International specialized medium for agricultural mechanization in developing countries

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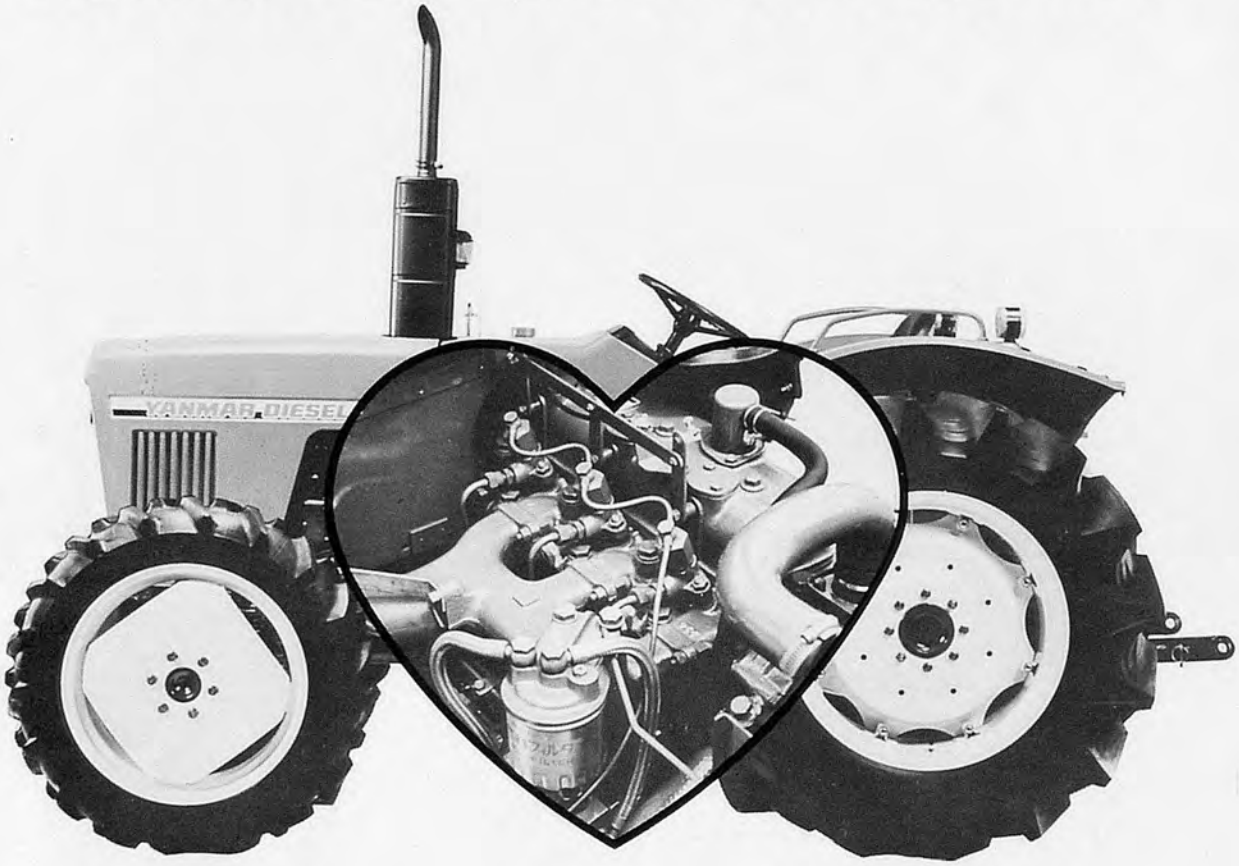
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VOL. XV, NO. 1, WINTER 1984

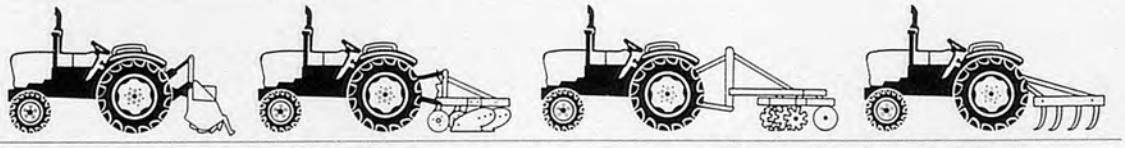
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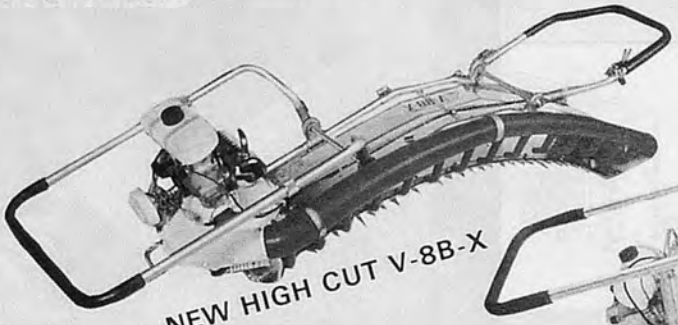
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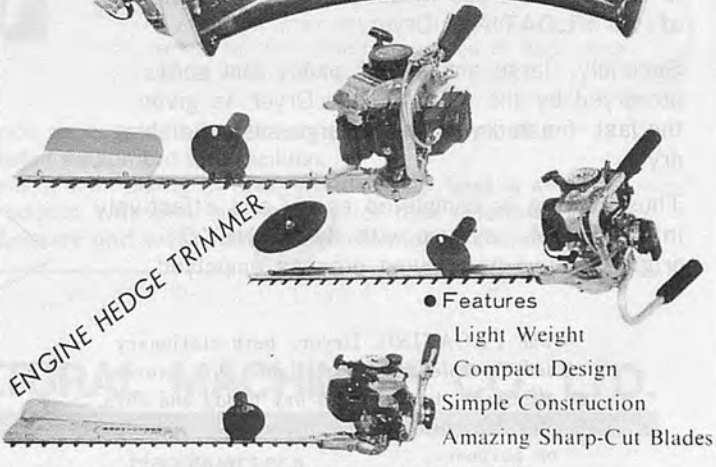
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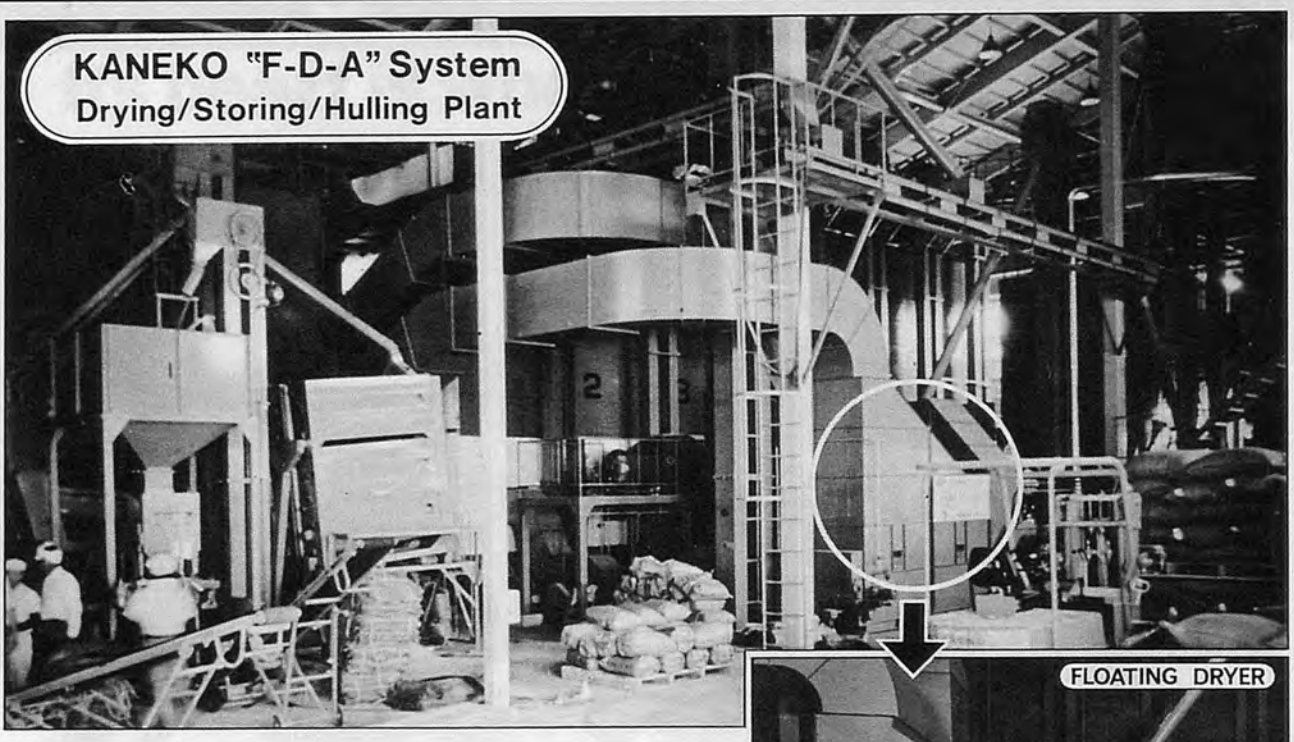
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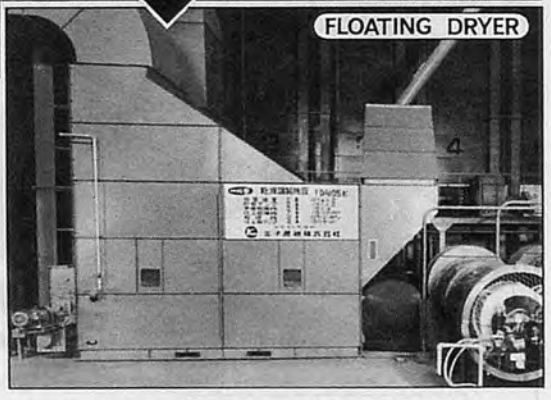
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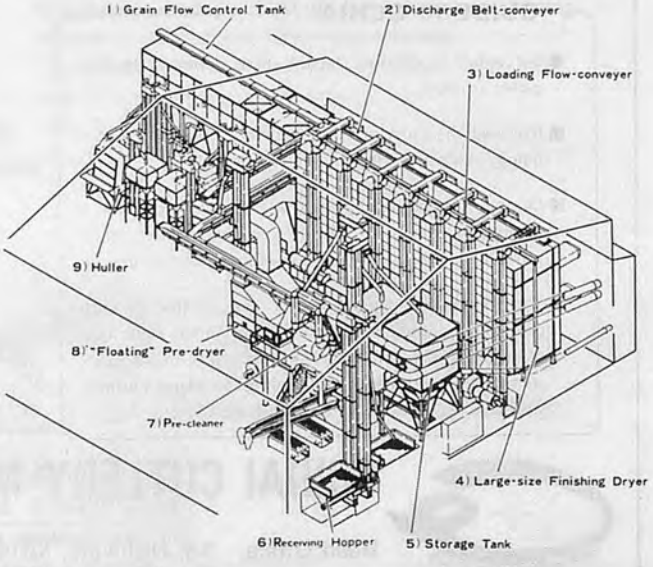
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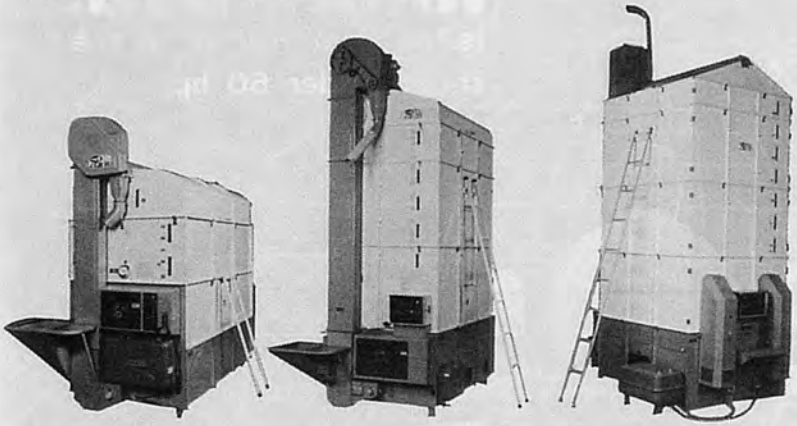
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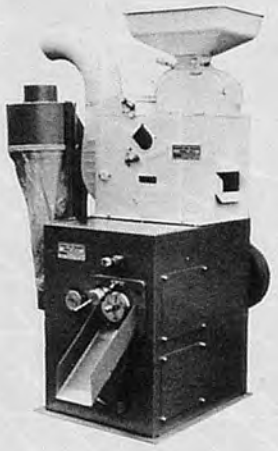


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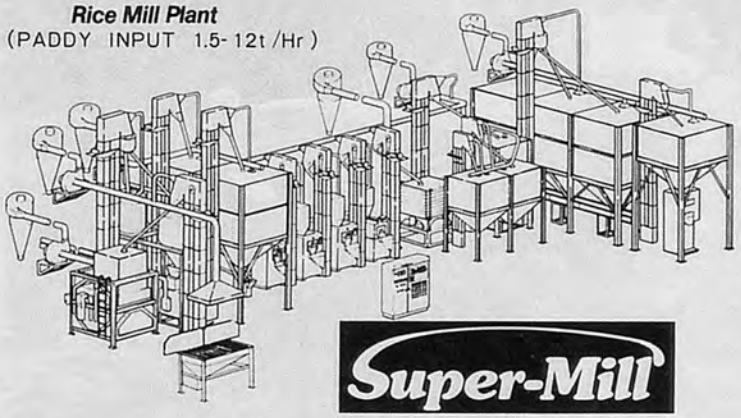


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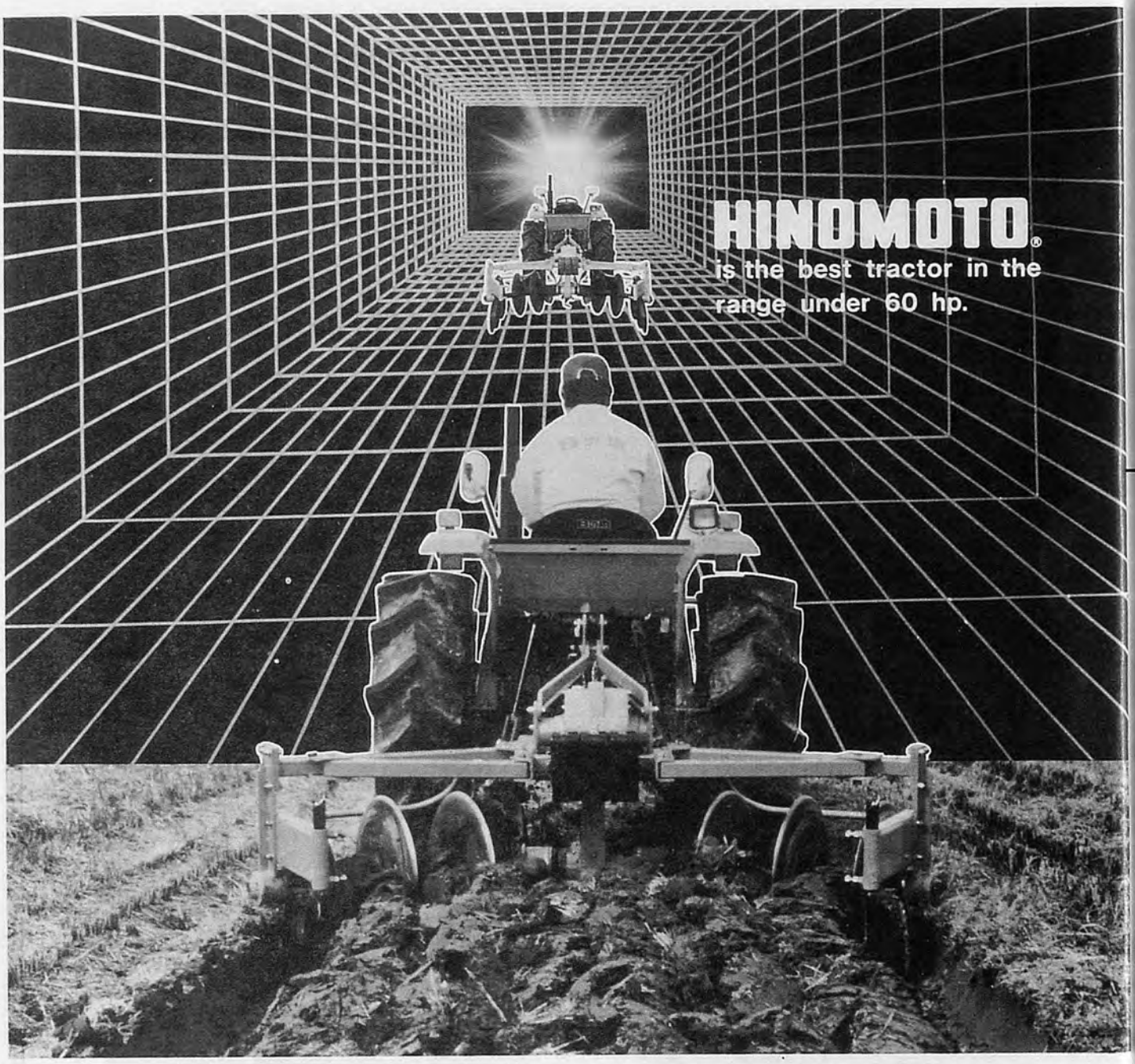
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This is the 42th issue since the issue, Spring of 1971

Editorial

1984 and Beyond

As we usher in the New Year, the AMA staff takes the opportunity to wish you all – our readers, contributors and co-editors, the very best that 1984 has in store for you. As a matter of fact, we wish you all continued success and happiness in 1984 and beyond.

In assessing the prospects that await us in 1984, it is useful to look back awhile and make the assessment in the light of the 1983 performance on a few randomly-selected indicators. For example, while East-West or North-South relations improved on a few minor issues, the relations are still generally cold, if not tense. For another, most news dispatches around the world forecast that business will be looking up in advanced, industrialized countries but not so in developing and underdeveloped countries. Other news dispatches see wealthy countries becoming wealthier and many poor countries not getting any wealthier. But for all these indicators, some schools of thought contend that never shall the twain meet because some countries are favored by Nature with adequate resources and many others are wanting.

Be that as it may. The AMA sees this dichotomy in a different light, i.e., wealthy countries need not become wealthier at the expense of other countries neither should they continue to be rich without lending a hand to the poor countries. Like many would say, the gap between the rich and poor countries can and should be narrowed down through a variety of ways. Outstanding among these is a strong and meaningful international cooperation on agricultural development as a lasting motive force to bring peace into the world. To be sure, it is imperative that agriculture be stabilized for the survival of mankind. While it is true that international cooperation has been tried in the past few decades with a lot of failures and a few successes, lessons could be learned from those experiences in continuing international cooperation efforts being the more logical approach to the agriculture development problems.

Another way of conceptualizing the East-West, North-South dichotomy is to see it as a differential between industrial and agricultural development efforts which in economically advanced countries one complements the other but not quite in backward countries. A case in point in this concept is that of the vital role of agricultural mechanization in countries where industrial and urban centers have absorbed farm labour, hence the need to produce farm products more efficiently and in great quantities. Necessarily, the manufacture of farm machines and the services that go with it join the stream of agro-industry development that all nations strive to attain – in 1984 and beyond.

Toward this end, the AMA stands committed to helping promote agricultural mechanization world-wide, relying, as in the years gone by, on the support and cooperation that its readers, contributors and co-editors continue to provide.

May you all have a prosperous NEW YEAR !

Yoshisuke Kishida
Chief Editor

January, 1984
Tokyo

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Direct Seeding with Coated Rice in Submerged Paddy Field (3)







by
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Abstract

The highlight of the DSSP system (Direct Seeding with Coated Rice in Submerged Paddy Field) were reported in Part 1. In part 2, the engineering contributions to the development of the DSSP system were focused on the description of the coating machine and the rice seeder fabricated for the DSSP use. The details of the coating chemical "Calper" were also discussed in Part 2.

This report (Part 3) provides key information necessary for the successful implementation of the DSSP system. Details of coating procedure, seeding operation, weed control, water management, and manure management practice are discussed. Examples of typical cultivation calender for DSSP practised in different prefectures in Japan are included in this report.

Introduction

The progress of stable rice cultivation technique has been achieved in Japan. The development of power rice transplanters and head-feed combines is one of the major contributions to the stabilization of Japan's rice production system. The conventional technique, however, cannot promise rice growers a sizable increase in profit in immediate future since the progress of the conventional technique has already reached its maturity. What is left for farmers is to expand their management scale and/or to adopt some other rice cultivation techniques which can give them an appreciable reduction of rice production cost.

The prospect of the DSSP is most promising among available alternative rice cultivation systems. The DSSP involves a minimum initial risk since it is a modification of the conventional transplanting type rice cultivation system although it is not just a simple substitution for the conventional transplanting procedure. The DSSPers must be aware of the alteration of rice crop growth pattern due to the difference in planting conditions of DSSP which does not have any negative influence on crop yield. Management practice and water control, however, should be rearranged to fit the growth pattern. Initial control of grass weeds which is not a problem in the conventional transplanting type system is an important procedure to protect the young seedlings.

There are other practical know-how and technicalities involved in the DSSP system presented in this report.

Implementation of DSSP

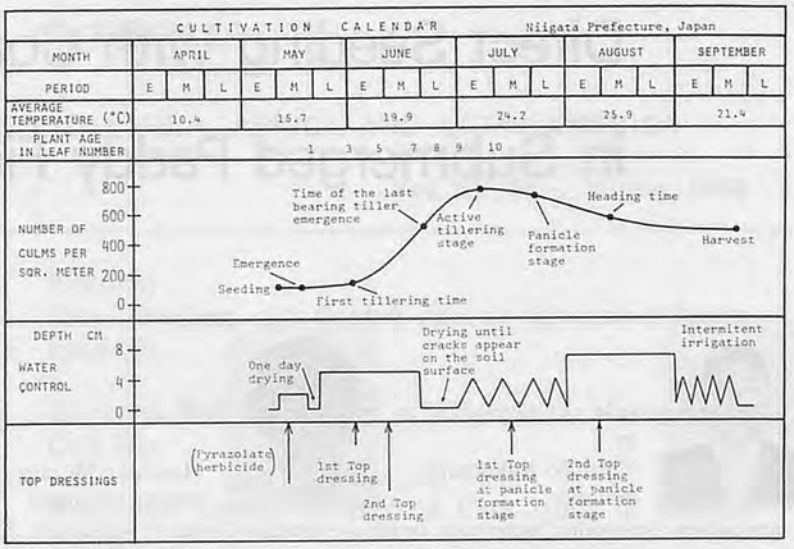
Rice Seed Preparation

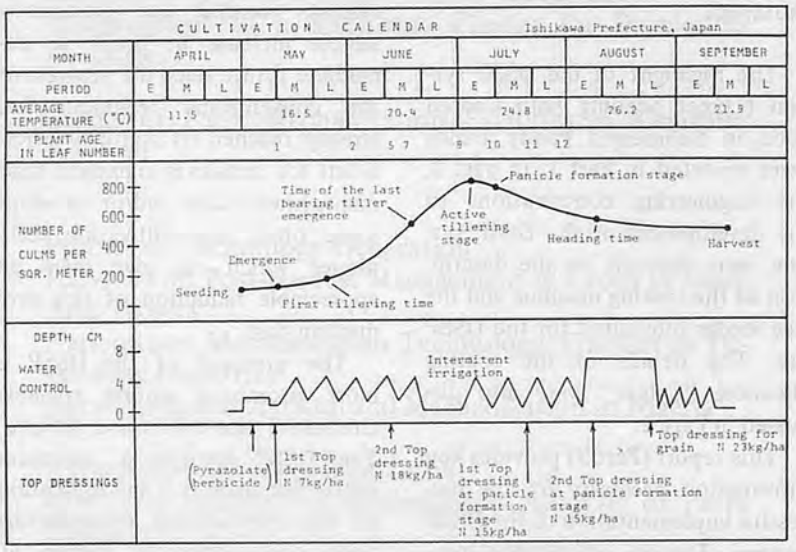
The reliability on high germination and emergence percentages of rice seeds is one of the vital requirements for the successful operation of the DSSP system. New seeds must be used for the DSSP. The quality of rice seeds can be inspected through selection by specific weight. The use of salt solution of which concentration is controlled to a desired specific weight is convenient and effective. Disqualified seeds whose specific weight is less than a set value float in the salt solution. The specific weight larger than 1.13 is recommended for the quality of rice seeds for DSSP use. Seeds must receive a fungicide treatment for which Captan can be used. The fungicide treatment eventually protects the paddy field from disease contamination. Seeds must be soaked in the water for 4 to 10 days. However, no pregermination is required.

Paddy Field Preparation

The paddy field preparation for

DSSP is basically no different from that of the conventional system. However, the following should be noted: i) The paddy field must be flattened and leveled thoroughly by puddling; and ii) The amount of fertilizer used for DSSP basal dressing is 20 to 40% less than that for the conventional system.





Coating Procedure

Rice seeds must be coated with Calper thoroughly, evenly and tightly. Calper is the oxygen source for seeds placed in the paddy soil. The seed coating can be performed manually with a little skill. However, the use of a coating machine is recommended for better application of the coating chemical. Seeds should not be soggy but moist when they are coated with Calper. To eliminate excessive water from water-soaked seed, the seeds must be placed in a net bag. The optimum amount of coating chemical is about the same for seeds to be sown at dry weight basis. The seeds should not be mixed with the Calper at once but should be applied gradually. The Calper absorbs water that sticks on the seed surface. Water needs to be sprayed onto the materials during the coating process from time to time. The coated seeds can be stored for 4 to 5 days without any harm. Storing coated seeds in a hermetic container such as plastic bag causes dissolution of coating chemical.

Seeding Operation

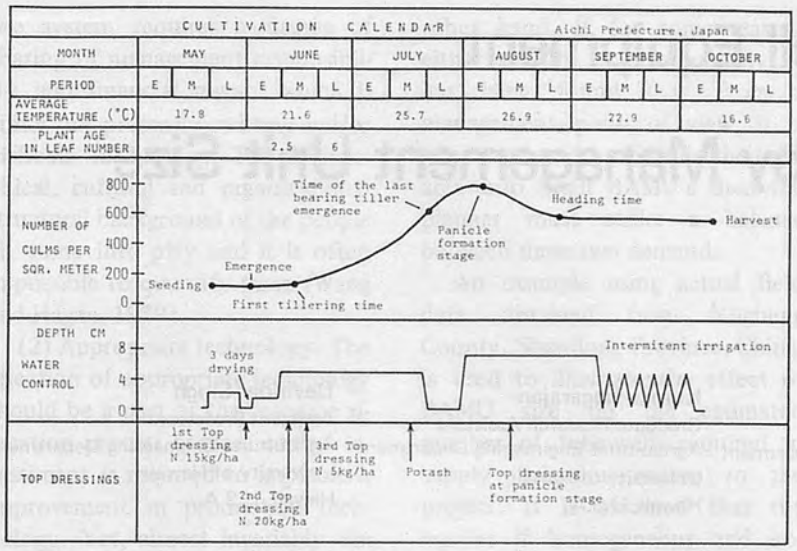
The seeding operation is the most critical procedure. The seeding depth should be kept fairly constant at an optimum depth of about 1 cm (± 5 mm). The seeding precision can be accomplished with use of a seeding machine designed specially for the DSSP use. The water in the paddy field must be drained prior to the seeding. The desirable condition of paddy soil is moist and soft like jelly. It should be made sure that Calper applied on the seed is dry when the coated seeds are put in use, otherwise the coating chemical would peel off before the seeds are planted. The DSSP requires 30 to 50 kg/ha of coated seeds for the best yield in Japan. Hill seeding results better yield than drilling. Less than 3 seeds shoud be placed in a hill or a density of 100 to 150 per square meter.

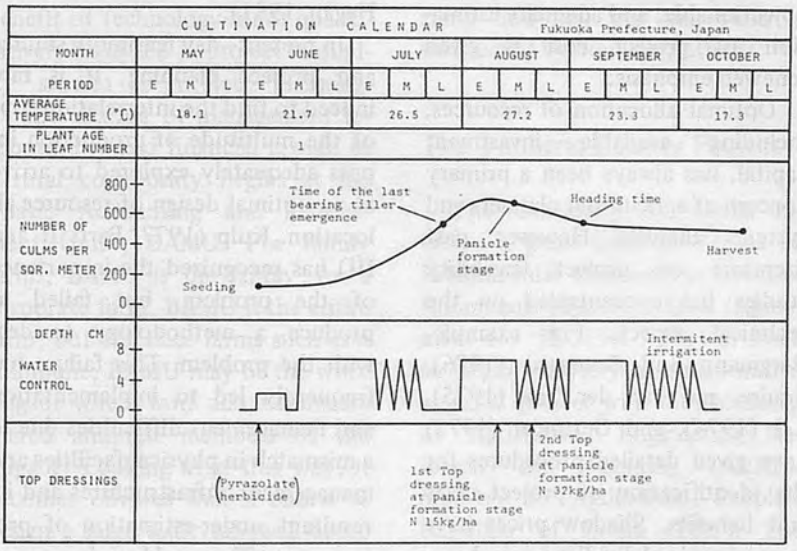
Weed Control

Rice seedlings growing in the paddy soil are highly susceptible to ordinary herbicides. A newly developed pyrazolate herbicide can be effectively and safely used for the initial control of grass weeds. In Japan, the pyrazolate herbicide is usually applied to the paddy field within 5 days after seeding.

Water Control

The paddy field must be submerged right after seeding. The initial water control affects directly the germination and emergence of sown seeds. The initial water depth should be no deeper than 5 cm. For well levelled fields, a water depth of 2 to 3 cm gives the best result. The field must be drained when 80% of the culms is established and should





allow to dry until cracks appear on the soil surface. The conventional water control technique may be applicable to most stage of the DSSP system.

Manure Management Practice

Nitrogenous fertilizer should be applied twice after the first tillering of the rice plant. The first N application is at the plant age in leaf number 1 to 2 and the second at the plant age in leaf number 5. Another nitrogenous fertilizer application is needed at panicle formation stage as practiced in the conventional system.

Cultivation Calendar

Many cultivation calendars for the DSSP operation fit for each specific local area are available. Those cultivation calendars have been established through trial operations of DSSP carried out in each local area. The following are examples of cultivation calendar actually used in Japan. Some of the examples are prepared by public agricultural organizations and some of them are made by DSSPers through their experiences. ■■

Irrigation Well Equipment as Affected by Management Unit Size



by
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Abstract

Allocation of investment capital is important in agricultural development planning. To achieve optimal allocation, the planner must evaluate the physical efficiencies of a proposed system and give adequate consideration to any implementation and management difficulties the proposed system may encounter. A key question in irrigation system implementation and management is management unit size. Existing social infrastructure must be considered in the structuring of irrigation management scheme. This paper shows the number of tube-wells required by a large system may well be related to the management scheme and must be considered in estimating investment requirement.

Introduction

In these days of tight budgets and high interest rates, project cost over-run has become increasingly objectionable, and adequate estimation of project cost is given renewed emphasis.

Optimal allocation of resources, including available investment capital, has always been a primary concern of agricultural planners and systems analysts. However, past literature on project feasibility studies has concentrated on the technical aspect. For example, Bergmann and Boussard (1976), Squire and van der Tak (1975), Lal (1974), and Gettinger (1972) have given detailed procedures for the identification of project costs and benefits. Shadow prices have been examined by Squire and van der Tak and others. Reutlinger (1970) and Pouliquen (1970), among others, have studied the elements of risk and uncertainty in project economic analysis. Generally, the economic analysis of an agricultural project begins with the assumption that an optimal production scheme, including crop mix, cropping schedule, and appropriate production technologies such as mechanization, is known to the planner. Furthermore, the appropriate infrastructure for project management is also assumed to be known, even though it is recognized that management organization of an agricultural production system must be influenced by existing social infrastructure (Wang and Hagan, 1981).

In present–day feasibility studies and project planning, it is rare indeed to find the interrelationships of the multitude of production inputs adequately explored to arrive at an optimal design of resource allocation. Kulp (1977, Parts II and III) has recognized the importance of the problem, but failed to produce a methodology to deal with the problem. This failure has frequently led to implementation and management difficulties due to a mismatch in physical facilities and management infrastructures and its resultant under-estimation of project cost. The problem has many faces, but in simple terms, one could readily recognize that one of the underlying difficulties is that physical considerations can be much more readily quantified than social considerations and in project analysis, especially project feasibility studies or project design, all analytical procedures require a substantial degree of quantification of data (Wang and Hagan, 1981).

The primary sources of influence of social considerations on agricultural project design come from:

(1) Project manageability: A physically efficient agricultural production system may be difficult to implement and manage if, in order to achieve physical efficiency,

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the system requires a degree of sharing of management responsibility and financial reward which is either not presently existing and/or difficult to develop. The philosophical, cultural and organizational structural background of the people all come into play and it is often impossible to quantify them (Wang and Hagan, 1979).

(2) Appropriate technology: The selection of appropriate technology should be a part of the resource allocation process because capital investiment is required to implement improvement in production technology. Yet, almost invariably the trade-off of the cost and the benefit of technology is not quantitatively analyzed in project feasibility studies or project planning.

The sharing of management responsibility and financial reward in a rural community begins at the "Basic Accounting and Management Unit", BAMU. For family farms, BAMU is the family; for a corporate farm, BAMU is the entire farm; but for state farms such as a commune, BAMU may be the work brigade where work and income are shared amongst members of the brigade. Looking at it this way, it becomes obvious that if one is to design a large scale tubewell based irrigated commune or other agricultural project then the size of the BAMU may have a serious bearing on the design of the irrigation system.

For example, if it is a 3 000 ha corporate farm then the entire farm is a single BAMU and the irrigation system design can be based almost entirely on physical factors, such as topography, ground water distribution, and water conveyance costs, etc. Within the limitation of physical constraints, it is obviously desirable to concentrate groundwater development in areas where unit investment can produce maximum return in ground water yield, and this desire must be balanced by water conveyance cost. On the other hand, if for some reason, either socially or economically, it has been found that, from a management point of view, it is advantageous to subdivide the total area into small BAMU's then the planner must strike a balance between these two demands.

An example using actual field data obtained from Yucheng County, Shandong Province, China, is used to illustrate the effect of BAMU size on the estimated number of tube-wells required to supply irrigation water to the project. It is assumed that the aquifer if homogeneous and isotropic and of uniform transmissivity and that the well yield is unaffected by boundary effects.

The Yucheng County Project

The University of Hawaii received a grant from the Office of International Cooperation and Development (OICD), USDA (Agreement No. 58-319R-1-298) in 1981 to begin a three-year collaborative research project with the Academy of Agricultural Engineering Research and Planning (AERP), Ministry of Agriculture, People's Republic of China (PRC). The primary objective of the project is to investigate methods and procedures in large scale agricultural production systems planning.

The Yucheng County in Shandong Province has been selected as the site for the collaborative research. The Yucheng County project is a part of the Northern China Plain Reclamation Project which covers nine counties in Henan, Shandong, and Anhui provinces. The PRC government has recently concluded a $60 million loan agreement with the World Bank to cover the foreign exchange portion of the project which amounts to approximately 1/3 of the project cost.

The Yucheng project area covers 475.3 km^2, of which 35 333 ha are potentially cultivable, but only 30 667 ha are being cultivated now. Within the county, 22 903 ha are affected by salinity of varying degrees.

The Yucheng County is located in the lower Yellow River alluvial plain. It is flat and sloping from southwest toward northeast with an average slope of 1/5000 and elevations varying from 21 to 26 m. Its rainfall varies from 600 to 750 mm per annum.

Irrigation water availability and the lack of drainage and flood control facilities are among the most important constraints that restricted agricultural production and prevented the realization of high yielding potentials of the land. Insufficient supply of fertilizers and shortage of working animals are some of the other production constraints.

To reclaim saline land and to insure adequate irrigation water supply, shallow wells, 40 to 60 m deep, must be developed. **Table 1** shows the distribution of outputs of existing wells in the county. There are a total of 3 651 wells in the county and the outputs vary from less than 30 m^3/h to over 100 m^3/h. The distributional pattern of well capacities also varies among the 19 communes. A total of 3 028 new wells are proposed. Whether or not the 3 028 wells will be able to adequately meet the irrigation requirement and how these wells should be distributed among the communes are two of the questions to be answered. Additionally, we would like to determine the effect of BAMU sizes on the number of wells required to meet the irrigation water demand.

