International specialized media for agricultural mechanization in Asian developing countries.

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AGRICULTURAL MECHANIZATION IN ASIA

VOL. XI, NO. 3, SUMMER 1980

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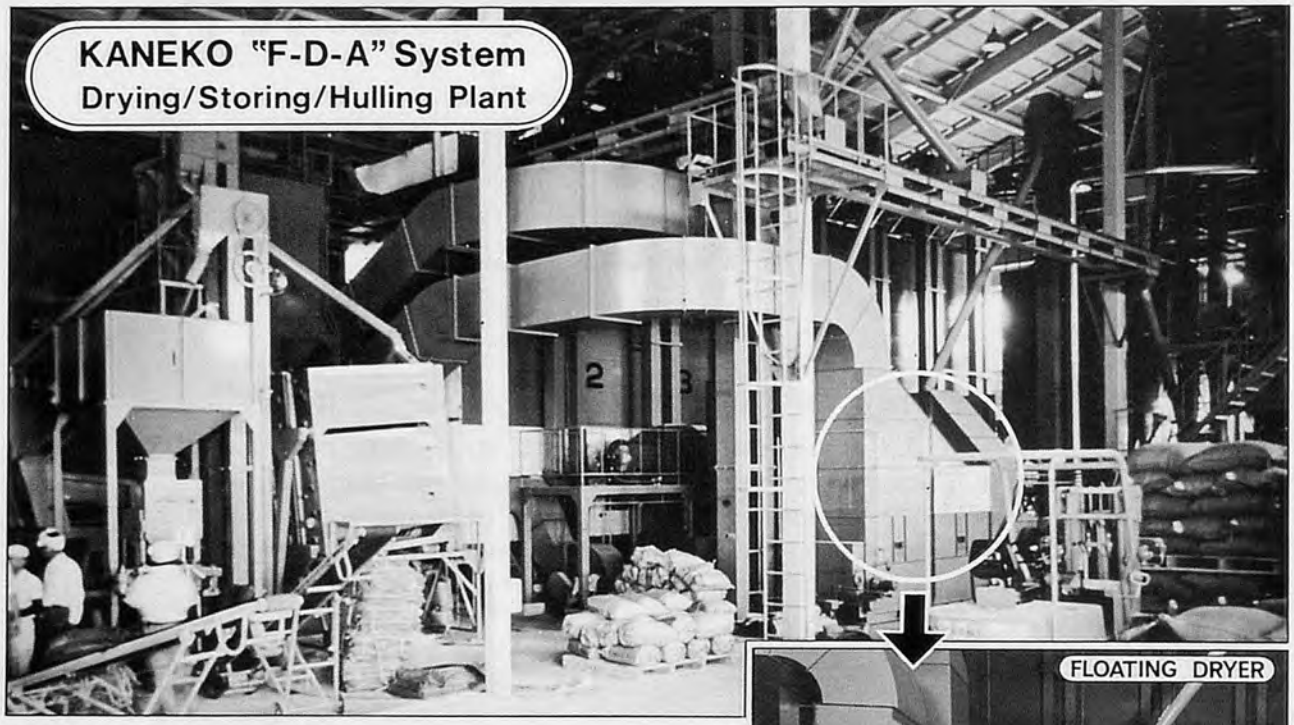

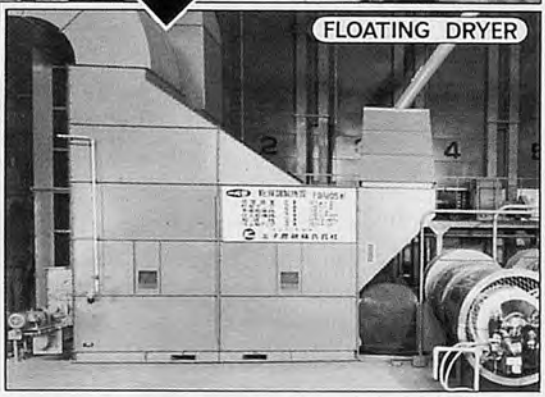

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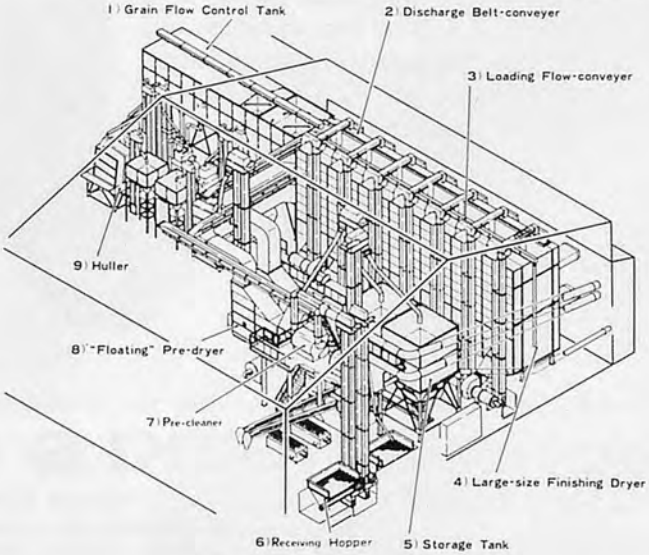

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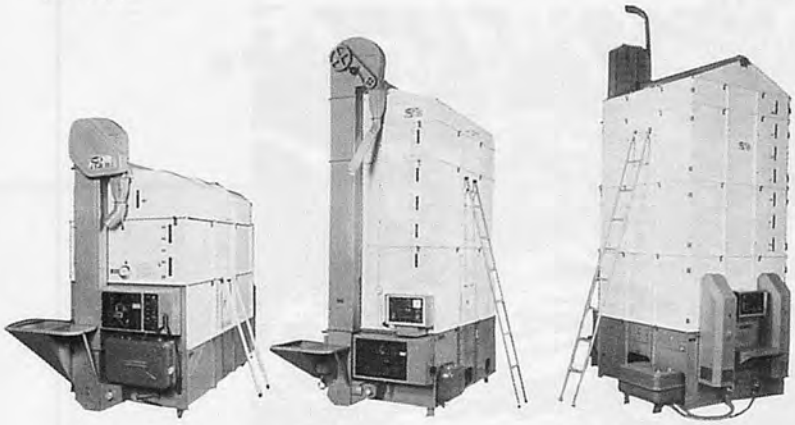

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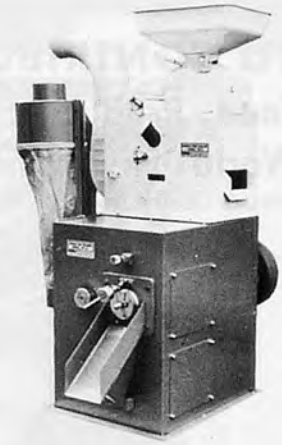

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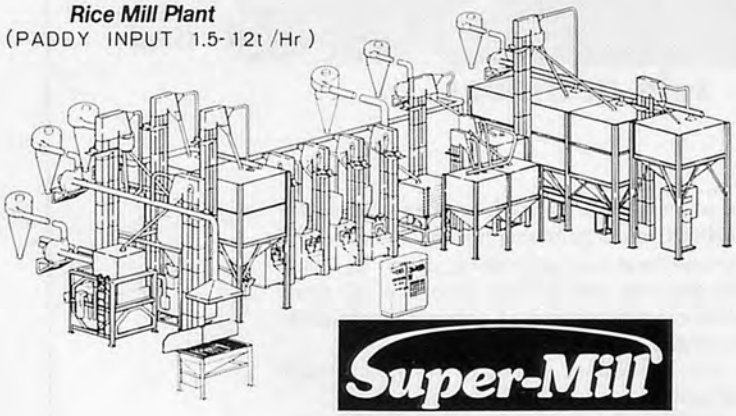

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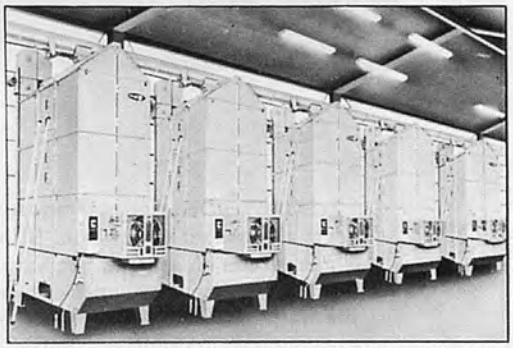

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This is the 28th issue since the issue, Spring of 1971.

Editorial

AMA and the Tasks Ahead

As we happily anticipate the AMA's 10th anniversary during the coming spring issue, we cannot but look back with pride and gratitude that its world-wide circulation over the past decade has increased beyond our expectations. This trend could be easily ascribed to an equally increasing number of manuscripts that we receive from far and wide, among other considerations. As a matter of fact, many of those manuscripts could not be accommodated at AMA's quarterly issues which is why plans are afoot to publish this magazine on a bi-monthly basis sooner or later depending on how fast we can reinforce its financial position from advertisements and other sources.

With this plan in view and in further anticipation of the continuing interest of agricultural manufacturers in promoting farm mechanization among the developing countries, the AMA looks forward to with hope that more and meaningful manuscripts from our contributors can be published and disseminated.

Among the timely topics on which we expect to receive manuscripts about relate to the current energy problem and the challenge of tapping energy from the sun. We are very much heartened by the many remarkable research results being generated regarding solar energy, in particular, the mass production of low-cost solar cells. These cells, as we understand it, are semi-conductors which convert the sun's rays into electrical current that is more powerful by a thousand-fold than the existing electrical currents, hence offer unlimited potential to power machines for both the industry and agriculture – sans oil and expensive power transmission lines. AMA's task in this regard continues to be the publication and dissemination of such useful information and development in the interest of the agricultural machinery manufacturing industries and the end-users of the farm machineries.

Another encouraging development is the potential use of uranium (which abounds in the ocean beds that can be extracted at low cost) for generating electricity – also, doing away with oil that is both unrenewable and threatening to be so prohibitive in price. Again, the AMA looks ahead in promoting this prospect.

In all, the AMA hopes to be equal to the tasks ahead given the continued support and cooperation of our esteemed contributors.

Chief Editor
Yoshisuke Kishida

July, 1980
Tokyo

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An Economic Evaluation of Bangladesh's Bamail Cooperative Farming Project

by
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Introduction

The higher growth rate of population than the production of rice, the main cereal crop, has resulted in the deficit of food grain production over the past few decades in Bangladesh. Import of food grain, thus has been on the increase and during the past few years an average 150 – 200 thousand tons of food grain have been imported annually. Efforts have therefore, been made from time to time to close this gap by taking recourse to various programs. The Bamail cooperative farming project is the outcome of one of such programs.

The project was undertaken following the recommendation of a seminar on cooperative farming held at the Bangladesh Academy for Rural Development (BARD), Comilla during April, 1972. The main feature of the program was that the farmers would post their farmlands voluntarily in the project and manage the cultivation of the land by a central management committee.

Objectives of the Study

The broad objective of the study is to see the socio-economic aspects of managing the farm for the cultivation of "boro" rice compared to individual management efforts and Kotwali Thana Central Cooperative Association (KTCCA) farms in the same area. The specific objectives of the study are: 1. To find out the comparative cost of production per "maund" of paddy in the cooperative farm and farms operated under individual management in similar conditions; 2. To determine the returns and relative net propitability of the two systems of farms. 3. To examine the causes of success/failure of the cooperative farming project.

Methodology

The members of the Bamail cooperative farm pooled their land of 19.16 acres in the farm. For comparison between the centrally managed farms and the individually operated farms under similar conditions, 15 plots of land belonging to 14 farmers were randomly selected to collect similar data under individually operated conditions. The items of costs on Bamail farms were all purchased costs. In case of individual farms, both family and purchased costs were involved. All the family costs were calculated as per the prevailing market rate for finding out the total cost. Similarly, data for KTCCA farms were collected.

The data for the study has all been collected from two evaluation reports of the farm (1, 2).

Analysis and Findings

Cooperatives and cooperative farming – A cooperative is a business owned, controlled and patronized by its members and operated by and for them on a non-profit basis. It is a business owned by the people who use it, not to earn profits on their money invested in its capital, but to obtain some needed service or services at the lowest possible cost, consistent with the continual functioning of the business.

Cooperative farming, generally is an organization of farmers, which comes into existence as a result of conscious effort to affect certain socio-economic changes in the countryside. In a cooperative farm individual participants voluntarily pool some or all of their resources. The farm is managed by a central body of representatives of the participating members.

The cooperative farm may be of two types. In one, called the "divided farm" in Italy, the "cooperative village" or "moshave"

in Israel and by other names such as "joint tenancy society" in other countries, the families belonging to the co-operative each cultivate a plot of land leased to them by the cooperative which may itself own the land or may lease it from the government or other owner.

The second type of co-operative farm is that in which all individual holdings are pooled to form one large estate. It is called an "undivided" co-operative farm in Italy, a "Kibbutz" in Israel, a collective or "Kolkos" in Russia, a peasant work cooperative in Yugoslavia, and by various other names. The "ejidos" of Mexico can be either divided or undivided (3).

The Bamail Cooperative Society

The Bamail cooperative farming project was undertaken following the recommendation of a seminar on cooperative farming held at the Bangladesh Academy for Rural Development, Comilla in 1972. The seminar endorsed the idea of conducting cooperative farming experiments at different locations of Bangladesh and, as a result, four experiments were conducted at four different places during the "boro" 1972 – 73 season: Bamail at Comilla, Shimla at Mymenshingh, Rangunia at Chittagong and Gurudaspur at Rajshabi districts. In fact, the first cooperative farming experiment was conducted by Kashinathpur-Balarampur Deedar cooperative society under the sponsorship of The Comilla Academy in the "boro" season of 1968.

Bamail is a village under the Kotwali Thana of Comilla district and is situated in the north-easterly direction about four miles away from the Comilla town. There are about 87 farm families representing about 62% of the total households in the village. Of this 29 farmers joined the co-operative farm with a total land area of 19.16 acres. the village had already a cooperative society under the umbrella of the Comilla Kotwali Thana Central Cooperative Association.

Management of the Farm

The Agricultural Cooperative Federation (ACF) was the promoter of the Bamail cooperative farm through the village cooperative society. Two separate contracts were signed between the ACF and the society and between the society and the members of the cooperative. Under the terms of contract the former was to ensure the supply of credit, fertilizers, insecticides, and water (from the deep tube-well).

A six-member committee of management was selected from among the participating members for managing the farm. A paid accountant maintained accounts of all costs and expenses of the farm operation. He was also responsible for maintaining other records of the farm.

Costs of Inputs and Labor

The total cost per acre in the cooperative farm, the individual farms, and KTCCA farms were Tk. 1,209, 1,448, Tk. 2,061, respectively. **Table 1** shows the per acre cost according to four categories; namely, labor, including the management; cost for the cooperative and KTCCA farms; equipment and draft power; material inputs such as seeds, fertilizer, pesticides and irrigation.

The higher cost for the individual farms may be attributed to equally higher costs incurred for irrigation fertilizers, seeds, pesticides, etc. The high cost for KTTCA farms may be attributed to high labor and managerial costs. The individual input categories are discussed below.

Human Labor

Of the 29 cooperating families, only 9 contributed their own and/or family labor. The total labor requirement was 1,307 man-days. Only 11.9% or 156 man-days of labor were provided by the participating families. The rest of the labor was hired. Due to non-availability of labor in time all the operations of the farming, i.e. land preparation, sowing, harvesting were delayed. It may be mentioned here that all the participating farmers had lands outside the co-operative, which they farmed individually at the same time.

For the individual farms, family labor contributed 37 percent and the balance (63 percent) was hired.

The per acre labor requirement for the KTCCA farms was 68-man days compared with 23 and 75 for the individual and farms, respectively.

Power and Equipment

The main source of power were the bullocks. No tractors were used by either the Bamail cooperative or the individual farms. However, KTCCA farms used tractors in addition to bullocks. The costs per acre (in percent) for power and equipment were 16, 10 and 7 percent of the total costs for

Table 1 Comparative Costs of Farms by Type of Input (Unit: Tk)

Type of Input	Bamail Farm		Individual Farm		KTCCA Farm	
	Cost		Cost	%	Cost	%
Human labor	652.92	53.99	770.68	53.22	1,513.43	73.53
Power and equipment	193.68	16.01	138.88	9.59	138.70	6.70
Material inputs	256.49	21.21	338.42	23.57	284.46	13.80
Irrigation	106.35	8.79	200.00	13.82	125.00	6.06
Total	1,209.44	100.00	1,447.98	100.00	2,061.26	100.00

Source: Bari Fazlul, Bamail Cooperative Farm, Bangladesh Academy for Rural Development, Comilla, 1975.

the cooperative, individual farms and KTCCA farms, respectively.

Farm Inputs

The per acre costs for farm inputs for the Bamail cooperative farms and KTCCA farm were not very much different. But for the individual farms it was much higher. The individual farms had to pay for commercial rates of fertilizers and pesticides unlike the cooperative farms which received these inputs at a low price.

Irrigation

The cost incurred by the cooperative farms for irrigation were not significantly different. But the individuals' farms incurred much higher cost because they purchased water from the tube-well groups at high costs and used indigenous method of irrigation. However, the cooperative farms used water from the tube-well entirely and paid the normal rent for it.

Farm Returns

The actual yield per acre of paddy received by the farmers of the Bamail, KTCCA and individual farms were 27.5, 47.8 and 29.7 maunds. Becasue of lack of drying facilities, individual farmers lost some of the harvest. The individual farms received Tk. 130.00 per maund of paddy on average, the Bamail farm received Tk. 102.40 per maund and the KTCCA farm received the lowest, Tk. 88.50 per maund. The higher average price of the individual farms may be due to the better bargaining capacity of the owners of some of the individual farms.

The value of the total production was Tk.2,920, 4,326 and Tk. 3,961 in Bamail, KTCCA and individual farms, respectively. The net return per acre, therefore, in Bamail, KTCCA and the individual farm was Tk. 1,711, 2,264 and Tk. 2,513, respectively.

Why Cooperative Farming Failed

Evidently, the farmers in the community did not find the cooperative farming idea attractive. They tended to be more self-centered in terms of putting more attention to their individual farms. Add to this the fact that the majority of the members of the cooperative farm were relatively large landowners who were simultaneously preoccupied with other affairs, hence no time to devote to the project.

In addition, the Khammar (farm) Committee of six members who were charged with managing the business affairs of the cooperative never got together to discuss the problems of the association. Four of the members, in the first place, were not registered members of the cooperative since their lands were not part of the pooled farms.

Owing to the lack of adequate man-hours devoted by the members to their cooperative, labor had to be hired to operate the farm. And since the cooperative could not afford to pay competitive wage rates to the laborers, very few were interested to work in the cooperative. As a result, farming operations were delayed that led to poor harvest.

Conclusions

1. The farmers lacked proper motivation in joining the farm. Those who joined were either pressurized to join or they joined in the expectation of getting inputs easily. Many of the farmers had a wrong notion of the project and felt that they were leasing the land on contract just as in sharecropping.
2. The most important lesson from the Bamail cooperative farming experiment is that the partial, instead of total pooling of the land and resources cannot make such a project successful.
3. Better management in timely sowing, plowing and harvesting operations could increase the yield and hence the profit of the members of the farm. The managing committee should be formed only with members of the cooperative farm and no outsiders should be allowed in the committee. Further, all groups, i.e., 'big' or 'small'' farmers should be represented in the committee.
4. Marketing played a very important and vital role. Better storage and marketing facilities could have helped improve the situation.
5. Absentee farmers seemed to be benefitted more which means disincentives to the small ones. Laborer's efficiency decreased due to lack of supervision.
6. Creation of certain infrastructures such as threshing floor, godown for storage, drying machines are important for the success of a cooperative farm but which the Bamail experience did not provide.

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Role of Standardization in the Power Tiller Industry Development

by
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Introduction

The minimum farm power requirement for obtaining a reasonable output from one hectare of land has been estimated at between 0.38 and 0.6 kW (0.5 to 0.8 hp) in the US. The Fifth Plan Task Force of Planning Commission of India recommends 0.8 hp for maximizing agricultural production in India. This means that India's 140 million hectares of cultivable land needs 84 gigawatt (84 GW) or 112 million hp compared with the current 37.5 GW or 50 million hp less than half of the power requirement.

Human and animals are the traditional sources of farm power in the 20 country. The introduction of farm mechanization by mechanical sources was taken up in the early years of the country's planning. Imported tractors were used for land reclamation and heavy-duty agricultural operations prior to independence but the advent of planned development emphasized self-sufficiency and high productivity. A tractor is economical only up to a certain limit of the agricultural area. Even so, the farmers with small holdings need to benefit also from mechanization.

Status of the Power Tiller Industry

A large number of power tillers (Akitu, Yanmar, Mitsubishi, Satoh, Kubota, Hako and Agria) were imported from Japan for study at various research centres during 1955 to 1960 in terms of their suitability to local conditions. On the basis of the observations of the testing, plans were made to manufacture the power tiller in the country and to popularize the same among farmers. From 1963 onwards the Government gave licence for manufacturing the power tillers to six manufacturers for a production capacity of 40,000 units per year instituted as shown in **Table 1**.

Licences for the Maharashtra Co-operative Engineering Society, Kolhapur and the Indequip have since been revoked and a sub-licence was given to the Bihar Agro Industries Corporation to assemble of 5,000 tillers in collaboration with the Kerala Agro Machinery Limited. The present licensed capacity is 31,000 units. In 1974, power tiller ceased to be imported as the indigenous manufacture seemed adequate as shown in **Table 2**.

Table 1.

Name of Unit	Make	Power Rating (hp)	Licenced Capacity (Unit)
Krishi Engines Ltd. Hyderabad	Krishi (AK 170)	5 to 8	3,000
V.S.T. Tillers & Tractors Ltd, Bangalore	Mitsubishi	8 to 10	5,000
J.K. Satoh Agril Machines, Kanpur	SATOH	5 to 7	6,000
Kerala Agro Machinery Ltd, Athani	Kubota	8 to 12	12,000
Maharashtra Co-op Engg. Society Ltd, Kolhapur	Mayur (Yanmar)	10	4,000
Indequip Engg Ltd, Ahmedabad	Iseki	8	10,000
			40,000

Table 2.

Year	Production (Units)	Import (Units)
1965–66	266	412
1966–67	261	611
1967–78	264	567
1968–69	228	1291
1969–70	219	2226
1970–71	361	2900
1971–72	1,279	1583
1972–73	1,010	112
1973–74	1,541	147
1974–75	2,221	–
1975–76	2,540	–
1976–77	1,758	–
1977–78	1,636	–
1978–79	2,147	–

Problems of the Industry

Considering the role a power tiller can play in mechanization of farmers of small holdings, particularly for paddy cultivation and hilly areas, the Planning Commission estimated that by the end of the Fourth Plan the demand would catch up to 80,000 units per year. There was an increase in demand for all types of agricultural equipment, including tractors, especially in intensive farming areas even as the total demand of power tillers was nowhere near the projected demand. Even the projected 10 percent production of the licenced capacity was not achieved. In order to determine the reasons for this shortfall and to suggest ways and means of increasing the popularity of power the tiller, the Government set up a committee in 1973.

The Committee, in its report two years later, observed that the power tiller being a new source of power for Indian farmers needed a vigorous promotional efforts through demonstrations and publicity. Need for a more simpler design with diesel engine instead of petrol or kerosene engine, reduction in retail price, creating confidence in the farmers through organized sale and service network as well as availability of matching equipment was felt. The committee recommended that standardization of the raw material, components and parts of the power tiller could result in cost reduction.

The Indian Standards Institute

The Institution of Engineers has been acting as the Indian Committee for the British Standards Institution since 6 August 1919. Generally, British and American standards are applicable for India. But the need for a national standards organization for laying down domestic standards was realized, and a proposal for setting up such an Institution was first raised at the 12th Industries Conference held at Lucknow in December 1940. By 1947 the Indian Standard Institution (ISI) with headquarters at Delhi was established with the active support of industrial, scientific and technical organizations in the country.

The aims and objectives of the Institution include the preparation of standards relating to products, commodities, materials and processes, and promotion of their general adoption at national and international levels; certification of industrial products; assistance in the production of quality goods; and dissemination of information relating to standardization.

Standardization of Power Tiller

Keeping in view the recommendation of the Government committee on power tiller, a sub-committee has been set up under the Agricultural Tractors and Power Tillers Technical Committee of ISI for speedy processing of standards.

The non-availability of the proper quality of raw materials, specially steel, is a major factor in the production cost of the power tiller. The low volume of production of individual units, coupled with multiplication of specification indicate that the demand for the tiller is not substantial. Hence, whether the raw material is locally produced or imported, prices would be high. It was, therefore, felt that standardization of raw material would go a long way in solving this problem. The panel set up to consider the rationalization of steel was of the view that 30 grades of steel already rationalized for the automobile and the ancillary industry (by the Structural and Metals Department of the ISI) would also serve the purpose of power tiller. However, the manufacturers should study the applicability of these grades and on the basis of experience the number of grades could be further narrowed down.

Ancillary items – The indigenous manufacture of power tillers need various components for engine, transmission, etc. from the ancillary units since all components cannot be processed by the manufacturers themselves. These components have a major influence on the total production cost of the power tiller. The Indian standards on various ancillary components, such as fuel injection system, piston, piston rings, liners, bearings, V-belts, gears, sprockets and chains, oil seals, electrical components and rubber products have already been published. The work on air cleaner, tyres, tubes and wheel rims has also been initiated.

Rotavator components – The rotavator is an important equipment attached to the power tiller for soil working purposes. Blades are the main wearing components of the rotavator. In order to ensure the interchangeability, an Indian Standard IS:6690-1972 has been published. This standard covers the material, hardness, essential and recommended dimensions, etc., for the straight and hatchet type of blades. The subjects such as blade shaft and blade holder have been taken up for the formulation of standards and the data are being collected for the purpose.

Method of tests – In initial stages, mostly the field trials of the power tillers were conducted. However, with the setting of the Tractor Testing Station at Budni, testing on the scientific lines was started. Though the need for a comprehensive test code for power tiller has since been felt, it is now possible to prepare a draft on the subject. On the lines of tractor test code, the draft incorporates a definition of those terms which are

associated in testing, classification, specification sheet, method of selection for testing, running-in, preliminary adjustments, fuel and lubricants, operating conditions, measuring tolerances, etc. Detail procedure for various observations and tests, such as checking of specification, test at no-load, engine performance test, rotary shaft test, drawbar test, determination of turning ability and centre of gravity, brake performance, air cleaner oil-pull over, noise and vibration, power drop and wear as well as continuous running tests have been covered.

Safety and comfort – While the quality of the product in terms of its long serviceability is important, the comfort and safety of the operator of the machine is equally important. In this connection man-machine interacting factors are required to be dovetailed in the process of designing the machine. Various controls and their location on the machine is one such important factor. In IS:8133-1976 attempt has been made to provide guidelines for the location of various controls and their mode of operation for walking type tractors. This standard also stipulates actuating forces required to operate various controls. Since the use of symbols for various controls eliminates language barrier, IS:6283-1971 has also been published to provide symbols for these controls.

General standards – The Indian standards on sampling of agricultural machinery and tractors (IS: 7201-1974) and glossary of terms (IS:7015-1972) are also applicable for power tillers.

Implementation of Standards

The benefits of standardization can only be reaped if the standards are implemented by manufacturers in designing and manufacturing the power tillers and by the purchasers in making the purchase on the basis of these standards. Besides, cost reduction which is the prime concern at the moment, a number of other advantages, such as assurance of quality, interchangeability, etc. are achieved. Implementation would also reveal difficulties, if any, in adopting them and would thus provide a feed-back to make the standard more realistic.

Certification

For providing the advantages of standardization within reach of common consumer, the ISI is implementing a Certification Marks Scheme under the Indian Standrds Institution (Certification Marks Act). This enables ISI to grant licences to manufacturers and provide goods in conformity with relevant Indian standards to apply the ISI mark on their products.

Conclusion

The power tiller industry is growing and promises to contribute significantly in the mechanization of small holdings, paddy cultivation and in hilly areas. However, the high cost of the machine is a constraint in its popularization. The standardization of components and material has been recognized as one of the solutions for reducing the cost which can be achieved only if the standards already evolved are implemented.

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Production Technology of Japanese Rotary Blades for Rotary Tillage

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Introduction

Agricultural mechanization is one of the important factors in the rationalization of agricultural work. The application of machines to farm work has been made to increase the farmer's labor productivity during the past century. In other words, the burden of agricultural work has been reduced, and the output per worker has been greatly increased.

It can definitely be said that tillage is one of the basic operations in agricultural work. Especially, rotary tillers have been generally used to replace plows and harrows so far used in paddy rice fields.

Although the design process and theories of rotary blades have been intensively studied,[1)2)] it is also necessary to study other efficient methods of manufacturing, because the consumption of rotary blades has been increasing every year. In fact, Japan has more than three millions tractors and about one million riding tractors in 1980. The standard equipment of tillage is rotary tillers. Therefore, consumption of rotary blades attains a great number which is said more than ten millions a year.

Production of the rotary blades is one of the important and big businesses in Japan, just like plow-manufacturers in European countries. In addition the retail price of rotary blades equipped to a rotary tiller in the importing countries is more than double of that in the producing countries. Therefore, it is advisable for each country to locally produce the blades as consumptive parts.

The objective of this paper is to review and offer a conceptional technology of production-line of rotary blades (NATA ZUME) in Japan. NATA ZUME is the name of rotary blades in Japanese.

Acknowledgement: The authors wish to express their gratitude to Taiyo Co. Ltd., Kobashi Co. Ltd. and other companies for their useful information and discussion on the manufacturing rotary blades.

Production-Line of Rotary Blades

Hammers, used for manufacturing of rotary blades in olden times, have been replaced by the press and bending machines in the production-line. The out-model burners also have been improved with automatic regulators, in order to have an appropriate temperature for the heat treatment process of rotary blades. The production-line of rotary blades can be split up into three main processes. These are the forming, the heat treatment and the painting processes, respectively.

Forming Process

The shape of rotary blades is equivalent to that of the share and mouldboard of plows. Unlike the European blades (L type), the edge curve of rotary blades (NATA ZUME) has an effect on the characteristics of soil cutting resistance and phenomenon of entwining grass or straw on it. A general form of the rotary blade is shown in **plate 1**, and its drawing forms by main Japanese manufacturers are becoming almost similar[2)] as shown in **Fig. 1**.

1) Material

Selection of the proper material

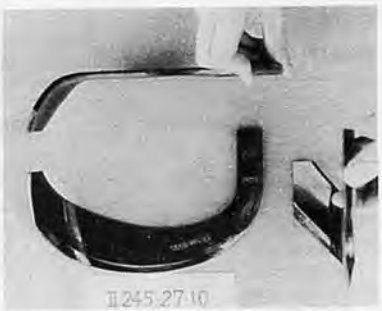


Plate 1 A Rotary Blade in Japan[1)]

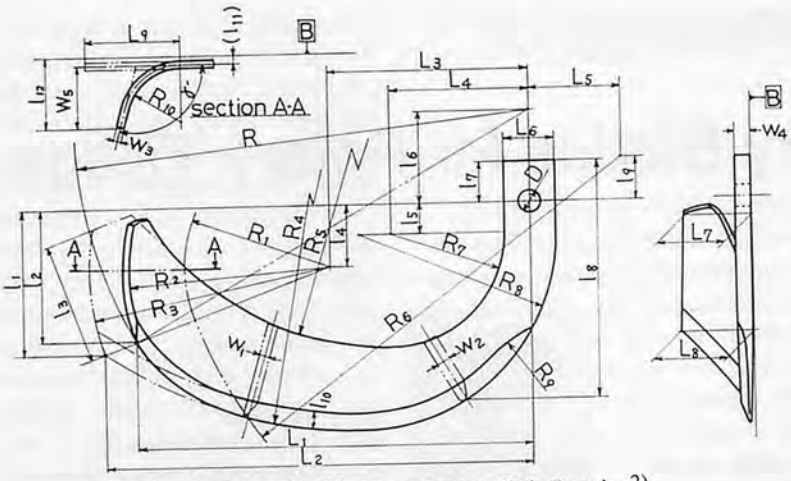


Fig. 1 An Example of Japanese Rotary Blade Drawing[2)]

for a particular application on rotary blades is important from the standpoint of cost, durability, availability and machine performance. Rotary blades should generally be designed to utilize the lowest cost material that will perform satisfactorily and give adequate life. There are many materials which can be used for the manufacture of rotary blades. As spring steel and carbon tool steel have a good springy structure, hardening property and resistance to abrasive wear after heat treatment, they have been widely used to make the rotary blades in mass production in Japan.

According to JIS (Japan Industrial Standard), the spring steel JIS G 4801 (SUP 6) and the carbon tool steel JIS G 4401 (SK 5) have the chemical compositions as shown in **Table 1**. Specially, the spring steel which has a tension strength of 125 kg/mm^2 after heat treatment, is recommended. This material is also used for leaf spring of vehicles.

2) Preparation

The steel-band (SUP 6 or SK 5) is cut into pieces by a punching press-machine of about 30 tons. The size and thickness of each piece depend upon the forms of rotary blades which are determined by the demand of farmers under the cultivating conditions. Their forms are shown in **Fig. 2-a**. There are other methods; the steel-band is elongated after pre-heating process which is explained in the next stage. Then it is cut into two as shown in **Fig. 2-b**, or the steel-band is simply cut into pieces without any forming process.

3) Pre-Heating

In order to make the form of blades easily, the steel-band is heated sufficiently to become elastic. There are many methods to heat a metal-blade. In the case of a rotating burner, the steel piece is put into an oil or gas burner which is turned counter-clockwise as shown in **Fig. 3**. When this steel piece takes a turn in the burner within 5 to 6 minutes, it would be heated to about 1,200°C. The putting of the steel pieces in and out of the burner may be done manually, when there is sufficient labor source, but if not, it is done mechanically. After this pre-heating, the steel pieces are proceeded to the next stage immediately.

4) Forming Press of Blade

The steel-pieces are pressed to become thinner. The hammer (press-machine) was used in such process by a skilled worker in the olden times. One of the advanced processes is explained as follows:

The steel-piece is inserted into the groove of a rotating roller-press as shown in **Fig. 4**. The depth of this groove decreases gradually according to the shape of each portion of the rotary blade, so that a holding portion has a uniform width and the piece becomes wider at the blade-tip. For example in Japan, 8mm and 10mm thickness at the holding portion gradually decrease to 4mm and 4.5mm

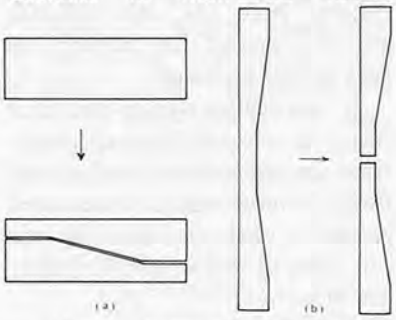


Fig. 2 Forms of Steel Bands

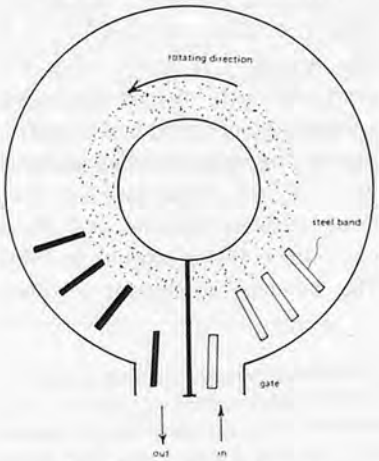


Fig. 3 Turning Oil Burner

Table 1. Chemical Composition (%) of Materials

Chemical Composition \ Kind of Material		Spring Steel SUP 6	Carbon Tool Steel SK 5
Carbon	(C)	0.55 to 0.65	0.80 to 0.90
Silicon	(Si)	1.50 to 1.80	0.35 max
Maganese	(Mn)	0.70 to 1.00	0.50 max
Phosphorus	(P)	0.035 max	0.030 max
Sulfur	(S)	0.035 max	0.030 max

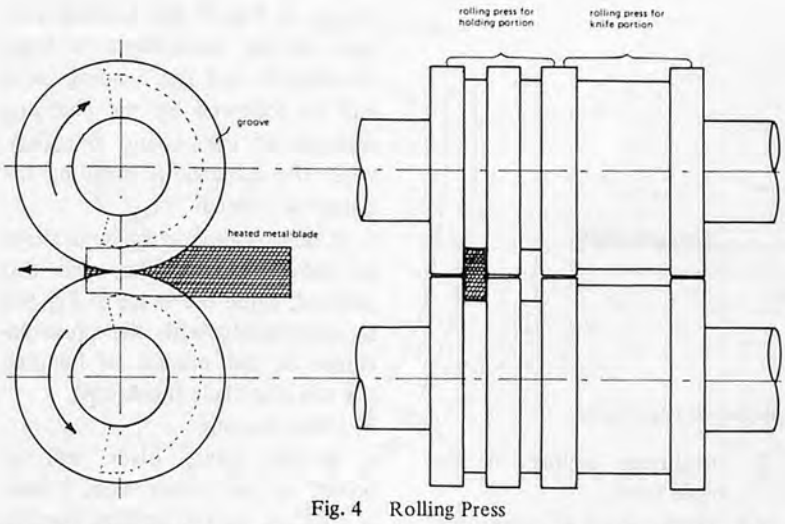


Fig. 4 Rolling Press

respectively, at the tip of the knife portion in the case of power tillers and small tractors. The whole view of the blade is shown in **Fig. 5**.

