque as speed reductions occur in the transmission system.

Appendix III : Traction Example

A small tractor fitted with two 7.50-16 traction tyres has a mass of 680kg which loads each tyre to approximately 70 percent of its rated value. In order to pull 5 kN the tractor must work at 35 percent slip whereas if fitted with 9-24 tyres it would pull 5kN at 25 percent plip **(Fig. 11)**.

Neither set of tyres would, however, be loaded to their respective maxima. If the tractor mass was increased to 960kg so as to load the 7.50-16 tyres fully **(Fig. 12)** it would pull 5kN at 15 percent slip (and 6.4kN at 25 percent). To load the 9-24 tyres fully would require a tractor mass of 1345kg and it would then pull 5kN at 7 percent slip (and 9.9kN at 25 percent).

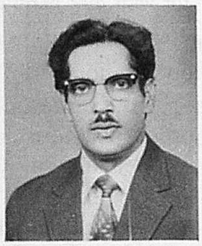
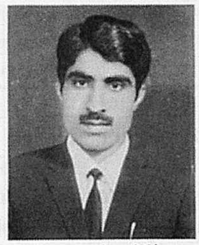
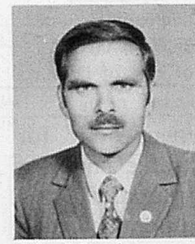
Appendix IV : Derivation of Basic Design and Operating Costs-An Example

(Assumptions are indicated thus*)

1. Specification	
*Acceptable work rate on primary cultivation	0.5 ha/day
i.e. (in 8 hours) cultivation area rate is	0.173 m^2/s
*Single tine, disc or mouldboard width	0.25 m
Thus mean forward speed required is	0.69 m/s
*Field eficiency	65%
Thus actual forward speed is	1 m/s
*Pull required by implement	5 kN
Thus power required by implement at 1 m/s is	5 kW
*Slip at tyres	15%
*Transmission loss	20%
*Temperature and altitude deviating	15%
Thus engine power required is	8.8 kW
For pull of 5kN at 15% slip, tyre size required is	7.50-16
Tyre loading (each)	4.7 kN
Thus rear axle load is	958 kgf
Thus minimum tractor weight is	1000 kgf
2. Predicted Operating Costs	
Time for 1 primary cultivation operation	16 hours/ha
*Time for secondary operation	5.3 hours/ha
Total time (1 primary+1 secondary+2 weeding)	32 hours/ha
Diesel engine specific fuel consumption	0.36 l/kWh
Thus fuel consumption at full power (65% of the time) is	3.25 l/h
*Consumption during turning etc. (35% of the time)	0.81 l/h
Thus fuel consumption per hectare (16 hours) primary cultivation is	38.3 litres
*Average fuel consumption during subsequent operations	1.1 l/h
Then fuel consumption per hectare (5.3 hours) secondary cultivation is	5.83 litres
Thus total fuel consumption per unit area (4 operations) is	55.8 l/ha
Fuel cost (at £0.18/l)	£10.00/ha
*Tractor life	5000 hours
Annual usage (5 years life)	1000 hours
Then area cultivable at 32 h/ha is	31 ha
*Initial tractor cost	£2000
*Spares/repairs over 5 years	£1500
Thus fixed cost per unit area is	£22-60/ha
Thus total cost (fixed and variable) per unit area is	£32-60/ha

■■

Comparative Performance of Two-Wheel and Four-Wheel Tractors

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Abstract

Arguments have frequently been advanced in favour of small-sized tractor for general use in Pakistan. It may be realized that in the plains of Pakistan, during hot summer days, the conditions are so dry that eyen the last traces of moisture from the soil are pulled out by sun. During monsoon season, when most of the rain occrus in a short period of time followed by a torturous bright sun, the wet soil becomes so hard that it behaves like concrete. Operations from ploughing to planting may, therefore, be rushed through at top speed during a short time between the onset of rains and torturous bright sun. Is a small tractor suitable for breaking the hard soil and preparing the seedbed without any loss of time ?

The studies on wheat cultivation reported here indicated that operations with power tiller and garden tractor were slow and their costs of operation per hectare were up to three times the cost of a general-purpose tractor. Further, their ability to penetrate the soil for reducing its strength was limited. No differences were, however, noted between the emergence of wheat seedlings for operations with garden and general-purpose tractors. It was explained that soil, crop and machine variables were important in addition to economics for selecting a suitable size of tractor. It was concluded that an integration of such variables could lead to an optimal solution for the power required to perform farming operations under Pakistan conditions.

Introduction

There has been a considerable debate in Pakistan on the use of small tractors for general use in agriculture. It has been argued that such tractors, developed in South East Asia, where the size of farm is small are particularly suited to Pakistan. It may be realized, in this connection, that the climatic conditions of Pakistan are different from countries like Japan, where power tillers and small tractors have been developed and used. In the wheat belt of Pakistan, where very little rainfall occurs, the soil strength is comparatively very high. In hot summer days, even the last drop of water from soil is drawn out. In the monsoon season, when most of the rain occurs in a short period of time followed by a torturous bright sun, the wet soil becomes a hard concrete-like surface. Studies conducted by Sheikh (1972) indicate that the force required by mechanical equipment to penetrate through the first few layers of soil dried from the wetted condition was almost exponential in nature (with a sudeen increase). Consequently, the power to break up and pulverize the top layers of soil, under such conditions, cannot possibly be supplied by a small tractor like a power tiller could.

The studies on tractorization in Pakistan have usually been the products of lone economists, who have not had the opportunities to examine the interaction between the equipment and its technology. For example, Hamid (1973) suggested that a 10-hp, two-wheel tractor was optimal for Pakistan conditions and advocated its manufacture in Pakistan. His hp calculations were based upon the formula developed by Chancellor (1969), who mainly considered economic factors like the cost of tractor, fixed charges, operational costs, etc. Soil, crop and machine variables important for determining the hp, were not at all considered before suggesting their manufacture in Pakistan for general use.

Two-wheel power tillers have been mainly used in South East Asia for paddling operations in paddy fields. It is also being manufactured and used in India under these conditions. The Indian National Commission

Table 1. Comparative Tractor Cost of Operation

Cost Item	Power Tiller	Garden Tractor	General-purpose Tractor
Diesel oil with lubricants	3.00	4.50	6.00
Labour (operator & helper) Rs. 25/− per day (a day=6 hrs.)	4.20	4.20	4.20
Repair=10% of cost of equipment	1.80	3.60	8.00
Depreciation=10% of cost of equipment	1.80	3.60	8.00
Interest=10% of cost of equipment	1.80	3.60	8.00
Insurance=2% of cost of equipment	0.36	0.72	1.60
Housing=4% of cost of equipment	0.72	1.44	3.20
Overhead costs=30% of cost of labour	1.26	1.26	1.26
Total	14.94	21.92	40.26

(1976) has recommended it for light tillage jobs, water pumping and spraying operations. Their adaptability for general use may be questionable. This ssudy was, accordingly, undertaken to assess and compare the performance of different types of tractors for wheat cultivation in Pakistan.

Materials and Methods

The following types of tractors along with different implements were used for tillage operations in order to assess their performance :

A. Chinese 2-wheel power tiller, 12 H.P., model Dong-Feng-12, type 195 (diesel) wlth Chinese rotovator.

B. The above Chinese power tiller with Chinese double plow.

C. German 4-wheel garden tractor, 18 H.P., model A-18 (diesel) with rotovator.

D. Massey Ferguson 4-wheel general purpose tractor, 47-H.P. model MF-135 (diesel) with disk harrow.

Tillage operations the above mentioned equipment were compared in the following order :

A vs C—Power tiller-rotovator was compared with garden tractor-rotovator.

B vs D—Power tiller double plow was compared with Massey-Ferguson tractor-disk harrow. The double plow of power tiller is not like a moldboard plow and inverts the soil partly. Consequently, it was compared with the disk harrow, wich partly inverts the soil.

Each of the above operatins (A,B,C & D) were applied twice on 3 plots of equal size, selected randomly from 12 plots with a total area of 1.20 ha. (3 acres). After tillage oprations, wheat seeds were planted by a carefully calibrated grain-drill. The central portion of each plot was, however, planted by a hand drill so as to avoid localized dumping of seeds, which may result from the opration of an automatic grain--drill. The data on emergence was recorded from such a central area after 4 weeks of planting, before irrigation.

The data on the properties of soil such as penetration resistance, bulk density and shear strength was taken after performing tillage operations. At least 3 readings of such soil characteristics were taken from each plot with measuring instruments.

Results and Discussion

Cost of Operation

The cost of tillage operations was determined in respect of power tiller, garden tractor and general-purpose tractor using the following basic information :

i) Cost of Chinese power tiller equipment······ Rs 18,000.00

ii) Cost of garden tractor with equipment····· Rs. 36,000.00

iii) Cost of field tractor (M.P.) with equipment····· Rs. 80,000.00

iv) Life of tractors in hours ·····Rs. 10,000.00

v) Diesel oil consumption :

a) Power tiller······1/2 gallon per hour.

b) Garden tractor·········3/4 gallon per hour.

c) General purpose tractor ······1 gallon per hour.

vi) Field capacity.

a) Power tiller ······1/4 acre/hour (about 0.1 ha)

b) Garden tractor······1/2 acre/hour (about 0.2 ha)

c) General purpose······2 acre/hour (about 0.8 ha)

With this information, the cost of operation has been calculated (**Table 1**) for different modes of power :

Cost of tillage operation per acre in rupees (1$=10 rupees).

i) Power tiller=59.76

ii) Garden tractor=43.84

iii) Geneual-purpose tractor=20.13

It may be noted that the cost of operation per acre with power tiller is three times that of the general-purpose tractor.

Table 2. Penetration Resistance of Various Tractor Sizes

Tractor	kg/cm²*		
Power tiller with rotovator	3.4	3.6	3.5
Power tiller with double plow	1.6	0.5	0.6
Garden tractor with rotovator	0.5	0.6	0.5
General purpose tractor tor with disk harrow	0.5	0.7	0.7

*Mean of three values taken from each plot

Effect on soil Resistance

The analysis of the data on penetration resistance shown in **Table 2** indicate significant differences resulting from the application of the different types of tractors. The resistance was found maximum when operations were conducted with the power tiller.

Effect on Density

No significant differences were noted between the levels of density for different types of tractors up to 10 cm. depth.

Effect on Shear Strength

The linear regression analysis of data on shear strength is shown in **Table 3.**

Equations :

$S=46.6+0.249N$······Power tiller with rotovator

$S=95.2+0.159N$······Power tiller with double plow

$S = 66.5 + 0.240N$······Garden tractor with rotovator

$S = 40.85 + 0.267N$······M.F. tractor with disk harrow

Where :

S = Shear strength of soil in (gm/cm^2)

N = Normal stress of soil in (gm/cm^2)

The above equations indicate that the general-purpose tractor is comparatively better in reducing the shear strength of soil. The use of power tiller and garden tractor results in higher values of the shear strength.

Emergence

Significant differences were noted in the percentage emergence for plots operated by different types of tractors, as may be seen in Table 4.

The analysis of variance showed significant differences in the percentage emergence of wheat seedlings for different tractors. The mean values of emergence for plots operated with garden and general purpose tractor were, however, almost equal.

The above results indicate that different types of tractors and their implements had different effects on soil characteristics and emergence of the wheat seedlings, as well as on the cost of operation. The penetration resistance and strength of soil resulting from the tillage operations conducted by a two-wheel power tiller as well as its cost of operation were high as compared to the 4-wheel garden and general-purpose tractors. Thus the use of small tractors for wheat cultivation is less economical.

Field performance

Difficulties were encountered in the use of the Chinese power tiller for seed-bed preparation as follows :

i) Steering was difficult and it exerted unnecessary strains on the shoulders of the operator.

ii) It compacted the soil and left it uneven.

Table 3. Shear Strength of Soil (unit : g /cm^2)*

Mode of Power	Plot 1	Plot 2	Plot 3
Power tiller with rotovator	141,209,295	138, 241, 254	129, 209,286
Power tiller with double plow	141,227,246	141, 227, 246	141, 230,265
Garden tractor with rotovator	148,236,385	127, 209, 325	124, 216,281
General-purpose tractor with disk harrow	129,236,345	134, 232, 295	146, 213,332

*Values correspond to normal stresses of 351,702 and 1,053 gm/cm^2, respecting

Table 4. Percentage Emergence of Wheat

Plot No.	Power Tiller with Rotovator	Power Tiller with Double plow	Garden Tractor with Rotovator	General purpose Tractor with disk harrow
1	13	29	50	42
2	17	31	31	44
3	19	15	35	35

iii) Movement through the fields, across water courses and over slight slopes was a problem.

iv) Its implements penetrated to shallow depths with lesser degree of pulverization.

Optimum power

The foregoing analysis cautions on the use of small-sized tractors for wheat cultivation from the standpoint of operational costs, soil characteristics and emergence. Hamid (1973), however, advocated the use of a 10-hp tractor, as an optimum size tractor under Pakistani conditions. His calculations were besed on the following formula developed by Chancellor (1969) :

Optimum horse power

$$= \sqrt{\frac{LW(C+LD)}{AK}}$$

Where :

A = ratio of annual fixed charges to initial cost of tractor.

K = initial cost of tractor per rated horse-power.

C = operation costs proportional to time of operation (operator's wage).

W = rated horse-power hours required per year for each unit of land.

D = the average penalty in cost per acre/working hour for the delay in time between the start of operation and its completion.

The following values were used by Hamid in calculating the optimum size of tractor for Pakistan.

A = 0.20, K = Rs. 650.00 per rated H.P., C = Rs. 3.30/hour. L = 14.5 acres, W = 95 H.P. hours acre, D = 0.04.

The substitution of these values in the formula gave the optimum horse-power as 10. Hamid assumed the value of K = Rs. 650.00/rated horse-power in 1973, whereas the cost of a 10-hp garden tractor, which was manufactured in Pakistan at that time by Heavy Mechanical Complex, Taxila was Rs. 20,000.00 i.e., K = Rs. 2,000 per horsepower. With this value, the optimum horse-power from the above formula comes to 5.77. Presently, the price of a 2-wheel Chinese power tiller of 12 H.P. with plow is Rs. 18,000, i.e., K = Rs. 1,500/rated H.P., which when substituted in the formula gives the optimum horse-power as 6.5. This means that with the rise in price of tractor, the optimum horse-power decreases. The formula, therefore, should be used with reservations.

Further, the above formula does not take into account the soil, as a ssbstrate for plant growth, on which it is to be finally operated. Sheikh (1972) developed the following theoretical fomula for the draft/H.P. required to pull tillage implements through soil :

Draft = P Sin $(B_1 + B_2)$ [CDL {Tan $(45^\circ + \phi/2)$ + Cot $(45^\circ - \phi/2)$} + Q {(Sin $(45^\circ - \phi/2)$ Tan $(45^\circ + \phi/2)$ + Cos $(45^\circ -$

$\phi/2)\} + W \tan(45^\circ + \phi/2)]$

Where :

$P = 1/[(\sin(B_1 + B_2) + \cos(B_1 + B_2) \tan(45^\circ + \phi/2)]$

Q = inertia force $= \frac{w}{g} DL \ V^2 \sin B_1 / \sin(B_1 + \theta)$

$W = (WDL^2/2) \ [(\cot B_1 + \cot(45^\circ - \phi/2)]$

D = Width of cut of implement (cm or ft)

W = Density of soil (gm/cm^3 or lb/ft^3)

g = Acceleration due to gravity (cm/Sec^2 or $ft\ sec^2$)

L = Depth of penetration of implement (cm or ft)

V = Speed of tractor (cm/sec or ft/sec).

B_1 = Angle of inclination of implement (degrees)

B_2 = Angle of soil to metal friction (degrees)

ϕ = Angle of internal friction of soil (degrees).

C = Cohesion of soil (gm/cm^2 or lb/ft^2)

$\theta = 45^\circ - \phi/2$

$$\text{Horse Power} = \frac{\text{Draft in lbs.} \times \text{Speed in ft/sec}}{550}$$

The above equation takes into account the soil and machine variables, which are important for horse-power calculations.

Different values of soil and machine parameters yielded different values of horse power. **Table 5**, for example, shows the values of house-power required under different soil and implement conditions.

The power required to pull an implement thus varies with the following parameters :

1. Density of soil (w).
2. Soil to metal friction (B_2).
3. Shear strength of soil (C, ϕ)
4. Speed of tractor (V)
5. Angle of inclination of implement (B_1)
6. Depth of implement (L)
7. Width of cut of implement (D)
8. No. of bottoms of implement.

There is a need to reconcile the economic and technical factors (soil, crop and machine), before suggesting an optimun horsepower for Pakistan. The conditions of soil and crop vary from place to place and, therecore, the task of suggesting an optimum size tractor for Pakistan is rather difficult. However, a machine, by definition, is said to be satisfactory in its performance, if it fulfils the following conditions : technically suitable, economically feasible, and acceptable to the end users.

There may, consequently, be many alternative types of products which may be considered satisfactory under different agro-climatic conditions of Pakistan, fulfilling the above three requirements of suitability, feasibility and acceptability. Again, by definition, an optimum size machine is one which is the best of all satisfactory alternatives. This requires an integration of the knowledge of economics, engineering and agriculture for computer programming in order to evolve an optimal solution for the power required to perform farming operations.

Table 5. Horse-power for Different Soils and Implements

Item	One-Bottom Plow	Two-Bottom Plow	Three-Bottom Plow
$B_1 = 25^\circ$, $D = 10''$, $L = 6''$, $C = 2.5$ psi.	4.0	8.0	12.0
$B_1 = 25^\circ$, $D = 10''$, $L = 6''$, $C = 3.5$ psi.	4.8	9.6	14.4
$B_1 = 25^\circ$, $D = 16''$, $L = 12''$, $C = 2.5$ psi.	14.3	28.6	42.9
$B_1 = 26^\circ$, $D = 16''$, $L = 12''$, $C = 3.5$ psi.	18.3	36.6	54.9
$B_1 = 40^\circ$, $D = 16''$, $L = 12''$, $C = 3.5$ psi.	32.3	64.6	96.9

($V = 5$ miles/hours, $g = 32\ ft/sec^2$, $\phi = 30^\circ$, $w = 110\ lb/ft^3$)

Conclusions

The following conclusions are drawn from this study on the comparative performance of different types of tractors for wheat cultivation :

1. The cost of tillage operation per hectare of a power tiller of 12 H.P. is three times the cost of operation of a general purpose tractor of 47 H.P.
2. The penetration resistance of soil resulting from the application of power tiller was highest.
3. The shear strength of soil determined after the tillage operations was maximum for power tiller and garden tractor.
4. No significant differences in the emergence of wheat seedlings were noted for operations with garden and general purpose tractor. The emergence in case of power tiller was, however, low.
5. Power tiller was difficult to operate and it exerted unnecessary strains on the operator's shoulders.

Further, its movement over water courses was a problem.

6. Economic factors alone should not be considered for suggesting an optimum size of tractor.
7. Soil, crop and machine variables are important in addition to economic factors, for determining a proper tractor size.
8. An integration of the knowledge of economics, engineering and agriculture is necessary in order to develop an optimal solution for the power required to perform farming operations.

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Farm Machinery Marketing and After-Sale Service Network in Japan

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Marketing of Agricultural Machinery

Distribution system of agricultural machinery

The distribution system of agricultural machinery in Japan (both imported and locally manufactured) may be divided into two routes: one, via the agricultural cooperatives and the other via the trading companies.

The diagram shows the flow of the distribution system and how the total shipments of the suppliers on the top box (taken as 100%) were handled. The trade represented an estimated value of some 622 billion yen for 1976. As shown in the diagram, some 31% of the total machinery was supplied to agricultural cooperatives (of which approximately 26% to the national federation of agricultural cooperatives (ZEN-NOH), organized at the central level, and the remaining 5% or so to the local prefectural economic associations) with about 69% distributed through the trading companies.

One important characteristic of the distribution of machinery via the ZEN-NOH is the fact that the local agricultural cooperatives at the prefectural level are responsible for the first assessments of the number of orders or intents to purchase for agricultural machinery.

The price negotiations with manufacturers are based upon this initial volume. Together with the other relative merits of the system from the manufacturers' view point, it means that great importance is attached to the price negotiations with the ZEN-NOH.

