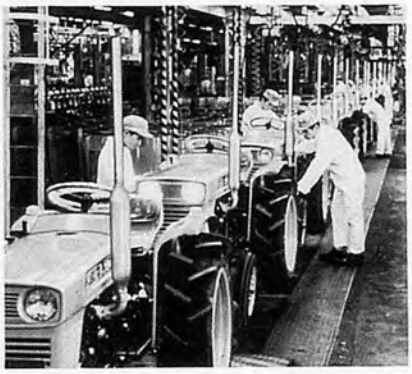
International specialized media for agricultural mechanization in Asian developing countries.

AMA

AGRICULTURAL MECHANIZATION IN ASIA

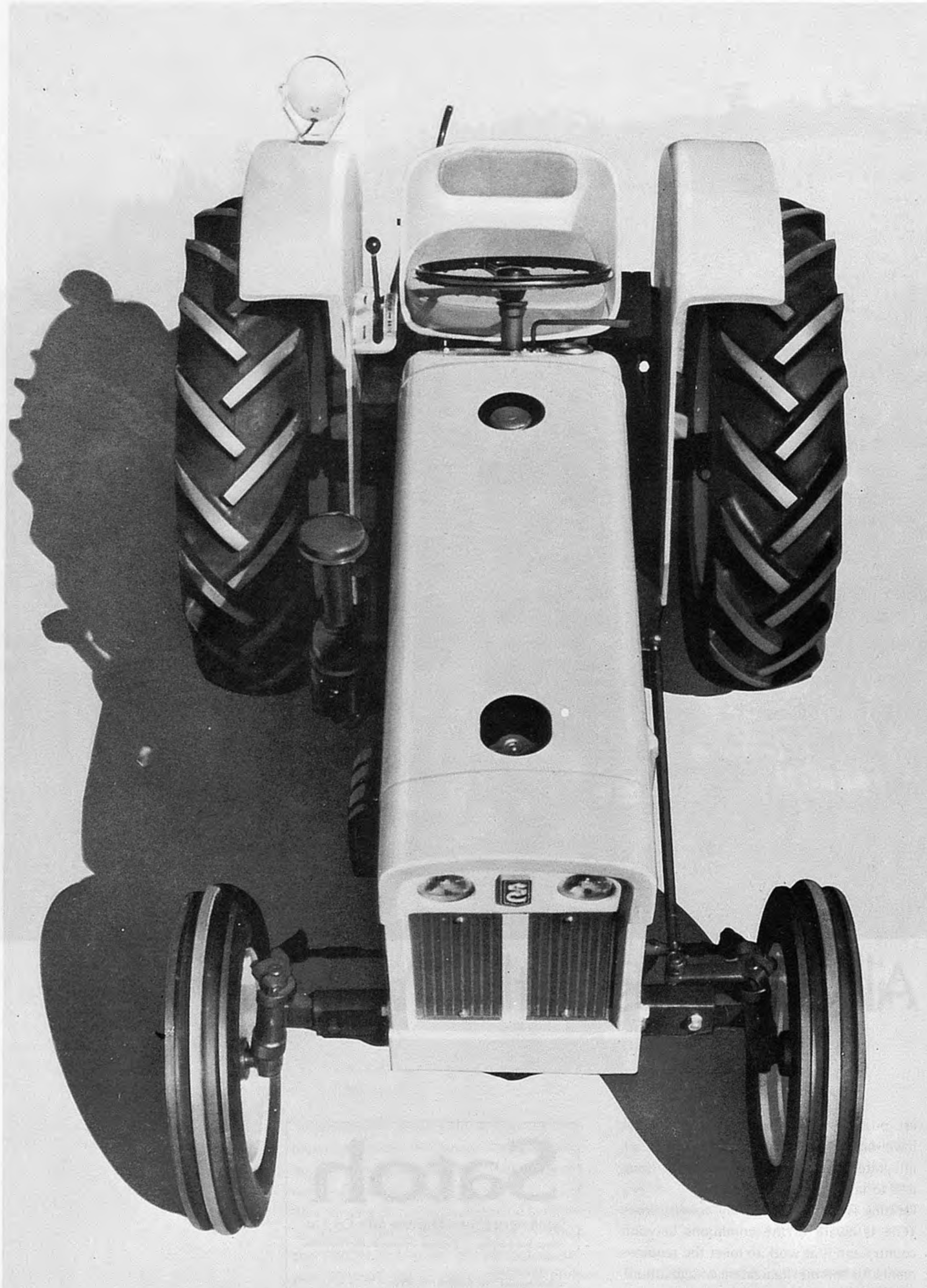
VOL. VII, NO. 1, WINTER 1976

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

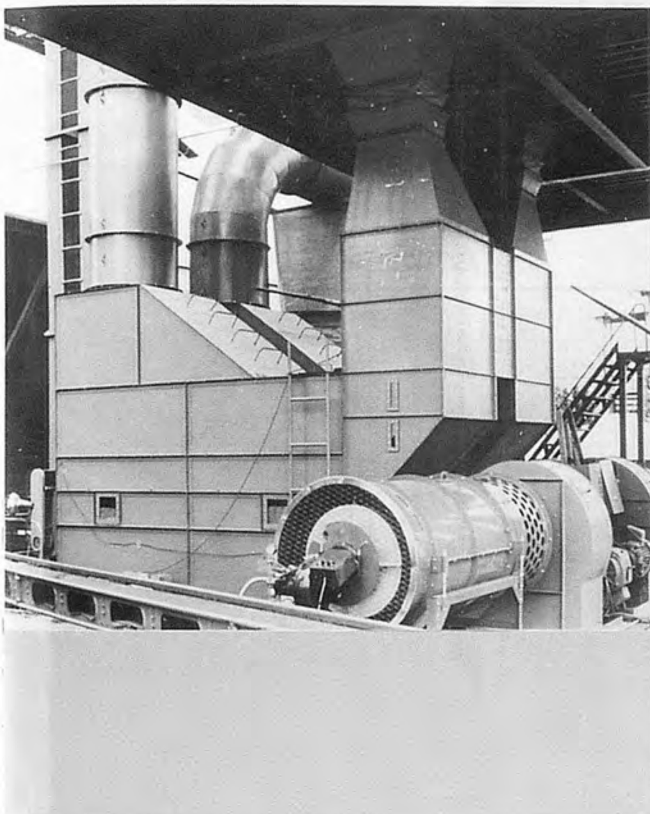


Man Tills the Earth's Soil in

"Mother Earth" blesses those who seek her blessings wisely. All human beings should be given an equal opportunity to enjoy the earth's blessings.
This concept of love for humankind and love for earth is the guiding principle on which the SATOH enterprise has labored for the past 50 years. All its agricultural machines and implements are built and developed on this lofty principle.
Among the many manufacturers of agricultural machines and implements in Japan, SATOH enjoys top popularity. Its 300 engineers and other technical experts devote their full time and energy to many research works.
Their main objective is to promote mechanized agricultural industry and achieve high-



KANEKO FDA System
Large-scale Grain Drying & Preparing Plant



Features of Floating Dryer.

- Pre-brying and pre-cleaning is carried out at the same time.
- It is easy to keep paddy in the storage tank for short term. because the Dryer can make row paddy to half-dryed one.
- It has high capacity with even drying for small scale equipment.
- It is very compact type. There are two types of mobile type and fixed one.
- The operating ratio of small Co-operative Rice-Drying Facility "Rice Center" is very improved.
- All sorts of granular materials can be dryed.

Features of Large Type Finishing Dryer.

- The holding capacity is so big that the power of Finishing Dryer is most demonstrated in handling large volume of paddy.
- The dryer is most suitable for drying row paddy because of adopting triangular perforated pipe in draft system.
- The kracked or over-dryed rice is never occurred due to warm, not hot temperature air (35°C).
- There are two types of non-recirculation type with a moisture control equipment and a recirculation one.
- Facility cost is cheaper because of being installed in the out of door.