5) Forming of Holding Portion

There are two types of the holding portion of rotary blades[14] (NATA ZUME), as shown in **Fig. 6-a** and **b**. The sectional dimensions "width (A) x thickness (B)" of the holding portion are:

$$(20 \text{ to } 35\ ^{+0}_{-0.1}) \times (8 \text{ to } 12^{+0.5}_{-0.5})$$

The size has to be selected depending upon the maximum stress (σmax) acting on curved beam of rectangular section which will receive bending and twisting stresses expected in the farm work.

In the case of the bent holder type, the holding portion of rotary blade is slightly bent **(Fig. 7-b)** and pressed to be straight **(Fig. 7-c)**. The metal-blade from the previous rolling press does not have a smooth end at the holding portion, thus it is cut to have better and safe shapes by the punching press **(Fig. 7-a)**. The edges at the holding portion were grinded in olden times as shown in **Fig. 7-d**.

6) Bending of Knife Portion

Entwining phenomenon of grass or straw on the rotary blades occurs more easily in the soft soil of paddy fields than the hard soil of upland fields. According to the experiments done in Japan and the Philippines, the edge curve angle α_t (between radius direction and the tangential line of the edge curve) at the tip portion is recommended to be 57.5° and α_n at the rotary axle is 67.5°[12]

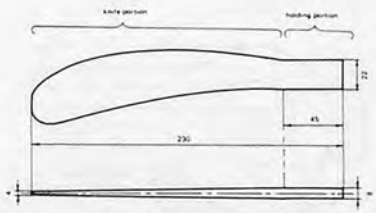


Fig. 5 Example of Shape after Rolling Press

The shape of the knife edge curve was obtained as a curve which was calculated by the spiral equation of polar co-ordinate. The edge curve of the straight blade portion is calculated by the following equation:

$$r = r_o \sin\alpha_o \left[\sin^{-1}(\alpha_o + K\theta)\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

- r: calculated radius of the spiral that depends on the variable θ in the function (mm).
- r_o: maximum radius at the tip point of edge curve (mm)
- α_o: edge curve angle at r_o (degree)
- K: constant ratio which is determined from the changing angles α_t to α_n ($K = \frac{1}{18}$ is recommended by Sakai)[3]

The edge curve of the sidelong portion (blade-tip) is obtained by substituting angle α' into the following equation:

$$r = r_o e^{-(\cot\alpha')\theta} \quad \ldots\ldots\ldots (2)$$

Hence, α' is the edge curve angle of the blade-tip before bent. It is approximately calculated by the

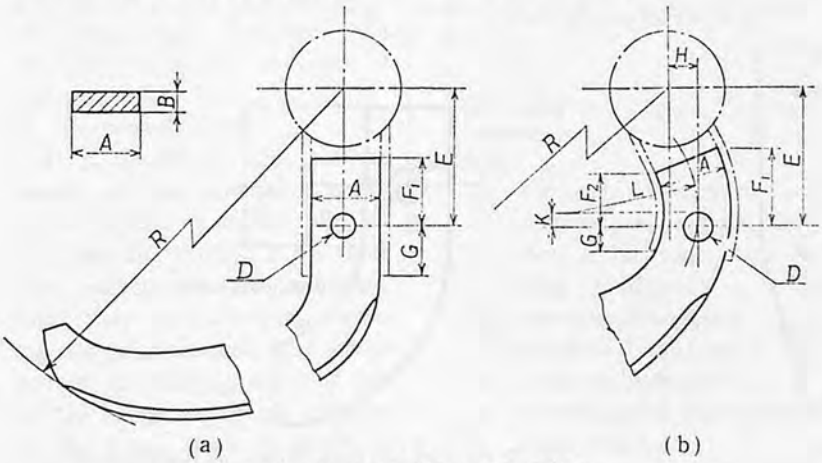


Fig. 6 Types of Holders (JIS B 9210)

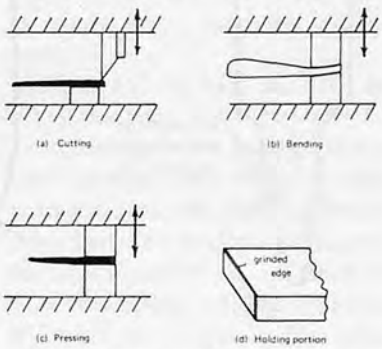


Fig. 7 Forming of Holding Portion

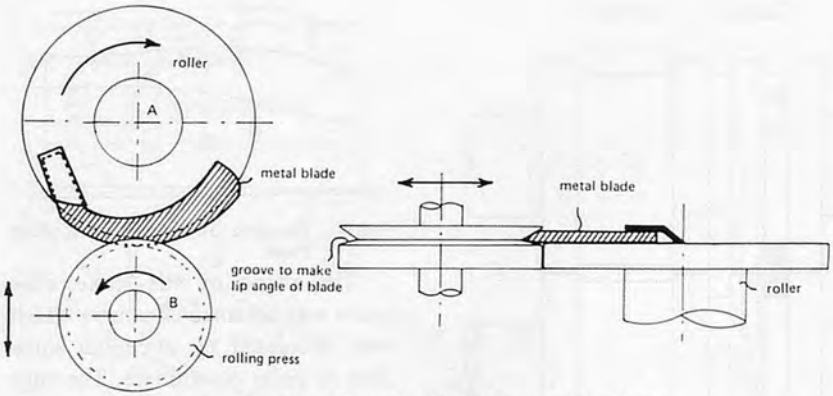


Fig. 8 Bending Rollers for the Making of Edge Curve

following equation:

$$\alpha' = \alpha_t + [\tan^{-1} (\frac{n\pi\sqrt{H(2R-H)}}{30v-n\pi(R-H)}) + 90°] \ldots\ldots\ldots\ldots (3)$$

Where

n: rotating speed of the rotary axle (rpm)

H: maximum tillage depth (cm)

v: forward speed of the machine (cm/sec)

R: maximum radius of the blade (cm)

α' is usually about 4° bigger than angle α_t.

In this process, the edge curve and the lip angle of the blade are formed by two parallel rollers in opposite rotating directions. As shown in **Fig. 8** the holding portion of the metal-blade is fixed in roller A, and the bending curve will be followed by the changing distance of the A and B rollers, while the lip angle is made by the groove of roller B.

It will become irregular in shape as shown in **Fig. 9-a** with this method, while the shape in **Fig. 9-b** is made easily with the press-machines in the process of bending the sidelong blade (blade-tip).

7) Hole Making

As the rotary blade will be bolted to the rotary axle, a hole is punched on the holding portion of the blade by a punching press-machine. In order to use a 10mm bolt for the blades of a power tiller, this hold will be $11^{+0}_{-0.5}$ mm in diameter. The relative length

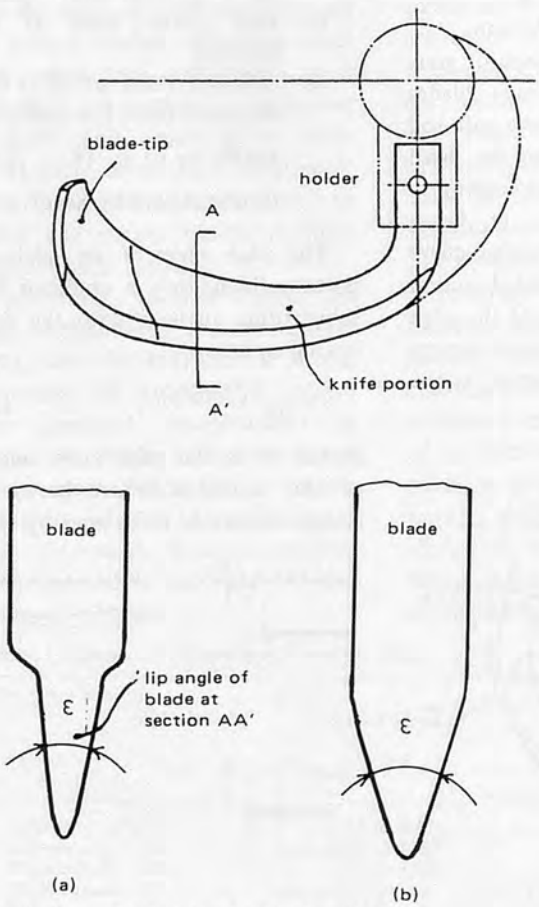


Fig. 9 Types of Lip Angle of Rotary Blade

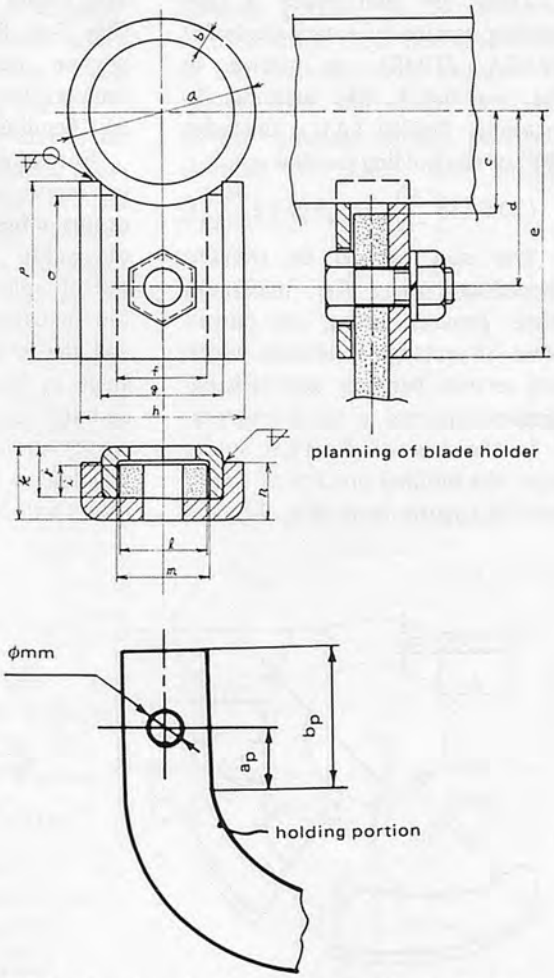


Fig. 10 Planning of a Blade Holder and Holding Portion of Rotary Blade2)

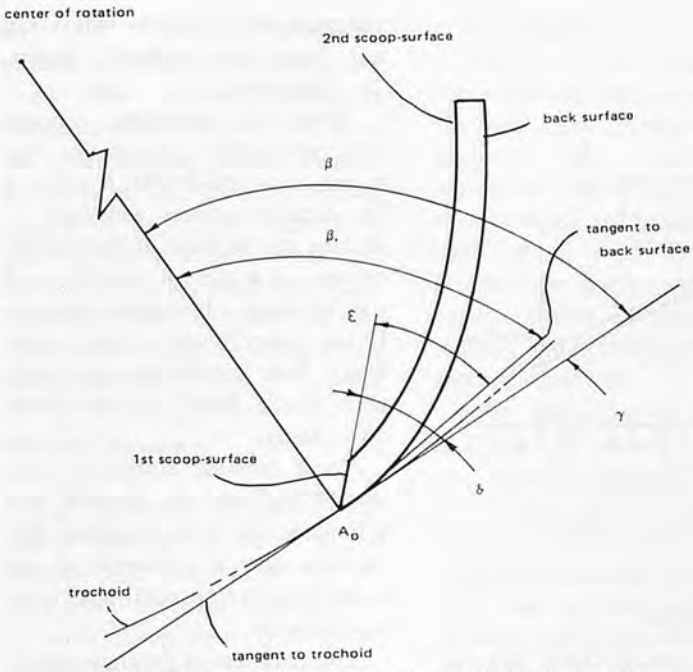


Fig. 11 Cross Section of the Sidelong Blade (Blade-Tip)

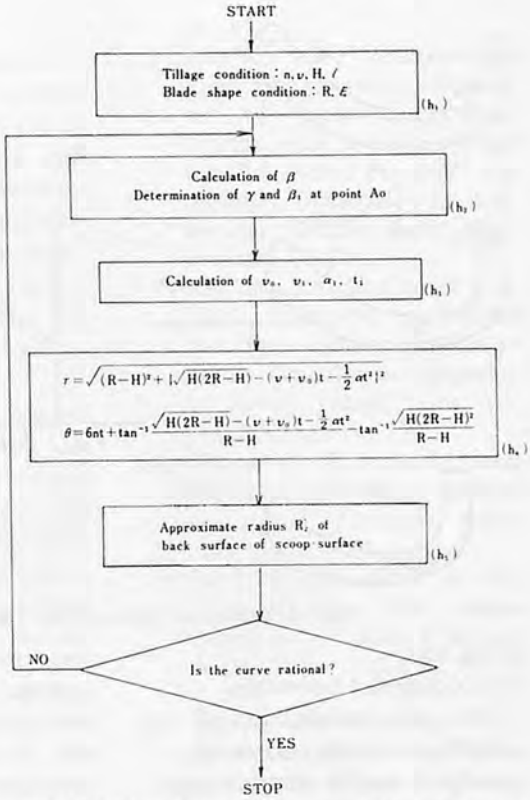


Fig. 12 A Flow Chart of Planning Design for Scoop-Surface Vertical Section2)

of the holding portion and location of the hole for the bolt is shown in **Fig. 10**.

8) Punching Mark and Cutting Tip of Knife Portion

The metal-blade is put into a press-machine to punch a manufacturer's name or mark of brand and a part number or type number at the middle knife-portion. The depth of these marks is usually 0.2 to 0.3mm. The size and location of letter marks are carefully decided in order to avoid the bending trouble and breaking of the blade. The rotary blade has a special shape at the tip of knife portion which will be explained in the next stage. Therefore, this tip portion is cut to make it straight.

9) Forming Blade-Tip

It is possible to say that the quality of the cultivating rotary blades depend upon the form of this blade-tip, because it has three main effects on the cultivating soils. They are pulverizing, throwing and mixing actions. The scoop-surface of blade-tip which is one of the most important portions of the rotary blade is shown in **Fig. 11**[11]. The characteristics of some angle factors of the scoop-surface were also studied[4)5)6)7)8)9)10)]. Cutting angle δ and relief angle γ of the blade-tip as shown in **Fig. 13**, are calculated by the following equations:

$$\gamma = \beta - \beta_1 \quad \ldots\ldots\ldots\ldots (4)$$

$$\gamma = \cos^{-1}\left[\frac{30v}{R}\sqrt{\frac{H(2R-H)}{(30v)^2 - 60n\pi v(R-H) + (Rn\pi)^2}}\right] - \beta_1 \quad \ldots\ldots\ldots\ldots (5)$$

$$\delta = \epsilon + \gamma \quad \ldots\ldots\ldots\ldots (6)$$

Where,

β: the angle between the back surface and the radial direction at the edge point A_0 (**Fig. 11**) (degree)

β_1: scoop-angle (degree)

H: depth of tillage (cm)

R: radius of blade (cm)

n: rotating speed of the rotary axle (rpm)

v: forward velocity of machine (cm/sec)

ϵ: lip angle at the blade-tip (degree)

The cultivating resistance increases with the increase in the relief angle γ of the rotary blade, however there is a good effect to throw the soil back and to support the machine weight, thus the scoop-angle β_1 is determined from the objective of cultivating conditions as follows:

- 40° to 55° for soft soil such as sandy or muddy soil.
- 55° to 75° for normal soil such as sandy loam, loam and clayey loam.
- 75° to 85° for hard soil such as heavy clay and dry soil.

According to the analysis of soil clod motion and blade cutting characteristics, the planning-design flow-chart for vertical sections of the scoop-surface is obtained[11)] as shown in **Fig. 12**. The blade-tip is formed by a press-machine with molds of rational shapes as shown

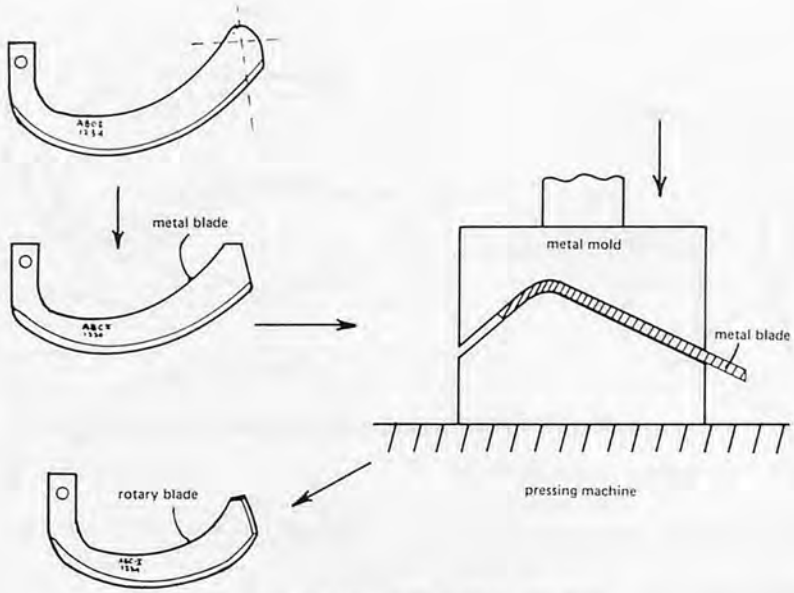


Fig. 13 Bending of Sidelong Blade (Blade-Tip)

in Fig. 13.

10) Cooling and Inspection

The hot metal-blade will be cooled slowly by water or air (mostly by air) for safety of inspectors and to prepare for the heat treatment in the next process. Then it is inspected thoroughly, and if every part of the rotary blade is right, the blade is proceeded to the next stage by conveyor.

Heat Treatment

Heat treatment is an operation or combination of operations, which involves heating and cooling of the metal or an alloy in the solid-state in order to obtain certain desirable conditions or properties (Increasing the hardness of steel is directly related to its carbon content). Plow-shares, disk-plows, disk-harrows and rotary blades are examples of agricultural machinery parts that are heat treated in order to become more serviceable implements.

In this case, after the metal-blades have only undergone the forming process, they do not have sufficient hardness, ductility and uniform structure. In addition the residual stresses are built in. Therefore, these metal-blades have to undergo the heat treatment process in order to be used effectively and to have durably a ductile characteristic. The heat treatment process is carried as follows:

1) Hardening

Hardening is a heat treatment for certain steels, which generally involves heating to a certain degree of temperature at a determined period interval according to the characteristics of the material, and then cooling rapidly by immersion in liquids or gases or by contact with another metals.

In this method, the metal-blades are heated to about 830°C to 860°C. Then they are cooled rapidly in the quenching medium. The hardness of the metal-blades may be controlled by the kinds of quenching mediums used and the degree of the heating temperature. Usually, they are cooled in quenching oil which will drop the temperature quickly to about 80°C. There are many kinds of oils which can be used for this cooling process, but Bioquench 70 oil is usually used in Japan.

The temperature is sometimes still dangerous in the handling process. Therefore, the metal-blades will be cooled again down to a low temperature by water, which can not burn the worker's fingers.

2) Tempering

After the hardening process, the metal-blade is usually too strong, hard and brittle. It will not be suitable for use and tend to shorten the lifetime of the blades, because of a lack of ductility and the presence of residual stresses. If the rotary blade is used under heavy load conditions, especially with shock loads, it will break down easily.

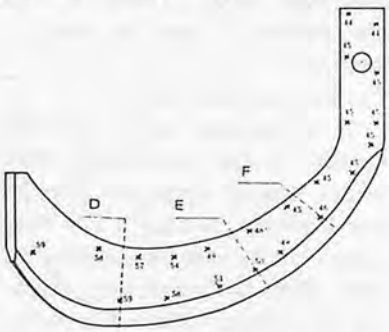
These internal stresses in the metal-blade may be relieved, and a limited degree of toughness and ductility also is recovered in the metal-blade by an additional heating operation.

The hardness of Japanese blade-tip is usually 55 to 60 H_RC, while the holding portion of the blade is adjusted to be 40 to 48 H_RC.

In the first tempering stage for the blade-tip, the whole blade is tempered to be of 55 H_RC, applying about 300°C tempering temperature in Japan. This temperature is closely related to the carbon content of the spring steel. SUP 6 contains 0.55 to 0.65% carbon content. Then the metal-blade is cooled slowly in air.

3) Tempering Process for Holding Portion

The breakdown of the rotary blades, especially NATA ZUME in Japan usually occurs near holding portion. Therefore, this portion



D Structure: Martensive + Toolsite H_R C 59
F Structure: Sorbite Structure H_R C 46
E Structure: Toolsite + Sorsite Structure H_R C 50

Fig. 14 Distribution of Hardness in Rotary Blade13)

undergoes the second tempering process to become more stick and tough. The holding portion is heated again to about 500°C in the other rotating burner. Then it is cooled by air. Thus, the holding portion of the rotary blade has a good springy structure and hardness of about 43 to 48 H_RC. After heat treatment, the hardness of the rotary blade is distributed as shown in **Fig. 14**.[13]

Finishing Process

The forming process of the rotary blade is completed in this process. The metal-blade will be coated or varnished with lacquer, in order to prevent rusting and appreciate beauty of the blades. It may be done by putting metal-blades on hooks which are connected to a rolling belt. Then each metal-blade will be put into lacquer tank for a short time. Then they are dried in air or by an electric drier.

Conclusion

It is possible to manufacture rotary blades by one skilled engineer with a hammer. However, in Japan, system of mass production is applied to produce more than 70,000 blades in a peak month by one of leading manufacturers. There are several methods of manufacturing blades in Japan. The authors investigated their up-to-date production technologies. The production-line of rotary blades is composed of the following processes:

A) Forming process
B) Heat treatment
C) Finishing Process

One of the most important problems for the designer is to create the most favorable shape of rotary blades for the actual soil and vegetative conditions. Manufacturer's knowledge in the heat treatment of materials is important, because the quality and durability rotary blades depend on the method and technique of this heat treatment process.

The operations of the production-line of rotary blades are automated to increase the output of blades and to improve the worker's productivity. Therefore, this production-line will be operated by two or three persons, instead of seven or eight persons in the case of blades made manually.

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The Palm Oil Industry in Malaysia and Its Need for Agricultural Engineers

by
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Abstract

The palm oil industry in Malaysia is the second largest export earner and very well established technologically and economically. The government has recently established several agencies to develop and make the palm oil a most competitive enterprise. Future projections of both production and export of crude and refined products are very encouraging. The uses of palm oil, besides traditional ones like foodstuff and cooking media, are also being expanded rapidly in the industrial areas.

This paper stresses the need for qualified agricultural engineers to fully exploit the potential of the palm oil industry as regards optimum productivity and the right environment.

Introduction

Malaysia's palm oil industry has experienced a tremendous growth rate in the past and an outstanding growth rate is predicted for the future. The technical know-how available in the hands of enterpreneurs and agricultural engineers can further boost the industry and make it more competitive in the world market.

Tun Tan Siew Sin (1979) cited that the shortage of labour in estates would become worse in the years to come, and the only solution is increased mechanisation unless rubber trees are allowed to remain untapped and oil palms unharvested. His view is that engineers would have to play a vital role in the plantation industry in the future. Hence, innovative engineers are urgently needed. He suggests that engineers should look into the possibility of an oil palm mechanical harvesting pole, as the present bamboo harvesting poles being used are ineffective when the palms reach a height of about 30 feet. Because of this, such palms are being felled for replanting even though they are still yielding well.

Agricultural Engineering and Its Potential for Palm Oil Industry

Agricultural engineering is the application of the art and science of engineering to agriculture, horticulture, forestry and their products. It is interdisciplinary in both engineering and non-engineering subjects. Pure and applied sciences like biology, physics, chemistry, mathematics, thermodynamics and agriculture form a part of it. Basic engineering disciplines of electrical, mechanical and civil together with those developed later (bioengineering, chemical and food engineering, electronics and instrumentation engineering) are also included. This versatile coverage at the training level gives to the agricultural engineer the necessary knowledge for solving specialised problems of the profession and practice.

Agricultural engineering is classified into several areas for a systematic study and specialisation:

Soil and water engineering – This area is based on conservation techniques of soil and water; soil and water resource management; flood control; soil-plant dynamics and erosion of soil; land reclamation and agricultural land development.

Irrigation and drainage engineering – This specialization is allied to soil and water engineering.

Farm power and machinery – Sources of power like electric

motor, internal combustion engine, human and animal to run the machines; agricultural machinery such as tractors, ploughs sprayers, dusters, seeders, planters, cultivators, harvesters, trailers; logging and sawing machinery; land-levelling and development machinery are the subjects in this discipline.

Light structure – Land development and planning for human and animal shelters; farm structures for human dwellings, animals, grain storage, silos, equipment and machinery sheds, workshop; farm and forest roads, small bridges, rural water-supply and sanitation; engineering properties of biomaterials, engineering materials and other non-biomaterials are the component subjects for light structures.

Process engineering – Basically, processing changes the form and characteristic of any farm or forest product to render it suitable for a particular use. This includes cleaning, sorting, grading, drying, milling, dehydration, mixing, refining, oil, extraction, packing and storage.

Food engineering – This discipline includes freezing, freeze-drying, canning, bottling, preservation of food and food products, manufacture of butter, cheese and other milk products, including food packaging.

Environmental engineering – Cause, effect, prevention and remedy of air and water pollution are the important subjects covered in this field; Agricultural waste treatment and utilization together with agricultural chemical-residues; effluent discharge from processing plants, e.g., palm oil mills discharge into rivers.

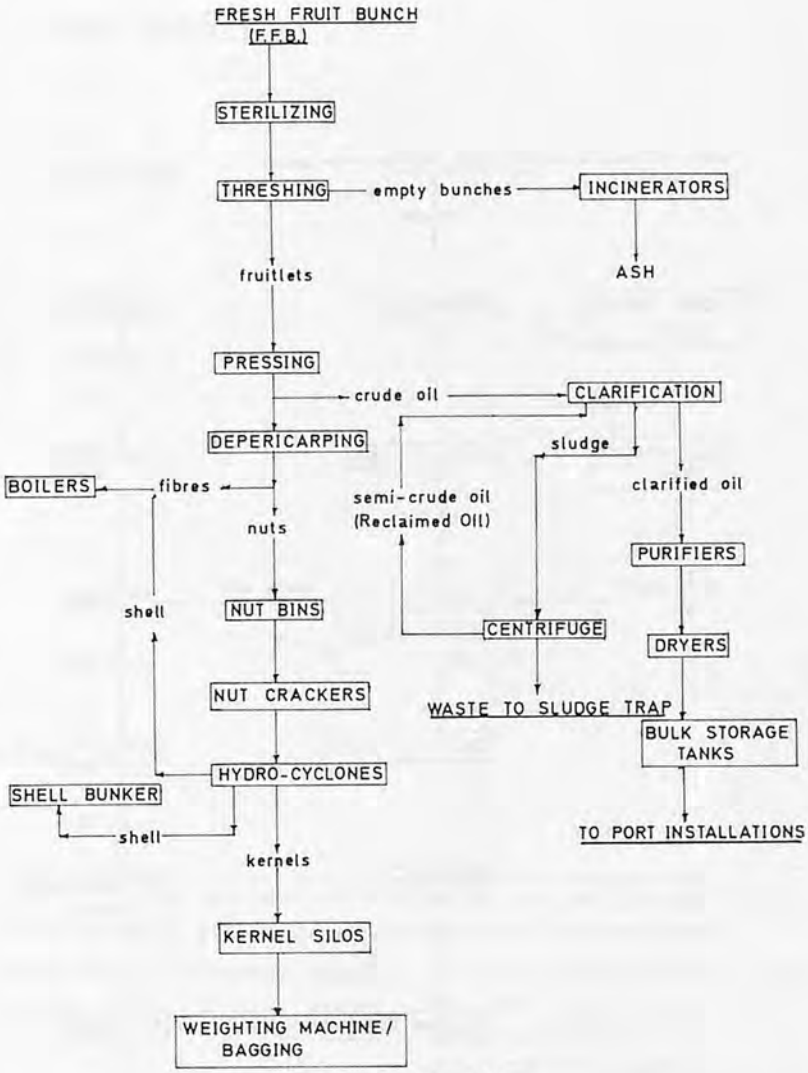

Fig. 1 Palm oil mill flow

Government Organisations Related to Palm Oil Industry

In the palm oil industry is a considerable investment by the private sector and government heavily involved. Agricultural engineers can maintain and further develop the industry by associating themselves with the following government organisations:

Palm Oil Registration and Licensing Authority (PORLA)

The Plam Oil Industry (Licensing) Regulations of 1979 requires all those in the industry to apply to PORLA for licences. The law covers mills, refineries, principal firms, estates and others involved in palm oil, including small holdings. The poor response in licensing by the smallholders, at present, is attributed to the poor communication or ignorance of the law. The implementation becomes further difficult in the absence of satisfactory statistics to indicate the estimated number of smallholdings in the country. The task of the authority is to issue proper standards and quality control of palm oil.

Palm Oil Exchange

Recently the government has drawn up a legislation to set up a palm oil exchange which is expected to be operational by the end of 1979. The legislation would not only cover futures trading in palm oil but all other forms of futures trading undertaken by firms established in the country.

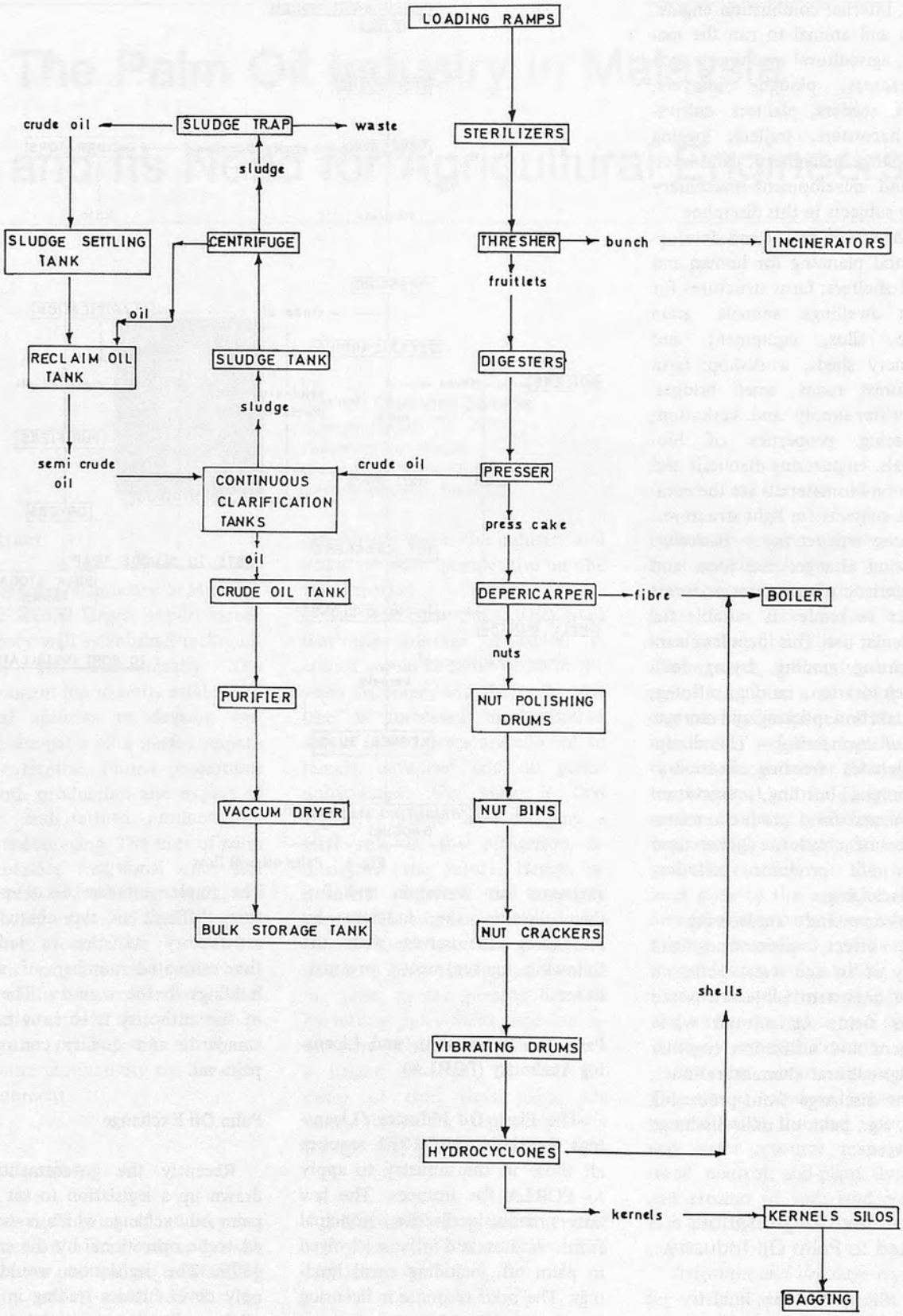

Fig. 2 Processing stations

Palm Oil Research Institute of Malaysia (PORIM)

This agency was established very recently with the aim of increasing the quality of palm oil, making it more competitive through research and, therefore, help speed up the development of the palm oil industry.

Palm Oil Research and Development Board

The board, set up under the Palm Oil Research and Development Act of 1979, comprises 12 members and a chairman.

Both PORIM and R & D Board will establish appropriate specifications for standard and premium grades of Malaysian palm oil, the high quality of which, therefore, could be maintained and further enhanced. The emphases of the research policies are:

(i) Breeding and selection to develop high yielders and the development of a hybrid variety for producing higher quality oil.

(ii) Utilisation of palm oil in the manufactured products and improving blending as well as processing.

(iii) Quality control.

(iv) By products, effluent and minimising of waste and environmental pollution.

Federal Land Development Authority (FELDA)

This federal statutory body helps develop land for village area and settle families concerned in the production of palm oil, rubber, sugarcane, cocoa and coffee.

FELDA Transport Corporation

This corporation is wholly owned by the FELDA and handles the transport of FELDA's palm oil, latex and latex concentrate and sugarcane. The transport vehicles owned by the corporation include tankers, lorries, tractors, loaders and trailers.