Analysis

Table 1 shows the distribution of existing tube-well capacities in Yucheng County. The wells are classified into 5 categories: $<30\ m^3$

Table 1 Modified Distribution of Well Capacities with Computer Parameters, Yucheng County

	Commune	No. of Wells ηi	Frequencies f_{i_1}	f_{i_2}	f_{i_3}	f_{i_4}	f_{i_5}	Mean μ_i m³/h	Std. Dev. σ_i m³/h	$M_i=\frac{1}{\mu_i}$	$K_i=(\frac{\mu_i}{\sigma_i})^2$
1	Chengguan	172	2	59	109	1	1	56.2500	13.5414	0.0178	17
2	Shiliwang	91	9	61	21	0	0	43.2967	14.0480	0.0231	10
3	Ershilipu	102	1	18	63	18	2	65.3922	16.9550	0.0153	15
4	Shitun	362	2	60	275	10	15	63.1353	14.6868	0.0158	18
5	Ahren	310	2	30	277	0	1	62.4032	8.7552	0.0160	51
6	Lunchen	381	9	23	289	48	12	66.8766	15.3756	0.0150	19
7	Yuanying	143	0	2	141	0	0	64.6503	2.9468	0.0155	481
8	Juchen	303	75	17	161	48	2	55.4785	26.0352	0.0180	5
9	Litun	278	0	6	272	0	0	64.4604	3.6399	0.0155	314
10	Xinzhan	321	0	60	253	5	3	61.1371	11.4443	0.0164	29
11	Maguantun	200	67	96	37	0	0	36.2500	17.6777	0.0276	4
12	Fangshi	162	8	148	6	0	0	39.6913	7.3657	0.0252	29
13	Shanji	125	5	77	39	4	0	48.8000	15.2083	0.0207	10
14	Dacheng	180	48	122	10	0	0	34.7222	13.2100	0.0288	7
15	Zhangzhuang	128	8	101	19	0	0	42.1484	11.3235	0.0237	14
16	Liangzhuang	121	32	48	39	1	1	42.4380	20.6268	0.0236	4
17	Laifeng	41	7	20	14	0	0	44.2683	17.5913	0.0226	6
18	Xindian	154	9	80	65	0	0	49.0909	14.8022	0.0204	11
19	Zhangji	81	13	64	4	0	0	37.2222	11.1804	0.0269	11
	County	3651	288	1092	2099	135	37	54.9589	18.0842	0.0182	10
		m_j	15.0	40.0	65.0	90.0	110.0				

$\mu_i = (\frac{1}{\eta_i}) \sum_j m_j f_{ij}$ = mean value of well capacity for commune i, m³/h

$\sigma_i = \left(\frac{\sum_j m_j^2 f_{ij} - \eta_i u_i^2}{\eta_i - 1} \right)^{1/2}$ = standard deviation of well capacity for commune i, m³/h

η_i = number of wells in commune i

f_{ij} = frequency of wells (existing no. of wells) in commune i(=1,2 . . . 19), and well capacity class j(j=1. . .5 for well capacity< 30, 31–50, 51–80, 81–100, >100 m³/h, respectively)

m_j = mean value of the well capacity for class j, m³/h

M_i, K_i = Erland parameters for commune i; K_i is rounded to nearest integer value.

/h, 30-50 m³/h, 51-80 m³/h, 81-100 m³/h and >100 m³/h. Assuming that these 5 categories can be approximated by their mean values, 15 m³/h, 40 m³/h, 65 m³/h, 90 m³/h and 110 m³/h, the parameters of the well capacity distribution are computed. Yucheng County as a whole has an average well yield (μ) of close to 55 m³/h with a standard deviation (σ) of 18 m³/h. However, for individual communes the well yields varied widely from μ_{19} = 34.7 m³/h and σ_{19} = 13.2 for Zhangji Commune to μ_6 = 66.88 m³/h and σ_6 = 15.4 m³/h for Lunchen Commune.

Using Table 1, it was found that the data can be adequately represented by the Erlang Function. (Morse 1963, pp. 42-43).

$$Y = e^{-KM\chi} \sum_{n=0}^{K-1} (KM\chi)^n / n!$$

Where Y = Probability that $\bar{X} \geq \chi$

$$K = (\frac{\mu}{\sigma})^2$$

$$M = \frac{1}{\mu}$$

χ = Desired capacity, m³/h

χ = Acutal capacity of a single well, m³/h

Figs. 1 and 2 give visual verification that the Erlang Function can be used to approximate the probabilities that the capacity of a single well, $\bar{X}$, will exceed a certain value χ. Figs. 1 gives the Erlang Function plot for the entire country with $K_c = \mu_c/\sigma_c$ = 10 and $M_c = 1/\mu_c$ = 0.0182 and Fig. 2 represents the Chengguan Commune data with K_1 = 17 and M_1 = 0.0178. All individual commune data were plotted. Table 2 gives tabulated values for the Erlang Function K = 17 (Chengguan Commune) which shows the probabilities that the aggregated outputs from N wells will at least equal to $n\mu$, where μ is the estimated theoretical mean of well yield in m³/h in Chengguan Commune.

It has been estimated that an additional 165 540 m³/h will be needed to meet the peak irrigation water at the Yucheng County. In the county, agricultural production is managed under a four-tier structure, including the county, the commune, the production brigade, and the work team. It is therefore possible to manage water production and distribution considering the four levels of BAMU sizes, County-BAMU, Commune-BAMU, Brigade-BAMU, and Work Team-BAMU. Yucheng County has about 56 000 ha of cultivated area, the communes range from 1 400 to 4 500 ha in size, an average brigade has less than 100 ha, and work teams range from 10 to 20 ha in size.

We wish to estimate the effect of management structure, that is the BAMU sizes, on the number of additional wells that will be required to meet the peak irrigation water demand in Yucheng County.

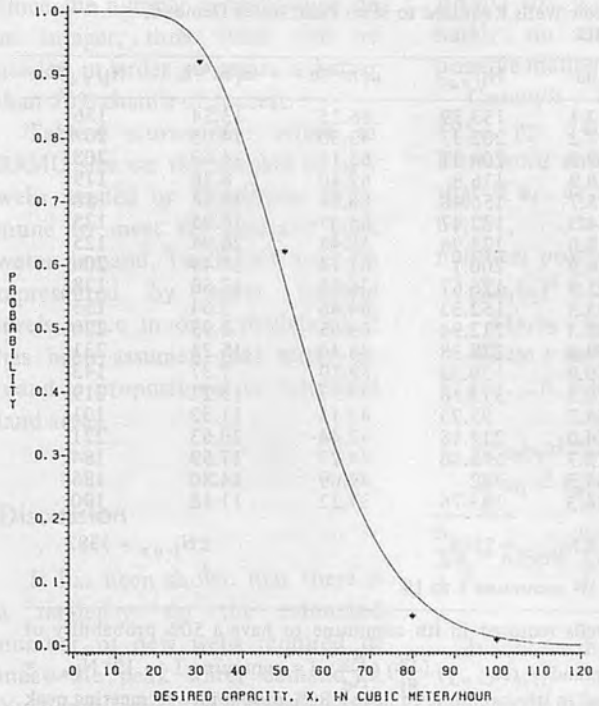


Fig. 1 Probability that actual well capacity, $\overline{X}$ will exceed a certain desired capacity, χ. Yucheng County K=10, M= 0.018195

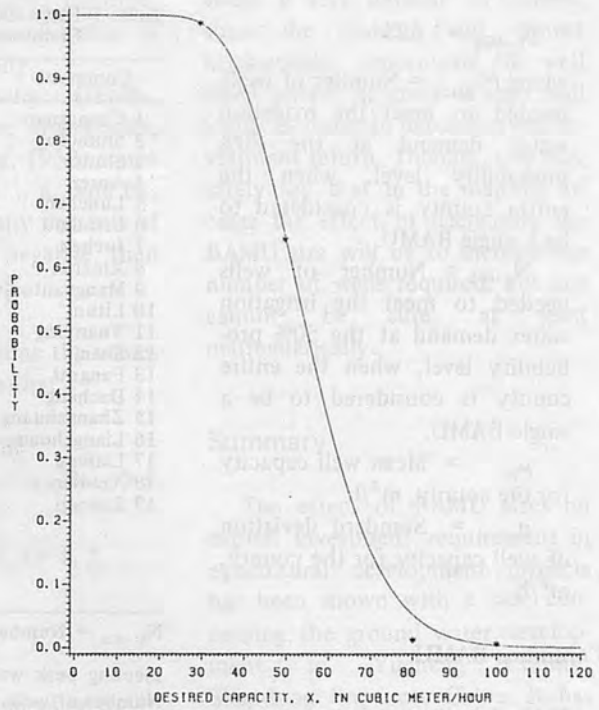


Fig. 2 Probability that actual capacity, $\overline{X}$ will exceed a certain desired capacity, χ. Chengguan Commune K=17, M= 0.017778

Table 2 Probability that Output from N Wells is at Least Equal to n x Mean, m^3/h

Individual Well Capacities are in an Erlang Distribution with k = 17

n =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
N																				
1	.4677	.0005																		
2	.9998	.4772	.0048																	
3	1.000	.9961	.4814	.0138																
4		1.000	.9869	.4839	.0255	.0001														
5			1.000	.9742	.4856	.0384	.0004													
6				.9999	.9602	.4868	.0515	.0010												
7				1.000	.9997	.9461	.4878	.0643	.0019											
8					1.000	.9992	.9324	.4886	.0764	.0032										
9						1.000	.9984	.9195	.4892	.0880	.0047									
10							1.000	.9972	.9072	.4898	.0988	.0066	.0002							
11								1.000	.9957	.8958	.4902	.1090	.0088	.0003						
12									.9999	.9938	.8852	.4907	.1186	.0112	.0004					
13									1.000	.9998	.9916	.8752	.4910	.1276	.0139	.0006				
14										1.000	.9998	.9891	.8659	.4913	.1360	.0167	.0009			
15											1.000	.9996	.9864	.8572	.4916	.1440	.0196	.0013		
16												1.000	.9994	.9835	.8491	.4919	.1515	.0227	.0017	
17													1.000	.9992	.9804	.8414	.4921	.1585	.0258	.0021
18														1.000	.9989	.9773	.8342	.4924	.1652	.0291
19															.9999	.9985	.9740	.8274	.4926	.1715
20															1.000	.9999	.9980	.9706	.8210	.4927
21																1.000	.9998	.9975	.9672	.8150
22																	1.000	.9998	.9969	.9637
23																		.9999	.9998	.9962
24																		.9999	.9999	.9997
25																		.9999	.9999	.9999
26																		.9999	.9999	.9999
27																		.9999	.9999	.9999

Country BAMU

Table 1 shows also that estimated mean value of an individual well yield in the country is μ_c = 54.96 m^3/h with a standard deviation of σ_c = 18.08 m^3/h. Since the total desired capacity, 165 540 m^3/h, is large as compared to the μ_c, the total number of new wells needed will be large. So, the sum of the yield of the new wells will tend to be normally distributed according to the central limit theorem.

Therefore,

$$N_{C,0.5} = \frac{165\,540}{54.96} \cong 3\,012$$

and $$\frac{(N_{C,0.8} - N_{C,0.5})\mu_C}{(\sqrt{N_{C,0.5}})\sigma_C} = 0.8418$$

$N_{c,0.8} = 3\,028$

where $N_{c,0.8}$ = Number of wells needed to meet the irrigation water demand at the 80% probability level, when the entire county is considered to be a single BAMU.

$N_{c,0.5}$ = Number of wells needed to meet the irrigation water demand at the 50% probability level, when the entire county is considered to be a single BAMU.

μ_c = Mean well capacity for the county, m^3/h

σ_c = Standard deviation of well capacity for the county, m^3/h

Table 3 Estimation of New Wells Required to Meet Peak Water Demand, Commune-BAMU

Commune	A_i ha	$N_{i,0.5}$	μ_i m^3/h	σ_i m^3/h	$N_{i,0.8}$*
1 Chengguan	2912.1	153.39	56.25	13.54	156
2 Shiliwang	2957.2	202.37	43.30	14.05	207
3 Shitun	4509.3	204.31	63.14	14.69	208
4 Anren	2488.9	116.8	62.40	8.76	119
5 Lunchen	3295.7	156.48	66.88	15.38	158
6 Ershilipu	2764.3	122.47	65.39	16.95	125
7 Juchen	2733.0	123.96	55.48	26.04	125
8 Xinzhai	3746.9	200.1	61.14	11.44	206
9 Manguantun	2755.9	126.67	36.25	17.68	128
10 Litun	3143.3	152.33	64.46	3.64	155
11 Yuanying	2605.3	212.94	64.65	2.95	220
12 Shanji	3059.4	228.38	48.40	15.21	231
13 Fangshi	2040.9	139.33	39.70	7.37	143
14 Dacheng	3670.3	313.18	34.72	13.21	319
15 Zhangzhuang	1364.7	95.93	42.15	11.32	101
16 Liangzhuang	3784.0	214.18	42.44	20.63	221
17 Liafeng	2672.7	178.88	44.27	17.59	184
18 Xindian	3034.3	182	49.09	14.80	186
19 Zhangji	2334.3	185.76	37.22	11.18	190
		$\sum_i N_{i,0.5} = 3318$			$\sum_i N_{i,0.8} = 3382$

i = commune 1 to 19

$N_{i,0.5}$ = Number of wells required in ith commune to have a 50% probability of meeting peak water demand = $(N_{c,0.5})\left(\frac{\mu_c}{\mu_i}\right)\left(\frac{A_i}{A_c}\right)$, i = commune 1 to 19; $N_{i,0.8}$ = Number of wells required in ith commune to have a 80% probability of meeting peak water demand; μ_i = Mean value of well capacity for ith commune; σ_i = Standard deviation of well acapacity for ith commune; A_i = Cultivated area, ith commune.
* Number rounded off to the next higher integer.

Commune-BAMU

Table 3 indicates that, considering each commune as a single BAMU and no sharing of water between communes, then 3 318 new wells will be needed in order to have a 50% probability that the outputs of the wells will be sufficient to meet the peak demand at each commune. If the probability level is raised to 80%, then 3 382 new wells will be needed.

Brigade-BAMU and Work Team-BAMU

Data on Chengguan Commune is used to show the effect of Brigade-BAMU and Work Team-BAMU on the number of wells required to meet the calculated peak water demands.

The calculated peak water demand for the Chengguan Commune is :

$$165\,540 \times \frac{2\,912.1}{55\,872.3} = 8\,628\ m^3/h$$

Table 4 shows that

$$N_{1,0.5} = \frac{8\,628}{56.25} = 153.39 \cong 154$$

and $N_{1,0.8} = 156$. In other words, if we consider Chengguan Commune as a single BAMU, and all well outputs are considered pooled together (aggregated) before distribution, and that adequate conveying distribution facilities are available to distribute the pooled water source, then there is a probability of 80% that 156 new wells can produce greater than or equal to 8 625 m^3/h.

If we are to reduce the BAMU to a size that will require 112.5 m^3/h to meet its peak water demand, since the μ for Chengguan Commune is 56.25 m^3/h, it follows that on the average two wells are required to meet the water demand.

The Chengguan Commune has a well capacity distribution function that can be approximated by an Erland function of μ = 56.25 m^3/h and K = 17. Therefore, using Table 2 we see that two wells give a probability of 47.72% of being able to supply the required 112.5 m^3/h, and three wells will have a probability of 99.61% of producing sufficient water to meet the demand.

Table 4 Effect of BAMU Sizes on Estimated New Wells Required to Meet Peak Water Demand, Chengguan Commune (μ = 56.25 m^3/h, σ = 13.5414 m^3/h, K=17)

Item	BAMU Sizes in terms of m^3/h	Average number of wells needed	Recommended number of wells	Estimated number of wells needed in the commune
Work team	2 x 56.25	2/(0.4772)*	3/(0.9961)	231
	3 x 56.25	3/(0.4814)	4/(0.9869)	206
	5 x 56.25	5/(0.4856)	6/(0.9602)	186
Brigade	10 x 56.25	10/(0.4902)	11/(0.8958)	170
	15 x 56.25	15/(0.4916)	16/(0.8491)	165
	20 x 56.25	20/(0.4927)	21/(0.8150)	162
Chengguar commune	8,628	154/(0.5)	156/(0.8)	156

*n/(P): P is the probability level that the sum of the outputs from n wells will be equal to or more than the m^3/h requirement shown in column 1.

Since the number of wells must be an integer, three wells will be needed in order to assure a better than 50% chance of success.

Table 4 shows the effect of BAMU size on the number of new wells needed by Chengguan Commune to meet the assumed peak water demand. The BAMU sizes are represented by water demand levels, since in our calculations it has been assumed that water demand is proportional to cultivated land areas.

Discussion

It has been shown that there is a tendency for the estimated number of new wells required to meet the peak water demand in Yucheng County to increase when the BAMU size is being reduced.

The Chinese agricultural production management policy is changing. Under the "Individual Farm Responsibility" system, increasing emphases are being placed on giving the individual farm family more responsibility and autonomy in the management of its own production under the general guidance of production quotas and prices. This trend clearly enhances the desirability of small BAMU sizes since the extent to which an individual farmer can influence management decision is somewhat inversely proportional to BAMU sizes.

From an economic point of view, in this particular exercise, small BAMU sizes reduce water conveyance losses and water conveyance facility cost, but at the cost of increasing capital investment for new well development.

These factors must all be taken into consideration in order to arrive at an optimal design.

At this time, one may well ask if the above result can be generalized. For example, can one not say that the number of wells required will always increase when the BAMU size is decreased? Unfortunately, no such generalization is possible mathematically.

Cauchy's Inequality (Hardy, 1952, pp. 34-35; see also Hardy, Littleword and Polya, 1952) states that if $a_1, a_2, a_3, \ldots, a_n$ and $b_1, b_2, b_3, \ldots, b_n$ are any two sets of numbers positive or negative, then

$$(\Sigma a_r b_r)^2 = \Sigma a_r^2 \Sigma b_s^2 - \Sigma(a_r b_s - a_s b_r)^2$$

Where r and s assume the values $1, 2, \ldots, n$, it follows that

$$(\Sigma a_r b_r)^2 \leqq \Sigma a_r^2 \Sigma b_r^2$$

If $a_n \geq a_{n-1} \geq \ldots a_2 \geq a_1 > 1$,

$\sum_1^n a_i = n\bar{a}$ and $\sum_1^n b_i = n\bar{b}$, $i = 1, 2, \ldots, n$.

It follows that

(1) $\sum_1^n \frac{b_i}{a_i}$ is maximum when $b_1 = n\bar{b}$ and $b_2 = b_3 = \ldots = b_n = 0$

(2) $\sum_1^n \frac{b_i}{a_i}$ is minimum when $b_n = n\bar{b}$ and $b_1 = b_2 = \ldots = b_{n-1} = 0$

(3) $\frac{n\bar{b}}{\bar{a}} \leq \sum_1^n \frac{\bar{b}}{a_i}$ when $b_1 = b_2 = \ldots = b_n = \bar{b}$ and $\Sigma(\bar{b} - b_i)^3 = 0$

(4) $\sum_1^n a_i = n\frac{\bar{b}}{a}$ when $\frac{b_i}{a_i}$ = constant

Let b_i be the peak water demand for the ith BAMU and a_i be the mean well output for the ith BAMU then the total number of wells needed can vary from $\frac{n\bar{b}}{\bar{a}_n}$ to $\frac{n\bar{b}}{a_1}$, and $\frac{n\bar{b}}{a_n} < \frac{n\bar{b}}{\bar{a}} < \frac{n\bar{b}}{a_1}$, where $\frac{n\bar{b}}{\bar{a}}$ is the number of wells needed at the 50% probability level when the entire area is taken as a single BAMU. Therefore, it is conceivable that the number of wells may actually decrease while the BAMU size is reduced.

However, in actual practice the above is very unlikely to happen, since the designer will, almost instinctively, concentrate the well development in areas of high well yields in order to maximize well investment return. Thereby, one may safely say that in the majority of cases the effect of decreasing the BAMU size will be to increase the number of wells required, but one cannot be sure, at least mathematically.

Summary

The effect of BAMU sizes on capital investment requirement in agricultural development projects has been shown with a case concerning the ground water development in Yucheng County, Shandong Province, China. It has been shown that the number of new wells needed to meet the assumption that ground water developed within the BAMU will be shared, but there is no sharing between BAMU's.

Several levels of BAMU sizes were tested: the county as a whole, the commune, and a range of sizes that covers work teams to brigades.

The basic data availability was rather limited but the procedure used is quite general and can be used to evaluate other similar cases.

Because of the relatively large number of wells, the sum of the well capacities for the county and commune are assumed to be normally distributed. At the lower level, they are assumed to be Erlang functions.

It has been estimated that for the county-BAMU an addition of 3 028 new wells will allow the county to have 80% probability of meeting its agricultural peak water demand. For the commune-BAMU, it was estimated that 3 382 additional wells will be needed for the same purpose. This is a possible increase of 11 to 12%. For the commune-BAMU case at the 80% probability

level, it was found that 156 new wells will be needed by the Chengguan Commune. When BAMU was reduced to 20-well size, which is approximately the brigade size, the well requirement was found to be 162, an increase of 4%. When the BAMU size was reduced to 5-well size, which is approximately the work team size, the estimated well requirement was found to increase to 186, an increase of 19%.

These are significant increases in capital investment required for the well development and since the initiation of the "Individual Farm Responsibility" system in China, there is a strong and consistent movement toward small BAMU sizes and there is a strong indication that sociologically the preferred water management unit may be the Work Team-BAMU. If it is so, there is a possibility that higher investment in tube-well development may be required.

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Renewable Energy Sources: A Case Study in Kenyan Village



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Abstract

Developing countries have a primary need to develop farming at least to achieve food self-sufficiency and raise the standard of living of the rural population (which accounts for roughly 60% of the total) and improve the locally existing conditions. This approach calls for an increase in energy consumption.

Because of the socio-economic and energy conditions prevailing in the emerging countries and of the geographical scattering of their populations, locally available renewable energy sources to be utilized within a short-bound circuit appear to be the most suitable technically and economically to meet regional household and production requirements. The various renewable energy exploitation technologies are examined in terms of their consistency with the demand curves of the agricultural world, so that their utilization has to be envisaged as integrated energy systems, to be modularly implemented and economically applied to wide areas having similar climatic and agricultural conditions. At the end of the report, an example referring to a small village in Kenya is shown.

Agriculture and Energy in Developing Countries

From 40% (in Latin America) to 80% (in Africa and Asia) of the population of the developing countries are scattered over wide rural areas. Most of them barely survive; they busy themselves with farming or animal husbandry, the greater part of this production being used for their own alimentary needs. Yet, agriculture accounts for between 25 and as much as 60% of the G.D.P. of these countries.

Crop yield is mostly very poor because of unsuitable agronomic cycles and lack of chemical or biological fertilizers, insufficient irrigation and mechanization. Furthermore, lack of adequate post-harvest and storage facilities causes high product losses (up to 30%), thereby reducing the availability of food and industrial goods. The consequence for these countries is a gradually worsening standard of living.

The rural populations of the D.C. for the greater part live in small communities, according to age-old patterns at corresponding cultural levels and in a closed economy, away from food or conventional supply sources. In the last 50-20 years, both population growth and the lure of a higher standard of living caused the young to move into the towns, creating severe social and economic problems.

Hence, as set forth in the 4-5 years economic development programmes of almost every emerging country, there is a primary need to:

- Accelerate the development of agriculture as a stability factor by operating on the existing territorial and social background and giving priority to basic food crops for local consumption;
- Improve rural living conditions by fostering the growth of suitable crafts or cottage industries linked (upstream and/or downstream) with agricultural production;
- Operate on the actual "fragile" situation as is, without endeavouring to bring about revolutionary changes which would not be consistent with the social and cultural background of the populations.

At present, the demand for conventional energy in the D.C. is very low. World Bank data show that in 1980, against a worldwide consumption of 6 800 million t, these countries accounted for a mere 12% (816 million t), but also for some 73% of the world's population.

Moreover, the urban populations, which average less than 30%

of total, have the lion's share in this consumption. An approximate evaluation indicate that the rural populations only account for 20% of conventional energy demand; this means that more than 1 900 million people use a mere 150 million t yearly. This population exceeds by 65% the total of the developed countries, while per capita consumption is less than 2% of that of an inhabitant of the industrial countries.

The picture changes however when taking into account the consumption of renewable energy, specifically biomass energy, and chiefly wood energy. FAO estimates that this accounts for 170 million t/year. Therefore, since this consumption is essentially concentrated in the rural regions, the populations of such regions burn some 320 million t/year in total or 0.17 t/year per inhabitant, 53% coming from renewable sources.

If the above two facets are interrelated, it immediately appears that the major problem facing the developing countries is how to develop their agricultural-rural system while meeting the system's future energy demand. This calls for massive utilization of renewable energy of direct or indirect solar origin or from biomass conversion with suitably simple, efficient, reliable, modular, low cost technologies. Such technologies should make available, as far as possible, integrated, self-sufficient energy systems to be operated within limited boundaries and capable of meeting the specific present and future "professional" and "household" needs, in relationship with the improved standard of living due to the development of local farming crafts and cottage industries.

This viewpoint is especially significant when considering that, still according to the World Bank, the conventional energy demand of the emerging countries in 1990 will be 1.8 times that of 1980. However, to achieve the rural energy demand of the rural populations should be at least three times the current value. Thus, by that time demand is expected to attain some 1 100 million t/year, and renewable sources should and could supply upwards of 85% thereof. This will allow developing local agriculture while improving socio-economic conditions of the affected populations.

Role of Renewable Energy

Implementing this programme calls for well defined strategies and therefore, consistent research, production, promotion and diffusion.

Hence, the need to define a basic "philosophy" for the application of renewable energy in the agricultural-rural system of the D.C. and to assess the feasibility of diffusing these technologies in different situations, in terms or simple, standardized solutions suitable for low-cost manufacture and installation, by exploiting the scale economies obtained by mass production.

- As concerns the first item, recent experience proved that:
- The energy demand curves of the agricultural-rural world are extremely variable in time and by type of userpoint;
- Most renewable energy technologies show a low degree of energy output elasticity **(Tables 1,2)**;
- Energy from renewable sources (of direct or indirect solar origin, or by biomass conversion), having low concentration, are best exploited in a short-bound circuit, i.e., within the immediate area where such resources are produced.

As a consequence, such technologies should be designed for small userpoints (of the order of a few to a few tens of kW each). Actually, the average energy load per inhabitant can be assumed between 1.5–2 and 5 kW, roughly broken down as follows:

- One-third for stationary heat (household, farming and industrial) userpoints;
- One-third for stationary electricity userpoints; and
- One-third for movable userpoints for agricultural mechanization.

With this assumption, taking into account the geographical scattering of rural populations and of a base group of 100 people, it seems that the ideal unit should be rated 30 to 50 kW for stationary users and 3 to 20 kW for the simple farming machines needed by local agriculture.

Costs could be kept at a minimum because of the short distance covered by the raw materials and generated energy and by possible mass production of standard equipment which would lend maximum reliability and elasticity to the system and cut maintenance.

Since, as mentioned before, the performance of certain individual sources of renewable energy is hardly consistent with the user' needs, fullfilling the energy demand of the agro-forestry-food system and of the minor rural world by a single source becomes difficult. A source having low operating elasticity would require overdimensioning and/or large storage facilities to meet the peak demand, and these technologies would certainly be priced above any economic competitiveness. Other sources, although having high operating flexibility, would have to cover too large an area to meet the energy demand of a given village and would therefore also become uneconomical. Hence the need for a solution based on a suitable combination of renewable sources, depending on their specific characteristics: integrated energy systems.

Table 1 Technologies for Use of External Renewable Energies to Meet Stationary Energy Requirements of Agricultural and Rural System

Input	Technology	Output	Running elasticity	Storage requirements	Level of knowledge	Size of plants	Competitiveness
Sun	flat plato coll.	heat	L	H	O	S	+
	concen. coll.	heat	L	H	O	S	+
		electr.	L	H	NR	S	–
	photovolt.	electr.	L	H	O	S	–+
		heat	L	H	NR	S	–+
Wind	rotors	heat	L	M	O	S	+
		mech.en.	L	M	O	S	+
		electr.	L	H	NR	S	–
Micro-hydraulic	turbines	mech.en.	H	L	O	S	+
		electr.	H	L	O	S	+
Geothermic	–	heat	M	L	O	B	+–
		electr.	M	L	O	B	+–

Legend: H = High; M = Medium; L = Low; O = Operational; NR = Need refinement; S = Small; B = Big

Table 2 Technologies for Use of Biomass to Meet Energy Requirements of Agricultural and Rural System

Effluents value	Process	Output	End uses	Running elasticity	Storage requirements	Level of knowledge	Size of plants	Competitiveness
L	combustion	heat	ST	H	L	O	S	+
		mech.en.	ST	H	L	O	S	–
		electr.	ST	H	L	O	S	–
L/M	gasification	heat	ST	H	L	O	S	+
		mech.en.	ST/MO	H	L	O	S	+–
		electr.	ST	H	L	O	S	+–
L/M	Pyrolysis	heat	ST	M	M	NR	B	–
		mech.en.	ST	M	M	NR	B	–
		electr.	ST	M	M	NR	B	–
H	anaerob. ferm.	heat	ST	L	H	O	S	+
		mech.en.	ST	L	H	O	S	+–
		electr.	ST	L	H	O	S	+–
H	alcoholic ferm.	mech.en.	MO	M/L	L	NR	B	–
		electr.	ST	M/L	L	NR	B	–
		chemic.	ST	M/L	L	NR	B	–

L = Legend; ST = Stationary equipment; MO = Mobile equip.; H = High; M = Medium; L = Low; O = Operational; NR = Need refinement; S = Small; B = Big

An Integrated System in a Kenya Village

On the basis of the above considerations, a study* was carried out in 1981 on a typical rural village in Kenya, lying some 100 km southeast of Nairobi, approx. 1 600 m., on intensively farmed, hilly, prevailingly slimy ground.

The village counts 3 families consisting of 35 people who draw their livelihood from the surrounding farmland and some livestock (**Fig.s. 1 and 2**). The terraced farm covers some 20 ha on sloped ground, with a max slope of 10%; the crop pattern is: pastureland, 6.7 ha; maize, 4.6 ha; pigeon peas, 3.6 ha; mixed maize-pigeon peas, 3.7 ha; mixed beans and coffee, 0.6 ha. Cultivation practices are very scanty and carried out manually or with animal drawn implements. The crops are rain-fed.

Production is not sufficient for the alimentary needs of the resident population. The extremely rudimentary storage facilities are small, raised granaries; losses amount to 12–15%.

* Pellizzi G., Bodria L., Sangiorgi F., De Poli F., Bartolelli M., Bartolelli V., Zancocchia C.: Sviluppo agricolo e uso delle energie rinnovabili in villaggi rurali tipo della Repubblica del Kenia – PENAGRI-CNEN Report, Rome, July, 1981

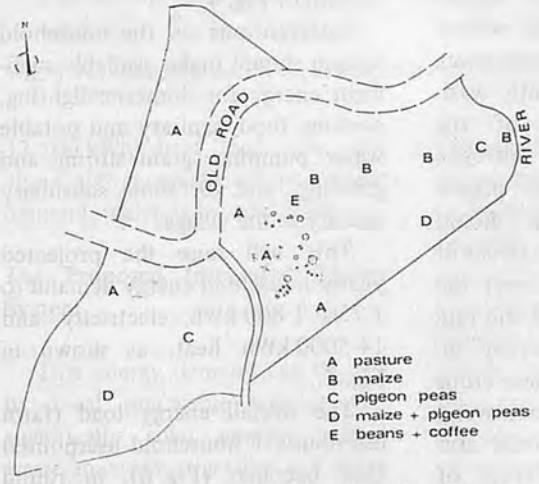


Fig. 1 Plan and cropping pattern of the village's farm.

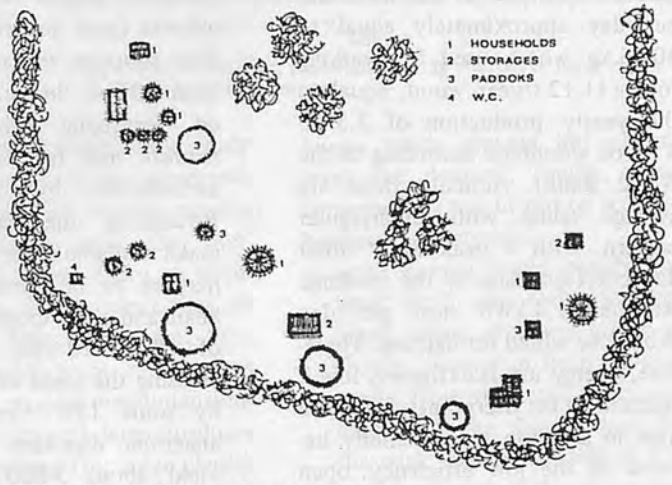


Fig. 2 Plan of the considered village.

Livestock is 35 head of cattle of which 6 milking cows and few goats and poultry. Cattle is traditionally pasture-fed and restricted to paddocks at night (some 15 daily). Thus, manure partly pile up and are then spread over the fields twice a year, in February and August, before the rains. Protected storage causes the excreta's fertilizing power to drop by more than 70%.

Besides farming practices and animal husbandry, the village's activities are limited to wood gathering and cooking food. The fare is mainly a mixture of maize grains, beans and pigeon peas boiled for some 3 over an open wood fire. Cooking is done every other day. The diet is supplemented by milk, a few eggs and meat from the livestock.

Yearly the village buys 900-1 000 kg of maize grains and as many beans (some 30% of internal production), as well as sugar and salt for their direct alimentary needs. Water for livestock and the household comes from rain water ditches and/or shallow wells dug at some 1 m depth in the bed of a stream running at farm boundary. Lighting is by paraffin lamps.

Present Energy Demand

The village's current energy demand, human and animal work excluded, is assessed at 110 kWh heat per day approximately equal to 30-35 kg wood, used for cooking food (11-12 t/year wood, equal to the yearly production of 3.5 to 4 ha of woodland according to the World Bank). Actually these are average values with an irregular pattern, with a peak every other day corresponding to the cooking. Another 1.4 kWh heat per day should be added for lighting. Therefore, energy use is extremely low if referred to the userpoints, but quite high in absolute terms, chiefly because of the low efficiency, open fire cooking process and because the foodstuff is not previously milled (Fig. 3).

System Improvement Intervention

The analysis outlined above showed certain simple interventions to be feasible:

- Improving existing agricultural and animal production, cutting losses and raising yield to attain food self-sufficiency and have a marketable surplus;
- Improving the standard of living of the population while reducing the present consumption of wood.

Interventions on the farming system concern:

- Introducing suitable pastureland exploitation techniques by multishift, intensive methods on restricted area, storing part of the forage grown during the two rainy seasons for later use during droughts. These two operations will raise the available nutritive value by 30% with a corresponding higher meat and milk yield while more manure will be available since the cattle will be restricted for a longer time during the dry season but will require some 17 000 kWh heat and 1 700 kWh electricity per year;
- Installing suitable recovery and anaerobic digestion facilities to produce biogas from animal excreta (and household waste). This solution will recover more than 70% of the currently wasted fertilizing value of the manure and facilitate nitrogen assimilation by the plants. Restricting the cattle should make available some 90 t/year of manure to be spread over the bean and grain crops at the rate of 15 to 20 t/ha, thereby increasing the yield of these crops by some 15%. Conservatively, anaerobic digestion should also yield about 3 000 m^3/year of biogas;

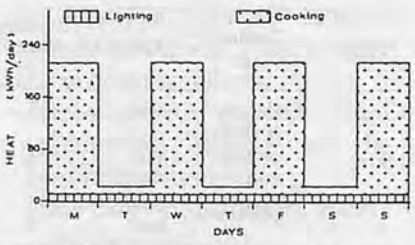


Fig. 3 Present energy consumption curves of the village.

- Adopting simple irrigation techniques for the bean and grain crops (4 ha) and consequently increasing the yield, by digging a pond of 8 000 m^3/year capacity on the farm premises. This solution would increase the yield of the irrigated land by some 40%. Pumping water requires between 2 350-2 400 kWh/year;
- Recovering maize and bean crop byproducts, to supplement cattle and goat fodder;
- Drying beans and maize, thereby cutting the losses by some 15%, with a further energy outlay of 1 800 kWh heat and 180 kWh electricity per year.

By implementing these suggestions, self-sufficiency should be attained and about 1.7 t/year of biogas should be available from anaerobic digestion.

Total energy demand for production only would, however, attain 4 250 kWh electricity and 19 000 kWh heat, with the demand pattern of Fig. 4.

Interventions on the household system should make available sufficient energy for domestic lighting, cooking food, sanitary and potable water pumping, grain storing and grinding, and for some subsidiary activity in the village.