Outline of FDA System-120

Harvested Area··························300ha
Volume of Harvested Paddy········8t/ha
Harvesting Term························20days
Volume of Drying Paddy/day······300ha × 8t/20days = 120t
Initial moisture Content············· 25% (Average)
Final moisture Content················15%

KANEKO Drying machine for agricultural products

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AGRICULTURAL MECHANIZATION IN ASIA

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Preface

We have published "AMA" semiannually since 1971. From this year, we will publish "AMA" four times a year. This is the first issue of our new quarterly "AMA". Here, I would like to express our gratitude to all of readers contributers and co-operative editors who contributed their devotion to "AMA". "AMA" has been developed internationally by the readers who do not spare their co-operation and kind advices.

Now facing to New Year, there is not necessarily a good outlook for world economics and food situation. FAO had very serious discussion on this urgent problems at the last annual meeting, where Mr. Saouma of Lebanon was elected as a new leader of FAO. It can be said that it is one of the biggest news of 1975 in the world agricultural policy.

While the gap between South and North is extended, the world balanced peace cannot be achieved without the solution of agricultural problems in developing countries. It is now required for the sufficient supply of food that we should timely utilize natural resources including solar energy as much as we can, maximizing the land productivity with effective agricultural mechanization. For this purpose, it is urgently needed to promote the extension of multiple-cropping method and establishing the small scale mechanization system for it.

We are going to grapple with the problem positively on "AMA". We would like to ask for your kind co-operation by sending us any advices, contributing articles, reports, news and etc. to enrich "AMA" more and more.

Asking your co-operation and thanking you all.

Yoshisuke Kishida

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA

Vol. VII, No. 1, Winter, 1976

The Interdependence of Selective Agricultural Mechanization and Local Manufacturing in Developing Countries

by
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Should and developing country attempt to implement a long-term agricultural mechanization program with imports of sophisticated, capital intensive, labor efficient mechanical power units and associated equipment? The posistion taken and supported by this paper is no. The adverse economic effect that the hard currency cost of imported technology has on an often precarious balance of trade in many developing countries can be critical. However, a potentially more serious aspect of the long-term importation of mechanization equipment is the establishment of the developing country in a dependent position for food—a basic and strategic national commodity.

Wijewardene (1975) reported that imported tractors and power tillers retailed in Malaysia from 150 to 200 percent of the price a farmer in the country of manufacture would pay; because of freight and profit margins for the additional exporters, importers, distributors, dealers and salesmen. This is a high price for equipment designed and developed for another country having different farming and economic conditions. The high purchase price and hard currency cost, connected with the fact that the importer has no control over further price increases or the possiblity of having the supply cut off entirely, makes importation untenable. Malaysia has had a bitter experience with reference to dependency on importation of power tillers and chemical fertilizers—prices have risen precipitously and supply is interruptable without notice.

The lesson seems clear from the Malaysian example that the third world countries should develop selective and appropriate mechanization essential for meeting their food production targets and which can be realistically manufactured locally. The agricultural engineers of Malaysia and all simillar developing countries must then rise above their earlier role of testing and adapting foreign manufactured equipment for local marketing, to the development of selective equipment that is appropriate for local manufacture and utilization.

The stated expectation of some that farming in developing Asian countries will follow along the American/European pattern has not materialized. Farms in some countries have in fact become smaller, not larger, due to the pressures of population. Appropriate mechanization must extend the arm of the farmer, not displace him. The term selective or appropriate agricultural mechanization implies consideration of: (1) the needs and means of the farmers, (2) adaptability to local manufacturing, (3) capability of increasing yields and total food production, (4) minimizing post production losses, and (5) minimum social costs of unemployment, labor displacement, and income disparity. This paper is mainly concerned with the local manufacturing aspect of selective agricultural mechanization.

Selective Mechanization and Manufacturing: A Direction

The capabilities of local manu-

This paper was prepared specifically for presentation before the Agricultural and Industrial Engineering Division of ASEE at the Annual Meeting at Ft. Collines, Colorado, June 19, 1975.

facturers vary greatly between countries. However, in developing countries with excess labor (unemployment and/or underemployment) and limited capital, the manufacturing enterprises must be labor intensive with minimum capital requirements. This implies comparatively small manufacturers, dispersed throughout the country and diversified as to types of machines produced. The term intermediate technology is used to describe this approach to agricultural mechanization. Koegel (1971) states that an engineering solution must be consistent with the locality in question-capital, materials and skills.

Possibly the developmental approach being used by China, with small farm machinery manufacturers located in various commune villages, is a model worth considering by many developing countries. The local manufacturers are unquestionably best acquainted with local conditions and needs; however, on the other hand, they may be somewhat deficient at the outset in design, fabrication, assembly and marketing know-how. Local manufacturers thus will need much technical assistance in getting started.

The International Rice Research Institute (IRRI) is providing considerable leadership in the Asian region in developing "intermediate technology" and introducing it to local manufacturers. Considerable more assistance and effort are, however, still needed in the latter phase of local manufacturer acceptance and fabrication. Training and development of many local entrepreneurs and artisans for the small manufacturing processes is needed. The blacksmithing trade must also be propagated to provide local assistance to farmers for repair and maintenance of machines. The exclusion of this service segment from the local manufacturing sector will limit spread of the concept of local manufacturing (Chuta and Liedholm, 1974).

Even if agreed that local manufacturing is at the intermediate technology level, it must be recognized that this includes a wide range of alternatives. What may be intermediate technology in one area may well be advanced under a different set of circumstances in another area. Consequently a selective approach within the intermediate technology spectrum is still as important as when the transfer of the "lumpier" advanced technologies are considered.

In a self-analysis, USAID (1972) recognized the problems of capital-intensive equipment as donor aid and suggested as an alternative program the support of local, small scale manufacturing firms:

> "Past donor aid efforts to developing countries have too often concentrated upon introduction of their own capital-intensive equipment to meet local needs rather than looking towards a local manufacturing sector, i.e., a procurement in LDC's where more appropriate technology may be available. Emphasis should be given to programs and policies which favor labor-intensive technologies in industry where feasible and encourage small-scale firms in particular."

A move toward small-scale manufacturing is a commendable change of policy of a dominant international funding agency. As this change of emphasis develops, the matter of selection of appropriate equipment for utilization by the small farmers should be given major attention. Well conceived and managed credit and distribution programs should be designed mainly to make equipment available to small farmers (e.g., Gotsch, 1972). Large farmers, even without special credit programs, cannot necessarily be blamed for procuring equipment and tractors with which they can make a profit. Large farmers play "the rules of the game" for self survival as does every individual. Ideally, however, the "rules of the game" must be so designed by the central planners and policy makers so as to minimize the economics of scale and provide equal returns to all.

Economic Perspective

The concept of selective mechanization and its relationship to local manufacturing is closely intertwined with the existing economic environment. If the role of the local manufacturer is to be understood within the economic framework, it is necessary to consider (1) the capital-labor relatech the manufacturer operates, and (3) the total economic package which is involved.

Capital-Labor Relationships

The solution of production problems with mechanization has, in the Western countries, been a substitution of capital in the form of machinery for labor. This substitution has persisted due to the availability of cheap capital as compared to expensive labor. Increased land productivity has thus been a much lesser stimulant and objective of mechnization. It is now generally recognized that the needs in most developing countries require mechanization solutions formulated to increase land productivity rather than labor efficiency.

This does not mean that labor productivity is unimportant, but rather that the first priority should be directed toward increasing yields per land unit. A basic problem regarding machine introduction, whether it be for agricultural or industrial purposes, has been a lack of recognition of the basic labor and capital differentials between the developed and developing countries.