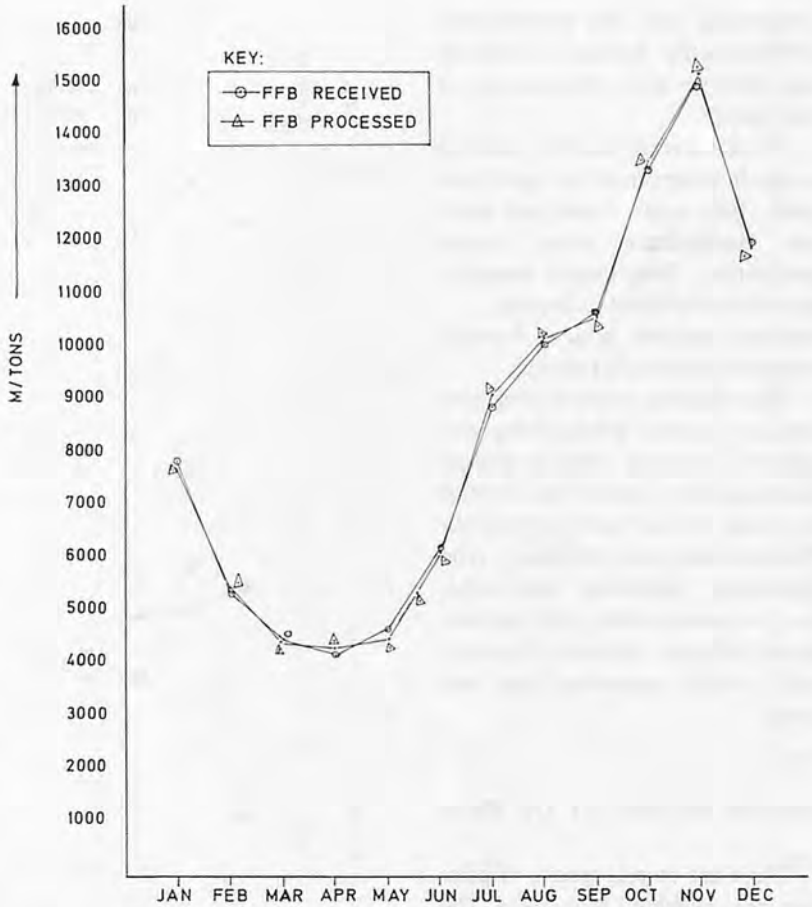

Fig. 3 FFB received and processed in 1978 for one typical mill

FELDA Mills Corporation

This is also wholly owned by FELDA and is responsible for the operation of all FELDA palm oil mills, rubber factories bulking and refining installations.

FELDA Security Services Corporation (FELSCO)

This is responsible for all security arrangements in FELDA and its subsidiaries.

FELDA Oil Products (FOP)

Incorporated in 1975, the FOP is a joint venture of three partners in the field of palm oil refining and manufacturing and marketing products and by-products based on palm oil. The joint venture partners consist of FELDA, palm oil producer; MITSUI (JAPAN), trader; and ADK (JAPAN) technology.

FELDA - Johor Bulkers (FJB)

This private company is the only palm oil terminal operator that could use palm oil bulking facilities. It avoids the duplication of facilities, overcrowding of gantries and coordinates the development and operations of the port in Pasir Gudang.

Malaysian Agricultural & Research Development Institute (MARDI)

The overall objective of MARDI is to intensify research activities according to the research priorities identified and to develop new technologies to increase the income in

consonance with the government's new economic policy of eliminating poverty and restructuring of the society.

It has several specific standing research programmes on padi, oil-palm, field-crops, cocoa and coconut, horticultural crops, animal production, fundamental research, agricultural-product-utilization, research services, project development and sociological studies.

The oil palm research programe aims to increase productivity and reduce production costs as well as improving the quality and extend the range of end uses of palm oil. The activities cover breeding, crop physiology, agronomy and nutrition, crop-protection, mill processes and effluent control, oil quality and further processing and end uses.

General Aspects of Oil Palm

There are several species of palm tree from which oil is obtained. The tree is coarsely ringed and attains a height of about 10 meters. It is topped by a crown of feathery leaves from 3 to 5 meters in length.

The plam is usually grown by germinating seeds in nurseries and kept in polybags for 12 to 14 months before they are transplanted. The palm bears fruits in about three years, and reaches peak yield between the 8th and 10th year. While the normal life of a palm is 60 years or more, commercially productive life may be 30 to 35 years only.

The fruit forms in a bunch in the upper leaves and the colour of the fruit is deep orange to reddish brown. Each fruit consists of an outer pulpy layer (mesocarp) enclosing a nut which contains the brownish black kernel (endocarp). Palm oil is obtained from the fibrous mesocarp while the kernel oil is extracted from the endocarp.

The oil palm tree is vulnerable to attack by pests, weeds, insects rats and diseases on the leaf, fruit, trunk.

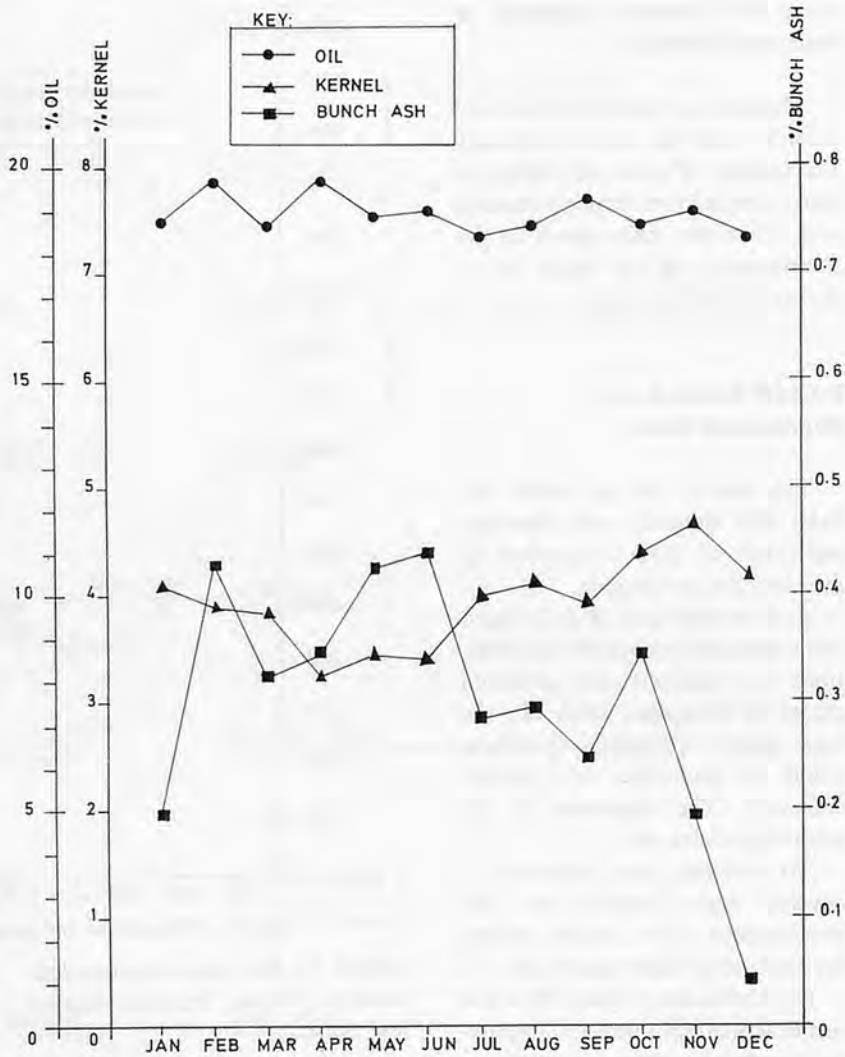

Fig. 4 Extraction rates of palm oil, palm kernel and bunch ash in 1978 for one typical mill

Harvesting Oil Palm Fruits

The yield of inland palms is less than those in coastal areas, that is 3-1/2 to 4 tons/acre/year for the former and 4 to 5 tons/acre/year for the latter. Harvesting is done once a week.

The criteria for a ripe bunch that can be harvested is normally subjective and the engineering properties can be used for more specific harvesting. Usually, 5 to 10 loose fruits on the ground indicate that the fruits are ripe and ready for harvest.

Harvesting is done mostly by means of a sharp chisel for short trees. Some of the important supervisory points during harvest are;

(a) After the bunch is harvested, no fruit should be left behind around the tree as they either germinate or attract rats and are considered as a loss.

(b) No unripe or hard bunch should be harvested.

(c) It is better to reject all undesirable bunches like aborted-bunch (due to poor pollination) and rotten bunch (which can be judged from the rotten massy

stalk).

(d) After harvesting, fruits should not be left in the field for more than 24 hours because they become sour due to the increase in their free fatty acid (FFA) contents.

(e) It is to be ensured during harvesting that no long stalk is left attached to the harvested bunch because it would add weight to the bunch unnecessarily.

(f) Premature cutting of fruits will cause a loss of extraction whereas over ripe fruit bunches will have increased free fatty acid contents.

Palm Oil Production in Malaysia

Production output of palm oil rose by 10.2% in 1978, compared with increase of 10.5% and 16% in 1976 and 1977 respectively, and an average annual growth rate of 21.1% during 1971–77. This decline was due to the effects of drought during the beginning of 1978. Likewise, the production of palm kernels rose by 9.3% in 1978, compared with an increase of 19.3% in 1977. The palm kernel mills in 1978 consumed the entire output and 10,800 tons of imported plam kernels compared with 17,000 tons imported in 1977 (**Table 1**).

From 1977, the number of refining and fractionating plants in production rose by 4 to 28 and in 1978, the government approved 9 refining and fractionating plants, bringing the total number approved to 60.

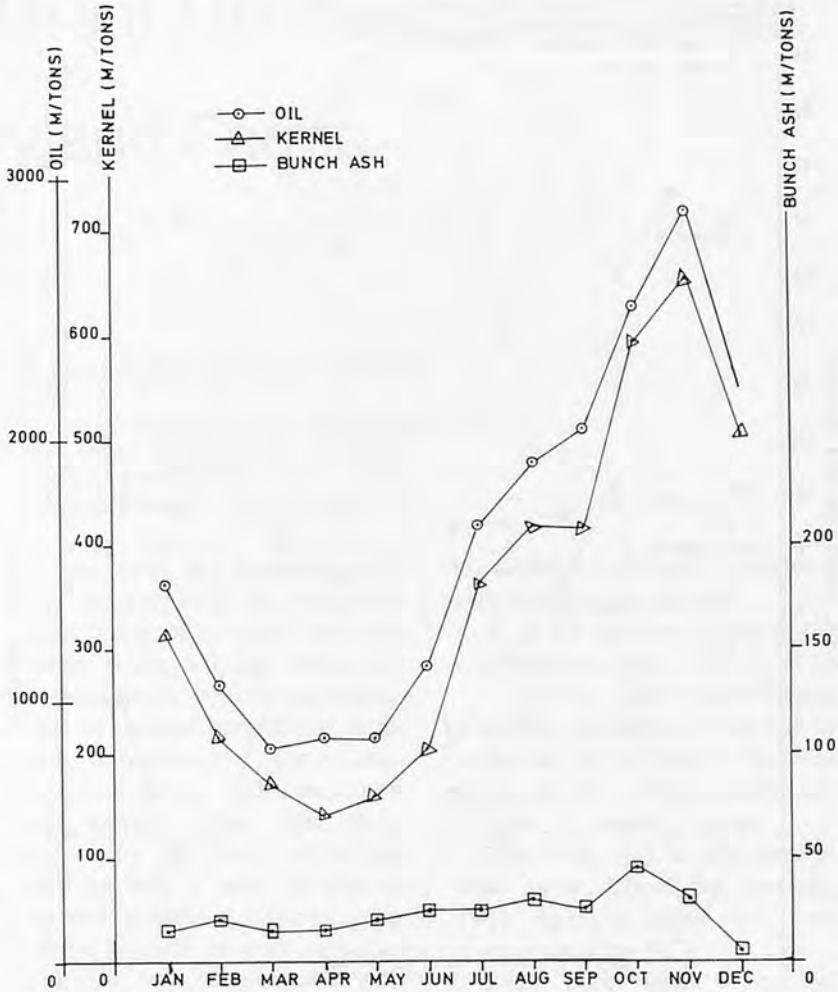

Fig. 5 Oil, kernel and ash production in 1978 for one typical mill

Table 1. Area, Production and Yield of Oil Palm

Item	1977	1978 Preliminary	1977	1978 Preliminary Percent Change
Area (000 hectares)				
Planted	769.5	801.6	10.3	4.2
Harvested	549.9	615.8	27.5	12.0
Production (000 tons)				
Palm oil	1611.6	1777.8	16.0	10.2
Palm kernels	334.8	365.8	19.3	9.3
Yield (kg/harvested hectare)				
Palm oil	2930.7	2887.0	– 9.0	– 1.5
Palm kernels	608.9	594.0	– 6.4	– 2.4

Future Projections

The production of palm oil in Malaysia is projected to increase from 2.3 million tons in early 1980's to 4 million tons by 1985 and 5.5 million tons by 1990. This means markets are to be found for the rapidly rising quantities of the oil. It would be necessary to capture an increasing share of the world market from the present 13% to about 22% by 1985. It is because Malaysian exports of palm-oil are expected to rise to about 20 to 25% of the world's total exports of oils and fats in the next decade.

Uses of Palm Oil

In Malaysia, palm oil is now refined prior to export whereas about ten years ago it used to be exported in the form of crude oil. It is bleached and split into liquid and solid fractions. One company manufactures cooking oil, vanaspati (shortening), i.e., ghee

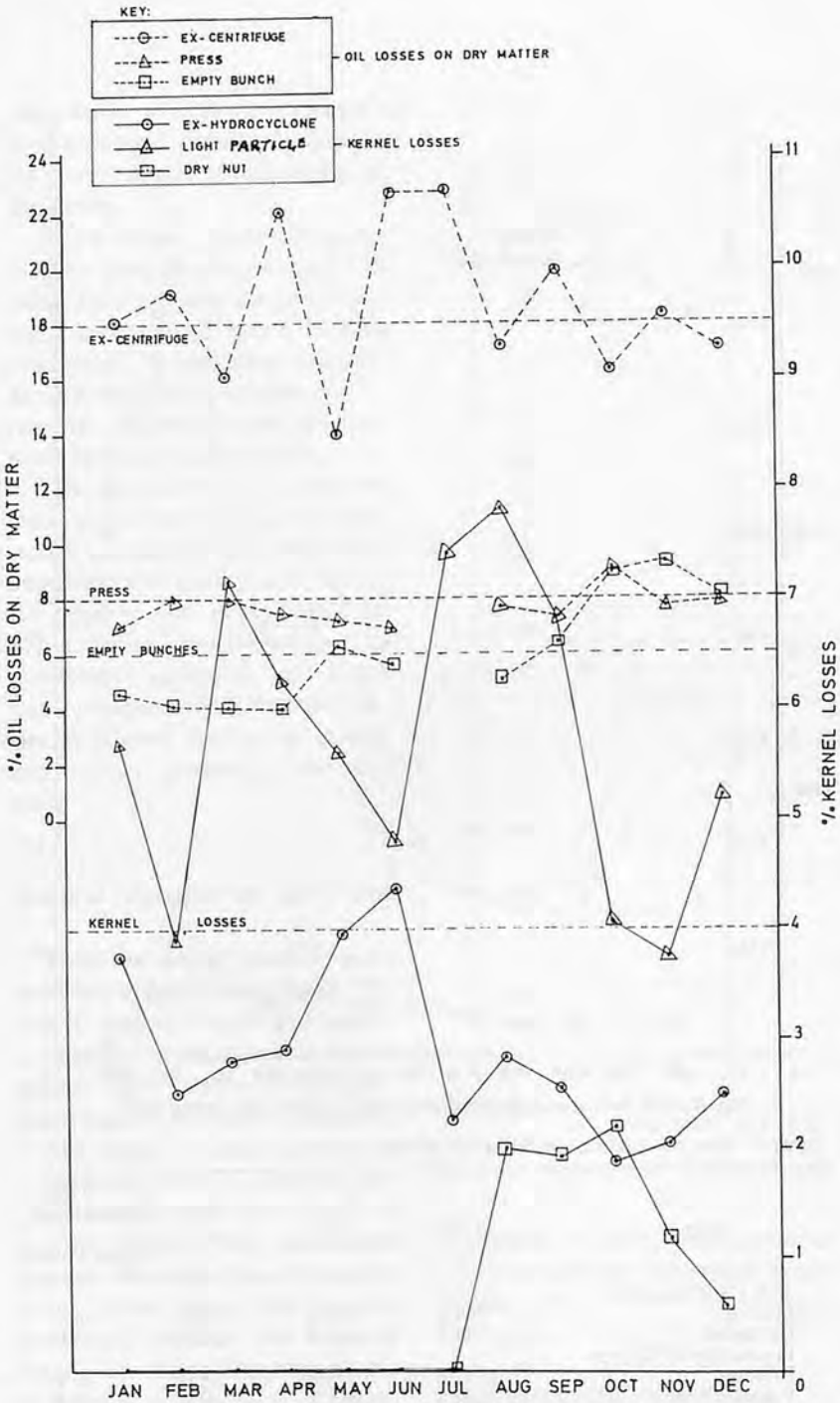

Fig. 6 Oil losses and kernel losses in 1978 for one typical mill.

and soap is obtained as by-product. Another firm produces oleic, stearic acids and glycerine which are the examples of palm oil used as chemical raw material. Hydrogenolysis can yield fatty alcohols to be converted into sodium alkyl suphonate detergents. Ester exchange can yield a series of esters from simple methyl stearate to more complex stearates. Plastic industries use them as plasticizers whereas methyl stearate has been shown to be a good diesel fuel.

The University Sains Malaysia has patented a new method of processing palm oil and extracting carotene, a rich source of vitamin A. Thus the main uses of palm oil are for shortening, margarine type products, cooking oil and salad oil. It is also used in the manufacture of grease, soap, candle, lubricants, cosmetics, and chemical cleaning products.

In the U.S.A., it is used as a flux in the production of tin plate. It acts to spread, lubricate and protect the tin film which is applied in molten form to the base steel sheet, or the metal being plated.

An agricultural engineer can apply the principles of systems engineering, including optimisation-techniques to the existing operations of the palm-oil industry. The manual methods can be partially or wholly substituted by mechanised methods, which in turn, are again subject to more advanced research in engineering.

In order to achieve optimum results, it is necessary to carefully study each operation of the palm oil industry. Some operations are developed by the agricultural scientists for producing the raw material (at the farm-terminal) to be processed in the mills. Other operations are undertaken by engineers and technologists for primary, secondary and tertiary processing.

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Effects of Different Mechanization Levels in Spanish Dryland Farms

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Summary

Five levels of mechanization are established for the agricultural farms, and particularized for four cases of cereal dryland farms. Based on the equivalent unit of work "Ent", an index of mechnization is defined, considering the human work and that of the machinery. Very simple expressions define work-capacity, productivity and energy consumption. The variation of these items is studied for Spanish cereal dryland farms in relation to the index of mechanization.

Introduction

Taking as a basis the theories relative to the establishment of an index of mechanization developed by Nowacki, T. 1971, 1974, although introducing some modifications, the indexes of mechanization for four Spanish cereal dryland farms from a lesser to a greater level of mechanization have been obtained.

Although the two farms with lower indexes of mechanization are hardly used now in Spain, they have been considered only as an element of comparison with two popular ones.

This study is a summary and a particularization of the cereal dryland farms of a more extensive nature which is being carried out to analyze the level of mechanization of various agricultural farms and its incidence in the productivity of labour and nonrecoverable energy outlays. The aforesaid study has been carried out with the help of linear programming and includes a sufficiently extensive interval of work capacities and yield to cover more than 90% of the farms taken into account. In this particular case average values have been used for the purpose of reaching practical, concrete results although we insist that its validity is defined by those average farms with fields comprising between 0.5 and 2 ha and average cereal productions of 2 t/ha.

Definition of Concepts on Index Mechanization

Technical Work on the Farm

This is arrived at by the sum of the jobs carried out by the different energy sources of the farm. Its expression is:

$$L = \Sigma\, \xi \,.\, U \,.\, T_u \text{ (E)}$$

Where:

U is the energy source (workers, horse-drawn machinery or mechanically operated machinery).

T_u is the application time of the said energy sources.

ξ is the corrector-coefficient describing the overall efficiency or utilization in the time of the rated power of the energy source considered.

The farm work is expressed in work units defined by Nowacki, 1971, which is called "Ent" and is represented by "E".

This work unit is reached through two concepts: one of energy and the other of human output.

From the energy point of view 1 Ent we established as equivalent to:

$$1E <> 1kW, h$$

and from the point of view of human output:

$$1E <> 1h\ TH$$

that is, it is equivalent to 1 hour of work of the operator.

The multiple kE is also widely used:

$$1kE = 10^3 E$$

When the technical work refers to the unit of area cultivated or production (hectare or ton) there is specific technical work and it is

expressed in small letters: 1(E/Ha, E/t or kE/ha, kE/t).

Work Provided by Machine

In accordance with Nowacki five degrees of mechanization are established:

a) Degree of mechanization M_1 – This is defined as those operations carried out exclusively by human labour.

The work provided by the machines or tools operated by man $L_{MH}(E)$ is the function of the coefficient of utilization of time employed on the job and of the continuity in the human physical effort.

The value of the corrector-coefficient of the two factors that compose the job at this degree of mechanization is $\xi_{MH} = 0,1$, so that:

$$L_{MH} = 0,1.H.T_H(E)$$

H being the number of operators and T_H the time which these devote to manual operations.

b) Degree of mechanization M_2 – It includes the work carried out by a man aided by horse-drawn machines.

The work outlay of horse-powered machinery $L_{MK}(E)$ is proportionate to the number of working horses K and to the time T_K used in the work, considering the corrector coefficient ξ_K of utilization of the physical effort of the draught horses during the work as equivalent to 0.5.

The general definition takes the form:

$$L_{MK} = 0,5.K.T_K(E)$$

c) Degree of mechanization M_3 – It represents the first degree of motorization, motorized machinery coexisting with a high participation of operators and horse-powered machinery.

d) Degree of mechanization M_4 – It corresponds to motorization characterized by the use of machinery whose only energy source is of a mechanical kind though directed by man.

The work outlay of motorized machines is proportionate to the maximum output of the powered machines N and to the time T_M used in the work.

$$L_{MM} = \xi_M . N . T_M(E)$$

The value of the corrector-coefficient of tractor-powered machines ξ_M which is present in various operations depends on the efficiency of the tractor power, the resistance of the tool and the degree of utilization of the equipment power in the duration of the work. In the general expression $\xi_M = 0.2$ is accepted as average for the calculations, when N is expressed in kW, so that the expression of the work provided by mechanically powered machines takes the form:

$$L_{MM} = 0,2 . N . T_M (E)$$

e) Degree of mechanization M_5 – This corresponds to automation, that is, the machines work by themselves, controlled by automatic systems with man merely supervising their work. This level is rare in agricultural work except in the case of automatic irrigation.

Index of Mechanization in Agriculture

It represents the percentage of work of the machines in the total of human work and that of the machinery:

$$W_{ME} \quad \frac{L_M}{L_H + L_M} \times 100 \ (\%)$$

Work of the Machines

This is the sum of the work outlays by hand, horse and tractor-powered machines.

$$L_M = L_{MH} + L_{MK} + L_{MM} \ (E)$$

The technical work L_M due to the machines is increased by 20% on average with the purpose of including the times of displacement.

Human Work

It represents the energy equivalent to the work carried out by the personnel devoted to the development of a technical process.

The human work outlay representing the function of the effort is proportionate to the number of people employed H and their work time T.

$$L_H = \xi_H . H . T (E)$$

The corrector-coefficient of personal work ξ_H expresses the degree of efficiency or utilization of the productive capacity and the time of work of the personnel. This coefficient reflects the function or effort of the worker employed.

The value of the corrector of the work of the personnel depends on the capacity of production of the said personnel, their preparation, degree of enthusiasm for the work, etc., usually varying between 0.5 and 2. By definition for an average worker and for our calculations we shall take $\xi_H = 1$, that is:

$$L_H = H.T (E)$$

meaning that the labour outley expressed in (E) is the same as the number of hours-man employed in the work.

On the other hand, as the times of preparation and displacement are not considered in **Table 1** of yields, the work of the employees L_H averages 40%.

Work Capacity of Machines

We have used the classifications of times of work approved by the O.E.C.D. and stated in the book by Ortiz-Cañavante, J. 1972. To summarize, the main times established are:

TE: Effective time

TA: Additional time (turning, provision, upkeep of the material)

Table 1 Work Times for Various Operations on Cereal Dryland Farms

Task	a) Non-mechanised Farm			b) Farms Mechanised to 1st Level			c) Farms Mechanised to 1st Level			d) Farms Mechanised to 3rd Level		
	Implements-tools	TN (hM/ha)	TNk (hT/ha)	Machines-implements	TN (hM/ha)	TNM (hT/ha)	Machines-implements	TN (hM/ha)	TNM (hT/ha)	Machines-implements	TN (hM/ha)	TNM (hT/ha)
1st ploughing	Y-moldboard plough	24,24	24,24	T-two furrow plough	6,66	6,66	T-two furrow plough	6,66	6,66	T-two furrow plough	6,66	6,66
2nd ploughing	"	20,00	20,00	"	5,33	5,33	"	5,33	5,33	"	5,33	5,33
3rd ploughing	"	18,00	18,00	"	4,66	4,66	"	4,66	4,66	"	4,66	4,66
Loading-unloading of fertilizer	Y-cart (2 workers)	0,80	0,40	T-trailer (2 workers)	0,40	0,20	T-trailer (2 workers)	0,40	0,20	T-trailer (2 workers)	0,40	0,20
Applying fertilizer	Broadcast	3,20	–	Broadcast	3,20	–	T-fertilizer by gravity	1,60	1,60	T-centrigual fertilizing machine	0,60	0,60
Harrowing	Y-harrow	3,20	3,20	T-harrow	1,60	1,60	T-harrow	1,60	1,60	T-harrow	1,60	1,60
Sowing	Broadcast	4,00	–	T-seed drill (2 workers)	4,00	2,00	T-seed drill	2,66	2,66	T-seed drill	2,66	2,66
Weeding	Hoe	40,00	–	T-oultivator	1,07	1,07	T-herbicide sprayer	1,07	1,07	T-herbicide sprayer	1,07	1,07
Loading-unloading of fertilizer	Y-cart (2 workers)	0,80	0,40	T-trailer (2 workers)	0,40	0,20	T-trailer (2 workers)	0,40	0,20	T-trailer (2 workers)	0,40	0,20
Application of fertilizer	Broadcast	3,20	–	Broadcast	3,20	–	T-fertilizer by gravity	1,60	1,60	T-centrigual fertilizing machine	0,35	0,35
Reaping	Sickle	26,66	–	T-reaper sheaves	5,33 11,43	2,66 –	T-binder (2 workers)	4,00	2,00	Combine-harvester with grain tank (N - 50 kW)	1,65	1,65
Transporting cereal	Y-cart (2 workers)	16,00	8,00	T-trailer (2 workers)	6,40	3,20	T-trailer (3 workers)	6,00	2,00			
Threshing	Y-thresher (2 workers)	45,72	22,86	T-disc thresher (2 workers)	10,66	5,33	Thresher (4 workers)	5,33	1,33	Staw baling	2,34	2,34
Winnoving, cleaning	Fork-sieve	13,33	–	Motorized winnower (2 workers)	4,00	2,00						
Straw to barn	Y-cart (2 workers)	4,00	2,00	T-trailer (2 workers)	3,64	1,82	T-trailer (2 workers)	3,64	1,82	Transport grain T-2 trailer	2,87	2,87
Grain threshing floor-granary	"	4,56	2,28	"	2,88	1,44	"	2,08	1,44			
To produce-merchant	"	32,00	16,00	"	3,60	1,80	"	3,60	1,80			
Total		239,71	117,38		78,46	39,97		51,43	35,97		30,59	30,19

Y – Yoke / T – Tractor

TP: Preparation time (in buildings or place of work)
TD: Displacement time
TR: Rest time
TM: Los time

The times established in **Table 1** correspond to the so-called "standard time" (TN), that is, all the aforementioned less the time of preparation and that of displacement.

The total time of work (TTT) is equivalent to the sum of the six main times and the total work yield (η_t) is the quotient between the effective time and the total time of work:

$$\eta_t = \frac{TE}{TTT}$$

The theoretical work capacity S_t of a machine is obtained in function of its work width and its speed v(k m/h):

$$S_t = \frac{av}{10} \text{ (ha/ha)}$$

Its value is the inverse of the effective unitary time TE (h/ha):

$$S_t = \frac{1}{TE} \text{ (ha/h)}$$

The effective work capacity S_e is obtained by multiplying the theoretical work capacity by the total work yield

$$S_e = \eta_t \cdot S_t \text{ (ha/h)}$$

Analogously, its value is the inverse of the total time of unitary worK: TTT (h/ha):

$$S_e = \frac{1}{TTT} \text{ (ha/h)}$$

Productivity and Energy Consumption

Once the indexes of mechanization of the various farms are obtained, it is advisable to determine their incidence in the productivity of the various means of production (principally labour and machinery) and in the non-recoverable energy consumption of a petrochemical origin in the working of the machines for each of the farms.

a) Productivity of labour A_H – It is defined as the work carried out in function of the labour employd. Its value is the same as the converse of the specific technical work of the labour force:

$$A_H = \frac{1}{1_H} \text{ (ha/kE) or (t/kE)}$$

We shall use the first unit in **Table 2**: ha/kE which gives us the area worked in hectares for each kiloent of labour (1000 h TH).

b) Productivity of work of machines AM – In an analogous way to the previous case it is defined as the work carried out in function of the machinery employed:

$$A_M = \frac{1}{1_M} \text{ (ha/kE)}$$

c) Total productivity A – It is the inverse value of the technical work, of the labour L_H and the machinery L_M

$$A = \frac{1}{1} = \frac{1}{1_H + 1_M}$$

$$= \frac{A_M \cdot A_H}{A_M + A_H} \text{ (ha/kE)}$$

d) Energy outlay – In this case we refer to the energy used to work the machines of a petrochemical origin or non-recoverable, its value being:

$$1_{MM}(E/ha) <> 1_{MM}(kW.\ h/ha)$$

Influence of Mechanization Index in Productivity

Prior Considerations

We begin by establishing orderly the cultivation operations which are carried out on cereal dryland farms in Spain and which are usually:

Ploughing-reploughing-loading and unloading fertilizer-fertilizing seed-beds-harrowing-sowing-fighting weeds-loading and unloading fertilizer-fertilizing cover crop-harvest-inv-transporting the grain-transporting straw or pressing.

The characteristics of these operation are described below (**Table 1**) as they can be carried out with various energy sources, with a variable number of workers (it is specified when more than one is used) and with different tools, machines or implements; the standard times used in carrying out the mentioned task are also established (according to data drawn up by our Department of Agricultural Mechanization and according to the Ministry of Agriculture, 1968) for farms with average fields, which as we have said, have an area of between 0.5 and 2 ha and an average cultivation yield of 2 t/ha.

The four technical processes considered refer to Spanish dryland cereal farms which we define as:

a) Non-mechanized farms: comprised of a yoke of mules with primary implements (plough, harrow, cart and disc thresher).

b) Mechanized farms to the first level: with a tractor of 25 kW, a two-furrow plough, harrow, seed drill, cultivator, reaper, disc thresher, winnower and trailer.

c) Farms mechanized to the second level: with a tractor of 25 kW, two furrow plough, fertilizer by gravity, harrow, seed drill, herbicide sprayer, binder, thresher and trailer.

d) Farms mechanized to the third level: with a tractor of 25 kW, two-furrow plough, centrifugal fertilizing machine, harrow, seed drill, herbicide sprayer, harvester, baler and trailer.

The fact that the same 25 kW tractor is maintained in the three mechanized farms is due to the purpose of obtaining comparable results. On the "c" farm the thresher is worked by the 25 kW tractor and on the "d" farm a self-propel-

led combine-harvester with 3 m cut and a grain tank, and with a 50 kW motor is used.

Obtaining the Results

Below we present the method of calculation of the various parameters considered, based on the data of **Table 1**.

a) Unmechanized farms:

– Technical work of manual labour:

TN_H = Standard time of those workers employed in manual labour = TN-H. ($TN_k + TN_M$) = TN-Standard time of those workers employed in task with horse power and/or mechanical power = 90, 30 (h TH/ha).

T_H = Total time of work (TTT_H) of the workers employed in manual labour = 1, 2 . 90, 39 = 108, 47 (h TH/ha).

$l_{MH} = \xi_{MH} . H.T_H = 0, 1 . 1 . 108, 47 = 10, 85$ (E/ha)

– Technical work of task with horse-power:

TN_k = Standard time of machines with draft horses = 117,38 (hY/ha).

T_k = Total time of work (TTT_k) of those horse-drawn machines = 1, 2 . 117, 38 = 140, 86 (hY/ha).

$l_{Mk} = \xi_k . K . T_k = 0, 5 . 2 . 140, 86 = 140, 86$ (E/ha)

– Human work:

TN = Standard time employed by workers in the development of the technical process = 259, 71 (h TH/ha)

T = Total time of work employed by the workers in the technical process 1, 4 . 259, 71 = 363, 59 (h TH/ha)

l_H = H.T = 1 . 363, 59 = 363, 59 (E/ha)

– Index of mechanication:

$$W_{ME} = \frac{l_M}{l_M + l_H} \cdot 100$$

$$= \frac{151,71}{151,71 + 363,59} \cdot 100$$

$$= 29,44\ (\%)$$

b) Farms mechanized to the first level:

– Technical work of manual labour

TN_H = 17, 83 (h TH/ha), T_H = 1, 2 . 17, 83 = 21, 40 (h TH/ha)

$l_{MH} = \xi_{MH}.H.T_H = 0, 1 . 1 . 21, 40 = 2, 14$ (E/ha)

– Technical work of task with mechanical power (non-recoverable energy outlay):

TN_M = 39, 97 (hM/ha) TM = 1, 2 . 39, 97 = 47, 96 (hM/ha)

l_{MM} = 0, 2 . 25. 47, 96 = 239, 82 (E/ha)

– Work of the machines:

$l_M = l_{MH} + l_{MM}$ = 2, 14 + 239, 82 = 241, 96 (E/ha)

– Human work:

TN = 78, 46 (h TH/ha) T = 1, 4 . 78, 46 = 109, 84 (hTH/ha)

l_H = H.T = 1 . 109, 84 = 109, 84 (E/ha)

– Index of mechanization:

$$W_{ME} = \frac{l_M}{l_M + l_H} \cdot 100$$

$$= \frac{241,96}{241,96 + 109,84} \cdot 100$$

$$= 68,78\ (\%)$$

c) Farms mechanized to the second level:

– Technical work of task with mechanical power (non-recoverable energy outlay).

TN_M = 34, 64 + 1, 33 = 35, 97 (hM/ha) T_M = 1, 2 . 34, 64 + 1, 33 = 42, 90 (hM/ha)

In the thresher it is not necessary to multiply by 1, 2 as times of displacement are not considered.

l_{MM} = 0, 2 . 25 . 42, 90 = 214, 50 (E/ha).