In the second channel, the remaining 69% of the total shipment is handled by wholesalers, dealers and sales companies. Of the total shipments 6% is distributed to the economic associations, another 4% is sold to farmers via the agricultural cooperatives, 18% is directly sold to farmers, and 41% is distributed to dealers and retailers (of which 38% is supplied to farmers and 3% to the local agricultural cooperatives).

From the above, it is obvious

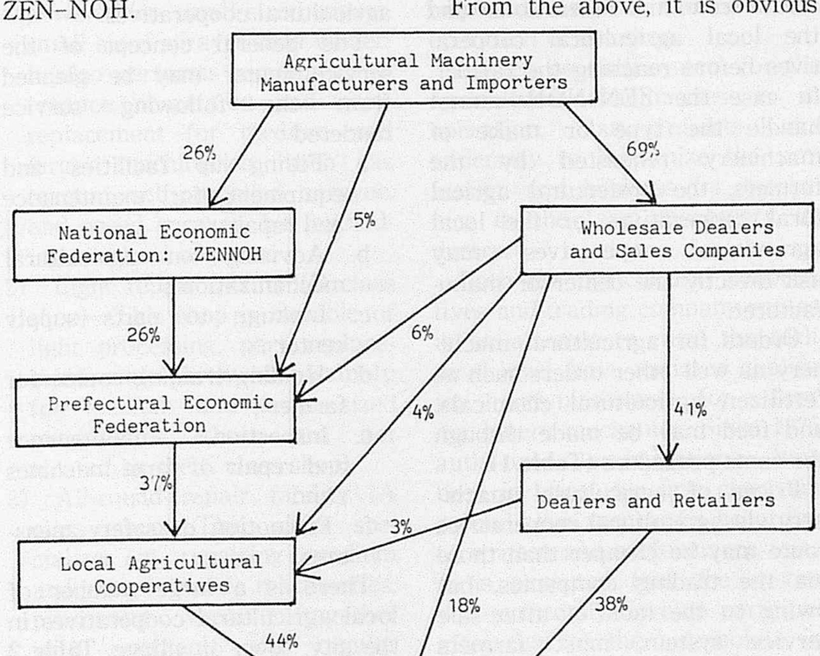

Fig. 1 Flow Diagram of Farm Machanery Distribution

※Presented at ORD/ASPAC Food and Fertilizer Technology Center-sponsored Seminar on Farm Mechanization for Small Farms held in Taiwan, September 18-23, 1978.

that the purchase of agricultural machinery is fairly evenly divided between the two distribution channels.

Currently, a continuing battle between the two channels of distribution system is going on trying to gain an advantage over the other in the relative share of total sales. But discussions between two sides take place on common concerns of profit and loss lately.

The agricultural cooperative route

The system of handling the agricultural machinery via the agricultural cooperative route is generally based on the method of advance order. The farmer initiates the order of machinery with the local cooperatives which, in turn, makes a subscription to the prefectural economic federations and the ZEN-NOH. The latter, will purchases the agricultural machinery from contracted manufacturers. The machinery is delivered to the ZEN-NOH and on to the prefectural economic federations and the local agricultural cooperatives before reaching the farmer. In case the ZEN-NOH cannot handle the type or make of machinery requested by the farmers, the prefectural agricultural cooperatives or the local agricultural cooperatives may ask directly the dealer or manufacturer.

Orders for agricultural machinery as well other orders such as fertilizer, agricultural chemicals, and feed may be made through the same procedure **(Table 1)**.

Prices of agricultural machinery via agricultural cooperatives route may be cheaper than those via the trading companies, but owing to the lack of after-sale service system, most farmers have the machinery repaired at manufacturers' or dealers' repair shops. As a result, the demand for machinery via agricultural

Table 1. Share of Farm Inputs Handled by Agricultural Cooperatives

(Unit : percent)

Stage	Fertilizer	Agr. chemicals	Feed	Agr. Machinery
ZEN-NOH	70	50	39	26
Prefectural Agr. Coop.	81	56	42	37
Unit Agr. Coop.	89	75	45	44

cooperatives is comparatively small.

To overcome this weak point, the ZEN-NOH has set up maintenance amd repair shops as well as spare parts supply centers in Prefectural Federation Cooperatives and Unit Agricultural Cooperatives. In addition, five agricultural machinery training centers have been set up all over the country for the purpose of training good mechanics.

The performance of the ZEN-NOH, therefore, is not confined to selling agricultural machinery, but advising farmers on choosing and utilizing agricultural machinery as well. Furthermore, in an attempt to atrength the service system, more centers are planned to be established among the local agricultural cooperatives.

The general concept of the service center may be gleaned from the following survice rendered :

a. Filling up facilities and equipment for maintenance and repair ;
b. Advising on agricultural mechanization ;
c. Linkage to parts supply center ;
d. Holding training course for farmer ;
e. Inspection, maintenance and repair of farm machines ; and
f. Promotion of safety measures.

There is a large number of local agricultural cooperatives in the city, town or village. **Table 2** shows the relation between member households and number of local agricultural cooperatives.

Table 2. Distribution of Local Agricultural Cooperatives by Size of Membership

Member households	Number	Percentage
Less than 500	1,746	35.3
500 – 999	1,504	30.4
1,000 – 1,999	1,016	20.5
2,000 – 2,999	372	7.5
3,000 – 4,999	246	5.0
More than 5,000	68	1.4
Total	4,952	100.0

The trading company route

The quantity of agricultural machinery sold directly to farmers via the trading company route occupies 56% of the total. There are 8,409 dealers, 31% of which have less than two employees and 2% have more than ten employees.

There are two ways of delivering the machines via the trading company route. a) manufacturer → wholesale dealers → dealers, and b) manufacturer → sales company → dealers (retailers)

Most wholesale dealers have joint business deals with retailers. The wholesale dealers' shops maintain a high quality of maintenance and repair. They supply the agricultural machinery to local agricultural cooperatives through the prefectural economic federation.

The manufacturers of farm machinery have recently a promoted sales company systems in order to secure thier distribution route by including dealers in the route and save on distribution cost.

The manufacturers hold their agency meetings, perform demonstrations on new agricultural machinery and allocate the sales volume to each agency for each agricultural season.

These local dealers and agency organize prefectural agricultural machinery dealers' cooperatives according to the prefecture or brand of machines they deal with. They are federated into the All Japan Agricultural Machinery Dealers' Cooperatives at the national level. They have a variety of projects ranging from loaning operation, educational campaign, insurance and mutual aid.

The fierce competition between the agricultural cooperative and trading companies in the distribution of farm machineries in Japan has recently evalued a plan between then to consider the following aspects :

a. Laying down of ground of rules governing fair-competition ;
b. Standardization of techniques for maintenace and repair ;
c. Common program of management of spare parts and store house ;
d. Education of mechanics ;
e. Promotion of employees' welfare ; and
f. Promotion of farmer-customer welfare

Prices of agricultural machinery

The agricultural cooperatives are generally able stabilize farm machinery prices due to low overhead costs reasonable margins. In comparizon, prices of machinery via the trading company route have not been stabilized so far because up to the present time prices are usually decided upon by agreement between the dealers and farmers.

The excessive supply of agricultural machinery in the market has resulted in a sales "war", e.g., heavy discount sales. The margins for agricultural machinery are estimated at 5% to 12% for wholesale dealer and 20% to 35% for retailer.

In 1977, the prices of agricultural machinery were relatively stable. Such prices are indicated in **Table 3.**

Table 3. 1977 Price List of Farm Machinery (Unit : '000 yen)

Machinery	Size	Price Range
Power tiller	6–7 ps	250–450
Small tiller	3–4 ps	150–250
Tractor	11–20 ps	800–1,500
Tractor	20–30 ps	1,200–2,000
Rice transplanter	2–4 row	250–450
Sprayer	2–4 ps	60–150
Combine	10–15 ps	900–1,600

For purposes of taxation, the junk values of agricultural machineries as fixed by law are 8 years each for tractors and engines, and 5 years each for power tillers, transplanters, sprayers and combines. However, according to an investigation, agricultural machineries that exceed their junk value age are power tillers, sprayers, and rice hullers. Those that normally do not reach the junk value by years are tractors, rice transplanters, rice binders and combines.

After-sales Service for Agricultural Machinery

Repair facilities

Repair facilities for agricultural machinery are classified the Ministry of Agriculture and Forestry into four groups according to their functional characteristics.

1) Inspection and adjustment facility (C class shop)—This shop is capable of repairing small-sized machineries such as power tiller, small sized engine, small sized sprayer, and binder. It also performs regular maintenance, inspection and part-replacement for medium and large machineries such as tractor, self-propelled sprayer, and speed sprayer, but excluding overhaul of parts.
2) Light repair facility (B class shop)—This shop is capable of light processing, part replacement and partly disassembly for medium and large sized machineries (those are not treated by the C class shop).
3) All-round repair facility (A class shop)—This shop specializes in repairing medium and large sized machineries, processing repair (together with overhaul) and regular inspection.
4) Super all-round repair facility (Super A class shop)—This shop provides first class repair jobs for all types of farm machineries. There are also D class shops which are not numerous nor important.

The trading company route accounts for 7% of the super A class shops ; 17% of A class ; 37% of B class ; and 40% of C class. On the other hand, 42% of the shops above B class and 58% of the C class shops are found among the agricultural cooperative route :

A typical set of standard equipment and facilities of the C class group of repair shops is shown in **Appendix A.**

Mechanics for maintenance and repair service

An organized system for vocational training of mechanics for the maintenance and repair service of automobiles is enforced in Japan. The system requires intensive training and skill development, government examination and license for automotive mechanics preparatory for employment or opening up a repair shop, including government inspection and regulation on the operation of the shop.

As yet, no such system for the agricultural machineries is in operation, but efforts are underway to legitimize the profession and business for mechanics in the farm machinery industry.

Both the agricultural cooperatives and trading company routes, in an attempt to raise the technical level, have initiated qualifying examinations for farm machinery mechanics. Since 1975, authorized examinations have been in effect for first class and second class mechanics according to written and performance tests. It is expected that the system will eventually develop patterned after that of the automobile industry.

Table 4. Availability of Power Tiller Spare Parts Within 5 Days After Order, 1975

(Unit : percent)

Years After Sale/ Sale Year	Piston Ring	Clutch Plate	Rotary Tine
10 years/1965	72.5(37.5)	67.5(21.6)	79.1(51.2)
8 〃 /1967	82.5(42.5)	81.0(29.7)	81.4(55.8)
6 〃 /1969	85.0(45.0)	89.1(40.5)	81.4(55.8)
4 〃 /1971	85.0(45.0)	89.1(42.5)	81.4(55.8)
2 〃 /1973	90.0(47.5)	91.8(43.2)	83.7(58.1)
0 〃 /1975	87.5(47.5)	91.8(43.2)	83.7(58.1)

Note : Figures in parenthesis indicate the rate of supplying spare parts or the spot.

Spare parts supply

Japanese manufacturers of agricultural machinery are required by law to supply spare parts regularly in accordance with regular period, the expected life of the machinery. As a matter of fact, many manufacturers make spare parts available beyond the expected life of the machinery.

Compared with the automobile spare parts industry, the rate of supplying spare parts on the spot for farm machinery is still relatively low. Also, prices of spare parts for farm machineries vary widely.

A survey was made recently to investigate the time required for obtaining spare parts after order. A summary finding is shown in **table 4.** More and more, manufacturers are making efforts to supply spare parts efficiently. As a matter of fact, computerization has already been introduced by large manufacturers in managing the spare parts supply.

An example of the inventry of spare parts for one kind of power tiller at a prefectural sales company, its branch and subdealers is provided in **Appendix B.**

Distribution Problems of Agricultural Machinery

Repression of model change

Under a mass production system for farm machineries, large manufacturers tend to corner a large share of the market and attempt to saturate their sales routes. And in their drive to increase sales of new machines, manufacturas frequently change the models. As they stimulate consumers' demand for their new products the process inevitable and almost simultaneously, increases the production costs–time it causes cost-up of the products.

The author conducted a survey of the sale of 20-25ps. tractors among large manufacturers, and found that in addition to the availability of tractor models for popular sale and models that are intended for long term sale, there is also a considerable number of models intended for quick sale.

At the present time, frequent changes of models are controlled independently by the manufacturers in order to lower their cost of production, hence retail prices with the end of view of selling more units.

Improvement in use efficiency of agricultural machinery

The mean size of land holdings of Japanese farmers is less than 1.1 ha. On the other hand, the proportion of full time farm households (none of the family members is engaged in occupations other than agriculture) averages not more than 12% of the total.

The above situation not withstanding, the advent of agricultural machineries came about together with large sums invested in them. Non-agricultural income, consequently, is used to pay agricultural machineries. As a matter of fact, the so called "poverty owing-to-mechanization" syndrome has greatly influenced both the trading company and the agricultural cooperative routes.

As a solution to this problem, it has become necessary to establish a cooperative system of use of agricultural machinery based on contract and effective coordniation amony the users of the machinery.

The ZEN-NOH also has started providing consultancy services on agricultural management to farmers as a part of its program of pre-sale service system.

Standardization of machine parts

Even as the spare parts supply system has been improved, manufacturers and dealers are sometimes perplexed with too many kinds of the same item of spare parts. A typical supply center may carry some ten thousand different types of spare parts the total quantity of which may run to hundreds of thousands of pieces.

Consequently, the need for standardization of spare parts supplied from many brands is keenly felt. They are as follows :

a) Engine (oil element, piston ring, glow plug, injection nozzle, fuel strainer, light valve, etc.),
b) Transmission (oil seal, V pulley, brake lining, clutch wire, etc.),
c) Others (rotary tire, cutter knife, transplanting tine, etc.).

Control of distribution of agricultural machineries

Over-production of agricultural machineries results in a severe competition in sale among the manufacturers. Discounts are resorted to and the price is often decided by face-to-face negotiation with farmers. Aditionally, a fierce competition among dealers can escalate into gift giving and offer of all-expendes paid pleasure trip of the customers,

In order to regulate such competition, the manufacturers have agreed to observe the following procedure when offering sales and side benefits :

a) Clear statement of retail price of the machinery ;
b) Self-control in selling with gifts to boot ;
c) Self-control in selling with free trips ; and
d) Inclusion of guarantee sheet pertaining to the quality of the machinery.

In the guarantee sheet, the period of assurance and the contents for gratuitous service are all clearly noted.

Utilization of second-hand machineries

Second-hand machineries that are traded by farmers for brand new ones are repaired well for resale, except for a few that have become scraps. The demand for second-hand machineries in Japan represents 40% of the total demand.

In the agricultural machinery business, there are no organized used machine markets as the case of used car lots. The prices of second-hand machineries are not standardized. Therefore, their distribution is not as widespread as that of used cars. In the sale of used farm machinery, it is important to assure the quality and safety in operation.

Table 5. Estimation of Re-sale Value of Traded-in Second-hand Machineries

(Unit : Percent of initial price)

Age of Machinery	Used in Good Condition	Used in Severe Condition
1 year	65	55
2 years	55	40
3 〃	35	20
4 〃	20	5

Table 5 shows the pricing of traded-in second-hand machineries in relation to age and conditions of use of the machinery.

Protection system for consumers

In order to ensure the users' safety, the manufacturers of the farm machinery have made efforts to create a compensation system for those who are injured in accident while operating tne agricultural machinery. However, there is still only a small number of consumers availing themselves of the compensation system.

Appendix A

Cleass C Shop Maintenance and Repair Equipment

A. Machine equipment (one set)

Basic-Electrolyte hydrometer, battery charger, tachometer, air compressor, equipment for washing, electric drill, compression gauge, nozzle tester, valve lifter, thermometer, piston ring tool, tyre gauge, steam cleaner, bench drill, bench grinder, spray gun, gas welder, sheet metal processing tool.

B. Tool Sets

a) For measurement—Calipers, thickness gauge, vernier calipers, tape measure, and steel measure.
b) For overhaul—Monky wrench, double-ended wrench, valve wrench (clearance adjusting), double off-set wrench, pipe wrench, T-head wrench hollow set wrench, box wrench, gear puller, bearing puller, tire service tools, driver, shock driver, plastic hammer, plier, cutting plier, and stud remover.
c) For processing—Files, reamers, taps-and dies, soldering set, saw for metal, scissors, and scraper.
d) Other tools—Grease gun, vice, screw extractor, hammer, cutting nipper, garage lamp, rigid rack, engine cleaner, washing pallet, portable jack, parts box, tool box.

C. Service car

Mobile service car equipped with on-the-spot repair equipment.

Appendix B

Inventory of Spare Parts of power Tiller (A Company Case)

(Unit : number/500 power tillers)

Spare Part	Prefectural Sales Company	Branch	Sub-dealer
Body			
rotary tine(16 pieces)	150	20	10
stand	10	5	2
facing of clutch	4	2	0
brake shoe	4	2	0
main clutch wire	10	2	1
throttle wire	20	2	1
steering clutch wire	10	2	1
stand wire	5	0	0
Engine			
head gasket	5	1	0
piston ring	5	1	0
piston	5	1	0
ignition coil	10	2	1
breaker	10	2	1
valve seat	10	2	1

(1) Each 500 power tiller

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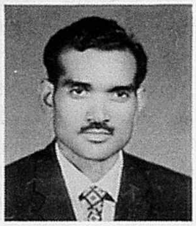
On-Farm Scale System of Leaf Protein Extraction Process



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Abstract

In an on-farm scale system of leaf protein extraction process, fresh juice can replace expensive fish meal in hog feeds. This juice can also be used in chick growth and human food in different forms. The pulp can be fed directly or ensiled. The ensiled pulp is similar, and in some instances, better than dry grass when fed to lambs. An investigation was made to look into the economic feasibility of leaf protein extraction process on real arable form in U.K. It was observed that a farm system that includes, as an activity, the extraction of leaf protein from forage crops for feed on the farm affecting little the farm operation, has an economic advantage, over systems with conventional forage feed production, over a wide range of cost and resources condition.

Introduction

Rouelle in 1973 observed that when the juice extracted from the leaves was slowly heated a substance was precipitated that had similar properties to that of the inside of wheat grain and nutritious part of milk (1). Experiments in Hungary on feeding pigs have shown that leaf protein can replace at least 25% of normal protein supplement such as soya-bean or peanut meal (2). The use of leaf protein in chick growth shows that it compares favorably with soyabean. Many experiments in India and else-where have shown that even green whole leaf protein juice when heat treated can be used in many different forms to over come deficiencies in human food.

The pressed residue can be fed direct, dried or made into silage. Feeding trials on dairy cows have shown little or no loss in milk when fed with silage from processed grass rather than fresh or field wilted grass (4). A. S. Jone found that the intake and digestibility of ensiled pulp is similar, and in some instances, better than dried grass when given to lambs. The juice remaining after the protein has been removed has some, if little nutritional value, and has been used as base for microbiological growth. Generally, in the drying units in U. S. A. this whey is sprayed back to the pressed crop drying, otherwise it can be returned to the land as fertilizer (5).