It is not the purpose of the

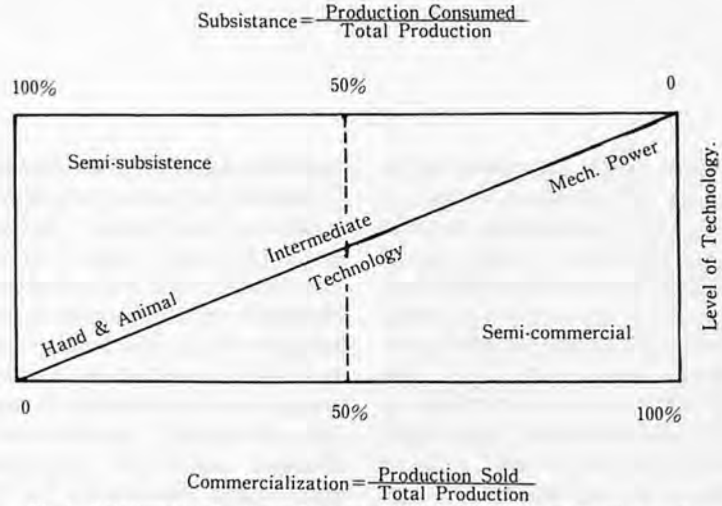

Fig.1. Relationship Between Comercial and Subsistence Production and the Lev- el of Technology

authors to re-argue these factor relationships, as it already has been ably done by Ruttan (1972). However, in emphasis of this point, Harrington (1975) made an interesting comparison between India and the United States. An Indian farmer would require 25 man-years of labor to pay for a typical 35 h.p. tractor, while a U.S. farmer would pay for the same tractor with two man-years of labor.

As a consequence, selective mechanization and local manufacturing must develop equipment that will increase yields rather than labor efficiency. Mechanization may, however, include some nominal labor-displacing characteristics to solve limited periods of peak labor demands. The development of mechanized Japanese agriculture has been basically one of increasing land productivity (Hayami and Ruttan, 1971) with an agricultural machinery industry which complemented this approach (Kishida, 1971).

The Market Served

Unsuccessful attempts to introduce advanced technology in developing countries indicates a lack of understanding of the market for agricultural machinery. In most developing countries, the farm machinery market can be divided into a subsistence sector and a commercial sector.

This diverse market is illustrated by the following graph, in which subsistence farmers are represented on the upper horizontal axis, and commercialization on the lower horizontal axis. The term "subsistence and semi-subsistence" describes those farmers to the left of the midpoint, and "commercial and semi-commercial" describes those to the right of the midpoint. The ratio of production consumed to total production indicates the degree of subsistence for farmers. Likewise the proportion of production sold to total production indicates the degree of commercialization. Consumption and market decisions are thus intertwined for most farmers. The degree of dependence upon his own farm production for consumption and survival considerations, as compared to selling and maintaining an income, thereby affects decision-making and economic behavior. (Wharton, 1969). The "level of technology" is then imposed upon the center portion of the graph. The evolution of mechanization development from hand and animal power, associated with the subsistence level, to a more advanced machine form, associated with commercialization, is indicated. This trend is not necessarily mandatory or even desirable, but does usually represent the development toward commercialization.

The level of technology within any one country may then quite diverse from hand to mechanical power, or be represented quite accurately for a specific local area by only a narrow band on the graph. This implies then that imported equipment geared for highly commercial farmers is generally inappropriate for other than a small segment of farmers. Even when attempts are made to "simplify" the advanced equipment, results are frustrating because what seems simple and inexpensive to the Western trained person may not be that simple and inexpensive to the farmers of the developing country. As a result the process of technological transfer and adoption is often unsuccessful because of the failure to recognize and understand the local market conditions in which the equipment is to be introduced.

On the positive side, the graph indicates that most of the machinery market is in the range of intermediate technology. The appropriate technology is then in this intermediate range. This offers an opportunity for local manufacturing. Small manufacturers can adapt directly to the particular requirements of the local market served, and thus provide the appropriate level of technology compatible both with his manufacturing capability and the farmers' needs.

The Total Economic Package

Consideration of the total economic package requires the farmer to become a manager. The value and market for products will vary from area to area. In some areas there may also be some economically important by-products. The local manufacturer must also be aware of product values so he can adapt machine designs to maximize the total economic impact in that area. Machines from manufacturers in another area may, for example, miss the significance of a local high value by-product. This consideration is particularly important for harvesting equipment, since agricultural production is then first separated into different products and by-products.

Gaiser (1974) reported on a situation in Lebanon where a straw and leftovergrain mixture (tibn) resulting from tread threshing was the principle livestock roughage. An imported combine lost this valuable by-product by spreading it on the field, while two local methods (a locally manufactured stationary thresher and an animal sled) retained this by-product. Under these market conditions, the locally made thresher yielded the greatest income, followed by the combine and animal sled. It is interesting to note that a year later the price of tibn doubled and the animal sled then rivalled the combine as an income producer. In this example the locally manufactured equipment more nearly fulfilled the total economic needs of the farmers.

The Engineer and Local Manufacturer: Three Case Studies

How can mechanization be developed that is selective, both with reference to the feasibility of the local manufacturer, as well as for serving the local agricultural and societal needs of increased food production, labor utilization and income distribution? In order to explore this question further, three approaches to selective mechanization for local manufacturers are summarized here through case studies:

1. Local design and manufacturing based on established engineering principles. (Bennett, 1971)
2. Development of a new design principle to meet a new set of circumstances. (Strohman, McColly and Stout, 1967)
3. Adoption and extension of an existing practice from one developing country to another. (Wu and Esmay, 1975)

Local Design and Manufacture

Bennett in South India was involved in developing a bullock-powered tillage system for dryland farming and a rasp-bar mini-thresher and winnowing machine for harvesting. The basic premise was that through innovative local design and manufacture of selective machines, yield-increasing changes could be successfully applied and introduced. The dryland tillage operation was accomplished through the fabrication of a bullock-drawn chisel tool with fertilizer attachment. The chisel operation loosened the soil and the attachment deposited fertilizer at the bottom of the trench. After the first rain, a bullock drawn ridger was used to furrow the soil and the seeds were placed in the bottom of the furrow just above the fertilizer, thus taking advantage of the water-seed-fertilizer relationship.

Bennett further observed that there were labor shortages during the rice harvesting period and that excessive shattering losses occurred throughout the "laborious traditional systems of hand and animal threshing". After testing many existing machines, he decided "to take an objective look for a suitable machine system that would more nearly suit the Indian conditions". A simple, low-cost machine that could be made at Bangalore was the manufacturing objective. The thresher had to be easy to move by hand or on bullock carts and "very simple" to adjust. Rather than reinvent the threshing machine, the rasp-bar/concave threshing cylinder was used. A local steel furniture manufacturer produced the first model which was named the Mysore Mini-Thresher.

"Initially 10 units were made - then 20 units, and a dealer organization was set up for the field-proved machine that would stand the farm test for both performance and durability. This machine can be positioned directly on the rice field. Fresh-cut green straw can be carried to the machine and threshed by pushing the entire bulk through the cylinder. To save the grain, it is now possible to eliminate traditional threshing floors and transport operations of hauling grain bundles from field to village. Grain losses from handling are eliminated."

A New Design Principle

As Bennett noted, it is not always necessary to re-invent an existing principle. On the other hand, sometimes a new idea is needed to cope with the existing circumstances. A new threshing technique for harvesting standing grain developed by Strohman, McColly and Stout (1967) illustrates this point. The new high-yielding rice varieties introduced in Asia shatter easily, thus "any means of cutting or gathering which is not gentle to the stalk will result in much grain loss". The developers further observed:

"Because of the tendency of rice to lodge and shatter, the only successful alternative to hand harvesting has been the self-propelled combine with a pickup reel. These machines are too large and expensive for most of Asia."

The observed need then was a low-cost harvesting machine which would be compact and light. Moreover it was desired to prevent straw damage so that this by-product could be used for other purposes; or if to be plowed under, the straw should remain held in the ground. It was further determined that cleaning as a part of the threshing operation was unnecessary since cleaning equipment was already traditionally located on the farms.