– Work of the machines:

$l_M = l_{MM}$ = 214, 50 (E/ha)

– Human work:

TN = 46, 10 + 5, 33 = 51, 43 (hTH/ha) T = 1, 4 . 46, 10 + 1, 2 . 5, 33 = 70, 94 (hTH/ha)

l_H = H.T = 1 . 70, 94 = 70, 94 (E/ha)

– Index of mechanization:

$$W_{ME} = \frac{l_M}{l_M + l_H} \times 100$$

$$= \frac{214,50}{214,50 + 70,94} \times 100$$

$$= 75.15\ (\%)$$

d) Farms mechanized to the third level:

– Technical work of task with mechanical power (non-recoverable energy outlay)

TN_M = 30, 19 (hM/ha)

l_{MM} = 0, 2 . 1, 2 (25 . 28, 54 + 50 . 1, 65) = 191, 04 (E/ha)

– Work of the machines:

$l_M = l_{MM}$ = 191, 04 (E/ha)

– Human work:

Table 2 Summary of Results Obtained for Four Kinds of Cereal Farms

Item		Dryland cereal farms			
		a) Non-mechanized	b) Mechanized to 1st level	c) Mechanized to 2nd level	d) Mechanized to 3rd level
Work of machines	l_M (E/ha)	151,7	242,0	214,5	191,0
Human work	l_H (E/ha)	363,6	351,8	285,4	233,9
Total work	$l = l_M + l_H$	515,3	351,8	285,4	233,9
Index of mechanization	W_{ME} (%)	29,4	68,8	75,2	81,7
Non-recoverable energy outlay	l_{MM}(E/ha (kW.h/ha)	–	239,8	214,5	191
Productivity of labour force	A_H(ha/KE)= = $\frac{1000}{l_H}$	2,8	9.1	14,1	23,4
Productivity of machines	A_M(ha/kE) = = $\frac{1000}{l_M}$	6,6	4,1	4,7	5,2
Total productivity	A(ha/kE) = = $\frac{1000}{l}$	1,9	2,8	3,5	4,3

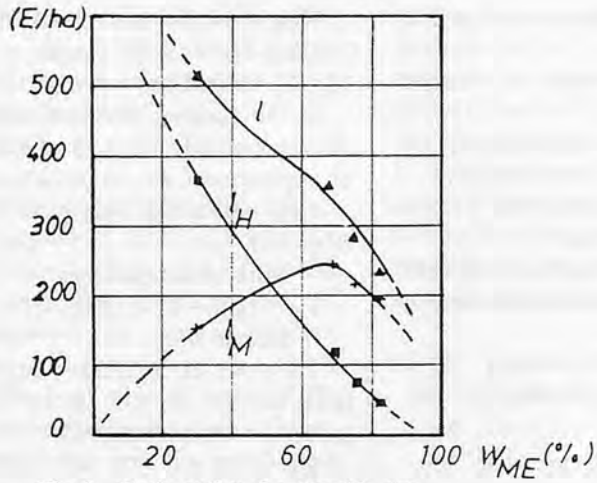

Fig. 1 Work outlay for Spanish dryland farms related to index of mechanization (l_H: Human work, l_M: Work of the machines, l: Total work).

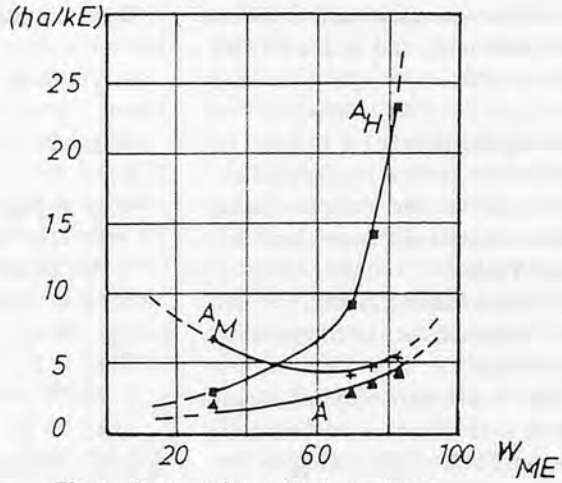

Fig. 2 Productivity related to index of mechanization (A_H: Productivity of labour, A_M: Productivity of machines, A: Total productivity)

TN = 30, 59 (hTH/ha) T = 1, 4 . 30, 59 = 42, 83 (hTH/ha)

l_H = H . T = 1 . 42, 83 = 42, 83 (E/ha)

– Index of mechanization:

$$W_{ME} = \frac{l_M}{l_M + l_H} \times 100$$

$$= \frac{191,04}{191,04 + 42,83} \times 100$$

$$= 81.69\ (\%).$$

In **Table 2** all these results are reflected together with those of the productivity obtained immediately.

Discussion

The results contained in **Table 2** referring to Spanish cereal dryland farms with different levels of mechanization are represented in **Fig. 1** and **2**, and in view of the same the following conclusions can be drawn:

1. The human work l_H progressively descends as the value of the index of mechanization W_{ME} of the farms rises due to the fact that there exists an inverse relation between the time employed by the workers to the development of the technical process and the level of mechanization of the same.

2. The technical work of the machines l_M increases with the index of mechanization until the maximum value is reached (approximately 70%) in which due to increasing the work capacity of the machines the energy outlay per surface unit diminishes as the index of mechanization rises.

3. The specific total work diminishes with the index of mechanization.

4. The productivity of the labour force increases in an exponential way with the index of mechanization.

5. The productivity of the machines A_M, analogously although in an inverse way to the technical work l_M decreases with the index of mechanization until a minimum value is reached corresponding to a value of the index in the region of 70%. This is due to the fact that each time the number of mechanized tasks is increased for the same area independently of whether or not the labour force decreases. As from this minimum value the productivity of the machines increases with the index of mechanization due to their greater work capacity and to the fact that less time of utilization of the machines is needed for the same area.

6. The total productivity, A, increases with the index of mechanization, tending to coincide with the productivity of the machines A_M for values of the index of mechanization higher than 80% as the human work decreases drastically.

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Agricultural Mechanization in Tonga

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Introduction

The Kingdom of Tonga is primarily an agricultural country located between Latitudes 15°S and 23.5°S and Longitudes 173°W and 177°W which places this group of islands just to the west of the International Dateline, south of Samoa and south east of Fiji. Tonga consists of three main island groups: Tongatapu and Eua, Ha'apai and Vava'u. There are 169 islands in total out of which 36 are inhabited. The capital of this kingdom is Nuku'alofa.

The total population of this kingdom is nearly 92,000. The average size of holding is nearly 8.25 acres. The topography on the main island is level which allows all sorts of tropical crops to be grown. The main crops grown are; taro, cassava, kava, melons, maize, yam, cucumber, pumpkin, pawpaw, tomatoes and other vegetables, pineapples, banana and coconut, etc. Pig raising and fishing are very common and have become a way of life for the Tongans. The soils vary from sandy loam to sandy clay loam and the distribution of rainfall is fairly uniform throughout the year. Root crops are the staple of the people. **Fig. 2** shows a taro crop waiting for harvest.

Status of Agricultural Mechanisation

Farm mechanisation in Tonga is very well organised. The primary agricultural operations like clearing and levelling of land, ploughing and harrowing is carried out by the Services Division of the Ministry of Agriculture through its Agricultural Machinery Pool. This pool takes care of most of the custom hiring work which is quite similar to agro-industries corporations of other countries. **Fig. 3** shows the various agricultural machines stocked at the Agricultural Machinery pool. **Table 1** lists the distribution of these farm machineries and equipment.

Fig. 1 Nuku'alofa, Capital of Tonga

Fig. 2 A taro crop waiting for harvest

Fig. 3 Agricultural machines at the Agricultural Machinery Pool of Services Division of M.A.F.

Fig. 4 A tractor with fuel and machine ready to go to a village for custom hiring work

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Table 1 Distribution of Farm Machinery, 1979

Item / Equipment		Unit	Remarks
Tractors:			
	International	2	
	Ford	23	
	Massey Ferguson	25	
	Caterpillar	6	
Disc Ploughs:			
	Three disc	20	
	Two disc	5	
Disc harrow		40	
Cultivator		9	
Slasher		10	
Knapack sprayer		3	
Digging fork		2	(used for mannual work)
Cane knife		1	(used for mannual work)
Spade		1	(used for mannual work)
Hand hoe		2	(used for mannual work)

Table 2. Farm Operation and Machinery Used*

Operations	Machinery and Equipment Use
Land clearing and levelling	Caterpillar and leveller
Slashing	Tractor and slashers
Ploughing	Tractor dram disc ploughs
Harrowing	Disc harrows
Cultivation	Cultivators
Post hole digging	Post hole diggers

* An average of $T.50/hr is charged farmers for custom hiring of most of the above operations since 1965.

Fig. 5 Horses are mostly used for pulling carts

Fig. 6 A wind mill in operation in Tonga for harnessing natural source of energy

Need for Mechanization

Horses in Tonga number between 5,000 and 6,000. Each horse of average size develops 0.8 to 1 HP for agricultural purposes on 12,000 farms or an average of about 0.5 HP per farm. Each adult person develops about 0.1 HP and each family had 4-5 adults or about 0.5 HP power available from human resources. Hence each family has 1 HP available for agricultural purposes which is rather high compared to other Asian countries.

The size of farms and farming systems currently practised in Tonga will discourage the farmers from taking up agriculture as a business if and when tractors are introduced as source of power. Animal-based system of mechanisation with appropriate farming practices seems adequate for the country's needs.

However, there is need to develop suitable mechanization package of practices for some of the important crops in the country through the establishment of an agricultural engineering and farm mechanisation research programme. ■■

Appropriate Agricultural Engineering Technology for Bangladesh

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Abstract

Farming in Bangladesh is still traditional. Local technology is less efficient and less effective but can be improved. Labour, draft power and local technology are the main concerns for the development of an appropriate technology for Bangladesh and after determining the status of these components, possible solutions may be found. These solutions then can be brought into shape by following appropriately designed programmes keeping in view the socio-economic conditions of the farmers, types of soil and the available draft power.

Introduction

Low productivity and low level of technology are the basic characteristics of Bangladesh agriculture. The increase in production efficiency is a must in order to meet the present and increasing demand for food. The scope for achieving increased production through increase in land area is limited and so the only alternative is the vertical production expansion which implies increased production per unit of land per unit of time.

Bangladesh is a labour intensive country, no doubt, but labour is not a supplement for the machine every time. The performance of machines is much more superior to that of labour in respect of the time, quality and the quantity. Abundant supply of labour cannot help in increasing the food production if the inputs like equipment and draft power are inefficient, ineffective and in short supply.

Determining Appropriate Technology

1st step: Study of Labour Availability

A study has to be carried out to determine the level of labour availability all over the country at particular periods of the year for particular agricultural operations by the following procedure.

i) The country has to be subdivided into smalle areas where the studies would be carried out.

ii) Determine the normal availability of the labour for the agricultural operations in each of these areas in every month of the year.

iii) Determine the total requirement of labour for the agricultural operations in each of these areas in every month of the year.

iv) Carefully investigate the effects of labour migration on local labour demand and supply.

v) Then plot the data as shown in the **Appendix Figure.**

The graph clearly indicates the labour "Deficit" and "Surplus" at a particular period or the agricultural operations of the year. This deficit indicates that an appropriate machine must be used as the supplement of the labour power at that particular period of the year to complete the operation within optimum time. The operational type of the machine will be specified by the operational period of the year at which the labour deficit occurs.

2nd step: Study Animal Draft Power Availability

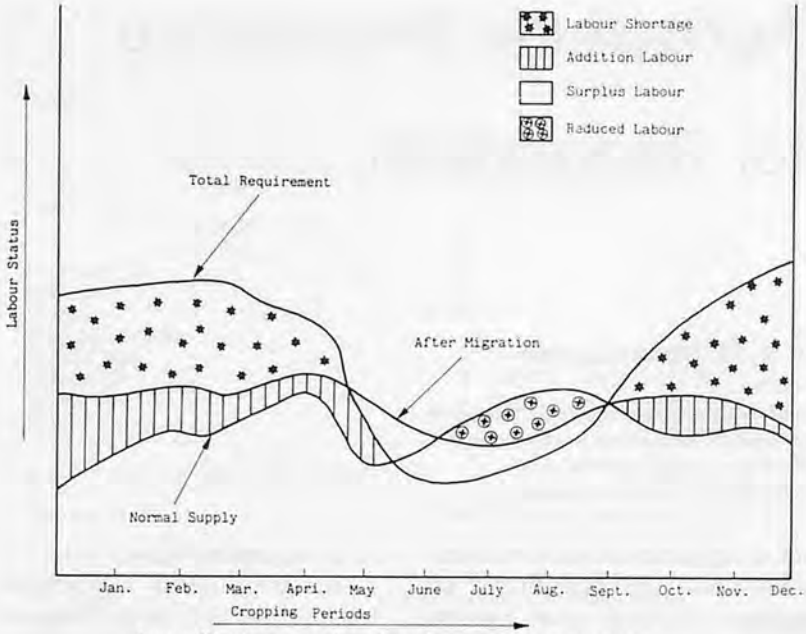
A study of the animal draft power available will justify labour substitution by an appropriate power fource.

i) The country may be divided into several regions.

ii) One or two districts from each region may be choosen for the study.

iii) Sample farm households have to be selected from each district from which the following information should be taught: total farm areas, cropping pattern, cropping intensity, cultivated land area each crop and life cycle of the crops, and total number of draft animals.

iv) Energy requirement per acre for the production of main crops at various stages of farm opera-



Appendix Figure: Labor Requirement and Availability

tions should be determined.

vi) Determine whether draft power is adequate or not.

3rd step: Study the Problems of Technology

i) Land preparation – There is a remarkable shortage of animal draft power in Bangladesh for preparing the land. It takes at least 21 days to complete a good seedbed for one acre rice crop with seven operations which are usually required using the country plow drawn by a pair of bullocks.

The performance of the general type country plow is extremely unsatisfactory in respect of its rate of cultivation and the effectiveness in plowing.

ii) Sowing and planting – Paddy transplanting and broadcasting by human labor is inefficient. Broadcasting is still the only process of planting the "Aus" and jute crops in the country which demands large quantity of seeds much of which is unnecessarily wasted.

iii) Spraying and plant protection – Spraying in Bangladesh is also wasteful where paddy straw and coconut leaves are used to flick the insecticides. This manual and crude type of application is not only dangerous but also inadequate in respect of spraying quality, effectiveness and timeliness. Neither are there sufficient facilities for maintaining and repairing the imported sprayers, hence insecticides are stacked in the godown as the sprayers are unrepaired and the crops are being damaged in the field by the insects.

iv) Post-harvest – The estimate of post-harvest quantitative losses of rice crop due to physical and biological causes vary from about 8% to as high as 22% (1). At 10% post-harvest loss for rice as are lost in Bangladesh annually which is equivalent to Tk. 2,500 million, some 1.2 million tons based on the annual rice production figure of 12 million tons per annum.

v) Irrigation – The cost of water for irrigation from tubewells is quite high. Both the capital and recurring costs involve expenditure in foreign exchange considering that present system of irrigation in the country is too small and inefficient.

Possible Solutions

The research operations in agricultural engineering in Bangladesh should be aimed at the following problems:

i) Improvement of the traditional plow and harness system which can appreciably reduce the draft requirements and give better performance.

ii) Design of a small diesel power unit which can be manufactured locally at reasonably low cost so that a good number of farmers can buy and maintain them.

iii) Design of appropriate seed drills for "Aus" paddy, jute and wheat which can reduce wastage of seeds.

iv) Design of appropriate sprayers which can be accepted by the farmers as a whole and can be repaired and maintained easily with local resources.

v) Appropriate mechanization of the post-harvest operations to reduce the post-harvest losses.

vi) Design of indigenous system and technology and to improve the existing water utilization system to increase the overall irrigation efficiency.

Developing Appropriate Technology in Bangladesh

The level of technology will always be influenced by the socio-economic conditions of farmers, types of local soil and draft power available locally.

A single appropriate version of any farm equipment may not be appropriate for the entire country considering the area if there are variations even within a country. Hence the following procedure needs to be taken into account:

Improvement of Local Technology

i) Divide the country into several sections according to soil types and determine the different status of farmers in respect of their land holding capacities.

ii) Carry out a survey on animal draft power available per farmer

all over the country to decide whether an improved animal drawn implement may be introduced for specific areas or appropriate mechanical appliances should immediately be introduced in areas to supplement the shortage of the animal draft power.

iii) Carry out a survey on labour power available in the country. Labour shortage in some areas at particular times of the year will clearly indicate that an appropriate machine for that particular operation must be used as the supplement of labour power.

iv) Carry out a survey on the traditional agricultural technology in the country and identify the problems. On the basis of the problems, frame out a list of tentative solutions and design equipments based on local conditions.

v) Carry out a survey of existing technology in the country and study local equipment with respect to their effectiveness and efficiencies.

vi) Select equipments that can give the desired effect.

vii) Improve or change local equipment to make them appropriate for the other group of farmers without sacrificing its effectiveness and efficiency.

viii) Introduce a higher technology of the same equipment for the able group of farmers.

ix) Demonstrate the use of selected equipments to the other soil regions of the country and study their performance. Introduce necessary improvements to make them appropriate and follow procedures (iv) and (v) above.

x) Design new versions of the same equipments on the basis of the results of the technology survey and try to find its suitability in many parts of the country.

xi) Establish training facilities in every thana centre to impart training to local black-smiths and carpenters to enable them to manufacture, repair and maintain appropriate equipments.

xii) Encourage local manufacture and fabrication of appropriate agricultural machinery and their spare parts at strategic areas of the country.

xiii) Establish an effective system of repair and maintenance of all agricultural equipments and machinery at strategic places in the country.

xiv) Learn from experiences and the programmes of neighbouring countries.

xv) Import technology from developed countries and improve on them for appropriate use by local farmers.

xvi) Organize a central and regional institutes which will be responsible for the development of appropriate agricultural technology in the country.

xvii)Research capabilities of existing research organizations have to be strengthened and their activities have to be oriented towards the implementation of the policies of the central institute.

Conclusion

Mechanization of agriculture in Bangladesh is necessary to the extent that it is appropriate and that it does not create unemployment.

Adaptive and development research will be the appropriate measure to bring about a rapid change in the development of the traditional technology of the country. Technology of the neighbouring countries having similar agro-climatic and soil conditions with those of Bangladesh may be sometimes suitable for the local conditions after necessary improvements and modifications. Hence, transfer of technology is an important aspect in developing appropriate technology for agricultural in Bangladesh.

However, Bangladesh has to develop her own technology which may be the same as the imported technology in principle but should be in such a form and system that it could be manufactured, maintained and repaired by the local resources.

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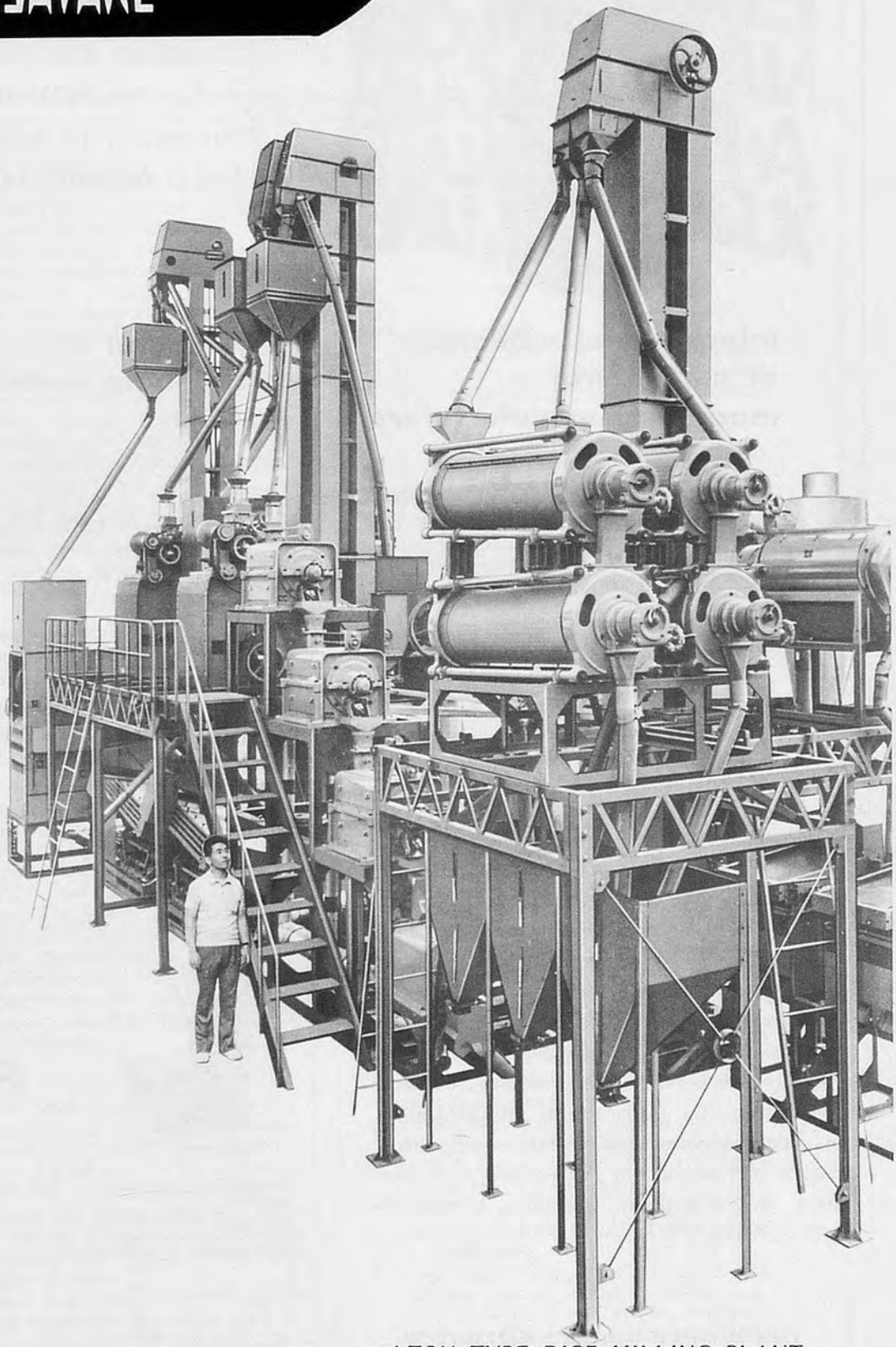

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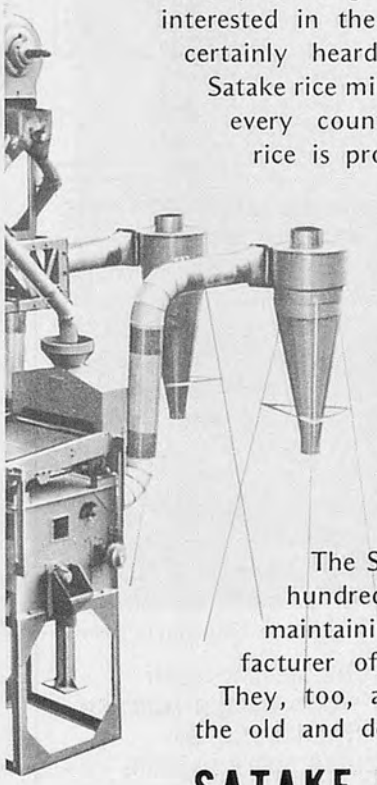

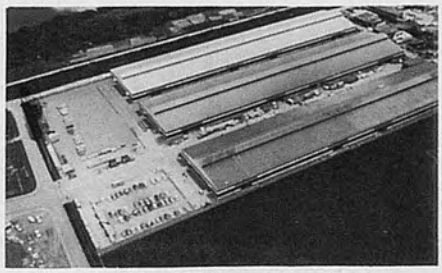

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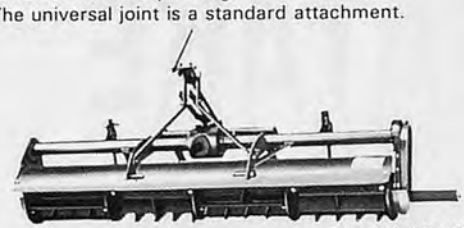

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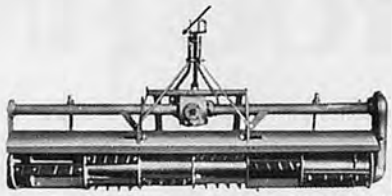

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Human and Animal Energy and Farm Power Needs in Developing Countries: the Case of India

by
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Introduction

It is estimated that 2/3 of energy input in farming comes from animals, 20 percent from humans and only 10 percent is derived from other forms of energy (4). Scientists estimate that if energy could be doubled on the farms the output could be optimised to great advantage. Animals are the cheaperst source form of energy. Fossil fuel is not only becoming more exhorbitant but also limited. Hence, the need to exploit animal energy output and its efficient utilization. Animal energy is appropriate and sufficient to most needs and in many farming situations, particularly in developing countries.

The potential of animal energy for agricultural development has yet to be fully recognized and endorsed by policy makers, planners or professionals in India. However, attempts by leading scientists have assessed the energy output of work animals. The size of draft animals depending upon the breed,

Table 1. Distribution of Cultivators, Agricultural Labours and Working Animals in India by State Farms*

State	Total Human Population	Cultivator 10^6		Agricultural Labour 10^6		Farm Worker %	Total Live Stock Population x10^6	Working Cattle		Cattle (000) Buffaloes		Working Cattle %	Human Power HPx10^6	Animal Power HPx10^6
		M	F	M	F			M	F	M	F			
Andhra Pradesh	43.50	4.79	1.01	3.53	3.28	29	33.06	4.97	0.24	1.17	0.05	19	1.26	3.21
Assam	14.96	2.30	0.11	0.39	0.02	18	8.21	1.90	0.10	0.16	0.03	26	0.28	1.08
Bihar	56.35	7.16	0.42	5.01	1.80	25	27.95	7.09	0.24	0.64	0.06	28	1.43	4.01
Gujarat	26.70	3.17	0.45	1.25	0.64	20	15.10	3.02	(a)	0.03	(a)	20	0.55	1.52
Hariyana	10.04	1.27	0.04	0.04	0.03	17	5.09	0.93	0.01	0.05	(a)	19	0.17	0.49
Himachal Pradesh	3.46	0.59	0.31	0.04	0.01	27	4.70	0.87	(a)	(a)	(a)	18	0.09	0.43
Jammu & Kashmir	4.62	0.83	0.07	0.04	(a)	20	4.29	0.60	(a)	0.04	(a)	14	0.09	0.43
Karnataka	29.30	3.60	0.48	1.72	1.00	23	22.42	3.44	0.32	0.21	0.02	17	0.68	1.99
Kerala	21.35	1.04	0.07	1.20	0.71	14	4.94	0.37	(a)	0.21	(a)	11	0.30	0.29
Madhya Pradesh	41.65	6.54	1.56	2.23	1.84	29	39.99	9.37	0.17	1.10	0.01	26	1.21	5.32
Maharastra	50.41	4.92	1.62	2.93	2.47	23	26.36	5.82	0.03	0.27	0.02	23	1.19	3.07
Meghalaya	1.01	0.18	0.13	0.03	0.02	35	0.76	0.09	0.02	(a)	(a)	14	0.03	0.05
Orissa	21.94	3.22	0.15	1.55	0.39	24	17.57	4.46	0.21	0.54	0.04	29	0.53	2.62
Punjab	13.55	1.66	(a)	0.78	(a)	18	9.30	1.48	(a)	0.22	0.03	18	0.24	0.86
Rajasthan	25.76	4.57	0.65	0.54	0.21	23	38.88	3.86	(a)	0.01	(a)	9	0.59	1.93
Tamil Nadu	41.20	4.30	0.59	2.82	1.68	22	24.13	4.02	0.61	0.26	0.07	20	0.91	2.48
Tripura	1.56	0.22	0.02	0.08	(a)	20	0.74	0.18	(a)	(a)	(a)	24	0.18	0.09
Uttar Pradesh	88.34	14.52	1.18	4.22	1.23	23	49.10	13.44	(a)	1.46	0.02	30	2.11	7.49
Manipur	1.07	0.17	0.08	(a)	(a)	23	Na	Na	Na	Na	Na	–	0.02	2.50
West Bengal	44.31	3.84	0.11	2.86	0.41	16	19.65	4.44	0.09	0.47	0.01	25	0.72	2.50
Nagaland	0.52	0.10	0.10	(a)	(a)	38	0.34	(a)	(a)	(a)	(a)	3	0.02	(a)

* (a) Below 10^4, Na-Not available, Hp calculated at 0.1 per human and 0.5 per animal.
Figures are rounded at second decimel pint. Totals may not add preasely becuse of rounding.
Source 1. Census of India 1971. 2. Ministry of food and Agriculture G.O.I. 3. Statistical abstract of Punjab 1975 (p-131-132).

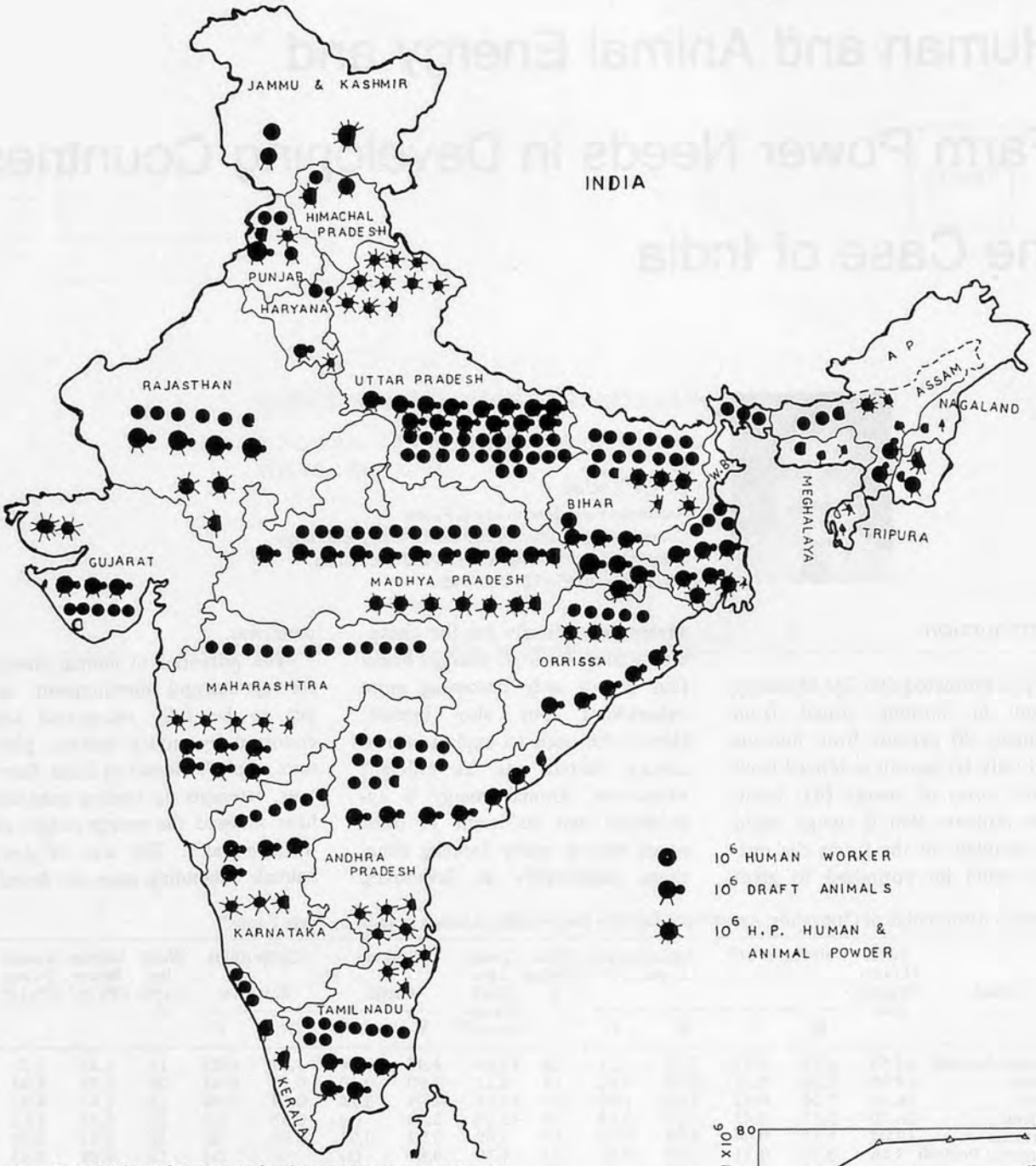

Fig. 1 Distribution of human and animal power, by state farms

feed and conducive regions varied in India. Based on 1971 census (1) laborers and farmers constitute 4.7% of the total population. The state-wise human energy potential are shown in **Table 1** column 14. Based on the calculations total power produced by human being is 12.60 million H.P. The total energy produced by 79.50 million draft cattle is 39.75 million H.P. The distribution of animal and human energy potential by state farms is shown in **Fig. 1**. Maximum animal power is available in U.P. 7.49. M.P.-5.32 and Bihar 4.01 million H.P. depending upon the grass area in the respective states and conditions conducive to the draft animals. The best advantage of this form of energy is its suitability to reach remotest places.

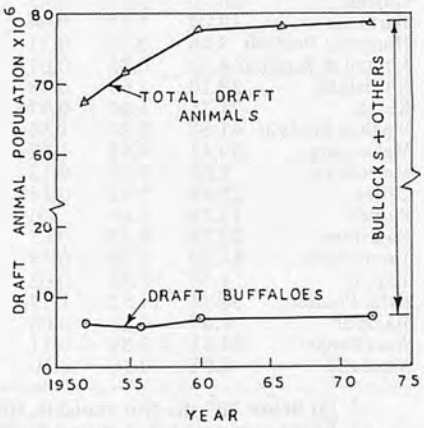

Fig. 2 Draft animal position in India

The draft animals are of many varieties in the country but bullocks and buffaloes both males and females are the main sources. **Fig.** 2 shows the total draft animal population and use of buffaloes on farm. The difference of two indicate the bullocks and other minor draft animals. Though the total draft animal population is increasing, the rate of increase of buffaloes is higher due to increase in lighter work and conducive conditions for their breeding and much less care needed for their maintenance in comparison to the bullocks and other animals.

The above indicated census has been done long back and information may be taken as indicative only. The new census work is afoot to be published in India in 1981. Since then only above information can be taken as authentic documents though situation might have been changed considerably. It is understood that animal draft power is proportional to animal weight and feeding rate. The draft capacity of bullocks has been estimated to vary from 0.4 H.P. to 0.6 H.P. Even certain breeds of animals have greater pulling potential. The energy output that can be attributed to this performance may exceed 0.5 H.P. For 79.50 million draft animals in the country, the total work capacity will therefore be 0.5 x 79.50 million H.P. and for 126.0 million human worker 0.1 x 126 million H.P. On an average one bullock can produce 0.5 H.P. and a human worker 0.1 H.P. for 6.-8 hours of a day. However, instantaneously, this power may in deed be many times higher.

Improvement in Utilization of Animal Energy

Though sufficient data are not available it can be acertained that animal energy is not being utilized up to its optimum level. Improvement in the utilization of the existing capacity will lead to increased productivity. It can be secured in the following ways by:

1. Distributing the animal use hours throughout the year by adopting suitable crop rotation without undue burden to the animals.
2. Improving the man-animal-machine system efficiency.
3. Improving the animal life and breeds.

To improve man-animal-machine farming systems and to achieve the objectives of improved utilization of animal energy R and D efforts must be intensified.

Improved Design of Farm Implement

Bullock-drawn traditional implements are generally less efficient in performing the task. It is due to its poor design to operate efficiently in varied soil conditions. It is generally observed that animal drawn tools are in single unit. This requires comparatively more force than a twin tool unit. Further it is noticed that depth of cut of a tool on a single unit imposes higher draft than a twin bottom same size tool with slight variation in depth of cut. A twin or multi-bottom tools when spaced at particular interval imposes a lesser draft. Zalenin (6) states that interaction caused by waves of two tools reduces the draft requirements. A further work done by Zalenin on an experimental drag scoop to determine the length and with of teeth on scoop blade and spacing between teeth influenced the draft requirement. All the Bakkhar blades being used in the country for dry land conditions have similar limitations.

A rotary tool of power tiller requires less force than other rigid tools. If length of two tines are slightly varied the draft is influenced. Further, a variation in speed of two consecutive times develop a complex interaction and hence the draft. An oscillating tillage tool reduces the draft requirement of a tool (2).

It is observed that the mode of operation of tools affect the energy expenditure. For example, a hand pump operated by a lever gives much less water per labour and energy expenditure is also more than the same pump operated by bicycle using leg cranking (3).

Studies conducted by Yadav *et al* (5) on operation of hand hoe and wheel hoe indicates that hitting and digging by plane hand hoe needs less energy per stroke but most tiresome due to its lifting action. The wheel hoe, during its operation is transported on wheels while on return stroke and requires less energy without exhausting the operator.