System of leaf protein extraction

There are two systems of leaf protein extraction : one on an industrial scale and the other on an on-farm scale system. The industrial fractionation system can be used in the feed industry to produces, for example, a dry protein concentrate. In this system the protein is coagulated in the juice by steam heat precipitation at 75-85°C. This juice, containing the finely precipitated particles, can be used directly for animal feeding or further processed. The protein particles can be removed from the liqour by vibrating screen, a centrifuge and further dried by means of a filter-belt press to produce a filter-belt press to produce a cake containing about 60 percent moisture. The cake may finally be dried further using a fluidised bed, flask or rotary drier to produce high protein feed concertrate with about 9 percent moisture content. The liqour remaining after the removal of the protein can be disposed of in several way such as by irrigation into land, or partially dried and added back to the fibre residue. Even the possibility of producing microbial protein fermentation has been considered (6). In this system the protein is coagulated in the juice by steam heat precipitation at 75-85°C. This juice containing the finally precipitated particles, can be used directly for animal feeding or further processed. Schematically

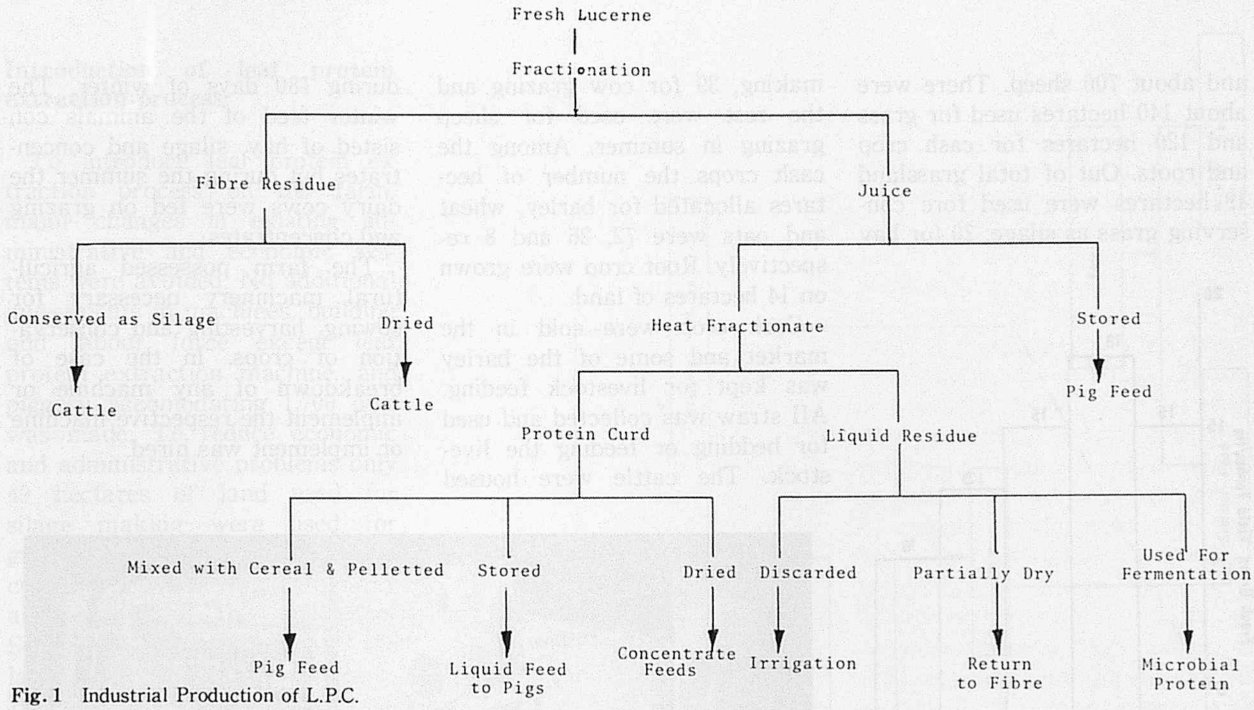

Fig. 1 Industrial Production of L.P.C.

this can be represented in Fig.1.

In an on-farm scale system there is no further fractionation and drying of crude protein. The juice is directly fed to pigs in place of expensive fish meal and pulp is used by cattle or conserved as silage. This system is very simple, economical and practicable for on-farm use (12). Schematically this system has been represented as in Fig.2.

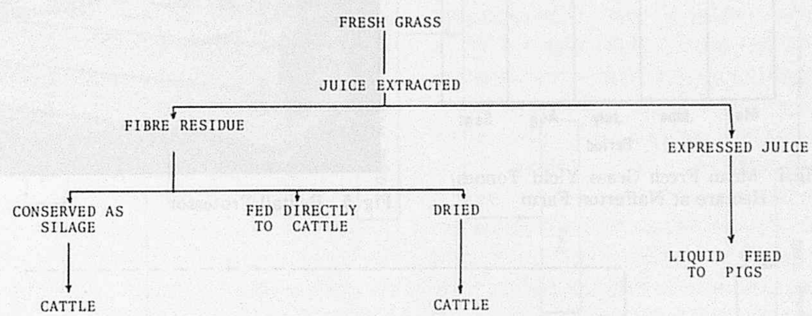

Fig. 2 On-Farm Scale System of L.P.E.

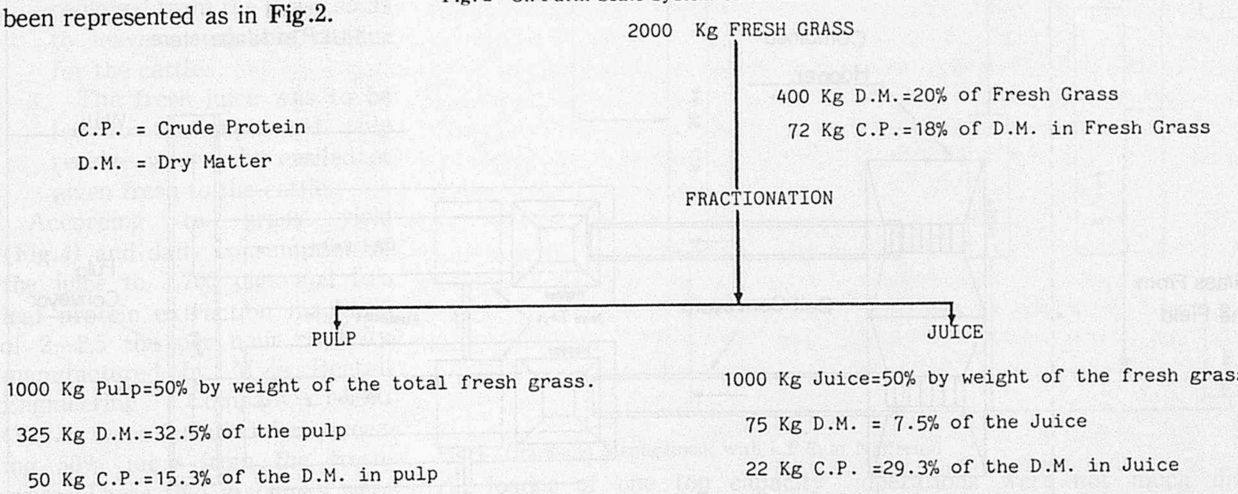

Fig. 3 Grass Fractionation

Introduction of an On-Farm Scale System on an Arable Farm

Nafferton farm without leaf protein extraction process

This was a rented farm of 296 hectares situated in the Tyne Valley about 12 miles East of Newcastle. The main enterprises on the farm were dairying, fat lambs and cash crop productin. The farm was primarily commercial and no detailed experimentation was undertaken. The principal aim of this analysis, However, was to investigate the economic feasibility of leaf protein extraction from grass and its consumption by pigs.

In the main livestock enterprises, there were 225 dairy cows and about 700 sheep. There were about 140 hectares used for grass and 120 hectares for cash crop and roots. Out of total grassland 49 hectares were used fore conserving grass as silage, 20 for hay making, 39 for cow grazing and the rest were used for sheep grazing in summer. Among the cash crops the number of hectares allocated for barley, wheat and oats were 72, 26 and 8 respectively. Root crop were grown on 14 hectares of land.

Cash crop were sold in the market and some of the barley was kept for livestock feeding. AII straw was collected and used for bedding or feeding the livestock. The cattle were housed during 180 days of winter. The winter feed of the animals consisted of hay, silage and concentrates but during the summer the dairy cows were fed on grazing and concentrates.

The farm possessed agricultural machinery necessary for sowing, harvesting and conservation of crops. In the case of breakdown of any machine or implement the respective machine or implement was hired.

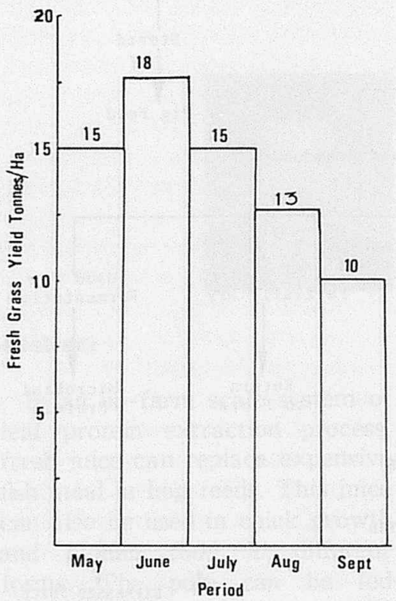

Fig.4 Mean Fresh Grass Yield Tonnes/ Hectare at Nafferton Farm

Fig. 5 Bentall Protessor

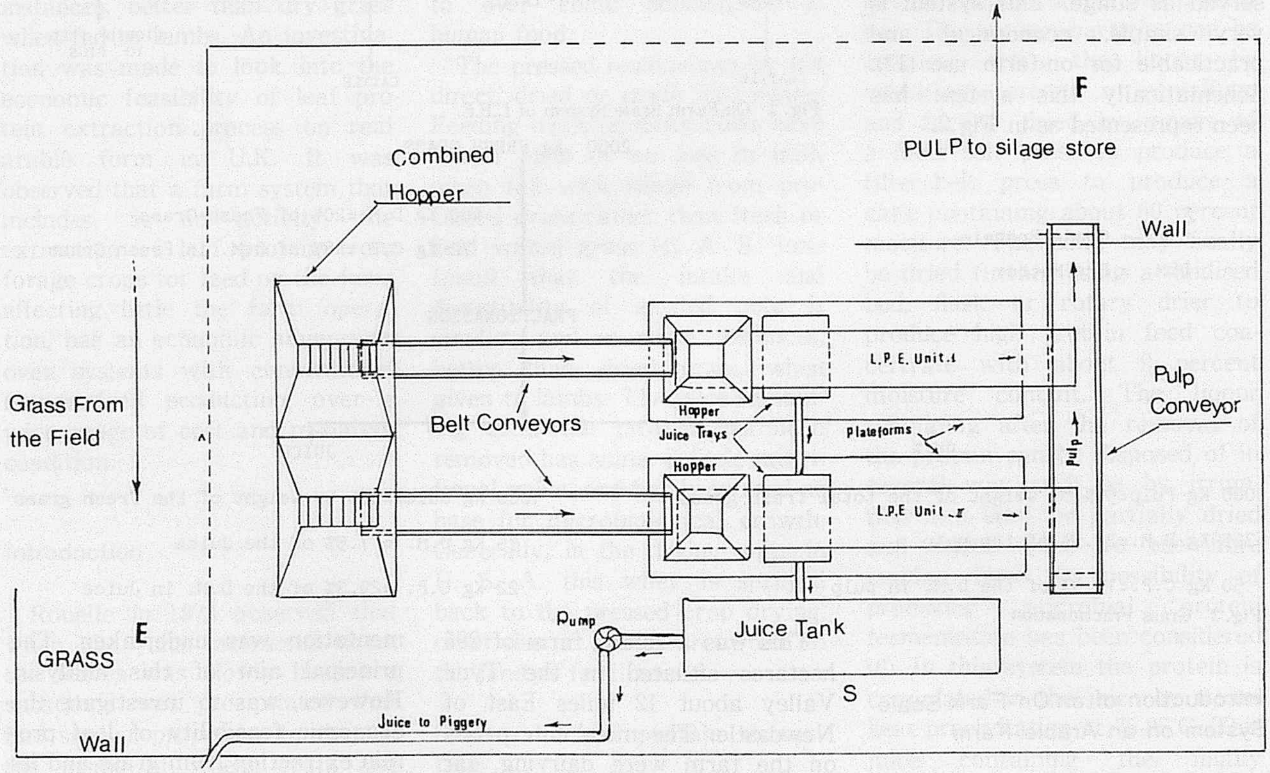

Fig. 6 Working Position of L.P.E. Machines (Not to scale)

Introduction of leaf protein extraction process

To introduce leaf protein extraction process on the farm, major changes in existing administrative and economic systems were avoided. No additional investments in machines, building and labour force except leaf protein extraction machine, and piggery accomodating 1,700 pigs was made. To reduce economic and administrative problems only 49 hectares of land used for silage making were used for grass factionation. Only three cuts starting from middle of May and ending in the middle of Septmeber were made on the land used for silage making. However, the following assumptions were also made in the process of grass fractionation.

1. In processing the fresh grass equal division by weight of grass pulp and liquid juice was made (**Fig. 3**).
2. Only the protein not efficiently utilized by the ruminants, that is about 20% of D. M. in the juice, had to be removed from the grass so as to leave a valuable residue for the cattle.
3. The fresh juice was to be fed to the pigs and pulp residue was to be ensiled or given fresh to the cattle.

According to grass yield (**Fig.4**) and daily consumption of the juice to 1,700 pigs and two leaf protein extraction machines of 2—2.5 ton per hour capacity manufactured by M/s Bentall Engineering Company U.K. (**Fig.5**) were installed for squeezing 50% juice from the fresh-grass. These two machines were supposed to run for five days a week and each machine working for about four hours a day. As the life of fresh juice is up to three days (7), therefore, there was no problem in storing extra juice for feeding to the pigs on Saturday and Sunday. A wheth-

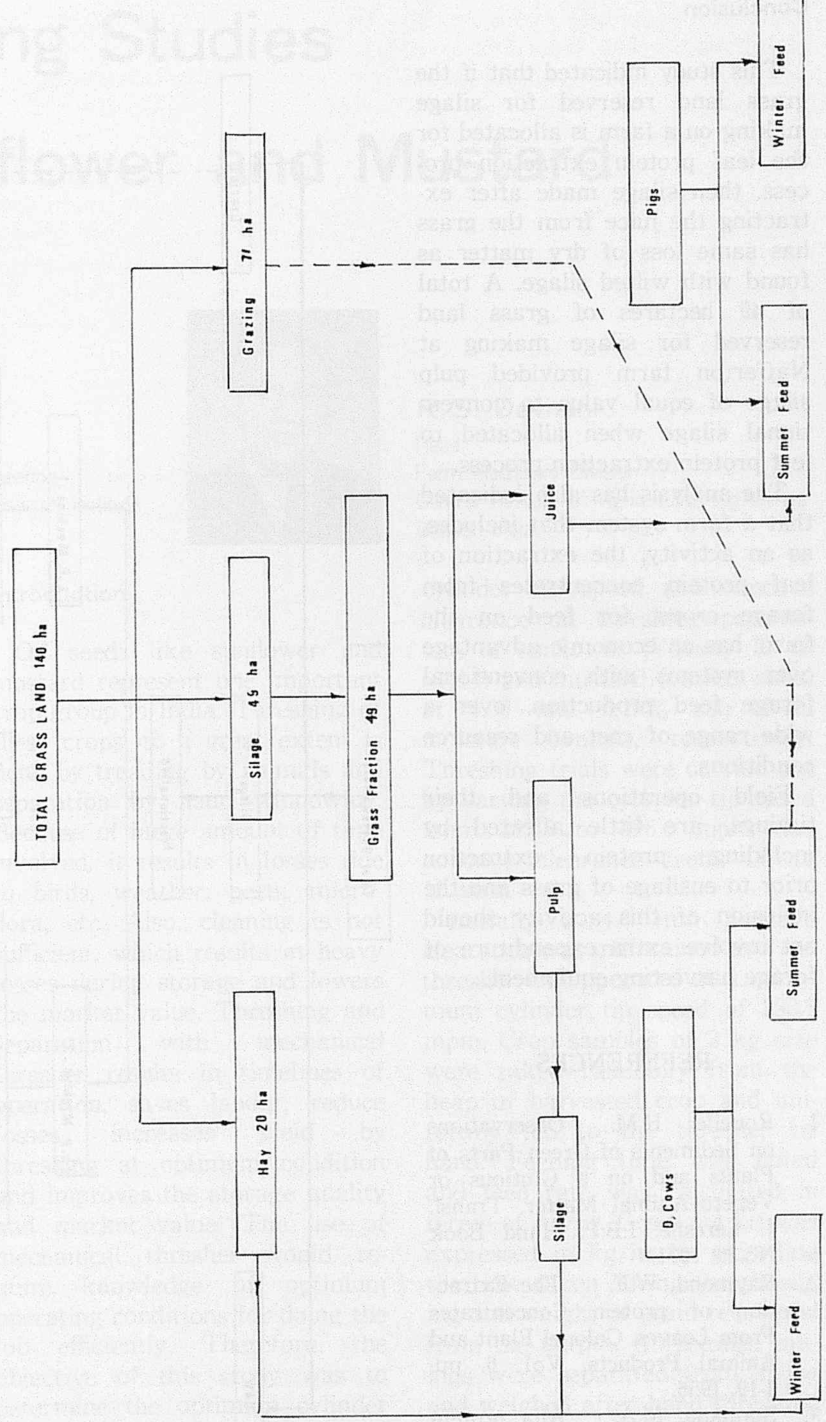

Fig. 7 Grassland Management with L.P.E. at Nafferton

rill loader of one ton capacity available on the farm was used to load the fresh grass into the combined hopper of leaf protein extraction machines and to carry the pulp the to the silage store (**Fig.6**). To introduce the leaf protein extraction process the labour force and other farm operations were not much disturbed. Flow diagrams of **Fig.7**, 8 show ultimate leaf protein extraction process at the Nafferton Farm. With the introduction of this system on the farm there was an increase of about £ 9,000 per year in the farm gross profit.

Conclusion

This study indicated that if the grass land reserved for silage making on a farm is allocated for the leaf protein extraction process. then silage made after extracting the juice from the grass has same loss of dry matter as found with wilted silage. A total of 49 hectares of grass land reserved for silage making at Nafferton farm provided pulp silage of equal value to conventional silage when allocated to leaf protein extraction process.

The analysis has also indicated that a farm system that includes, as an activity, the extraction of leaf protein concentrates from forage crops, for feed on the farm, has an economic advantage over systems with conventional forage feed production, over a wide range of cost and resource conditions.

Field operations and their timings, are little affected by including protein extraction prior to ensilage of grass and the inclusion of this activity should not involve extra expenditure of forage harvesting equipment.

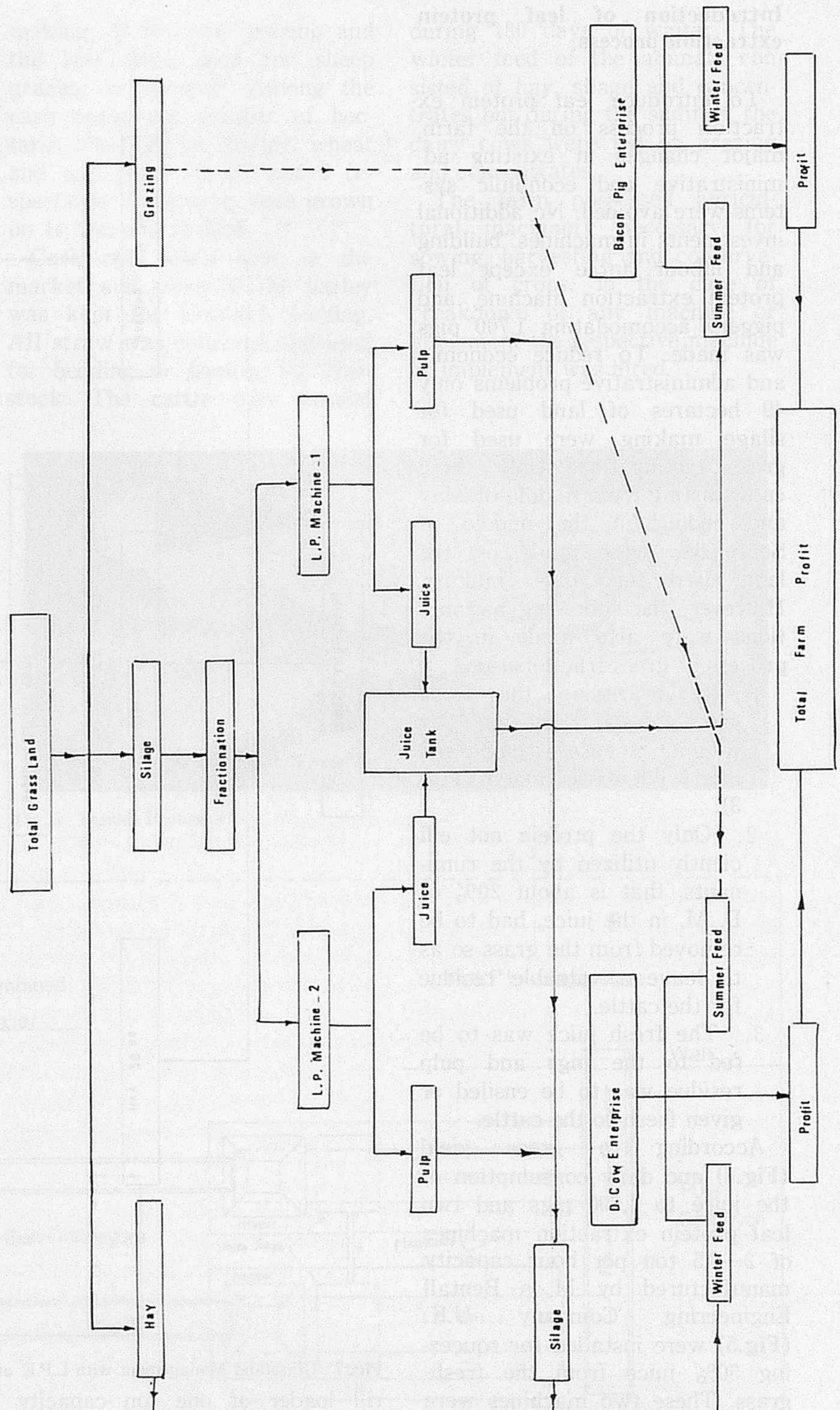

Fig. 8 Flow Diagram of Comptete L.P.E. at Nafferton

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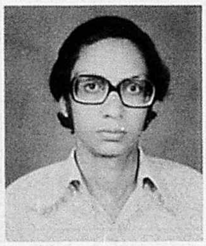
Threshing Studies on Sunflower and Mustard



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Abstract

Threseing trials by varying cylinder tip speed and concave clerance were conducted on sunflower and mustard in order to determine optimum operating conditions of a mechanical thresher. Cylinder tip speed was found to be in indirect relation with feed rate, grain output, threshing efficiency, energy consumption and visible grain damage and in inverse relation with germination percentage. By increasing concave clearance feed rate, grain output and germination percentage increased threshing efficiency and visible grain damage decreased and energy consumption remained constant. All threshing parameters were highly correlated with the cylinder tip speed and cancave clearance and were significant at 0.01 level of probability. Recommended cylinder tip speeds and concave clearances for sunflower and mustard were 496.0 mpm and 12.0mm, and 413.0mpm and 4.0mm for oil extraction and 288.5 mpm and 12.0 mm for seed purposes, respectively. The mustard seed did not germinate with the standard procedure.