To meet these conditions a new harvesting method was developed:

"...a section of the stalk immediately below the head was fed into the space between a rotor and a concave without severing the plant from the ground.

As the machine moved forward the heads were pulled down and entered the clearance space between the rotor and the concave. The clearance was adjusted so that as the heads passed over each of the concave bars in turn, the kernels were struck by the rotor bars near the point of attachment to the straw and were then removed from the straw.

As the motion of the head was opposed to that of the beaters, the removal of the kernels started at the base of the head. In the conventinal threshers the removal starts at the tip, since the head travels in the same direction as the beaters."

Technology Transfer from Other Developing Countries

Wu and Esmay (1975) have summarized another approach to the rice harvesting problems in Southeast Asia. As stated previously, a persistent problem is the shattering characteristic of the high-yielding varieties:

"...preharvest shattering losses may be minimized by timely harvest, and post-harvest losses may be nearly eliminated by proper handling... A means of threshing the stalk paddy as near to the point of cutting and as soon after cutting should be introduced in order to minimize shattering losses."

It is believed that a widely accepted machine must meet the following prerequisites: (1) Have an acceptable low cost-"This, in general, means without mechanical power"; (2) be lightweight so that it can be easily moved by manpower. The application of such a thresher would mean that field drainage is necessary, and that some means must be available to handle the uncleaned, wet grain paddy after threshing. The introduction of the foot-pedal drum thresher will fulfill these prerequisites. It is lightweight, of simple design, readily reproducible locally from indigenous materials at nominal cost, easily operated and maintained, and is labor intensive. It must be noted, however, that the introduction of such a simple machine in, for example, Indonesia would necessitate a considerable change in the traditional harvesting system. Currently in Indonesia each rice stalk is individually hand cut about 20 cm. below the head bound with others into small bundles, transported to a building or village site for sun drying, and then marketed in this stalk paddy form. The introduction of the drum thresher requires a longer cut stalk with which to hold the heads against the drums. The introduction of this threshing operation would also necessitate some improved drying operation beyond the typical sun drying. Along with minimizing post production field losses, this new threshing system would utilize more farm labor as the threshing and drying would both be done on the farms rather than at central processing plants.

The drum thresher has been used successfully in Taiwan for two or three decades. Based upon 1972 cost data, the foot-pedal drum thresher rented for 20C per hour, and the break-even point was 27 hours of use per year. A similar cost projection for an engine-powered drum thresher more than doubles the investment (from $24 to $75) without appreciable increase in capacity, and extends the break-even point to 60 hours. Even though the drum thresher has been extremely successful in Taiwan, it was not successfully adopted in Bangladesh. The reason for non-acceptance was that the thresher was modified to a one-man operation to reduce construction costs. Continuous operation by one man is extremely exhausting, thus the farmers did not like it. Unfortunately the cost-saving modification overlooked the Japanese and Taiwanese team approach to operation, and made it unacceptable. Although field threshing minimizes shattering losses from handling a wet grain paddy is produced which must be dried immediately. If sun drying is not feasible, the introduction of a small (one ton) batch dryer with forced low-temperature drying air (30 to 40°C) is suggested.

These case studies represent three different approaches to solving agricultural mechanization problems with locally manufactured machines. All of the solutions, however, have several points in common: (1) a recongnition of the local conditions and problems, (2) development of a technology suitable for the prevailing conditions, (3) transferability of the technological solution to local manufacturing, and (4) recognition that land productivity and reduction of losses were predominant criteria in arriving at selective mechanization solutions.

Local Manufacturing and Economic Development.

The interrelationships between local manufacturing and overall economic development are so close in terms of labor use that the posistive contribution of small-scale industry must be further emphasized. Mechanization of agriculture has been roundly criticized for its labor-displacing characteristics, while similarly inappropriate industrialization has drawn only minimal attention, when they both possess the same labor-capital problems. It had been the contention of some (e.g., Liedholm, 1973) that smaller artisanal firms, of which blacksmithing would be one, make intensive use of the apparent abundant factor, labor, and less use of the apparent scarce factor, capital.

Chuta and Liedholm (1974) in a progress report on research of rural small scale industry in Sierra Leone, stated that even though the manufacturing output increased slightly (annual real rate of 2%) and the economy as a whole increased at an annual real rate of 3.7 percent during the 1965/66—1970/71 period, the number employed in the "large scale" manufacturing sector actually declined at a 4.5 percent annual rate. Small-scale industry in Sierra Leone on the other hand accounted for 95 percent of the total industrial employment and within this sector, it was estimated that carpentry and blacksmithing contributed a total of 34 percent of the small-scale industrial employment. This lends credence to the viewpoint that small-scale firms generally employ labor-intensive techniques in preference to capital-intensive techniques associated with "large scale" manufacturing, given the prevailing factor-price relationship of cheap labor and expensive capital of most developing countries.

Conclusion

The interdependence of selective agricultural mechanization and appropriate local manufacturing has been substantiated. Intermediate technology selected for maximizing land productivity and labor utilization is fortunately most adaptable to local manufacturing as compared to complex, expensive machinery. No country on a long term basis can afford the imbalance of payments drain and dependency status associated with the importation of agricultural mechanization technology for food production.

Selective mechanization systems should not only enhance crop yields, minimize losses and thus, increase total food available; but, also should minize the risk of crop failures for the farmers. Farmers will not adopt new cultural practices and apply costly inputs until assurance is provided for a successful crop. Thus, the risks against traditional crop failures must also be reduced. These include such things as lack of water, plant untrition, problems of weeds, insects, diseases and poor drainage.

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Changes in Energy Use Patterns from 1971 to 1974 on the Selected Farms in a Farming District in Northern India

by
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Introduction

In the period between 1971 and 1974, the farms studied have added a significant number of inanimate power sources to make more mechanical power available on the farms to increase production. In 1971, there were only 15 tractors in the seven villages under survey, and 41 more tractors had been added by July 1974. Similarly, the number of electric motors and diesel engines increased from 116 in 1971 to 272 in July 1974. Along with the tractors, electric motors and diesel engines, many more machines and implements have been added on these farms. In spite of the increase in price of fuel and electricity, the use of inanimate energy on farms has increased quite significantly.

In 1971, a year-long survey was conducted of inputs and outputs on the holdings of 26 farms in seven villages in Meerut district.* The survey was conducted primarily to detail energy inputs by farms using following six levels of mechanical technology, referred as categories:

Category 1: Farms with most or all acreage unirrigated and having animate energy sources only. Some acreage might be irrigated by canal or Persian wheel.

Category 2: Farms with most or all acreage irrigated by Persian wheel or canal and having animate energy sources only. Some acreage might be unirrigated.

Category 3: Farms using an electric motor or diesel engine to power an irrigation pump only, and using animate energy for all other production activities.

Category 4: Farms using an electric motor or diesel engine to power an irrigation pump as well as to power other machines such as wheat threshers, cane crushers and maize shellers.

Category 5: Farms having a tractor (and no electric motor or diesel engine) and using it to power irrigation pump and other stationary machines, along with tillage and transportation activities.

Category 6: Farms having a tractor and using it mainly for tillage and transportation activities, and having an electric motor or diesel engine to power an irrigation pump and other stationary machines.

This report was presented at the XIII Annual Convention, Indian Society of Agricultural Engineers, Allahabad, U.P., India, Dec. 30, 1974 to Jan. 1, 1975.

*General findings from the initial survey are reported in: Energy Inputs and Agricultural Production under Various Regimes of Mechanization in Northern India, by G. Singh and W.J. Chancellor, Transactions of the ASAE, Vol. 18, No. 2, p. 252-259, 1975.