This will raise the projected yearly household energy demand to 1 750–1 800 kWh electricity and 14 5000 kWh heat, as shown in Fig. 5.

The overall energy load (farm userpoints + household userpoints) thus becomes (Fig. 6), in round figures, 6 000 kWh electricity and

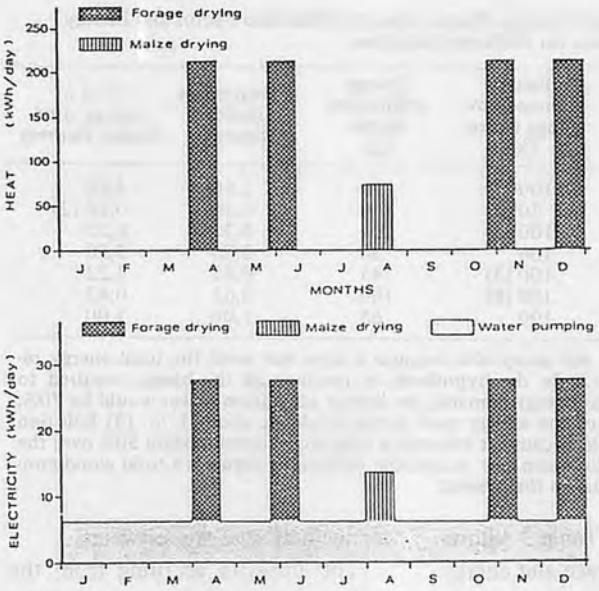


Fig. 4 Foreseen energy consumption curves for agricultural production.

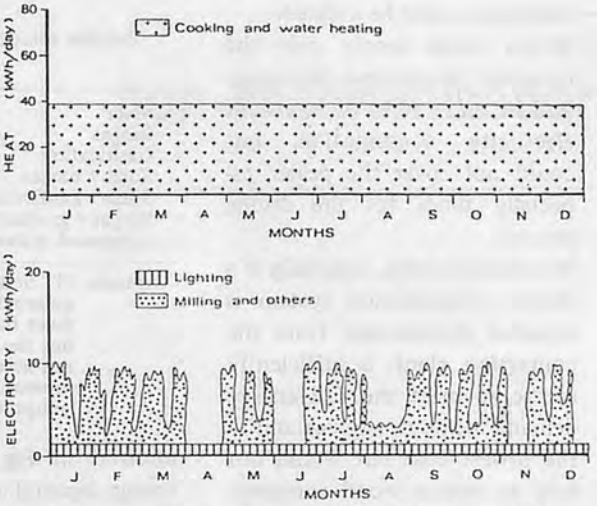


Fig. 5 Foreseen energy consumption curves for household requirements.

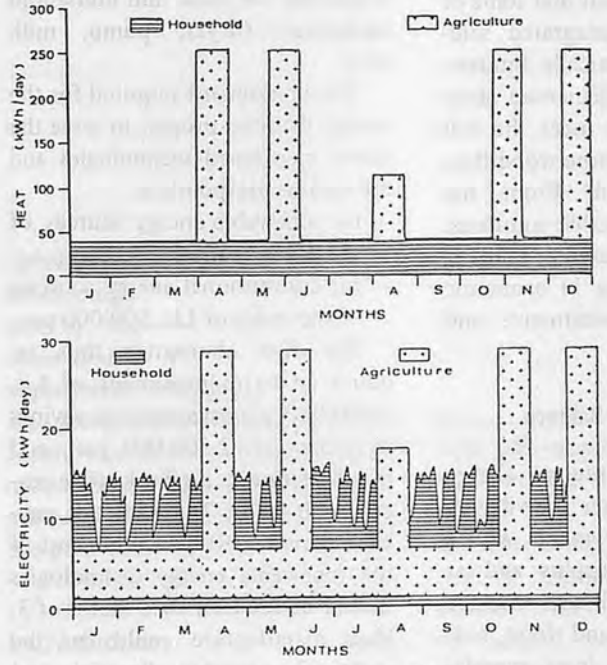


Fig. 6 Foreseen total energy requirements for the village and farm.

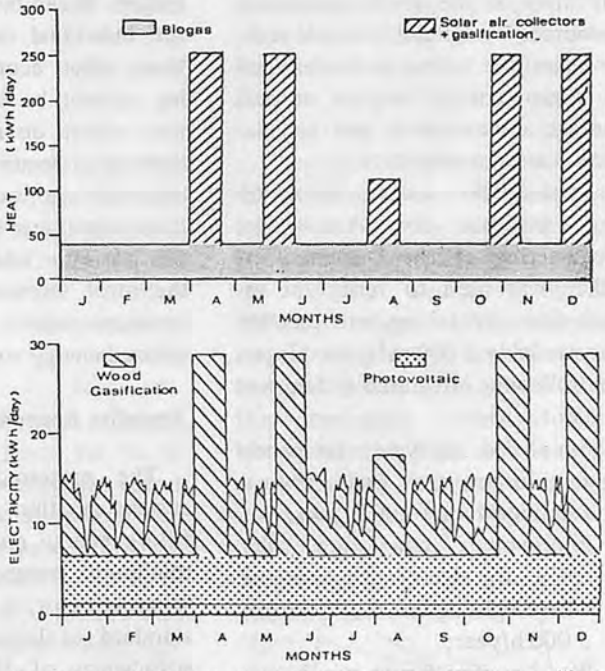


Fig. 7 Use of different renewable energy sources to meet village and farm requirements.

33 500 kWh heat per year, for about 40% increase over the present demand, which is for heat only.

The Proposed Integrated Energy System

This energy demand can be met by local renewable sources and specifically solar energy, animal waste anaerobic digestion and wood combustion and/or gasification. The region is not sufficiently windy for aeolian energy to be considered.

Because of the widely varying demand pattern and the concurrent need to cut down on wood consumption, it is evident that, as mentioned before, meeting the global demand from one source only would require overdimensioning the facilities with large surpluses of unused energy (for solar plants) and a significant storage system; biogas needs storage but cannot meet the demand; finally, wood consumption would not be reduced because the facts are:

- Solar energy could satisfy the total heat and electricity demand, albeit at a very high cost chiefly because of food cooking needs. However, since the equipment is to be dimensioned for the peak loads, only 27% of output heat and 55% of output

electricity could be utilized;
- Biogas could supply only the constant (permanent) heat user-points and 10% of constant electricity consumption, but could not cover the peaks, especially those for the drying process;
- Wood gasification, especially if a simple co-generation system is installed downstream from the conversion plant, is sufficiently elastic to meet the full energy demand without wastage and at the lowest cost but would not help to reduce wood consumption.

The only way out, therefore, is the integration of two or possibly all three of the above mentioned resources, by suitable low cost technologies; the system to be designed to keep energy surplus output, storage requirements and installation costs at a minimum.

A simulation program set up by the Institute for Agricultural Engineering of the University of Milan was used to verify the assumption. By taking into account the available 3 000 m^3/year biogas, the following integrated system was laid out:
- Simplified, air-type solar panels for forage and grain drying, running about 1 200 h/year;
- Photovoltaic conversion solar energy for electrified fences and village lighting, running for some 3 000 h/year;
- Wood gasification to supply mechanical energy for forage and grain ventilation and engine waste heat recovery to operate the dryers during the night without solar energy storage, and to drive the grinding mill and other equipment, for 3 000 h/year total;
- Biogas energy for cooking food (about 1.2 t/year) and sanitary hot water (0.1 t/year), these being steady demands the year over.

The above is graphically summarized in Fig. 7. Table 3 shows energy demand coverage and energy output utilization for the various possible solutions and gives investment and utilized energy cost indices. It can be seen that some of the individual or integrated solutions, albeit economically interesting, cannot be implemented since they either do not meet the full demand or require more wood than currently consumed. From the three remaining possible solutions, the last (the integrated system) is the most interesting in economic terms as regards investments and utilized energy cost.

Table 3 Energy Demand Coverage Factor, Energy Utilization Factor and Energy Used Cost Factor for Different Solutions

Possible solutions	Energy demand coverage factor (%)	Energy utilization factor (%)	Investments (index figures)	Cost of energy used (index figures)
Solar	100	36	2,50	4,50
Biogas	20 (1)	100	0,16	0,10 (2)
Gasification	100 (3)	100	0,35	0,23
Solar + biogas	100	38	2,05	3,50
Solar + gasification	100 (4)	45	0,85	1,23
Biogas + gasification	100 (4)	100	0,65	0,42
Integrated system	100	65	1,00	1,00

Remarks: (1) Solution not acceptable because it does not meet the total energy requirements. (2) In the hypothesis to produce all the biogas required to meet the total energy demand, the energy utilization factor would be 70%, but the cost of the energy used factor would be about 1.75. (3) Solution not acceptable because it requests a total wood consumption 50% over the present. (4) Solution not acceptable because it requests a total wood consumption equal to the present.

Tentative Economic Balance

The suggested integral energy system can thus cover the village's future energy requirements with a minimum energy surplus and at minimum cost; it will also raise the standard of living and food self-sufficiency of the local population and cut wood consumption. Now, some comments are needed on the cost/benefit ratio.

For this purpose, the above improvements were considered as a priority requirement as set forth in the country's economic development plan and the solution based on renewable energy was compared to that based on conventional energy to feed the same userpoints. The calculations are based on a ten year investment write-off at 14% interest and on the current costs for technologies and products.

The benefits accruing from the proposed interventions are of the order of Lit. 4 200 000 p.a., against an investment outlay of Lit. 4 000 000 for farm and household equipment (dryer, pump, mill, etc.).

The investiment required for the energy facilities proper, to serve the above mentioned technologies and the various userpoints is:
- for renewable energy sources, of the order of Lit. 8 500 000 p.a.;
- for conventional energy sources, of the order of Lit. 500 000 p.a..

The first alternative thus requires an extra-investment of Lit. 8 000 000 p.a. against fuel savings of some Lit. 2 500 000 p.a., and the investment payback time exceeds 30 years. To bring this payback period to 10 years, the cost of the renewable energy technologies should be reduced by a factor of 3. Mass manufacture could cut the costs of anaerobic digestion and gasification technologies by some 30% as compared to the assessed values, and efforts should concentrate on the photovoltaic equipment (which at present accounts for 80% approx, of the total outlay), for which the literature points out that the costs could possibly be reduced by 3 or 4 times in the medium term.

It should also be noted that the average investment outlay to achieve these objectives is around 1.6 million lire per person. ■■

Development in Rice Production Mechanization



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Abstract

A review of the developments in the mechanization of rice production was carried out through literature search, visits and personal communication. For the developed and industrialized countries, rice production has been fully mechanized while most of the farm operations in rice production in developing countries are still carried out by manual labor. But quite some developments in the form of appropriate technology machines are going on in these countries. Japan has developed some small motorised machines which are adequate for small scale farmers in the poor countries.

Introduction

Rice contributes 21.2% of man's calorie intake (USDA, 1970), (Fig. 1). It is the principal food for most of the developing countries, mainly the heavily populated countries of South Asia. Its nutritional value (cal/100g) in next to maize among the staple foods of the low income nations (Table 1).

Rice is a plant that can flourish under widely differing climatic conditions. The main producing areas are the countries enjoying subtropical and warm climate. But the crop also thrives over a wide range of conditions within about 45° latitude North and 40° South of the equator. But within the above stated latitude, the chief limiting factor to the growth of rice is water supply.

Temperature and soil type also have effect on the growth and yield of rice. The average temperature required through the life of the plant must not be less than 25°C and variations between day and night temperatures promote maturity of kernels. Rice can grow on different types of soils with pH ranging from 4.5 to 8. For wet rice, or sometimes called swamp rice, alluvial plains are suitable lands, because of good rate of organic matter and good moisture and nutrient content. But for rainfed rice production, the most suitable soils must be selected on their properties to store rain water and make it available to the plant during the growing seasons.

A lot of work has been done and is being done to increase production, especially in the developing countries. This increase in production is being achieved by mechanization. Mechanization has been defined in different ways by different authors but refers mainly to the use of any mechanical means to facilitate agricultural operations and reduce or eliminate drudgery.

With this definition in mind, therefore, the main objective of this paper is to survey the work done in the mechanization of rice production in the world, in general, and in the developing countries, in particular. The main sources of information were the literature and personal communications. Attempts will be made to cover all the available machinery in the different stages of production operations, pointing out any special features that may be beneficial to the developing countries. It is hoped that this paper will be useful to researchers and practising engineers who are involved in rice

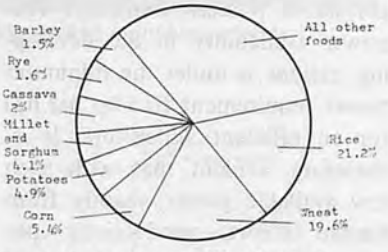


Fig. 1 Man's sources of food energy.

Table 1 Calorific Values of Some Foods

Food	Calories (cal/100g)
Cassava root	390.94
Cassava flour (Gari)	384.34
Cocoyam	382.63
Yam tuber	385.85
Yellow yam	385.69
White yam	381.18
Rice grain	394.77
Maize	409.65

production mechanization. The mention of any brandname does not necessarily mean automatic recommendation of that brand. Its recommendation will depend on favorable test results.

Scope of Mechanization and Appropriate Technology

Mechanization is one of those major inputs which facilitate the increase of agricultural productivity. Farm power shortage has been known as a major constraint to agricultural development. Statistics on farm power and machinery (FAO, 1974) have shown that the number of four-wheel tractors and crawler tractors used in the world agriculture in 1970 was 15.6 million, of which 14.3 million were estimated to be in the U.S.A., Canada, Europe, including U.S.S.R., Australia, New Zealand and Japan. Only 1.3 million tractors were estimated to be used in the rest of the world.

This distribution of tractors is closely related to the power availability in the world agriculture. In the developing countries, power availability averages 0.1 to 0.20 hp per ha, while it reached 1.4 hp per ha in the U.S.A., and 4.7 hp per ha in Western Germany. This power availability in the developing nations is under the minimum power requirement (0.5 hp per ha) for an efficient agriculture. It is, therefore, evident that with such low available power, mainly from human effort, productivity per farmer will remain at subsistence level.

The main cause of the low availability of agricultural power in developing nations is that they depend exclusively on imported machinery from developed countries. These machines cost a lot of money in comparison with the farmers' income. Other factors that constitute obstacles to tropical agricultural mechanization include complexity in the designs of the imported machinery, lack of spare parts and skilled labor to operate and maintain the machines. Ibrahim (1979), therefore, stated that the future of farm mechanization in emerging nations lies on the nations' efforts to manufacture simple and functional machinery.

This view has been postulated for long by many agricultural engineers and agriculturist under the broad terminology of "Appropriate Technology". Schumacher (1974), described appropriate technology as the know-how and equipment designed to help the poor to help themselves. Baumer (1981) went further to say that appropriate technology, assumed for self-development, should cover unsatisfied basic needs, it is directed towards the situation of the poor, the majority of the population. But I would rather simply define appropriate technology as "the technology of the people, by the people and for the people". It should not be an inferior technology. Appropriate technology must not be a technology which increases the delay and dependence of the low income countries on the high income ones. It must be a stepping stone in the process of development, resulting either from the adaptation and efficient use of the advanced technology of local conditions or the improvement of local technology.

Therefore, in this paper there will be much emphasis on developments in appropriate technology machines in rice production from land preparation to threshing.

Land Preparation

The developments in the mechanization of land preparation will be dependent on the soil types and problems associated with them. Generally, there are two major soil types encountered in the valleys and river basins where most of the world rice are cultivated. They are clay soils rich in humus and peat soils. The first type is easy to cultivate and needs little or no fertilization in the first cropping. But the cultivation of peat soils is not an easy job as far as land preparation is concerned. Grist (1965), has summarized the main problems connected with peat soil cultivation in rice production as follows:

1. Once the surface skin of a virgin peat bog has been broken by implements behind the tractor, it may be unable to support any more equipment until either it has drained or it has had time to regenerate a skin.
2. Many of the tropical peat soils don't have a satisfactory skin.
3. It may be found that after a year or two of cultivation, the peat soil becomes toxic to plant growth and satisfactory yields can be obtained only by excavating the peat and cultivating the sub-soil.
4. Peat swamps are frequently endowed with submerged timbers and soft spots, both of which are serious hazards to mechanical cultivation.

From the above, it may be pointed that only dry cultivation is possible on bottomless soils, success depending on the use of low pressure tractors.

A few attempts have been made to reduce the difficulties encountered when cultivating peat bottomless soils. One of these is the method of floatation which helps to improve the mobility of the machinery. In this method, wheels of the tractor are kept near the surface by using tracks, wide wheels, large diameter wheels or float in order to distribute the weight of the machine over as great an area as possible. Allen and Haynes (1955), in Malaya had proved that on bottomless

mineral soils, track layers with wide plates or swamp blocks were successful but wide wheels were less satisfactory. Pneumatic types were also successful, but there was great variation in the tread pattern of different makes and careful selection was necessary. Bombar - Dier type of half-tracks have been found to be of outstanding value under bad condition; they permit operation to be extended to both earlier and later in the season. Under all conditions mounted implements are favoured.

Cage extension to the standard pneumatic tyre equipment also assured good stability and floatation on bottomless land. This is extensively used in Japan and many parts of Asia.

Sakai *et al* (1981) described the manufacture and use of Japanese cage wheels.

Seeding and Transplanting

Rice is planted either by direct seeding or sowing or by transplanting. There have been scientific arguments for and against the two methods. Experience and experiments in all the production areas of Java confirm that higher yields may be expected from transplanted paddy than from direct broadcasting or drilling. Experiments in Ceylon (Lord, 1935) have shown that with six or seven months' paddy, transplanting increased the crop by 30 to 46%, but with the 3 to 4 months varieties, which was the most popular in Ceylon, it was doubtful whether transplanting would prove profitable. Paul (1945) considered that transplanting in Ceylon was superior to broadcasting but not necessarily to drilling. In India, the increase in yield through transplanting has been 15 to 30% (Ramiah, 1954).

Experiments in Philippines (Palis and Calma, 1948) proved that transplanted paddy developed faster, was more uniform, taller and matured later than broadcast seed.

In Italy, paddy is either drilled, broadcast or transplanted by mechanical means. Wickizer and Bennete (1941) noted that in some parts of Japan, rice had been sown directly, on paddy field as thickly as was customary with transplanted rice and the yields had been approximately the same. In California, where there is no transplanting, yields compared favourably with those obtained in parts of the orient other than Japan where yields are fairly high.

Equipments for Rice Seedlings and Transplanting

The trends now are for equipments that can perform simultaneously seeding and fertilizer application. Experimental Centre of Farm Machinery Studies (C.E.E.M.A.T.) in the Republic of Benin, reported some examples. These included fertilizer sprayers with oscillating tube for use as seeder. The latter type has a rolling speed ranging from 5.5. to 6.5 km/h with a performance of 2.3 to 3.8 ha/h. Another type included germinated grains seeders with rows used in mud or wet soil condition.

Examples are Somas type (**Fig. 2**) seeder attached to a tractor by 3-point hitch. It was tested and found adequate in Malagasy and it had inter-row of 4.0 cm.

The International Institute for Tropical Agriculture (I.I.T.A.) in Ibadan designed and successfully tested a 4-row rolling injection planter for rice and other cereals (**Fig. 3**). The planter is quite unique because it is specifically designed for the rural farmers and for zero-tillage operations. It is simple, easy to understand, assemble, adjust and use. It has a few moving parts, thus minimizing the problems of mechanical breakdown and mainte-

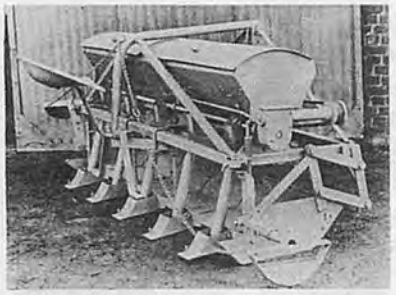


Fig. 2 SOMAC Type seeder used in mud or wet soil conditions.



Fig. 3 Four-row rolling injection planter (designed at IITA).



Fig. 4 IRRI multi-hopper seeder.

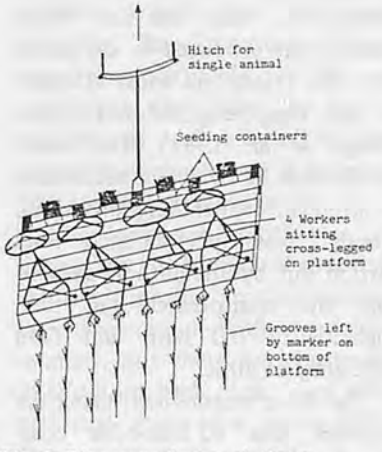


Fig. 5 Rice transplanter platform (designed in Israel).

nance. A single row unit can be hand-pushed comfortably and its operation on an uneven soil surfaces has been quite satisfactory. But it has two disadvantages. Firstly, the spacing within rows is fixed and secondly, the maximum speed is limited to 3.5 km/h.

The International Rice Research Institute (I.R.R.I.) in the Philippines has produced a multi-hopper seeder (Fig. 4). The IRRI seeder is light-weight and compact with a low center of gravity. It is built entirely of local materials and it has six rows. Its initial investment and operating costs are low, making it ideal for small farmers. The basic specifications of this seeder are 50 kg hopper capacity; 35-50 kg/ha seeding rate and 7 man h/ha seeding capability.

Transplanting, though a time consuming operation, is a popular method of rice production in many Asian countries. China, Italy and some other countries have developed improved transplanters to reduce the time consumed.

Grist (1965) reported that the ILCM type transplanter, using power take-off, and developed in Po Valley, of China, performed very well with tractor of about 1.5 t, equipped with steel wheels having a width of 65 mm and provided with spikes. Also, report from China indicated improved rice transplanters have been developed since 1956 when the first transplanter was produced in the country. The latest and most efficient is the Tung-Feng-2AZJG-12 type (Singh *et al*, 1981). The transplanter has 12 rows and needs only 3 attendants (including operator). Results from performance tests carried out by the authors showed that the transplanter had field capacity of 0.07 ha/h and field efficiency of 20%.

The labor requirement using the machine was 42 man-h/ha compared to 157 man-h/ha for manual transplanting. This Chinese type of transplanter is widely used and manufactured in Malaysia, Thailand, Iran, Pakistan and the Republic of Korea.

In India, a 10-row manually operated paddy transplanter patented as "Annapurna Transplanter" has been reported (Swain and Maity, 1981). The manufacturers claimed that labor requirement, using the machine was 30-53 man-h/ha. But the authors indicated that the labor requirement for tray filling was high (602 man-h/ha).

Another type of transplanter was reported to have been developed in Israel (Ben-Nun, 1973). The implement consisted of a wooden platform, (Fig. 5), pulled by a buffalo or a pair of bullocks. Four workers are seated cross-legged on the platform, holding the seedlings in their laps. Special recesses are provided on the platform for extra seedlings. Under the platform are attached eight wooden markers and each worker seated with his back to the direction of travel, transplants two of the rows marked in the mud. In Japan, there have been a variety of rice transplanters. These include Kubota Rice Transplanter NR-4, Minoru transplanter LT-4F-D2, and Mitsubishi transplanter MPR 5000.

Weed Control

Much of the developments in this area has been more of agronomic and chemical rather than engineering. There are basically two methods of weed control: mechanical and chemical methods. Machinery for these methods have been fully developed and are in use. Duff and Orcino (1971) indicated that the timing rather than the frequency of weeding was a major determinant of effective weed control for rice. Recommendations have been made for the first weeding to be done 2-3 weeks after sowing followed by a second weeding three weeks later and if necessary a third one (Moomaw, 1971). For irrigated rice, the most important factor in weed control is good water management, although good land preparation reduces weeds and also reduces labor used in controlling the weeds that remain (IITA, 1974; Johnson) and Link, 1970). Paddling has been reported (Pothecary, 1970) to be a very good weed control measure. Secondary tillage, two to three weeks after primary tillage may be the most effective, in that germinated weed seeds can then be destroyed easily.

Planting techniques can influence weed growth. Transplanted rice is reported to be less affected by weed growth than direct seeded rice (I.I.T.A., 1974). Plowing in rows results in less weed competition and requires less weeding time than broadcasting provided the same seed rates are used (Pillainayagan, 1974), while broadcasting naturally rules out mechanical weeding (Chabrolin, 1969). In irrigated rice fields, rotary weeders have been used with success, although some supplementary hand weeding around the plants may still be necessary, more so if the rice is direct seeded.

Harvesting and Threshing

Many different harvesting systems are being practised in the rice producing countries, but much of the rice in the world is still harvested by hand (FAO, 1976). Rice harvesting in the U.S.A., Australia and Europe is nearly completely carried out by combine harvesters, except in some areas where fields are too small for these harvesters. In such cases, mowers are used.

Developments and improvements in these countries center on reducing harvesting losses by

better designs in the threshing and cleaning chambers.

In South America, and to a certain extent in Central America, combine harvesters are becoming more and more popular, especially on the larger farms with upland rice. In the greater part of Africa, except for a few large scale farms, shifting cultivation is still a common practice and full mechanization and more sophisticated methods of harvesting are at the very early stage of development. In Asia, where small farms are in the great majority, relatively little development has taken place, except in Japan which has been fully mechanized mainly through small harvesting and threshing machines. Pandey and Devnani, (1981) have developed an improved sickle for harvesting rice. The performance of this sickle was found to be superior to the existing ones.

Some new small rice combines, adequate for the medium size farmers have appeared in the Japanese market (AMA 1981). They included:

1. Iseki 2-row combine harvester HL 1400, 1200 with axial-flow, single threshing cylinder. It is equipped with automatic direction control and monitor on operator's panel and the working width is 77 cm.
2. Kubota combine "Skyroad" RX 900, 2-row combine with water-cooled 9.5 PS/3000 rpm engine and a working width of 70 cm.
3. Kubota combine NX 2000 E, 3-row with double cylinder thresher. It has a water-cooled 20PS/3000 RPM diesel engine and a working width of 102 cm. There is also a more sophisticated, 4-row type with grain bagging facility.
4. Mitsubishi combine M 750, 2-row, for small holding. It is equipped with automatic direction control, stephens speed change and a 8.5 PS/2500 RPM diesel engine.
5. Yanmar diesel combine TC 580, 2-row for small holdings.

The same company markets another version designed for operation in submerged paddy field. It has a higher clearance, broader crawler and water-tight cover for transmission. These types of machines meant for small medium-size farmers have helped to enhance the rice production mechanization in Japan.

In other developing countries where harvesting is done by hand or mower, efforts are being made to develop appropriate-technology threshers. Different types of pedal threshers have been reported in Nigeria and India (Oluleye, 1982). **Fig. 6** shows a version of pedal thresher developed in Nigeria. A modified "Hampasan" (paddy thresher) **(Fig. 7)**, designed in Philippines has been found to be very efficient.

IRRI (1978) reported the development of rice threshers in Pakistan. One of them was the standard axial-flow thresher which encountered some problem in the threshing, screening and aspiration system. Some of the changes made to correct these problems were:

1. Spacing between the concave bars at the feed portion was reduced from 6.4 mm to 4.8 mm to correct the passage of unthreshed panicles through the concave at the feed end.
2. Tray link angle was reduced from 62° to 55° to reduce the piling up of straw caused by the slow movement of the threshed material from the oscillating tray.
3. A front steering wheel with handle replaced the parking stand.



Fig. 6 Pedal thresher (designed at the University of Ibadan, Nigeria).



Fig. 7 A modified "Hampason" paddy thresher (designed in Philippine).

Summary

Mechanization of rice production in developed countries has reached the stage of more complexity in design of machine. This is due to the advanced level of literacy and technological skill. On the other hand, in the developing countries, most of the machinery and equipment used for rice production mechanization, are imported from the developed countries. These machines in most cases, are unsuitable for the soil conditions and have to be reconditioned and adapted to the conditions prevailing in these areas. This is a short-term solution.

The long-term solution is the design and production of machines in these countries, by the engineers in co-operation with the agronomists. But there are constraints in executing such plans, even if the technical know-how is available. One of these constraints is that most of the raw materials will be

imported. Most of the developing countries don't have iron and steel industries which is the life wire of any manufacturing industries. Nigeria is one of the developing countries now developing an iron and steel industry. It is hoped that when the industry is in full operation and production, the agricultural machnery manufacturing industry, which is long over-due for the country, will be established.

In general, a lot of developments have been going on, in the area of rice production mechanization, especially in the developing countries, in the form of appropriate technology machines.

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Development of a Sugarcane Planter for Developing Countries



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Abstract

A drop type, two-row, tractor-drawn semi-automatic sugarcane planter has been developed with a unique feature of rotating drum for uniform placement of the sets. It opens the furrow, places sets, chemical and fertilizer and covers as well as compacts the cover. A team of five men, including the tractor operator, is required for its efficient operation. Its effective field capacity is 0.5 acre/h and the forward speed is about 2 km/h. The uniformity of set dropping was fairly good up to 2.5 km/h forward speed. The maximum observed eye damage was 2.73% only.

Introduction

Sugarcane is a major cash crop in the developing countries. It is growing in Asia, Africa, and Latin America. It is planted in more than 3 million ha of land in India. There are different methods and systems of sugarcane planting prevalent in the world. Basically, it involves opening of the furrow, placement of the chemical in the furrow, placement of the treated sugarcane set and fertilizer, its covering and compacting. Sugarcane planting is a tedious, time-consuming and expensive operation.

Traditionally, sugarcane has always been planted manually. However, to reduce the cost of planting, drudgery and for proper placement of the fertilizer, machinery for sugarcane planting has been developed in many countries of the world (1,2,3,4,5,6,7,8,9,10, 11,12,13). These machines are basically of two types widely known as cutter planters and drop planters. In cutter planters, the whole sugarcane stem is fed (12, 13). The machine cuts it to a predetermined length and carries it to the furrow. In drop planters, pre-cut sugarcane sets of desired length are fed into the machine. The rest of the operations are performed in both machines.

For developing countries where sugarcane is grown in small fields and power available is low, the drop-type planters are better suited. The Indian Institute of Sugarcane Research has done pioneering work in developing drop type sugarcane planters (2,3,9,10,11). Drop type planters are more suited to Indian conditions. Some of these machines are now being commercially manufactured for wide use by the farmers. One of the problems with drop type planters is the difficulty in achieving a uniform set placement. It is very difficult to correct a missing hill or skip. The two-row tractor-drawn semi-automatic sugarcane planter described in this paper overcomes this problem.

Development Considerations and Details of the Planter

Agronomic Requirements

Sugarcane is planted in rows. The row-to-row spacing varies from 60 to 90 cm in Punjab, India. The Punjab Agricultural University recommends a row-to-row spacing of 90 cm (8). However, most of the farmers still plant at about 60 cm spacing. The recommended seed

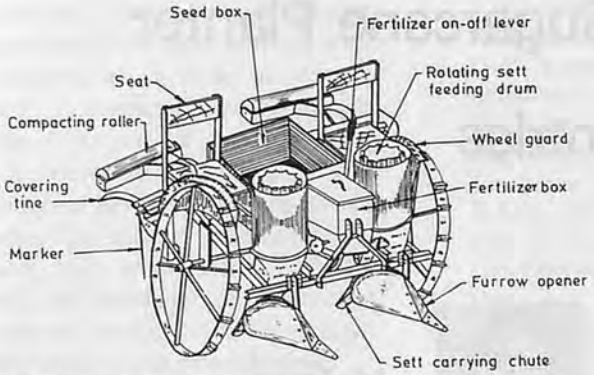


Fig. 1 Two-row tractor-drawn mounted type semi-automatic sugarcane planter.

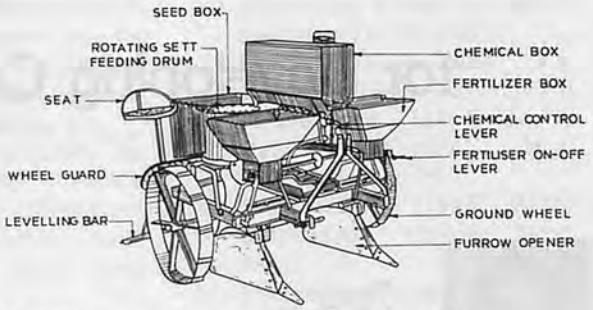


Fig. 2 Two-row semi-automatic sugarcane planter.

rate is 20 000 three-budded or 15 000 four-budded sets.

The salient design and functional requirements of the planter are:

a) The machine is a mounted type. b) Total weight, including sugarcane sets, fertilizer and two men on the machine should not exceed 600 kg. c) A 25 hp or above tractor is used for operating the planter. d) A standard sugarcane set of 50 ± 2.5 cm length should be used. e) The machine should plant end to end and with about 20% overlap. f) The sugarcane set should not touch the fertilizer. h) The depth of furrow and covering over the sets should be adjustable.

Mechanical Details of the Planter

The sugarcane planter consists of a frame, two furrow openers, two seed chutes, two vertical rotating drums with 12 circular vertical seed compartments in each drum, one seed container, a fertilizer hopper, two operator seats and a chain and sprocket drive from ground wheels. The overall arrangement of these parts on the planter is shown in **Fig. 1**. The commercially available planter has a Gamma BHC tank and is shown in **Fig. 2**.

The main frame is made of channel iron of 7.5 x 4.0 x 0.5 cm. It is 166 cm long and 81 cm wide. The diameter of the ground wheel is 75 cm. Length and diameter of the vertical rotating drums is 30 and 29 cm, respectively. The fertilizer hopper is 30 x 30 cm square and 29 cm, respectively. The ferti- above the ground is 45 cm.

The height of the bottom of the feed drum from the ground is 73 cm. Dimensions of the seat are 39 x 39 cm. The seed box is 61 cm long and 38 cm deep. It is trapezoidal in shape. Its sides are 58 and 53 cm long. The set chute is 45 cm long and 22 cm wide at the lower end. The lower end of the chute is about 9 cm above the ground.

The rotating drum and the fertilizer metering unit are powered by the ground wheel through a central shaft. A chain and sprocket drive have been used. For end-to-end placement the speed ratio between the ground wheel and the central shaft is 1.0 to 0.71 and for overlapping it is 1.0 to 0.88. The bevel gears are used for driving the drum. The speed ratio between the central shaft and the rorating drums is 1.0 to 0.61. The overall speed ratio for end-to-end placement of the set between the ground wheels and the rotating drum is 1.0 to 0.43. However, in case of overlapping the ratio is 1.0 to 0.53.

The fertilizer is covered by a small covering attachment. The sets are covered by covering tines followed by compacting rollers as shown in **Fig. 3**. The rollers are 15 cm in diameter and 25 cm long. The furrow openers are standard ridgers similar to those used in potato planters. The depth of furrow as well as covering is ad-



Fig. 3 Field performance of the planter showing the set placement and covering of the sets.

justable. Markers are provided on the machine to guide the tractor driver in maintaining uniform row-to-row spacing. Fertilizer cut-off mechanism is also provided. A separate chute is used for carrying sets when planting is done at 60 cm row-to-row spacing.

Field Performance of Planter

General Performance

The machine was tested at the farms of the College of Agricultural Engineering, Ludhiana and Sugarcane Research Station, Jallandhar of the Punjab Agricultural University. The machine opens the furrow, places the fertilizer and sets as well as covers and compacts it. For field evaluation of the machine, the sugarcane was cut into 50 cm



Fig. 4 The sugarcane planter and feeding of the sets in the drum.

long pieces.

The machine was pulled in the field by a 35 hp tractor. Two men were feeding the sets in the rotating drums as shown in **Fig. 4**. They picked five to six seed sets each time and fed one set in a seed compartment at a time. The set was carried along by the rotating drum until it lined with the opening provided in the drum. The set fell through the opening into the speed chute and was guided into the furrow.

It was observed that the size and shape of the opening in the bottom plate as well as the length and inclination of the seed chute are important factors affecting the feeding and proper placement of the set. The machine-planted crop germinated well and has given good yield at the College farm.

Uniformity of Set Dropping and Placing

The experiment was conducted on three varieties namely: COJ 1148, COJ 67 and COJ 64. The results are given in **Tables 1, 2 and 3**.

As a design feature, the machine is to place predetermined number of sets over a given length for end-to-end as well as overlap planting. The uniformity of set dropping and placement depends on the capability of the person feeding the sets, forward speed of the machine and cane characteristics. The results presented in **Tables 1, 2 and 3** show that the uniformity of set placement is seriously affected beyond 2.5 km/h forward speed. In fact it was observed that on a continuous basis for uniform set placement the forward speed should be about 2 km/h.