Introduction

Oil seeds like sunflower and mustard represent one important crop group in India. Threshing of these crops, to a great extent is done by treading by animals and separation by hand winnowing. Because of large amount of time involved, it results in losses due to birds, weather, pests, microflora, etc. Also, cleaning is not sufficient, which results in heavy losses during storage and lowers the market value. Threshing and separation with mechanical thresher results in timelines of operation, saves labour, reduce losses, increases yield by threshing at optimum condition and improves the storage quality and market value. The use of mechanical thresher would require knowledge of optimum operating conditions for doing the job efficiently. Therefore, the objective of this study was to determine the optimum cylinder tip speed and concave clearance for the threshing of above crops.

Material and Methods

A specially designed variable speed with adjustable concave clearance, rasphar thresher (Sharma and Devnani, 1978) was used to determine the effects of cylinder tip speed and concave clearance on threshing parameters of sunflower (Variety E. C. 68414) and mustard (variety-sufla) at 4.00 and 6.15% sun dried moisture content, respectively. Threshing trials were carried out by varying the cylinder tip speed from 288.5 to 496.0 mpm and concave clearance from 4.0 to 12.0mm.

Initially a 4.0 mm concave clearance was maintained and the thresher was operated at a mimimum cylinder tip speed of 288.5 mpm. Crop samples of 2 kg size were taken randomly from the heap of harvested crop and uniformly fed to the thresher by hand. Feeding time was noted and feed rate was calculated in terms of kg/hr. Grain output was expressed in kg/hr by recording the time taken during the threshing and weight of grain recovered from the output. Unthreshed tailings were separated from straw and weighed after hand threshing and cleaning in order to determine threshing efficiency in terms of percentage of total grain recovered. Energy consumed during the test period was directly read from energy meter and expressed in Kw/hr of feed rate. Visible grain damage was obtained by dividing the quantity of total broken, skinned and damaged grain to the total weight of

Table 1. Statistical Analyses for Threshing of Sunflower

Regression Equation	Multiple Correlation Coefficient (R)	Coefficient of determination (R^2, %)	Standard Error of Estimate (%)
FR=153.2150+0.9464CS+7.0542 cc	0.9944 *	98.88	0.26
GO=61.6228+1.1703FR−0.4196CS−4.8813 cc	0.9627 *	92.68	1.73
TE=93.2149−0.0599FR−0.0670 CS−0.6029 cc	0.9681 *	93.72	1.48
EC=1.4307+0.0005 FR+0.0116 CS	0.9999 *	99.98	0
GP=133.813+0.1077 CS+0.4729 cc	0.9938 *	98.76	0.29

* Significant at 0.01 level of probability.
Ekplanation of symbols :
FR − Feed rate (kg/hr).
CS − Cylinder tip speed (mpm).
CC − Concave clearance (mm).
GO − Grain output (kg/hr).
TE − Threshing efficiency (%).
EC − Energy consumption (kw hr/of feed rate).
GP − Germination percentage (%).

Table 2. Statistical Analyses for Threshing Mustard

Regression Equation	Multiple Correlation Coefficient (R)	Coefficient of Determination (R^2, %)	Standard Error of Estimate (%)
FR=65.9710+0.0550CS+0.7950CC	0.9614 *	92.43	1.78
GO=7.2804+0.4231FR−0.0135CS−0.1950CC	0.8041 *	64.66	8.33
TE=101.367−0.1656FR+0.0243CS−0.6255CC	0.8689 *	75.49	5.78
EC−11.1244+0.0416FR+0.0071 CS	0.9721 *	94.50	1.30
VGD=1.8511+0.0092 CS−0.0617 CC	0.9433 *	88.99	2.62

* Significant at 0.01 level of probability.
VGD−Visible grain damage (%).

recovered grain and expressed in percentage. To determine internal grain damage, germination tests were carried out on 100 randomly selected grains taken from each sample of the threshed grain. The number of ungerminated grains gave the percentage of internal grain damage. The cylinder tip speed was increased in 41.5 mpm steps and a similar procedure was adopted for other speeds and 8.0 and 12.0 mm concave clearances, respectively.

Results obtained were statistically analysed for their signifi cance and mathematical models of each threshing parameter were fitted by multiple regression technique (Shedecor and Cochran, 1968).

Results and Discussion

Effects of the cylinder tip speed and concave clearance on each threshing parameter of sunflower and mustard are plotted in **Fig.** 1 and 2 and their statistcal analyses is given in **Table** 1 and 2. It can be concluded from the figures that the feed rate is directly proportional to the cylinder tip speed and concave clearance for both the crops (R=0.9944 and 0.9614). The grain output also increased with an increase in the cylinder tip speed and concave clearance and higher output was associated with the higher feed rates, cylinder tip speeds and concave clearances (R=0.9627 and 0.8041). The mustard crop was over-dried which resulted in heavy shattering losses and, perhaps, a reason for lower correlation value.

The study also indicated that the threshing efficiency increased with an increase in the cylinder tip speed and decrease in the concave clearance. From regression equations it can be concluded that for higher threshing efficiency, the feed rate should be low at the higher cylinder tip speeds and lower concave clearances. Multiple correlation coefficient between the threshing efficiency and feed rate, cylinder tip speed and concave clearance for mustard was lower (R=0.8681) than for sunflower (R=0.9681), perhaps because of nature of the crop itself.

It was also noted that the energy consumtion was higher in mustard than in the sunflower, at the same rate of material flow (feed rate) and cylinder tip speed. It was girectly proportional to the feed rate and cylinder tip speed (R=0.9999 and 0.9721) and remained unaffected by the change in concave clearance. Also, the cleaning and separating unit consumed higher energy in the case of mustard grains cleaning than the sunflower grains.

At higher cylinder tip speeds visible grain damage was negligible at all the concave clearances for sunflowers, as compaired to mustard grain damage (up to 2.50%), **Fig.** 2. It increased with the increase in the cylinder tip speed and decrease in the concave clearance, with a multiple correlation coefficient of 0.9433. Germination percentage, as a measure of intermal grain damage was directly proportinal to the concave clearance and inversely proportional to the cylinder tip speed with a multiple correlation coefficient of 0.9938 for the sunflower crop, **Fig. 1.** The mustard grain did not germinate in the laboratory when a standard procedure was followed.

Recommendations

The recommended cylinder tip speeds and concave clearances are those at which the visible grain damage should be within 2% (Bunnelle et al; 1959 ; Kolganov, 1958 ang King ang Piddolls, 1959), to maintain better storage qualities. As the visible grain damage was negligible for sunflower, therefore it could be

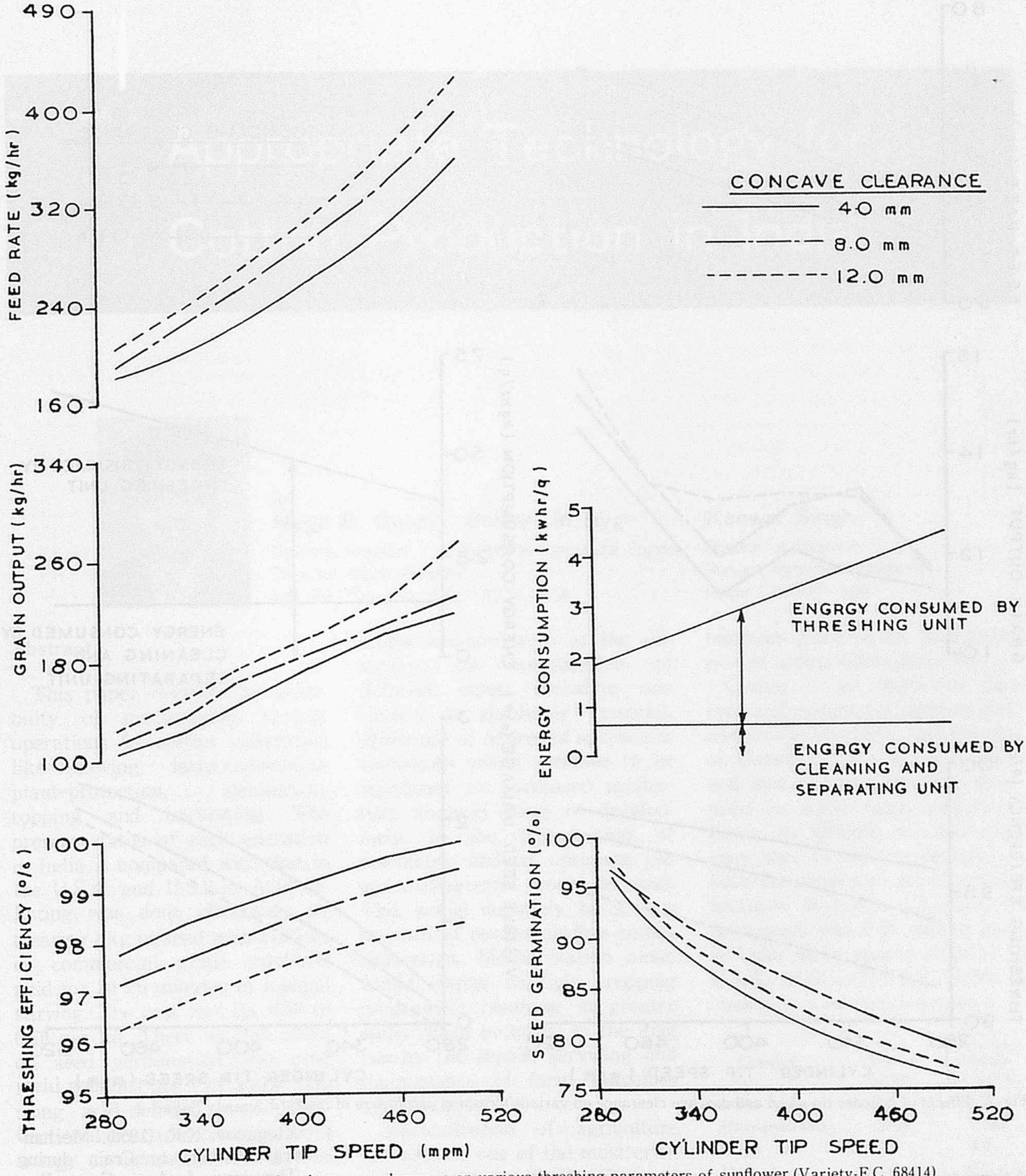

Fig. 1 Effects of cylinder tip speed and concave clearance on various threshing parameters of sunflower (Variety-E.C. 68414)

threshed at higher cylinder tip speed and higher concave clearances, i.e., 496.0 mpm and 12.0 mm for higher grain output (278.0 kg/hr) and threshing efficiency (98.3%). Similarly, the mustard could be threshed at 413.0 mpm cylinder tip speed and 4.0 mm concave clearance for 1.83% visible grain damage and 97.1% threshing efficiency.

For seed purpose, the crops should be threshed at slower speeds and higher clearances to have internal grain damage within 5% (Chestney, 1969 ; Kolganov, 1958 and Richey et al. 1961). The germination tests on hand threshed sunflower grains indicated 98% germination, whereas with thresher this was obtained at 12.0mm concave clearance and 288.5 mpm cylinder tip speed. It dropped to 76% as the cylinder tip speed was increased to 496.0 mpm at the same concave clearance. Therefore, for seed pursose the cylinder tip speed should be from 288.5 to 330.0 mpm at 12.0 mm concave clearance. The mustard seed did not germinate in the laboratory, but certainly it should be threshed at lower speed and at higher clearances, than that recommended earlier.

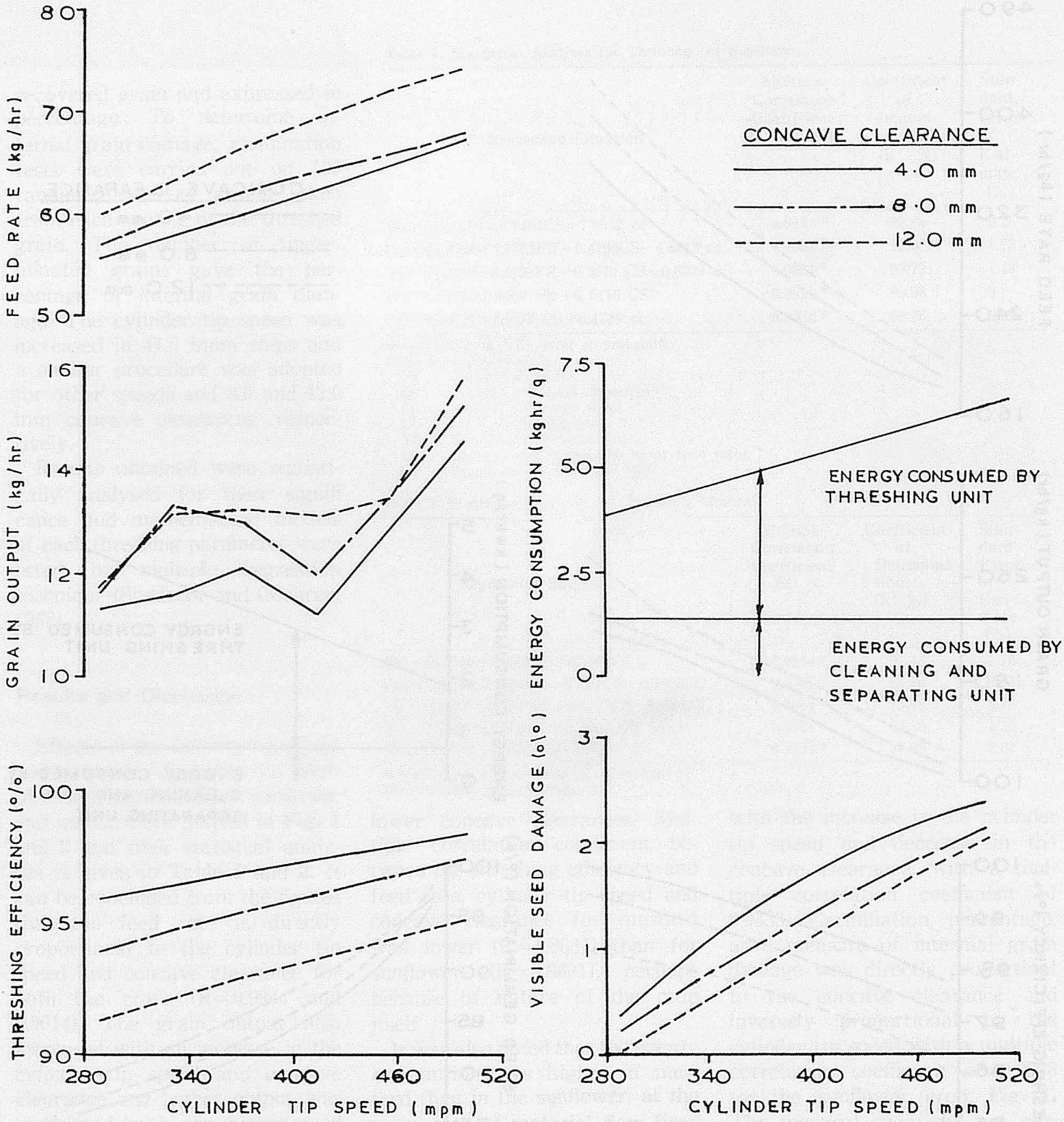

Fig. 2 Effects of cylinder tip speed and concave clearance on various threshing parameters of mustard (variety Sufla)

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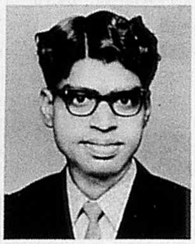
Appropriate Technology for Cotton Production in India



by

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Abstract

This paper reviews the possibility of mechanizing various operations in cotton cultivation like sowing, inter-cultivation, plant-protection, defoliation, topping and harvesting. The present status of each operation in India is compared with that in the U.S.A. and U.S.S.R. Acid-delinting was done effectively by treating l kg of seed with 112.5 cc of commercial grade sulphuric acid for 20-25 minutes of manual stirring. The cost was Rs. 0.50 to 0.60 per kg. There was no effect on seed germination and crop yield was increased by about 24% using acid-delinted seeds. Conventional practices consume more energy as compared to improved practices. Post-harvest technology problems, which hinder mechanization, are also discussed.

Introduction

In these days of green revolution where maximization of production/unit area is the objective, the optimization of different inputs including machinery is absolutely essential. While use of improved agronomic techniques would continue to be significant for increased production, its next stage of development in the introduction of machinery and its optimum use and management would be vital. This would definitely be a step forward in revolutionizing cotton cultivation. Mechanization alone would enable multiple cropping programme resulting in greater employment potential in the long run by the repair, servicing and maintenance of farm machines and tractors (21).*

Mechanization of agriculture has become one of the most critical requirements in the State of Haryana. Efforts are being made to make a breakthrough in mechanizing different operations of cereal crops. Haryana and Punjab have attained almost complete mechanization for wheat starting from seed-bed preparation to post-harvest technology. However, little attention has been given to the mechanization of cotton cultivation (5).

Cotton is an important cash crop and occupies a premier position in the economic development of Haryana State. Its cultivation and manufacture has been practiced in India since prehistoric times. In 1969-70, it's harvested area was 7.7 million hectares in India as compared to 4.3 million hectares in the U.S.A. (20). Its production was 6.50 million bales in India as compared to 13.10 in U.S.A., 11.60 in U.S.S.R. (**Table l**).

Table 1. Area and Production Trends in Cotton Production, 1969−70(20)

Country	Area (Million acres)	Production (Million US bales)
India	18.8	6.5
Haryana(India)	0.038	0.302
China	12.5	8.0
U. S. A.	11.0	13.1
Brazil	8.5	3.2
U. S. S. R.	6.8	11.6
Pakistan	4.0	3.0

This data reveals that the area undrer cultivation in India was much more as compared to other countries whereas production is lowest. About 90% of cotton produced is mechanically harvested in U.S.A./U.S.S.R. whereas it is solely hand picked in India (20) where it is still cultivated with

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*Numbers in parenthesis refer to appended references.

old methods. In view of this it is almost essential that adequate attention be paid to the mechanization of this crop so that economic return per unit area would increase.