Changes in Categories

Out of the 26 farms included in survey, 10 of them added machines and implements to the extent that it resulted in the change in category, a change towards more power use and mechanization. The other 16 that did not change category also added a significant number of machines and implements resulting in a higher degree of mechanization. The changes in categories during 1971 to 1974 are given below:

Category	Number of farmers during 1971	1974
1	5	3
2	7	5
3	4	2
4	4	9
5	2	1
6	4	6

The details of these changes are given in **Table 1** and are summarized here. Out of the 5 farms in category 1 in 1971, one changed to category 4 because of the installation of an electric tube well and purchase of a thresher, and second farm changed to category 2 through the installation of a Persian wheel. Out of 7 farms in category 2 in 1971, 2 shifted to category 4 and one to category 3. Three farms of category 3 out of a total of 4 shifted to category 4. One farm each of category 4 and category 5 shifted to category 6.

The farms that did not change their categories had installed more tube wells powered by electric motors and diesel engines, and had acquired more implements like bullock harrows, cultivators, sprayers, seed drills and rubber-tired carts.

Changes in Land Farmed

To the 1971 total figure of 344.64 acres for all farms in the survey, an additional 31.09 acres was added. Of this increase, 6.67 acres was rented in on shares, while the balance was purchased. There were no land sales or out rentals. It is interesting to note (**Table 1**) that all acreage increases were undertaken by farms having tractors (categories 5 and 6).

Changes in Permanent Labor

There were numerous changes in the permanent labor (family plus permanently hired) component on individual farms (**Table 1**). The net result was an increase of 6.5 family laborers and 5.5 other permanent laborers. Of the total increase of 12 laborers, 5 were for farms formerly in category 6 and 5 for those formerly in category 1.

The total land increase (31.09 acres) when divided by the total permanent labor increase (12 workers) amounts to 2.59 acres per permanent laborer—a ratio equal to, or lower than that for any category in the original study, and considerably lower than the 1971 overall ratio of 4.20 acres per permanent laborer. This indicates a general increase in labor use intensity for the farms surveyed.

Table 1. Changes in land, labor, animal power, machinery and equipment from 1971 to 1974

Farm code	1971 category	1974 category	Land changes (acres)	Changes in labor: Family	Changes in labor: Other perm.	Changes in draft animals: Bullocks	Changes in draft animals: Buffalo	Other changes
11	6	6		+1	+1	+1	+2	+One rubber-tired cart
12	4	4			−3	−2		
13	3	4						+Thresher
14	3	3		−1	+1.5	−1		+One electric motor (5 hp.), tubewell, cultivator and foot sprayer
15	4	6				−2		+Tractor (35 hp.), tine tiller, trailer, two tubewells (electric 5. hp. each)
21	2	4		$+\frac{1}{2}$			+1	+Rubber-tired cart, tubewell (7.5 hp. motor), thresher
22	6	6	4.67 purchased 6.67 rented in (shares)			−1	+1	+Tubewell (electric 5 hp.), rented in seed drill and sugarcane planter
23	4	4		−1				+Diesel engine (15 hp.)
24	4	4		+1				+Diesel engine (10 hp.), 5 row seed-drill
25	6	6		+2	+1	+2	+2	+Tubewell (electric 10 hp.), and diesel engine (10 hp.)
31	2	2					+1	+Tubewell (electric 7.5 hp.), thresher
32	2	2						Purchases water from tubewells
33	2	2						+Rubber-tired cart, purchases tubewell water
34	2	2				−1		+Rubber-tired cart, purchases tubewell water
35	6	6	6.00 purchased				+1	+Cane crusher and one boring for irrigation used by tractor
41	1	1			+1			
42	1	4		+2			+1	+Tubewell (electric 7.5 hp.), thresher, corn sheller, rubber-tired cart
43	1	1		+1	+1	+1		+Rubber-tired cart, bullock harrow
44	1	1						
51	3	4		−1	+1			+Diesel engine (12.5 hp.), thresher, cane crusher
52	2	3				−1	+1	+Purchases all irrigation water from tubewells, cultivator
53	3	4		+1	+1		+1	+Tubewell (electric 10 hp.), thresher, flour mill, oil mill
61	5	5	5.75 purchased			−2		+One tractor sold and another purchased with tine tiller
62	5	6	8.00 purchased			−2	+1	+Tubewell (electric 10 hp.), diesel engine (5.5 hp.)
71	1	2		−1	+1		+1	+Bullock cart (wooden wheels)
72	2	2		+2			+2	+Two rubber-tired carts

Table 2. Custom rates and daily wages

Item	Basis of rate	Rate (rupees) 1971	Rate (rupees) 1974
Harrow with tractor	one acre	20.00	30.00
Tiller with tractor	one acre	16.00	24.00
Electric motor	one horse-power hour	0.35	0.48
Diesel engine	one horse-power hour	0.60	1.00
Bullock (0.3 hp. rating)	one hour	0.50	0.80
Bullock (0.5 hp. rating)	one hour	0.60	1.00
Bullock (0.7 hp. rating)	one hour	0.75	1.40
Labor (Valeedpur)	one day (8 hrs.)	5.00	9.50
Labor (Kinanagar)	one day (8 hrs.)	4.00	8.00
Labor (Dabathwa)	one day (8 hrs.)	4.00	7.50
Labor (Chhur)	one day (8 hrs.)	5.00	10.00
Labor (Chitoda, Mohammadpur and Alamnagar)	one day (8 hrs.)	3.00	6.00

Changes in Draft Animal Power

For the 26 farms surveyed (73 total draft animals in 1971) there was a decrease of 8 in the total number of bullocks and an increase of 15 in the total number of male draft buffalo (**Table 1**). This represents a sizeable increase in draft animal power since bullocks typically have a power rating between 0.5 to 0.7 hp while male draft buffalo generally can be rated at approximately 1.0 hp. It is interesting to note that the four farms formerly in category 6 added a total of two bullocks and 5 male draft buffalo.

Changes in Prices and Supplies

Changes in custom rates for various power sources and daily wages for laborers are given in **Table 2.**

Canal irrigation charges also increased significantly between 1971 to 1974. Per-acre canal irrigation charges for sugarcane, wheat, barley or paddy, and maize during 1971 were rupees 36.00, 13.50, 5.00 respectively while during 1974 these rates were rupees 64.00, 20.00 and 10.00 respectively. The prices of various fertilizers increased almost twofold. The prices paid for agricultural products also increased tremendously but fluctuated greatly.

Effects of Cropping Pattern Changes on Energy Requirements

Cropping Intensity Changes: If the crops grown on the 31.09 acres of newly acquired land are temporarily ignored, the crop acreage reported in 1974 was 505.38 while that reported in 1971 was 525.32, indicating a decrease in cropping intensity from 1.524 in 1971 to 1.470 in 1974. However, if sugarcane is counted as 1.67 crops (one planting of sugarcane would be reported during 3 years while occupying the land for 5 half-year crop seasons) the intensity of cropping in 1974 (1.822) would exceed that in 1971 (1.727) indicating an actual increase of approximately 5 percent in the intensity of land use (**Table 3**).

Only minor fluctuations in sugarcane-corrected cropping intensities could be detected for farms in categories 2 through 6 (**Table 3**). However, a major effort to increase cropping intensities was recorded for farms in category 1 with sugarcane-corrected values increasing from 0.93 in 1971 to 1.369 in 1974.