Table 1 Uniformity of Set Placing of COJ 1148 Sugarcane Variety

Operating speed (km/h)	Position of set dropping	Total number			Average		Length	
		Sets dropped	Gap	Overlap	Gap	Overlap (cm)	Unplanted (%)	Overlapped (%)
1.0		50	26	22	6.18	8.06	7.12	6.81
1.5	End	50	19	27	9.99	8.46	5.58	9.75
1.75	To	49	29	20	5.95	6.68	3.70	5.02
2.00	End	50	2	23	7.78	8.79	9.92	9.42
2.50		47	19	26	13.63	12.50	6.10	9.81
3.00		47	18	24	26.93	12.45	16.02	13.86
1.00		56	29	26	6.20	7.23	5.75	6.87
1.50	Over-	57	18	38	9.42	11.02	3.94	15.70
1.75	Lap	55	18	36	8.91	12.54	7.47	18.20
2.00		46	6	39	11.14	11.20	2.77	16.77
2.50		46	16	29	15.66	13.89	6.72	17.24
3.00		42	15	26	48.54	14.63	32.60	20.09

Table 2 Uniformity of Set Placing of COJ 67 Sugarcane Variety

Operating speed (km/h)	Position of set dropping	Total number			Average		Length	
		Sets dropped	Gap	Overlap	Gap	Overlap (cm)	Unplanted (%)	Overlapped (%)
1.00		35	18	16	6.10	8.12	5.60	6.78
1.50	End	37	13	23	9.91	8.69	5.59	9.00
1.75	to	37	17	19	6.21	6.59	3.83	5.06
2.00	End	36	12	23	17.67	8.40	9.72	9.00
2.50		36	8	27	15.77	13.94	6.13	9.55
3.00		33	12	21	25.38	13.95	16.03	13.87
1.00		43	22	20	6.20	7.20	5.75	6.87
1.50	Over-	44	11	23	9.30	10.76	4.10	15.40
1.75	Lap	42	10	31	18.92	12.60	7.56	18.25
2.00		43	5	37	11.14	11.20	2.77	16.77
2.50		37	11	25	15.66	13.89	5.91	17.24
3.00		34	9	24	48.54	14.63	29.93	13.09

Table 3 Uniformity of Set Placing of COJ 64 Sugarcane Variety

Operating speed (km/h)	Position of set dropping	Total number			Average		Length	
		Sets dropped	Gap	Overlap	Gap	Overlap (cm)	Unplanted (%)	Overlapped (%)
1.00		50	27	22	6.09	8.02	5.55	6.77
1.50	End	48	18	27	8.93	8.35	5.32	9.00
1.75	To	48	27	20	6.10	6.40	4.34	5.06
2.00	End	49	20	27	7.66	8.40	9.72	9.00
2.50		43	18	2	15.57	11.78	5.51	9.58
3.00		41	16	24	25.00	13.45	16.52	13.87
1.00		58	25	29	6.15	7.23	5.75	6.86
1.50	Over-	52	14	37	9.27	10.76	4.10	15.36
1.75	Lap	56	18	36	8.91	12.54	7.47	18.20
2.00		52	14	38	11.14	11.15	8.23	17.02
2.50		47	9	31	15.57	13.80	4.88	17.04
3.00		44	10	33	46.76	13.14	29.40	12.54

Eye Damage

The results of eye damage test for the three varieties are given in **Tables 4, 5 and 6**. As the speed of the operation increases the percentage eye damage for all varieties and for both the positions of set dropping also increases. However, it varied within a range of 1.49 to 2.73% only. The percent eye damage was greater in the case of the overlap planting than the end-to-end planting.

Table 4 Cane Top Eye Damage, COJ 67 Sugarcane Variety

Operating speed (km/h)	Position of set dropping	No. of sets dropped	Total no. of eyes	No. of eyes damaged	Damage (%)
1.00		35	282	4	1.49
1.50		37	259	5	1.83
1.75	End to end	37	264	6	2.27
2.00		36	264	6	2.37
2.50		36	263	7	2.46
3.00		33	265	7	2.54
1.00		43	275	4	1.54
1.50		44	270	5	1.85
1.75	Overlap	42	270	6	2.12
2.00		43	265	6	2.26
2.50		37	268	6	2.34
3.00		34	264	7	2.65

Diam. at node – 2.23 cm; Size of set – 50.84 cm; Diam. at internode – 1.9 cm; Length of run – 25 m.

Table 5 Cane Top Eye Damage, COJ 64 Sugarcane Variety

Operating speed (km/h)	Position of set dropping	No. of sets dropped	Total no. of eyes	No. of eyes damaged	Damage (%)
1.00		50	262	6	2.08
1.50		48	265	6	2.18
1.75		48	263	6	2.19
2.00	End to end	49	275	7	2.36
2.50		43	273	7	2.46
3.00		41	278	7	2.51
1.00		58	265	5	1.88
1.50		53	266	6	2.23
1.75	Overlap	56	264	6	2.26
2.00		56	264	6	2.26
2.50		47	273	7	2.56
3.00		44	264	7	2.57

Diam. at node – 2.07 cm; Size of set – 50.84 cm; Diam. at internode – 1.96 cm; Length of run – 25 m.

Table 6 Cane Top Eye Damage, COJ 1148 Sugarcane Variety

Operating speed (km/h)	Position of set dropping	No. of sets dropped	Total no. of eyes	No. of eyes damaged	Damage (%)
1.00		50	298	5	1.76
1.50		50	289	5	1.81
1.75		49	246	5	2.14
2.00	End to end	50	287	6	2.26
2.50		47	275	6	2.29
3.00		47	254	7	2.67
1.00		56	278	5	1.81
1.50		57	282	6	2.21
1.75	Overlap	55	254	6	2.29
2.00		46	225	4	2.43
2.50		46	278	7	2.52
3.00		42	272	8	2.73

Diam. at node – 2.16 cm; Size of set – 50.48 cm; Diam. at internode – 1.86 cm; Length of run – 25 m.

Table 7 Distribution of Primaries/ha for Two-rwo Spacings and Two Types of Plantings

Row to row spacings	Type of planting	No. of primaries per m	No. of primaries per ha
60 cm	End to end	4.78	80 932
60 cm	Overlap	5.86	99 217
90 cm	End of end	4.78	53 954
90 cm	Overlap	5.70	64 338

Germination Test

The number of primaries after five weeks of planting for two-row spacings and two types of planting is given in **Table 7**. These germination count provides a maximum of 99 217 primaries/ha in case of the 60 cm row-to-row spacing with overlap planting. The minimum number of primaries was 53 954/ha in case of the 90 cm row-to-row spacing with end-to-end planting. In either case the number is more than enough to give good plant population.

The effective field capacity of the planter is about 2 ha/day. Its speed of planting was about 2 km/h. The limiting factor to forward speed was the speed of manual feeding of the cane sets. A team of five men, including the tractor driver, is required for proper operation of the machine. Two men feed the set in the drum while the other two charge the seed box. The seed box is located in the rear of the machine and is filled while the machine is actually planting.

Conclusions

A tractor-drawn, two-row mounted type, semi-automatic sugarcane planter has been developed and successfully tested. The cost of planting with the machine was about U.S.$8/acre at current wage rates. There is a net saving of about 8 to 10 man-days/ha in sugarcane planting with the planter. The machine is being manufactured by few manufacturers in Punjab. The planter has very few regular maintenance requirements except that the fertilizer box should be cleaned after use and bearings and drive mechanism should be properly lubricated.

(*Continued on page* 42)

Status of Farm Mechanization Facilities in Khairpur, Pakistan



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Introduction

Power machines have made it possible to cultivate waste and barren lands. Agricultural production has greatly increased, fewer farmers are producing more food than ever before and at a reasonable cost. The increased production could be credited largely to the mechanization such as improved cultural practices and more effective application and better use of mechanization facilities have advocated a profitable venture under average field conditions. Many field operations need to be completed within a short time for getting optimum results and maximum returns, particularly in repeated cropping system. Other merits of farm mechanization could be assigned to the improvement of working conditions and the performance of the jobs that would otherwise be difficult or impossible by traditional methods.

Lack of mechanization facilities have, in the past, been one of the major causes of failure in attempts to adopt modern farm technologies. The improvement in the supply of mechanization facilities has been going on during recent years and is receiving substantial boost. Properly operated and well maintained modern machines will operate for long periods and do a great deal of work before major repairs are required. Machine breakdowns can be very costly not only from the standpoint of repair expenditures but of the effect on crop yields as well. The objective of this study was to study all the relevant factors such as availability of farm power and machinery, credit facilities, spares and repair facilities for proper utilization of farm machines.

Review of Literature

The need for increased food production has made farm mechanization the responsibility of all who are concerned with production. The contribution of farm mechanization inputs in the improvement of agriculture is obvious from the literature referred to below.

Crossley (1979) concluded that 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.

Sarker and Sarker (1979) concluded that agricultural mechanization will only be possible if the following important services are developed simultaneously: i) Establishment of service centers with adequate repair and maintenance facilities and skilled mechanics in the rural areas; ii) Establishment of training and vocational centers imparting training to agricultural engineers, extension workers, technicians, operators, mechanics and farm workers. Providing educational facilities for the rural masses; iii) Creating job opportunities for the displaced labour by establishing more industries and agro-based factories; iv) Manufacture of multipurpose small implements and machinery should be encouraged in the country; and v) Government must provide service facilities for the successful implementation of mechanization.

Bashir (1979) suggested that as far as possible efforts should be

made to start manufacturing of tractors and implements in the country. This would go a long way in expanding job opportunities for the displaced labour as well as to solve the spare parts problems which is so acute at present. Repair facilities should be augmented in order to improve the efficiency and increase the useful life of the machines/implements. Proper attention should be paid to training a requisite number of skilled workers who would undertake manufacturing, assembling and repairing of machines. In order to increase the efficiency of skilled workers in assembling and repairing machines, the number of tractor makes should be reduced to the minimun.

According to FAO (1960) mechanization contributes most to increased agricultural production by permitting optimum timeliness in carrying out farm operations. Delays due to machine breakdowns can be very serious. A machine out of service at harvest time can well mean the loss of an entire crop. Further, it is stressed that lack of maintenance facilities has, in the past been one of the major causes of failure in attempts to introduce mechanical equipment. The importance of availability of spare parts and supplies for the efficient operation of a workshop is well recognized. The range of parts that can be economically kept in stock will depend to a great extent on the numbers of individual makes and models of machinery that will be handled.

Lonnemark (1967) stressed upon the establishment of necessary training facilities in operation, repair and maintenance is a considerable task which must be faced and entailes the setting up of specialized training institutes in several different fields of activity. Furthermore, tractor cultivation cannot be performed successfully or economically if the land is made up of small or scattered fields, not cleared of stones and tree stumps or well drained. Adequate roads and communications as well as access to the fields for the machinery must be in existence or constructed in advance. Trained operators, mechanics and supervisory staff must be available together with adequate maintenance and repair facilities and spare parts. He concluded that the change from primitive hand-operated or animal drawn implements to modern farm machinery cannot be achieved overnight, and it is better to make steady progress than to hurry and incur heavy losses of capital and confidence. It is important to stress that adequate training in operation, repair and maintenance of farm machinery is a fundamental requisite for the successful introduction of mechanization.

Johnson and Lamp (1966) reported that the effect of mechanization upon total production is not readily obtainable because of the many scientific advances associated with mechanization. Improved seeds, the utilization of fertilizers, improved weed control and more skilled farmers are all contributing factors to increased production potential. The major factor in increasing total productivity has been the change from animal to tractor power. The areas required to feed the horses have been diverted to other uses.

They further expressed that machines allow the optimization of many cultural practices such as tillage and seeding, cultivation, fertilization and pest control. Machines permit timeliness of operation which minimizes crop losses.

According to Qureshi (1978) tractor use accelerates land preparation and harvesting operations, facilitates multicropping and increases labour productivity and employment. Mechanization increases employment opportunities due to the increased cropping intensities, higher yields, and changes in cropping patterns. Tractors provide much cheaper draft power than is available from animal sources.

Survey Procedure

Khairpur, being one of the promising districts of Sind, spreads over an area of 5 490 sq.km, having a wide scope in agriculture and industry, was selected for studying the utilization of farm mechanization facilities. These facilities were categorised into i) credit facilities for the purchase of tractors; ii) farm machines and other agricultural inputs; and iii) the agencies which provided tractors, farm machines, fertilizers, insecticides and pesticides, tractors and implements repairs and other necessary agencies for efficient utilization of the facilities. A survey was undertaken in order to identify the tractor dealers, farm machines dealers, spare parts dealers, implement manufacturers, tractor and implement repair shops, fertilizer dealers, insecticides-pesticides dealers and sugar mills available in the district. Besides, a total of 60 tractor farms were selected for the present study. Stratified random sampling method was followed for selecting the tractor farms. Each sub-district of the district formed a stratum. Within the stratum 10 tractor farms were randomly selected.

The data regarding the crops grown, tractors, farm machines available, fertilizer use and plant protection measures followed on individual farm were recorded on a pretested questionnaire.

Credit Facilities

Farm mechanization requires large initial capital investment for the purchase of farm machines and using the facilities efficiently and effectively. The growers are not in a position to manage huge amounts

for buying power machines. There is a lack of co-operative farming which otherwise could solve many problems of the farmers for adopting mechanization.

The credit facilities provided by various agencies in the distict are shown in **Table 1**. It is evident that the Agricultural Development Bank of Pakistan advances the biggest loan against short, medium and long term conditions. These loans advanced to the farmers were for the purchase of tractors, tractor implements, tube-well installation and insects/pests control equipment. The role of the Muslim Commercial Bank Ltd, United Bank Ltd, and Habib Bank Ltd, was also encouraging.

The National Bank of Pakistan and the Allied Bank of Pakistan Ltd has also contributed in the field of farm mechanization by distributing the loan to the growers. The sugar mills at Ranipur had also released the loan to the growers, the loans were seasonal and productive. These loans had been granted to the growers of sugarcane area mainly for the purchase of fertilizers, insecticides/pesticides and seed.

The credit facilities provided by various agencies showed that these agencies disbursed maximum amounts of loans to a greater number of growers at Khairpur, Gambat and Kotdiji than Faizganj, Mirwah and Nara.

Table 1 Credit Facilities Provided to Farmers by Different Agencies in Khairpur

Loan Advancing Agencies	Sub-districts						Total
	Khairpur	Gambat	Kotdiji	Faizgaj	Mirwah	Nara	
Agricultural Development Bank of Pakistan	3 158 (79)	4 707 (91)	2 766 (105)	341 (7)	2 087 (54)	308 (8)	13 367 (344)
National Bank of Pakistan	58 (5)	30 (2)	41 (3)	36 (6)	45 (2)	120 (6)	320 (24)
United Bank Ltd	75 (15)	150 (9)	130 (12)	90 (14)	55 (7)	80 (11)	580 (68)
Habib Bank Ltd	100 (7)	95 (9)	65 (7)	25 (2)	–	150 (13)	435 (38)
Muslim Commercial Bank Ltd	150 (12)	75 (9)	57 (7)	59 (8)	41 (5)	25 (2)	407 (43)
Allied Bank of Pakistan Ltd	35 (3)	65 (8)	45 (5)	– –	– –	75 (7)	220 (23)
Sugar Mills	–	–	250 (1 205)	–	–	–	250 (1 205)
Total	3 576 (121)	5 122 (128)	3 354 (1 344)	551 (37)	2 228 (68)	758 (47)	15 589 (1 745)

Remark: Parentheses shows the number of farmers.

Table 2 Number of Farm Mechanization Facilities Available in Khairpur

Farm Mechanization Facilities	Sub-district						Total
	Khairpur	Gambat	Kotdiji	Faizganj	Mirwah	Nara	
Wheel type tractors	220	180	258	114	215	149	1 136
Bulldozers	20	–	–	–	–	–	20
Tractor dealers	3	1	–	–	–	–	4
Tractor spare-parts dealers	9	9	2	1	1	–	22
Farm machinery dealers	5	3	1	–	–	–	9
Farm machinery manufacturers and dealers	10	6	2	1	1	–	20
Tractor repair shops	10	15	5	–	–	–	30
Farm machinery repair shops	12	15	3	2	2	–	34
Tubewell boring agencies	3	1	–	–	–	–	4
Tubewell repair and spare parts dealers	5	2	1	–	–	–	8
Fertilizer agencies	24	26	12	5	8	3	78
Inseciticide/pesticide agencies	8	5	3	2	6	–	24
Agricultural extension service	1	–	–	–	–	–	1
Sugar mills	–	–	1	–	–	–	1

Mechanization Facilities

The different mechanization facilities available in the district are shown in **Table 2**. These were 1 136 wheel type tractors owned by farmers and 20 bulldozers which were Government operated. The Agricultural Engineering Workshop was responsible for organizing the services of bulldozers and providing these facilities to the farmers on hire basis.

In all, four tractors and nine farm machinery dealers were present in Khairpur district. Spare parts facilities were provided by 22 tractor and spare parts dealers, Similarly, 20 farm machinery manufacturers were present in the district.

For major repairs, 30 tractor repair shops and 34 machinery repair shops provided the facilities for the tractors and farm machines owned by the farmers. Besides, many other small shops were providing repair facilties in the interior of the district.

In all, the district possessed 4 tube-well boring agencies and 8 tube-well repair shops along with spare parts facilities which also encouraged farm mechanization.

Loan and other facilities for mechanization were also provided by

sugar mills, cotton factories, agriculture extention centers and cooperative societies.

The credit facilities had greatly contributed in the advancement of farm mechanization but to overcome the problems of mechanization, it still needed more credit inputs to build up more workshops, repair shops, roads, training centers, farm machinery manufacturers. Lonnemark (1967) also suggested training centers, repairs and maintenance facilities as the measures for advancement of farm mechanization.

Fertilizers, insecticides, pesticides agencies and improved seed dealers also helped to achieve high yields.

Tube-wells and Surface Pumps

Table 3 shows the distribution of tube-wells and surface pumps in the district. In all, the district had 788 tube-wells, 684 electric powered and the rests were diesel engine. Besides, 240 surface pumps supplemented irrigation: 100 of them electric powered and 140 operated by diesel engines. Khairpur dominated in the population of tube-wells followed by Gambat.

Table 3 Number of Tubewells and Surface Pumps in Khairpur

Sub-district	Tubewells				Surface pumps				Total
	Private		Government		Private		Government		
	Electric	Diesel	Electric	Diesel	Electric	Diesel	Electric	Diesel	
Khairpur	55	–	270	1	–	–	5	–	331
Gambat	25	70	165	–	–	25	–	–	285
Kotdiji	–	–	115	–	–	–	–	–	115
Faizganj	–	20	–	–	–	–	–	–	20
Mirwah	–	13	54	–	–	–	–	–	67
Nara	–	–	–	–	72	115	23	–	210
Total	80	103	604	1	72	140	28	–	1028

Table 4 Tractor Makes Owned by Selected Tractor Farmers in Khairpur

Tractor Make	Year of Purchase											Total
	Up to 1970	71	72	73	74	75	76	77	78	79	80	
Fiat	2	–	–	–	3	–	2	3	5	5	7	27
Ford	1	–	2	–	1	–	–	3	6	4	2	19
Massey Ferguson	–	–	–	–	–	3	2	2	4	–	–	11
Belarus	–	–	–	–	1	1	–	1	–	–	1	4
International Harvester	–	–	–	–	–	–	–	2	–	1	–	3
Total	3	–	2	–	5	4	4	11	15	10	10	64

Table 5 Number of Tractors Available on Selected Tractor Farms in Khairpur

Make, Model and hp	Sub-Districts						Total
	Khairpur	Gambat	Kotdiji	Faizganj	Mirwah	Nara	
Fiat-480, 48	2	3	4	3	2	2	16
Fiat-640, 64	1	–	–	2	4	4	11
Ford-3600, 46	–	1	1	2	–	–	4
Ford-4600, 62	2	4	4	1	3	1	15
MF-135, 47	4	2	2	–	1	2	11
MTZ-50, 55	1	–	–	2	–	1	4
IH-44, 46	1	–	1	–	–	1	3
Total	11	10	12	10	10	11	64

Tractors on the Farms

Table 4 shows the year of purchase of various makes of tractors possessed on the selected tractor farms in Khairpur district during 1979-80 which are distributed as follows, 42.19% Fiat, 29.69% Ford, 17.18% Massey Ferguson, 6.25% Belarus and 4.69% International Harvester tractors were owned by the 60 selected tractor farmers. Of these, only 7 tractors were purchased up to 1974 and the rest of 57 purchased during 1975 to 1980. The number of Fiat tractors was high in the area as the operating cost of this tractor was lower as compared with other makes of tractors (Khan 1980). It was observed that majority of the tractors selected for study were being used effectively and efficiently.

Tractor-Drawn Machines on the Farms

The tractor-drawn machine owned by the progressive farmers are shown in **Table 6**. This gives an indication of standard of farm mechanization and economical position of the farmers of district Khairpur. The cultivator was the common implement owned by all the tractor owners. The leveller was the next important machine owned by a majority of the tractor farms. Trailers ranked at third position and disk plows at fourth one.

The farmers of Khairpur and Gambat owned the highest quantity of machines whereas the farmers of Nara sub-district owned lowest number of implements. Wheat threshers were owned by all the sample farmers of Khairpur district except Nara sub-district. None of the farm possessed a tractor operated sprayer. A new implement locally named as panj or seven haree (**Fig. 1**) consisting of a small moldboard plow bottom bolted to each shank of a cultivator was possessed by 15 farmers of the area.

Table 6 Number of Tractor-Drawn Farm Machines Available on Selected Tractor Farms in Khairpur.

Tractor-Drawn Machine	Sub-districts						Total
	Khairpur	Gambat	Kotdiji	Faizganj	Mirwah	Nara	
Moldboard plow	1	1	1	1	1	–	5
Disk plow	3	7	11	3	9	1	34
Cultivator	10	10	11	10	10	11	62
Punj/Seven haree	8	5	–	–	2	–	15
Rotary cultivator	1	–	–	–	–	–	1
Disk harrow	1	1	1	8	1	–	12
Ridger	1	–	–	–	–	–	1
Leveller/Blade	10	10	11	10	9	10	60
Wheat drill	–	1	1	–	–	–	2
Cotton drill	–	1	–	–	–	–	1
Cotton and wheat drill	–	2	–	–	–	–	2
Wheat thresher	2	5	2	5	2	–	16
Trailer	5	7	6	5	7	6	35
Peg harrow	–	–	–	1	–	–	1
Total	42	50	44	43	41	28	247

These implements were found on the farms of Khairpur, Gambat and Mirwah sub-districts.

Mechanization Inputs

The quantity of fertilizers utilized by the selected farmers is given in Table 7. All farmers were inclined to use various kinds of fertilizers for maximizing the crop yields. However, the majority of the farmers applied lower fertilizer doses than the recommended one for different crops in the area. The fertilizer agencies, 78 in number, helped in achieving better crops and yields by prompt and regular supply of required fertilizers for the area. The wheat and cotton crop utilized the highest amounts of all the three types of fertilizers.

Table 8 shows the plant protection measures adopted by the sample tractor farmers. The insecticides agencies in the area provided complete instructions to the farmers regarding the proper use of insecticides. In all, the six sub-districts of Khairpur had 24 agencies which supplied the insecticides to the farmers for saving the crops from insects. All the sample tractor farmers sprayed the crops and gardens according to the instructions supplied.

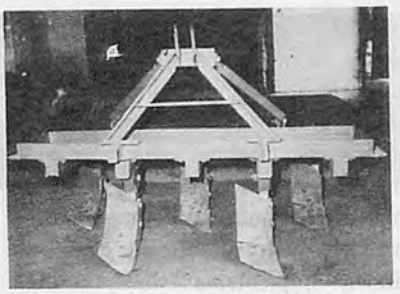


Fig. 1 A common tillage implement "Panjharee"

Conclusions and Suggestions

The existing tractor repair workshops, farm machinery manufacturers and tractor spare parts dealers were insufficient. The tractors and farm machines were not properly managed to meet the needs of farmers. The tractor owners generally lacked the know-how of mechanized farming and were not fully aware of improved methods and techniques. No institution for training the tractor operators was provided in the district.

Tractor farming developed the land and improved tillage. The majority of the tractors were of 48 horsepower being 53% of the total tractors studied.

Table 7 Use of Fertilizers on Selected Tractor Farms

Crops	Total Cropped Area (ha)	Fertilizers					
		Urea		D.A.P.		N.P.	
		Area (ha)	Quantity (Bags)	Area (ha)	Quantity (Bags)	Area (ha)	Quantity (Bags)
Wheat	1534	1534	5390	1080	2856	454	2122
Sugarcane	263	263	949	214	528	47	228
Oilseeds	156	151	330	140	234	37	60
Cotton	1285	1269	4341	1071	2755	198	705
Jowar	125	192	252	153	323	39	73
Guar	130	146	219	111	180	35	49
Vegetables	34	20	63	19	45	1	4
Garden	319	52	707	303	1067	303	211
Fodder	244	195	200	168	159	27	31
Other crops	43	17	16	16	27	6.41	2

Table 8 Plant Protection Measures on Selected Tractor Farms

Crops	Basudin 10 GR		Thimet 10 GR		Diazinon 10 GR		Nuvacron 40 EC		Thiodan 5 EC		Thiodan 5 GR		Azodrin 40 EC		Sumithion 50 EC		Carbicron 100 EC		Endrin 20 EC		Zolaned 41 EC	
	Area	Q'y	Area	Q'y	Area	Q'y	Area	Q'y	Area	Q'y	Area	Q'y	Area	Q'y	Area	Q'y	Area	Q'y	Area	Q'y	Area	Q'y
Sugarcane	20	300									8	200							24	180		
Oilseeds			4	50									7	5								
Cotton			24	300					34	80											12	30
Jowar					8	100																
Vegetables							2	1	1	1												
Garden									81	200			40	100	81	200	91	50				

Remark: Area–Area operated, ha; Q'y–Quantity, kg.

The cultivator was the most common implement owned by all the tractor owners. The leveller was the next and the trailer was third important machine owned by a majority of the farms. The farmers of Khairpur and Gambat owned the highest quantity of the tractor-drawn implements whereas the farmers of Nara taluka possessed the lowest number of tractor implements. Plowing was the important tillage practice which utilized the highest tractor work hours. The suggestions made are summarized as follows:

1 Efforts should be made to improve farm mechanization system and to introduce machines on bullock farms.
2 Liberal institutional credit may be made available to the farmers with minimal procedural delays.
3. Training facilities must be introduced for providing training in operation, repair and maintenance of farm tractors and machines.
4 The implements and other machines need to be manufactured locally.
5 Well equipped repair workshops should be established at the taluka level, whereas, small repair shops for minor repairs be maintained in the nearest market places.
6 Efficiently run custom hiring service stations should be operated for economic and viable introduction of mechanization.
7 Efficient advisory services for proper guidance of farmers need to introduced in the selection, purchase, use and maintenance of power machines.

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Process of Technology Generation



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Introduction

The problem facing the appropriate technology movement is not only to develop new technology, but also to build up an innovation system. This can be attained from two complementary angles: production and consumption. Production or supply is represented by the inventors and entrepreneurs who develop a new technology, manufacture a new product or provide a new type of service. Consumption or demand is represented by the people who will be buying or using these new products and services. These two aspects are closely interlinked and any attempt to build up an effective innovation system must consider them simultaneously. There is little point in developing a new technology, however ingenious or appropriate it may be, if no effort is made at the same time to develop a market for it. In fact, most innovations end up in failure because of this very weakness in marketing.

However, it is somewhat naive to believe that success or failure is determined principally or exclusively by missmatches between demand and supply, or technology and the market. Turning to the developing countries, one can observe that the innovation system, which in some areas appears very ineffective and sometimes totally paralysed, is in some other areas very effective. Witness, for instance, the very rapid diffusion of products such as transistor radios, watches, metal household goods, mechanical sewing machines or Western-style of clothes, the eagerness which farmers in tropical areas make the transition from thatched roofs to tin roofs, or the amount of work which goes into saving up enough for the purchase of a second-hand automobile.

The remarkable receptivity of the market to modern products of this type is a very important social and cultural phenomenon. Yet its significance tends to be overlooked both by national policy makers and by the appropriate technology proponents. For the farmer, these products and technologies are much less interesting or important than steel mills, dams, petrochemical plants or universities. For the latter, they are all too often seen as the very expression of an industrial society to which they are seeking an alternative.

Institutions Involved

The institutions which are presently playing the most active part in the development and discussion of new appropriate technologies can be divided into three categories:

Higher education institutions – These are rather small groups which originate from and are closely linked with similar institutions;

Governmental, private or semi-public – This specialises in intermediate technology and works primarily on a national basis; and

Multinational groups or research centres – Examples are the London-based Intermediate Technology Development Group (ITDG), Volunteers in Technical Assistance (VITA) in the United States or the International Rice Research Institute (IRRI) in the Philippines.

These institutions all play a major part in identifying the needs for appropriate innovations. Most of them are actively involved in the development of new hardware or software. Few of them, however, are directly engaged in manufacturing activities.

The appropriate technology groups play in effect the role of a mediator in the innovation process. In the innovation system of the highly industrialized countries, there is no need for a mediator: the industrial firm, which is one of the main agents of innovation, performs within the same organizational framework the three functions of identifying a demand for innovation, developing the

technology to meet this need and bringing the technology to the market place. In rural societies living at subsistence levels, there is no equivalent institution, and the task of the appropriate technology groups, or for that matter, of all the institutions which in one way or another are concerned with development, is to try to identify the real needs of the local communities, develop or introduce technologies and organizational means which can somehow meet these needs and, what is probably the most difficult of all, contribute to initiating a process of development based on the internal innovative forces of the local community.

Most of the appropriate technology groups currently working in the developing countries are too young and their experiments are too new to allow for any meaningful generalizations about their mode of operation. Some general observations can nevertheless be made, notably as far as the identification of needs for innovation is concerned.

Higher Education Institutions

The university is primarily an institution of higher education and higher learning. Its function is neither to act as an industrial entrepreneur or management consultant, nor to play the part which belongs institutionally to government agencies, industrial firms or non-profit associations. Faculty members may, of course, in their individual capacity take on a number of activities outside the university primarily as advisers and consultants but the institution to which they belong is geared essentially to education and learning in the strict sense of the term.

The second point is that even if universities did want, or were allowed to play a much wider role than for which they were originally designed, they probably could not. For one thing, the task of educating thousands of students is in itself a formidable task. The problem is particularly acute in the developing countries: one need only to look at the teacher/student relations or their financial situation to realize that education alone is more than a fulltime preoccupation. There is an obvious temptation to say that the university can do everything. Does it not after all, harbour some of the country's best minds? The temptation, however, is at best illusory, and at worst potentially damaging to its educational mission.

In several highly industrialized countries, universities have played, in some cases, an important part in industrial and technological innovation, and one can infer, by analogy, that the higher education institutions in developing countries also have a role to play in their local appropriate technology innovation system.

The involvement of universities in intermediate technology is also, in most cases, politically marginal, in the sense that it does not generally result from a deliberate policy of the university as such, but rather in response to pressures on the part of activist student movements and as a result of the entrepreneurial activities of individual faculty members. In this perspective, involvement in appropriate technology might be viewed as a means of letting off steam and neutralizing in a constructive way the internal political tensions in the university. What must also be considered here is that in several developing countries, the internal problems of higher educational institutions are compounded by their potential establishment of political role in society. Universities, or rather the student body, are often violently opposed to the ruling political elite of the country and in effect a revolutionary force. The examples of Thailand, South Korea, Sri Lanka and several Latin American countries show this very clearly (N. Jequier, 1976).

In the last 15 years, higher education has been one of the fastest growing sectors of the economy in the developing countries, as can clearly be seen from the number of new universities which were set up or the dramatic increases in the number of students. One of the main motivations behind this explosive growth of higher education was to bring underdeveloped societies into the modern world by building up a massive technological and educational basis. The somewhat optimistic ideology which legitimized the creation of hundreds of new universities and which was actively promoted by international institutions, aid agencies and private foundations has today lost much of its veneer and given way to a more sober assessment of what higher education can effectively achieve.

Whatever the failings of the university — and here the disappointment is the inevitable counterpart of exaggerated expectations — it is still the most affective means of providing young people with the skills and training necessary in a modern industrialized, or industrializing society. Universities have a basic commitment, institutionalized in their curricula, their entrance requirements, their communications system and their quality control procedures, to modern technology.

Encouraging universities to develop intermediate technology requires a modification of their reward and promotion system. In most institutions, the evaluation of a faculty member's performance — which determines his salary level and promotion prospects — is based to a large extent on publications. This yardstick is perfectly legitimate if research, preferably of

a high quality, is accepted as one of the main missions of the university. It is, however, strongly biased against those who are very good teachers but poor researches, and it does little justice to the other missions of a university, and notably to its educational role and its education role and its contribution to economic and social development. One consequence of the student unrest which swept many universities of the world a few years ago has been a rehabilitation of 'consumer satisfaction', (e.g., through performance ratings given by the students to their professors) as one of the bases for evaluating a faculty member's salary and promotion prospects.

Changes in the evaluation methods can and do take place, and there is no reason why in the universities of the developing countries, contributions to the development of intermediate technology might not also be taken into account. In fact, from a social point of view, such activities are probably much more useful and rewarding than a publication in a recognized foreign scientific journal, and the knowledge that they would also serve as a basis for the professional evaluation at the end of the academic year would provide a powerful motivation to do more.

Research Allocation

In deciding how to improve the productivity of a sector of its economy, a country has three primary options. Under the direct transfer option a country simply screens and adopts the best of techniques from other countries without altering such technology through research of its own. Under a second option a country can screen technology from abroad and, through a program of "adaptive research", modify or redesign the borrowed techniques to suit its own resource endowments. Finally, a country may elect not only technology but scientific knowledge from other countries and to undertake a comprehensive research program in order to produce its own techniques.

In attempting to understand the ways in which the modern agricultural research institution responds to the institutional and physical environment in which it finds itself, it is helpful to conceptualize the institution along the lines suggested by Blase and Paulson (Binswanger *et al*, 1978) in their model of agricultural experiment station performance (Fig. 1). This figure attemps to show the internal or intermediate processes and activities of the research station relating to the external environment in which it operates.

Experiment station production processes involve the transformation of flow inputs and stock resources into such intermediate processes and activities as program planning or building relationships with other institutions. These intermediate activities are then transformed into the three final outputs of information, capacity and influence.

The development of leadership is an extremely important intermediate activity. Leadership also

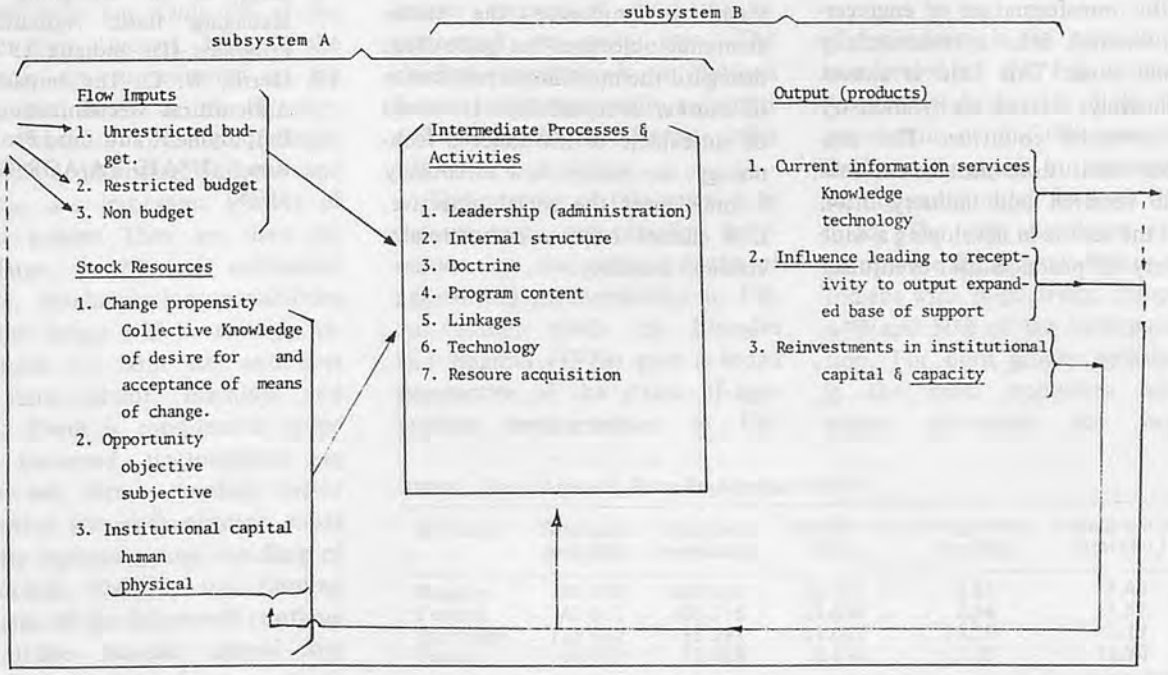


Fig. 1 System model of an experiment station development (Binswanger).

involves resource acquisition. Leaders must be able to visualize and describe to others how the experiment station or research laboratory can contribute to the solution of current problems, and they must be capable of mobilizing and allocating both financial and scientific resources so as to produce high returns to scientific and technological effort that society has come to expect (Binswanger, 1978).