Mechanization of Various Operations

Where there is any discussion on the use of machinery in cotton production, someone usually makes the point that there is little need to improve farming by the use of labour-saving machinery due to the fact that with old implements he can produce as much cotton as he can harvest. Also, if an artist of the past decade/before is asked to depict a typical scene in the cotton belt of northern India, undoubtedly he would have sketched a group of labourers in this field. Though the introduction of new varieties has increased the yield and average daily wages, yet labour shortage exists at peak periods. If we are really keen on producing as large an income as possible in order to maintain a high standard of living, then we must think of mechanizing various operations of cotton production. It appears that the use of labour-saving machinery coupled with improved soil condition is the only way for India can increase its cotton yield. One of the factors that contribute to high yield in other countries is the mechanization of cotton production (25). Mechanized cultivation facilitates timely operation of plant protection measures, picking, etc. **Tables 2, 3, 4** show the energy -input requirements for cotton cultivation. **Table 5** shows different machines used in U.S.A./ U.S.S.R./India for cotton cultivation (2). The possibililty of mechanization of various operations is discussed in the following lines.

Seed bed preparation

Mechanical power hastens seed-bed preparation and timely sowing of crops. Seed-bed preparation and planting nearly consume 20% of the energy required in cotton production up to marketing. Available machinery can now be used for optimum results in cotton cultivation.

Sowing operation

With improved methods of seed-bed preparation and consequent increased cost, planting accuracy is necessary not only

Table 2. Average Monthly Energy inputs for Cotton Cultivation (3).

Month	Conventional Method			Improved Method		
	Man-hrs/ acre	Tractor HP-hr/ acre	Bullock hrs/acre	Man-hrs/ acre	Tractor HP-hr/ acre	Bullock hrs/acre
May	116.14	20.50	18.35	19.65	64.70	2.52
June	54.50	–	–	40.16	20.64	–
July	147.40	–	–	33.30	23.98	–
August	150.50	–	–	45.53	24.33	–
September	68.90	–	–	24.70	2.48	–
October	343.50	–	–	318.35	1.24	–
November	279.44	–	–	206.00	–	–
December	51.90	–	–	94.98	33.60	–
Total	1,212.28	20.50	18.35	782.65	170.97	2.52

Table 3. Animate Energy Required for Cotton Production in India for Conventional Technologies per ha/month (9)

Month	Irrigated		Unirrigated	
	Human	Animal	Human	Animal
April	19.00	11.00	–	–
May	10.00	2.00	–	–
June	13.00	2.30	3.50	2.00
July	2.00	2.30	13.00	9.00
August	3.70	2.00	12.20	7.70
September	6.00	–	11.00	–
October	24.00	–	14.60	0.30
November	10.00	–	11.00	–
December	–	–	2.00	–
Total	87.70	19.30	67.30	19.00

Table 4. Energy Input Requirements for Cotton Cultivation in India per acre (3).

Operation	Man-hrs/ acre	HP-hrs/ acre	Bullock hrs/acre	HP-hrs/ acre	Tractor HP-hrs/ acre	Total HP-hrs/ acre
a) Conventional Practices:						
Seedbed preparation	8.67	0.06	15.28	0.96	18.35	19.4
Sowing	5.22	0.06	5.22	0.33	–	0.4
Irrigation	64.0	0.80	–	–	–	0.8
Interculture	262.3	3.28	–	–	–	3.3
Insect pest control	211.60	2.65	–	–	–	2.7
Topping	12.09	0.15	–	–	–	0.2
Harvesting	634.0	7.93	–	–	–	7.9
Stalk disposal	14.32	0.18	–	–	–	0.2
b) Improved Practices:						
Seedbed preparation	2.39	0.03	–	–	64.7	64.7
Sowing	1.26	0.01	2.52	0.16	–	0.2
Irrigation	64.0	0.80	–	–	–	0.8
Interculture	53.65	0.67	–	–	62.75	63.4
Insect pest control	34.8	0.44	–	–	9.92	10.4
Topping	12.09	0.15	–	–	–	0.2
Harvesting	614.	7.67	–	–	–	7.7
Stalk disposal	0.975	0.01	–	–	33.60	33.6

Table 5. Different Machines for Cotton Cultivation (2)

Operation	U. S. A.	U. S. S. R	India
Planting	Tractor drawn, multipurpose planter	Tractor drawn, multipurpose planter	i) Single row cotton drill ii) Kera method (behind the plough) iii) Single row wooden seed drill (south India) iv) Multi-coultered wooden seed drill (Tiphan) in south India
Interculti-vation	(a) i) Lister cultivator equipped with rotary hoe ii) Sweep cultivating tool iii) Rotary cross harrows	i) High clearance tractor drawn cultivator ii) Sweep cultivating tools	i) Kasola ii) Triphali (bullock drawn) iii) Guntake or Bahkar iv) Khurpi/Khurpa v) Spade
	(b) Flame cultivation	–	
	(c) Chemical weed control i) Application of pre-emergence and post emergence herbicides by power operated sprayers	Same as in USA	
Plant Protection	Tractor operated insect control sprayers/dusters	Tractor mounted power sprayer (High clearance)	i) Hand/power operated sprayers and dusters ii) Low volume tractor operated iii) Air craft sprayer
Defoliation	Tractor operated defoliator		Nil
Harvesting (Picking)	i) Spindle type mechanical pickers ii) Stripper type mechanical pickers	i) Mechanical pickers ii) Mechanical strippers	i) Hand picking ii) Snapping
Ginning and Pressing	Power operated ginning and pressing machinery	Power operated ginning and pressing machinery	Power operated ginning machines and steam power operated pressing machines

for a desired crop stand but also for the saving of seed. Seeding of cotton with seed-drill will also cut down the cost on post-sowing operations. The present practice of sowing is a pora method, i.e., behind the plow using ginned cotton seed (treated with cow dung and soil). This seed cannot be drilled with the machinery available as it will clog in the seed-chute/hopper. Before one can think of mechanizing this operation, he should have first free seed. Cotton is mechanically planted in other countries like U.S.A., U.S.S.R. and Israel. The study on acid-delinting at Haryana Agricultural University, Hissar (Haryana), reveals that acid-delinting of ginned cotton seed was done effectively by treating one kg of seed with 112.5 cc of commercial grade sulphuric acid in 20-25 minutes of manual stirring at at total cost of Rs 0.50 to 0.60 per kg. There was no effect on seed germination (2, 10, 11, 17, 19). Crop yield was 1,961 kg/hectare for the acid-delinted seeds as compared to 1,586 kg/hectare in the case of conventional ginned seeds (3, 5, 10, 14, 16). The process of acid-delinting need to be mechanized (5). There are no acid-delinters available, in India at the present time. There is a possibility of using seed-treaters, painted with acid -proof paints for this process. Acid-delinted seeds have manifold advantages over the ginned cotton seeds (10, 17). These are : i) Lint coating is completely removed, ii) Seeds can be treated with chemicals easily ; iii) Leaf spot disease is controlled ; iv) Pinkboll worm is killed with the acid, ; v) Seed coating gets stratified (softened) ; vi) The selected seeds which survive the chemical processing cycle after weak, light and immature seede are eliminated during the washing, grading and spreading operation, are of superior quality with better germination potential ; vii) Disease-free seed is obtained ; viii) Seed germination is easier and quicker ; ix) Flow of seed is just like that of wheat ; x) Seeds do not cling to one another and avoid clogging of seeds in the seed-drill /planter ; xi) Plant to pllant distance can be obtained thus giving desired crop stand ; xii) Uniform distribution of seed is possible thus reducing cost on thinning and reduces energy -input requirements ; xiii) Seed rate varies from 10-20 kg/hectare with the pora method using gainned seed whereas it can be reduced to 6-10 kg/hectare if drilled with seed-drill/planters using delinted seeds ; xiv) Different sizes of seeds can be obtained by using seed-cleaners /graders ; and xv) Acid-delinting is profitable due to returns obtained from excess yield.

Inter-cultivation

Weeding/hoeing in cotton is very costly, laborious and a time-consuming operation. Mechanizing this operation is one of the dependable ways of minimizing the cost of hoeing. Khurpa, khurpi, spade, kasola, wheel-hoes, and desi plough are commonly used for weeding in Haryana. Thinning is done with the help of khurpi. Manual labour requirement varies from 10-12 man-days/acre as compared to 5 man-hours/acre for mechanical weeding (9). Labour is becoming less available for seasonal operations like this. Thus self-propelled power-driven equipments can replace the old manual equipments (5). The Haryana Agricultural University developed one such power-weeder (2, 3) which was able to do the satisfactory job of weeding. This unit is operated by 2 hp petrol engine (5) and costs about Rs 3000.

Plant protection measures

A large number of machines varying from hand syringe to aeroplane spraying are available. Tractor operated sprayer can be used for cotton at a later stage only if one has a high clearance tractor. Aerial spraying has proved a great success. Farmers, in general, prefer this as this unit is available on custom basis.

Defoliation

Defoliation is recognized as a definite aid to mechanized production. It makes possible an earlier harvest of a larger portion of the crop at a better grade as it speeds up the drying and opening of mature bolls. The removal of leaves reduces the amount of green leaf and trash content in the harvested cotton (24, 25). In some cases, it also aids in insect control. This operation has not yet been practiced in northern India but already mechanized in countries like USA/USSR (**Table 5**). A one-year study on the effect of defoliants on the percentage of fall of leaves, reveals that application of 3 litres, plus 1 litre after 10 days, of grammaxone had the highest percentage of leaf-fall and had no effect on crop yield (4).

Topping

Topping is the practice of cutting of the terminal bud of the main stalk to prevent further growth and to avoid lodging by tall-growing plants. Lodged cotton is difficult to defoliate/harvest either by machine or hand labour. Lodging also results in conditions favourable for boll rot. Topping in India is done by hand while in other countries (**Table 5**) it is machine-topped where all the branches about the height of the topper blade are cut off. About 12 man-hours/acre are required for topping by a pair of scissors (**Table** 4) . There is a great scope for the development of some suitable topper machine either tractor-operated or by aeroplane.

Harvesting

Picking of cotton by pick-proper and snapping method is tedious, hard work and is ten times costlier than irrigation and about twice for weeding. Due to impending scarcity of labour, its mechanization is getting important in other countries. In the USA, few bales of cotton were harvested with picking machines in 1942. The percentage of cotton harvested mechanically rose from 25% in 1953 to 75% in 1963 in the U.S.A. At present almost all cotton produced is mechanically harvested. One machine does the job of 26-36 persons engaged in cotton picking (20, 24, 25). Six-hundred-thirty-four man-hours/acre are required in cotton picking using conventional practice of hand picking in India (3). One grown-up person can pick 20-70 kg of cotton per day as compared to average picks of about 870-2,180 kg by a single row spinkle type cotton picker. In order to meet the scarcity of labour in India during peak periods, mechanization of picking operation is a must. The use of picking machines is, no doubt, profitable but these are for the bigger farms. Smaller and cheaper machines suitable to Indian conditions are needed because of small size of holdings. However, private enterpreneurs/agro-industrial corporation or some other government agencies should be encouraged to import a few machines for trial under Indian conditions as was done in the case of combine harvestors (20) for wheat.

Stalk disposal

Stalk disposal is the final operation in a crop season. Seed-bed preparation cannot be adequate if the residue from the previous crop is too large to be covered or worked into the soil for decomposition. Large stalks, roots and stubble on/near the surface will tend to clog the openers, prevent covering and make accurate uniform planting extremely difficult. It is desirable to chop the stalk as fine as possible. It can be accomplished by disk harrows/rolling stalk-cutters. Power shredders also do a better job. In India, the general practice is to cut the stalks with "gandasi" and then the field is irrigated and 2-3 harrows are made. The cut stalks are use as fuel. Cutting the stalks with garden scissor requires about 14 man-hrs/acre as compared to 1 man-hr/acre with tractor operated shredder (3). The cost of operation of cutting the stalks with rotary blade cutter comes out to be Rs 9 per acre (15). The possibility of their use as manure after finally chopping them and mixing in the soil needs study. Use of cotton sticks as a raw material for the manufacture of cardboards also needs to be investigated.

Post-Harvest Technology Problems

Pamphlet No. Dec 8D/NCA/Dec/36.6 by the Directorate of Cotton Development, Bombay-1 lists some of the post-harvest technology problems relating to cotton cultivation as follows :

1. The harvesting of "kapas" (cotton) or picking is done when the bolls have fully opened and the puffed-up floss prominently emerges from the bolls. Bolls on different plants in the cotton field

and even on the same plant do not open simultaneously, therefore, cotton has to be picked up in many stages.

2. The use of mechanical pickers is not considered suitable under Indian conditions because the crop is harvested in 2-8 pickings, the holdings of farmers are small to permit the use of mechanical pickers, and suitable plant types having special blooming characteristics to permit machine harvesting have not been developed. There is a possibility of the use of shoulder-mounted vacuum type picker.

3. Harvesting losses at the farm level in the cultivators' field range from 1 to 5% depending upon picking, handling, losses resulting from shredding of floss. Some pickers (human power) pick cotton which has greater trash content. It reduces quality of cotton picked.

4. Under the purview of Mechanization of marketing operations, the handling, transport, storage and processing are the various important aspects which need special attention.

5. At present most of the growers do not have proper storage facilities.

6. Pre-cleaning of cotton is neglected by many processors because it adds to the processing cost. No standard pre-cleaning machinery is available in the conutry. It is essential that this should be introduced on a compulsory basis in all the ginning factories.

7. Machines for cotton processing are not frequently lubricated and cleaned. Some of the ginning machines are not set according to the fibre length and seed size.

8. Pressing of cotton lint into bales needs special attention. The pressing machines in use are very old and defective and these do not give proper pressure for packing cotton bales. Bales do not have standard types of hopes and sometimes are not covered with hussain cloth. This increases losses during handling and transport.

9. Presently cotton sticks are used as fuel in India. The possibility of their use as manure after finely chopping them and mixing in the soil needs further investigation. Use of cotton sticks as raw material for the manufacture of cardboards and such other articles also needs to be investigated. Use of cotton leaves for the manufacture of citric acid should also be examined.

10. Unavailability of sufficient manual labour at the time of hand picking poses another problem.

11. Acid-delinters are not available in India to make available acid-delinted seeds to the farmers.

Conclusion

The technical talent of the country has to make a resolute effort for taking care of the pre-production and post-production provisions on the modern lines by thinking of mechanical cultivation of cotton and giving it a practical shape. Time has come when the community should realize the use of machinery for various operations of cotton cultivation. World Bank /FAO/U.S. Agency should come forward to make available acid -delinters and mechanical pickers in India.

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Tobacco Curing in Bangladesh

by
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Introduction

Tobacco is one of the important agricultural cash crops of Bangladesh. It is next to jute and tea and is grown in every district of the country. Rangpur area grows rich tobacco in quality and quantity.

About 109 varieties of tobacco are grown in Bangladesh. They are classified broadly on the basis of purpose of use (**Table 1**). The annual production of tobacco in Bangladesh is on the upswing. Production area and yield are shown in **Fig. 1**.

According to the report of Planning Commission, the annual per capita consumption of tobacco is 1.8 lb. **Table 2** shows the annual consumption of tobacco by use.

At the beginning of 20th century a huge quantity of Zatty and Matihary tobacco was exported. During the years before 1970 this country was considered as a cigarett tobacco deficit area and the demand was met by importing from abroad at the cost of Tk. 150 to 200 million per year. However, after liberation, the conutry could not export tobacco sufficiently and had to reduce the quantity imported. Yearly export and import data are given in **Table. 3.**

Table 1. Tobacco Varieties and Use

Purpose	Variety
Cigarett Tobacco	Haryson special, Macniar-12, N. C. -95, N. C. -2, N. C. -512, Pocker-254, Barley-21, Sesmeria, Hicks, Orinako, Verginia gold, Hoye-Barley etc.
Hookha (Smoked by the villagers)	Vengy, Surzamukhi, Noakhel Matihary, Zatty etc. (native variety)
Zarda, Kiman, Natchy (used for chewing)	Matihary, Zatty etc.
Cigar	Manila, Sumatra, Zatty, Kello No. 49 and Matihary

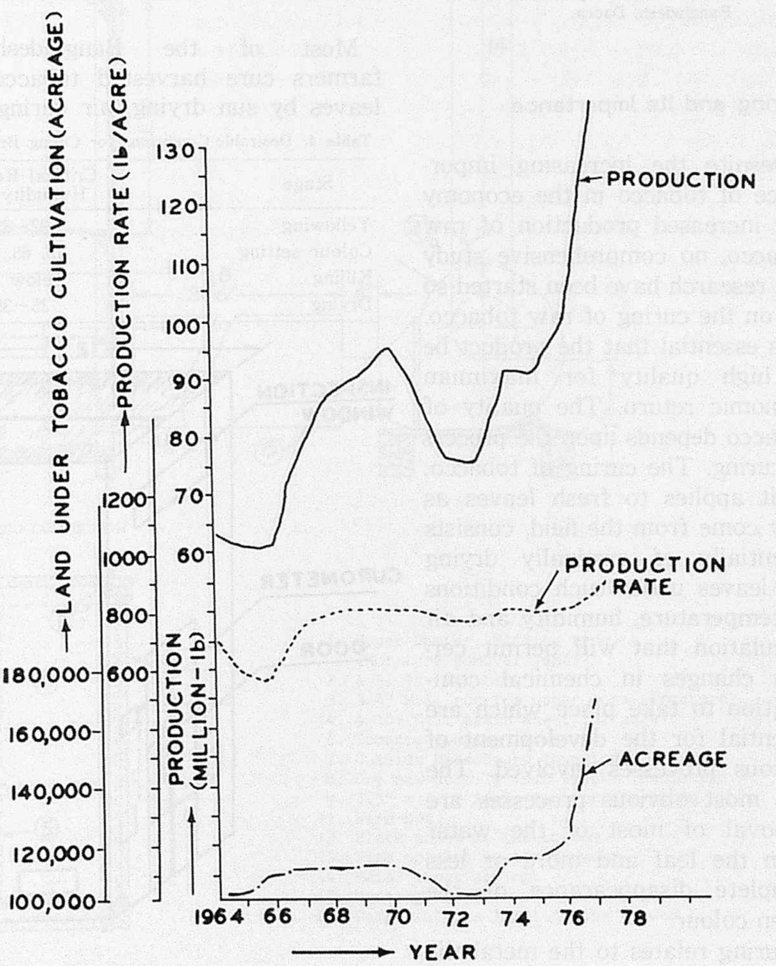


Fig. 1 Tobacco production, yield, and acreage, 1964–1977 (Source : Directorate of Agriculture, Government of the People's Republic of Bangladesh, Dacca)

Table 2. Yearly Consumption of Tobacco, by Use

Item	Quantity (Million lb.)	Percentage
Cigarett	50.00	38.59
Hookha (smoking)	61.50	47.47
Biri (smoking)	10.66	8.21
Zarda, Kiman (chewing) Sada Pata.	6.56	5.06
Cigar	0.82	0.67
Total	129.54	100.00

Source : Bichitra (A Bengali Weekly) 20th January, 1978.

Table 3. Import and Export of Tobacco 1967 — 77

Year	Import (Million-lb)	Export (Million-lb)
1967	33.73	3.45
1968	41.42	2.19
1969	41.36	0.07
1970	36.23	0.31
1971	—	—
1972	45.00	—
1973	20.51	—
1974	14.90	0.20
1975	14.40	—
1976	9.50	0.15
1977	0.83	—

Source : Directorate of Agricultural Marketing (Export and Import Division) Govt. of the People's Republic of Bangladesh, Dacca.

Curing and Its Importance

Despite the increasing importance of tobacco in the economy and increased production of raw tobacco, no comprehensive study and research have been started so far on the curing of raw tobacco. It is essential that the product be of high quality for maximum economic return. The quality of tobacco depends upon the process of curing. The curing of tobacco, as it applies to fresh leaves as they come from the fieid, consists essentially of gradually drying the leaves under such conditions of temperature, humidity and air circulation that will permit certain changes in chemical composition to take place which are essential for the development of various processes involved. The two most obvious processes are removal of most of the water from the leaf and more or less complete disappearance of the green colour.