All the above and many more are the problems in bullock and manually operated tools. These needs specific R and D attention to reduce the work on animals to obtain the same or even more work.

Thus there exists a great scope to improve the design, thereby increasing the work efficiency of animal machine systems. Also new applications should be found which will help the farmer to make better use of his animal energy resources.

Improved Animal Energy Harnessing Device

Today in India, ploughing is mostly done by a pair of bullocks or buffaloes. On some hard task a team of animals are used. Also a single animal is used for light jobs. The harnessing device for operating these machines/implements is a yoke which rests on the neck against the hump. The efficiency of this system is poor as most of the machines have their

centre of work at an inclination. This also develops sore necks and various cancerous diseases. A system which could reduce the load inclination and provide the comfort at the animal's neck without throwing away the yoke will be most useful and efficient. Some of the implements may use weight principles for operation. Similarly, the design of farm implements to be used for threshing, grinding and many other operations could be improved.

On hitch type implements, the distance between the hitch point and centre of resistance on the plough bottom is some times large. Though this distance reduces the inclination but reduces the effective control of the system. Certain studies are essential on this aspect as it has direct correlation between the depth of penetration and length of hitch before the full depth of penetration is reached.

Though the general practice is to yoke a beam on the neck of the animal, there exists some scope to hitch on neck to shoulder distributing the load considerably and reducing the hitch inclination.

Animal Care, Breeding and Improved Veterinary Services

India, in general, does not lack of man power and animal power. However, the present organization and infrastructure of veterinary health care and delivery system is believed by many to be inappropriate and insufficient. The system must be operational in its own way, but it has not been able to cater to masses of cattle owning farmers in the villages. There is a need for special study in this respect. There is certainly a very good case for primary veterinary health centers.

In general, the first three years of animal life is very crucial for the development of work capability and maximization of energy output. Ramaswamy (4) in his paper had suggested a country-wide study should be made on the practices of rearing and training work cattle to obtain the maximum energy from a work animal. The care of animal is important during the working life. Bullocks and buffaloes drawing heavy carts, and horses drawing "akka"* at higher speed are provided with hoof nails. Though this generates heat it prevents hoofs wearing of the animals. Suitable materials need to be examined. Heavy load on the neck some times causes cancerous diseases to the animals. A better designed yoke pad and hitching provisions with low draft machines may be a solution to this problem. In China, it has been found that animals working in puddle are provided with shoes which reduces the incidence of foot diseases. A similar provision can be made in India as well to reduce the incidences of diseases and improving the performance of the system.

Summary

The land holding capacity of the average farmer is quite low and tractorization and use of other form of energy being well beyond the reach of peasant farmers in the country, any intensified agricultural production programme may stem from the doption of improved agricultural practices with improved tools. The animal and human energy may continue to be the most suitable power mode for many for years to come. Only a few cases may be exception to this.

The fullest exploitation of human-animal energy resources through R & D work on farm implements and developing exotic draft animal breeds may partly form the solution to this problem.

*Akkas are common light horse drawn carts for transporting passengers in cities through short distances.

Acknowledgement

The author is thankful to the Dean of the College of Agricultural Engineering and Technology for providing the facilities for this work.

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Benefits from Dug Well Irrigation—A Case Study in Some Districts of Orissa (India)

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Abstract

This paper examines the irrigation benefits to farmers and offers a basis for determining their ability to pay back the loan previously received for the construction of dug well. The study was made in the districts located in various distinct geophysical regions of Orissa. The net benefit derived from dug well irrigation ranges from Rs. 2,550 to Rs. 5,500 per hectare. Three farming models are proposed and farm budgets prepared. The cultivators are able to repay the loan within five years with marginal benefits.

Introduction

Water is an essential input to crop production. Use of high yielding varieties, chemical fertilizer and scientific methods of cultivation have increased the water demand for raising crops. As the largest available source of water lies underground, increased demands for water have stimulated development of this water resource. Of the methods available to tap ground water, the tubewells give better yield but the economy of the Orissa farmers puts a constraint upon its construction. More than 80 percent of the farmers have land holdings less than a hectare a scale too small for the use of a tubewell. Hence, the open well has taken an important place for ground water exploration as it has proved to be a great asset to the farmer owning it. Dug wells serve as insurance against drought or irregular distribution of rainfall for the "Kharif" crop and provide adequate supply of irrigation water to raise crops in the winter and summer months.

Regions Suitable for Open Wells

Open wells can be constructed in any part of the State of Orissa depending on the occurrence of suitable aquifers within easy reach from the ground level. The coastal and river alluvium along the banks of important rivers include one or more numbers of sandy aquifers with good potential of ground water. About 10,000 square miles of land with alluvial formation in the State provide scope for the installation of 1.07 lakh open wells

Table 1. Distribution of Proposed Dug Well, Orissa

District	Number of Proposed Dug Wells
Balasore	40,000
Cuttack	64,000
Puri	52,820
Ganjam	65,540
Koraput	64,750
Phulbani	14,580
Dhenkanal	47,680
Keonjhar	28,680
Mayurbhanj	34,820
Sundargarh	25,690
Sambalpur	56,460
Balangir	33,320
Kalahandi	21,600
Total	550,000

Remarks: The dug wells proposed are of size 20' dia, 25' to 35' depth which can be operated by 3 H.P. electric or 5 H.P. diesel pump. In case they are to be operated by a "tenda" (local method of lifting water) the numbers fixed for each district can be doubled

for irrigation.

The eroded plains in the State are mostly underlaid with weathered rock at a depth of 5 to 30 ft. The top layer of the bed rock is weathered in the natural process of oxidation, hydration, leaching, expansion and contraction. The weathered rock is porous and fractured to serve as a storage for ground water. These eroded areas cover the central and western parts of Orissa and can have 4.43 lakhs of open wells for irrigation purposes. **Table 1** shows the distribution of dug wells proposed to be constructed in various districts of Orissa. The total area that can be provided with assured irrigation from open wells is 33 lakh acres in "Kharif" and 16.5 lakh acres in "Rabi" seasons.

Table 2. Economics of Dug Well, Bolangir

Crop	Area Sown (ha)		Gross Value of Product (Rupees)		Cost of Cultivation (Rupees)		Net Value of Products (Rupees)		Net Incremental income (Ruppes)
	Before	After	Before	After	Before	After	Before	After	
Kharif									
Paddy	0.40	0.40	400	720	150	300	250	420	–
Rabi									
Wheat	–	0.20	–	750	–	350	–	400	–
Vegetables	–	0.10	–	650	–	200	–	450	–
Total	0.40	0.70	400	2,120	150	850	250	1,270	1,020

Table 3. Economics of Dug Well, Dhenkanal

Crop	Area Sown (ha)		Gross Value of Products (Rupees)		Cost of Cultivation (Rupees)		Net Value of Products (Rupees)		Net Incremental Income (Rupees)
	Before	After	Before	After	Before	After	Before	After	
Kharif									
Paddy	0.30	0.30	280	700	100	300	180	400	–
Rabi									
Wheat	–	0.20	–	750	–	300	–	450	–
Groundnut	–	0.10	–	300	–	100	–	200	–
Total	0.30	0.60	280	1,750	100	700	180	1,050	870

Financing the Construction of Open Wells

During the last five years, the State Government, in cooperation with the credit institutions and commercial banks launched a massive dug well development programme on long term and short term bases. Short term cooperative credit does not exceed five years, but the long term credit ranges between 7 and 15 years. Short term credit is mostly for the construction of small diameter wells of shallow depth costing less than Rs. 3,500. These loans are issued without collateral and at an interest rate of 14.5 percent.

The long term loans are issued by State Land Development Banks against the mortgage of landed securities. They are of longer maturity period and carry an interest rate of 10.5 percent to 11 percent.

Study Area

The five districts of study were Bolangir, Dhenkanal, Ganjam, Kalahandi and Sambalpur. In these districts, some dug wells were examined and interviews were made with the farmers.

Bolangir District

The average size of holding in this district is 2.93 hectares. The diameters of the 72 wells examined in this district were between 12′ and 15′ and the depths were between 20′ and 25′. The unit cost of the wells ranged between Rs.3,000 and Rs. 4,000. Water levels in the last week of March were within 12′ from the ground surface.

Paddy is grown on over 80 percent of the area during the "Kharif". The "Rabi" season crops grown are paddy, wheat, vegetables, onions, pulses, etc. The effective area irrigated was about 0.4 hectare. The benefits derived from a well is shown in **Table 2**.

Investments on dug wells in the State undertaken by the community are mostly supported by subsidies from different organisations. Marginal farmers receive subsidy of 33-1/3 percent of the capital cost, small farmers get 25 percent of the cost and the tribals, 50 percent of the cost. The average cost of construction can easily be repaid within 5 years by the farmers.

Dhenkanal District

The average size of holdings in this district is 1.62 hectares and the effective irrigated area is about 0.40 hectare. Sixty wells were examined. The characteristics of the popular size of wells in this district are: size of the well; 10′ dia x 25′ deep; unit cost, Rs. 3,000; "ayacut" area, 0.30 ha; and loan, repayment period, 5 years.

The economics of the dug wells in the district is shown in **Table 3**.

Ganjam District

About 60 wells were examined in the district where the average size of holding is about 1.30 ha divided into smaller operational units. Relevant details regarding the most popular size of wells are as follows: size of well, 8′ dia. x 25′ deep; unit cost, Rs. 3,000; "Ayacut" area, 0.20 ha, and period of loan replayment, 5 years.

The incremental income after development as estimated above enables the cultivator to repay loan liability within 5 years. Owing to better transport facilities in the district, the cultivators are able to get better prices for their produce as compared to their counterparts in other districts.

Kalahandi District

This district is comparatively dry as it depends mostly on well irrigation. The average size of holding is about 3.95 hectares but the farms are scattered in different plots. The relevant particulars of the wells are: size of well, 13′ dia. x 22′ deep; unit cost, Rs. 3,500; "Ayacut" area, 0.40 ha; and period of loan repayment, 5 years.

The economics of investment for an area of 0.4 hectare in the district is given in **Table 5**.

A cultivator would get an incremental income of Rs.1,190 adequate to meet his loan commitment in 5 years.

Sambalpur District

The average size of holding of the cultivator in this district is 2.14 hectages. These holdings are, however, subject to fragmentation as in other districts of the state. The cultivators are enterprising and they are also responsive to new methods of cultivation. Some 42 wells were studied and their particulars follows: size of well, 10′ dia. x 30′ deep; unit cost, Rs. 3,500; "Ayacut" area, 0.30 ha.; and period of loan repayment, 5 years.

The economics of a tubewell in the district is given in **Table 6**.

The farm holdings would generate adequate income after development to meet the capital cost of small-diameter dug wells. After meeting the loan repayments a small surplus would be generated. It would, however, be desirable to determine a marginal size of farm holding, the net incremental income out of which it should not only be adequate to meet the annual loan commitments but also to take care of any fall in prices or fall in gross production in bad years.

Table 4. Economics of a 0.20 ha Farm, Ganjam

Crop	Area Sown (ha)		Gross Value of Products (Rupees)		Cost of Cultivation (Rupees)		Net Value of Products (Rupees)		Net Incremental Income (Rupees)
	Before	After	Before	After	Before	After	Before	After	
Kharif									
Paddy	0.20	0.20	240	560	80	240	160	320	
Rabi									
Chilly	–	0.12	–	1,200	–	500	–	700	
Vegetables (Melon/pumpkins)	–	0.08	–	400	–	160	–	240	
Total	0.20	0.40	240	2,160	80	900	160	1,260	1,100

Table 5. Economics for 0.40 ha Farm, Kalahandi

Crop	Area Sown (ha)		Gross Value of Products (Rupees)		Cost of Cultivation (Rupees)		Net Value of Products (Rupees)		Net Incremental Income (Rupees)
	Before	After	Before	After	Before	After	Before	After	
Kharif									
Paddy	0.40	0.40	450	960	180	400	270	560	
Rabi									
Wheat	–	0.20	–	600	–	250	–	350	
Onion	–	0.20	–	800	–	250	–	550	
Total	0.40	0.80	450	2,360	180	900	270	1,460	1,190

Table 6. Economics of Dug Well Investment, Sambalpur

Crop	Area Sown (ha)		Gross Value of Products (Rupees)		Cost of Cultivation (Rupees)		Net Value of Products (Rupees)		Net Incremental Income (Rupees)
	Before	After	Before	After	Before	After	Before	After	
Kharif									
Paddy	0.30	0.30	380	780	180	300	200	480	–
Rabi									
Wheat	–	0.20	–	500	–	230	–	270	–
Vegetables	–	0.10	–	680	–	200	–	480	–
Total	0.30	0.60	380	1,960	180	730	200	1,230	1,030

Model Farming

Based on the climatological conditions and keeping the generally adopted cropping pattern in different districts the State is proposed to be divided into three district groups with farm models as indicated in **Table 7**.

Corresponding to the above three models, farm holdings of 0.40 ha., 0.50 ha. and 0.50 ha., respectively, have been considered as acceptable units for being supported by small-diameter dug wells. Farm budgets with reference to these units are discussed below:

Table 7. Design of Farm Models Based on Cropping Pattern

Model	District	Cropping Pattern
Model 'A'	Dhenkanal, Balasore, Sambalpur, Sundargarh, Phulbani, Cuttack, and Mayurbhanj.	Kharif – Paddy Rabi – Paddy, Wheat, Pulses, Vegetables
Model 'B'	Ganjam, Koraput and Puri	Kharif – Paddy Rabi – Ragi, Chillies, Groundnut and Pulses.
Model 'C'	Dolangir, Kalahandi and Keonjhar	Kharif – Paddy Rabi – Millets, Wheat Onions, Vegetables

Table 8. Accounts of Farm Budget (Unit: Rupees)

Area (ha)	Model	Unit Cost	Subsidy	Loan Assistance	Net Surplus Before Development	Net Incremental Income After Develop-	Loan Instalment on 5 Year Basis 14.5 percent In-	Balance
Alluvial plane								
0.40	A	2650	662	1988	310	985	586	399
0.50	B	2650	662	1988	438	1272	586	676
0.50	C	2650	662	1988	410	1340	586	754
Erosional plane								
0.40	A	2300	575	1725	310	985	509	476
0.50	B	2300	575	1725	438	1272	509	763
0.50	C	2300	575	1725	410	1340	509	831

Farm Budgets

In preparing the farm budget it was assumed that water would be drawn: from the dug well with manually-operated water lifts, namely: single or double "tenda" which are considered efficient to irrigate upto 0.50 hectare of land. The economics of a model farm is shown in **Table 8**.

Conclusion

An assured irrigation is essential for raising crops to meet the food requirement of a growing population. As the economy of Orissa is poor, small lift irrigation projects can well replace big flow irrigation projects. Different banks are now extending loans to finance the construction of dug wells. ■■

Agricultural Mechanization in Developing Countries

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Irrigation and Agricultural Development in Bangladesh

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Introduction

Bangladesh occupies a land area of 14.2 million ha of which 9.1 million ha or 64% is under cultivation. Rice is the major staple accounting for about 85% of cereal grain consumption of the country's population of about 80 million. The average farm size is about 1.4 ha which presently maintains an average cropping intensity of 149. But the average yield is very low, about 1.9 t/ha of rough rice/paddy.

Since 1960 Bangladesh has chronically faced a food-deficit situation and the extent of the yearly import of food grains between the period 1969–70 and 1977–78 averaged about 1.6 million tons. The food grain production in 1978–79 fell short of the requirement by a far bigger margin than the average of other years because of severe crop damage and crop failure due to prolonged drought reportedly the worst in the last 50 years. The year 1979–80 does not seem bright because of unfavorable weather again. By 1986, the food grain requirement will increase by about 6.5 million tons over that produced in 1977.

Given the above facts, what may be the future of food production in Bangladesh? What have been the past agricultural development trends and major production constraints? How does irrigation development relate to the agricultural development efforts of the country, and what are the future potentials of developing intensive irrigated agriculture to achieve self-sufficiency in food? This paper examines some of these vital issues, especially in the context of water supply from rainfall and irrigation development which is the primary requirement for agricultural mechanization and modernization.

Role of Climate

Agricultural productivity in Bangladesh is almost entirely (90%), dependent on the prevailing climate. The most dominant climatic factors are rainfall (total amount and distribution) and monsoon flood. The people have to a large extent learned to live with the recurrent yearly normal floods.

It is truly said that the major problem of agriculture in Bangladesh is excess water and drought. This paradox resolves

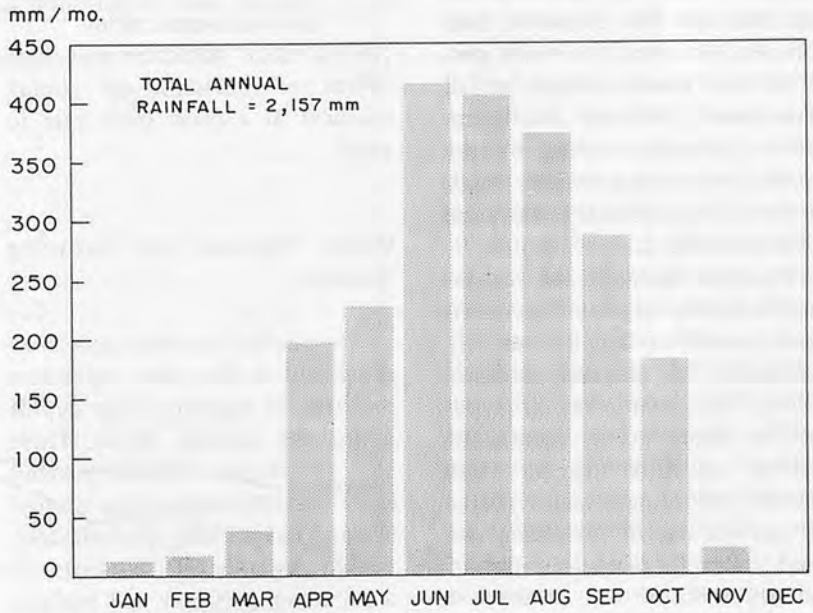

Fig. 1 Rainfall distribution of 9 Districts, Bangladesh (Av. of 35 years: 1934–1969)

itself when one looks at the annual rainfall distribution (**Fig. 1**). About 96% of the total 2,157 mm rainfall occurs during April–October leaving the remaining 5 months of the year dry. When the excess rainfall during the monsoon period, usually June–October, coincides with peak discharges of the three mighty rivers – the Brahmmaputra, the Ganges and the Meghna – that drain a huge catchment area totaling over 150 million ha severe flooding ensues. A seasonal "normal flood" submerges about one-third of the total land under water of depths one meter or more.

Drought condition prevails over most of Bangladesh during the period November to April, when potential evapotranspiration far exceeds rainfall (Manalo, 1976). A rice crop cannot be generally sustained during this period from rainfall alone.

Two interesting features highlight the Bangladesh rainfall pattern. One is the high degree of variability of rainfall within the country. The mean annual rainfall varies from 1,400 mm in the district of Rajshahi in the west to about 5,800 mm in the Sylhet district in the northeast at the foothills of the Joyantia hills complex. However, the major part of the land receives annual rainfall of between 2,000 and 3,000 mm. The agroclimatic zoning of the country, according to the length of dry and wet periods of the year, is shown in **Fig. 2**.

The other feature is the year-to-year variability of rainfall at a given place portrayed by its monthly coefficient of variation (Manalo, 1976). The coefficient of variation is higher in the months of October to April than in other months, indicating a higher degree of uncertainty of obtaining the mean monthly rainfall in one of the dry months than in the wet months. High values of rainfall dispersion as found by Manalo

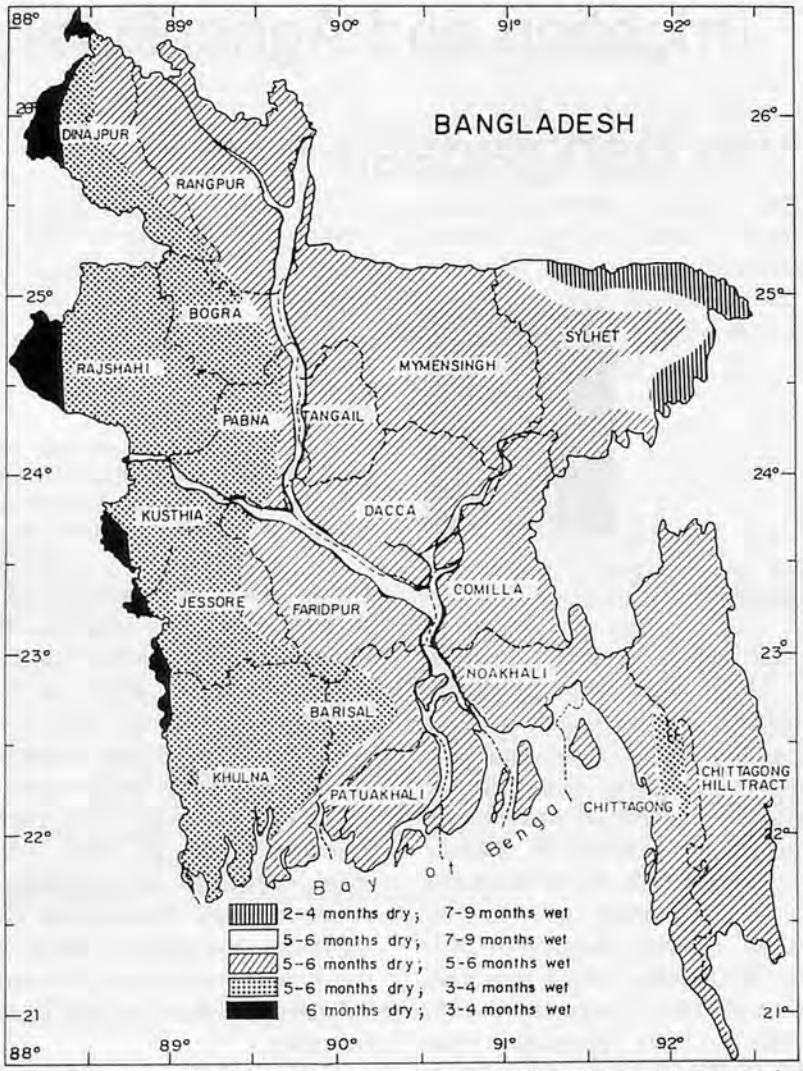

Fig. 2 Climatic zones of Bangladesh according to number of wet and dry months in the year (Manalo, 1976)

(1976) also indicate the high degree of variability of rainfall amounts at a place from year to year.

Water Regimes and Growing Seasons

The rainfed rice areas have been classified into five water regimes on the basis of standing water depths during the growing season. These are: (1) shallow rainfed lowland (5-15 cm); (2) intermediate rainfed lowland (15-50 cm); (3) semi-deep rainfed lowland (50-100 cm); (4) deep water (100 cm and higher); and (5) upland. The first two categories comprise about 3.0 and 2.4 million ha, respectively (**Table 1**). The areas under the three other categories total about 3.8 million ha.

Because of the characteristic rainfall pattern, three main rice growing seasons have evolved: "aus" (summer); "aman" (autumn); and "boro" (winter), as shown in **Table 2**. Most of the transplanted "aus" and "aman" crops are produced in shallow rainfed and intermediate rainfed areas as described above. Broadcast "aman" crops are grown in the deep water areas. The "aus" crop accounts for about 25% and the "aman" for 58% of the total rice produced in the country today. Supplementary irrigation facilities

Table 1. Rice Areas Under Different Water Regimes: Present and Potential Yields, 1978.

Water Regime	Area (million ha)	Present av. yield (mt paddy/ha)	Present potential yield (mt paddy/ha)
Shallow rainfed lowland (15–15 cm)	3.0	2.00	2.50
Intermediate rainfed lowland (15–50 cm)	2.4	2.00	2.25
Semi-deep rainfed lowland (50–100 cm)	1.5	1.50	1.50
Deep water (100 cm and above)	1.3	1.25	1.25
Upland (unbounded)	1.0	1.00	1.50
Irrigated	1.1		
Wet season	0.1	2.5	3.50
Dry season	1.0	3.5	4.50

Source: Ahmad and Nasiruddin, 1978.

Table 2. Main Rice Seasons and Relative Contribution to Total Yield, 1977/78.

Season	Growing Period	Percent of 1977/78 Total Yield
Summer (Aus)	March–August	24.5
Autumn (Aman)	July–December	58.0
Winter (Boro)	November–March	17.5

for these two crops are not substantial. "Boro" rice, which contributes the remaining 17% of the total rice production, is grown during the dry season and is entirely irrigated **(Table 2)**.

Use of Modern Rice Varieties

The effort to introduce high yielding modern varieties (MVs) of rice in Bangladesh was first made in the late 60s. The MVs easily became popular for the "boro" season rice because of the high yields obtained with high solar radiation and with irrigation water. In 1969–70, about 27% of the "boro" rice area used MVs and expected to double by 1973–74 **(Fig. 3)**. The use of MVs for the "aus" season increased slowly but steadily. But for "aman" season the popularity of MVs gradually rose to 14.5% of planted area in 1973–74 after which it steadily declined. The MVs in the "aman" season now occupy only about 4% of the total area planted in the season (Bangladesh Bureau of Statistics, 1979).

The area planted to MV in the boro season increased from about 27% in 1969–70 to about 55% of the total in 1973–74; virtually no further increase occurred after that. The total MV use in all seasons increased steadily from 1969–70 up to 1973–74 and reached about 16% of the total rice area. It has since slightly declined primarily because of a substantial decline in MV use in the "aman" season.

Research has established that the modern varieties, although bred for optimum performance under optimum input levels, can outyield the traditional rice varieties even under low or zero input levels (Zaman, 1976). The percentage of total area grown to MVs contributes about two times the percentage of total rice produced in the country **(Table 3)**. Why then is the use of MVs in the "aus" and "aman" seasons so low? Also, why did MV "aman" increase substantially during the period 1967–74, but declined sharply after that? The low moisture regime in March–April is considered the most important constraint to the expansion of MVs in the "aus" season, which also directly interferes with growing MV in the "aman" season. Further elaboration of this situation follows.

The seeding time for "aus" should be between March and April, if MV transplanted "aman" has to be grown after "aus" from the available rainfall. But the rainfall during this time is substantially lower than the evapotranspiration requirements as seen in **Table 4**. The seeding of an "aus" crop in March is thus very risky. In April, the difference between the water requirement and available rainfall diminishes substantially in some districts, e.g., Mymensingh, Chittagong, Sylhet, Comilla, and Noakhali. An estimated 830,000 ha is reported to be favorable for direct seeded MV "aus" crop in these five districts (Brammer,

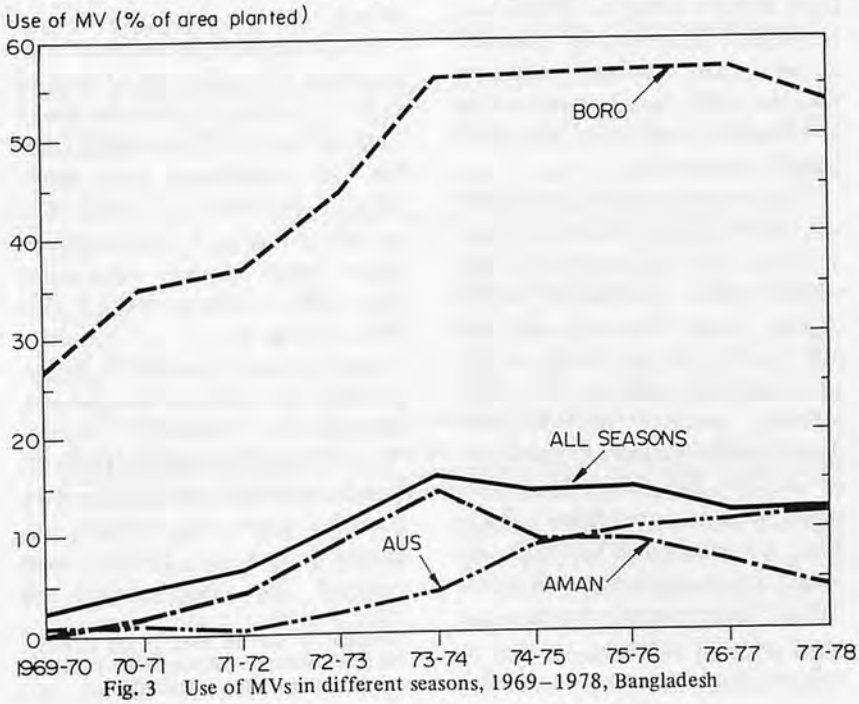

Fig. 3 Use of MVs in different seasons, 1969–1978, Bangladesh

Table 3. Used MVs and Relative Contribution to Total Yield, 1972–78.

Year	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78
Percent of total area under MVs	11.0	15.6	1.47	15.0	12.9	12.0
Percent of total production from MVs	25.0	33.7	30.6	29.4	25.2	23.0

Source: Bangladesh Bureau of Statistics., 1979.

Table 4. Mean Monthly Rainfall (RF) and Evapotranspirational Requirement (ET) in cm During March-June for 8 Districts.

(Unit: cm)

District	March		April		May		June	
	RF	ET	RF	ET	RF	ET	RF	ET
Dacca	4.6	13.7	11.9	17.8	24.1	18.8	35.1	13.7
Mymensingh	4.6	12.7	11.4	14.2	29.7	15.2	45.7	12.2
Rangpur	2.8	12.2	8.6	16.0	30.7	16.8	49.3	14.7
Bogra	2.5	12.7	5.6	16.3	18.0	17.3	33.0	13.2
Rajshahi	2.3	12.9	3.6	16.8	11.9	20.3	25.7	15.5
Khulna	3.3	14.2	7.9	16.8	16.0	18.8	34.3	15.5
Barisal	3.8	13.2	8.4	16.0	19.3	17.3	42.7	14.2
Chittagong	5.6	13.2	11.4	16.0	25.7	17.3	56.6	14.2
Mean	3.7	13.1	8.6	16.3	21.9	17.7	40.3	14.2

Source: IBRD, 1972

1974). If IR8 variety is seeded by early April, the crop can be harvested by early August which will allow the farmer time to prepare the land and grow a second crop of transplanted MV "aman" rice before the end of the monsoon season. But such direct seeding of MV "aus" in April is limited because, among other things, it involves more rigorous weed control.

In May the moisture regime becomes favorable and farmers usually prepare the seedbed of MV "aus" for transplanting in June. Such late transplanting leaves little opportunity for a successful second crop of transplanted MV "aman" because it can be planted only after the harvest of the "aus" in mid-September as the monsoon season ends in October. The traditional farmer practice in such a situation is to prepare the land very hurriedly, transplant 40– or 50–day old local variety seedlings which produce low yields due to inadequate water condition. Often severe drought stress coincides with the critical reproductive period of the rice crop. Farmers generally do not invest in fertilizers for such a local "aman" crop. On the other hand, if the MV "aman" is transplanted in June or early July and the recommended fertilizers are used, a good harvest can be obtained if the rainfall is normal. But both the MV "aus" and MV "aman" crops under rainfed conditions can be grown extensively in the country only with supplementary irrigation – first to establish the "aus" crop before the onset of the monsoon rainfall and then to save the "aman" crop from drought stress in October and November. However, as discussed earlier, direct-seeding techniques for the MV "aus" may permit a substantial area under two crops of MV crops also.

The primary reasons for the low use of MVs during the aman season are the lack of irrigation water which makes a traditional variety "aman" crop less risky after an MV "aus" crop and there are no suitable early maturing but high-yielding modern varieties that would enable farmers to grow two consecutive MV crops in rainfed water regime conditions. Therefore, transplanted MV "aus" followed by transplanted traditional "aman" have recently become the most popular cropping pattern in rainfed flood-free areas. It is, however, difficult to explain why the popularity of MV "aman" increased between the period 1969–70 and 1973–74 and declined thereafter. Irrigated "aman" rice cultivation also declined from 160,000 ha in 1969–70 to about 84,000 ha in 1976–77, a reduction of 52% in seven years. This fact further strengthens the contention that no suitable MV is available to farmers for the aman season. Some of this area was most likely planted to MV "boro" cultivation and some boro rice areas were shifted to wheat cultivation on account of the government's emphasis on increasing wheat production which requires much less water compared to rice.

Role of Irrigation

With developed irrigation and flood protection facilities, rice could be grown in all three seasons in Bangladesh. However, within the major public irrigation systems, farmers are encouraged to grow two rice crops and a third non-rice crop, such as wheat, mustard, lentils, etc., in the dry "boro" season.

Irrigation facilities were available to about 1.1 million ha of land in 1977–78 which constitutes about 11% of the total cultivable land, but has contributed only about 19% of the total rice production in 1977–78 (**Fig. 4**). The extent of other water regime areas and their yield contributions are also shown in **Fig. 4**.

Five distinct types of irrigation practices are observed Bangladesh: canal/gravity, tubewell, pumps, "doons", and hand pump. (**Table 5**). Canal irrigation usually involves pumping water from a river and distributing it by gravity canal system.* The larger projects in

*Because of the flat topography of most of the country, the scope for building reservoirs on rivers is negligible.

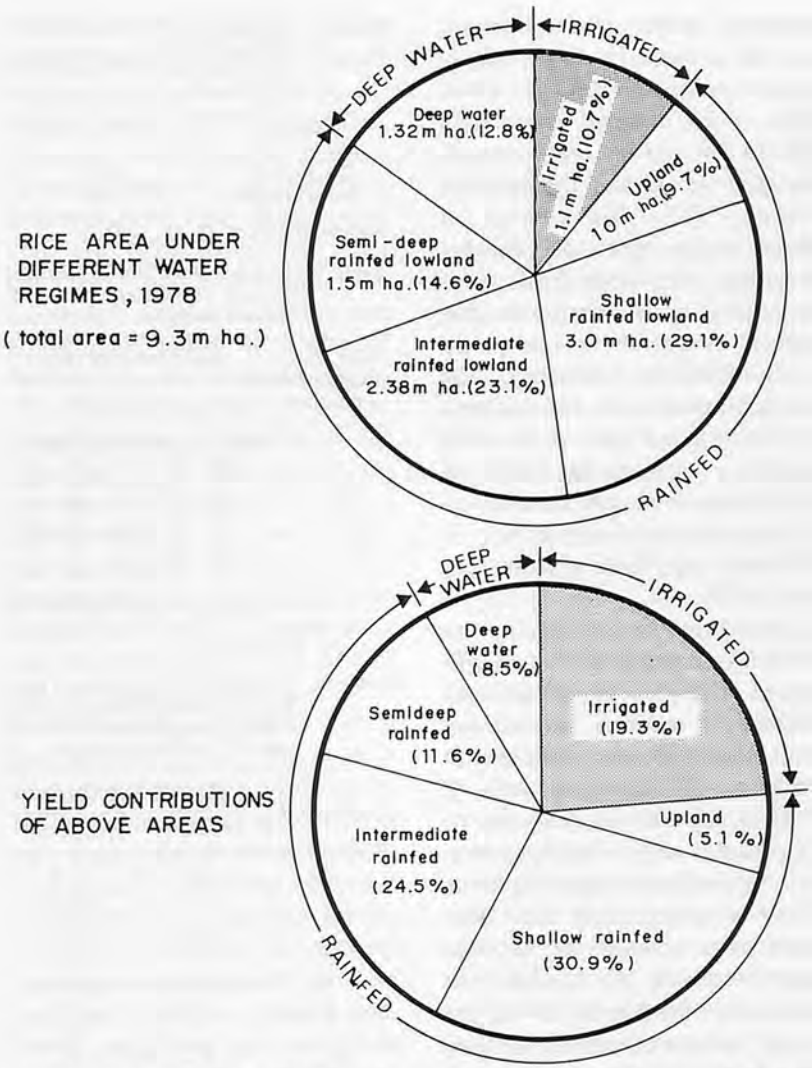

Fig. 4 Rice area under different water regimes and their relative contribution to total yield, 1978

Table 5. Types of Irrigation and Command Area, 1969–77*

Total area	1969/70	70/71	71/72	72/73	73/74	74/75	75/76	76/77
Irrigated (million ha.)	1.05	1.16	1.04	1.21	1.29	1.43	1.40	1.21
	Percent area under different irrigation types							
Canals	–	8.9	8.4	7.9	9.2	7.6	6.6	8.8
Tubewells	3.1	4.1	3.2	3.1	4.1	6.6	7.6	7.8
Power pumps (surface)	28.4	35.8	32.1	38.9	44.0	40.5	39.4	41.0
"Doon"**	37.0	31.1	34.8	30.8	26.6	26.8	28.0	24.2
Swing basket	4.0	4.6	4.5	3.2	3.2	3.3	4.1	5.4
Others	–	15.5	17.0	16.1	12.9	15.2	14.3	12.8

* Source of basic data: 1979 Statistical Yearbook of Bangladesh.