The technology is in a continuous flux. A research program must be organized in such a way that the staff are aware of advances in their own and in closely related fields. The allocations of resources to the production of research technology represents a capital investment in the capacity of the individual research worker, in the research institute that makes the investment, and in the broader research system of which the institute is a part.

Conclusions

Product development is essential in the transformation of engineering research into a commercially usable form. This field is almost exclusively catered to by industry in advanced countries. The academic institutions usually conduct basic research and industry often uses the results in developing a wide variety of products that eventually generate industrial activity. Product development and technology generation requires risk capital which the small-scale industries in the developing countries cannot afford. Funds for research are primarily available to the academic and research institutions in the developing countries, which are mostly in the public sector. Such institutions in the third world have therefore the responsibility to cater to the technology generation and the product development needs of small - scale industry.

The success of some appropriate technology programmes mainly in the Asian countries has important implications for the technology transfer and industrial development process in the developing countries. It has been demonstrated that it is possible to develop an indigenous industry through carefully tailored research and development programmes in public manufactured with existing simple production processes should be developed. The programmes must emphasize the importance of pre-project evaluation and *market studies*. In the selection of technology many social scientists emphasize the socio-economic objectives but quite often disregard the most important factor of *market acceptability*. It would be unrealistic to introduce a technology, no matter how effectively it may meet the social objective, if it cannot become commercially viable in a society.

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Agricultural Mechanization in Fiji



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Abstract

Agriculture is the most important sector of the Fiji economy. Most of the farming is carried out on small holdings and 67% of the farms are under 1 ha. The farms can be classified into subsistence, semi-subsistence and commercial farms. There are major differences in productivity and incomes between these farm types. Sugarcane farms dominate the commercial farms. The level of agricultural mechanization in Fiji is relatively low. Only 6% of the farms have tractors. Most of the tractors are concentrated on the sugarcane farms in the Western and Northern Divisions. Draught animals, comprising bullocks and horses, are important sources of farm power. They are used for a large number of cultivation tasks. Mechanization possibilities in the future will be strongly influenced by farm size and cost of farm labour, machines and fuel. There is considerable scope for increased tractorization on sugarcane farms. Another major potential for mechanization exists in the harvesting and bundling of sugarcane. Overall, the farming systems of the future will continue to utilize manual, animal and tractor-based technologies.

Introduction

The level of agricultural mechanization in any country is an important determinant of the extent to which the productivity of agriculture can be increased. Generally, the higher the level of agricultural mechanization, the higher is the potential productivity of agriculture. The main reason why agricultural mechanization enables an increase in farm productivity is because farm labour when combined with machines enables a greater amount of work to be performed per unit time. The classical example is a modern farmer cultivating with a tractor and a traditional farmer using a hoe.

The purpose of this paper is to present some very detailed information on the current status of agricultural mechanization in Fiji. An earlier study by Chandra and Sharma (1979) gave a broad perspective of the status of agricultural mechanization in Fiji. Since then much detailed information on the nature and extent of agricultural mechanization in Fiji has become available following the Fiji Agricultural Census of 1978. Hence, it is thought that this study will generate (a) an awareness of the status of agricultural mechanization in Fiji and (b) promote the cause of agricultural mechanization as one important way of increasing agricultural productivity.

Present Status of Agriculture

Agriculture is the most important sector of the Fiji economy. At present about 65% of the total population of 665 000 are rural dwellers, engaged in agriculture, fishing and forestry for their livelihood. The two dominant racial groups are indigenous Fijians and Indians who, respectively, comprise 44% and 50% of the total population. For both groups agriculture is the most important sector which accounted for nearly

Table 1 Farm Area and Farm Population in 1978

Divisions	Total farm area (ha)	Total farm population	Number of farms	Average farm size (ha)	Population per farm (no.)
Western	85 528	164 622	30 475	2.81	5.40
Central	47 611	85 516	18 699	2.54	4.57
Northern	125 032	35 291	11 072	11.29	3.19
Eastern	18 962	72 928	6 130	3.09	11.90
Total or Average	277 133	358 357	66 376	4.18	5.40

Table 2 Farm Size Distribution

Divisions	Farm Size (ha)										
	0.00–0.19	0.20–0.49	0.50–0.99	1.00–1.99	2.00–2.99	3.00–4.99	5.00–9.99	10.00–14.99	15.00–19.99	20.00–49.99	>50.00
Western	12 770	4 164	2 073	2 152	1 766	4 110	2 265	474	81	452	166
Central	10 565	3 232	1 885	1 185	388	477	422	151	22	127	245
Northern	2 270	1 094	471	546	750	1 408	2 213	818	598	531	374
Eastern	1 221	1 753	1 164	544	186	198	482	127	156	299	–
Total	28 826	10 243	5 593	4 427	3 090	6 193	5 382	1 570	857	1 409	785

Table 3 Farm Types

Divisions	Subsistence		Semi-subsistence		Commercial	
	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
Western	4 564	5 758	9 540	11 806	19 142	80 696
Central	5 091	12 233	10 599	24 795	3 004	10 584
Northern	2 274	27 033	4 836	55 464	4 590	47 035
Eastern	1 835	5 632	3 972	12 154	323	1 174
Total	13 764	50 656	28 947	104 219	27 059	139 489

Table 4 Farm Productivity ($)

Item	Subsistence	Semi-subsistence	Commercial
Gross output per farm	1 000	3 000	5 500
Gross output per hectare	272	833	1 068
Gross output per family member	185	556	1 019
Gross margin per farm	680	2 040	3 740
Gross margin per hectare	185	567	726
Gross margin per family member	126	378	693
Cash sales per farm	250	1 500	4 125
Cash sales per hectare	68	417	801
Cash sales per family member	46	278	764

Note: (1) Gross output is the value of all farm produce valued at the farmgate price. (2) Gross margin is gross output minus the variable costs. (3) Cash sales is the actual value of the farm produce sold. (4) All values are expressed in Fiji dollars as of October, 1982 when $F1.00 = $US1.04 = Yen 276.

360 000 persons or nearly 60% of the total population of Fiji (Fiji Agricultural Census, 1978). Table 1 shows the total farm area and farm population of Fiji in the four administrative divisions in 1978. The total farm area was 277 133 ha comprising 66 376 farms. The average farm size was 4.18 ha and the average farm population was 5.40 persons. The farm size distribution is strongly positively skewed with 67% of the farms being less than 1 ha as shown in Table 2. Very large farms of over 50 ha are uncommon in Fiji and represent only 1% of the total number of farms. Altogether agriculture contributes to about 30% of the gross domestic product of Fiji.

Farming in Fiji can be divided into three main types: subsistence, semi-subsistence and commercial farms as shown in Table 3. Subsistence farms are those where over 75% of the farm produce are consumed by the farm family. Semi-subsistence farms are those where about 50% of the farm produce are sold, the remainder consumed by the farm family. Commercial farms are those where over 75% of the farm produce are sold. The subsistence farms, which comprise almost 20% of all farms, average 3.68 ha and are located in remote, isolated areas of the main islands or in the outlying islands of the Fiji group. These farms have few economic opportunities either because of isolation and difficulty of access to markets or because of social, cultural and institutional constraints inhibiting development towards the monetized sector of the economy. Most subsistence farmers are Fijians. The main staple crops on Fijian subsistence farms are comprised of cassava, taro, yams, sweet potatoes, breadfruit, bananas and plantains. On Indian subsistence farms the main staple crops are rice, pulses and vegetables. Subsistence seawater fishing is an important source of protein for Fijian subsistence farmers living close to the sea.

The semi-subsistence farms comprise the largest number of farms (41%) with an average farm size of 3.60 ha. Most of the semi-subsistence farmers are Indians. The staple crops on Fijian and Indian semi-subsistence farms are similar to those on the subsistence farms. Production and consumption of farm produced foods are an important part of the economic activity of these farms (Chandra, 1982). The surplus farm produce not consumed are sold for cash in the urban markets. More small livestock enterprises such as poultry, pigs and goats are concentrated on the semi-subsistence farms compared to that on the subsistence farms. The commercial farms represent nearly 39% of the total number of farms and are strongly dominated by 21 000 smallholder sugarcane farms. Sugar is the most important export of Fiji contributing to about 75% of the annual foreign exchange earnings. Other important crops on commercial farms are coconuts, vegetables, rice, ginger and cocoa whilst the important livestock enterprises are dairy, beef, poultry, pigs and goats.

The avearage levels of farm productivity on subsistence, semi-subsistence and commercial farms are shown in Table 4. There are considerable differences in incomes between the three types of farms. The commercial farms generate much higher levels of gross output,

gross margins and cash sales per farm, per ha and per family member than the semi-subsistence or subsistence farms. Subsistence farmers are the least well-off members of the farming community. In terms of cash incomes subsistence farmers generate only about 6% of that produced by the commercial farmers.

Nature and Extent of Mechanization

The nature and extent of mechanization in Fiji agriculture are shown in **Tables 5-8**. Generally, the level of mechanization is low. For cultivation heavy reliance is placed on draught animals and animal drawn implements and less on tractors and tractor drawn implements. Only 6% of the farms have tractors. Most of the tractors are located on sugarcane farms which are concentrated in the Western and Northern Divisions. These Divisions, respectively, have 77% and 19% of all tractors in Fiji. The small islands of the Eastern Division have no tractors. Ploughs and trailers are the important tractor mounted implements.

An important source of farm power are the draught animals, bullocks and horses. They are found on 66% and 57% of the farms, respectively, in the Western and Northern Divisions. The Central Division is less important whilst the Eastern Division has no bullocks and only 4% of all horses which are used only for transportation of goods and people. Ploughs and harrows are the two important animal drawn implements whilst scarifiers are less important.

The commonest transportation mode are wooden sledges drawn by draught animals. Cars, motor boats and lorries, in that order, are also important. The Western and Northern Divisions have the highest concentration of transportation modes and implements. In the Eastern Division, which has a large number of small islands, motor boats are important mode of transport for goods and people.

As might be expected, most of the rice mills, threshers and winnowers are located in the main rice growing districts of the Central and Northern Divisions. Water pumps, knapsack sprayers and motor mowers are heavily concentrated in the Western Division. Overall, the level of agircultural mechanization in Fiji is relatively low.

Table 5 Tractors and Tractor Mounted Implements

Divisions	Tractors	Ploughs	Harrows	Scarifiers	Rotary cultivator	Trailers
Western	3 065	3 860	286	424	111	870
Central	169	165	32	151	52	40
Northern	766	619	198	70	45	434
Eastern	–	–	–	–	–	–
Total	4 000	4 644	516	645	208	1 344

Table 6 Draught Animals and Animal-Drawn Implements

Divisions	Bullocks	Horses	Ploughs	Harrows	Scarifiers	Ridgers
Western	29 648	25 688	16 543	12 730	6 854	201
Central	4 293	4 953	936	921	216	–
Northern	9 984	5 883	4 421	3 778	484	8
Eastern	–	1 568	–	–	–	–
Total	43 925	38 092	21 900	17 429	7 554	209

Table 7 Transportation Modes and Implements

Divisions	Lorries	Cars	Motor Boats	Sledges	Carts
Western	508	1 913	423	3 011	217
Central	193	145	277	499	–
Northern	241	413	636	1 656	72
Eastern	–	–	378	–	–
Total	942	2 471	1 714	5 166	289

Table 8 Miscellaneous Machines

Divisions	Rice mills	Threshers and winnowers	Water pumps	Knapsack sprayers	Motor mowers	Motor blowers
Western	2	2	573	2 686	507	2
Central	31	83	94	937	143	86
Northern	37	16	92	766	199	9
Eastern	–	–	–	106	67	–
Total	70	101	759	4 495	916	97

Mechanization Possibilities

The factors that will strongly influence future possibilities for mechanization in Fiji are farm size and cost of farm labour, machines and fuel. Since most farms in Fiji are small it may appear at first that the potential for mechanization are limited. However, given that the cost of farm labour will continue to rise rapidly, as has been the trend in the last decade, there would appear to be considerable scope for mechanization, even on farms as small as 2-4 ha. The only important constraints would be the initial price of machines and fuel costs. Fuel costs are likely to continue to rise rapidly, as has been the trend in the last decade and this may be the single most important factor inhibiting the long-term growth of tractorization in Fiji. Nevertheless, considerable

scope exists for increasing the numbers of small to medium sized tractors on sugarcane farms because it is on such farms that the escalating cost of farm labour and their unavailability would be felt most severely. Even now these are serious problems in the harvesting of sugarcane. In the case of root crops experimental data have shown that considerable scope exists for mechanized harvesting of cassave (Sharma 1978; Chandra and Sharma, 1981), in the planting and harvesting of taro (Chandra and Sivan, 1981) and in other crops (Sharma, 1977).

Another major potential for mechanization exists in the havesting and bundling of sugarcane. Presently all of the 3.75 million t of sugarcane produced annually are hand-harvested and hand-loaded on railway trucks and lorries for transport to the four sugar mills. Because of the cost and unavailability of farm labour serious consideration should be given to the adoption of mechanical harvesting and bundling methods. It is possible that small mechanical harvesters, which can operate on gentle topography close to the mills, may be suitable for Fiji conditions. In other areas, with restricted topography and farther from the mills, mechanical bundling of sugarcane for lorry transport to the mills has a major potential as noted in a recent study (Fiji Sugar Corporation, 1980).

However, the farming systems of the future are likely to continue to rely substantially on draught animal power. In some farming systems, such as in subsistence and semi-subsistence agriculture, draught animals will continue to be the most important technology for farm work. In other cases, especially in sugarcane farming, the importance of draught animals is likely to decrease and be substituted for by tractorization. In the final analysis the appropriate agricultural technologies of the future will continue to adopt manual, animal and tractor systems in different combinations for different situations.

Agricultural Policy Implications

What are the implications of this study for agricultural policies in Fiji? Given the rising cost of farm labour and its increasing unavailability, on one hand, and the need to increase the productivity of agriculture, on the other, so as to promote the overall growth and development of the nation, there is an urgent need to review the total agricultural policy in Fiji within the context of agricultural mechanization. In some farming systems, such as in sugarcane, there may be no other option but to increase the level of farm mechanization to counteract rising labour costs and also to increase the productivity of labour. Considerable savings in labour requirements could be made using tractors, harvesters and bundling system of sugarcane handling. These would be some of the benefits arising from increased agricultural mechanization. On the costs side the agricultual economy and in particular the sugarcane industry, will become more and more vulnerable to the world price of machines and fuel which are all imported into Fiji. What is presently required are debates on these and other issues in appropriate forums so that a proper and long-term agricultural mechanization policy can be developed.

Conclusions

The overall level of agricultural mechanization in Fiji is relatively low. Only 6% of the farms have tractors and these are mostly used in sugarcane farming in the Western and Northern Divisions. Considerable scope exists for increasing the level of tractorization. Mechanical harvesting and bundling of sugarcane also have a major potential for development because of the high price and unavailability of farm labour. In the long-term there is considerable scope for increasing the level of agricultural mechanization in Fiji. Nevertheless the farming systems of the future will continue to utilize manual, animal and tractor based technologies.

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Agricultural Mechanization Technology Transfer in Developing Countries



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Abstract

The factors responsible for persistent world food shortage, implications and drawbacks of transferred agricultural mechanization technology, complexities of cannons of technology transfer, and the role of advanced nations in this regard are analysed. Local manufacturing of small implements in poor countries is to be encouraged instead of relying upon readily available capital-intensive tractorization model to help complement and not to replace farm labor.

Introduction

The small farmers and rural families who constitute approximately 80% of the population in the third world countries are the real victims of today's food shortage due to insufficient production and poor distribution. Any project designed to help these poor often encounters many obstacles because they are always geographically remote and therefore hard to reach. Also, the projects from which they benefit are generally small and unsuited to conventional cost-benefit analyses. The persistent food import requirement of the third world in the context of the international food system indicates that the economic order as a whole is seriously malfunctioning. Approaching the problem from supply-demand equation's angle, it is concluded that it is the small farmer who is hurt most by the constraints on land, water, and energy; by skewing of research toward the commercial market and temperate agriculture; by the vagaries of weather; by the population growth rate; and by the rising food consumption of increasingly affluent elites. Finally, if one accepts the thesis that people are hungry because they are poor, and poor because they are powerless, it is clear that the hungry, poor, and powerless are the small farmers and the landless laborers, who toil away in subsistence agriculture (8).

The world hunger problem can be solved only through innovation, modernization, and some transfer of technology to help increase agricultural production, particularly in poor countries. The advanced countries should play a sincere role in helping these nations to overcome this grave issue of food shortage. The agricultural production can be increased through scientific, technological, and managerial breakthroughs such as introduction of high-yielding seeds, and the other agricultural inputs, like, appropriate machinery, tools, fuel, fertilizers, pesticides, and irrigation water. For the procurement of these facilities the small farmers require easy term credit, more equitable patterns of land holdings, and storage, transport and marketing facilities to assure them a fair return on their investment and labor.

Technology and its Transfer

Technology transfer connotes the movement of technology from its generation, through its dissemination and appropriate adaptation, to application in a given economic, political, social, and cultural context. It also covers the communication of technological information and the development of indigenous technology.

This is an accepted rule that "technology is either good or bad nor is it neutral", therefore, where modern agricultural methods or sophisticated machinery are introduced under the conditions of traditional agriculture, they can be extremely disruptive unless they are balanced by the creativity they often bring to societies. Technology which includes not only products but formulae, designs, and personal know-how is related primarily to production and supply, it tends to omit from the economic cost

calculations precisely those demand side values that are central to development. Technology being capital intensive is mainly suitable for advanced countries where the capital is cheap while in the third world countries the labor is cheap and the capital is scarce. Technology generally exhibits its efficiency in economy of scale, which may be altogether inappropriate for small farmers and other rural poor. Technology, for all its effectiveness, is a mean – source that produces resources and if these resources are not utilized properly then that technology is useless. Moreover, the technology inputs are only part of the development process, but they have to be adapted for use in different cultures and economic strings. The probability of collision cause is high because the technology is inherently dynamic, insatiable, and destabilizing but cultures tend to be relatively static and evolve slowly over time.

Depending on the nature of the new technology, the environment in which it is to be introduced, the ability and attitude of the recipients, etc., the form, duration and cost of technology transfer can vary enormously. Technology transfer process from industrialized to poor countries should observe the following steps for its effectiveness:

1. Acquaintance – first exposure to information about the technique.
2. Assimilation – study of general information about the technique, including costs.
3. Adaptation – relating the technique to the specific needs of the country.
4. Assessment (preliminary) – detailed evaluation of prospective benefits.
5. Application (pilot) – trial application of technique.
6. Assessment (final) – evaluation of advantages and disadvantages after pilot application.
7. Adjustment – modification in light of pilot experience.
8. Application – full application.
9. Accounts – verification of economic gains.

Technology transfer generally concentrates on technological aspects of its transfer and not the economic and human aspects. As a matter of fact, technology transfer should enable the country concerned to predict with reasonable certainty the type of technology which country can best utilize, the time and cost of effecting technology transfer, the likely influence of psychological factors in impeding technology transfer, and influence of other factors such as the background of the country concerned, incentives and disincentives for both farmers and management, etc.

If technology transfer is to justify itself by bringing real economic benefits to individual countries it must extend right through to the point of implementation. In practice this means that merely making the country aware of research results is not very effective unless it is followed by advice and assistance in adapting the research results to suit the individual countries concerned. The essential requirement is to motivate country leaders and farmers to make the necessary changes, otherwise the end result of technology transfer is failure.

Thus, technology itself is complex and its transfer makes it further complicated. Therefore, any type of mechanization, selective, intermediate or immediate coupled with appropriate technology transfer should be aimed to help the poor by making them either self-sufficient or at least self-reliant. Any appropriate system, in turn, will help abolish mass poverty, preserve ecosystem, and enhance human dignity.

Advanced Countries' Role

The role of advanced countries in helping to solve the world food problem and boost economic growth in less developed countries is very much questionable. It is common practice of donor countries whether as a disbursers of their own substance or as custodian of others', that they feel obliged to retain some degree of control over the use to which the donation is put. Also, they decide on the type of the aid to be given and not what is needed. They attach strings to these aids, which help them engulf the recipient countries into their spheres, so-called the super powers' monopoly. The recipients of such aid have their pride; they give the justification that they are at least as well qualified as others to assess their priority needs; they are understandably loth to become locked into a development strategy which may not be most appropriate to their circumstances.

The aid programs particularly designed for agriculture mainly consist of heavy equipment which is never suitable to the farming conditions of the recipient country. Personnel provided with these aid packages are always no doubt well-qualified but their unfamiliarity with the socio-economic problems of the poor country negates the program effectiveness.

May be, these aid programs do not intentially seek long-term benefits for these poor nations. If the developed countries want to see their aid programs really materialize, they should not impose their capital intensive-technology, rather they should use their experience to help set up local manufacturing and secure an appropriate technology even if it is to be imported from some non-donor country. In a self-analysis, USAID admits, "Past donor aid efforts to developing countries have too often concentrated upon introduction of their

own capital-intensive equipment to meet the local needs" (9) and suggests an alternative program in the support of local small-scale manufacturing and a procurement in less-developed countries where more appropriate technology may be available. This analysis further states that the emphasis should be given to programs and policies which favor labor-intensive technologies in industry where feasible and encourage small-scale firms in particular.

Technology transfer agreements between transnationals and third world governments in agricultural machinery manufacturing projects are usually confined to the actual installation of productive capacity, i.e., the factories and machines. These transnationals do not indulge themselves in the initial drafting of the projects and undertaking the preliminary studies, thus avoiding the direct responsibility in case of project failure.

The developing countries must take note of the long term perspectives of the industrially advanced countries in the sphere of both oil and food. The importance they attach to greater production of food within their own countries is indicated by the high level of protectionism. For example, tariff walls in western Europe average 60 –100% of the value of food imports compared with 4–20% in industrial goods. Indeed, they are developing their agriculture through "protectionism" and their industrial and energy sectors through "competition".

Drawbacks of Imported Technology

The strategies of technology transfer in developing countries are affected by different national resources, different international bargaining opportunities, and to some extent require a different ordering of social and economic preferences. The important implications in this regard are summarized as follows:

1. Policy decisions of the government in respect of the import technologies, desired level of development, support for labor-intensive technologies, etc.
2. Local capabilities and resources to adapt the technology.
3. Maintenance of the adopted technology, equipment, etc.
4. Ecological imbalance to be caused.
5. Socio-economic benefits to be accrued from it.
6. Adequacy of information policy and support.
7. Capability to select, evaluate, bargain, acquire, adapt, and further develop the technologies.

Undoubtedly, agricultural production can be dramatically increased in developing nations through mechanization (though more so through intermediate scale machinery). Through consolidation of holdings, satellite farms, or collectivization, vast economies of scale can also be achieved. Bangladesh could produce four times as much rice if it followed the Japanese model; India could produce three times as much wheat if it were farmed like United States (8). But none of these changes necessarily improves the lot of the poor and hungry, because the problem is not so much of production as it is the method of production and the distribution of benefits – just as the problem with the large technology transfer is in part the mode of its transfer. Therefore, a basic subsistence approach at these small farm levels integrated with selective mechanization could set the program in motion to help the poor.

There are three main steps of technology transfer generally emphasized: transfer of materials, transfer of knowledge, and transfer of capacity. It is very difficult to obtain any real benefit from the latter, thus limiting the effectiveness of the first two and, consequently, creating a socio-economic problem for a poor country. Also, the process of technology transfer and adoption is often unsuccessful because of the failure to recognize and understand the local market needs in which the equipment is to be introduced because these transfers generally take place through multinationals, national agencies, private firms, and transnational corporations which are not familiar with the exact local needs. The value conflicts arise not only out of ambiguous character of the values of technology, but also out of the cannons and mechanisms that deliver technology from rich countries to the poor. Agricultural mechanization is not all there is to technology, but it is the most conspicuous and the most generally understood form of technology advance.

The choice of the capital-intensive production technology cannot really benefit third world, where very few farmers can afford it, there is no likelihood of their income rising sufficiently to change this stage of affairs. Therefore, this choice means that the use of such technology remains confined to a small group of affluents "kulaks" or its benefits are appropriated by the state bureaucracy, rather than benefiting the mass of the people who will have been forced off the land under this system. Some of the well recognized affects of transferred technology are:

1. Imported machines or equipment generally miss the significance of a local high value by-product (4) – combine loses straw and leftover grain mixture which is the principal livestock roughage in the third world countries, where this by-product is generally saved by sledge-sleigh method. Stationary threshers are available, but obsolete in many countries.
2. Long term importation of

mechanization equipment makes the developing country dependent – a potentially dangerous strategy for the poor country (3). Also, cost of imported technology generally creates imbalance of trade, thus resulting in adverse economic effect.

3. Imported equipment retail 150–200% of the price a farmer in the country of manufacture would pay because of cost, insurance, and freight (CIF) and profit margin for exporter to importer and salesman – an extremely high price tag for equipment not designed and developed according to the farming and economic conditions of poor countries. Also, the price of the equipment being imported could rise and supply interrupted without prior notice because such things are beyond the control of the importer.
4. The type of equipment to be imported generally depends on the importer's decision – whatever he can easily dispose of with a maximum profit. Many times inadequate supply of spare parts of the equipment makes them soon functionless.
5. Importation of equipment limits the use of locally available raw material and the participation of local ingenuity and the technical potential (material and capacity) of the country including farmers, smiths, and carpenters. As a matter of fact, this is the group who pioneered the agricultural mechanization breakthrough in all the advanced countries.
6. The imported equipment is never within the buying range (financial means) of majority of the farmers – how can one conceive selling US$ 5000-15000 equipment to a farmer whose annual income is US$ 100-500. Import substitution has lead some of the transnational companies to invest in the third world, but, as has been noted, as far as agricultural machinery is concerned transnationals seem committed to the tractorization model.
7. Huge equipment designed for advanced countries and imported into poor countries become very quickly scrapped due to their poor maintenance, repair, and operation. Also, different management approaches (e.g. cooperatives) for the equipment have been futile.
8. Equipment use could save time for small farmers, but there is no provision made available to use this time productively – an overall national loss for the poor country.
9. Mechanization processes or systems adapted by several third world countries are generally not properly integrated with the developmental programs of the country or sector – a fruitless effort if the farm displaced manpower is not accommodated in other national developmental programs.
10. So far the imported technology displaces the farmer, rather than help him.

Appropriate Solution

According to the UN's Food and Agricultural Organization (FAO) estimates, an annual growth rate in agricultural production of about 3.8% is required in the developing countries if, by the turn of the century, hunger is to be eradicated and agricultural unemployment eliminated. Such growth would require an annual increase in investment in agricultural mechanization of the order of 3.4% (1). Thus, the countries having large food deficits will require substantial investments to achieve self-sufficiency.

In advanced countries, capital is cheap as compared to labor whereas the reverse is true in third world countries. Therefore, the real need of developing nations is to increase land productivity rather the labor efficiency. Thus, for any long term solution of the present food problem is to help increase production on small farms in the developing countries where the food deficit prevails, because:

1. Production increases can be achieved cheaply in relatively underdeveloped areas.
2. High shipping costs and attendant energy costs can be avoided.
3. Most of the world's underutilized cropland (in both acreage and yield) is located in third world countries.
4. The incremental gain from increased use of agricultural inputs is much greater in the developing than in the industrialized countries.
5. The dependency relationship often fostered by food transfer programs can be mitigated.
6. Undue food price rises in the industrialized nations and in the poor parts of the world can be prevented.
7. Self-respect among the rural poor could be revived and certain comfort of life can be realized.

Technology Transfer Alternatives

If the food production is to be increased where its shortage prevails, i.e., in the third world countries and also the transfer of technology responsible to enhance the agricultural production is to be limited, then the question arises: What other alternatives exist to achieve the food self-sufficiency goals in these areas? The only tangible solution is that the developing nations must design their agrarian systems that are capable of using labor more intensively while increasing agricultural output and rise above their role of testing

and adapting foreign manufactured equipment for local marketing to the development of selective equipment that is appropriate for local manufacture utilization. Import only the concepts, not the material, and try to manipulate with these concepts according to one's needs. Selective and appropriate agricultural mechanization essentials to meet food production targets of developing nations can be realistically manufactured locally (3). Obviously, selective or appropriate agricultural mechanization implies considering needs and means of the farmer, adaptability to local manufacturing, capability of increasing yields and total food production, minimizing post harvest losses, and minimizing social costs of unemployment, labor displacement, and income disparity.

Appropriate technology concepts relevant to a particular economic environment should be selected for scarce capital and labor abundant nations, i.e., the manufacturing enterprises must be labor intensive with minimum capital requirement. And the engineering solutions must be consistent with the locality in question – capital, material, and skills.

Established relationship between commercial and subsistence production and level of technology (3) indicates that most of the machinery market in the third world countries is in the range of intermediate technology-appropriate technology. This offers an opportunity for local small manufacturer to adapt directly to the particular requirements of the local market served, and thus provide appropriate level of technology compatible both with his manufacturing capability and farmers' needs.

Training and development of many local entrepreneurs and artisans for small manufacturing processes are to be encouraged. The welding, casting and machining trade must be propagated to provide local assistance to farmers for repair and maintenance of small machines. Small local artisan firms, of which black-smith would be one, make intensive use of the apparent abundant factor, labor, and less use the apparent scarce factor, capital (7). The exclusion of this important service segment from local manufacturing section will limit spread of the concept of local manufacturing. This approach will help spread small manufacturing throughout the country and diversify as to type of machines produced.

Agricultural machinery consists of four categories: hand tools, simple machinery and equipment, tractors and trailed implements, and self-propelled machines. The transition from hand tools to simple machinery is difficult because it requires higher order of engineering in the production of metal machine parts. If this transition is achieved the next one to tractors trailed implements is relatively easy.

How to develop a selective mechanization both with respect to the feasibility of the local manufacture as well as for serving the local agricultural and social needs for increased food production, labor utilization, and income distribution? For this, the following points are worth considering:

1. Local design and manufacturing based on established engineering principles – development of bullock powered tillage system, like, chisel tool with fertilizer attachment for dry farming and a rasp-bar mini-thresher and winnowing machine for rice (2).
2. Development of new principle to meet a new set of circumstances – not necessarily a re-invention of an already established principle but sometimes a new idea is needed to cope with existing circumstances. For example, the development of a new rice threshing technique for harvesting standing grain to minimize shattering losses of lodged rice (3).
3. Adoption and extension of existing practices from one developing country to another or from one region to another within a country. For example, a foot-pedal drum thresher which is light weight, simple in design, and readily reproduceable locally from indigenous material at nominal cost, easily operated and maintained, and is labor intensive. This model has been successfully used in Taiwan and can be used in Indonesia if considerable changes in the traditional harvesting system are made (10). Similarly, a Korean rice transplanter with necessary modifications can give satisfactory performance in Pakistani rice fields (6).
4. The production of agricultural machinery in the third world is overwhelmingly in the hands of small artisans, who supply the needs of the majority of agricultural producers. The local manufacturers are unquestionably best acquainted with local conditions; however, on the other hand, they may be somewhat deficient at the outset in design, fabrication, assembly, and marketing know-how. Local manufacturers, thus need assistance in getting started.
5. The large corporations have monopolized the market, thus the alternative for the medium-sized firms is to carve out for themselves through product specialization and extensive innovations. Such firms can be domestically-owned enterprises to help offset the concentration on heavy mechanized equipment of the transnational giants.
6. Establishment of new machinery companies should be encouraged which can be located near the buyers. Their products – hand tools, chemical appli-

cators, simple trailed machinery, irrigation devices, processing equipment, etc can be specifically adapted to local economic and social conditions. These companies can devote a large part of their time for maintenance services and also can operate short-run production. These artisan workshops can play an important role in development of intensive cultivation systems by gearing their production to the needs of the rest of the economy. Therefore, they should be developed as an essential source of technological and organizational innovation.

7. With falling land/worker ratios in the agricultural sector of many poor countries, the effectiveness of heavy machines is to be declined. Thus, rapid development of intensive agriculture necessitates technology innovation in the production of fixed agricultural machinery and in the production of equipment which will complement and not replace human labor. Mechanization should not increase agricultural unemployment, thereby worsening the pattern of rural income distribution.
8. Development of light motorized and fixed equipment helps in diversification and intensification of cultivation, it would also give greater scope to small and medium-sized engineering firms.
9. Adapt trailed assembly to a small scale production infrastructure and augment the application of biological-cum-chemical inputs. Indeed, in the long run, a biological-chemical model could replace the current emphasis on mechanization as the main means for increasing agricultural productivity. However, such a transition will be very costly and the relationship of the agricultural machinery industry to producers of biological and chemical agricultural products is not conducive to a change in the system which will suit agrarian practice in the third world (1).
10. The developmental approach being used in the People's Republic of China, capital scarce, labor-abundant situation, with small farm machinery manufacturers located in various commune villages, is a model worth considering by many developing countries.

An Imaginative Model

The development of the agricultural machinery industry in the third world should involve an analysis of the impact of proletarianization on all levels of production in the economy. In the past the development of agriculture as an "industry" has invariably meant the destruction of the small-scale enterprise and the proletarianization is now clearly under systematic pressure. This dominant property form is organically related to the deployment of an energy-intensive technology which leads to a concentration and centralization of decision-making power. Such a structure prevents a wide diffusion of information and creates a relatively rigid alternative hierarchy, making participation in managerial processes impossible for the majority of the people (1).

There are thus both social and material reasons for property ownership in small sections of the community – a process aggravated by a rapidly depleting physical environment. Failure to do so would inevitably result in increased worker alienation and class conflict, not an uncommon experience in the third world countries. The need to conserve resources and preserve social harmony requires the development of a different form of property ownership which would allow small farmers and artisans to retain their entrepreneurial capability and provide a medium for combining these skills with the greater production possibilities created by technological advance.

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Agriculture and Agricultural Mechanization in Nigeria



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Abstract

Nigeria is an OPEC country and is one of the fast developing countries of the world. It is endowed with abundant natural resources many of which are yet to be tapped. The present population is about 80 million with about 86 persons per km^2. About 60% of this population is engaged in agriculture. Thus, the country is predominantly agricultural and yet it is not selfsufficient in food. With its six different vegetation zones Nigeria produces several diverse crops and has a great potential for agricultural improvement through mechanization which can lead not only to self-sufficiency but exportation of several of crops as well. The "Green Revolution" programme launched by the present civilian government, if planned, directed and executed properly would surely go a long way in helping achieve that end.

Introduction

Nigeria is located between latitudes 4°N and 14°N and longitudes 2.5°E and 14.5°E in West Africa. It has an area of 923 769 km^2 (1).

There is a continuous widening of the gap between food demand and production. This is the most significant and disturbing feature of Nigeria's agriculture although it is the premier sector of the country's economy. Agriculture accounts for over 50% of the GDP, and until a decade ago, for about 80% of the total exports of the country (2). The key to the nation's economic growth, therefore, should be to raise the productivity of the agricultural sector irrespective of how viable any or all the other sectors of the conomy may be in order to conserve foreign exchange.

To boost agricultural productivity, many suggestions have been made in the past and many programmes have already been initiated such as transfer of advanced technology from developed countries; establishment of many research institutions; river basin development authorities for massive water storage and irrigation systems to supply even water throughout the year; development of credit systems; massive introduction and use of agricultural machinery and equipment; establishment of national industries; etc.

Climate and Soils

There is a wide variation in the climate and soils of Nigeria from north to south and its dominant effect on natural vegetation and distribution of crops is clear. Generally, six distinct vegetation zones are recognized: i) Sahel, ii) Sudan Savanna, iii) Northern Guinea Savanna, iv) Southern Guinea Savanna, v) Rain Forests, and vi) Mangrove Forests (swamps) (**Fig. 1**). These illustrate enormous diversity in the amount, intensity and duration of climatic parameters, particularly rainfall. The start and end of the rainy season, the amount and intensity of rain vary, to a large extent, from north to south (3). The heavier rainfall occurs in the south (about 2 500 mm/annum) with a duration of over eight months in the year and gradually becomes sparse at the north and north-east of the country (about 300 mm/annum) and with a duration less than four months in the year. This variation and the influence of the trade winds give two distinct wet and dry seasons which result in a major portion of the land area to fall under arid and semi-arid conditions with a long spell of dry months during which "Harmattan" weather comes in. This brings fine dust particles in the form of cloud from Sahara. Normally the dry period starts from October and ends in April and the harmattan weather gradually reduces to zero towards the southern coast.