Energy Requirements: The per-acre coefficients for energy requirements determined in 1971 for each type of crop grown by farmers in each category were applied to the crop acres reported in each category in both 1971 and 1974. While temporarily excluding the crop acreage grown on newly acquired land, it was found that changes in the cropping pattern had resulted in an increase of 11.8 percent in the total energy required for crop production (**Table 4**). When total energy

Table 3. Changes in acreages, intensity and energy per crop acre

Category	Geographical acreage 1971	Geographical acreage 1974	Crop acreage 1971	Crop acreage 1974	Sug. corr.* crop. int. 1971	Sug. corr.* crop. int. 1974	Energy/crop acre, hphr 1971	Energy/crop acre, hphr 1974	% Change
1	59.65	32.24	55.07	44.57	0.93	1.369	63.53	62.35	− 1.8
2	36.33	35.97	61.56	57.72	1.917	1.892	230.23	256.84	+11.5
3	29.20	14.58	48.27	21.21	1.902	1.979	392.08	454.71	+15.9
4	69.68	97.11	114.61	145.51	1.966	1.923	451.42	494.60	+ 9.5
5	54.26	34.00**	92.99	(39.67) 47.80	1.765	1.797	538.89	761.38	+41.0
6	95.52	161.93***	153.02	(196.28) 232.84	1.892	1.807	628.06	675.34	+ 7.5
	344.64	375.83 −31.09 acres acquired. 344.75 original survey area	525.52	549.65 (505.38)					

	1971	1974
Overall sugarcane corrected cropping intensity	1.727	1.820(1.822)

*Sugarcane corrected cropping intensity is computed counting one acre of sugarcane as 1.67 crop acres because 5 half-year crop seasons are required to produce 3 sugarcane harvests.

**5.75 acres purchased into this category from non-survey area.

***18.67 acres purchased into this category from non-survey area plus 6.67 acres rented in (on shares) from non-survey area.

Table 4. Changes in acreages of main crops and energy requirements

Category	Crop acres		HYV wheat acreage		Sugarcane acreage		Total energy requirements (hp-hr)	
	1971	1974*	1971	1974	1971	1974	1971	1974
1	55.07	44.57	0	0	0	3.5	3,499	2,778
2	61.36	57.72	7.75	12.60	13.24	15.50	14,126	14,825
3	48.27	21.21	18.01	5.54	10.90	8.50	18,926	9,644
4	114.61	145.51	35.76	32.33	33.65	61.84	51,737	71,969
5	92.99	39.75*	39.74	12.45*	4.17	16.60*	50,111	30,265*
6	153.02	196.62*	53.18	52.10*	43.00	75.57*	96,105	132,785*
Total	525.32	505.38	154.44	115.02	104.96	181.51	234,504	262,266
			−25.5%		+72.9%		+11.8%	
					Sugarcane corrected crop acres			
					1971	1974		
					595.33	626.45+5.2%		

*Excluding land purchased or rented since 1971.

values per crop acre were developed (total crop acreage including newly acquired land) increases in energy requirements were found for all categories except category 1 where a minor decrease was found.

The main reason for these increases in energy requirements was the 72.9 percent increase in sugarcane acreage. Sugarcane occupies the land for long periods and requires much irrigation. It needs considerable amounts of harvest energy as well as crushing energy for gur making, or alternatively, marketing transport energy. The fact that sugarcane requires no tillage energy during its two ratoon crops is responsible for the reduction shown in tractor and bullock energy requirements (**Table 5**). The high irrigation requirement of sugarcane resulted in an indicated 18.8 percent increase in electrical energy requirements.

Total human labor requirements were shown to increase by 12.9 percent (**Table 5**) while the casual labor component of this total increased by 29.0 percent. High labor requirements associated with sugarcane were again responsible for some of these increases. However, the large increases in casual labor requirement was in part due to a major increase in acreage falling into category 6 for which acreage much of the labor used is casual.

Generally sugarcane was the most intensive crop available to farmers. Their shift to this crop was, for the most part, the main reason for increased cropping intensities and increased energy and labor requirements. These changes which took place were of considerable magnitude despite the fact that the reductions in the acreage of H.Y.V. wheat (the second most intensive crop) were made to permit the increase in sugarcane acreage.

Effect of Prices and Supplies on Cropping Patterns

The most important objective of farmers is to get maximum return from their farming businesses. Due to the tremendous increase in price of fertilizers and the unassured supply of electricity, farmers have switched to crops like sugarcane which has low timeliness costs and is less prone to weather casualties. They have also switched to coarse grains such as sorghum and maize, requiring less fertilizer and less irrigation. Also, the procurement prices for wheat and paddy during 1974 were quite low and not based on actual production costs.

Conclusion

Farms using all levels of technology made dynamic changes in their operations during the three-year period examined. The main change was the increased use of irrigation water from electrical or diesel-powered tubewells. There was a general increase in intensity of production and the use of energy-supplying inputs. These included permanent labor, and draft animal power as well as electric motors, diesel engines and tractors. ■ ■

Table 5. Changes in energy requirements from various sources

Category	Permanent labor man-hr		Casual labor man-hr		Total labor man-hr		Bullock energy hp-hr		Electrical energy hp-hr		Tractor energy hp-hr	
	1971	1974	1971	1974	1971	1974	1971	1974	1971	1974	1971	1974
1	5866	5797	607	889	6473	6686	2891	2109	0	0	0	0
2	23417	21832	2367	2796	25784	24630	9572	9987	1474	2116	307	337
3	12201	6509	4322	2723	16527	9232	5237	2239	11904	6404	120	40
4	30803	34793	11105	13149	41908	47942	8521	8921	51234	56748	1772	1485
5	7572	7484	3990	5127	11570	12611	1043	1008	0	0	47915	27447
6	22898	32645	20980	31270	43878	63915	3293	4943	58573	80897	30012	40881
Total	102757	109060	43371	55954	146140	165016	30737	29207	123185	146165	80126	70190
%Change	+6.1		+29.0		+12.9		−5.0		+18.6		−12.5	

Development of the Agricultural Machinery Industry

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Potential of agricultural mechanization

Through mechanization of the agricultural operations the size of the labour force in agriculture will be reduced and labour becomes available for the manufacturing industries, including the agricultural machiKEry industry.

On one hand we notice a continuous flow of labour from agriculture to the industry, and on the other hand there is a continued increase of the use of industrial equipment that makes labour free from the farm. It is the development of this process, that also determines how the future development of the agricultural farm industry will be. In this paper we will deal with this problem on world level, whereby not only the differences between the industrialized and non-industrialized countries will be illustrated, but also the points of resemblance. An important point that asks for our attention is: what criteria have to be applied in the non-industrialized countries in order to achieve an optimal mechanization of agriculture and an optimal development of the agricultural machinery industry?

Agricultural mechanization in the industrialized countries

In the industrialized countries agricultural mechanization has already made much progress and it is still on its way to a higher level. On one hand the nature of the biological process of production demands that the implements are adjusted to this process, on the other hand also a certain adaptation of this process to the characteristic behaviour of the machines takes place.

As far as the size of the individual farm is too small for an economic use of the implements, various systems of cooperation between farms have been created to solve these problems. Only in those sectors of agriculture for which suitable machines have not yet been developed, much hand labour still exists. This is for instance the case with certain sectors of horticulture: the floriculture and the culture of mushrooms.

Mechanization has been strongly encouraged by increase of the wage level.

The effect of the development of the mechanization in industrialized countries in the period of 1950 till now will be demonstrated with the situation in the Netherlands as an example.

(i) Together with a decrease of the agricultural area in the Netherlands (1950: 2,34 million ha; 1970: 2,19 million ha) with 10%, the agricultural professional population decreased with 50%, while the net agricultural production increased with 75%. Consequently the net productivity per labourer increased with 125%.

(ii) The agricultural professional population decreased from 522.000 man-years in 1950 to 175.000 in 1974. Until the economic recession that started in 1974 all saved labour could receive full employment in the industry, trade and other sectors of economic life. Even 600.000 foreign workers were extra needed in the country to realize the industrial expansion which took place in this period.

(iii) In the manufacturing industry the distribution and repair service of farm machinery the level of employment increased. For Italy Politi calculated that 25% of the saved agricultural workers probably has found employJEnt in the business. For Holland this would mean 90.000 AK additional.

It is estimated that nowadays 70% of the agricultural machines produced in Holland is exported. From origin the agricultural machinery industry was founded to supply the local market, but because of the necessity of economy of scale, it has been developed into highly specialized industries, with sales organizations that are world wide.