Curing relates to the metabolic process of living cells under conditions of progressive drying which causes the death of the cells bringing about physical and chemical changes in the tobacco leaf. These changes require a specific degree of temperature rise and amount of moisture removal with respect to time. **Table.** 4 shows the typical dynamic changes of temperature and relative humidity necessary for producing high quality tobacco.

Curing Methods in Bangladesh

Most of the Bangladesh farmers cure harvested tobacco leaves by sun drying, air curing, and by the crude method of flue curing. The flue curing units are constructed by the farmers themselves. The materials used are bricks and clay (instead of mortar). Generally, wood is burnt to supply heat to the air passing through the suspended tobacco leaves. An isometric view of such a unit is shown in **Fig. 2**. In this type of units, the control of temperature, air supply and humidity is done by crude and rough method. As a result the cured tobacco cannot attain the desired quality.

Design and Construction of Curing Unit

Due to improser curing Bangladesh tobacco is inferior and cannot compete in the international market. Hence, it is important to improve curing not only to reduce the imports of high quality tobacco but also to export

Table 4. Desirable Conditions for Curing Bright Leaf Tobacco

Stage	Critical Relative Humidity (%)	Critical Temperature (OF)
Yellowing	92—85	4—8 above outside
Colour setting	75, 65, 50	105, 110, 120
Killing	below 10	170—200
Drying	25—39	140

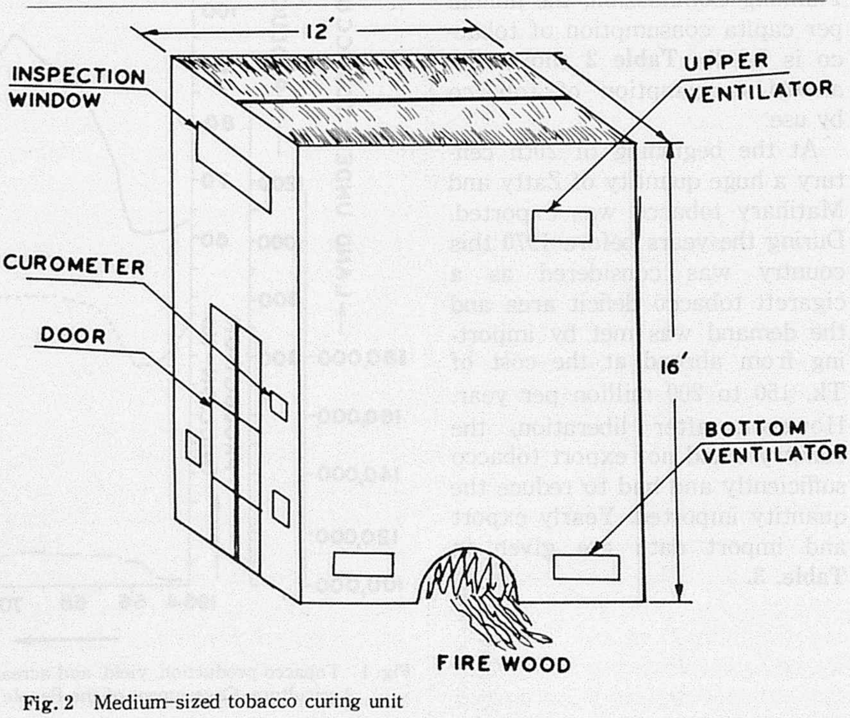


Fig. 2 Medium-sized tobacco curing unit

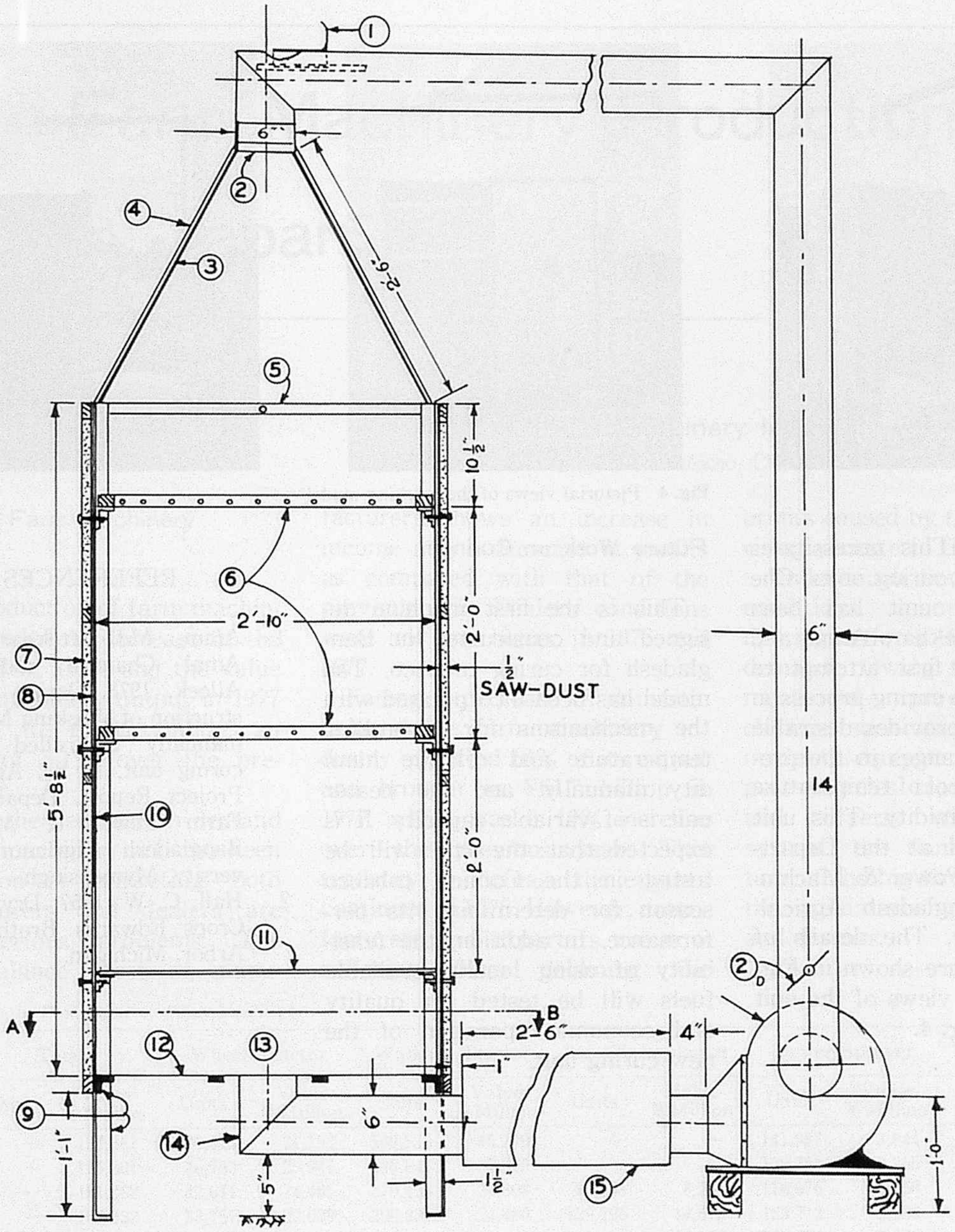
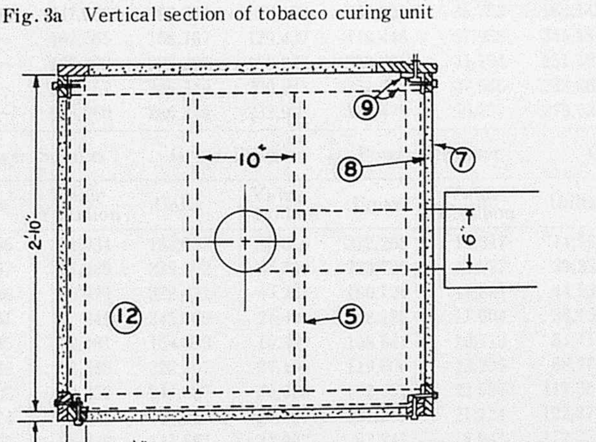


Fig. 3a Vertical section of tobacco curing unit



1. Upper Damper, Sliding type (Moisture removal vent)
2. & 5. 1" Flat bar.
3. 3/4" M.S. rod for upper cone-structure
4. & 10. G.I. plain sheet (32 gage)
6. Tobacco loading racks.
7. Outside Hard Board covering.
8. Dry saw-dust (½ inch thick) insulation.
9. 1.5" x 1.5" Angle bar for structure.
11. Wire net.
12. Black sheet at the bottom.
13. Pipe opening to the chamber.
14. Metal sheet piping.
15. Heating chamber.
2_D. Damper at the inlet of the blower.

Fig. 3b AB-section of the tobacco curing chamber

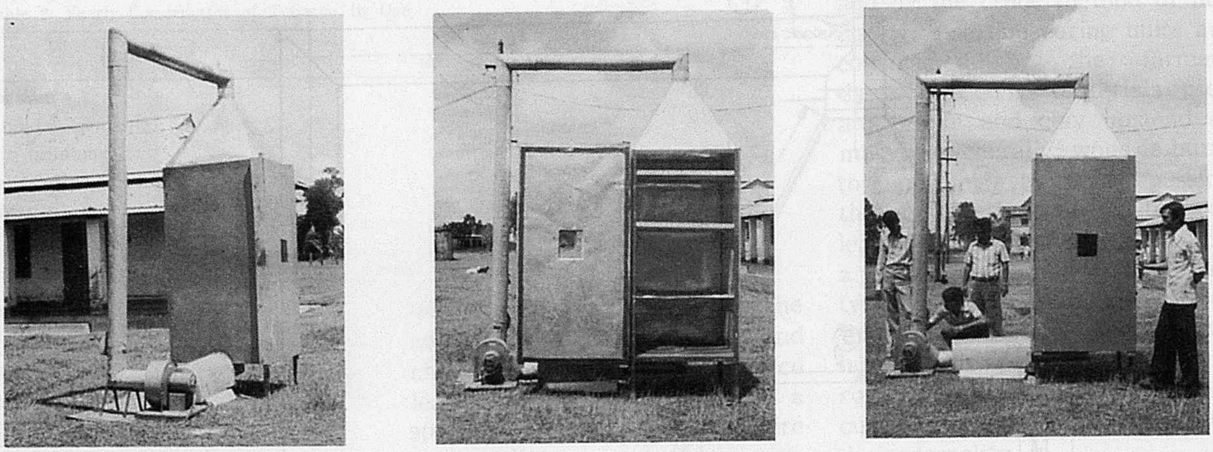


Fig. 4 Pictorial views of the working model

quality leaves. This necessitates improvement of curing units. One tobacco curing unit has been designed by Iftekhar, Amal and Aleek (1) as a first attempt to improve tobacco curing process in Bangladesh. It provides desirable physiological changes in the product by the control of temperature and relative humidity. This unit was constructed at the Department of Farm Power & Machinery of the Bangladesh Agricultural University. The details of the curing unit are shown in **Fig. 3.** The pictorial views of the unit are shown in **Fig. 4.**

Future Work on Curing

This is the first machine designed and constructed in Bangladesh for curing tobacco. The model has been incorpotated with the mechanisms for controlling temperature and relative humidity manually, and the heater unit is of variable capacity. It is expected that the unit will be tested in the Coming tobacco season for determining its performance. In addition, the feasibility of using locally available fuels will be tested for quality and economic operation of the new curing unit.

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Farm Machinery Production in Japan

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Status of Farm Machinery Industry

The production of farm machinery tendended to decrease in the latter half of 1977, and the value of farm machinery output in 1977 amounted to ¥658.9 billion, an increase of 5.1% over the previous year.

Due to the decrease in demand for farm machinery and the keen competition in marketing, both manufacturers and dealers are facing serious problems. The recent balance sheet of manufacturers shows an increase in income and a decrease in profits as compared with that of the previous year. Dealers' conditions were not any better in 1976 and 1977.

Facing a decrease in domestic demand the farm machinery industry exported 10% of its output and brought in ¥61.7 billion in 1977, which was a 40% increase over the previous year. This tendency to increase the exports continued in 1978. However, manufacturers and exporters are now suffering from declining the profits caused by the continuously rising yenrate to the US dollar.

Under such severe marketing conditions, manufacturers are making efforts to create new demands. Owing to the development and improvement of machinery, such as safety system, modern equipments for transport vehicles tractors, combines and dryers with automatic system, the domestic manufacture of the big-sized tractors, and the miniaturizing of combines and dryears.

Table 1. Yearly Production of Farm Machinery

Year	Total		Wheel Tractor		Walking Tractor		Rice Transplanter		Power Sprayer		Power Duster	
	Units	Value ¥ Million	Units	Value ¥ Million	Units	Value ¥ Million	Units	Value ¥ Million	Units	Value ¥ Million	Units	Value ¥ Million
1968	–	153,361	36,615	21,193	500,323	45,799	–	–	141,987	3,844	507,891	10,666
1969	–	175,201	46,753	25,947	440,845	37,875	–	–	130,781	3,265	252,313	4,976
1970	–	181,362	42,611	24,465	370,458	29,803	80,601	8,768	118,076	3,050	182,768	3,721
1971	–	154,932	33,757	22,039	296,839	24,480	129,796	14,679	153,712	3,886	126,191	2,880
1972	–	167,809	51,019	30,678	297,271	23,895	140,894	16,753	198,375	5,136	134,907	2,801
1973	–	247,883	99,394	59,123	351,921	35,753	186,142	25,686	227,708	6,437	221,561	4,881
1974	–	467,565	168,167	129,437	418,446	57,958	345,180	56,045	238,578	8,683	265,015	7,710
1975	–	496,702	207,285	166,277	303,205	41,764	251,437	48,157	147,173	6,333	199,452	7,158
1976	–	618,757	286,349	230,843	354,713	47,546	238,887	45,436	224,138	9,422	235,009	7,900
1977	–	658,960	266,344	232,938	370,473	50,722	279,635	53,565	219,975	11,204	238,960	7,840

Year	Blower Sprayer		Grain Reaper		Power Thresher		Combine		Power Rice Husker		Agricultural Dryer	
	Units	Value ¥ Million	Units	Value ¥ Million	Units	Value ¥ Million	Units	Value ¥ Million	Units	Value ¥ Million	Units	Value ¥ Million
1968	2,956	1,034	133,192	16,616	372,263	15,547	14,758	6,482	121,767	6,029	233,376	6,168
1969	3,567	1,388	239,102	38,729	273,780	11,927	39,224	16,846	110,771	5,631	206,284	7,305
1970	3,026	979	322,421	43,731	190,121	11,371	44,934	19,605	71,730	3,634	136,963	8,718
1971	2,151	849	245,369	27,404	142,185	11,604	38,159	15,166	53,995	2,593	110,122	7,101
1972	3,285	2,181	164,893	15,389	108,841	10,713	51,414	24,141	47,122	2,701	79,026	9,532
1973	4,189	2,568	222,607	24,195	119,600	13,235	68,279	36,387	59,401	3,960	102,745	14,864
1974	4,803	4,252	244,887	36,668	152,657	22,522	117,381	75,437	72,113	7,240	125,022	26,279
1975	4,024	3,378	152,187	26,607	121,297	21,724	127,271	110,638	73,853	10,146	93,570	25,820
1976	4,463	4,730	141,561	25,903	83,341	18,941	172,351	142,828	62,358	9,751	120,957	35,691
1977	6,205	6,917	116,466	22,187	72,106	16,808	172,908	143,396	75,658	15,464	161,845	54,553

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

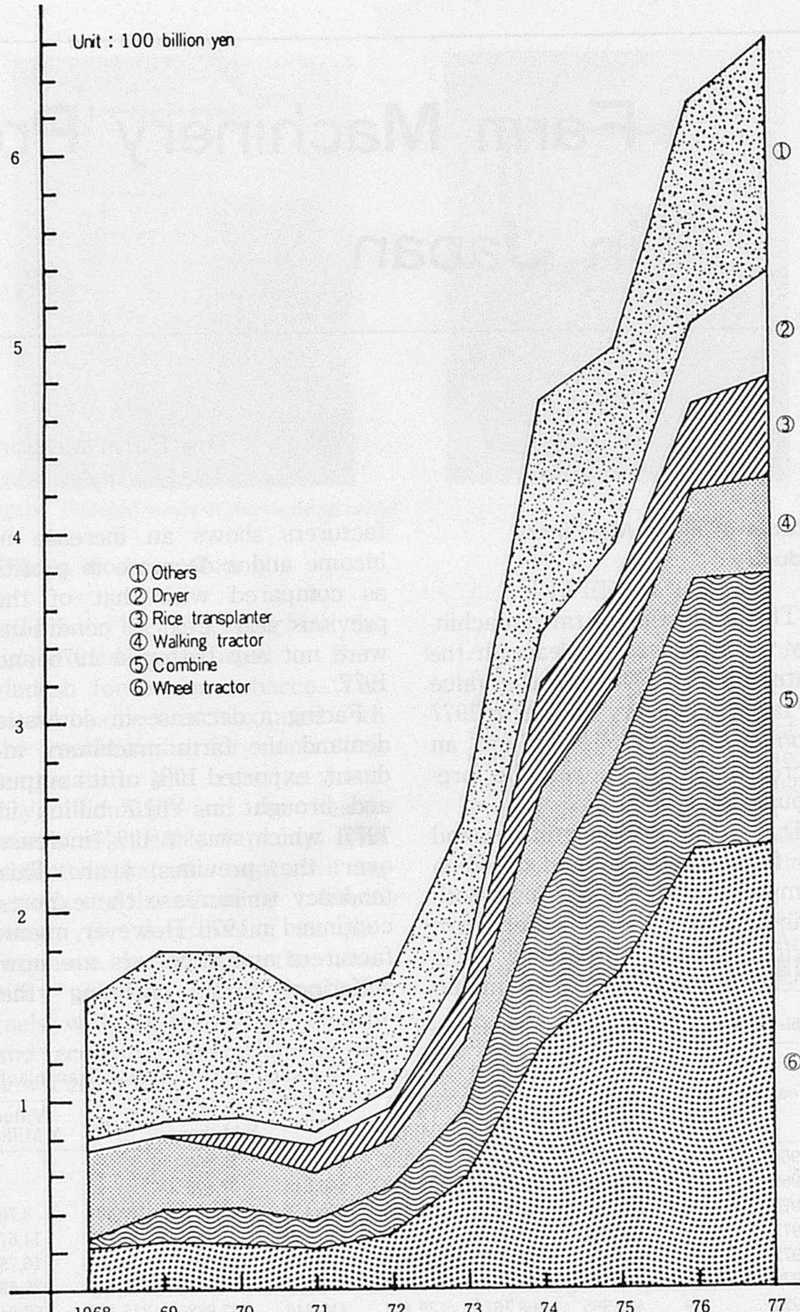
Trend in Farm Machinery Production

The value of farm machinery output in Japan has rapidly increased (¥248.0 billion in 1973, ¥467.6 billion in 1974, ¥496.7 billion in 1975 and ¥626.7 billion in 1976). However, the output amounted ¥659.0 in 1977, the previous year. The decline in value from 1976 was caused by the control of production of the main machinery such as tractors, combines, etc., because the farm machinery sales have suddenly diminished since the beginning of 1977.

The following production trends in 1977, are classified by kinds of farm machinery.

Four-wheel tractors : 266,344 untis (less than 20 ps—153,071 units, 20—30 ps—96,534 units, more than 30 ps—16,739 units). The total value of output was ¥232.9 billion. Production increased in the type of more than 20 ps (especially that of more than 30 ps) over the previous year, however, that of less than 20 ps decreased by 17.5%, hence the total production decreased by 7.1% or 20,295 units.

Combines : 172,908 units valued at ¥143.4 billion. Head-feed combines developed in Japan have spread in a full scale since 1968, and its output in 1976 reached 172,351 units. However, its production was curtailed in 1977 to only 172,908 units in order to diminish the stock, so the output in.