The soils and their formation in

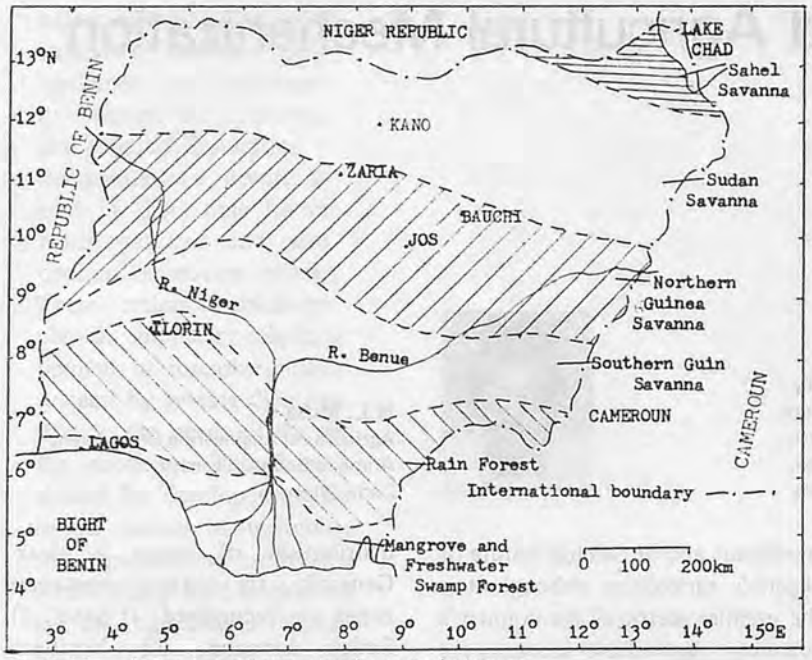


Fig. 1 Map of Nigeria indicating the six ecological zones.

Nigeria were in harmony with the climatic parameters and in turn have enormous diversification. Ferruginous tropical soils are the normal product of soil formation for most part of northern Nigeria (4) while alluvial deltaic soils are found at the extreme south of the country. Under drier than average conditions, brown and reddish brown soils of arid and semi-arid regions are found, while ferrallitic soils and ferrisols occur in area with higher and better distributed rainfall. Vertisols, eutrophic brown soils, and juvenile soils are found in some places.

The country experiences a fairly uniform temperature throughout the year and a little variation that exists is dependent on topography and location. The maximum and the minimum temperature are normally 35°C and 17°C, and the average variation is within 10° ±2°C.

Table 1 Land Utilization in Nigeria

Item	Area	
	million ha	%
Land area	91.08	96.6
Arable land	23.00	25.1
Permanent pasture	20.85	22.8
Forest and woodland	31.07	34.1
Other land	15.17	16.9
Total area	92.38	100

Source: FAO Production Yearbook, 1979.

Table 2 Production of Crops in Nigeria

Name of crop	Area harvested 1 000 ha			Yield t/ha			Total production 1 000 t		
	1977	'78	'79	1977	'78	'79	1977	'78	'79
Sorghum	6 000	6 000	6 000	0.62	0.63	0.63	3 750	3 770	3 785
Millet	4 920	5 000	5 000	0.60	0.61	0.62	2 950	3 060	3 100
Maize	1 620	1 638	1 665	0.87	0.83	0.90	1 350	1 480	1 500
Rice (paddy)	325	414	528	2.00	2.03	1.89	647	842	1 000
Wheat	14	14	14	1.56	1.56	1.50	21	21	21
Roots & tubers	2 848	2 850	2 951	8.74	10.09	10.02	27 730	28 755	29 565
Cassava	1 100	1 100	1 150	9.64	10.00	10.00	10 600	11 000	11 500
Grain legumes	4 210	4 210	4 215	0.19	0.20	0.21	800	852	903
Groundnut (in shell)	820	600	600	0.36	0.75	1.04	300	450	631
Palm oil	–	–	–	–	–	–	660	670	675
Peppers	65	67	68	0.08	8.96	9.12	590	600	620
Sugarcane	15	15	16	51.00	51.33	51.28	765	770	800
Cocoa beans	720	700	700	0.28	0.23	0.6	202	160	180
Seed cotton	704	635	567	0.35	0.19	0.19	234	117	110

Source: FAO Production Yearbook, 1979.

Land Utilization, Food Production and Consumption

Land utilization in Nigeria is shown in **Table 1**. Virgin land is still abundant and awaits to be developed for agriculture. Rough estimate gives 10 – 15% of arable land under current cultivation. Recent development of some large farms by private and government agricultural projects might have raised this figure to over 25 to 30% of arable land under cultivation.

Table 2 shows some of the crops produced in the country. The yield per ha is quite low compared to some countries but overall total production is not insignificant. The food import bill in 1970 was ₦ 58 million (one ₦ = 1.50 US $) and rose to ₦ 95.2 million in 1972 which reached over ₦ 1 020 million by 1978 (5). **Table 3** gives some of the food items imported. These import figures are likely to be higher each year due mainly to the rapidly increasing population, rural to urban migration and changing food habits. However, there is a great potential for increasing yield through the introduction of suitable and appropriate technologies which include mechanization for the development of agriculture.

Table 3 Important Food Items Imported into Nigeria during 1978

Item	Values (million ₦)
Rice	175.8
Sugar	157.2
Fish	125.7
Wheat	110.3
Maize	93.4
Beef & poultry	63.4
Vegetable oils and others	294.0
Total	1 020.0

Population

The population growth of Nigeria is about 2.5 to 3.0% per annum. **Table 4** gives the growth and the percentage population engaged in agriculture. It shows that agricultural population is on the decline being 56.0% in 1977. This is because of the movement of the people, especially the youth from rural to urban areas in search of white collar jobs. The result is an acute shortage of labour, particularly during the peak growing period. Population drift to urban and non-agricultural sectors may auger well for mechanization of agriculture with the creation of land and market situation such that it will take the advantage of large acreages and disposal of produce with profit to such markets. Flexibility in land tenureship is also created by labour drift from rural to urban areas which renders itself to possible large acreages in land holding for those who remain in the farms. These factors have created a favourable situation in Nigerian agriculture that will lead to mechanizing many of the production operations particularly to the reduction of labour requirements and drudgery and thus increases the productivity.

An estimate indicated that there are about 10 million farm families in Nigeria (exact figures are not available). Each family consists of three to six members and can farm about 1–3 ha, of land in the hoe farming systems. Farm size and the farmer's capacity to farm more land is increasing with the introduction of mechanization, hired labour force and other inputs, particularly fertilizers and pesticides.

Table 4 Population Distribution

Unit: 1 000

Year	Population		Economically active population	
	Total	Agricultural	Total	Agricultural (%)
1965	48 779	32 404	20 273	13 467 (66.4)
1970	55 073	34 178	22 277	13 825 (62.1)
1975	63 049	36 390	24 665	14 236 (55.7)
1977	66 778	37 366	25 747	14 406 (56.0)
1978	72 217	39 765	27 638	15 218 (55.1)
1979	74 595	40 420	28 337	15 254 (54.2)

Source: FAO Production Yearbook, 1979.

Means of Production in Existing Farming Systems

Human labour is the main source of farm power and accounts for about 90% of power in agriculture (6). Animal and tractor power have been in use but to a limited scale. Some factors limiting the application of animal and tractor power include the following (7):

- A large number of farmers live on subsistence level and have an extremely low capacity for investment on required inputs;
- The present infrastructure of the agricultural areas is unfavourable for large and full scale mechanized operations;
- A high level of illiteracy and lack of experience in use of machinery and equipment prevail;
- Almost all machinery have to be imported;
- Animal mechanization is limited to tsetse fly regions;
- Although Nigeria is an oil producing country, there exists a scarcity of fossil fuel, steel products, and spare parts for machinery, while the supply and delivery of these items are also irregular. Majority of the farmers are still dependent on their hand tools applying poor techniques of production and limited to a small acreage; and thus the productivity per ha and per farm worker is very low.

Farm Mechanization Status

A state of mechanization is identified in Nigeria's evolutionary process and which may exist in one, two, or all in combination in the country depending on locality and certain socio-economic and natural barriers:

1. Early development stage of traditional agriculture where the use of simple hand tools was and is the only technology that has sustained the population through ages.
2. The stage of the use of introduced improved hand tools, animal and tractor drawn equipment. The initial introduction of animal and tractor drawn equipment has mainly been concerned with land preparation and transportation only.
3. The stage of research and development for efficient application of modern technologies in Nigeria's unique agricultural production systems. This includes the intensified investigation into the use of motorized machines for all farming operations with respect to changes in climate, soils and crops. Use of imported seeds, fertilizers, livestock breeds, pesticides, cultural practices, etc. are also included.

Presently, manual power production system still contributes over 90%, while animal power only 7 to 9%, and tractor power less than 1% in all the domestic agricultural production (6). There is no well defined path or stage in the development of agricultural mechanization in the country (8). In fact, tractor power was introduced earlier than animal power (6). With this mixed state of mechanization in Nigeria, the following account can be made for tools and imple-

ments associated with each of the three power sources, and for the stationary devices.

Hand tools and equipment are presently playing a leading role, which consist of various hoes, cutlasses, matchets, axes, sickles and bare hands – these constitute all the major tools in some of the field production operations. Sometimes some post-harvest product processing operations are accomplished with bare hands, knives, mortar and pestle and grinding stone. Of particular interest, hand hoes are the major tillage tools and these have typical shapes and sizes **(Fig. 2)** depending on ecological conditions (9), particularly soil types, crops, cropping techniques, vegetation, rainfall and culture. The various shapes and sizes have been evolved through generations of trial and error. Since soil texture becomes higher northwards from Zaria **(Fig. 1)**, the further north one gets the easier it becomes to till the land. Thus the size of the hoes are smaller and lighter at those places while down south and around Zaria and Jos Plateau areas the soils are heavy and the size of hoes are larger and heavier. The shape of the hoe and also its handle size has definite bearing to the mode it is used. All these have led the hand hoes to have different names such as:

i) Weeding hoe (Fartanya) most adopted for weeding and some harvesting, including minor soil tillage. ii) Harvester (Magiribi) hoe is a special weeding hoe made heavier for cutting down stalks and sometimes ears of sorghum, millet and maize. iii) Ridging (Garma) hoe for ridging or to make ridges and other minor tillage work. iv) "Sungumi" hoe is a long handle specialized weeding hoe used for planting in light sandy soils of northern Sudan Savanna to the subsahelian areas. v) Ashasha hoe, a long handle hoe, for weeding in light soils where weed infestation is less severe.

Animal power and equipment are very limited in use due mainly to the tsetse fly problem and unavailability of locally produced animal drawn equipment. The Emcot ridger is the only animal drawn tillage implement which is available locally and widely used. Sometimes an ox-cart is also used. The John Holt Agricultural Engineering Company at Zaria manufactures the Emcot ridger which is used for ridging and ridge remoulding. Attempts are currently going on to popularize the use of Ariana and Arara tool bars which come along with various tillage attachments for efficient seedbed preparation and cultivation and also with a groundnut lifter attachment.



Fig. 2 Some hoes used in Nigeria.

Separate planter units are available with potential adoption such as the Super Eko planter of Senegal. The Institute for Agricultural Research (I. A. R.) at Zaria did some successful research in the use of donkey for farming. Donkeys are used in Nigeria only for transportation and the I.A.R. has shown that these can be used successfully for farming operation like planting and weeding **(Figs. 3 and 4)** for a certain type of soils of northern Nigeria (10).

Motorized power units and equipments in use are mainly standard size two-wheel drive tractors of 35–70 kW with mainly the implements for seedbed preparation, such as disc ploughs, disc harrows and disc/double mouldboard ridgers **(Fig. 5)**. Nigerian experience to date indicate that power tillers are not suitable (8) for primary cultivation or for seedbed



Fig. 3 Donkey used as a draft animal (planting).



Fig. 4 Donkey used as a draft animal (weeding).



Fig. 5 A tractor used for harrowing.

preparation of conventional dryland farming. Some other difficulties experienced are:

- Low rate of work with respect to the type of crops grown;
- Inability to work in fields not properly cleared of stumps;
- Low clearance as such unable to work on ridged fields which is a common method of cultivation in Nigeria;
- Too much vibration making the operator very uncomfortable and prices too high to afford by individual farmers;
- Lack of proper and matching implements to suit Nigerian soils, crops and vegetation;
- Lack of spare parts and inadequate after sales service;
- Lack of proper training of farmers for their efficient use.

Conclusive results, as such, cannot be drawn about power tillers. Optimistically, if some of the above difficulties are taken care of, may be the power tillers would be acceptable for some specific farm operations such as in rice, sugar and vegetable production.

In contrast to power tillers, tractors are gaining popularity in Nigeria at a very fast rate. Their first use dates back to 1930, but not popularized until "Tractor Hiring Units" (THU'S) were introduced by the then regional governments in about 1958. Since then the number of tractors have increased continuously. The THU's serve the farmers from farm centres established throughout each state by hiring of tractors, particularly for land clearing and land preparation (ploughing, harrowing and ridging) and for transportation. Not until recent times are some of these efforts being put in introducing mechanical planters with or without fertilizer attachment and sometimes combines for harvesting of wheat and rice in government schemes and projects.

In 1976, about 95% of the tractors were (11) medium type 37-60 kW range, 2.5% light type 26-37 kW range and 2% heavy type 75-104 kW range. In the same year, ten companies were identified to be distributing tractors of several types and makes such as Ford, Massey Ferguson, David Brown, International Harvester, John Deere, Steyr, Mercedez Benz, Deutz, Caterpiller, etc. Such wholesale importation of several kinds and makes of sophisticated machinery have not been backed by adequate supply of spare parts, repair facilities (**Fig. 6**), training of operators and similar after sale service facilities which have seriously hindered progress in agricultural mechanization in the country (8).

The tractor population in Nigeria is shown in **Table 5** but the actual number may be higher as the base was taken to be 10 000 in 1977 (11) with the projected tractor population to reach 200 000 by the year 2 000 with the mean power around 50 kW. The same estimate indicated that about 40 000 tractors (in 50 kW units) should be supplied in the year 2 000 to meet the agricultural mechanization needs of the country.

Stationary devices include the popular manually operated Kano type semirotary groundnut decorticators; water pumps powered by mostly 'Lister' diesel engines and windmills for domestic water supply; sugar cane crushers powered by horses, and community grain milling machines which are again powered by Lister diesel engines and/or electric motors. Many types of vegetable milling machines, grain grinding machines, maize shellers both manual and power operated, are appearing in the market. A few machines such as grain and vegetable milling machines and pounded yam machines are begining to be manufactured locally.



Fig. 6 Lack of spare parts and repair facilities made this modern sophisticated 'Combine' a 'Stationary thresher'.

Table 5 Agricultural Tractors in Nigeria

Year	Number
1976	7 900
1977	7 900
1978	8 100

Source: FAO Production Yearbook, 1979

Current Trends and Prospects of Mechanization

Several programmes were taken, as mentioned earlier, by various regimes of the Nigerian governments to improve agricultural output of the country. In the arid and semi-arid parts of the country the most pressing need is water conservation and utilization and erosion control and, thus, the government took the right decisions to develop 11 river basin development projects (12).. With all these river basin development programmes (**Table 6**), if properly developed and managed, the country could be self-sufficient in food within the near future.

The other programmes are the National Accelerated Food Production Programme (NAFPP) and the Operation Feed the Nation (OFN) which has been replaced by

Table 6 List of River Basin Development Authorities (RBDA)

1	Anambra – Imo RBDA
2	Benin – Overri RBDA
3	Chad Basin DA
4	Cross River BDA
5	Hadejia – Jama'are RBDA
6	Lower Benue RBDA
7	Niger Delta RBDA
8	Niger River BDA
9	Ogun-Oshun RBDA
10	Sokoto-Rima RBDA
11	Upper Benue RBDA

the "Green Revolution" programme. The NAFPP envisaged to establish 187 agro-service centres (13) throughout the country by 1982. It has also plan to establish an Agro-service Centre System (ASCS) with one national headquarter, 19 state branches and 2 500 ASCS Retail Centres in the country. Each of these retail centre would have the following equipment: 5 tractors, 10 plows, 10 harrows, 5 ridgers, 5 trailers, 5 planters, 5 fertilizer spreaders, 5 sprayers, and 5 threshers (15).

The government has also set up a number of development authorities' projects whose activities encompass all farming activities, including mechanization. In addition, a number of research institutes were established based on crops such as Horticultural Research Institute, Rice Research Institute, Cocoa Research Institute, Oil Palm Research Institute, etc.

Another way the government is influencing mechanization is through the setting up of commodity boards and production companies such as Groundnut Board, Cocoa Board, Cotton Board, National Grains Production Company, National Roots Crops Production Company, etc. These organization can help farmers in marketing their produce and advising them to adopt improved cultural practices.

In addition, there are departments of agricultural engineering in the universities, Nigerian Science and Technology Development Agency, ministries and colleges of agriculture, etc which are influencing farm mechanization through training, research and development.

There are already two companies which assemble tractors in Nigeria. These are Steyr in Bauchi and Fiat in Kano. The Steyr assembles Models 768 (70 hp) and 1108 (115 hp) while the Fiat assembles Models 300 (28 hp), 640 (60 hp) and 780 (70 hp). The Fiat company produces 2 500-4 000 tractors per year. If the two different makes of tractors are operationally satisfactory they would go a long way in solving some of the country's major repair and maintenance problems by servicing comparatively small number of several makes of tractors.

Efforts in mechanization now have centred around the establishment of a National Institute of Agricultural Mechanization at Ilorin, Kwara State, whose function would be to test, develop and fabricate agricultural machines and equipment suitable to Nigerian conditions.

With all these projects and programmes, the present civilian government has placed a greater emphasis on agricultural sector than ever before and has launched a "Green Revolution" programme for the country with almost a new approach to the agricultural development. This is an integrated and multi-disciplinary rural development approach which will take into account major factors affecting the welfare of the rural population during the next development plan. This approach would, in addition to promoting agricultural production, take efforts to improve social amenities in the rural areas through feeder roads, water supply, electricity, and storage facilities, etc.

Pilot Agricultural (Rural) Development Projects (ADPS) proved successful and would be extended throughout the country. This will be combined with the Accelerated Development Area (ADA's) programmes to cover the residual areas also (16).

The above account shows that several efforts are being taken for improving agricultural activities, including farm mechanization aspects. As already stated earlier, many of such mechanization efforts were not fully effective due mainly to wholesale importation of machinery from abroad. This is because many of the local crops (such as roots and tubers) and cultural practices (such as intercropping and ridge planting) there are no suitable machines to import from abroad. Similarly, for many of the post-harvest handling and processing activities, including storage works no such equipment exist elsewhere.

These points call for indigenous design and development of agricultural machinery which has to be functionally operative. That is, the various machines, equipment and gadgets have to be suitable to crops, applicable to most of the production oprations, simple to operate and maintain, appropriately sized to suit the scale of operation of the farmers and inexpensive to be within the farmer's financial reach.

It has been observed that established manufacturers in Europe, America and other countries do not find it economical to develop and produce special machines/equipment suitable to local crops and farmers (8). This has to be done by engineers, technocrats and researchers of the country. The government is to give due importance and incentives for such works.

Many useful works have been done and are being done on the design and development of the relevant agricultural machinery and equipment in the country. Examples are an automatic cassava cutting planter, a batch abrasion cassava peeler, a spinning disc mellon shelling machine, a two-band on-the-ridge fertilizer applicator, a corn dehusker, etc. of the University of Nigeria, Nsukka; a portable grain planter, a cowpea sheller, a cassava stem-cutting planter, a cassava root digger, a kenaf decorticator, etc. of the University of Ife, Ile-Ife; an animal-drawn rotary weeder (**Fig. 7**), a cowpea thresher, a groundnut

sheller (Fig. 8), a hand maize sheller, a ground-metered-shrouded-disc (GMSD) sprayer (Fig. 9), etc. of Ahmadu Bello University, Zaria. Similar other efforts are being taken by some other organizations, including International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, which has developed a punch planter, a cassava manual lifter, zero tillage technology, etc.

All the above taken together have began to form some elements of an agricultural technology development that surely is indigenous and capable of blazing a path to progress in Nigerian agro-technology. This, of course, needs the right kind of continued research and development before any particular device is ready for use and accepted by the farmer. The government has also to foster and nurture the local manufacturing and distribution of all those indigenously developed agricultural machines which are found to perform satisfactorily. There is also a necessity of coordinating and superintending all these activities at national level because efforts may be wasted by an individual researcher or organization by repeating the mistakes or duplicating successes made elsewhere in the country by other researcher or organization. The National Agricultural Mechanization Centre should start a programme which would be responsible for these works in order to ensure a sustained progress by assuming the authority and providing resources through fixing priorities, monitoring progress, identifying talents, giving incentives with proper recognition and effectively recommending urgency of the activities that are needed for overall development of agricultural mechanization.

Conclusion

The following points are emphasized for appropriate development of agriculture and its mechanization:

1. Agriculture will continue to be the mainstay of Nigerian economy. As such continued due attention for its overall development should be given.
2. There is a strong belief and conviction that the mechanization of Nigeria's agriculture is indispensable and inescapable for growth, industrialization and food supply.
3. Suitable or appropriate technologies should be innovated or adapted from existing technologies to suit local systems of production of various crops.
4. To fully reap the benefits of agricultural mechanization the country must dispense with exclusive dependence on foreign machinery. Rather, there is need to strengthen the activities for indigenously designed and developed agricultural machinery and equipment which are suitable to local conditions and within the managerial ability and financial reach of the farmers. Additional efforts and proper incentives should be given for local manufacturing and distribution of viable machinery evolving from such research and development.



Fig. 7 An animal-drawn rotary weeder (developed at the I.A.R.) at left led to the development of a rotary hoe developed and manufactured by M/S John Holt Agricultural Engineering Ltd, Zaria, at right.

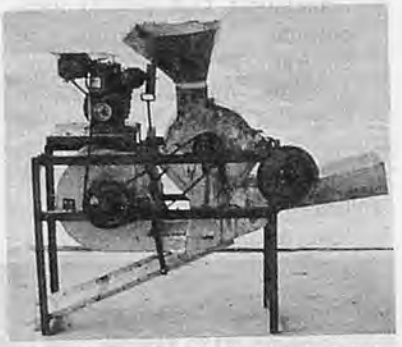


Fig. 8 A groundnut sheller developed at the I.A.R., A.B.U., Zaria.

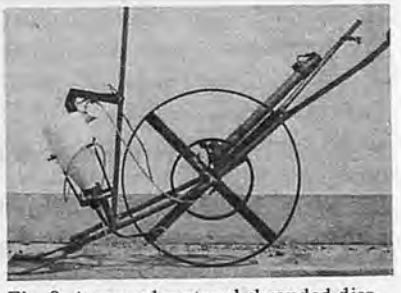


Fig. 9 A ground metered shrouded disc very low volume (GMSD-VLV) chemical sprayer developed at the Institute for Agricultural Research, Ahmadu Bello University, Zaria.

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Japanese Agricultural Machinery Catalogue '83

This bi-annual Catalogue is published in odd-numbered years. This 1983 edition introduces the latest models and designs of Japanese agricultural machines, equipment and facilities in 154 color and black/white photographs in 36 pages. Detailed specifications of each product are provided in 220 pages. It lists 300 leading machinery manufacturers in a directory that is conveniently indexed by trade and brand names of the product.

Other features in Japanese include recent breakthroughs and innovations incorporated in the design and functions of the new models.

The catalogue measures 18 cm x 25.6 cm, in limp cover and sells for ¥6,800 (sea mail) and ¥7,800 (air mail).

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Harvest and Post-Harvest Management of Crops in Semi-Arid Tropics

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Abstract

Crop production has increased substantially as a result of the green revolution in developing countries. The benefit of higher production is being lost in the absence of adequate harvest and post-harvest management required to handle this increased production. This paper reviews the existing pattern, problems identified, research gaps and appropriate directions to generate an efficient harvest and post-harvest management for semi-arid tropics (SAT) regions of India.

Introduction

Farming is a major agro-based industry in the semi-arid regions of the world. Crop yield has increased substantially with the introduction of new varieties, fertilizers and better land and water management. Crop production can be further increased by moving from single to double cropping which can most easily and reliably be practiced with irrigation facilities. However, increased cropping intensity is also possible in rainfed agriculture by better land and water management. It has been demonstrated that the introduction of short duration varieties has made this technique much more widespread where there is sufficient moisture to support a second crop (Krantz, *et al,* 1978).

The benefits of higher crop production are lost if appropriate harvest and post harvest management are lacking to handle this increased production. The inadequate harvest and post harvest management is created by the time and labour constraints at harvesting, threshing and drying operations.

This paper reviews the existing pattern and problems and identifies research gaps and appropriate directions for future research work to bridge the existing gap for the generation of an efficient harvest and post-harvest management required for loss prevention of cereals and pulses on the farm.

Characteristics of SAT Regions

The semi-arid tropics is defined as those areas in which rainfall is concentrated in a short period and exceeds evapo-transpiration for 2–7 months in a year. The average rainfall during this period may range from 500 to 1 200 mm, but is highly variable in time and quantity.

Much of the rain, however, occurs within the rainy season (Krantz, *et al.* 1978). Because of the uncertainties of the rainfall, the risk involved in agriculture are deterring farmers from investing in inputs such as fertilizers, improved seeds and improved agricultural machinery. Water is the most limiting factor in SAT areas for increased and stablized crop production. The SAT regions of Asia and Africa are characterized by small farm size. In Asia, 95% of farms are less than 10 ha in size while for Africa, the figure is about 85%. Crops are raised primarily under rainfed conditions. The average cropping intensity seldom exceeds 100% (Ryan, 1978).

Most of the developing SAT countries (particularly in Africa and Asia) are still heavily reliant on human labor and animal power for their farm energy. Human and animals provide up to 75–98% of the total power for different regions (Subramanayam, *et al,* 1975). Most farmers in the Indian SAT use basically three traditional implements, namely; a wooden (desi) plough; a blade harrow consisting of a steel blade fixed on a wooden frame; and two- or three-row seeder with hand-metering of seeds (Tiphan). All the three implements appear to be satisfactory in meeting the need of the farmer at a low level of production that generally prevails. The crop performance can be improved sub-

stantially by timely completion of the field operations, better placement of the seed and fertilizer and appropriate weed control measures (Bansal, *et al.* 1981).

Need and Relevance

Cropping Patterns

Cultivated fallow in the rainy season, (Kharif fallow) is a common practice in deep black soils of SAT regions (Madhya Pradesh, Andhra Pradesh and some parts of Maharashtra) in order to raise a crop in the post-monsoon season on residual stored moisture. Operational-scale research on natural watersheds at the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), India has demonstrated that substantial profits (after deduction of all costs including those related to capital investments) can be earned by higher input intensive farming systems than currently practiced by farmers (Binswanger, *et. al.* 1980). Rainy season crops with intercropping are considered feasible in a number of Indian situations as evident from **Table 1**.

The results of experiments at ICRISAT show that intercropping of maize/pigeonpea is more profitable than maize/chickpea sequential cropping in case of deep, medium and shallow vertisols (Binswanger, *et al.* 1980). Sorghum/pigeonpea and millet/pigeonpea are the other intercrops being evaluated for blacksoils and red soils under operational scale research at ICRISAT. When planted with pigeonpea as an intercrop sorghum, millet and maize should be harvested at high moisture contents at physiological maturity to allow the pigeonpea to receive an adequate amount of light for its growth. The introduction of short duration high yielding varieties has increased the intercropping and sequential cropping to a great extent. The second crop is raised on the residual moisture in the soil.

In recent years, there is a growing interest in relay cropping, which requires planting of second crop in the standing first crop. To allow the optimum growth of second crop, the removal of first crop is done as early as possible.

Unfavourable or unpredictable weather is the most common problem reported during harvesting and threshing of rainy season crop. This causes undue delay in harvesting and post-harvest operations resulting in quantitative and qualitative losses from rotting, discolouration and sprouting of grains. These losses are increased due to scarcity of labour during this crucial period. Pilferage, bird attack, insects, rats and other pests are also a part of the system tending to reduce the total potential harvest.

When sorghum and millet are raised in the rainy season, the ratooning of sorghum stubbles after harvest makes the planting of second crop more difficult and their growth is checked. Efficient methods and equipment are required to get rid of these stubbles. Besides this a suitable equipment is required for planting of the next crop in the standing sorghum or millet crop.

Early Planting and Harvesting of Rainy Season Crop

In many Indian SAT areas the effective rainfall for crop production is limited to 3 to 4 months only (June–September) with a normal rainfall of 800 mm per year. With a soil profile that can hold up to 400 mm of stored water, including 200 mm available water, the growing season can be extended to another 2 or 3 months. In order to make double cropping successful under these circumstances, it is necessary to grow short duration high yielding varieties so that a second crop can be planted under receding soil moisture. It has been proved that the planting of crops with the pre-monsoon showers would be a risk worth taking because dry sowing produce a vigorous crop (free from pests and diseases and minimize weed competition) (A.P. Agril. Diary, 1979).

A high-yielding variety crop (sorghum and millet) planted in the middle of June will be available for harvest during the last week of August or first week of September, with high probability of rainfall, high relative humidity and thus high soil moisture (**Figs. 1 and 2**). This creates harvesting and thresh-

Table 1 Predicted Cropping Systems for Selected SAT Regions and Soil Types in India

Region	Rainfall	Soil type	Cropping system
Sholapur (Maharashtra)	Low	Deep Vertisols[1]	Rainy season follow (possibly short duration low input rainy season crop in same years.
Madhya Pradesh	High	Deep Vertisols	Potential for rainy season croppings to be intersified.
Hyderabad (Andhra Pradesh)	–	Deep Vertisols	Preferably rainy season crops with intercrop.
		Alfisols[2]	Rainy season crops with intercrop.
Akola (Maharashtra)	–	Medium to shallow Vertisols.	Rainy season crops with intercrop.

1. Vertisol black soil. 2. Alfisols –Red soils Source: Binswanger, *et al.* 1980.

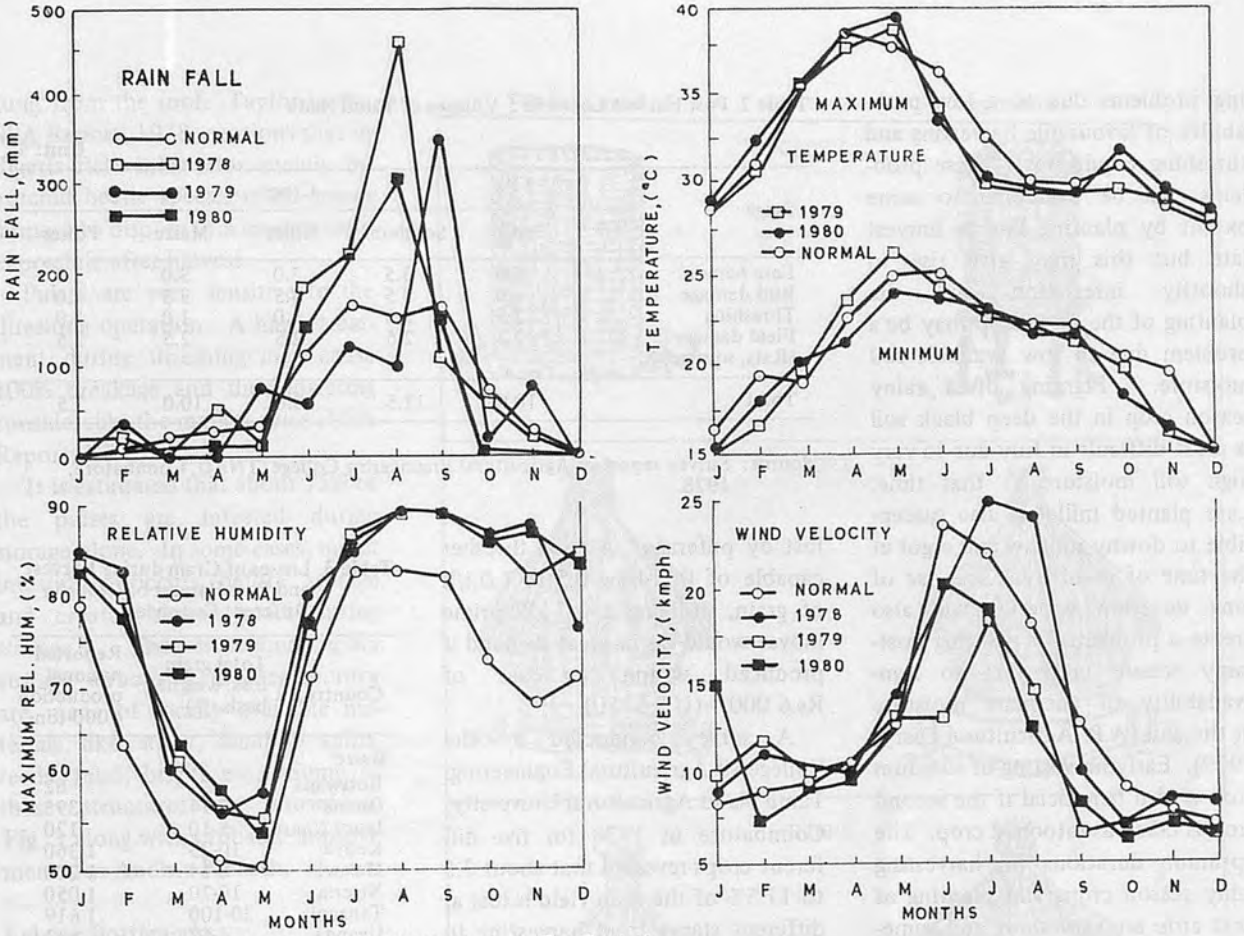


Fig. 1 Monthly weather conditions of Hyderabad, Andhra Pradesh

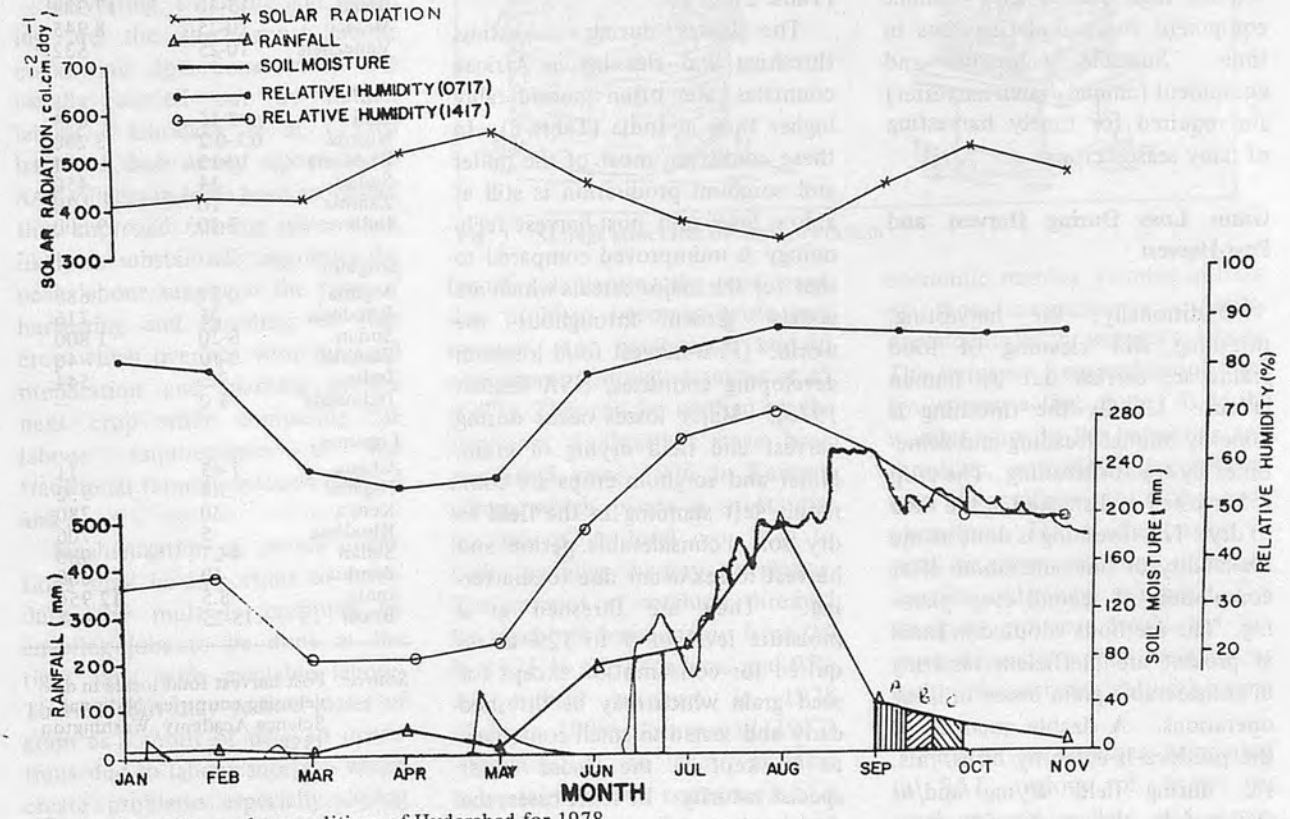


Fig. 2 Monthly weather conditions of Hyderabad for 1978

ing problems due to a low probability of favourable harvesting and threshing conditions. These problems can be overcome to some extent by planting late to harvest late but this may give rise to shootfly infestation and the planting of the next crop may be a problem due to low available soil moisture. Planting of a rainy season crop in the deep black soil is most difficult in July due to very high soil moisture at that time. Late planted millet is also susceptible to downy mildew and ergot at the time of maturity. The use of long duration varieties will also create a problem for planting post-rainy season crop due to non-availability of adequate moisture in the soil (A.P. Agricultural Diary, 1979). Early harvesting of sorghum crop is also beneficial if the second crop is taken as ratooned crop. The optimum durations for harvesting rainy season crops and planting of next crop are very short and sometimes overlap each other and may require high labour and suitable equipment for completing jobs in time. Suitable techniques and equipment (animal drawn harvester) are required for timely harvesting of rainy season crops.