** An indigenous device generally made of wood, 3 to 4 meter long, flume-shaped structure with a triangular or trapezoidal cross-section. The structure is suspended in a bamboo frame and is operated manually for low-lifting of water.

the country are of this type but they contribute only about 9% of the total irrigated area. Almost no new development has taken place in this category during the last decade. A few large canal systems have been in the implementation stage for a good number of years, but their progress has been very slow.

The tubewell category includes the deep tubewells, shallow tubewells, and hand pump tubewells. The area under tubewell irrigation has increased by 150% during on 8-year period, 1969–70 to 1976–77 (**Table 5**). This increase notwithstanding, the total command area of tubewells is less than 8% of total irrigated area. It should be mentioned that both canal and tubewell irrigation are generally developed in areas where multiple crops can be grown.

Power (centrifugal) pumps are seasonally operated and used primarily for the "boro" season rice cultivation. They are rented out to farmers or farmer groups on demand for low-lifting of surface water ponded from rivers, canals, or low-lying areas. Both deep tubewell and power pump systems are heavily subsidized by the government.

A large proportion of the total irrigated area in the country is under indigenous manual techniques, ("doons" and "swing baskets"), in which the public sector has no investment at all. These manually operated devices for low-lifting of water historically sustained a low-level irrigated agriculture in the country until about 20 years ago when the government started investing in "modern" techniques of water development for irrigation. The area serviced by "doons" has generally declined in recent years; a 35% reduction over the last 8 years in favor of the powered pumps in areas where surface water is available for low lift. The area under the swing basket water lifting device has essentially remained constant during the 1969–77 period.

Very little irrigation development has taken place during the period 1969–70 to 1976–77 even as substantial groundwater has been developed for tubewell irrigation. The total number of deep tubewells increased from 796 units in 1970–71 to 4,455 in 1976–77 (Bangladesh Bureau of Statistics, 1979).

But this increase still falls short of the 19,000 deep tubewell units that were planned to be installed during the 1973–78 Five-Year Plan. It is possible that several thousand more tubewells were sunk by the agency responsible for this project during the plan period, but they have not been fitted with pumps and other infrastructure facilities for full operation.

Hand pump tubewell development has been very impressive in the past several years. These are usually 6 m – 12 m deep, made of 3.8 cm diameter G.I. pipes and a simple strainer and are fitted with a reciprocating pumps that are operated manually. Each tubewell can irrigate about 0.4 ha to 0.6 ha for growing MV rice in the "boro" season (Bhuiyan, 1976). No accurate estimate is available on the number of hand pump tubewells in the country or their rate of growth, but the current number is expected to be several hundred thousands. Hand pump tubewells have become very popular in areas with shallow aquifer and high water tables. The government is supporting its expansion program by providing farmers with credit and other materials.

Slow Irrigation Development

1. *Too much emphasis on infrastructure* – In both the canal and deep tubewell sectors, the physical infrastructures receive almost all of the involved agency's attention. The goal is to "complete" the project. No agency seems to be responsible for ensuring the proper use of the completed facilities. Thus, the ultimate end is not attained.

2. *Water management is greatly neglected* – The existing irrigation projects could most likely irrigate twice the area they now cover if proper water management measures were practiced. The largest canal irrigation system in the country, the GK project, has been able to irrigate only an average of about 45% of its designed capacity of 48,380 ha over a 16-year period. (Bangladesh Water Development Board, 1977). The concept of water measurement and delivery according to actual field needs is lacking in its operational procedure. The result is a very low water utilization efficiency. The contrast between the GK project's performance and that of the DND project, which is smaller (4,090 ha) but follows some useful guidelines in its operational procedure, is quite striking **(Table 6)** (Bhuiyan, et al. 1979).

Deep tubewell schemes also are operating at very low levels of efficiency. The national average area irrigated by a deep tubewell (all deep tubewells are designed to discharge 57 li/sec) is only 9 hectares. The average daily operating period is only 5 hours per tubewell. Increasing the operating hours (which can be usefully done only when more demand for water is created) to 12 or 16 hours is technically feasible as far as the pumps and diesel engines are concerned and would increase the tubewells' capacity utilization two to three times the present level **(Table 7)**. A recent study of a sample of 10 tubewells within a small 2-village area, where agro-climatic, soil type and farmers technical background related factors were considered uniform, showed that tubewells which were well-managed could effectively irrigate as much as 30 ha. Others with faulty location, high conveyance losses, and organizational and social problems utilized a very small fraction of the potential **(Table 8)** (Bhuiyan, 1977). Powered pumps are reported to be utilizing less than 40% of their potential capacity (Andreau, 1979).

3. *High subsidy for irrigation water* – Irrigation water is highly subsidized in the public sector projects that include canal, deep tubewell and powered pump irrigation types. The development of the facilities costs nothing to the intended users. Such a system provides few incentives to farmers in terms of water use efficiency. Water distribution network development, which is left to the users of water, is most often incomplete, haphazard and inefficient. Therefore, farmers often grow dry season rice in highly permeable soil, the maintenance of water conveyance systems is badly neglected leading to excessive losses of irrigation water, and extensive over-use of water is commonly found.

Table 6. Comparative Water Utilization Efficiency (WUE) Values, Two Major Irrigation Projects, 1978 Dry Season.

Project	Av. WUE (%)
G-K Project	28.6
D-N-D Project	70.4

Source: Bhuiyan, et. al., 1979

Table 7. Irrigable Area From Standard 2-cusec (57 lit/sec) Capacity Deep Tubewells.

Peak Water Requirements (mm/day)	Daily Pumping Hours				
	4	8	12	16	18
	Min. Irrigable Area (ha)*				
5.1	16	32	48	64	72
6.8	12	24	36	48	56
8.5	10	20	30	40	48
10.2	8	16	24	32	40
11.8	7	14	21	28	36
13.5	6	12	18	24	32

* Coveyance losses are not included in calculation.
Source: IBRD, 1972.

Table 8. Performance of Deept Tubewell Irrigation Units in Two Villages Near Dacca, 1974–75 and 1975–76 Dry Seasons.

Tubewell No.	Service Area (ha.)	
	1974–75	1975–76
1	38.3	32.3
2	31.5	24.2
3	–	28.2
4	37.1	30.2
5	–	22.2
6	14.1	10.1
7	2.8	0.0
8	–	6.5
9	6.0	0.0
10	22.2	8.9

Source: Bhuiyan, 1977.

4. *Delay in completion of large projects.* – In the past almost all large scale irrigation development projects have suffered from excessive delay in their completion. The situation does not seem to have improved even now. The result is that the benefits accrued from them are extremely low. The incomplete projects inevitably face problems of finding the additional funding required to complete them.

5. *Non-accountability in institutional systems* – In most of the organizations of the government, including those related to irrigation development and management, there is little in the form of true accountability for actions or non-actions in support of or against planned development. The systems are, in general, rigidly structured and inflexible. Officials having innovative or unconventional ideas have, therefore, great difficulty in making any real impact. This is one reason why irrigation projects with serious problems are not appreciated nor are the causes of such problems understood, hence no serious efforts to solve them are attempted. On the contrary, duplication and multiplication of past mistakes and disregard or ignorance of past poor results from such designs continue to be done. Development cannot but suffer under such an inadequate institutional framework.

6. *Poor organization of users* – In both canal and tubewell irrigation systems, lack of joint planning by the water users from a field turn out or pump outlet creates highly inefficient patterns of demand-supply relationships. For example, the tubewell cooperative members most often do not plan the cropping schedule for the entire service area. As a result, the pump is operated on the basis of an individual farmer's expressed demand for water. The farmer pays for the expenses for running the pump to supply the required amount of water which includes a substantial loss due to seepage and percolation in the conveyance system. Thus, farms far from the tubewell are at a disadvantage. Systematic planning by the cooperative members of the crop schedule in their area should make irrigation possible with substantial increase in the efficiency of water utilization.

7. *Social and organizational constraints* – The socio-political atmosphere in the farming community is mostly in favor of the few, influential farmers. There are numerous examples of these rich farmers exploiting the less able and less socially-aware poor farmers. Government institutions have not been able to successfully avoid providing more support to the limited few over the more needy farmers who are greater in number. Thus one finds too many examples of government tubewells installed on the basis of the inadequately formed farmer cooperatives to meet the requirement to justify the high government investments. One also finds numerous cases of public deep tubewells located in places favorable only to the influential members in the community. Agricultural credit and input supply services reach these favored farmers much more easily than the poor ones. The results of such inequities directly affect real development and use of irrigation water.

Conclusions and Recommendations

Bangladesh faces a great challenge in expanding food grain requirements. By 1986, about 21.0 million tons of food grains would be required to feed its population. This amount is 6.5 million tons, or about 55% higher than the total grain production in 1977. The question that naturally arises is: can food self-sufficiency be achieved?

It will take a production growth rate of nearly 9% per annum to achieve food self-sufficiency by 1985, assuming that 13.5 million tons is the 1979–80 production figure, although this amount may not be achieved because of drought damage to the 1979 "aman" crop. In the 5 years between 1972–73 and 1977–78, rice production increased by an average of about 5% each year (Bangladesh Bureau of Statistics, 1979). Yet, there was little net increase in irrigated area during the same period. The use of MVs neither increased significantly during this period (**Fig. 3**). Production increases during this period mainly accrued from the higher use of fertilizer, about 70% of which is urea. The total consumption of fertilizer increased from 384,000 tons in 1972–73 to about 512,000 tons in 1976–77, an increase of over 8% per year (Bangladesh Bureau of Statistics, 1979).

It seems logical and reasonable to think that the 1985 grain consumption requirement can be met by increased production if substantial improvements can be made in the short run in certain sectors. Greater emphasis should be given to developing more irrigated areas and the use of MVs in shallow rainfed areas because of their higher production potentials. From the irrigation infrastructure which already exists and which can be further developed during the 1980–85 period, a total of about 2.0 million hectares can be irrigated for multiple cropping if the water is used with a reasonable level of efficiency. To achieve this, more low-lift pumps will have to be provided. There is a potential to add another 22,500 power pumps to the present number of 34,500 used during the "boro" season (Bangladesh Agricultural Development Corporation, 1978). Use of the low-lift pumps for

supplementary irrigation in the "aman" season should be organized to avoid drought damage and ensure stable yields. More tubewells will have to be properly installed and better use of their water ensured. Canal systems will have to improve their operational efficiency through better water management.

To achieve the self-sufficiency target, an adequate supply of fertilizers and chemicals to the farmers and at reasonable prices will have to be maintained. The rice-fertilizer price ratio must be maintained at a level that gives enough incentives for farmers to grow MV rice using recommended rate fertilizer use on suitable land.

The structures of the relevant government institutions should be modified to introduce a system of accountability and an incentive program. This is lacking in the existing government institutions. Such a measure is long overdue and if implemented properly, it will help create an overall positive effect in the concerned agencies.

It should be recognized that most irrigation systems in Bangladesh depend on pumping to lift water and as such there will be increasing pressure to conserve energy as prices of fuel energy continue to rise. Utilization of the pumped water to obtain the most economic returns would be essential. In this respect, irrigated areas with suitable soils should grow high yielding variety of wheat in the winter season which requires much less water than "boro" rice. Also, great emphasis should be given to managing irrigation water more efficiently. The necessary research and training activities should be conducted at appropriate levels with short-run and long-run effects.

A number of measures, in the long-run, will be essential to sustaining continued crop production adequate for the population. The development of supplementary irrigation facilities for "aus" and "aman" crops will stabilize the food grain production by eliminating the high year-to-year rainfall variability. Droughts in the form of the late arrival and the early departure of the monsoon are constant threats to farmers' use of modern rice technology. Supplementary irrigation would thus be a logical solution to the frequent drought problem. Hence, research should be done throughout the country to develop extensive supplementary irrigation in the present rainfed areas suitable for the "aus" and "aman" rice cultivation.

Another long-run measure that must be considered very seriously is land reform. This is a controversial topic for obvious reasons. However, the chief purpose of land reform should be focused on providing production incentives for the tenant farmers who constitute over 40% of the country's total. Also, it is essential that further land fragmentation be checked through suitable and strictly enforced legislation.

Basic infrastructure for marketing, rice processing and storage facilities are essential components of agricultural development which need to be developed. Also, there is a great need for a comprehensive study of the future draft power requirements for land preparation in the country and the implementation of workable plans to adequately meet that requirement.

The importance of controlling population growth rate can hardly be overemphasized. The current growth rate of about 2.8% per annum must be brought down as quickly as possible so that development benefits are not consumed by the expanding population. Population control measures within short time periods appears inadequate which must be strengthened and a long-term, well-conceived plan pursued seriously.

Governments have drawn agricultural development plans to achieve food self-sufficiency in the past but actual achievements have been typically modest. Therefore, much depends on how well the present government machinery perceives the real agricultural development issues and how well it can capitalize on the mistakes and experiences of the past and make use of that experience for positive gains. Undoubtedly, the challenge now is bigger than it has ever been before and so is the need for dynamic leadership in the government to conceive and effectively implement an effective agricultural development plan having both short and long term goals.

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Irrigation Potential in Orissa—A Need for Better Planning and Utilization

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Introduction

The State of Orissa is situated in the north eastern section of India and extends over a geographical area of 15.54 million hectares between 17°–50′ and 22°–30′N latitude and the medians of 81°–21′ to 87°–38′E longitude. The state consists of an extensive plateau interspersed with erosional plain which slope gently into the coastal plain along the Bay of Bengal. The net area sown in 1977–78 was 5.999 million hectares which is about 39 percent of the total. The area under forests is 7.144 million hectares which is about 46 percent of the total area. The uncultivable and fallow lands is about 2.399 million hectares. **Table 1** presents the land distribution and irrigation statistics by district for 1977/78.

The major source of water available for agriculture is obtained from rainfall which is recorded in 143 raingauge stations from 1901 and averages 1,421 mm per year **Table 2**. If 75 percent of this quantity is considered as useful rainfall for raising "Kharif" crops then the quantiy of rain available is about 1,007 mm per year. The major crop (paddy) grown in the state during the monsoon season requires about 1,500 mm of water for its normal raising, hence water available through monsoon rain is insufficient. The distribution of rainfall in the districts is not uniform. When the district of Mayurbhanj gets the highest rainfall of 1,646 mm., the district of Ganjam gets the lowest amount of 1,238 mm. The districts of Ganjam, Balangir, Phulbani and Dhenkanal are affected by droughts.

Table 1. Distribution of Land Area, Cultivated Area and Irrigated Area, 1977/78

District	Area Total	Gross Area Under Cultivation	Net Area Under Cultivation	Gross Area Irrigated	Net Area Irrigated	Percent of Gross Area Irrigated to Gross Area Cultivated	Percent of Net Area Irrigated to Net Area Cultivated
Balasore	647	528	422	90	66	17.1	15.6
Belangir	883	477	404	83	59	17.0	14.6
Cuttack	1,089	1,179	710	352	225	24.0	31.7
Dhenkanal	1,092	500	411	48	38	9.5	9.2
Ganjam	1,120	765	482	230	213	30.1	44.2
Kalahandi	1,158	639	474	39	32	6.0	6.8
Keonjhar	831	322	282	15	12	4.5	4.3
Koraput	2,702	954	841	47	37	4.9	4.4
Mayurbhanj	1,040	501	421	46	42	9.1	10.0
Phulbani	1,104	262	211	35	31	13.2	14.7
Puri	1,046	741	463	229	162	30.9	35.0
Sambalpur	1,749	729	589	213	134	29.2	22.8
Sundargarh	979	334	287	26	20	7.6	7.0
Orissa	15,540	7,931	5,997	1,449	1,071	205.4	178.6

Table 2. Average Annual Rainfall, by District

District	Average Annual Rainfall (mm)
Balasore	1,521
Bolangir	1,245
Cuttack	1,455
Dhenkanal	1,331
Ganjam	1,238
Kalahandi	1,530
Keonjhar	1,433
Koraput	1,487
Mayurbhanj	1,646
Phulbhani	1,306
Puri	1,392
Sambalpur	1,423
Sundergarh	1,471
Average	1,421

Effect of Climate on Yield

Drought, floods and cyclones have been hitting the cultivators every year as a result of which the production of paddy has gone down after 1964/65. In total production was a record of over 43 lakh metric tonnes. Paddy occupies an important position in Orissa's agricultural sector.

Due to the paucity and uneven distribution of rainfall during the past few years there has been no improvement in the yield of paddy. **Table 3** shows the information regarding area, production and yield rate of rice crop grown in Orissa from 1960/61 to 1977/78.

Ground Water Potential

The average annual rainfall in Orissa is 23.36 million hectare metre out of which the quantity lost as surface runoff 9.488 million hectare metre. The balance is lost through evaporation, and gravity.

There are three important zones of formation where the ground water is either stored or serves as media for transmission **Table 4.**

Existing Gravity Irrigation

The details of area commanded by the existing gravity irrigation projects now in operation in the State are shown in **Table 5.**

Table 3. Area, Production and Yield of Paddy

Year	Area (million ha)	Production (million tone)	Yield (Quintal / ha)
1960/61	3.8	3.7	9.86
1964/65	4.3	4.4	10.14
1968/69	4.3	4.0	9.32
1972/73	4.5	4.0	8.90
1976/77	4.4	3.2	7.35
1977/78	4.4	4.3	9.81

Table 4. Data on Occurence and Storage of Ground Water

Zone	Area (km^2)	Average Thickness of Aquifer (m)	Storage Coefficient	Utilizable Storage Capacity Available (million ha metre)
Costal alluvium	13,701	30.5	15%	6.3
River alluvium	17,591	7.6	15%	2.0
Weather zone in hard rock areas	125,698	3.1	5%	1.9
Total				10.2

Table 5. Gravity Irrigation Characteristics

Type of Irrigation Project	Nos. in Operation	Total Area Commanded (ha)		Total Crop Area (ha)
		Kharif	Rabi	
Major	5	665,707	400,653	1,066,000
Medium	8	117,799	2,143	103,225
Minor	N.A.	240,000	56,000	296,000
Total		1,023,506	458,796	1,465,225

Table 6. Actual and Potential Irrigated Areas

District	Irrigation Potential, 1977/78				Irrigated Ratio Area	Ratio Potentail
	Major and Medium	Minor Irrigation	Lift irrigation	Total		
	– – '000 ha – –				– – Percent – –	
Balasore	77.60	7.40	16.96	101.98	7.29	7.40
Bolangir	64.50	11.90	1.47	77.87	5.56	5.81
Cuttack	296.58	12.50	42.63	351.71	25.15	25.40
Dhenkanal	11.11	31.80	4.40	47.31	3.38	3.63
Ganjam	96.65	100.00	7.55	204.20	14.60	14.76
Kalahandi	13.57	19.00	0.80	33.27	2.38	3.03
Keonjhar	0.01	10.30	2.04	12.35	0.88	2.31
Koraput	5.07	23.20	7.91	36.18	2.58	3.07
Mayurbhanj	7.33	30.50	3.78	41.61	2.98	3.54
Phulbani	21.89	11.80	1.16	34.85	2.49	3.00
Puri	196.62	23.70	2.89	223.31	15.96	6.31
Sambalpur	187.82	18.30	3.66	209.78	15.00	15.90
Sundargarh	4.23	16.30	3.36	23.89	1.71	3.00
Total	982.98	316.70	98.61	1,398.39	–	–

Irrigation Potential During the Fifth Plan Period

In the beginning of the Fifth development Plan, the irrigation potential from all sources in the State was estimated at 634.83 thousand hectares. Only a small percentage of this potential has been exploited so far. The present area irrigated area is about 16 percent of the net cropped area. An additional irrigation potential of 187.64 thousand hectares has been achieved in major and medium irrigation projects in the state during the first four years of the Fifth Plan. The minor irrigation potential is about 54,197 hectares. Up to the end of 1977/78 the total irrigated area was 1,398 thousand hectares.

Need for Sound Irrigation Planning

In view of the importance of irrigation all possible steps should be taken not only to extend irrigation facilities to additional areas but also to make effective use of existing facilities. Dams across the major rivers at different points in their downward course will help conserve water and regulate supply in the canals in drought periods. Construction of field channels should be given priority in order to check excessive conveyance losses. Consolidation of holdings is a prior need before the construction of field channels. Unless a proper and coordinated irrigation planning is pursued it is difficult to visualise how agriculture, the primary economic activity in Orissa, can make rapid progress.

It is generally agreed that changes in agricultural practices are needed when irrigation is introduced into existing agricultural practices. Crop selection and cultural practices that increase crop yields will raise water use efficiency. To achieve maximum production per unit of water used, other factors, being controlled, plant growth, must be optimal. The lack of farmers' experience with irrigation is found to be a serious limitation in achieving production under many irrigation schemes.

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Harvesting and Threshing Losses of Wheat with Mechanical and Conventional Methods

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Abstract

Mathematical models were developed for the harvesting and threshing losses of wheat in the field. The harvesting losses with manual operations increased linearly with time, ranging from 3% in the first week to 7% in the third week, after the ripening of crop, indicating that a delay of two weeks in harvesting can seriously affect crop yield. Further, grain losses from the conventional winnowing operations were as high as 10% decreasing in a non-linear fashion with distance, and becoming negligible beyond a distance of 2.50 meters. With mechanical threshers, the grain losses ranged from 2% to 6% for the different locally made winnowers.

The cost of harvesting with reaper-binder and mechanical thresher is half that of harvesting with manual labour and threshing with bullocks and flail. Mechanical harvesting and threshing required 4 hours as against 48 man/bullock hours. However, these models have yet to be studied carefully for their technical suitability and acceptability under Pakistani conditions.

Introduction

Post harvest losses certainly reduce crop yields,. Koga(1977) recorded 4 percent losses on farmer's field and 1 percent in marketing and distribution of paddy in Japan; whereas, Bala (1978) observed 8-22 percent post-harvest losses, including losses from harvesting up to retailing of paddy in Bangladesh. Bala further stated that the post harvest losses of paddy on farmer's fields in India and Indonesia were 15% and 10%, respectively.

Little research has been conducted on post-harvest losses in Pakistan. Chaudhry et al (1968) indicated that grain losses during harvesting, threshing and winnowing of wheat, on the average, were about 5 per cent. The percentage losses reported in this study were based on interviews with farmers and, therefore, cannot be considered very reliable. Keeping in view the importance and degree of wheat losses, it was imperative to evaluate post harvest losses in the field under local conditions. The losses were due to shattering of grains and falling of ears due to wind and rain before and during harvest, bundling, transporting bundles to threshing floor, damaging and cracking of grains, winnowing, birds and rodents, transporting, processing, storing, and marketing. The study focussed on field losses during harvesting and threshing.

Materials and Methods

The study was conducted at the University of Agriculture, Faisalabad, during the wheat harvesting season of 1979. Since the shedding characteristics of the ears and grains differ with the wheat variety, a particular variety (LU-26, developed at the University) was considered in the experiments so as to eliminate inter-varietal effects and to reduce the number of variables. Procedures used for the determination of various losses follow.

Field Losses

Five plots of 9.29 sq.m. each were randomly selected from the acre for estimating the losses. From each plot, the crop was manually harvested, removed and the ears falling on the ground were collected. The collected ears and the harvested crop were threshed and weighed as (w_h and W_h),respectively.

For determining field losses in the process of bundling and transporting, the harvested crop was placed in small heaps in the field. The heaps were further assembled on a piece of cloth to make bundles weighing 25–30 kg each. The ears falling under the heaps and at the bundling spot, were gathered, threshed and weighed as (w_b). The bundles were then transported to the threshing floor. The ears falling at the lifting spot were threshed and weighed as (W_t). The bundles were threshed and the grains weighed as (W_p). This procedure was repeated for 5 bundles selected randomly from an acre of wheat. The losses were calculated as follows:

1) Percent harvesting loss

$$= \frac{w_h}{W_h + w_h} \times 100$$

Percent harvesting losses were calculated for the five plots and averaged as H_a

2) percent bundling loss

$$= \frac{w_b}{w + \overline{w}_h} \times 100$$

3) percent transporting loss

$$= \frac{w_t}{w + \overline{w}_h} \times 100 \text{ where,}$$

$$W = w_b + w_p + \omega_t$$

$$\overline{w}_h \approx \frac{H_a}{100 - H_a} \times W$$

The above procedure was repeated thrice in consecutive weeks to assess the effect of late harvesting. The analysis of variance and regression analysis were used to analyse the date.

Threshing and Winnowing Losses

Conventional method – Twenty five bundles, were placed on the threshing floor and were treaded by bullocks under large twings of thorny trees interwoven with wheat straw commonly known as "phala". The threshed material was manually winnowed through natural wind currents. Percentages in the straw were calculated at various distances from the point of starting of straw. The relationship of grain percentage and distances was established using regression analysis.

Mechanical method – Two cloth pieces 1.0 to 1.5 m and 1.5 to 7.5 m were laid down for assessing the ghundi* and thrower losses, respec tively. The thresher was operated at intervals varying from 1 to 5 minutes. The losses were calculated as follows:

$$\text{Percent ghundi loss} = \frac{w_g \times 100}{W_t}$$

$$\text{Percent thrower loss} = \frac{w_t \times 100}{w_t}$$

where

w_g = wt.of grains from ghundies (0 to 1.5 meter)

W_t = wt. of grains from thrower (1.5 to 7.5 m)

W = thresher's output per selected interval of time,

$W_t = W + w_g + w_t$

In a comparative study of various threshers, samples of grains 1/2 kilogram each were taken, broken grains sorted and weighed to determine the percentage of breakage. Similarly, samples were collected, impurities sorted and weighed to ascertain percent impurity.

$$\text{Percent breakage loss} = \frac{w_b \times 100}{w}$$

Percent purity

$$= \frac{(w - w_i)}{w} \times 100 \text{ where}$$

w_b = wt. of broken grain

w_i = wt. of impurities

w = wt. of sample.

Results and Discussion

Harvesting Losses

Percent harvesting losses (**Table 1**) increased as the harvesting was delayed after the ripening of crop. The analysis of variance indicates that the losses at the third week were significantly different from those of the first week. The regression analysis was used to develop the following mathematical equation that relates percent harvesting losses with delays in harvesting, using mean values of the data in **Table 1**.

$$H = 0.7067 + 1.105\,t$$

where:

h = Percent harvesting loss,

t = Time of harvesting after crop ripening (in week)

The trend of the losses (**Fig. 1**), with delayed harvesting in the present investigation is almost the same as noted by Chaudhry et al (1968). However, the degree of losses differs with the two studies. Seasonal fluctuations encountered during the years of these studies may partly account for the differences. Secondly, the method of observation adopted by Choudhry et al (1968) was based on interviews of farmers, a secondary source of information which could affect the true result.

Grains and ears tend to shed as the crop silightly over-ripens due to delays in harvesting which calls for the use of harvestors to speed up the operations and to avoid reductions in grain quantity. Further, the delays either in harvesting or threshing are subject to natural calamities like, wether, wind, rain, hailstorm, etc; that may deteriorate

* A small part of ear holding few grains.

Table 1. Percent Grain Losses

Plot	Week of Harvest After Crop Ripening								
	Harvesting			Bundling			Transporting		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
	---------- Percent of Total Product ----------								
1	2.53	1.80	5.74	1.16	1.56	2.50	0.35	0.35	0.71
2	1.27	2.86	4.22	0.84	1.68	1.61	0.34	0.36	0.64
3	1.72	3.87	3.34	1.11	1.37	1.86	0.30	0.58	1.12
4	1.90	3.61	2.96	1.46	1.58	2.35	0.26	0.31	0.71
5	1.85	2.07	4.06	0.85	1.38	2.09	0.28	0.34	1.10
Mean	1.85	2.84	4.06	1.08	1.51	2.10	0.28	0.41	0.86

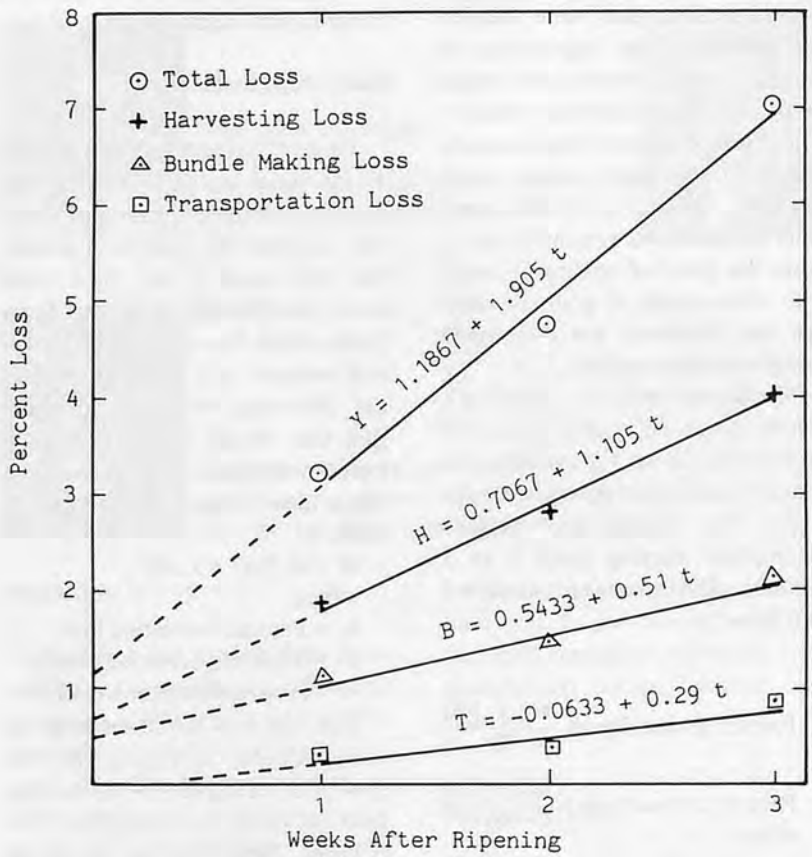

Fig. 1 Effect of delayed harvesting on grain losses

the quality of grain, in addition to affecting quatitative losses.

Losses in Bundling

Percentage losses in the bundling process for the advanced harvest are presented in **Table 1**. The effect of late harvesting on bundling losses was found statistically significant for the reasons discussed under harvesting losses. A regression analysis was used to develop the following mathematical equation that relates the percentage of losses with delays in harvesting, using mean values of the data in **Table 1**.

$$B = 0.5433 + 0.51\ t$$

where

B = Percent loss in bundling

t = Time of harvesting after crop ripening.

The above equation is graphically presented in **Fig. 1**. The losses may be eliminated by using combine-harvestor provided the first cost of the machine is not prohibitive. The use of wheat harvestor binder may reduce losses in bundling by virtue of its timely operation at suitable moisture contents.

Transport Losses

The percent losses observed during transit of the crop are not substantial. However, the effect of late harvesting on the losses was found significant. The transport losses included the losses in lifting the bundles and transporting them (**Table 1**).

A regression analysis was used to develop the following mathematical equation that relates percent transport losses with delays in harvesting, using mean values of the data in **Table 1**.

$$T = -0.0633 + 0.29\ t$$

where

T = Percent transport loss

t = Time of harvesting in weeks after crop ripening

Front-end, tractor-operated, fork type lift or combine harvestor may reduce the above losses.

Threshing and Winnowing Losses

Conventional method – Grain losses on the threshing floor were negligible in the conventional method. However, losses did occur during the winnowing process. A regression analysis was used to develop the following equation that relates percent grains in straw and the distance from the point of starting of straw heap:

$$Y = 3.2296 - 3.0735\ \ln_e^X$$

where

Y = Percent grain in straw

X = Distance from the point of starting of straw heap. (in meters)

The equation is graphically presented in **Fig. 2** which shows that grains were detected up to a distance of 2.5 m measured from the start of the straw heap. Beyond a distance of 2.7 m, the grain loss was almost zero.

No losses other than these of winnowing could be recorded in the conventional method. But expected deterioration in grain quality due to delays in threshing and drudgery of operations are the primary constraints which question the use of conventional method of threshing and winnowing.

Mechanical method – Using the procedure described earlier, the following losses (**Table 2**) were determined in various makes of locally manufactured wheat threshers.

Among the above losses, grain breakage is serious which may be associated with factors like moisture content of grains at the time of threshing, increased speed of thresher, faulty clearance in the threshing unit or any other mechanical fault in the thresher, Research trails may be conducted to locate and improve mechanical faults in the locally manufactured threshers with a view to reducing grain breakage.

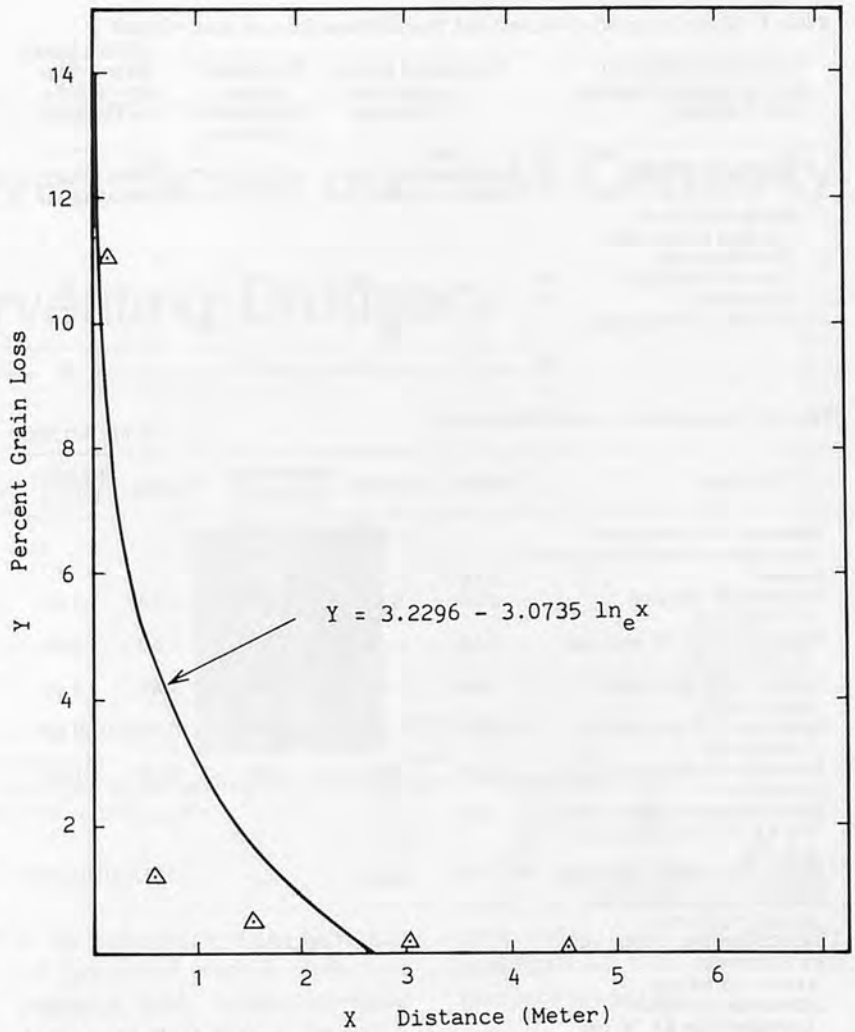

Fig. 2 Relationship of percent grain going into straw and distance measured from point strow heap sets in

Table 2. Comparative Performance of Different Threshers at 600 rpm

Make of Thresher	Output (kg/hr)	Percent Purity	Percent Breakage	Percent "Ghundi" Loss
Mughal (Faisalabad)	451	96	0.41	3.58
Chazi & Co (Mian Chunnun)	352	95	4.17	0.83
Sun light (Burewala)	354	94	6.00	–
LEFO (Lahore)	294	96	3.00	0.41
Ittefaq	415	98	2.00	–

Cost of Operation

Cost analysis of mechanical and conventional methods of harvesting and threshing was undertaken with a view to assessing their economic feasibility. The hours required to complete the operations as shown **Table 3** were first determined.