(iv) The real income of the Dutch farmer, doubled in this period. Also the general well-being improved, if we express this in: reduction of the working time and the work load, general cultural development and improvement of the image of agriculture.

However as negative results of mechanization should be mentioned: high peak loads in busy seasons, an increased risk for severe accidents, noise; mechanic vibrations, as well as the increased appeal on the scarce supply of fossil energy.

(v) In agricultural mechanization we can distinguish 3 faces:

1. improvement of hand implement;
2. mechanization based on animal traction;
3. power mechanization.

Since 1945 especially the power mechanization has been increased in the industrialized countries, while the number of work animals (in Holland practically only horses) was reduced from 250.000 to some thousands in the period 1950-1970.The consequence was that more feed became available for other live-stock. Under influence of the increased use of fertilizers and concentrates, based on import, an increase of the number of dairy cattly was further stimulated.

(vi) The agricultural mechanization in the industrialized countries has been- and still is- one aspect of a continuously changing society. To the extent that the agricultural portion of the population is getting relatively smaller (1950: 14%; 1974: 5%) the differences between the rural society and the other elements of the society are also reduced.

Let us summarize the potential benefits of agricultural mechanization for the economic and social development of the society.

—It stimulates the intensification and extension of agriculture through mechanization of land clearing and land improvement operations; multicropping schemes improved farm practices; better timeliness of required operations; reduction of pre-harvest and postharvest losses and improved postharvest handling and storage systems.

—Agriculture is characterized by a seasonal distribution of labour requirements that leads to an alternation of peak and slack periods. Peak periods like harvesting and tillage without mechanization are often extended over a too long period that leads to a reduction of the cropping intensity and yield levels. With the aid of appropriate mechanization systems these bottlenecks can be avoided and this will lead to an increased intensity of the use of land, labour and other resources.

—Mechanization can be applied to reduce product losses, production costs and an excessive load of the farm working family. In non-industrialized countries the level of product losses is estimated at an average of 30% of what is grown on the field. Especially under conditions of severe stress like this is the case in the low humid tropics the working capacity of man and animals is substantially reduced by heat stress. For temperatures above 25°C it is estimated that one degree increase of temperature will reduce the physical working capacity by 5%. The health conditions of the labour force as well as the weather conditions e.g. the air humidity influence this capacity.

—On the foreign exchange position the import of farm machinery as well as their components and raw materials for manufacturing has a negative effect. This effect can be neutralized by

=development of a national industry based on indigenous materials and products;

=export of farm machinery;

=increase of exports of agricultural goods as a result of production increase due to mechanization.

Agricultural mechanization in the industrializing countries

If we make an observation of the industrializing countries —often referred to as developing counries—from the angle of the potential role agricultural mechanization can make in their agricultural and industrial development the following characteristic is obvious (1, 2, 3, 4, 5, 6, 7, 8):

—there is an urgent need to increase the agricultural production;

—a high proportion of the population is employed in agriculture: 35-85%;

—the population is rapidly increasing: 2,0-3,5% p.a;

—a large proportion of the population is at preasent underemployed;

—the infrastructure of the agricultural areas is usually unfavourable for mechanized operations;

—except in Lation America and parts of Africa agricultural land is scarce;

—the size of the land holdings is on the average very small, especially in Asia;

—millions of farmers live on a subsistent level and have an extremely low capacity for investment;

—fossile energy, steel products and other parts for machinery manufacturing are ususally very scarce and delivery is very irregular;

—the buyers market for farm machinery is very variable because of instability of yield levels, product prices and government policies;

—a high level of illitteracy and lack of experience with engineering theory and practice.

It is obvious that this characteristic indicates the difficulty and complexity of the problems engaged with agricultural mechanization in industrializing countries.

Because of basic differences in the industrializing countries we simply cannot copy the pattern of machanization, described in par. 2, but a entirely different strategy for an appropriate mechanization system has to be developed.

In such a strategy key factors are:

—the agricultural mechanization should support programs of agricultural development that are directed to extend the agrirultural production and the employment in the rural sector;

—only such mechanization is appropriate that is required to reclaim new land, to improve already available land and to support those agricultural operations that increase the cropping intensity level, the crop quality and yields to such a level that could not be achieved by any other economic method;

—it is emphasized that the mechanization should be aimed at a maximum utilization of already available resources: farm labour, draft animals, local manufacturing skills, repair shops, etc.

In general local manufacturing of simple, sturdy, well adapted farm equipment is the only solution to get agricultural mechanization well developed on a mass level. It simplifies adaptation to local needs, reasonable servicing and it reduces the costs of production and maintenance.

Present level of agricultural mechanization in various parts of the world.

The world has now to its disposal 1, 5 billion ha cropping land on which one or more crops per year are grown. Another 0,5 billion ha can be added by reclamation, mainly in South America and Africa. Besides the world counts 3 billion natural pastures, forests, etc. (3). Farming is practised by 315 million farmers, of which 80%, mainly in Asia and Africa, only dispose of hand tools (hand-hoe, sickle, e.d.), 15% disposes besides that on simple animal implements, as the beam-plough, the levelling beam, and the threshing cradle. Only 5% of the farmers has the disposal of higher developed implements, of which the agricultural tractor has a central position. As mechanization has reached a higher level, also higher productivity levels per ha and per worker are achieved. We can illustrate these relations in different ways:

The quantity of work energy per ha (kW/ha) cropping land and the corresponding yields of rough rice (in q/ha).

Note: Man is estimated as equivalent to 0.07 kW, animals to 0.3—0.7 kW and tractors, pumps, etc. according to the power of the combustion engines or electric motors.

For 1969 F.A.O. calculated the energy supply (kW/ha) and the rice yields (q/ha) as follows:

U.S.A.…0.75, 52 q /ha
Europe…0.68, 46 q /ha
Latin America…0.20, 16 q /ha
Asia
(excl. China)…0.14, 20 q /ha
Africa…0.11, 15 q /ha
World…0.26, 20 q /ha

Rice is taken as an example because rice is for more than half the world population the most important daily food. The figures illustrate clearly that an increase of the level of energy corresponds with higher yield levels (cropping intensity=land use index, not included).

The presently available work energy is in the industrialized countries nearly for hundred percent supplied by **mechanical power**, in the other countries still to a substantial level by **men and animals** (9):

In the future the total supply of human and animal power supply in agriculture will probably only increase slightly as several opposite factors will get more impact: family planning and industrialization. It means that additional power supply required to increase food production must primarily come from **mechanical power sources.**

The productivity of labour and the corresponding capacity of the farm working population to produce enough food for others and to obtain a reasonable economic and social welfare.

Again rice production is a good example.

A FAO world questionnaire on rice cultivation techniques showed a variation of kg's of rough rice per hour of labour of 1 to 100. In a traditional system (mainly handwork): 1500 hrs/ha and 15 q/ha and in a fully mechanized system: 45 hrs/ha and 45 q/ha. All other presently applied practices and methods in the world are in between these limits.

Another example (9) is the labour requirement for tilling a soil, approp. 15—20 cm deep. Depending on the tillage system it is:

spading/hoeing…500 hrs
with animals and plough…25 cm width 1.0 km/h 60 hrs
with two wheel tractor…(5 kW) 35 cm width 2.5 km/h 20 hrs
with four wheel tractor…(40 kW) 70 cm width 6.0 km/h 4 hrs
(Field efficiency rate: net requirement/total requirement =0.6)

Next to an improved operational quality and a better time-

	human	animal	mechanical
U.S.A.	0.01	—	99.99
Europe	0.39	—	99.61
Latin America	4	22	74
Asia	26	51	23
Africa	35	7	58

liness of performance mechanization in general leads to a **reduction of labour requirements** for a certain operation. Such a reduction is only tolerable—in case unemployment is a risk—if it is compensated by complementary employment on the farm or in other activities like in manufacturing, distribution and maintenance of equipment.