Grain Loss During Harvest and Post-Harvest

Traditionally, the harvesting, threshing and cleaning of food grains are carried out by human labour. Usually the threshing is done by animal treading and sometimes by tractor treading. The crop is harvested and stacked in the field to dry. The threshing is done at the availability of time and labour after completion of second crop planting. The methods adopted in India at present are inefficient resulting in considerable grain losses in these operations. A sizable quantity of the produce is eaten by birds, rats, etc. during field drying and/or damaged by the attack of fungi or lost by pilferage. A good thresher capable of threshing 0.5 to 1.0 t/h of grain, utilizing a 3.7 kW prime mover would be in great demand if produced within a cost of Rs.6 000/–(U.S.$750).

Table 2 Post Harvest Losses in 5 Villages of Tamil Nadu

Unit: %

Stage	Crop				
	Paddy	Sorghum	Millet	Maize	Pulses
Late harvest	4.0	3.5	3.0	3.0	3.0
Bird damage	1.0	3.5	3.5	3.5	1.0
Threshing	2.5	2.0	1.0	1.0	1.0
Field damage (Rats, squirrels)	2.5	2.5	2.5	2.5	2.5
Total	10.0	11.5	10.0	10.0	7.5

Source: Survey report of Agricultural Engineering College, TNAU, Coimbatore, 1978.

A survey conducted by the College of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore in 1978 for five different crops revealed that about 7.5 to 11.5% of the crop yield is lost at different stages from harvesting to cleaning for market or consumption (Table 2).

The losses during harvesting, threshing and cleaning in African countries are often considerably higher than in India (Table 3). In these countries, most of the millet and sorghum production is still at a low level and post-harvest technology is unimproved compared to that for the major cereals which are widely grown throughout the world. (Post-harvest food losses in developing countries, NSA Report 1978). Major losses occur during harvest and field drying of grain. Millet and sorghum crops are commonly left standing in the field to dry for a considerable period and harvest losses occur due to shattering. They are threshed at a moisture level of 9 to 12% as required for consumption except for seed grain which may be threshed early and sealed in small containers to be kept in the house under special security. In some cases, the seed grain is kept unthreshed and

Table 3 Losses of Grain during Harvest and Post-Harvest of Crops in Different Countries.

Country	Total grain loss, weight basis (%)	Reported national production ('000 tons)
Maize		
Botswana	–	62
Ghana	7-14	395
Ivory Coast	5-10	120
Kenya	10-23	1 360
Malawi	6-14	1 200
Nigeria	10-70	1 050
Tanzania	20-100	1 619
Uganda	4-17	623
Zambia	9-21	750
India	6.5-7.5	6 500
Brazil	15-40	17 929
Mexico	10-25	8 945
Venezuela	10-25	532
Millets		
Mali	2-15	804
Nigeria	0.1-0.2	3 200
Rhodesia	10-15	564
Sudan	14	450
Zambia	10	30
India	7-10	9 600
Sorghum		
Nigeria	0-37	3 680
Rhodesia	25	716
Sudan	6-20	1 800
Zambia	0-10	46
India	7.5	544
Indonesia	4.0	–
Legumes		
Ghana	7-45	11
Nigeria	5.4	932
Kenya	30	280
Rhodesia	5	706
Sudan	4-27	980
Zambia	40	600
India	8.5	12 956
Brazil	15-25	1 923

Source: Post harvest food losses in developing countries, National Science Academy, Washington 1978.

hung from the roof. Taylor in the NSA Report, 1978 mentions that in Nigeria field infestation mainly by bruchid beetle species often causes farmers to dispose of a crop as soon as possible after harvest.

Pulses are very sensitive to the threshing operation. A harsh treatment during threshing may cause 100% breakage and thus lowering considerably the market price (NSA Report, 1978).

It is estimated that about 75% of the pulses are infested during storage alone. In some cases, insect infestation occurs before storage and creates higher losses during storage. The traditional grain storage structures in this country are made of locally available materials like straw, bamboo splits, reeds, mud, bricks etc. Some of these structures are shown in Fig. 3 along with probable improvements for Andhra Pradesh.

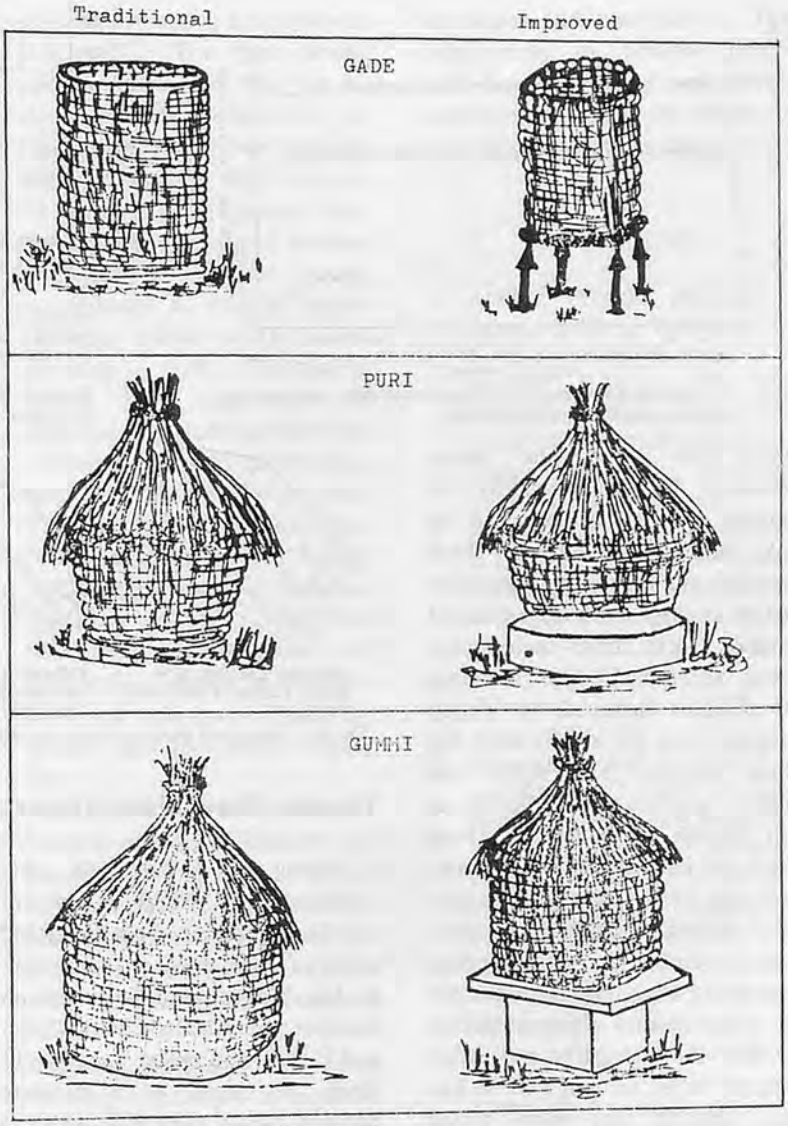


Fig. 3 Storage structures of Andhra Pradesh

Labour Bottlenecks

Harvesting, threshing and cleaning are the three most labour consuming operations which are usually carried out by human labour. Ghodake *et al.* (1976) based on their survey reports in six SAT villages in India have estimated that improved farming systems are likely to substantially aggregate the peak labour supply at the time of harvesting and threshing of first crop which overlaps with the land preparation and planting of the next crop while comparing the labour requirements in the traditional farming systems (Figs. 4 and 5).

Mechanization of certain operations may be important to introduce the multiple cropping by enabling jobs to be done at the right time with available labour. This in turn may reduce losses of grain as a result of delayed operations due to labour shortage which create problems especially during harvesting time. With the overlapping of planting the next crop, this problem becomes acute and requires to mechanize certain operations. (Mongkoltanatus *et al,* 1979). This can be verified by the fact that 5 threshers have been purchased since 1976 in Kanzara village which plants a substantial portion of its food crop area to high yielding variety sorghums. The amount of sorghum threshed by machines has gone up from 0% in 1975 to 90% for local and 97% for hybrid sorghum in 1978 (Calagar, 1978). Kemp *et al* (1977) observed that the labour problem in certain African countries is of a different nature. For cultural and economic reasons, farming in most of these countries is currently dependent upon women's labour. The farms are frequently controlled by women acting alone. It is the women who do the harvesting and threshing, sometimes because no men are available for doing such operation. The mechanization of small threshers will bring economic benefits and relieve drudgery. The threshing process should not become dependent upon male labour within the existing cultural framework.

Most of the threshers being used in SAT regions of India for sorghum and millets and some-

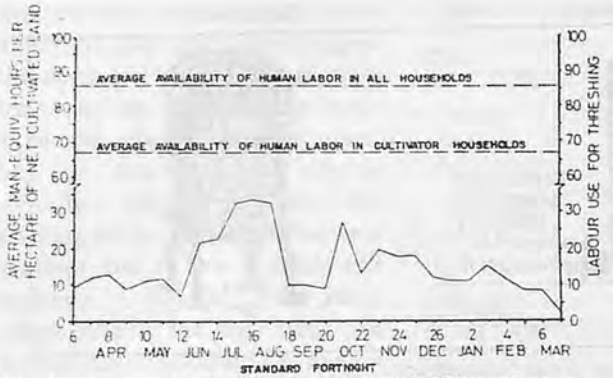


Fig. 4 Average seasonal human labour availability and use on all farms in Kanzara (1975–76)

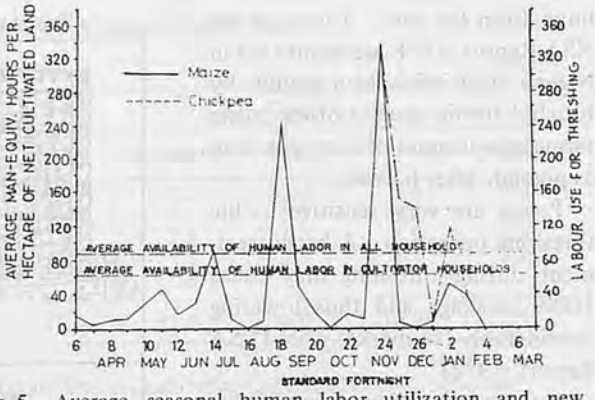


Fig. 5 Average seasonal human labor utilization and new watershed based technology

times even pulses are wheat threshers designed primarily on hammer mill principles used to make bhusa in north India. These are either manufactured in northern part of country or being duplicated locally. Apart from their higher power requirements as compared to threshers designed for paddy (ranging from 20 to 50 kW-h/t for wheat against 5–8 kW-h/t for paddy) these are not safe in operation (Pathak, *et al* 1978). These threshers had resulted in many accidents to the workers engaged for threshing. Most of the accidents are due to the faulty feeding systems on the threshers and some due to the absence of proper guards for the moving parts and poor labourers hired for this job. It has been reported that about 1 200 persons are being incapacitated by the use of poorly designed threshers every year in India. (Agricultural Engg. Today, July–August, 1980). The introduction of safe feeding devices (Fig. 6) may help in preventing some of these accidents (Verma, *et al,* 1978).

It has been reported that threshers with rasp bar and spike tooth cylinders primarily designed for paddy threshing are quite safe in operation but these threshers need several modifications in order to thresh sorghum and millet efficiently (Verma, *et al* 1978, Duff, *et al* 1975), Singh *et al* 1979, Singhal *et al* 1982).

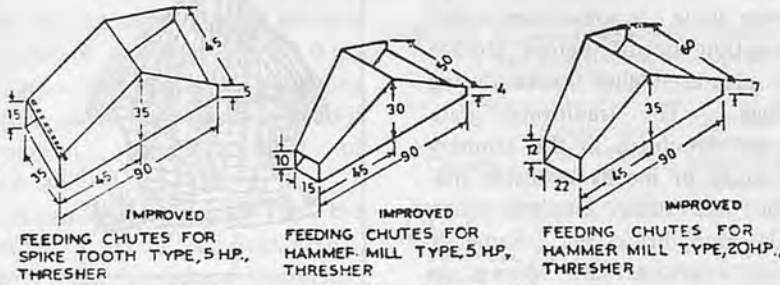


Fig. 6 Improved feeding chutes for different types of threshers.

Threshing Characteristics of Crops

During 1978–79 trials were conducted at ICRISAT on different threshers available from India and abroad (Small, medium and large). It has been found that sorghum varieties in particular CSH-1, CSH-6 and CSH-8, and millets are very difficult to thresh at a moisture content higher than 15% which is most common at the time of harvesting rainy season crops. When these crops are threshed at high moisture levels, it results in a considerable amount of seeds with glumes (5 to 15%) reducing the market price considerably (20 to 25%) (Parthsarthy Rao, 1979). An efficient multicrop thresher operated with a 3.7 kW prime mover and capable of threshing high moisture major crops grown in SAT regions will be highly welcomed by the farmers.

Level of Mechanization Needed

The phrase farm mechanization is commonly understood as an introduction of tractors and associated equipment to replace a large number of labours. The adoption of small tools and equipment for certain farm operations may help the small farmer by relieving him from drudgery. An example may be the introduction of a small to medium capacity thresher which will help the farmer to do the job in time with the labours available on the farm (Kaul, 1979).

Some researchers believe that the mechanization will reduce the total labour requirement (Binswanger, 1979). Mechanization with new agricultural technology requires more labour in order to increase yield. The additional labour is employed for handling a greater volume of crop produced. (Mongkoltanatus, *et al,* 1979). However, full mechanization is not possible in any case in developing agricultural countries. The development of suitable machines for harvesting, threshing and cleaning will enable the farmer to use the right equipment to get his produce

at the right time. Since the harvesting duration of rainy season crop overlaps with the planting of second crop, suitable planting equipments and methods are also desired to complete these operations in time.

Most of the harvest and post-harvest centers in India including IDRC-ICAR Operational Research Centres are concentrating their efforts on processing and storage of grains and by-product utilization on farm. Major crops included are rice, wheat and maize (Pandya, *et al,* 1980).

Future Areas of Research

The future efforts may be concentrated in the following areas to reduce the grain losses of crops resulting in the better harvest and post harvest management in the SAT regions of Asia and Africa.

1. Studies should be conducted to assess the probable effective field working days available with the farmer for the harvesting, threshing and cleaning and temporarily holding of rainy season crops and planting of next crop using different probability level of rainfall and soil moisture data. This study will help in the assessment of critical labour requirements during harvesting of rainy season crops within the optimum duration of harvest and planting of postrainy season crops under the traditional and improved farming systems. This study will also predict the expected quantitative loss of grains due to delay in post-harvest operations and several constraints with the farmer.
2. Efficient methods are required to hold the freshly harvested rainy season crops temporarily between harvesting and threshing to reduce the losses from unpredictable weather, molds, insects and pests and sometimes delay in processing due to labour shortage. The post-harvest operations on this crop can be done on the availability of labour after completion of planting for next crop. The crops can be stored either (a) using structures based on natural aeration as suggested by grain storage unit located at IITA in Nigeria (Moody, 1980) or (b) raised platform with transparent covers, with application of chemical salts and the like. This temporary duration of holding a crop may last for 4 to 6 weeks. The effectiveness of these structures may be evaluated for the rate of grain moisture variation, intensity of insects and pests infestation, development of micotoxins, change in germination rate and loss of grain by various agencies during holding time.
3. Efforts may be concentrated to develop suitable techniques and equipments to get rid of sorghum and millet stubbles allowing the second crop to grow either in sequential or relay cropping systems on operational scale.
4. Efficient thresher with/without cleaning mechanism is required to thresh a wide range of cereal and pulse crops grown in SAT regions to reduce the grain losses by unpredictable weather, theft, fire hazards, etc.

Suitable methods are required to store the farm produce with minimal grain losses during storage by insects and pests, which are severe in these regions particularly while storing pulses and oil seeds.

Conclusion

The losses incurred during various stages of post production of cereal and pulse crops can be minimized by adopting improved techniques and equipments. The development of suitable equipment for harvest and post-harvest operation may help the farmer in completing the job timely.

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AMA ABSTRACTS AND INDEX, 1971–1980

– A Key to Wealth of Information –

As the AMA enters its 13th year of publication this year, the Editorial Staff deems it appropriate to commemorate the event by publishing "Abstracts and Index 1971-80" in May, 1983 for only ¥2,000 a copy, including sea mail postage.

During the decade 1971-1980, more than a thousand articles were received by AMA from readers and co-editors. Over 600 of these contributions were published from which the abstracts and index in various aspects of agriculture and agricultural mechanization in developed and developing countries were arranged for use as a handy reference by students, government officials, ressearchers and academicians interested in agriculture and agricultural mechanization. For example, at a glance, the abstract and index tell about the content of the article, author and AMA issue number. The publication form is A3 size (18.5 cm x 21 cm) 82 pages.

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Effect of Inflation in Depreciation Analysis of Farm Equipment



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Summary

Inflation is a global phenomenon. Because of inflation the monies accumulated under depreciation head of a farm equipment may not be sufficient to buy a new machine after expiry of its economic life. This deficit has to be made up otherwise it puts a financial burden on the farming enterprise.

An analytical model to incorporate the effect of inflation in straight line depreciation method of farm equipment has been developed. It has been shown that for low inflation rate, its effect on depreciation analysis appears to have small impact but inflation at rates exceeding 10% may produce extremely serious consequences.

Introduction

Inflation is usually described in terms of an annual percentage that represents the rate at which this current year's prices have increased over the previous year's prices. Inflation has a compounding effect. Inflation is a global phenomenon which poses more serious problems in developing countries in comparision to the industrialized countries. In Nigeria, official inflation rates were recorded to be as high as 23% in 1976 and as low as 11.3% in 1979 (Annon. 1981). Because of inflation, the cost of farm equipment or any product continue to rise. A farm manager in the process of calculating cost analysis of a farm equipment sets aside some money under depreciation head with a view to replacing the existing machine after expiry of the economic life with a new machine. Because of inflation, the cost of farm equipment would rise to such an extent that the monies accumulated under depreciation head may not be sufficient to buy a new machine. This deficit has to be made up otherwise it puts a financial burden on the farming enterprise.

Depreciation Methods

The Value-Time Function

It can be assumed that the value of an asset decreases yearly in accordance with one of several mathematical functions. However, choice of the particular model involves decisions as to the life of the asset, its salvage value and form of mathematical function. A typical value-time function is shown in **Fig. 1** (Thusesen *et al.*, 1977).

The following four depreciation methods are currently used: i) straight-line, ii) declining balance, iii) sum-of-the-year digit, and iv) sinking-fund methods. **Fig. 2** compares various methods of depreciation. Assuming that all depreciation methods accomplish the same thing by the tenth year, the primary difference is in the rate of depreciation. Because of simplicity, straight-line method is the most common choice (Decarmo and Canada, 1973).

Inflation

Inflation represents the rate at which current year's prices have increased over the previous year's prices. Inflation has a compounding effect. **Table 1** shows the development of compound amount factor.

Thus the relationship between the purchase price, P of a farm machine and the future price, F, of it

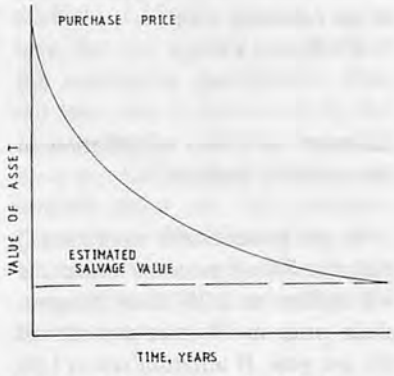


Fig. 1 A typical value-time curve.

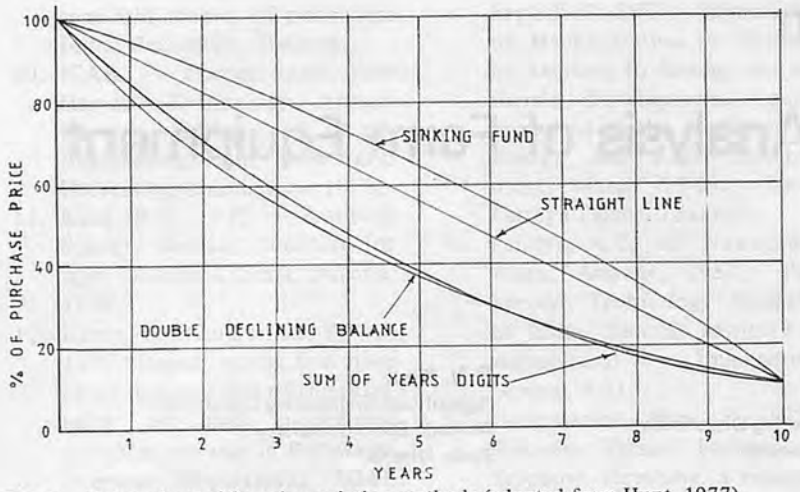


Fig. 2 Comparison of four depreciation methods (adapted from Hunt, 1977).

Table 1 Development of Single-Payment Compound Amount Factor under Inflationary Conditions

Year	Amount beginning of the year	Effect of inflation during year	Compound amount at end of year	
1	P	PI	P + PI	= P(1+I)
2	P(1+I)	P(1+I)I	P(1+I) + P(1+I)I	= P(1+I)^2
3	P(1+I)^2	P(1+I)^2 I	P(1+I)^2+P(1+I)^2 I	= P(1+I)^3
–	–	–	–	–
–	–	–	–	–
n	P(1+I)$^{n-1}$	P(1+I)$^{n-1}$I	P(1+I)$^{n-1}$ + P(1+I)$^{n-1}$ I	=P(1+I)^n = F

in the n th year at constant inflation rate, I can be represented in the following form:

$$F = P(1+I)^n \quad \ldots\ldots\ldots\ldots \quad (1)$$

Fig. 3 shows the relationship between the rate of inflation and the future price of the machine in any year elapsed after the purchase of the machine.

If the inflation changes in each year, a more generalized relationship between the future price and the purchase price of the machine at the end of the n th year will be of the following form:

$$F = P(1+I_1)(1+I_2) \ldots\ldots\ldots (1+In) \quad \ldots\ldots\ldots \quad (2)$$

Inclusion of Effect of Inflation in Depreciation Analysis

It can be seen from equation (1) that the future price of a machine will inflate to 1.79 times the purchase price in 10 years at a rate of 6% per year. If inflation rate is 12% per year, the future price of the same machine in 10 years will become 3.1 times the purchase price. At higher inflation rates, the future price will increase dramatically.

In a straight-line depreciation method under non-inflationary conditions the total money accumulated under depreciation charge will be 0.9 times the purchase price of the machine (salvage value being 10% of purchase price) after expiry of its economic life as shown in **Table 2**. Under inflationary conditions, this money is not sufficient to buy a replacement. The effect of inflation can be included as follows in the case of straight line method of depreciation analysis:

$$D_n = \frac{n}{L}\,[P(1+I)^n - S] \quad \ldots\ldots \quad (3)$$

$$C_n = P(1+I)^n - D_n \quad \ldots\ldots \quad (4)$$

$$d_n = D_n - D_{n-1} \quad \ldots\ldots \quad (5)$$

where, D_n = comulative depreciation charge upto n th year; n = number of years elapsed after purchase of the machine; L = life of the machine, years; S = Salvage value of the machine; C_n = remaining value of the machine after n th year; d_n = annual depreciation charge in n th year

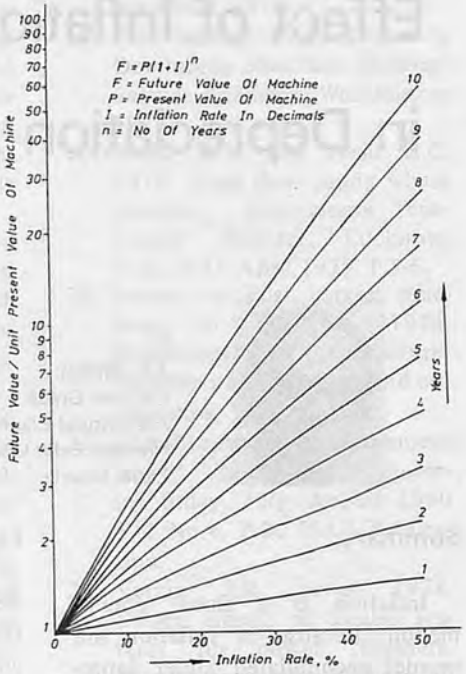


Fig. 3 Ratio of future and purchase value of machine affected by inflation in the number of years.

Reduction Formulae

For simplicity the inflation rate may be considered as constant throughout the life of the machine. Taking the life of the machine as 10 years and the salvage value of the machine equal to 10% of the inflated price of the machine, equation (3) and (4) can be reduced as follows:

$$D_n = 0.09nP(1+I)^n \quad \ldots\ldots \quad (6)$$

$$C_n = P(1+I)^n(1-0.09n) \quad \ldots \quad (7)$$

$$d_n = 0.09\,P[n(1+I)^n - (n-1)(1+I)^{n-1}] \ldots\ldots \quad (8)$$

Table 2 shows the future price, total depreciation, remaining value and annual depreciation charge at the end of each year of a machine.

It may be seen from **Table 3** that the total depreciation charge after 10 years is 1.6117 times the purchase price. Still the remaining

Table 2 Variation of Future Price, Remaining Value and Depreciation Charge as a Function of Purchase Price, P in Non-Inflationary Conditions under Straight Line Depreciation Method

End of year n	Future cost at n th year F	Total depreciation Dn	Remaining value Cn	Annual depreciation charge dn
1	1.0P	0.09P	0.91P	0.09P
2	1.0P	0.18P	0.82P	0.09P
3	1.0P	0.27P	0.73P	0.09P
4	1.0P	0.36P	0.64P	0.09P
5	1.0P	0.45P	0.55P	0.09P
6	1.0P	0.54P	0.46P	0.09P
7	1.0P	0.63P	0.37P	0.09P
8	1.0P	0.72P	0.28P	0.09P
9	1.0P	0.81P	0.19P	0.09P
10	1.0P	0.90P	0.1P	0.09P

Table 3 Variation of Future Price, Remaining Value and Depreciation Charge as a Function of Purchase Price P, at Constant 6% Annual Inflation Rate under Straight Line Depreciation Method

End of year n	Future cost at n th year F	Total depreciation Dn	Remaining value Cn	Annual depreciation charge dn
1	1.06P	0.0954P	0.9646P	0.0954P
2	1.1236P	0.2022P	0.9214P	0.1068P
3	1.1910P	0.3216P	0.8694P	0.1194P
4	1.2625P	0.4545P	0.808P	0.1329P
5	1.3382P	0.6022P	0.736P	0.1477P
6	1.4185P	0.7660P	0.6525P	0.1638P
7	1.5036P	0.9473P	0.5563P	0.1813P
8	1.5938P	1.1476P	0.4462P	0.2003P
9	1.6895P	1.3685P	0.321P	0.2209P
10	1.7908P	1.6117P	0.1791P	0.2432P

Table 4 Total Depreciation, Remaining Value and Annual Depreciation Charge of a Machine as a Function of Purchase Price, P at 6% Annual Interest Rate under Sinking-Fund Depreciation Method

End of year n	Total depreciation Dn	Remaining value Cn	Annual depreciation charge dn
1	0.683P	0.9317P	0.0683P
2	0.1407P	0.8593P	0.0724P
3	0.2175P	0.7825P	0.0768P
4	0.2988P	0.7012P	0.0813P
5	0.3851P	0.6149P	0.0863P
6	0.4764P	0.5236P	0.0913P
7	0.5736P	0.4264P	0.0972P
8	0.6763P	0.3237P	0.1027P
9	0.7852P	0.2148P	0.1089P
10	0.9P	0.1P	0.1148P

Table 5 Variation of Future Price, Remaining Value and Depreciation Charge as a Function of Purchase Price, P, at Constant 12% Annual Inflation Rate under Straight Line Depreciation Method

End of year n	Future cost at n th year F	Total depreciation Dn	Remaining value Cn	Annual depreciation charge dn
1	1.12P	0.1008P	1.0192P	0.1008P
2	1.2544P	0.2258P	1.0286P	0.1250P
3	1.4049P	0.3793P	1.0256P	0.1535P
4	1.5735P	0.5665P	1.0071P	0.1872P
5	1.7623P	0.7931P	0.9693P	0.2266P
6	1.9738P	1.0659P	0.9080P	0.2728P
7	2.2107P	1.3927P	0.8180P	0.3268P
8	2.4760P	1.7827P	0.6933P	0.3900P
9	2.7731P	2.2462P	0.5269P	0.4635P
10	3.1058P	2.7953P	0.3106P	0.5491P

value of the machine is 10% of the future price. At the given inflation rate the farm manager will have the money available which may be needed to replace the machine under normal economic conditions.

One may argue that the depreciation charge accumulated over the years can be reinvested so that it may earn same interest and the principal and interest may be sufficient to buy a new machine. If the annual depreciation charge is invested at an interest rate of 6% compounded annually*, the total money available at the end of economic life of the machine (assumed to be 10 years) can be calculated in the following manner:

$$\Sigma d'n = 0.09P[(1+0.06)^9 + (1+0.06)^8 + \ldots + (1+0.06)^1] + 0.09\,p \quad \ldots\ldots\ldots \quad (9)$$

where $\Sigma d'n$ = total depreciation charge after n years invested at 6% interest rate.

Equation (9) yields $\Sigma d'n$ to be equal to 1.1863 P. This it can be seen that the farm manager has still to make up a shortfall of 0.6045 times the purchase price of the machine (future price at 6% inflation rate after 10 years—total depreciation charge after 10 years invested at 6% interest rate).

Proposed Method versus Sinking Fund Method

It is generally argued that the sinking-fund method considers the problem of depreciation as one of establishing a fund that will draw compound interest (Hunt, 1977). **Table 4** shows the depreciation charge, remaining value and annual depreciation of the machine at 6% interest rate compounded annually* as calculated by sinking-fund method. Even if the annual depreciation charge is invested at 6% interest rate compounded annually, the total money available at the end of the life of the machine may be calculated in the following manner:

$$\Sigma d'n = 0.0683P(1+0.06)^9 + 0.724P(1+0.06)^8 + \ldots\ldots + 0.1089P(1+0.06) + 0.1148P \quad \ldots\ldots\ldots \quad (10)$$

Equation (10) yields $\Sigma d'n$ to be equal to 1.1513P. Thus it can be seen that the sinking-fund method for calculating depreciation does not take care of inflation fully, the farm manager has still to make up a shortfall of 0.6377 times the original price of the machine. (future price 6% inflation rate after 10 years-value of depreciation charge after 10 years invested at 6% interest rate).

* Interest rate has been chosen to be 6% just to have an identical condition with that of inflation rate.

Effect of Rate of Inflation on Replacement of Machinery

Table 5 shows the variation of future price, remaining value and depreciation charge as a function of purchase price, P, at constant 12% annual inflation rate under straight-line depreciation method. In 10 years time the future price of the machine becomes 3.1058 times the purchase price whereas the total depreciation charge obtained from **Table 2** invested at 12% interest rate will yield in only money equal to 1.5794 times the purchase price of the machine. Thus the manager has to make up a shortfall of (3.1058P–1.5794P) = 1.5264 P.

Thus it can be seen that at the higher inflation rates the financial burden on the farming enterprise will be very high.

Conclusion

An analytical model for inclusion of effect of inflation under straight line depreciation method has been developed. For simplicity constant inflation rate (throughout the life of the machine) has been assumed. However, the same technique can be applied to other depreciation methods with variable inflation rates (in the life span of a farm equipment).

It has also been demonstrated that for low inflation rates, its effect on depreciation analysis may have small impact but high inflation rates may produce extremely serious consequences. The farm manager must take steps to rectify the situation in their machinery management system.

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Development of Low-Cost Indigenous Technology to Minimize Water Losses due to Seepage in Irrigation Canals



by

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Abstract

A study was conducted with a view to investigating the scope for application of indigenous low-cost materials for lining small irrigation canals. For this purpose materials were collected and different types of lining mixtures were prepared to test their suitability both under laboratory and field conditions. The following lining mixtures were found suitable as canal lining materials:

i) Clay (69.5% clay, 28.3% silt and 2.2% sand) when lined with a thickness of 5 cm.
ii) Clay-jute (mixed at the rate of 6 kg small pieces of jute per m^3 of clay material) – when lined with a thickness of 7 cm.
iii) Clay-soil (soil available in the field which contains 5% clay, 53% silt and 42% sand) – when mixed at a ratio of 1:3 and lined with a thickness of 7 cm.

Introduction

The success of irrigated agriculture mostly depends upon the judicious and efficient utilization of irrigation water. Only a portion of the water delivered to a farm land is beneficially used by the crops and about one-third of all the water diverted is lost in the conveyance and distribution system in the form of seepage, evaporation, operational losses and tail water losses (waste). Out of these losses, seepage through the bottom and sides of irrigation canal is most important. Studies at different places show that total seepage losses may amount to 50% of the total discharge through the canal system. Besides, such a heavy loss of irrigation water, excessive canal seepage also contribute to water logging of farm lands, salt and alkali concentration in the soil, resulting in costly maintenance of roads and drainage system and a reduction in agricultural outputs (ICID, 1968). In order to conserve irrigation water, it is, therefore, necessary to take steps to control seepage losses from the canals.

It is observed that the percentage of seepage losses from small canals is normally greater than in large canals. Priyani (1967) reported that ordinarily 25% of the loss takes place in small farm ditches. To minimize these water losses, canals need to be lined with a suitable material.

Seepage losses in an unlined channel may cause much loss of valuable irrigation water. Kanwar (1972) reported that losses in unlined irrigation channel in India have been about 47% of the total amount diverted. Dutta (1981) conducted experiments in three minor irrigation projects of Bangladesh and reported that the conveyance loss through the canals in the project area was as high as 60% of total water diverted.

The government of Bangladesh has launched a comprehensive programme to bring a large portion

of cultivable land under irrigated agriculture through shallow tubewells, deep tubewells and low-lift pumps. But many of the projects so far completed have proved to be either slow or low-yielding. Even the Bangladesh Agricultural Development Corporation (BADC) could not attain the target-irrigation-coverage of 25 ha by using a water source of 57 ℓ/sec. This is mainly due to the losses of irrigation water through the bottom and sides of the irrigation canals and lack of water control.

These water losses may be controlled by using lining materials such as concrete, stone, brick, bentonite earth mixtures, rubber, plastic, and asphalt compounds, natural clay of low permeability, etc. Concrete more or less meets all the requirements for lining than any other materials. But its high initial cost leads to the use of a low-cost lining material for channel. Therefore, a study with low-cost linings was undertaken to investigate the scope for the application of indigenous low-cost material for lining small canals with the following specific objectives:

i) To identify suitable indigenous low-cost lining materials.
ii) To study the performance of selected linings under field condition.
iii) To determine the roughness co-efficient (Manning's n) of the selected low-cost linings.