The cost* of operation for the different machines were estimated based on the following basic information:

Cost of 1.52 m reaper binder
= Rs. 15,000 (tractor operated)
Cost of 1.5 m reaper binder
= Rs. 30,000 (tractor operated)
Cost of MF-135 tractor
= Rs. 65,000
Cost of thresher
= Rs. 25,000 (tractor operated)
Cost of a pair of bullocks
= Rs. 6,000
Life of tractor
= 10 years
= 10,000 hrs (1,000 hours/year)
Life of tractor
= 6 years
= 2,400 hrs (400 hours / year)
Life of bullocks
= 10,00 hrs (1,000 hours/year)
Life of reaper-binder and reaper
= 10 years
= 10 years
= 5,000 hrs (500 hours/year)

a) *Cost of mechanical harvesting*

The cost of harvesting one acre of wheat with tractor = 25.50 + 18.90 = 44.40.

Cost of tractor operated thresher for threshing one acre of wheat (1,100 kg wheat).
(cost of operation for 100 kg of wheat Rs.–8.41) Rs. 92.50

Total cost of harvesting (with binder) 44.40 + 92.50.
and threshing mechanical thresher (both tractor operated) one acre of wheat (1,100 kg) 136.90.

Time required for one acre = 2 hours for cutting & binding + 2 hours for threshing 4 hours.

b) *Cost of manual harvesting and threshing with bullocks (one acre of wheat).*

Cutting with sicle (16 man hours) R. 16 x 3 = Rs. 48.0 (Rs. 3 per hr.).

Binding with hand (8 man hours) Rs. 8 x 3 = Rs. 24.0 (Rs. 3 per hr.).

* Rs. 9.8 = US$1.0

Table 3. Hours Required to Harvest and Thresh Wheat from an Acre of Land

(Unit: hours)

Conventional (Manual Harvesting and Threshing with Bullocks)		Mechanical Reaper + Conventional Threshing		Mechanical Reaper + Mechanical Threshing	Reaper-Binder + Mechacal Threshing	
Cutting with sickle	16	Cutting with reaper (1.5m)	2	2	Cutting & bundling	2
Binding by hand (4 man in one day)	8		8	8		–
Threshing with bullocks and flail	16		16	2		2
Winnowing	6		6	–		–
Gathering and sacking	2		2	–		–
	48		34	12		4

Table 4. Comparative Costs of Harvesting

(Unit: Rp./hr)

Cost Item	Bullock	Tractor	Mechanical Thresher	Reaper	Reaper-binder
Diesel oil with lubricants (one gallon diesel oil per hour)	–	15.00	–	–	
Fodder	2.00	–	–	–	
Repair (10% per year of initial cost	0.60	6.50	6.25	1.50	3.00
Depreciation (10% per year of initial cost	0.60	6.50	6.25	1.50	3.00
Interest (14% per year of initial cost)	0.84	9.10	7.50	1.80	3.60
Insurance (2% per year of initial cost)	0.12	1.30	1.25	0.30	0.60
Housing (4% prer year of initial cost)	0.24	2.60	2.50	0.60	1.20
Labour-bullock operate tors for Rs. 30/ per day (a day 6 hours)	5.00	–	–	–	
Labour-tractor operator and helper for Rs. 40 per day (a day = 6 hours)	–	6.67	–	–	
Labour-thresher 6 men for Rs. 90 per day (a day = 6 hours)	–	–	15.000	–	
Labour-Reaper binder attendants for Rs. 30 per day (a day = 6 hours)	–	–	–	–	5.00
Labour-reaper attendents for collecting and sacking 4 attendents for Rs.60 per day (a day 6 hours)	–	–	–	10.00	
Overhead cost 50% of labour (management)	2.50	3.34	7.50	5.00	2.50
Total	11.90	51.10	46.25	20.70	18.90

Field Capacity/Operating Capacity 1/6 Acre per Hour		2 Areas per Hour	550kg Wheat per Hr.	One Acre per Hr.	One Area per Hr.
Total cost of operation per acre or per 1,100 kg of wheat (In one acre 1,100 kg of wheat is obtained (in rupeas)	71.40	25.50	92.50	20.70	18.90

Threshing with bullocks and flail (16 hours) = Rs. 16 x 11.90 = Rs. 190.40 (Rs. 11.90 per hour from the above **Table**).

Winnowing (6 man hours) Rs. 6 x 3 = Rs. 18.0.

Gathering & sacking (2 man hours) Rs. 2 x 3 = Rs. 6.0.

Total cost (48 hours) Rs. 286.4

Time required for one acre = 48 hours 2 days or 12 hours for 4 men (a day of 6 hours).

Conclusions

Harvesting losses increased linearly with time after reipening of the grains, i.e., from 3% in the first week to 7% in the third week.

Grain losses from the conventional winnowing operations were as high as 10% but decreased in a non-linear fashion with distance, becomming negligible beyond a distance of 2.50 meters.

Grain losses from locally produced mechanical threshers ranged from 2% to 6% and the cost of mechanical harvesting and threshing is half the cost of conventional harvesting with manual labour and threshing with bullocks and flail.

Mechanical harvesting and threshing required 4 hours as against 48 man/bullock hours with conventional method. The cost of the latter operation per acre is 2.80 times the cost of operation with the former.

The cost of threshing with bullocks and flail is twice the cost of threshing with a mechanical thresher.

The time required with mechanical threshing is 1/8 of the time required for threshing with bullokcs and flail.

Losses resulting from weather hazards can be avoided by using reaper-binders. However, their technical suitablility and acceptability under Pakistan conditions need to be investigated further.

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Effect of Improved Sickle on Field Capacity and Wheat Harvesting Drudgery

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Abstract

This study was undertaken in April, 1978 in Delhi State for comparing the field performance of "Krishi Udyog" sickle (improved) and traditional sickles. All the fields and farm workers (male and female) for the test were selected randomly. The comparison was made for the same person, in the same field and on the same day to avoid the effect of variables like health, temperature, crop denisty, field condition, etc. The workers were requested to comment on different sickles about ease of operation, performance, etc. The results indicate a better performance of the "Krishi Udyog" sickle over traditional sickles for wheat harvesting by the same person. Female workers preferred the "Krishi Udyog" sickle but at the same time most of them were unhappy with its handle. This improved sickle has been found economical than the traditional counterparts. However, it was found inconvenient for use by the left-handed workers.

Introduction

In India much of the harvesting of agricultural crops is carried out manually with locally developed small hand tools such as the sickle. The sickles used in different parts of the country come in various shapes, sizes, manufacturing process and handles provided on it. Improvements in this tool will lead to ease of operation, better performance efficiency and durability. A better tool requires lesser efforts which results in increase in working capacity of the individuals. Attempts are, therefore, being made to improve the existing sickles as well as to introduce improved sickles form other countries. The Maharastra Agro-Industries Development Corporation Limited (MAIDC, Ltd.) has introduced a "Krishi Udyog" sickle which is based on the Japanese design that is suitable for paddy harvesting in Japan.

The study was undertaken to determine necessary changes required in the use of the "Krishi individuals. Attempts are, there-on the farmers' field and suggestions for modifications, if any, were noted down and necessary modifications were made in the handle of the sickle.

Review of Literature

Tomotake Takasaka (1971) reported that the Taiwan sickle which resembles the "Krishi Udyog" sickle was developed at the end of 19th century in Taiwan and has continuously been improved for better harvesting of paddy and Wheat.

Kawashima (1954) suggested that the more the serrations on the sickle blade, the more effective is its cutting power. He recommended that maximum efficiency in the cutting by serrated sickle will be obtained when the blade serrations is elliptical with eccentricity of 0.7 mm, angle of 80–90°, pitch of serrations at 2.2 mm, and angle of blade with handle at 160°.

Yoshida (1962) found that shearing force prodominates the frictional cutting force in most of

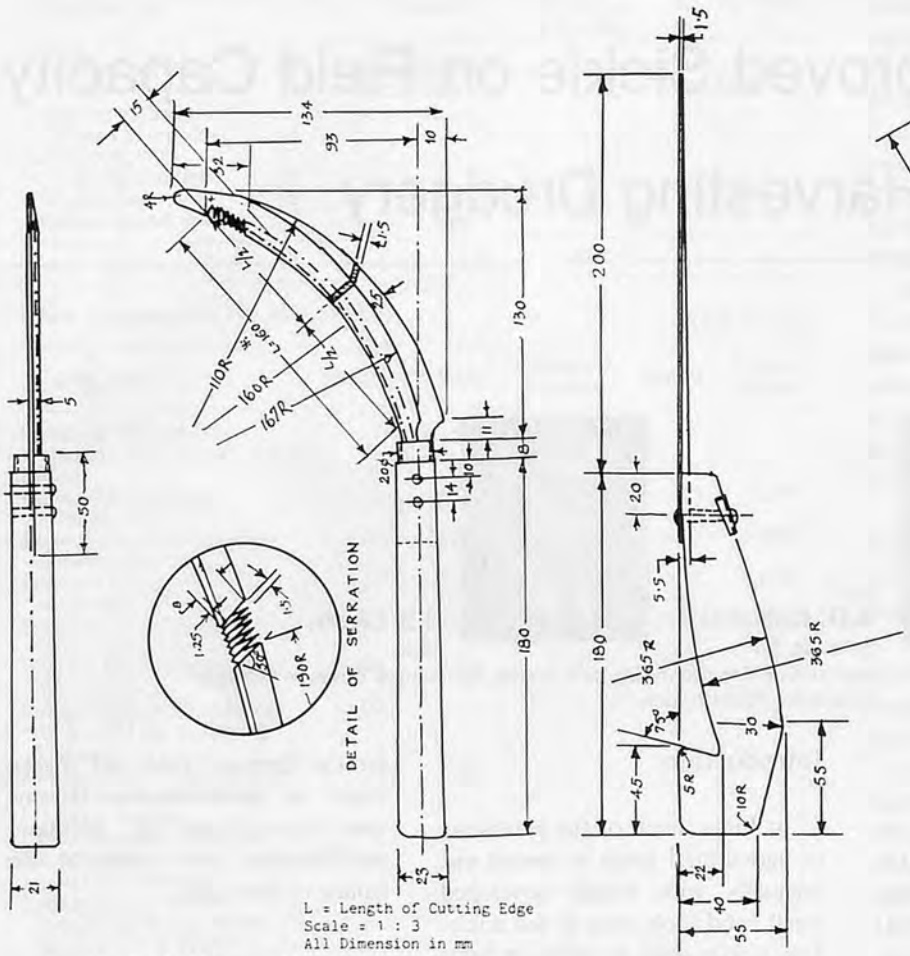

Fig. 1 Krishi Udyog sickle with original handle

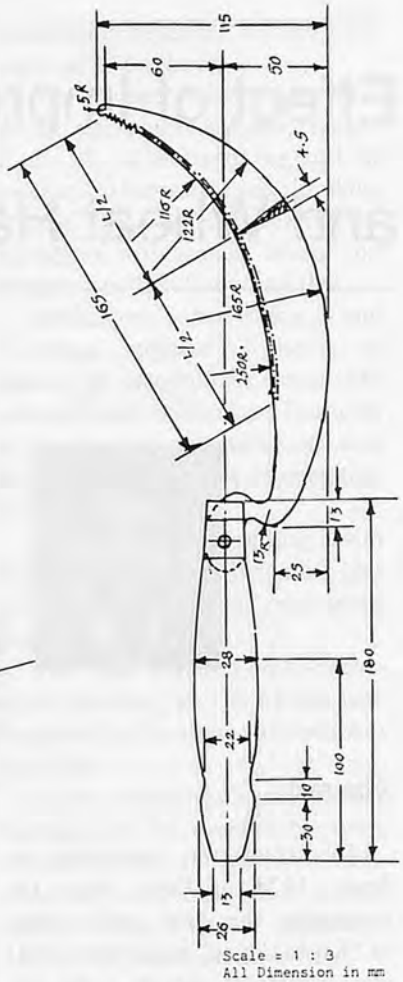

Fig. 2 local sickle

the Indian sickles.

Srivastava et al (1963) reported that the Japanese serrated blade and plain blade sickles gave 20 and 30 per cent higher output than the serrated blade Indian sickles, respectively.

Singh and Singh (1978) reported that: a) the I.S.I. sickle requires less force than any other Indian sickle; b) the serrated edge requires less force than plain edge; c) materials of construction for sickle blade do not have significant difference in force requirement for harvesting.

Dewnani and Pande (1978) evaluated that the "Krishi Udyog" sickle was best, followed by the "Krishi Udyog" sickle and traditional sickle for wheat harvesting.

Materials and Methods

The study made a comparative performance of the 'Krishi Udyog' sickle (Fig. 1) and traditional sickle (Fig. 2). Field tests for wheat harvesting with different sickles and workers were arranged for the purpose. Two villages, Kanjhawala and Najafgarh, were selected in Delhi State for the field tests. A field with normal wheat crop standing and ready for harvest were selected. Labourers (male and female) of different age groups and working habits were requested to use the "Krishi Udyog" sickle. The time of start was noted for each worker and they were allowed to work with it as long as they felt like working. After completion of work the itme was noted and size of area harvested was measured. Then the same workers were requested to work with the traditonal sickle and time of starting of work was likewise noted.

After completion of work the workers were requested to comment on the use of both sickles for advantages/disadvantages, ease of working, any changes required for further ease of operation and increasing harvesting efficiency of the workers. The tests for each sickle were completed on the same day, for the same person and at the same field to avoid the influence of other variable viz. weather, daily temperature, health of worker, and crop density. The shape of handle of the sickles were based on the individuals convenience

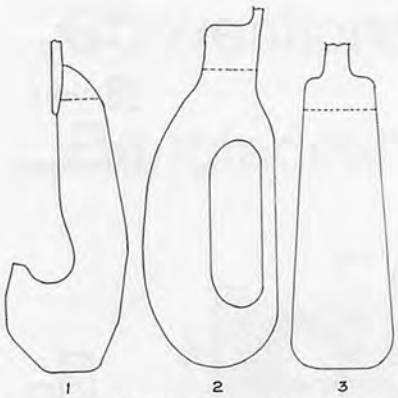

Fig. 3 Different shapes of handles of local sickle

(Fig. 3). The collected data/observations were analysed, for different labourers, for time required per unit area (min/m^2) for wheat harvesting with both the sickles which indicated the performance efficiency of the workers. Twelve new "Krishi Udyog" sickles were used and examined for manufacturing defects such as improper fitting or handle, handle ring and formation of grooves on the cutting edge.

Table 1. Comparative Harvesting Time by Male Harvesters for Two Types of Sickles

(Unit; min/m^2)

Age Group (year)	Position of Harvester After Bailing				Position of Harvester Before Bailing			
	Sitting		Bending		Sitting		Bending	
	LO*	KU**	LO	KU	LO	KU	LO	KU
15–20	–	–	–	–	–	–	–	–
21–25	1.10	1.20	0.86	0.80	0.42	0.39	–	–
26–30	–	–	0.89	0.70	0.39	0.32	–	–
31–35	1.41	0.87	0.75	0.70	0.52	0.54	–	–
36–40	0.96	0.92	1.01	0.62	–	–	–	–
41–45	–	–	–	–	–	–	0.44	0.46
46–50	1.18	0.81	–	–	–	–	–	–
Average	1.16	0.95	0.88	0.71	0.44	0.42	0.44	0.46

* Traditional sickle (control).
** "Krishi Udyog" sickle.

Table 2. Comparative Harvesting by Female Harvesters for Two Types of Sickles

Age Group (year)	Position of Harvester After Bailing				Position of Harvester Before Bailing			
	Sitting		Bending		Sitting		Bending	
	LO*	KU**	LO	KU	LO	KU	LO	KU
15–20	1.83	1.44	1.41	1.05	–	–	0.60	0.57
21–25	1.24	0.94	1.41	1.34	0.80	0.63	–	–
26–30	–	–	–	–	–	–	0.70	0.58
31–35	1.22	0.79	0.49	0.26	–	–	0.59	0.63
36–40	0.86	1.04	1.41	0.95	–	–	–	–
41–45	1.14	0.91	–	–	–	–	–	–
46–50	1.88	1.22	–	–	–	–	–	–
Average	1.36	1.06	1.11	0.90	0.80	0.63	0.63	0.59

* Traditional sickle (control).
** "Krishi Udyog" sickle.

Results and Discussion

Performance Efficiency

Tables 1 and 2 indicate the time required for wheat harvesting for both the sickles.

For both age groups and harvesting operations, harvesters required lesser time using the "Krishi Udyog" sickle than for the control sickle. The harvesters tend to take more time in the sitting position while cutting the stalks.

Female harvesters required, on the average, more time to harvest an area, then than male counterparts in both cases. The female workers preferred the "Krishi Udyog" sickle to that of the traditional sickle. For both sexes, time was required for harvesting per unit area using the "Krishi Udyog" sickle.

Where n: No of observations
D: Average of the difference

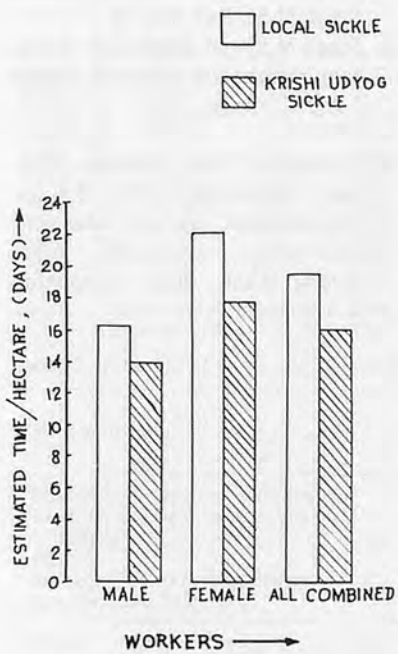

Fig. 4 Performance of the sickles for wheat harvesting by different workers

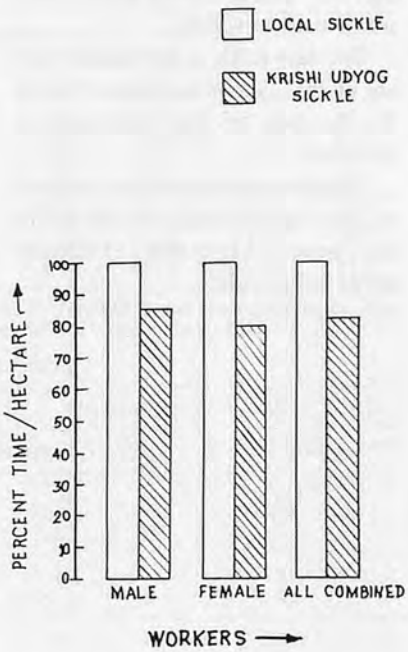

Fig. 5 Percentage time required for wheat harvesting with Krishi Udyog sickle and local sickle

Table 3. Analysis of Data for Wheat Harvesting Using Two Type of Sickles

Harvester	n	D	SD	't' Calculated	't' Table value
All harvesters	45*	0.148	0.233	4.249	2.015
Male	19	0.111	0.216	2.243	2.101
Female	23	0.209	0.223	4.509	2.074

* Three male harvester were left-handed.

Table 4. Estimated Man-days per Hectare for Harvesting Wheat Crop Using 'Krishi Udyog' and Traditional Sickles

Harvester	Average Time (min/m²)		Man-days* Per Hectare	
	Traditional sickle	Krishi Udyog sickle	Traditional sickle	Krishi Udyog sickle
Male	0.78	0.67	16.25	13.90
Female	1.06	0.85	22.15	17.80
All harvesters	0.94	0.77	19.50	16.00

* 8-hour day.

between the value for two sickels.

SD: Standard deviation.

The estimated harvesting time per hectare for using each of the sickles is shown in **Table 4**.

Summary

The "Krishi Udyog" sickle is more efficient for wheat harvesting and preferred by both male and female harvesters.

The test sickle is not suitable for use by left-handed harvesters due to the location of the serrations on the blade.

Improvements and modifications in the original handle of this sickle for better harvesting efficiency needs to be made.

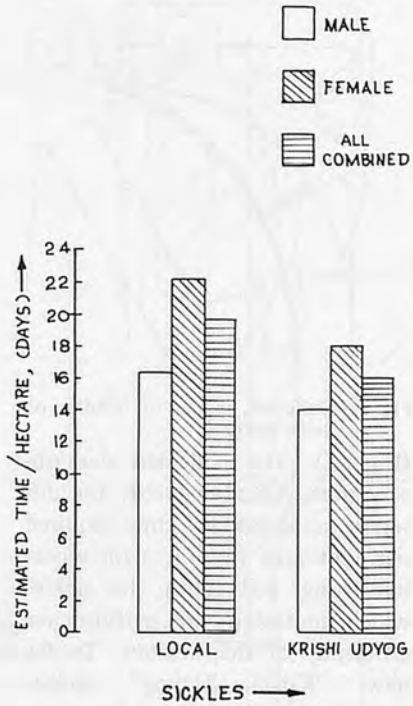

Fig. 6 Performance of the farm workers for wheat harvesting with Krishi Udyog sickle and local sickle

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Conventional Rural Storage Structures: Bangladesh Experience

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Abstract

Rural storage structures are frequently of poor construciton and are susceptible to rodent and insect attack. Farmers store paddy, rice, pulse, oilseed, etc. for their own need, normally for a period of one year. Traditional storage structures like "gola", gunny bags, "dole" and steel drum are generally used in different districts of Bangladesh. Food grains are kept in all these storage structures and in most cases the structures are made air-tight by placing lids in their opening, plastered with mud and cowdung. The structures are normally kept on platforms 30 to 40 centimetres above the ground level to avoid dampness.

Introduction

As population increase so does the gap between the quantity of food grain produced and quantity required. This has necessitated the economic use of existing food supply in the form of reduction of spoilage in storage which, in some cases, is estimated to be as high as 22 percent (Farouk, 1975). To cope with this problem, Bangladesh has to import huge quantities of food grain every year. **Table 1** shows the food production and food grain importation during 1961–71.

The problem of food grain shortage is common among the farmers, but very few realise the extent of damage done to the commodity during storage. An estimate of quantitative losses of food grain at each stage is shown in **Table 2**.

However, the farmers store food

Table 1. Population, Production and Imports of Food Grain

Year	Total Production	Seeds etc. (10%)	Net Available (domestic)	Import	Total Available for Consumption	Population (million)	Per Capita per Day (gram)
			----- million mt -----				
1960–61	9.70	0.97	8.73	0.73	9.46	55.57	465
1961–62	9.66	0.96	8.70	0.41	9.11	57.29	434
1962–63	8.91	0.89	8.02	1.46	9.48	59.07	437
1963–64	10.66	1.06	9.60	1.02	10.62	60.70	476
1964–65	10.55	1.05	9.50	0.36	9.86	62.79	432
1965–66	10.53	1.05	9.48	0.92	10.40	64.61	440
1966–67	9.63	0.96	8.67	1.18	9.85	66.48	407
1967–68	11.21	1.12	10.09	1.03	11.12	68.41	445
1968–69	11.44	1.14	10.30	1.14	11.44	70.39	443
1969–70	12.11	1.21	10.90	1.56	12.46	72.43	470
1970–71	11.25	1.12	10.13	1.55	11.68	75.01	412

Source: Agricultural Production Plan (1972–77) and Food Self-sufficiency Programme (1974–75), May 1972. Ministry of Agriculture, Dacca.

Table 2. Estimate of Waste and Loss of Food Paddy

Source of Loss	Percent Lost or Wasted	
	Marketing Study*	Farmer Interview**
Shattering during and after harvest	1.1	1.5
Transit from field to premises	0.6	N.A.
Threshing	1.7	2.0
Drying	1.7	5.0
Storage (due to rotting, insects	3.1	7.5
Handling and Trans port	N.A.	6.0
Total	8.3	22.0

Source: Farouk, S.M. 1975.
* 1970 estimate of a marketing group.
** 1974 interview of farmers in Dacca.

grains like paddy, oil seeds, pulses, etc. for their own need between one harvest to another. The period of storage may range from one month or less to one year or more. Paddy is generally stored for one year.

Storage Practices

The different types of storage structures used by farmers vary in different parts of the country. These are as follows:

Earthen Container

a) "Matka" is made of burnt clay and is of spherical shape. It has a small hole at the top through which grain is filled in. Its capacity varies from 150 kg. to 250 kg. They are generally kept on a raised platform, filled with grains and the top hole is closed with a lid plastered with mud (**Fig. 1**).

Some large "matkas" are treated with oil and kept underground, generally in the floor of the houses when the opening is kept at the floor level. These are used for keeping parboiled rice in the districts of Barisal, Khulna and Patuakhali.

b) "Jala" is an oval-shape container, also made of burnt clay with a hole on top for filling it with grains. Its capacity varies from 15 kg to 100 kg. Rice and pulses are generally stored in this type of centainer (**Fig. 2**).

c) "Kuthi". This may also be of various shapes such as spherical, rectangular, circular and made of straw, cowdung and mud. There are two openings: one on top for filling it with grains and the other at the bottom for emptying it. When the "kuthi" is filled with grain, the opening is closed with mud lid. The capcity of this kuthi ranges from 80 kg. to 1 ton. These are also placed on the raised platforms inside the houses.

Fig. 1 "Matka"

Fig. 2 "Jala"

Fig. 3 Gourd (left) and Jar (right)

Fig. 4a "Dole"

Fig. 4b "Dole"

d) Jar. The capcity of this earthen container varies from 15 to 20 kg. and are generally used for storing paddy, pulse, etc. These are made of burnt clay and are available in the markets in rural areas. Like most other containers, it has a hole on top which is closed with a lid (**Fig. 3-right**).

Woven Bamboo Containers

a) "Dole". These may be rectangualr, oval or circular containers made of plaited bamboo, plastered on both sides with clay and cowdung. Rectangular shaped "doles" are usually reinforced with bamboo splits and are large as to contain ½ ton to 3 tons grains. The circular or oval structures are entirely made of woven bamboo without any reinforcement and contains 80 kg. to 1 ton grains. These are open top structures and when filled with paddy, the opening is closed with a lid made of straw and cowdung. This type of containers are usually kept on raised platforms in houses. **(Figs. 4a and 4b).**

"Gola"

This is a small hut used mostly by the rich farmers for storing either parboiled rice or paddy. It is usaully circular in shape and installed in home-yard. Its capacity ranges from 1 to 9 tons. **(Fig. 5).**

The "Gola" is built on a bamboo platform 50 cm to 60 cm above the ground and its roof is made of hay or tin. The side walls are usually made of woven bamboo mats plastered on both sides with a mixture of mud and cowdung.

Metal Containers

a) Steel drum. These are cylindrical containers of about 0.2 ton-capcity. An opening on top is for filling it with top through which grains are filled in. The drum is usually kept on a raised platform about 15 cm from the ground level **(Fig. 6).**

b) Kerosene tin. These rectangular kerosene tins are locally available in markets. One opening of about 10 cm in diameter is made on top of the tin which can be closed with a lid of tin. Its capacity is about 15 kg. and is generally used for stering parboiled rice, pulse, oil seed, etc. **(Fig. 7).**

Gunny Bags

Gunny bags are extensively used throughout the country in the transport of food grains and in commercial godowns for storage. Farmers generally use gunny bags for temporary storage. The capcity of these bags varies from 40 kg. to 100 kg. **(Fig. 8).**

Gourd

Dried, mature gourd cases are used by farmers as small storage container in some districts of Bangladesh. After filling the gourd case with rice, pulses etc, the neck is normally closed with cloth. McFarlan (1970) reports that by surface treatment with linseed oil or varnish and careful attention to sealing the stopper, complete control of infestation can be achieved. **(Fig. 3–left).**

Summary and Conclusion

The earthen containers, woven bamboo 'doles' and gunny bags are frequently used in the rural areas of Bangladesh. Metal containers are also popular but costly, hence less used. Bangladesh farmers store paddy and rice in four different conditons: (a) paddy or rough rice; (b) paddy seeds; (c) parboiled rice; and (d) white rice. As parboiled rice is less liable to insect attack, farmers generally store it for their own need. They generally keep food grains in all these structures with a mositure content less than 13% and keep the containers air tight.

Oil-treated underground earthen containers like matkas are very popular in some southern disticts of Bangladesh and are mostly used for storing parboiled rice.

Gunny bags are inexpensive and are popularly used as temporary

Fig. 5 "Gola" (Source: Pest Infestation Control Laboratory, Slough, U.K.)

Fig. 6 Steel drum

Fig. 7 Kerosene tin

Fig. 8 Gunny bags

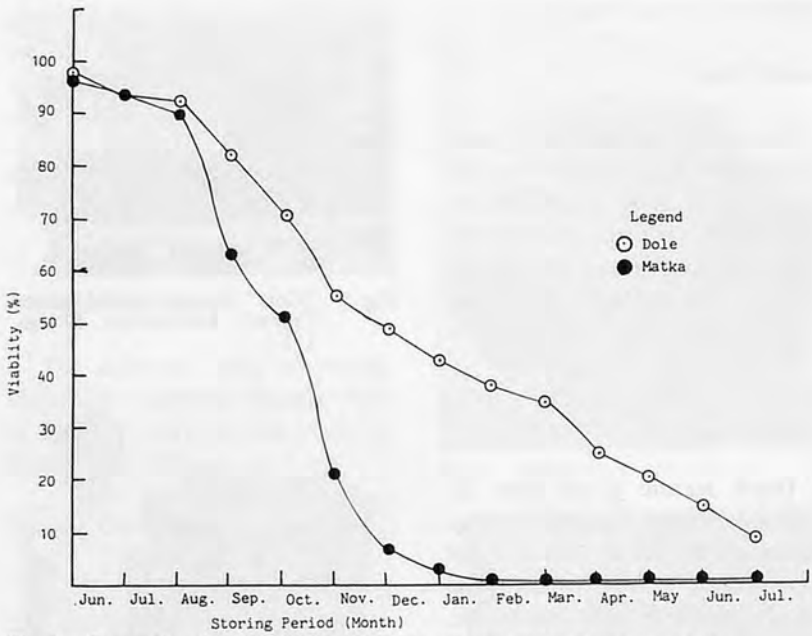

Fig. 9 Curves showing the viablity of paddy stored in "dole" and "matka"

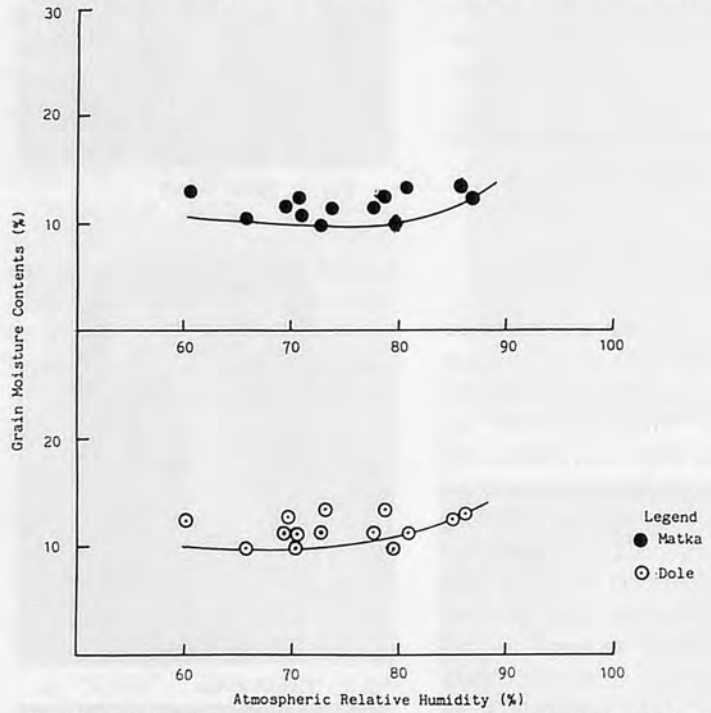

Fig. 10 Relationship of grain moisture content and atmospheric relative humidity during storage

containers for food grains. However, they are susceptible to rodent and insect attack. Steel drums are rat-proof unless they are airtight. Moisture content of the stored grain builds up to more than 13% and as a result, insects may attack the food grains.

Insects and rodents are responsible for the major losses of food grain in Bangladesh. The common insect pests of paddy and rice in Bangladesh are rice moth, brown beetle, rice weevil, lesser grain borer, and grain beetle. The farmers generally store food grains for one season and in most cases keep the small storage structures in one portion of their houses on raised platforms. Underground structures are also kept in the floors of the houses. In many cases, the farmers do not use any fumigant in grain storage.

For storing parboiled rice, however, the farmers use plant leaves like "neem" *(Milia azadirachta)*, Mango *(Mangifera indica)* and garlic *(Allium sativum)* which are placed along with the grains in different layers during storing.

Post-harvests waste and loss of food grains in Bangladesh is substantial and needs to be minimized through such means as imparting new knowledge to farmers on storing food grains.

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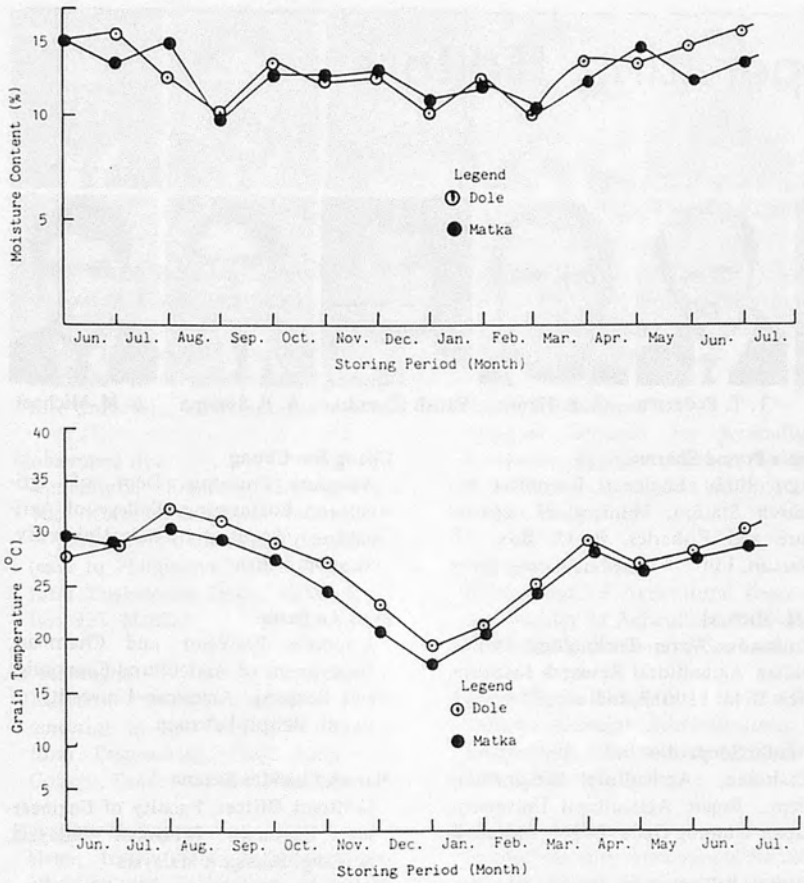

Fig. 11 Relationships of grain temperature and grain moisture content with storing period in "dole" and "matka"

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A Studay of the Performance of Planters on Wet Clay Soils

by
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Introduction

Agricultural production in the Sudan has reached a state of development whereby further mechanization of production operation is essential. The need for further mechanization is more acutely felt due to shortage in labour supply and increasing wages coupled with the large horizontal and vertical expansion of agricultural production in both irrigated and rainfed areas.