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

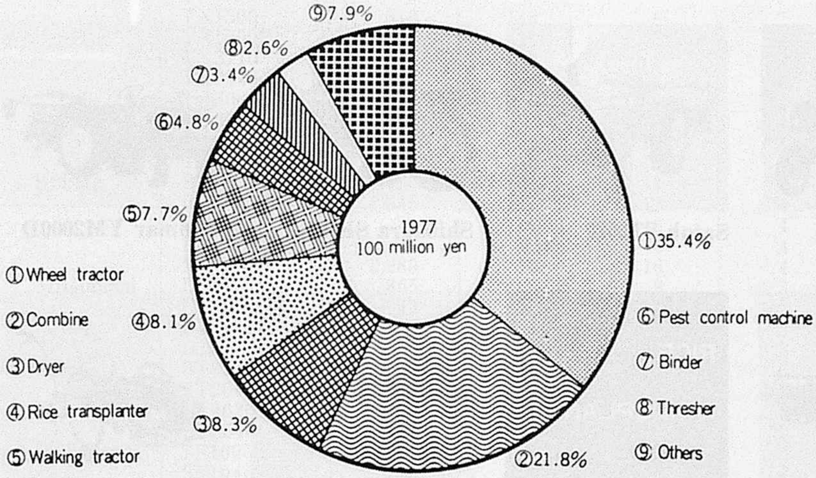
Fig. 1 Yearly production of farm machinery

Dryers : 161,845 units, ¥54.6 billion. Grain dryers, which have been developed in efficiency corresponding to the spread of combines, increased 28,448 units in production over the previous year, 85% of its production being the circulation type.

Rice-transplanters : 279,635 units, ¥53.6 billion. Power rice transplanters, which began to spread after 1970, reached the peak of production in 1974 with 345,180 units, but after that, its output decreased in 1975 (251,437 units) and in 1976 (to 238,887 units), and increased again in 1977 to 279,635 units.

Walking type tractors : 370,473 units, ¥50.7 billion. Regarding this type of tractors, over 3.2 million have already spread and most of the actual demands are new ones.

Grain binders : 116,466 units, ¥22.2 billion. This binder was popularized for reaping rice and about 320,000 units at the zenith of 1970, were manufactured but after that, its production decreased due to advent of combines.



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

Fig. 2 Percentage distribution of farm machinery production by selected machines

Power threshers : 72,106 units, ¥16.8 billion. These have also decreased due to the development of combines.

Hullers : 75,658 units, ¥15.5 billion. Their production has been regularized in the last few years, to a maximum of 70,000 units per year.

These eight kinds occupied 89.5% of the total output of farm machinery in 1977.

The value during the period from January to October in 1978 was ¥456.8 billion (21.6% decrease comparing with the same period of the previous year), i. e., the trend in production decrease has continued for fiteen months since last August. ■■

New Products Presented This Spring
(Tractors, Rice Transplanters and Combines)

In manufacturers of agricultural machinery in Japan, they keep making efforts to research and develop new products, so as to meet demands in farm villages and to supply farmers with efficient and economical agricultural machinery. In consequence, every year a number of new improved products are shipped to markets.

A lot of outstanding new products have presented by various maufacturers this year, too. So, concerning tractors, rice transplanters and combines, let us introduce specifications by its models respectively from new products of this year to you.

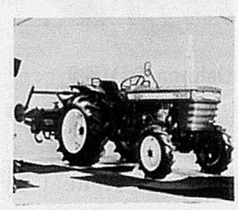
As to price, we write ones already made public in addition, though they are standard retail price in Japan.

WHEEL TRACTOR

Hinomoto E232

Hinomoto E324

Iseki TX1300



Iseki TS3110

Iseki T6500

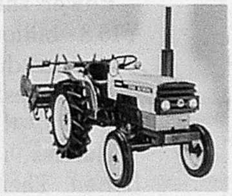
Kubota L2402DT

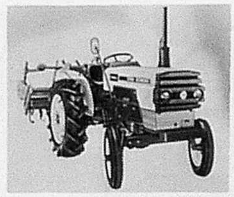
Kubota L4202DT

Kubota M7000DT

Mitsubishi D2050


Mitsubishi D3250


Satoh ST2020


Satoh ST2620

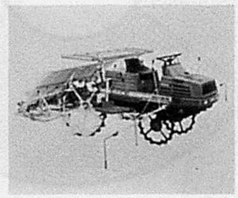

Shibaura SF1040T

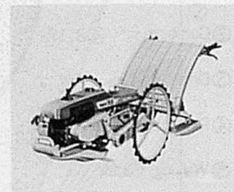

Yanmar YM2000D

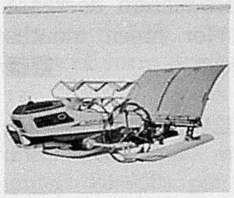

Yanmar YM3110D

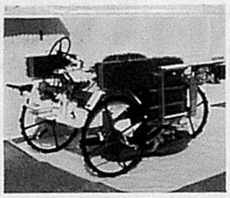

Yanmar YM3810D

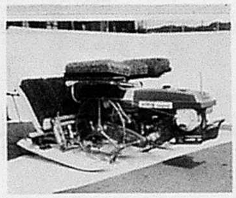
RICE TRANSPLANTER

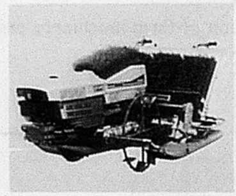

Iseki PL620


Kubota NS300


Mametora MSP4A

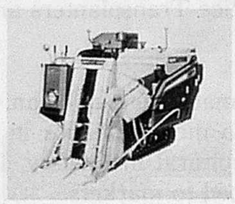

Minoru LTR4F


Mitsubishi MP450

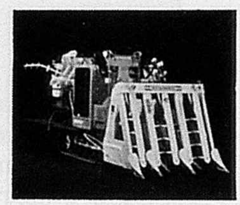

Yanmar YP400

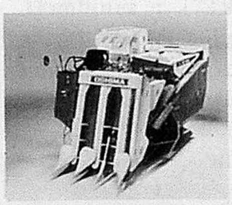
COMBINE HARVESTER


Fujii FK3100

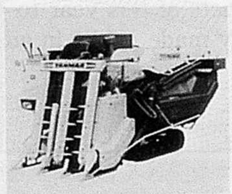

Kubota NX1300

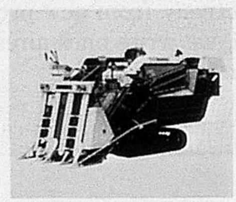

Kubota NX2000


Mitsubishi MC3100


Oshima RD1800


Satoh HI300D


Yanmar TC1500


Yanmar TC3000

SPECIFICATIONS

Tractor (Wheel Type)

Brand	Model	Weight (kg)	Engine Output (ps)	Transmission		Riding Arrangement		Retail Price (¥ Thousand)
				Forward	Reverse	Four Wheel Drive	Rear Wheel Drive	
Hinomoto	E152	664	16	6	2		○	
	E154	781	16	12	4	○		
	E182	712	18	12	4		○	
	E184	852	18	12	4	○		
	E232	882	23	12	3		○	
	E324	1,645	32	24	6	○		
Iseki	TX1300	480	13	6	2	○	○	
	TX1300F	510	13	6	2	○	○	

	TX1500	510	148	6	2	○	○	
	TX1500F	540	148	6	2	○	○	
	TS3110	1,196	31	8	2		○	1,980
	TS3910	1,380	39	18	6	○		2,300
	T 5000		48	20	4		○	3,230
	T 6500		65	20	4		○	3,750
	T 9000	2,900	85	16	4		○	
	T 9000F	2,900	85	16	4	○		
Kubota	B1600	620	16	12	4		○	
	B1600DT	645	16	12	4	○		1,150
	L4202		42	16	4		○	
	L4202DT		42	16	4	○		2,850
	M7000DT	2,280	79	16	4	○		4,665
Mitsubishi	D2050	865	20	9	3		○	
	D2050FD	940	20	9	3	○		
	D3250	1,180	32	15	3		○	1,830
	D3250FD	1,300	32	15	3	○		
Satoh	ST2020	865	20	9	3		○	
	ST2040	940	20	9	3	○		
	ST2620	1,110	26	15	3		○	
	ST2640	1,225	26	15	3	○		
Shibaura	SF1000T	3,500	105	16	4		○	
	SF1040T	3,700	105	16	4	○		
Yanmar	YM1601(D)	,720	16	12	4	○		
	YM1610(D)	730	16	12	4	○		
	YM1700B(D)	830	17	8	2	○		
	YM2000B(D)	880	20	8	2	○		
	YM2210B(D)	995	22	15	5	○		
	YM2610(D)	1,230	26	15	3	○		
	YM3110(D)	1,300	31	15	5	○		
	YM3810(D)	1,325	38	15	5	○		

Rice Transplanter

Brand	Model	Dimensions L × W × H (mm)	Weight (kg)	Engine Output (ps)	Number of Row	Efficiency (min/10a)	Retail Price (¥ Thousand)
Iseki	PL620-A90	3,350 × 2,370 × 1,530	480	7.5	6	20	
	PL620-80	3,350 × 2,200 × 1,530	450	7.5	6	20	1,120
	PL620-90	3,350 × 2,200 × 1,530	450	7.5	6	20	1,120
	PL820-A90	3,350 × 3,030 × 1,950	500	7.5	8	15	1,300
Kubota	NS300	2,018 × 860 × 920	80	1.4 ~ 2.6	2	40 ~ 70	225
	NS330	2,160 × 1,144 × 900	110	1.6 ~ 2.6	3	40 ~ 50	
Mametora	MSP-4A	2,380 × 1,480 × 867	125	2.5 ~ 3.5	4	30	435
Minoru	LTR-4F	3,480 × 1,396 × 1,520	345	3.5 ~ 5.0	4	25 ~ 35	1,100
	LT-6F	2,450 × 1,800 × 1,020	215	2.5 ~ 3.5	6	20 ~ 30	740
Mitsubishi	MP450	2,400 × 1,500 × 950	150	2.5 ~ 3.5	4	30 ~ 40	445
Yanmar	YP400	2,370 × 1,620 × 930	160	1.9 ~ 2.4	4	30 ~ 40	440
	YP430	2,370 × 1,620 × 930	160	1.9 ~ 2.4	4	30 ~ 40	450

Combine (Auto Thresher Type)

Brand	Model	Dimensions L × W × H (cm)	Weight (kg)	Engine Output (ps)	Cutting Width (cm)	Efficiency (min/10a)	Retail Price (¥ Thousand)
Fujii	FK1500	376 × 227.5 × 178	1,165	15	102	35 ~ 60	1,700
	FK3100	440 × 230 × 198	2,350	28	165	15 ~ 25	4,050
	FK3100G	440 × 238 × 198	2,550	28	165	15 ~ 25	4,600
Iseki	HL3500G	544 × 223 × 198	2,657	32	140	15 ~ 20	
Kubota	NX 800	300 × 145 × 156	610	8.5	75	60 ~ 90	1,000
	NX1000	300 × 154 × 156	660	9.0	75	50 ~ 80	1,100
	NX1300HA	337 × 145 × 169	950	11.5	75	38 ~ 60	
	NX1300HM	340 × 145 × 169	955	11.5	75	38 ~ 60	
	NX2000	339 × 165 × 190	1,360	20	102.5	25 ~ 40	
Mitsubishi	MC3100	430 × 168 × 198	2,350	28	165	15 ~ 25	3,700
	MC3100G	430 × 168 × 198	2,550	28	165	15 ~ 25	4,600
Oshima	RD 900	287 × 155.5 × 158	710	9	70	50 ~ 80	
	RD1300	325.5 × 167 × 165.5	900	13	80	45 ~ 70	
	RD1800	390 × 198 × 168	1,450	18	105	30 ~ 60	
Satoh	H1300D	350.5 × 209.5 × 172	875	13	80	40 ~ 60	
Yanmar	TC1000(S)	281 × 172 × 162	800	9.5	75	55 ~ 75	1,100
	TC1200K(A)	286 × 164 × 165	960	13.5	77	40 ~ 60	1,520
	TC1350(A)	286 × 164 × 165	980	13.5	77	40 ~ 60	1,600
	TC1500(A)	338.5 × 168.5 × 183.5	1,130	14.5	105	33 ~ 50	1,850
	TC3000KG(A)	412 × 168 × 198	2,500	30	135	15 ~ 20	4,780

NEWS

Ninth Session of EIMA
Nov. 8–12, 1978, Bologna/Italy

The ninth session of EIMA, "International Exhibition of Agricultural Machinery Companies", organized by UNACOMA with the participation of the "Ente Autonomo" of the Bologna Fair, opened on 8 November 1978 at Bologna. 1030 exhibitors from 23 different countries throughout the world were present.

The exhibition permitted the visitors to appreciate the most recent progress in the manufacture of machinery aimed at alleviating the toil of agricultural workers, bringing about new methods of working and harvesting and increasing the productivity of agricultural companies.

The principal companies were all present, in fact, showing the complete range of their products. The presentation at EIMA of their latest products was the proof of the validity of the formula which has been adopted by the exhibition of Bologna over the past 9 years.

The division into 13 different market sections facilitated the location and choice of machinery on the part of the operators who, during the first 3 days reserved exclusively for them, worked with the maximum tranquility, without being disturbed by the general public, for whom the last 2 days were reserved, or by publicity. The latter is prohibited by a rule, strictly enforced by the organizers, which also offers the advantage of facilitating and macking cheaper the preparation of the stands.

The site of the fair of Bologna which encompass EIMA is in a strategic position difficult to equal in other cities housing similar exhibitions.

The indoor stands, centrally heated, are situated close to the railway station, the motorway and the airport, offering easy and rapid access to visitors.

The next session of EIMA —14 to 18 november 1979— will be another demonstration of the vitality of this industrial sector, the productivity of which, in a market which is continually expanding, compares positively with that of other industrialized countries, second in Europe only to Germany.

AGRITECH'79
Sept. 10–13, 1979, Tel-Aviv/Israel

Israel's seventh Agricultural Mechanization and Technology Exhibition "Agritech 1979" will take place at Tel-Aviv Fair Grounds, from 10 to 13 September 1979.

Since the first Machinery Exhibition in 1964 revolutionary changes have occurred concerning the quality as well as the variety of mechanical equipment put to use in all branches of Israeli agriculture.

Agritech 79 represents a showcase for Israel's dynamic achievements and technology in promoting impressively high yield some of the highest in the world.

245 exhibitors, representing hundreds of firms will take part in the exhibition. A considerable amount of iocally produced equipment, which has earned recognition in many parts of the world for innovation and durability, will also be shown.

Agritech has become a focal point for Israeli firms and foreign visitors alike.

We invite you to join us in Tel Aviv during September where new ideas and technologies can be explored together.

Take a look at a major categories you'll see displayed :

Irrigation Systems
Automation and remote control
Accessories and pipes

Machinery & Equipment
Tractors
Farm mechanization for all purposes
Soil cultivation & seeding implements
Spraying & fertilizer distributing equipment
Green houses & climate control
Orchard & horticultural mechanization
Fish pond mechanization
Harvesting implements for field crops and vegetables
Sorting & grading systems
Refrigeration storage and warehousing

Agrochemicals
Fertilizers
Plant-protection chemicals

Livestock Handling
Livestock & farmyard mechanization
Milking systems & installations for cows and goats
Poultry feeding & handling equipment
Feeding & handling equipment for cowsheds
Veterinary sanitation materials
Pharmaceuticals & chemicals

Research & Development
Use of solar energy systems in agriculture
Agricultural safety equipment & systems
Agricultural material handling & transportation

Preliminary Timetable

Sunday, 9 September

all day	arrival of participants from abroad
2 p.m. —8 p.m.	Registration and distribution of material

Nonday, 10 September

10 a.m.	official opening by the Minister of Agricuture for exhibition, buyers and journalists.
Evening	Reception

Tuesday, 11 September

All day	Exhibition, business meetings and demonstrations of developments in mechanization and equipment
Afternoon	Professional symposium

Wednesday, 12 September

All day	visits to agricultural sites industrial plants

	and field demonstrations.
Evening	Free
Thursday, 13 September	
All day	Open day. Professional meetings between visitors and local producers for an exchange of ideas.

for further information please contact :

The Organization Committee, AGRITECH'79
P.O.Box 29732 Tel-Aviv, Israel
OR
The Israel Commercial or Agricultural Attaché at your nearest Israeli Consulate.

Interregional Symposium on Solar Energy for Development

Feb. 5–10, 1979, Tokyo/Japan

International Seminer on Solar Energy for Development was held in Tokyo, for one week from February 5 to 10, 1979.

The United Nations Conference on New Sources of Energy, which took place in Rome in 1961, made a significant impact in this area and provided a stimulus for the subsequent activities of the United Nations in developing new and renewable sources of energy. However, the price of conventional energy was low at that time and so there was little incentive to actively develop new sources of energy. In the light of the current world energy situation, the United Nations is proposing to convene a major international conference on new and renewable sources of energy which, if endorsed by the General Assembly, may take place in 1981. In 1976, on the recommendation of the Advisory Committee on the Application of Science and Technology to Development (ACAST), the Economic and Social Council adopted a resolution (2031 LXI) calling, inter alia, for the convening of seminars and exhibitions to be held on Research and Development in non-conventional sources of energy, with the co-operation of Member States.

Following the adoption of this resolution, an approach was made by the Government of Japan to the United Nations to sponsor jointly with a Japanese Organizing Committee an international Symposium in Tokyo with the object of promoting international co-operation in the field of solar and wind energy research and development. This Symposium was the result.

As a joint venture, this Symposium was provided a forum for the following :

(a) A "state of the art" review of the development of technology and the prospects and problems of utilizing solar and wind energy sources ;
(b) Individual scientists from the participating developing countries to discuss their contribution to research and development in solar energy ;
(c) An exchange of information relating to, and the assessment of, country programmes in the participating developing countries in research and development on solar energy ; and
(d) An examination of the possibilities of international co-operation with particular reference to the transfer of technology from the developed to the developing countries.

The agenda were based upon the following broad headings :

(a) Solar collectors : design and testing
(b) Solar heating and cooling applications
(c) Solar power : thermodynamic cycle engines ; photovoltaic solar cells ; and applications
(d) Wind energy
(e) Storage : system design and applications for solar and wind energy

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For Agricultural Mechanization in Asia

ASAE Eslablished the New International Department

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by Merle Esmay (Cooperating Editor)

The American Society of Agricultural Engineers (ASAE), with some 7500 members, is increasing its activity in international programs. A new International Department has been established and Merle Esmay was appointed the director.

ASAE consists of three councils each headed by a vice president. In each of these three councils ; administrative, technical and regional, there are a number of departments. The new International Department was established under the Administrative Council. Previously there was only an International Relations Committee under the Professional Development Department of the Administrative Council.

Qualified professional Agricultural Engineers from any country are eligiblę for membership in ASAE, and nearly ten percent of the societies membership consists of residents and citizens of other countries as well as USA citizen members who reside abroad. The new International Department will provide more visibility, program potential, committee activity and service to ASAE's international members. All of the USA and Canadian resident members are represented through the regional council. The 700 or non-USA and Canadian resident ASAE members have previously been without direct representation within the three top councils of the society. The establishment of the new International Department provides desirable representation.

A new Executive Committee has been appointed for the International Department. These committee members along with the International Director are formulating new bylaws and a broader committee structure for the department. It should be stressed that ASAE is not necessarily trying to become an international society and is not trying to compete with CIGR (Congres International du Genie Rural). ASAE does, however, allow and encourage individual foreign professionals to join and as indicated, quite a few hundred have become members. It is believed that inasmuch as a significant number of professional Agricultural Engineers residing outside the USA and

NEWS

Canada have joined, ASAE then should provide them with the best possible professional service. This strengthening of international activities in ASAE can be complementary to CIGR and its activities.

CIGR is a federation of Agricultural Engineering societies with its headquarters is Paris. ASAE joined CIGR some 15 years ago and national Agricultural Engineering societies around the world are also encouraged to join CIGR. The IXth CIGR (once-every-five-year) International Congress of Agricultural Engineering will be held July 8-13, 1979 at Michigan State University, East Lansing, Michigan, USA. This will be the first time ever that the CIGR International Congress has been held outside of Europe. It follows one week after the National ASAE summer meeting of ASAE, which will be held in conjunction with the Canadian Society of Agricultural Engineers (CSAE) at Winnipeg, Manitoba, Canada June 24-27, 1979. This will be an excellent time for Agricultural Engineers from around the world to come to the United States and Canada and participate in two outstanding professional meetings. Bus tours of interest are being planned between Winnipeg and East Lansing the week between meetings. Write to Prof. Clearence Hansen, Agricultural Engineering Department, Michigan State University, East Lansing, Michigan 48824, USA, for CIGR Congress registration information.