The economy of Bangladesh is characterized by a labour-surplus economy. Even with a reasonable success in controlling population growth, the employment situation cannot be appreciably improved without adequate employment generation in rural areas. Therefore, researches where possible should be oriented to the application of technologies which are specifically directed towards the employment generation in rural areas. With this point in mind, the layout and the operational programme of this study has been planned.

Materials and Methods

Preliminary Investigation

Different types of low-cost indigenous materials were selected to study their suitability as lining materials. Initially, the materails which are relatively impermeable and possess binding and sealing characteristics were collected. During the selection of materials the cost and their availability to a farmer at local level were under primary consideration.

The following materials were selected in order to prepare suitable mixtures to be used as lining for small irrigation canals:

a) Earth Materials:

i) Heavy clay (69.5% clay; 28.3% silt and 2.2% sand): available near experimental site; such type of clay is generally available in most of the low-land areas of Bangladesh.
ii) Sand: collected from the shoal of river.
iii) Available soil (53% silt, 42% sand and 5% clay): silt-loam in character and available in most of the places of Bangladesh.

b) Cow dung, Saw-dust Jute:

The above materials were mixed in different proportions and suitable pastes were prepared with water. The pastes were exposed to sunshine with varying thickness to observe their plastic and bonding characters. After a number of large trials, the lining mixtures which seemed to be impermeable, hard and free from cracking were selected for field trials to study their resistance against erosion, to calculate seepage rate and to determine their roughness co-efficient. The promising combination of lining materials selected after preliminary investigation is presented in **Table 1**.

Table 1 Specification of Different Low-Cost Lining Materials Selected for Field Investigation

Lining materials	Mixing ratio	Thickness (cm)
Clay	Heavy clay	2.5, 7, 7.5
Clay+cowdung	1 : 1	2.5, 7, 7.5
	1 : 2	
	1 : 3	
	1 : 4	
	2 : 1	
	3 : 1	
	4 : 1	
Clay+Soil	4 : 1	5, 7.5
	5 : 1	
	1 : 3	
	2 : 3	
	1 : 2	
Clay+Jute	Clay : Jute	2.5, 5, 7.5
Soil+Cowdung	1 : 1	5, 7.5
	2 : 1	
	3 : 1	
	4 : 1	
	5 : 1	
Soil+Cowdung +Rice-Husk	1 : 1 : 1	5, 7.5
	2 : 1 : 1	
	3 : 1 : 1	
	4 : 1 : 1	
	5 : 1 : 1	

Field Investigation

The ponding method was used to measure the seepage losses through different types of linings. For this purpose test ditches of trapezoidal shape were excavated randomly in the field with the following dimensions:

Bed width b = 0.60 m, side slope i = 1:1, length of the ditch l = 1.50 m, depth of the ditch d = 0.3 m.

The ditches were excavated on elevated land so as to avoid ground water entrance into the ditches directly. The depth of water table below the ground surface ranged from 2.5 m to 3.1 m during the study period. The land was dry and soil was homogeneous silt-loam.

Fig. 1. Shows one of the cross-sections of the test ditches. The ditches were lined with those materials which were found suitable or satisfactory after preliminary investigation as specified in **Table 1**. The seepage rate through the sides and bottom of a ditch was calculated by ponding method. The following equation was used for the computation of

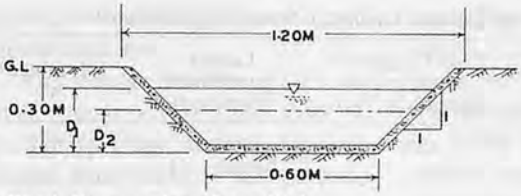


Fig. 1 Cross-section of test ditch.

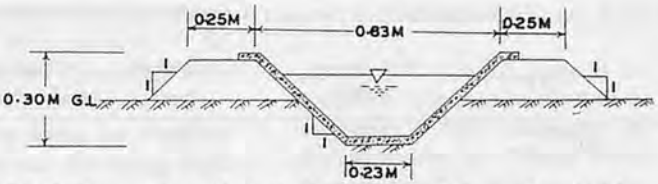


Fig. 2 Cross-section of irrigation canal lined with low-cost materials.

seepage rate:

$$S = \frac{W(d_1 - d_2)\,L.\,24}{P.\,L.\,t} \quad \ldots\ldots(1)$$

where:

S = Seepage rate M^3/M^2/day, W = average width of water surface in m, d_1 = actual depth of water at the beginning of measurement in m, d_2 = depth of water in m after time 't', L = length of ditch in m, P = average wetted perimeter in m, t = time interval between d_1 and d_2 in h.

The ditches were filled with water to a certain level as shown in **Fig. 1**. At first, the initial depth d_1 was recorded and after a certain interval of time, t h, the final depth d_2 was recorded. The depth of water in the test ditches was measured for a period of one week continuously at different time intervals. The fall in water level was mainly due to seepage through the bottom and sides of the ditches and evaporation losses from the free water surface. The apparent seepage rates through lining were adjusted for actual rate by deducting evaporation losses during the period.

After computation of seepage rates of different linings, their character and suitability were observed in a typical farm irrigation channel capable of carrying 0.056 cumec water. The different parts of the channel were lined carefully with the preliminary selected lining materials. The conditions of linings in the channel were kept under careful observation for a period of three months. During the period, the characteristics of the linings were observed in the channel at flowing condition. The cross-section of the irrigation channel lined with low-cost materials is shown in **Fig. 2**. The linings which were found relatively durable, and less susceptible to damage either by insects, rats, weed growth or by erosion due to high-velocity flows were finally selected.

Computation of Manning's 'n' for Selected Canal Linings

Roughness co-efficients of linings (Manning's n) were ccalculated by rearranging the Manning's equation as in the following form:

$$n = A/Q.\ R^{2/3} m^{1/2} \quad \ldots\ldots(2)$$

where:

- n = roughness co-efficient of cross-sectional area of the
- A = cross-sectional area of the channel, m^2;
- Q = discharge through the channel, cumec
- R = hydraulic radius, and
- m = bottom slope of the channel.

The discharge in the channel was measured by a standard type V-notch at the upstream of the channel. The data were recorded for varying depths of flow for each type of lining. From the channel dimensions and discharge data, 'n' - was calculated using equation (2). Finally, the cost of different linings were computed, considering a typical farm ditch capable of carrying 0.056 cumec water.

Result and Discussion

The following types of lining which gave relatively high water tightness and which are easily available at lower initial cost and comparatively resistant to wearing, weathering and pest (worms, insects, rats etc) attack and can be constructed with unskilled or semi-skilled labourer, were selected and recommended for small irrigation canals at farm level.

i) Clay lining
ii) Clay-jute lining
iii) Lining with clay and available soil.

Table 2 shows the selected low-cost linings with their construction cost and other specifications.

The seepage losses which have been determined by the ponding method for the linings as specified in **Table 2** may vary from place to place depending on the extent of cracking of subgrade materials, depth to water table, soil moisture content of the ground and other factors. The presence of soil-moisture contributed by the ground water table and seepage losses from test ditches affected to some extent the accuracy of measuring the actual seepage rate of linings. However, the experiment showed that the seepage rate for the lined ditches was reduced to a considerable extent when compared to unlined ditches. In the experimental area, the seepage losses of the unlined ditches ranged from 0.1 to 0.127 m^3/m^2/day.

Though the soil-cowdung lining looks promising from the viewpoint of seepage losses and economy, these linings were damaged by insects, rats, weed growth and by water erosion.

Clay was found as an economical and effective method of controlling seepage losses. It has been observed that properly made clay-paste, when laid on the channel bed, can form a water-tight coat-

Table 2 Average Comparative Cost, Seepage Rate and other Specifications of the Selected Linings for Small Irrigation Canals

Type	Mixing ratio	Thickness (cm)	Seepage rate ($m^3/m^2/day$)	Cost[1]/100 m^2 for a typical farm ditch (Tk.)	Labour requirement (Man-days)	Meanings 'n'
1. Clay[2]	–	5.0	0.037–0.125	600/–	unskilled labour – 11	0.017
2. Clay-soil[3] (available)	1:3	7.0	0.033–0.063	350/–	unskilled labour – 17	0.017
3. Clay-jute	6 kg jute were mixed throughly with 1 m^3 of clay materials	7.0	0.045–0.072	900/–	unskilled labour – 11	0.018

Remarks: (1) Cost includes both excavation and lining costs, 1980 (2) Clay (2.2% sand, 28.3% silt, 69.5% clay) (3) Clay-soil (32.5% sand, 46.3% silt, 21.2% clay).

ing. A clay lining of 5.0 cm thickness, when carefully laid on the subgrade, prevented about 90% of seepage losses. But the lining has serious disadvantage of crackings, resulting from alternate drying and wetting. This problem can be solved to a satisfactory extent if the resulting crackings are repaired by another thin clay layering before supplying irrigation water into the canal. Clay should be mixed with water throughly to get a workable plastic mixture with the help of hand and spade. Plastic clay mixture may be placed as a plaster to the sides and bottoms of the irrigation canals by hand. This type of clay lining is suitable for small irrigation canals where discharge velocity is not more than 0.90 – 1.25 m/sec.

The shrinkage cracks of clay linings were reduced to a great extent when available soil (42% sand, 53% silt and 5% clay) was mixed with clay at a ratio of 3:1 for reparing lining pastes. The percentage of soil particles in the clay-soil pastes were 32.5% sand, 46.3% silt and 21.2% clay. When the pastes were laid 7.0 cm thick, the seepage losses through the sides and bottom of the canals averaged 0.048 cumec. The channel lined with clay-soil lining is capable of carrying discharges at a velocity not more than 0.90 m/sec. If sandy clay with plasticity index ranging from 12 to 24 is available, may be used as canal lining for controlling seepage losses from small irrigation canals.

The condition of clay lining was improved further when small pieces of jute were mixed with clay. For this lining when 6 kg of jute pieces (2 cm sizes) were mixed with 1 m^3 of clay was found suitable for removing shrinkage cracks of clay linings. Cracks resulting from alternate drying and wetting for clay-jute lining were not all serious. A velocity of about 0.90 – 1.25 m/sec in a clay-jute lined channel is permissible in order to avoid erosion. The seepage rate for such type of clay-jute layer ranged from 0.045 – 0.072 $m^3/m^2/day$.

The cost per 100 m^2 of canal lining for a typical farm ditch ranged from Taka 350 to 900 only when clay, clay-soil and clay-jute were used as lining materials (**Table 2**). Whereas, for pucca canals the cost was about Tk. 11 000 for 100 m^2 of lining works. The cost of these linings may vary depending on the availability and source of

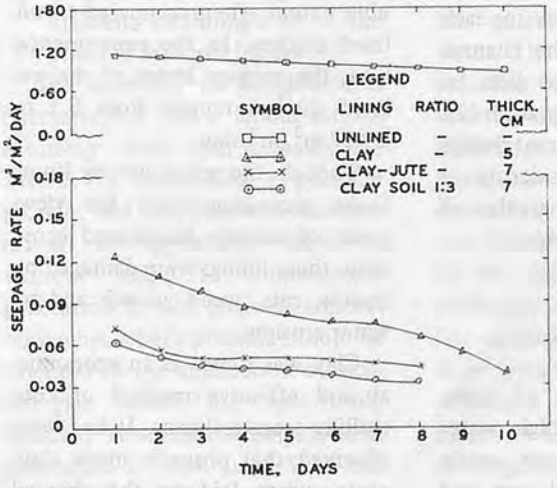


Fig. 3 Seepage rate and canal lining.

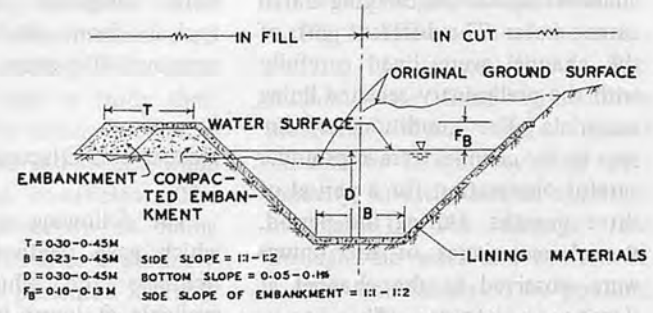


Fig. 4 Typical cross-section of farm channel to be lined with low-cost materials.

materials, working season and labour cost, etc.

The seepage rate through the unlined canals varied from 0.90 to 1.13 $m^3/m^2/day$ whereas the same ranged from 0.033 to 0.25 $m^3/m^2/day$ when clay, clay-soil, clay-jute etc were used as canal linings. This is a clear indication of huge savings of irrigation water which can be utilized for increasing command area, consequently making irrigation an economic input in the field of agricultural production. This kind of low-cost indigenous linings will not only save irrigation water but also may play an important role in soil conservation by controlling erosion. The nature of the curve showing the relationship between seepage rate through the lining and elapsed time is presented in **Fig. 3**. The seepage rate of the linings is higher at the initial stage and it gradually decreases with elapsed time and finally attains a constant rate. **Fig. 4** shows a typical cross-section of a farm channel to be lined with low-cost materials with recommended dimensions.

Table 2 also shows the unskilled labour requirement for lining small irrigation canals with low-cost materials. Therefore, the application of low-cost technology for lining small irrigation canals will not only improve irrigation command but also will create employment opportunities for the unemployed rural people.

Duration of these linings will be dependent upon proper maintenance which is a continuous requirement soon after the construction is completed. Growth of weeds, aquatic plants and sedimentation in the canal restricts flow of water, reduces canal capacity and damages linings. Therefore, all kinds of weeds and sediments should be cleaned as and when necessary.

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ERRATA

Vol.XIV, No.1, Winter 1983

Design-Related Physical Properties of Selected Agricultural Products; by A.N. Waziri and J.P. Mittal, p59-62.

The following corrections may be made:

Roundness[1] = Ap/Ac . . . . . (1)

= $\Sigma r/NR$ . . . . . (2)

$s = 0.25w^{1.25}$ . . . . . (10)

where s = surface area of an orange (cm^2)

w = weight of an orange (g)

Conclusions : No. 5

The surface area of an orange has a power law relationship with respect to its weight.

ABSTRACTS

A WORD TO AMA CONTRIBUTORS AND READERS

Every year the AMA receives from all over the world more than a hundred articles for publication of which only 60 – 70 are selected and published for reasons of space limitation and editorial policy.

However, beginning with this Winter 1984 issue, the AMA management will run a new column from time to time entitled *ABSTRACTS* as an effort to utilize useful articles that could not otherwise be published. This means that only the abstracts and, of course, the author (s) identity of those articles will be drawn and published like the following six articles:

Energy Recovery in Man-Powered Pumps: Islam, S.M. Nazrul, Associate Professor, University of Engineering and Technology, Dacca, Bangladesh.

Man powered pumps are widely used in many developing countries where ground water is close to the soil surface. These pumps are popular for lifting ground water both for irrigation and for drinking water in areas where ground water is available within 6 m. At the present stage of energy crisis the human energy is the dearest kind of energy which is used to drive the pumps. Some modifications to the indigenous pumps can save sweat energy and it can be used effectively. Energy losses in relation to man powered pumps have been discussed in this paper. Energy loss due to unsteadiness can be reduced by introducing surge chamber in the suction line. In this regard two pumps (UNICEF hand pump and MCC rower pump) have been studied experimentally with and without surge chamber in the suction line. The capacity and efficiency of the pumps increase with the addition of surge chamber at moderate heads. The pumps with surge chamber can be operated with less effort and the operator finds it more convenient. The interfacing of man and machine also improves.

Estimation of Consumptive Use of Alfalfa in Saudi Arabia: Aziz, M.H. Abdel and Mohammad Saeed H. Saeed, Head and Lecturer, respectively, Agricultural Engineering Department, Agricultural College, King Saud University, Riyadh.

The existing methods for the estimation of consumptive use (or evapotranspiration) are either cumbersome or suited only to particular areas within a certain range of weather conditions. The use of these equations is not justifiable under the hot and arid conditions found in Saudi Arabia. As such, a study is needed to arrive at simple equations, based on easily available data, for use in irrigation practice and research in this country. As a first step, the work was carried out on alfalfa crop, under hot and arid conditions at the Agricultural Research Station of the Agricultural College at King Saud University, in Dirab.

Two lysimeters were used in the study and consumptive use of alfalfa was determined by the water balance method. It was found that the consumptive use was considerably under-estimated by other evaporation formulae, namely; Rijtema, Penman, Modified Penman, Blaney and Criddle, and Thornthwaite.

The evapotranspiration from 20 cm tall alfalfa was found to have a good correlation with evapotranspiration (ET) at other stages and hence was chosen as a reference.

If ET_{20} = Reference ET; ET_{min} = ET soon after cut

ET_{max} = ET at full development stage

H = Short wave solar radiation, mm/day

t = temp. in degree C ; $\emptyset$ = relative humidity in decimal

E_A = Evaporation from class A pan, mm/day

E_{Pi} = Evaporation from Piche evaporimeter, mm/day

ET can be estimated from the following equations:

$ET_{20} = 0.3H + 0.18t^{1.2} - 6 \quad \emptyset$ with $ET_{max} = (ET_{20} - 2.2)1.4$

and $ET_{min} = 0.55ET_{20}$ or $ET_{20} - 4$, whichever is

maximum

$ET_{20} = 0.8\ E_A$ with $ET_{min} = 0.6\ ET_{20}$ and $ET_{max} = 1.15\ ET_{20}$

$ET_{20} = 0.67\ E_{Pi}$ with $ET_{min} = 0.6\ ET_{20}$ and $ET_{max} = 1.22\ ET_{20}$

$ET_{20} = 0.37t$ with $ET_{min} = 0.6\ ET_{20}$ and $ET_{max} = 1.23\ ET_{20}$

Physical and Thermal Properties of Paddy Husk Briquettes: Singh, Didar; M.M. Kashyap and Amar Singh, Assitant Professor, Professor and Head and Assistant Research Engineer, respectively, College of Agricultural Engineering, Punjab Agricultural University, Ludhiana, Punjab, India.

The study was conducted to prepare briquettes from paddy husk. The molasses, sodium silicate and mixture of molasses and sodium silicate in different proportions were used as binders. The optimum parameters such as particle size, quantity of binders and compression load in relation to its physical and thermal properties were determined. The study reveals that the briquetting of paddy husk by using binders in the proportion of 10% or more is possible with a pressure of over 300 kg/cm^2. The density, durability and combustion efficiency of the briquettes increased with a decrease in particle size of the raw material and increase in the compression load. The particle size of 48 mesh and above was found superior over other material used as binder.

Comparative Study of Sweet Pepper Surface Area Using Peeling and Analytical Methods: Mittal, J.P. and O. Osunde-MacFoy, Ahmadu Bello University, Zaria, Nigeria.

The surface area of the Hungarian Yellow Wax variety sweet pepper (*capsicum annuum* L.) was determined by the peeling method and the mathematical formula assuming it to be of conical shape. It was found that the peeling method for determining the surface area of sweet pepper is quite accurate but time consuming. Alternatively, one can use the mathematical formula for quick determination of the surface area of the pepper fruit. A relationship between the surface area and the weight of the pepper was also determined.

Physical Properties of Sunflower Seeds: Nag, K.N. and Pratap Singh, Dean of the College of Technology & Agricultural Engineering and Head, Department of Farm Machinery and Power, respectively, Udaipur and V.M. Salokhe, Mahatma Phule Agricultural University, Rahuri, India.

The design of a machine for shelling sunflower seeds is influenced by the size (length, breadth, and thickness) of the seeds. With the help of a large number of measurements of the principal dimensions, empirical equations are proposed to express the correlation between the three principal dimensions for the two most commonly recommended sunflower varieties in India. From the measurement of either length or breadth of the seed, additional set of equations have been proposed to estimate the projected area of the sunflower seeds with reasonable degree of accuracy.

The Effect of Exchangeable Sodium Percentage (ESP) on Soil Hydraulic Conductivity at Low Electrolyte Concentration. Hoque, M.R. and L. Petersen, Assistant Professor, Department of IWM BAU, Mymensing, Bangladesh and Associate Professor, Department of Soil Science & Geology, The Royal Veterinary and Agricultural University, Copenhagen, Denmark, respectively.

Columns containing two types of soil, one clayey and the other one sandy, were leached with solutions of calcium and sodium chlorides. All the solutions had constant low salt concentration (5 meq/l) but different levels of sodium adsorption ratio (SAR) to give the soil columns ESP value ranging from 0-30 at equilibrium. After equilibrium between soil and solution had been obtained, the saturated hydraulic conductivity were measured in all the columns. Marked decrease in hydraulic conductivities were noticed with increasing SAR in the leaching solution and thereby with increasing soil ESP. The reduction in hydraulic conductivity with increasing ESP from 0 to 7.5, 15 and 30 was 37, 81.5 and 92.6%, respectively, in the clayey soil and 25, 66 and 99.7%, respectively, in the sandy soil. ■■

NEWS

AG ENG 84
Churchill College, Cambridge University
April 1-5, 1984, Cambridge, U.K.

The National Institute of Agricultural Engineering, Silsoe will celebrate its diamond jubilee with an international conference – AG ENG 84 – at which important topics in agricultural engineering research will be reviewed and specialist agricultural engineers will present their latest research and development via lectures and poster sessions.

C.I.G.R.
10th International Congress of Agricultural Engineering
September 3-7, 1984, Budapest, Hungary

The 10th International Congress of CIGR is organized by the Hungarian National Committee of CIGR in cooperation with the Hungarian Scientific Society of Engineers (ETE), the Scientific Society for Building (ÉTE), the Scientific Society of Mechanical Engineers (GTE), the Scientific Society for Transport (KTE), the Hungarian Society of Agricultural Sciences (MAE), the Hungarian Electrotechnical Association (MEE), and Hungarian Hydrological Society (MHT) on the premises of the University of Horticulture, Budapest, 3-7 September, 1984. The management of CIGR and Organizing Committee of the 10th Congress are expecting applications of experts and organizations who take an interest in the field of agricultural technical sciences.

Further bulletins and application forms can be obtained through:
Mr. G. Szalai
Congress Coordinator
1055 Budapest
Kossuth L. tér 6-8
Hungary

The Second Training Course
"Introduction to Ergonomics"
Oct. 22-Nov. 16, 1984, Wageningen, The Netherlands

The joint (CIGR/IAAMRH/IUFRO) working group "Promotion of Ergonomics in the Tropics" (P.E.T.) is organizing the 2nd TRAINING COURSE "INTRODUCTION TO ERGONOMICS", specially held for 12 staff members from tropical countries (researchers, teachers and extension officers) in agriculture or forestry who want to incorporate ergonomics into their regular job.

The training course will be held from October 22 – November 16, 1984, in Wageningen, The Netherlands.

For information please write to: Secretary Joint Working Group P.E.T.: F.J. Staudt, Bosbouwtechniek, L.H.; P.O.Box 342; NL-6700 AH Wageningen, The Netherlands.

VISTA – Video Information for Sales, Training and Advertising
Case Tractors, U.K.

Following the introduction of VISTA to their retail network, Case Tractors at Meltham announced the launch of the first video programme to be marketed under the VISTA label – "Understanding Traction" which has been made with both uses in mind. As the title implies, the programme covers the controversial topic of wheel-slip, and tractor ballasting and weighting.

Whilst trying not to lay down hard and fast rules, the programme attempts to point out the dangers of using too much weight as a means of reducing wheel-slip, and stresses the importance of a desired amount of wheel-slip under certain conditions.

The subject is ideal from a training point of view and supports the new product training philosophy now evident at Case. From a showroom point of view, the programme not only covers a subject of interest, but displays the popular 1490 tractor in action in what was, at the time, of shooting, the most atrocious weather conditions. *More power to the 4WD drive argument.*

Priced realistically at £10 per tape, Case distributors can look forward to more VISTA programmes. Already, two new tapes are at the editing stage – one covers the importance of pre-delivery inspection, the other discusses the operation, adjustment and maintenance of the new Case Lower-Link Sensing System.

During 1984, Case are committed to producing 10 programmes from the UK. These will be supplemented by programmes scheduled by the Case Video Production Unit in the USA. Subjects to be covered are Sales and Service Training, Parts Merchandising, and Sales and Service Management, as well as 'routine' publicity materials. ■■

Computer-Aided Design Reduces Cost of Centrifugal Pumps

The latest computer techniques were used to develop a new range of single-stage, end-suction centrifugal pumps announced by Weir Pumps Ltd.

The resulting Isoglide pumps are claimed to achieve more dependable operation at lower cost; and the use of many common components by pumps of different sizes offers significant reductions in spares inventories. Applications are expected to be in water treatment and supply, in irrigation, and for hot and cold water circulation in heating and air-conditioning systems, food, drink and other process plants, and industry in general.

The pumps are available in close-coupled (Isoglide HC) and long-coupled (Isoglide HL) versions. They conform to the international standard specification ISO 2858, and are interchangeable with other pumps to that specification without disturbing pipework. Their 32 frame-sizes provide flow capacities from 6 to 900 m^3/h at heads from 4 to 150 metres.

Simpler Maintenance: Impellers



are closely matched to motor rating to obtain maximum performance from the smallest-possible motor. Close-coupled pumps come with a standard 4-pole or 2-pole TEFC (totally enclosed, fan-cooled) metric electric motor. Long-coupled models can be supplied as complete pump-sets, with electric motor, coupling and bedplate; most sizes may alternatively be engine- or belt-driven.

The pumps' 'back-pull-out' design allows the complete rotating assembly to be removed without disturbing suction and discharge pipework or pump alignment. Hydraulic balancing of impellers minimizes axial thrusts and extends bearing life, so reducing maintenance downtime.

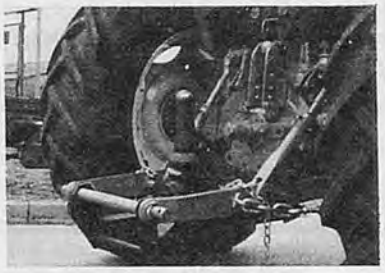
For further information contact:

Weir Pumps Ltd
Cathcart
Glasgow G44 4EX, Scotland

The An-T-Flip-Hitch designed by the Pool organization in Great Britain

The needs of agriculture demanded a new design, to give farmers the advantages of weight transfer technology and at the same time to allow quick coupling and uncoupling of tractor and trailer. The increased traction and stability as well as safety added to the capability to haul much heavier loads with a considerably lower horsepower tractor was greatly appreciated by farmers.

The An-T-Flip-Hitch is Poole's design for farming applications. It consists of three main components. Two bolts fix the hitch on the lower link bar of the tractor 3-point linkage. One man can mount or remove the hitch in just one minute. The An-T-Flip-Hitch is now



available from the British manufacturers.

For further information contact:

John E. Colman Associates
Colson House, Cornard Tye
Sudbury, Suffolk CO100QA,
U.K.

New Product from Afula Agricultural Equipment Ltd, Israel

Afula Agricultural Equipment Ltd has developed a unique, patented, 3-point multi-height fork lift. The 3-point fork lift can lift up to 1 200 kg as high as 1.5 meters. The lifting action is balanced and parallel at every height. The fork lift attaches easily and quickly to a 3-point linkage. It is simple to operate and extremely versatile. The fork lift is constructed of stainless steel.

The 3-point fork lift can convert almost any tractor into a powerful loading vehicle that can then lift, stack and move large containers and storage pallets.



For further information contact:

M.A.E. Metals (1979) Ltd
P.O.Box 240 Afula Zip 18101,
Israel ■■

BOOK REVIEW

Evaluating Technology for New Farming Systems: Case Studies from Philippine Rice Farms

By C. Barlow, S. Jayasuriya and E.C. Price

Dr. Colin Barlow, joined the IRRI as visiting scientist in January 1977. Soon afterward he was joined by Dr. Sisira Jayasuriya, Dr. Edwin Price, IRRI agricultural economist for cropping systems research, worked with Barlow and Jayasuriya to conduct research on methods of evaluating experimental technology for small rice farms. Titled the *Whole-farm Analysis Project*, the work subjected the myriad interactions of crops and other farm activities to more careful analysis than was previously possible. With this work, economic evaluation of new multiple-cropping technology has moved fully within the context of the whole "farming system" around which the day-to-day life of a farmer and his family revolves.

The cropping systems program at IRRI is indebted to the Australian National University for supporting Dr. Barlow's work, particularly during the later stages of computer analysis, manuscript preparation, and typesetting. IRRI Visiting Editor Debrah Jefferson edited the earlier drafts of the manuscript, and later assistance was given by Ms. Gloria Argosino of the Information Services Department.

This book provides a detailed view of factors that affect the adoption of techniques for multiple cropping recently developed by the IRRI Cropping Systems program. The authors provide a helpful insight on cropping systems research and the economics of small rice farms in Asia.

Size: 22.5 x 15cm, 110p.

Published 1983 by International Rice Research Institute
P.O.Box 933, Manila, Philippines

Adoption, Spread, and Production Impact of Modern Rice Varieties in Asia

By R.W. Herdt and C. Capule

Modern rice varieties (MVs) were introduced in tropical Asia in 1965 with the widespread testing of Taichung Native I and release of IR8. China had earlier developed fertilizer-responsive semidwarf varieties using a gene for dwarfing that later went into the parentage of IR8 and other semidwarf varieties. By 1980 nearly 40% of the rice area in South and Southeast Asia was planted to MVs and new hybrid rices were being grown in China. Despite their rapid spread, many questions are still asked about the spread of MVs and the technology associated with them. Where are MVs grown? What farmers grow them? What contribution have they made to production? This publication brings together the information that is available to answer these questions.

The first section documents the development and introduction of MVs in major South and Southeast Asian rice growing countries. The second section describes the methodology used to estimate the contribution of improved varieties to the increases in production that have occurred since 1965. It is estimated that by the early 1980s MVs contributed about $4.5 billion annually to the value of rice produced in Asia. In the third section of the monograph, the authors review many earlier studies that describe the MV adoption pattern and associated factors. Special attention is given to the question of farm size and adoption.

Size: 23.5 x 15cm, 54p
Published 1983 by IRRI

Major Weeds of Rice in South and Southeast Asia

By Keith Moody

Weeds of rice in South and Southeast Asia can be identified by reference to published floras, but these are not widely available and many are outdated. No book that describes and illustrates the principal weeds of rice is available.

Major weeds of South and Southeast Asia includes colorplates and descriptions of what the author considers the most widespread weeds of rice in the region, based on information available in the literature and a survey of weed scientists. Weeds that are important in only one or two countries are not included.

Because of the large number of plants regarded as weeds in rice, the author was selective in determining the most important. The author fully realizes that some species he considers important will be considered unimportant by other scientists, and vice versa.

The weed species are listed alphabetically by family and by scientific name within each family. Because this book is intended for use in an area where many languages are used, common names have been avoided. A minimum of botanical terms is used. A comprehensive glossary is included for those who are unfamiliar with the botanical language.

Size: 17.5 x 10cm, 79p
Published 1981 by IRRI ■■

A NOTE TO AMA CONTRIBUTORS

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b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are typewritten, double-spaced, about 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.

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   vi) bibliography
b. The pages must be numbered (Arabic numeral) successively at the top center. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e.g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by .number, e.g., "Figure 1. View of the Farm Buildings".
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e. Express measurements in the metric system and crop yields in metric tons per hectare (t/ha) and smaller units in kilogram or gram (kg/plot or g/row).
f. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
g. Convert national currencies in US dollars and use the later consistently.
h. Round off numbers, if possible, to one or two decimal units, e.g., 45.5kg/ha instead of 45.4762kg/ha.
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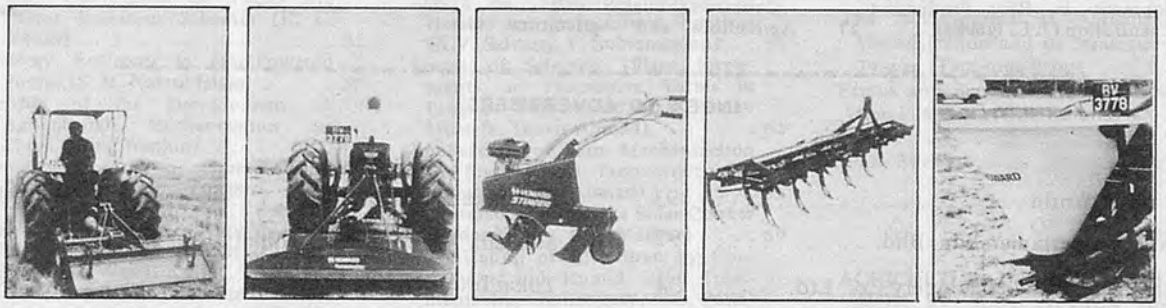


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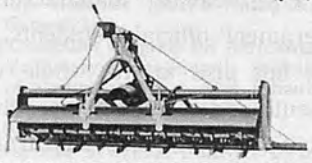
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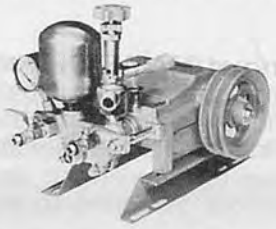
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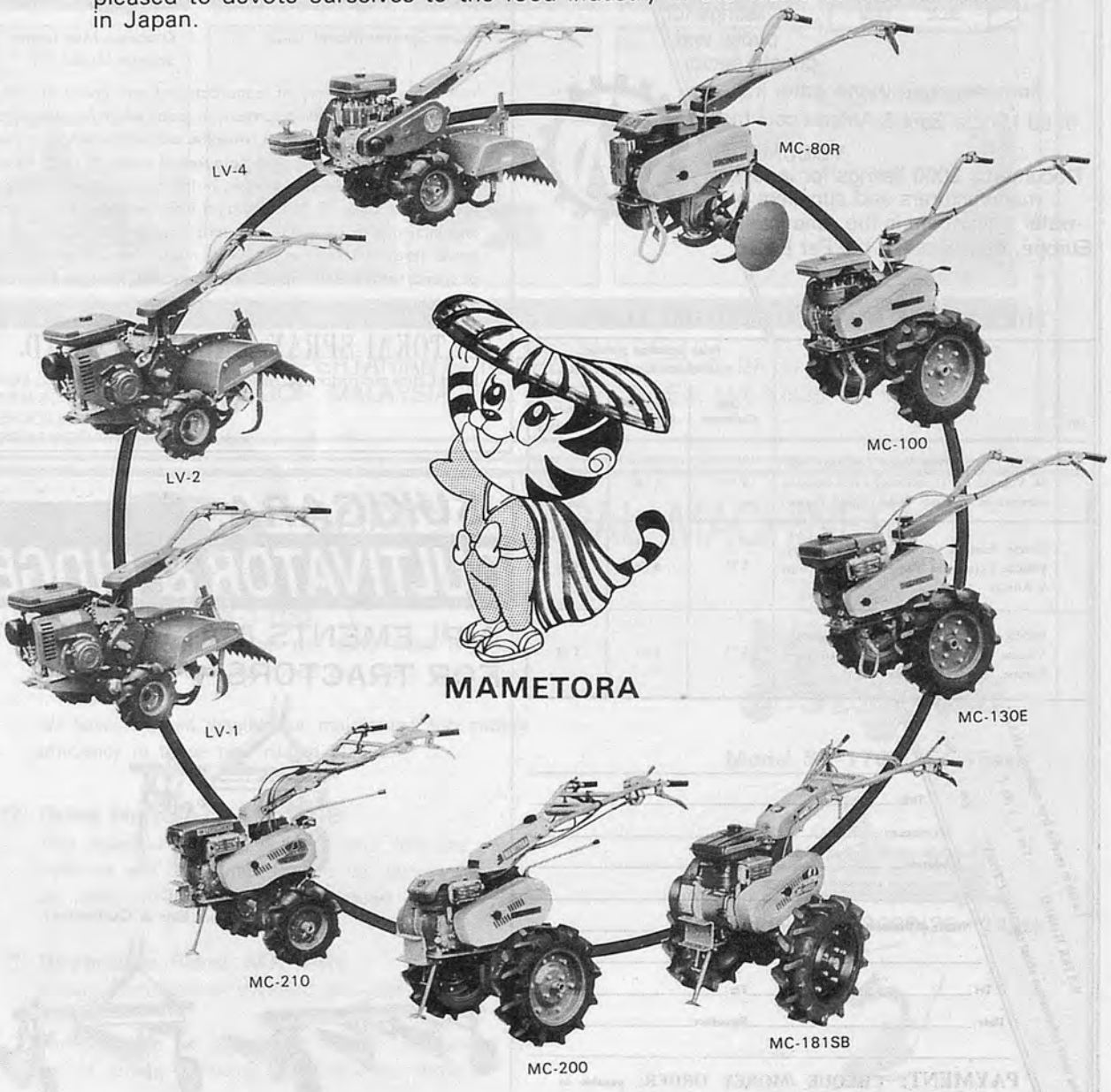
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