Crop planting is one operation where mechanization is needed. The value of accomplishing planting at the proper time has definite economic benefits. In general, considerable work has been done and is being done on the most appropriate dates for planting. Reduction in yield, quality, & market price may result if planting is not performed at the optimum time.

The scarcity of labour & partial overlapping of wet crop cultures of groundnut, cotton, & rice, in the Gezira Scheme, necessitate the use of mechanical planting. Introduction of planters has increased substantially in recent years for the following advantages:–

a) accuracy of seeding,
b) timeliness of operation,
c) high capacity of doing work,
d) facilitate other mechanical operation
i.e. (i) cultivation needs straight rows,
(ii) mechanical spraying needs straight rows,
(iii) mechanical harvesting needs straight rows,
(iv) mechanical cotton stalk pullers need straight rows,
e) efficiency in the use of labour necessary for better production.

Interest in ridge planting has arisen because of the yield response of row crops to different plant populations & planting patterns. Brown (11) cited that Colville speaking at the 1966 Hybrid Corn Industry Research Conference, Summed up the situation as follows:– "Next to weather and soil fertility improper plant population has been responsible for more below maximum yields than any other factor". Optimum plant population can be best achieved by use of mechanical planting where accurate spacing and seed rates can be controlled.

In Sudan, during the rainy season, the clay soils undergo an increase in soil moisture, which results in increased machine slippage, damage of ridges, stickness and blockage of seed tubes of planters. This blockage in turn resulted in low plant population and hence affected crop yields.

The objective of this study was to evaluate mechanical planting under wet clay soils in relation to:– a) plant population or seedling emergence, b) soil compaction before and after use of planter, c) tractor slippage, d) ridge dimensions, and e) moisture content at time of planting.

Summary

A commercial John Deere 4-row crop planter was studied to determine its performance under wet soil conditions. Field tests were set up to compare the performance of the planter at three levels of soil moisture. The experiments were conducted for two seasons. The test seeds were groundnuts.

The experimental design was a split-split plot with the main plots completely randomized. The effect of the independent variables, soil moisture content, furrow openers, & seed tubes on plant population as well as their interactions were studied. Other parameters studied were soil compaction, tractor slippage and ridge dimensions. Field date were collected, & processed and analysed statistically.

Soil compaction was increased significantly, at the 0% and 1% level, after the use of the planter. Wet soils were less affected than dry soils.

*A thesis submitted to the University of Khartourm in partial fulfilment for the Degree of Master of Science (Agriculture).

University & Institute Activity News

Tractor wheel slippage increased as soil moisture content increased. The increase in tractor wheel slippage was significant in the first season and highly significant in the second season.

Ridge dimensions were measured including ridge height & width. The effect of planter on ridge height deformations was very highly significant in the first season and significant in second season. The effect of planter on ridge width was highly significant in first and second season.

The effect of soil moisture on plant emergence was significant at the 1% level in first and second season. The mean number of plant population decreased with increased soil moisture content. The combined season analysis gave a highly significant effect of soil moisture on seedling emergence.

The effect of the two types of furrow openers used showed a significant effect on plant emergence in the first season, while in the second and the combined season analysis no significant effect was shown.

Seasonal variations on planter performance was found to be insignificant. The first season gave a plant population with a mean of 47,292 plants per feddan, while the second season gave a plant population with a mean of 43,722 plants per feddan.

The interaction of seed tubes and furrow openers gave a significant effect on seedling emergence where the shovel types furrow opener and delayed seed dalayed seed tube showed better performance compared to other combination.

Interaction between the four combination of furrow openers and seed tubes with the three levels of soil moisture showed a very highly significant effect on plant population. The best combination was found to be between the modified opener and delayed seed tube, followed by the normal opener and delayed seed tube.

As a conclusion, mechanical planting of row crops under wet land is accompanied by low plant population due to blockage of seed tubes, increased wheel slippage and severe damage of ridges. ■■

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The 56th DLG-Exhibition
Sept. 12–18, 1980, Hannover/ West Germany

The 56th DLG-Exhibition – International Agricultural Show, 1980 in Hannover, will this time be held in September.

Perhaps the most important date for all those professionally involved with farming; the biggest agricultural show in Germany, from September 12–18. In Hannover.

1200 exhibitors and 450 additional representative firms from 28 countries will show new and established products in 13 halls and in 95,000 square metres of open space.

Now is the time to note and take advantage of new developments and to plan for the future. Be sure not to miss it.

Show programme

Agricultural machines, tractors, other machinery and equipment – livestock production (competitions for all breeds and races, international animal show, machinery and equipment for livestock husbandry) – feeding and feedstuffs – seeds and plant products – fertilizers, plant protection, mixed fodder – farm buildings – vegetables, fruit and market gardening, forestry, environment – current information and special displays.

EIMA-International Exhibition of Farm Machinery Industry
Nov. 12–16, 1980, Bologa/Italy

EIMA, organized in the interests of agricultural machinery manufactures and promoted by UNACOMA, is the ideal platform for the presentation of the world's new machinery and equipment, developed to facilitate and rationalize farm work and to accelerate the restructuring of agricultural activities by raising productivity.

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13 separate production sectors and absence of any form of advertising facilitate the comparison of technical characteristics and the choice of the machine which meets more closely farmer's needs and the ecological conditions in which it has to operate.

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(7) Equipment for harvesting.
(8) Equipment for threshing, selection and conditioning.
(9) Equipment for livestock husbandry.
(10) Equipment for the processing of products and for dairy work.
(11) Equipment for handling and transporting.
(12) Components, spares and accessories.
(13) Gardening machinery, small powered machinery and hand equipment.

12th International Conference on Agricultural Mechanization Held in Spain

12th International Conference on Agricultural Mechanization was held during 27 and 28 March in Zaragoza, Spain. The conclusions for the theme 'Future Trends on Livestock Mechanization: Housing, Feeding, MIlking and Waste Management' are as follows:

The trend towards large livestock concentrations, where automation is essential, must be compared to the improvement of the traditional farm.

Livestock housing and air-conditionning as factors having a decissive incidence on the production, must be designed to match each type of farm, not only considering the value of the animal production and the costs – thereto related, but also senitary conditions.

The mechanical systems for the preparation and distribution of feeds in livestock farms should be selected keeping in mind the labour savings, physical effort reduction and the maximum use of feed.

Enough solutions seem to exist at present for the mechanization of these operations and the selection of the several alternatives should be

made through economical criteria.

Slaughtering techniques should be improved since, besides their incidence on the performance, they have a substantial influence on the quality of the product. Similarly, the obtention and handling of by-products must be made in such a way allowing their full use. Finally, an excessively quick freezing of meat should be prevented.

Animal excrements should be increasingly used as fertilizer, in slurry condition, since it is more economical. To this end, they must be stored which means problems for mixing, handling and use that may be prevented through a separation of the solid and liquid fractions. This separation may also solve smell problems decreasing storage costs and the presence of pathogenous germs. Anaerobic digestion of manure may solve odour problems and produce methane gas that may be used as fuel, though much research should be made to get biogas generating plants being at the time practical and economical.

The above considerations are subject to the energetic alternatives available at every specific moment, keeping in mind the own resources generated within the agricultural farm. Anyway, it is advisable to set relatively short pay-off terms in the economical study of the projects, to closely follow the scientific and technological developments.

The Regional Network for Agricultural Machinery

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by
C. S. Sridharan
Officer-in-Charge, RNAM

Background

A fact-finding team of the Economic and Social Commission for Asia and the Pacific (ESCAP) visited 12 countries in Asia and the Pacific in 1968/69 and recommended the establishment of an "Agency for Farm Machinery in Asia" with the objective of organizing and supporting more permanent and continuous activity in the field of agricultural machinery in this region and to avoid duplication of research and development work. In 1974 a working group consisting of representatives of the United Nations Development Programme (UNDP), United Nations Industrial Development Organization (UNIDO), Food and agriculture Organization of the United Nations (FAO) and ESCAP visited 13 countries and recommended the establishment of a regional organization consisting of a network of viable institutions in the region, with a small regional co-ordinating body supported by international experts. It suggested that this organization should supplement the programmes and capabilities of national institutes and co-ordinate efforts, and should function as a clearing house for the exchange of information on design, development, extension and manufacture of agricultural machinery. Accordingly, the Regional Network for Agricultural Machinery (RNAM) was established initially at Bangkok and is now located at the Institute of Agricultural Engineering and Technology (INSAET), University of the Philippines, Los Baños, Laguna, Philippines.

Institutional Framework

The RNAM consists of a network of eight participating national institutions/agencies in India, Indonesia, Iran, Republic of Korea, Pakistan, Philippines, Sri Lanka and Thailand. A regional office headed by a Project Manager and supported by a Farm Machinery Expert, Information and Documentation Expert, Administrative Officer and some support staff implement the Project. A Governing Body and a Technical Advisory Committee have been established with representatives of the above-mentioned participating countries and representatives of ESCAP, FAO, UNIDO, UNDP and the International Rice Research Institute (IRRI) and co-operating countries, i.e., Japan, Israel and Australia. The former deals with policy issues, financial contributions, external assistance and inter-country co-operation and the latter with technical matters.

Activities to Strengthen Regional Co-operation

Based on the recommendations of the meetings of the Technical Advisory Committee (TAC) (January 1978), the Sub-committee of the TAC (June 1978), and the Governing Body (September 1978), the following activities have been implemented:

a) Testing, evaluation and adaptation of transplanters – This sub-network activity has been undertaken in India, Indonesia, Iran, Pakistan, the Philippines, Republic of Korea and Sri Lanka and is being co-ordinated by the Dean of the INSAET with the help of an expert on transplanters located there who periodically visits other centres and provides technical guidance.

b) Testing, evaluation and adaptation of harvesting machines – This has been initiated in India, Indonesia, Iran, Pakistan, the Philippines, Republic of Korea and Thailand. The Director, Central Institute of Agricultural Engineer-

ing, Bhopal, India, assisted by an expert, co-ordinates the programme. The prototypes of two paddy transplanters and two harvesting machines recommended by an FAO/UNIDO consultant and approved by an expert committee have been supplied to each of the participating institutions: Testing and evaluation are in progress.

The test codes on transplanters and harvesting machines were finalized by RNAM and circulated to the concerned centres for carrying out tests on a uniform basis.

c) Testing, evaluation and adaptation of weeders – The countries included in this activity are India, Indonesia, the Philippines, Sri Lanka, Thailand and Republic of Korea. The Superintending Engineer in the Department of Agriculture, Sri Lanka, who co-ordinates this activity, organized a workshop in the last week of April to discuss the status paper on weeders and in the light of recommendations, selected weeders will be evaluated in different countries.

d) Manufacturing technology of threshers and weeders – All eight participating countries will be involved in this activity. Co-ordination will be done at the Institute of Agricultural Engineering, Multan, Pakistan, with the help of production engineer (specialist in small farm machinery) who will visit manufacturers in different countries and advise them.

e) Training facilities – Based on the need of the sub-network activities, training facilities for nominess from different countries have been organized and 13 fellowships in 1978 and 30 in 1979 were awarded. Most of the training was organized at the Institute of Agricultural Machinery (IAM), Omiya, Japan and a few at IRRI, National Institute of Agricultural Engineering (NIAE), etc.

f) Sub-network workshop – Three annual workshops were organized at the co-ordinating centres which provided a forum for bringing together the principal investigators from different centres involved in a particular activity, to exchange their experiences, and review the progress.

g) Experts and consultants – Experts for the four co-ordinating centres and six consultants for other countries have been planned. Two experts have already been recruifed and two others will be recruifed shortly. One consultant has assisted in Thailand. Another is assisting in Indonesia and a third has completed his work on Appropriate Technology.

h) Bridging the gap between industries and farmers – Some of the national institutes have organized manufacturers' days and seminars, exhibitions and field demonstrations of newly-designed implements and discussions on problems involving manufacturers and farmers.

i) Bilateral exchange – Efforts are being made to organize a bilateral exchange of prototypes and technical literature. In order to make an appropriate selection, a Regional Catalogue of Agricultural Machinery is being printed.

j) Newsletters and technical digests – Five Newsletters and a digest on transplanters were printed and circulated. Several others will follow.

k) Documentation and abstract – Lists of publications and articles, by country and operation were compiled and supplied to various institutions.

l) Strengthening country information – Steps have been initiated to supply national institutes with their requirements on published literature. The various publications on mechanization put out by FAO have also been supplied to the national institutes. Eighteen technical circulars containing extracts and original papers and articles were likewise made available to those institutes.

m) Surveys and studies – A questionnaire for gathering relevant information was compiled and circulated to all member countries. A consultant will be appointed to analyze the data and make recommendations.

n) Visits of national experts – It has been possible for RNAM to organize technical meetings in which top-level experts from participating countries and United Nations agencies have come together for exchange of information. Seven such meetings have taken place so far.

The RNAM has become an important agency for Technical Co-operation Among Developing Countries (TCDC) in farm machinery in this region and it is hoped that with the help and co-operation of UN Agencies and participating and co-operating countries, it will continue to play a very effective and useful role in this neglected branch in the days to come, hence make useful contribution to the advancement of agriculture through appropriate mechanization.

Israelis Battle Bugs with Love Trap

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by

Dan Izenberg (Farm Features from Israel, January, 1980)

Rehovot – Israeli scientists here are successfully controlling citrus pests and other insects by trapping them with the aromatic allure of female bugs.

In an effort to eliminate the use of dangerous chemical pesticides, researchers with a new slant on romance have transferred the war against cro-devouring pests to the boudoir.

This modern version of the "Samson and Delilah story" has its origin in the pheromone, an odorous chemical compound secreted by insects to communicate with one another. Each phermone carries a different message, including danger and the invitation to mate.

Dr. Moshe Sternlicht of the Institute of Plant Protection at Israel's Agriculture Research Organization is one of the country's leading researchers in the exploitation of pheromones. The technique, pioneered in Germany and the U.S., is a simple one, he says. During the mating season, male insects are attracted by pheromones emitted by the females. This means that the bug population is concentrated in specific locations during a specific time for the purpose of reproduction. Exterminating them at the right time and place or even simply disrupting the reproductive process would enable farmers to significantly reduce crop destruction.

The trick, then, is to find a way to exploit the mating process and the answer lies in the phermone which triggers the cycle of reproduction.

Attacking Citrus Flower Moths

Each country, of course, deals with its own problems and each crop has its own nemesis. In Israel, in conjunction with a team of British researchers, Sternlicht and his colleagues have been working on the citrus flower moth; the *Prodenia*, which devours the cotton plant; the *Boarmia*, which attacks the avocado; scale insects; and other pests.

The technique is based on the identification, isolation and, if possible, the synthetic reproduction of the phermone. This work is done by chemical researchers and each insect is a story unto itself. Dr. Sternlicht has recently completed the analysis of the chemical structure of the citrus flower moth. Once the phermone has been isolated, it can be used in a number of different ways.

Chemical Siren Song

The most common trick is *monitoring*. The phermone is fastened to a crop along with a gluey transparent panel. The unsuspecting male is attracted by the scent and trapped - but not in the snares of love. The farmer counts the number of males caught per week and, by keeping a record over a period of time, can estimate exactly when the bug population in his fields is at its peak. Then – and only then – he sprays the crop, guaranteeing minimum use of chemical insecticides with maximum efficiency. This technique is based on random plantings of the phermone in order to get a reliable reading of the insect population. But Sternlicht says that when large numbers of phermone-emitting dispensers are scattered all over the orchard, the entire male population can be trapped and exterminated, without the need to spray them at all.

Another technique which is now being put into practice in Israel's cotton fields is known as *confusion*. This is an instance of the male having it too good. The phermone of the *Prodenia* is emitted from a vast number of special dispensers located all over the field. The male insect zeros in on one source of the smell then another, and soon becomes so confused about the whereabouts of its would be mate that it gives up.

An even more devious technique is known as *sterilization*. As the male insect approaches the phermone, it brushes past a substance which renders it sterile. The other side of this coin is the development of *anti-pheromones*, wherein the phermone substance is modified to produce a compound inhibiting the attractive power of the natural phermones being diffused by the actual females in the field.

These methods – the last two are still in the early experimental stages – not only destroy the bugs but also eliminate or drastically reduce the need for chemical sprays, with all their negative side-effects. In recent years, scientists say, the nations of the world spent more than $2.5 billion annually on two million tons of pesticides.

Dispensing Phermone

The effectiveness of these methods depends on efficient means for distributing the pheromone and trapping the insects. Sternlicht has devoted much time to this problem; recently he developed a new dispenser which allows for the uniform emission of the phermone for up to four months and does away with the adhesive plate, which needed frequent replacement. The insects are attracted to a funnel-like object and they slide down into a plastic bag which can accommodate a far larger number of insects than could earlier devices. The farmer has to replace the traps only once every four months, thereby saving valuable work hours. The device is already being commercially produced in Israel.

A different type of dispenser is being developed for the *confusion* technique. One such device involves the use of hollow fibers, tiny hollow plastic tubes filled with

pheromone and sprayed on the leaves of the crops.

So the war against pests continues and to those bug-lovers who might protest at the underhanded methods being developed, Sternlicht and his colleagues can only say, "All's fair in love and war."

G. Wallace Giles Receives Kishida International Award

G. Wallace Giles, professor emeritus, North Carolina State University, Raleigh, has received the Kishida International Award from the American Society of Agricultural Engineers (ASAE).

The award is presented annually to "honor those who have made original contributions in research, development or design . . . or in the management of food processing equipment or techniques of significant economic value to the food industry and the consumer."

Giles was honored during the Society's Summer Meeting June 15-18 in San Antonio, Texas.

ASAE is a non-profit technical, scientific and educational society committed to improving agriculture through the application of engineering principles. Headquartered in St. Joseph, Michigan, the Society's membership includes 8,700 full members and 2,000 student members in 50 states and 90 foreign countries.

Giles spent much of his professional career involved in international development of agriculture. From 1935-1961, he taught agricultural engineering at the University of Missouri and North Carolina State University.

In 1961, he joined the Ford Foundation as a consultant to the Government of India on a multidiscipline "Intensive Agricultural Development Program."

Later, he became a freelance consultant for various organizations in Pakistan, Iran, Ghana and Egypt, and returned to India on several assignments, including one administrated by the Indian Council of Agricultural Research.

With the exception of a few assignments in India, all of Giles' assignments were feasibility studies on agricultural mechanization, resulting in reports developed from data gathered first-hand at government, farm, industrial and regional levels.

G. Wallace Giles

Giles holds numerous patents, and has authored many national and international publications. He has been listed in *Who's who in Engineering, American Men of Science, Who's Who in south and Southwest,* and *Who Knows – and What – Among Experts and the Specially Informed.*

He is an ASAE Fellow and has been active on ASAE committees since 1949. He also is active in numerous scientific and honorary societies.

Giles obtained his bachelor's degree from the University of Nebraska and his master's degree from the University of Missouri.

He and wife Caryl reside in Raleigh. They have three children. ■■

NEW PRODUCTS

RAU-Multitiller

Wherever it is necessary to prepare a good seed bed with considerable impact force under difficult conditions, including problem soils, the new RAU-Multitiller is the right implement.

Soils can pose problems because they are heavy, wet, very dry, clumpy or very loose.

Depending on the application, the foremost implements in RAU-Multitillers are supplied in 2 different versions:

1. For working unbroken fields after the potato, root or silo-maize harvest and for stubble-breaking on fields without straw, using 30 cm duck-foot shares on 2 rows of strong heavy-duty cultivator tines (above picture).
2. For seedbed preparation on fields that have already been broken with the plough or heavy-duty cultivator were supplied with adjustable leveling harrows (below picture).

Because of the intensive manner in which they work, RAU-Multitiller have considerable impact force and thus enable considerable savings in time, energy and cost to be made.

(Hassia-Rau Vertriebsgesellschaft: D7315 Weilheim/Teck, West-Germany)

John Deere 2700 Plow

John Deere has introduced a new semi-integral plow that combines benefits of two previously

introduced models. The new "hybrid" 2700 Plow offers the high clearance of the 2800 and the manually adjustable cutting width of the 2600.

For plowing fields with a high volume of trash or stubble, the new 2700 Plow combines a full 33½ inches of under-frame clearance with sharepoints positioned behind, rather than under, the mainframe. Virtually unlimited vertical clearance provides for high trash-passing capacity.

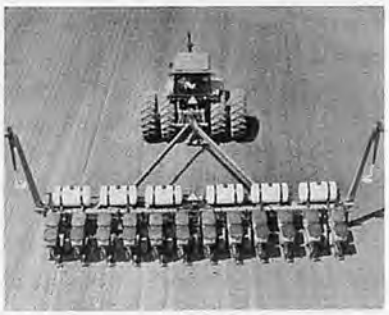
A cast shim, placed in front of or behind each standard, permits cutting 18- or 22-inch wide furrows, respectively. With the shim removed and stored in a cavity provided for this purpose on each standard, the new 2700 cuts 20-inch furrows. This versatility allows the operator to increase width of cut when using a bigger tractor; to narrow it in heavy trash or tough-to-plow soils; or to adjust it for spring or fall plowing conditions.

High-strength 8-inch square structural steel tubing forms the mainframe for the new 2700 Plow, providing the stamina for dependable work in the most difficult plowing conditions.

The new 2700 will be available in 4-, 5-, 6-, 7- or 8-bottom sizes for in-furrow plowing or 6-, 7- or 8-bottom sizes for on-land plowing. All mainframes except the 8-bottom size are expandable by one bottom.

(John Deere Intercontinental Ltd., Farm Equipment Sales Branch: 909-3rd Avenue, Moline, Illinois 61265, USA)

John Deere Front-Folding Planter



John Deere has extended the popular front-folding Max-Emerge TM Planter concept to include new models that will be available in limited quantities for the spring planting season this year. In addition to the 12-row wide (36- to 38-inch rows) and 16-row narrow (30-inch rows) models introduced last year, the line now includes 8-row wide (36- to 38-inch rows) and 12-row narrow (30-inch rows) models.

By pushing buttons on a seat-side console, the tractor operator can fold and unfold any of the models in this, the 7000 Front-Folding Max-Emerge Planter Series. Other buttons on the same console allow him to raise or lower the planters; raise, lower, or fold the markers. Only one remote control valve is required on the tractor; solenoid valves select the various functions on the planter and are easily serviced.

In the field, 3-section flexibility plus parallel-arm linkage of planter units and Tru-Vee TM opener depth-gauging result in accurate seed placement on either level or

rolling land. Two seed-rate transmissions permit planting with either half of the planter on point rows or to finish fields. A John Deere Population Monitor is standard equipment on all models of the Front-Folding Max-Emerge Planters to help ensure planting at the desired rate across all rows of these planters.

(John Deere Intercontinental Ltd., Farm Equipment Sales Branch: 909-3rd Avenue, Moline, Illinois 61265, USA)

Iseki T5000 Tractor

Water-cooled four-cylinder diesel engine is mounted, which was newly developed exclusively for medium-size tractor. The Tractor is featured in its 'Competence' for heavy workloads as well as long-time operations.

Optimum torque quality ensures steady and reliable drive-ability from low speed through high speed.

Emphasis on prevention of machine vibration and noises was especially placed. Quiet noise gives the driver no fatigue even in long-timer driving.

The Tractor is completely mechanized waterproof and dirt-proof. Even heavy workload in paddy field or swampy field cannot influence the Tractor's durability.

The Tractor adopts a wet-type disc brake of large capacity. The brake can work in constant stability even in heavy workload.

Safety cabin and safety frame were taken into consideration in the stage of designing, and finished in the newest freshness. In addition, factor of human respect was materialized. The driver can enjoy driving comfortably and feel at home.

Most suitable speed can be selected from among 20-speed forward and 4-speed reverse in accordance with the nature of work. Creep speed is also available. Various works of paddy field, upland field and dairying can be completed with high efficiency.

Equipped with hydraulic position control and draft control systems, which ensure higher accuracy in extended range of work.

Three-point linkage of one touch system allows very easy connection and disconnection of the farm working machines.

[Specifications]
Dimensions: 3,400 x 1,700 x 2,370 mm (L x W x H), Engine output: 48 ps, Exhaust: 2,775 cc, P.T.O.: Independent 2-step, Wheel base: 2,000 mm.

(Iseki & Co., Ltd., Foreign Affairs Division: 3-6, Kioi-cho, Chiyoda-ku, Tokyo, 102 Japan).

Iseki AC40R Cultivator

The AC40R is a lightweight, compact cultivator specially designed to increase work capacity. Equipped with an adjustable handle that controls lifting, lowering, turning and width variables.

Cultivating depths can be ac-

curately adjusted by its easily-operated depth bar (depth adjusting skid). Raising and lowering the depth bar is performed by applying the pin.

Wheel positions can be raised or lowered by simply attaching or detaching a pin.

The tilling unit's power transmission utilizes a highly durable gear change system.

Rotary pipes may be used to extend tilling widths.

Ridging work can be performed with an attached ridger.

Model AC40R is mounted the back-change lever on the handle pipe, so the operator can rotate normally or reversely the rotary shaft while grasping the handle grip.

Three-divisional fender is provided as standard equipment.

Belt cover of closed system ensures safety.

[Specifications]
Dimensions: 1,170 x 790 x 1,030 mm (L x W x H), Engine: 4-cycle air-cooled single-cylinder 2.1 ps, Weight (dry): 47 kg, Transmission system: Primary transmission – V belt · Main clutch – belt tension, Wheel size: 220 mm (Outer diameter), Tilling with: 576 mm, Number of blades: 16, Rotary shaft revolution: Forward – 92.2 rpm · Reverse –53.8 rpm.

(Iseki & Co., Ltd. Foreign Affairs Division: 3-6, Kioi-cho, Chiyoda-ku, Tokyo, 102 Japan). ■■

BOOK REVIEW

Appropriate Industrial Technology for Agricultural Machinery and Implements

—Monograph on Appropriate Industrial Technology No.4—

(UNIDO-Austria)

World trade in agricultural machinery and the closely allied subgroups represents one fifth of the total trade described under the broad classification "machinery non-electric". Trade has more than quadrupled in value during the period 1967–1975, growing from $4,581 million in 1967 to $19,210 million in 1975. Imports of agricultural machinery and pumps into developing countries accounted for 26 and 34 per cent, respectively, of total world trade in these two sectors. Statistical returns since 1974 have indicated a marked increase in the share of world trade accounted for by imports of agricultural machinery and allied subgroups into the developing countries. In addition to trade that originated in the principal exporting countries and which is reported in international statistics, there are imports of agricultural hand tools, animal-drawn equipment, simple machinery and specialized power-operated machinery that are not reported, as well as internal trade from the manufacture of agricultural machinery for local use.

This monograph deals with issues and considerations in PART ONE and contains selected background papers in PART TWO.

Size: 24cm x 16cm, 159pp, with paper cover

Published by UNIDO, P.O.Box 707, A-1011 Vienna, Austria

Guidelines for Evaluation of Transfer of Technology Agreements

—Development and Transfer of Technology Series No. 12—

(UNIDO-Austria)

The present volume represents a major effort of the secretariat of UNIDO to provide the business community and Governments in developing countries with a comprehensive text as an aid in dealing with technology transfer transactions. It provides the reader with considerable amounts of practical information on preparing and negotiating various technology transfer agreements.

Chapters I-VI examine in detail several types of technology agreements—technical assistance, patent, know-how, engineering services, trade mark and franchise—setting out their objectives and suggesting options to the licensee and to the national regulatory agency, so as to reap the maximum benefit to the national economy. Also, considerable attention is paid to the subject of process performance guarantees, and methods of evaluation are outlined.

Chapter VII deals extensively with remuneration for technology, presenting concepts of evaluating its price and, again, presenting options to the licensee. Chapter VIII provides the reader with condensed information on legal and administrative provisions in technology agreements and suggests the wording of basic clauses. Chapter IX discusses criteria for selecting technology and presents particularly important issues concerning its selection in developing countries. Chapter X deals with the pricing of products for which readily recognizable reference prices may not be available.

This study was prepared by Venkata R. S. Arni in co-operation with staff of the Technology Group of the secretariat of UNIDO.

Size: 30cm x 21cm, 72pp, with paper cover

Published by UNIDO, P. O. Box 300, A-1400 Vienna, Austria

Energy for World Agriculture

(FAO-Italy)

This publication is a further contribution to FAO's continuing efforts to provide information and guidance on a vital aspect of world agriculture: the more effective use of energy. It stresses that the present energy crisis is due not so much to a shortage of supply as to an overdependence on nonrenewable resources (especially petroleum) which are distributed unevenly throughout the world.

The rising cost of fossil fuels and the resultant increase in consumer prices pose a particular threat to achieving a better standard of living in developing countries, where traditional methods of food production cannot meet the needs of a rapidly growing population.

Although considerable commercial energy from nonrenewable resources is required to attain high levels of land and labour productivity, agriculture now accounts for only a small share of world energy consumption; it will continue to do so despite future increases in modern agricultural inputs (fertilizers, pesticides, machinery).

However, avoiding critical increases in the cost of food and other agricultural products requires careful planning for more efficient utilization of "scarce" commercial

energy resources, as well as greater reliance on such alternative, renewable resources as the sun, wind, water, geothermal energy and organic matter.

This book provides a comprehensive and well-documented assessment of present and future applications of energy in agriculture, with emphasis on future technological prospects for the use of renewable resources.

Written by B. A. Stout in collaboration with C.A. Myers, A. Hurand and L.W. Faidley

Size: 23cm x 15cm, 286pp with soft cover

Published by FAO, Via delle Terme di Caracalla, 00100-Rome, Italy

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Nebraska Tractor Test Data 1980

(U.S.A.)

This is a summary booklet which includes only tractors on the market as of Jan. 1, 1980.

Size: 16.5cm x 10cm, 72pp.

Published by Department of Agricultural Engineering, University of Nebraska-Lincoln, Lincoln NE 68583

Information Sources on Industrial Maintenance and Repair

–UNIDO Guides to Information Sources No. 36–

(UNIDO–Austria)

The United Nations Industrial Development Organization(UNIDO) promotes the use of industrial information in developing countries by giving guidance in improving local information facilities. As one of the means of promotion, UNIDO compiles directories and guides to selected information sources on branches of industry of primary concern to developing countries.

The directories and guides are not intended to be exhaustive, nor are they intended to be research tools; rather, they present sources considered to be of practical value to users. The data have been compiled so as to facilitate rapid access to the bodies referred to and the acquisition of the publications listed.

Maintenance and repair is an integral part of any constructional or engineering industry. Heavy investment on building and machinery and the increasing complexity of machinery and equipment in the industrial sectors have led to the parallel development of maintenance and repair activities.

UNIDO gives special attention to improving maintenance management and to creating consciousness of the need for maintenance at all levels. It has organized in-plant training programmes, courses, workshops and symposia in this field, providing advisory services to enterprises in developing countries. The Industrial Information Section offers its users a wide range of information on engineering aspects of maintenance and repair through the Inquiry Service.

Size: 21cm x 15cm, 87pp, with paper cover

Published by UNIDO, P. O. Box 300, A-1400 Vienna, Austria

Approved Practices in Beef Cattle Production

(U.S.A.)

The purpose of this book is to furnish a comprehensive list of activities which involve approved practices, along with information on how they should be conducted in the beef enterprise. An approved practice is one which has been tried and tested by state agricultural experiment stations, the U.S.D.A., and/or successful farmers in the community and found to be a desirable practice to follow for most efficient beef cattle production. Consequently, it is important that the producer know what the approved practices are and how to carry them out in order to attain the greatest success in the beef business. A summarizing list of suggested approved practices is presented in Appendix C.

The primary aim of this book has been to include all of the more important activities involving approved practices in the beef enterprise. The information has been carefully selected and condensed to eliminate a vast amount of reading in order to determine the best methods and procedures to follow in carrying out the practices.

Written by E. M. Juergenson

Size: 21.5cm x 14cm, 467pp, with hard cover

Published by The Interstate Printers & Publishers, Inc. Danville, Illinois. ■■

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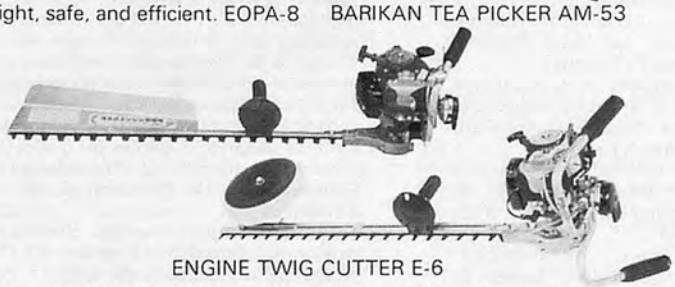

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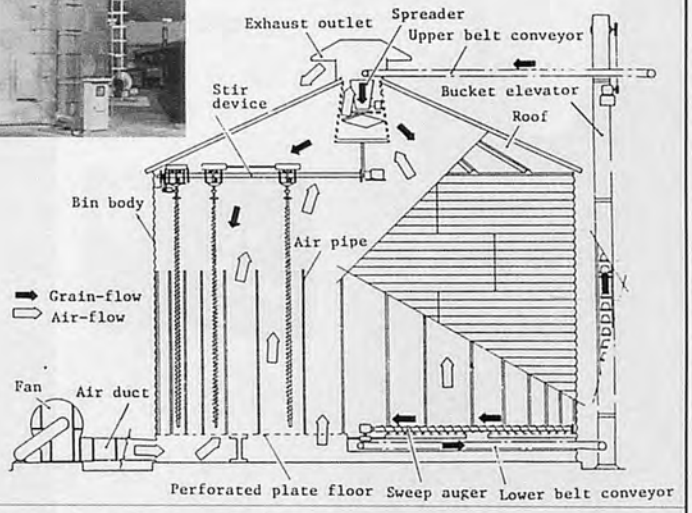

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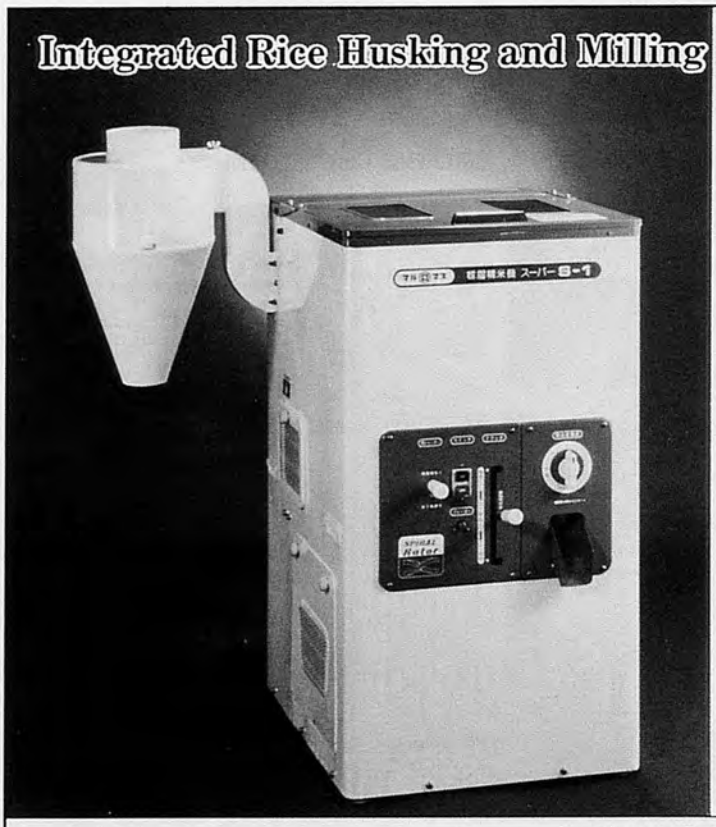

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