International Department Future Plans

The department will continue to sponsor the Kishida International ASAE Annual Award which was first presented at the 1978 annual summer ASAE meeting in Logan, Utah. The first award was presented in person by Mr. Yoshikuni Kishida, Chairman of the Shin-Noronsha Company Limited of Tokyo, to Professor Emeritus Ralph C. Hay of the University of Illinois. This prestigious award along with $1000 will provide additional interest, stimulation and visibility for expanded international activities in the future, particularly with reference to service in developing countries.

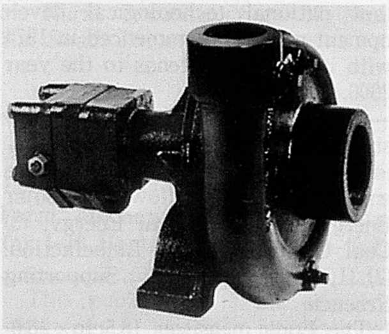
The A-411 International Relations Committee has generally sponsored one 1/2-day technical program session with a focus towards international activities at each of the two national ASAE meetings each year. Two 1/2-day sessions are scheduled in 1979 for each the June ASAE meeting in Winnipeg and the December meeting in New Orleans. One International Program session in Winnipeg, Canada will pertain to post grain production technology in tropical countries, and be jointly sponsored by the Electric Power & Processing Technical Division. The second program will focus on irrigation and water control in developing countries, and be jointly sponsored by the Soil & Water Division. The new ASAE International Department will continue and expand technical program sessions on international topics. A program session with a focus towards Agricultural Engineering in Mexico and Latin America is already being tentatively planned for the 1980 annual summer ASAE meeting in San Antonio, Texas.

A plan is being formulated by the A-411 International Relations Committee, and hopefully will be implemented for the 1980 annual summer ASAE meeting, to select and financially support up to five Agricultural Engineers from various developing countries to attened and present technical papers. It is hoped that such a sponsorship program can be implemented on an annual basis in order that ASAE might obtain more and better input from professional Agricultural Engineers abroad. Also the program will provide opportunities for more foreign professional Agricultural Engineers to travel to the USA and participate in technical meetings. We hope this might also lead to increased opportunity to publish in ASAE Transactions.

The International Department of ASAE will help other countries develop and strengthen the Agricultural Engineering profession whenever and wherever feasible. The first major effort of this type is being undertaken with Agricultural Engineers in the Latin American countries—our closest neighbors. ASAE's initial linkage and communications with Latin American Agricultural Engineers will be through the 150 ASAE members who reside in the various Latin American countries. A letter and questionnaire has been sent to these Latin American ASAE members to obtain their input on how the new International Department might help strengthen professional Agricultural Engineering in their countries. A newsletter is planned on some regular basis for added communications. Possibly the newsletter can reach beyond the 150 ASAE members to educational institutions, government agencies and industry. More extensive collaboration with Latin American Agricultural Engineers is hoped for in organizing and putting on improved technical meetings and in following up with good publications of technical literature.

Agricultural Engineers have a critical role to play in the production and processing of adequate food and fiber. Strengthening and recognition of Agricultural Engineering as a profession in all countries is necessary. Let me know how ASAE and the International Department can help your professional development process. ■■

Ace Centrifugal Pump



By taking their power from the tractor hydraulics, these new "Ace" pumps leave the tractor power-take-off free to drive other accessories, thus greatly enhancing the tractor utility value to the farmer /operator.

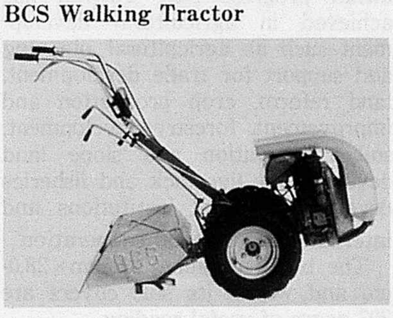
Embodying their own hydraulic motors, these centrifugal pumps can be mounted on the tractor in any position, or on separate trailer-mounted "nurse" tanks, even upside down. This type of installation is of special interest to applicators of anhydrous ammonia or liquid nitrogen, employing separate "nurse" tanks.

The Series FMC-HYD require a hydraulic oil flow of not less than 15 liter (4 gallons) per minute at 70 atmospheres (1,000 PSI) to produce output pressures from 3/4 to 7 atmospheres (10 to 100 PSI) and a flow of 4,500 to 17,000 liter (1,200 to 4,500 gallons) per hour.

Series FMC-200-HYD require a minimum of 30 liter (8 gallons) per minute flow of hydraulic oil and produce output pressures of 3/4 to 4-1/2 atmospheres (10 to 60 PSI) at a flow of 9,000 to 41,000 liters (2,400 to 10,800 gallons) per hour.

(Ferrex International, Inc. : 253 Broadway, New York, N.Y. 10007, USA)

BCS Walking Tractor



〔Specifications〕

Engine : 8 Hp gasoline or kerosene or diesel.

Operating speed : 3 forward+1 reverse (1 =1.2, 2 =2,6, 3 =11, Reverse=2.2km/hr.)

P.T.O. : 965 r.p.m.

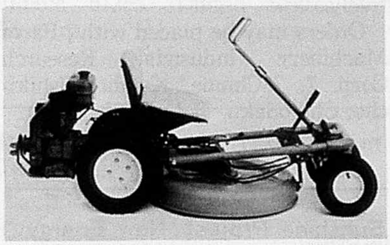
Wheels : Pneumatic tyres 4.00−8 or 5.00—12, Steel wheels optional.

Handle : Adjustable in height and sidewise, in several positions.

Implements : Rotary hoe of 20-30-42-52-66cm, Ploughs, Ridger, Trailer, Pumps, Mowing bar, Snow thrower, Lawn mower.

(BCS s.p.A. : Viale Mazzini. 161-20081 Abbiategrasso, (Milan) Italy)

BCS Lawn Mower MFR 701



〔Specifications〕

Engine : 4 strokes-gasoline 15 Hp, Diesel 13 Hp.

Gearbox : 4 foward speeds+1 reverse speed. (1 =3.5, 2 =4.5, 3 =6, 4 =10, Reverse=4 km/hr).

Pneumatic wheels : 23×8.50−12

Brakes : drum type on the wheels, independent control

Electric starter (optional).

Possibility of installation of a trailer foot-driven.

Cutting width : 1.27m.

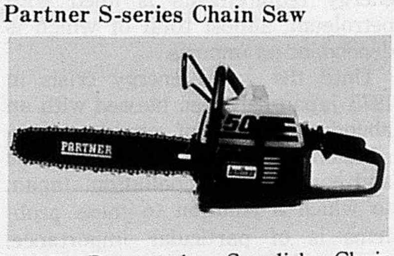
Cutting height : adjustable up to 20cm.

Mobile Knives on two discs.

Weight : 350kg.

(BCS s.p.A. : Viale Mazzini, 161, 20081-Abbiategrasso, (Milan) Italy)

Partner S-series Chain Saw



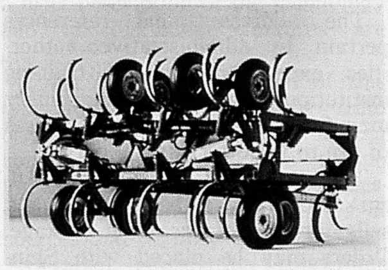
AB Partner-the Swedish Chain Saw manufacturer-is introducing a new range of models for 1979.

This range includes the professional chain saws P55, P70 and P100 presented in 1978. New models consist of two semi-professional saws with designations S50 and S55 which are replacing the successful Partner Farmer saws.

The Partner S50 and S55 saws have many fine features including a unique ignition system-known as Ignitron-and a comprehensive range of safety equipment which is otherwise only found on the most sophisticated professional models. That is why the S50 and S55 are referred to as semi-professional chain saws.

(AB Partner : Fack, S-431 20 Molndal 1, Sweden)

John Deere 1610 Chisel Plow



John Deere has introduced a new line chisel plows -- the 1610 Series -- to effectively use the horsepower available in today's larger tractors. These new chisel plows are stronger than earlier models in The Long Green Line™, with 4×4-inch frame bars increased to 5/16-inch wall thickness in high-stress areas. The 5×5-inch H-beam hitch extends beyond the center cross member of the mainframe to provide strength for in-the-field dependability.

These new 1610 Chisel Plows are available in 8-to 41-foot working widths, to match a variety of tractor sizes. Mounted models are available in 8-to 20-foot sizes. Drawn models begin at 11 feet. Wide-span drawn models fold neatly for easy transport and storage. Popular 19-to 27-foot widths feature a new horizontal fold that eliminates worries about low power lines. Vertical-fold models are available in 25-to 41-foot sizes.

(John Deere Intercontinental Ltd. : John Deere Road, Moline, Illinois 61265, U.S.A.) ■■

NEW PUBLICATIONS

1979 Farm Machinery Yearbook (Japan)

Between the covers of this 234-page yearbook are up-to-date comments, statistics and usefull addresses pertaining to agricultural mechanization in Japan. The commentaries focus on trends in Japan's agricultural development, agricultural machinery industry, production trends of agricultural machinery and results of agricultural machinery research efforts. On the other hand, the current statistics include those on agriculture, in general ; agricultural mechnization and international statistical data and information on farm machinery.

The addresses and references pertain to administrative authorities, experiment stations, training institutions, agricultural machinery manufacturers and foreign addresses of use to importers and exporters.

The yearbook measures 18.0 cm×26.5cm, with hard cover and sells for US$40, including postage. Orders may be placed with Shin-Norinsha Co. Ltd., 7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101, Japan.

Price Guide to Agricultural Machinery Sales (Japan)

In Farm Machinery Industrial Research Corp. we have investigated standard retail price of agricultural machinery in Japan. As a price guide to agricultural machinery sales we published following two publications (edition in Japanese) :

'1978 edition ; A Price Guide to Agricultural Machinery Sales' ——— This book limits principal agricultural machinery to ten types of engines, tractors power tillers, rice transplanters, binders, combine harvesters, self-propelled threshers and circulation dryers. We have gathered retail price of all brands and all types over 10 years (1969–1978). This is the most suitable guide-book to trade-in sale.

'1979 Spring edition ; A Price Guide to Agricultural Machinery Sales' ——— This book deals with 55 types for principal agricultural machinery and records spring price in 1979 of all types by 130 companies. In addition as reference data this contains principal specification of tractors and combines, tradind-in, standard service charges, a list of machinery admitted by safety test, a list of safety checking items and a list of names for leading organizations concerned etc.

Both of these books are pocket editions (14.5cm×9.0cm) so as to be handy. Further, these are easy to read because of bindings.

About 300 pages and sells for ¥2,200 including postage respectively.

Orders may be placed with ; Farm Machinery Industrial Research Corp. 7, 2-Chome, Kanda Nishikicho, Chiyodaku, Tokyo 101, Japan.

Sunshine Project : New Energy Research and Development in Japan (Japan)

Energy is an essential power of al the activities of mankind ; it is indispensable to the improvement of the standars of living and industrial progress.

Japan's energy consumption increased 4.1-fold, from 100-million kilolitres in oil equivalent (on the basis of primary energy supply) in 1960 to 408-million kilolitres in 1974. This represents an annual increase of 11%, a growth rate twice as fast as the world's average annual increase in energy consumption during the same period. At present, about 75% of the primary energy requirements is filled with petroleum, almost total of which is dependent on imports.

Until the world energy crisis in 1973 Japan had been blessed with an abundant supply of readily accessible oil. In the face the energy crisis and environmental pollution. Japan, to which a solution to these problems is of particular importance, must make the development of new energy technology a national project.

"Sunshine Project" is an important national technological development program commenced in 1974 with its horizon extends to the year 2000.

This publication is a comprehensive summary of the Sunshine Project. Included in the project are energy sources as follows : (1) Solar Energy, (2) Geothermal Energy, (3) Coal Gasification and Liquefaction, (4) Hydrogen Energy, (5) Supporting Reseach.

The Book measures 18.5cm×26.0-cm and within its soft covers are 40 pages of useful reading.

Published by Sunshine Project Promotion Headquarters, Agency of Industrial Science and Technology, Ministry of International Trade and Industry, 3-1, Kasumigaseki 1-chome, Chiyoda-ku, Tokyo, Japan.

JCRR and Agricultural Development in Taiwan (1948-78) (Taiwan)

This book is published by the Joint Commission on Rural Reconstruction, 37 Nan Hai Road, Taipei on the occasion of the 30th anniversary of the JCRR. The JCRR enjoys the reputation of one of world's most successful organizations in causing total development to happen in an island-country that is Taiwan. The book recounts the past 30 years of JCRR's activities in total rural development and leaves behind it many useful lessons of experience.

The book is written in Chinese and English, the latter, in a style that is easy reading. The main topics covered relate to the phenomenal progress that Taiwan has achieved in agricultural development such as agricultural planning and support for trade development, land reform, crop production and improvement, forestry development, soil conservation and slope land development, livestock and fisheries development rural institutions and international technical cooperation.

The book measures 21.5cm×28.0-cm and within its soft covers are 207 pages of useful reading.

NEW PUBLICATIONS

Publiphed by the Joint Comission on Rural Reconstruction, 37 Nan Hai Road, Taipei, Taiwan.

Agricultural Technology for Developing Nations
Farm Mechanization Alternatives for 1-10 Hectare Farms (U. S. A.)

This publication is the proceedings of a special international conference on "Agricultural Technology for Developing Nations : Farm Mechanization Alternatives for 1-10 Hectare Farms," was held on the campus of the University of Illinois at Urbana-Champaign, May 23-24, 1978. The conference was sponsored by the American Society of Agricultural Engineers, the Interfaith Center on Corporate Responsibility, and the University of Illinois at Urbana-Champaign.

The purpose of the conference was to provide concerned people with information about the opportunities and problems associated with farm mechanization as one element for relieving the food shortage in developing nations. Attention was given to the socioeconomic issues involved with agricultural technology transfer, and to the engineering and marketing problems specifically associated with small-farm technology.

The main contents of this Book are as follows :

Agricultural Technology for Increased Food Production in Developing Nations : Problems and Opportunities.

Audience Discussion.

Panel Discussion : The Socio-economic Impact of Farm Mechanization in Developing Nations.

Panel Discussion : Developing and Marketing

Equipment for Small Farms in Developing Nations

Single copies of this publication are free of change.

Single copies and information concerning cost of quantity requests may be obtained from

Roy E. Harrington, Product Planning Department, Deere & Company, John Deere Road, Moline, Illinois 61265, United States of America

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Development and Transfer of Technology Series No. 7
Technologies from Developing Countries (Austria)

Developing countries have frequently expressed the need for information on technologies evolved or adapted by other developing countries. Such information will be of benefit to them in the appropriate choice of technologies by providing alternatives and also a basis for promoting the exchange of information and sharing of experiences in this field. The *Ad Hoc* Committee on Long-Range Strategy for UNIDO in its recommendation concerning industrial information activities of UNIDO drew particular attention to these facts.

As part of its information activities UNIDO has been collecting information on technologies from developing countries through contacts with institutions related to research and development and other sources of information in developing countries as well as through journals, reports and other publications dealing with such matters.

This volume brings together in one place information on 138 technologies from developing countries. Generally, under each heading a brief description of the technology and its distinctive features are given.

Collection of information of this type is dependent on responses from organizations in the developing countries, and hence the technologies described herein are necessarily confined to the responses of sources that supplied information.

Detailed information concerning the technologies described in this volume may be obtained by writing to the licensors or to sources that are specified. Wherever money values are indicated, they are to be deemed to be approximate since they are liable to change in time.

Published by United Nations Industrial Development Organization (UNIDO), Vienna, Austria. ■■

BACK ISSUES

(Vol. 9 No. 1, 1978~)

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INDEX TO ADVERTIZERS

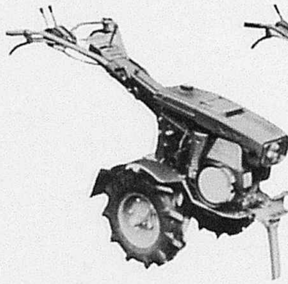
CONTRIBUTORS WANTED

This publication, published quarterly, has an objective to promote agricultural mechanization in developing countries. Its readers consist of so many people in various fields such as farmers, dealers, manufacturers, researchers, government officials, students, etc. not only in Asia but also in the whole world. To enrich contents and to reflect many opinions, we want contributors for **Agricultural Mechanization in Asia**". Articles, comments, investigations, reports and so on will be received with open arms. If you hope to contribute, contact us without delay.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7-2 Kanda Nishikicho, Chiyoda-ku, Tokyo, Japan (Tel. 03/291-5717~8, 3671~4)

CULTURE ALL OVER THE WORLD



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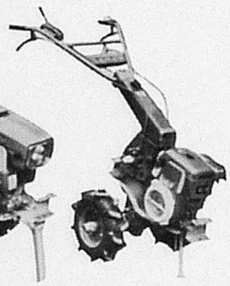

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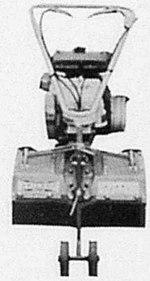

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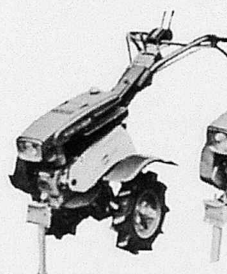

SKD-II

HMD-250

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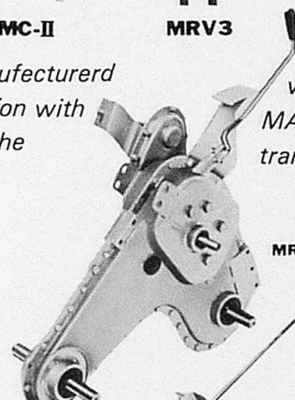
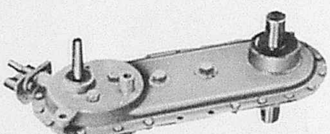
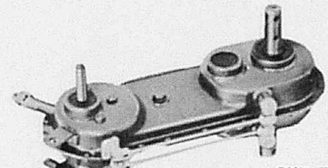
MAMETORA AGRICULTURAL MACHINERY.
transmission under oder.



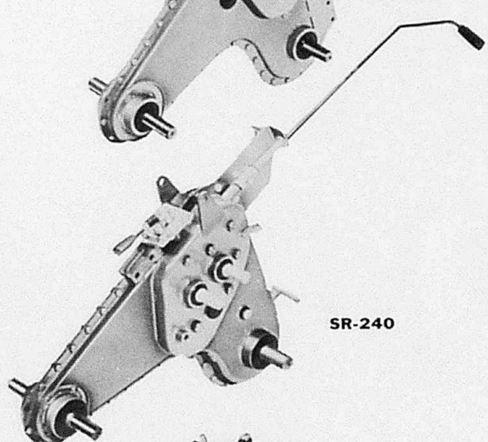
MRV3



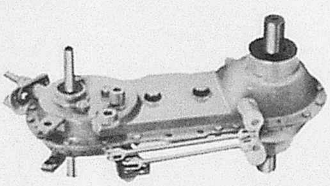
CMC-180



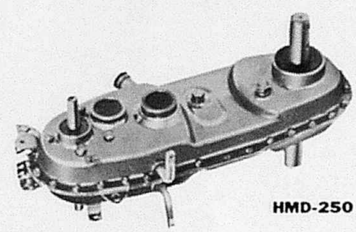
SKD-II



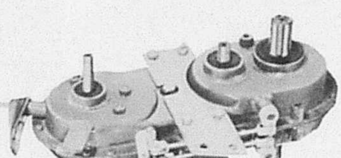
SR-240



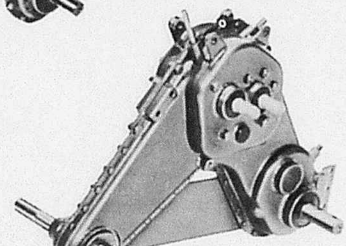
DMC-180



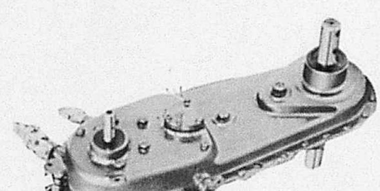
HMD-250



UK-13



JAN-800



PM-350

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