At a recent FAO Expert Panel (2) it was concluded from nine country studies that the employment reduction due to mechanization has in practice been compensated by one or more of the following steps:

—increase of land use intensity;

—increase of secondary employment: manufacturing, services.

There are however indications that if no proper mechanization planning exists, unemployment as well as waste of capital can take place.

The world outlook on agricultural mechanization (9)

The development of the number of farm tractors is a good indication of the development of power mechanization. In the industrialized countries investments in tractors take roughly 50% of the total investment in farm equipment. In industrializing countries this figure is estimated at 75%, as the use of tractors is less diversified and mainly concentrated on land improvement, soil tillage and transport.

The world tractor population in 1970 was estimated at 15,6 million tractors of which 92% were concentrated in: North America, Europe, Oceania, Japan and South Africa.

North America:

The total population is 5.4 million and it is expected that it will not change in the future. For replacement the annual needs will be 450 thousand. The power size of the average tractor will steadily increase (maximum at present: 225 kW).

Europe:

The population of 8 million in 1970 will increase to 11.06 million in 1990. Expansion will be mainly in Eastern Europe, Spain, Portugal and Greece. Average annual manufacturing requirements are estimated at 1.06 million.

Oceania:

It is estimated that the population will grow from 435 thousand in 1970 to 645 thousand in 1990. Average annual sales are estimated at 67 thousand.

Latin America:

A high increase of the tractor population is expected. 1970: 577,000, 1990: 2,232,000 tractors. Expected average annual sales by 1990: 334,000. Brazil and Argentina are nearly self supporting.

Asia:

Exclusive a large two wheel tractor population (in Japan only 4.5 million in 1970) the tractor population was in 1970: 786,000; for 1990 are estimated 5,290,000 four wheel tractors. Average annual sales by 1990: 952,000 tractors.

Several Asian countries have expanding manufacturing facilities for both type of tractors. Expansion is specially expected in the oilrich Western part of Asia.

Japan has considerable tractor export.

Africa:

Tractor population in 1970: 344,000. Estimated number in 1990: 1,330,000. Average annual sales in 1990: 199,000.

World:

1970 tractor population: 15.542 millions

1990 tractor population: 25.957 millions

Average annual sales by 1990:

North America	450,000
Europe	1,060,000
Latin America	334,000
Oceania	67,000
Asia	952,000
Africa	199,000
World	3,062,000

These annual sales numbers need adjustment in order to find the proper investment levels as in the industrial countries the farmers buy larger and more sophisticated tractors than in the developing countries.

For 1969 UNIDO calculated the world annual sales in agricultural equipment at $ 8 billion of which 23% was sold in Lation America, Asia and Africa. This figure corresponds fairly well with the FAO perspective figures presented in this paragraph.

Future development of agricultural mechanization and the agricultural machinery industry

In order to achieve in the industrializing countries a break-through from the 20 q/ha yields level of foodgrains to a higher level Giles (2) assumed the need for an increase to an energy supply of a minimum of 0.35 kW/ha. For Asia, Africa and Latin America the average level in 1970 was : 0.15 kW.

If we suppose that

—the human and animal power supply does not change considerably;

—the level of 0.35 kW should be reached in 1990;

—this increase is required for one billion ha of crop land, available in the industrializing countries,

It means that on the average 10 million kW has to be added annually. (The average estimated annual increase in tractor numbers is about $3^6 \times 10^5$. If we assume 30 kW/tractor the addition would be 10,8 million kW.) Not included are power units for irrigation, drying of products, etc.

If we further assume an average capital investment for power units including other equipment of $ 750/kW it would mean an **annual investment of 7.5 billion US dollar.**

This figure is high, also substantially higher than the figure for 1969 (including price changes). Because of the scarcity of capital in the developing countries this figures makes it clear that **means and ways should be sought to economize the capital requirements.** Such means could be:

(1) transferring knowledge and experiences about low and medium levels of technology from the industrialized countries to the industrializing countries; an action often referred to under the name of "appropriate technology".

(2) encouraging the development of small scale farm machinery industries that are able to manufacture: low cost, sturdy and simple farm equipment, that is well adapted to the requirements of the local market; both in size of the machines as well as in adjustment to specific crop properties, soil conditions and the agricultural infrastructure of the area.

(3) supporting both "transfer" and "development" by aid programmes in training on all levels involved:

—universities: (design and testing engineers, systems engineers, industrial managers, farm managers, teachers, extension specialists, etc.) and

—professional schools and training centres for farmers, tractor drivers, mechanics, sales-men, farm contractors.

(4) organizing systems of multifarm utilization of tractors and other farm machinery by promoting farm work contractor business and machine maintenance centres.

Schumacher (11) describes the justification for appropriate technology as follows:

"The technologies and equipment of the af:uent societies do not"fit" in conditions of poverty: it presupposes the availability of ample capital resources; it depends on the existence of an are large, but not into towns and villages where markets are small, because most of the people are very poor." (J. of Approp. Technology, vol. 1(1974)no. 1, pg. 1).

Among other, Kahn and Duff (4) conclude "that an effective mechanization of tropical agriculture will only be possible through the development of an appropriate mechanization technology that is compatible with local farm equipment industry—not by wholesale transfer of technologies from other parts of the world.

The development of a labour--intensive farm equipment industry in Asia hungs on the availability of machinery designs which can be economically produced with local materials and skills." (Journal of Appropriate Technology, vol. 1 (1974) no. 1 pg. 26/27)

In the development of an appropriate technology there are in general four different types of approach:

1. to invent a new design and a new technique of production,
2. to redesign local products and to improve local techniques and methods without a fundamental change of the local infrastructure,
3. to transfer a large scale technique into a small scale one,
4. to transfer appropriate technologies that are no longer used in the industrialized countries to the developing countries.

Which of these alternatives will make the most valuable contribution is not yet clear.

However too often the idea is launched that appropriate technology is primarily a matter of inventions. This is not true.

It is not true like some people think that e.g. a grain reaper or a thresher still has to be invented. Therefore it would be much better if:

—the manufacturers of agricultural implements in the industrialized countries would make available to the small manufacturers in the developing countries blueprints of e.g. animal drawn mowers and threshers, which are still in their files;

—the designers and manufacturers in the developing countries should more realize that much of what they think that still has to be invented, already some time ago somewhere else has been developed, but that primarily adaptation to local circumstances and production techniques has to take place.

There are many examples of intermediate technology, which show this situation. The biggest problem of transfer and introduction of technology is apparently communication. It is fortunate that now more interest is given to the realization of these connections: e.g. by establishing regional and national centres, where the agricultural machinery industry in the developing countries can receive information on design, construction and manufacturing of agricultural implements. There is a great need for putting together available experiences.

Another good example of communication is: a special quarterly journal on appropriate technology, the foundation of working groups on national and international levels and the organization of symposia and other meetings on which experiences are exchanged.

Useful work in the area of farm machinery is also done by international organizations and institutes, whereby especially the International Rice Research Institute (IRRI) in the Philippines and the international FAO project on rice mechanization should be mentioned. (5)

Both have made a contribution in the past to evaluate equipment that is available on the world market for small rice farming and to design simplified and improved implements.

The IRRI has disposed blueprints of small tractors, sowing, hoeing- and threshing machines to various manufacturers in S.E. Asia and these industries have benefitted substantially from this information. With aid of the forementioned FAO-project e.g. an European ricethresher was introduced in Africa with the result that now a manufacturer in Senegal has obtained the rights of licence to produce for the African market.

In many industrializing countries the development of the farm machinery industry is remarkable.

An example of the development of intermediate technology is shown in the State of Punjab in N.W. India.

This State has only 1.5% of the area and 2% of the population of the country but it owns 20% of the farm tractors and 50% of the grain harvesting and threshing machinery of India. In 1970 there were 725,000 farms and the net cropping area was 3.9 million ha (average 5.4 ha/farm).

The real and estimated energy supply is (10):

	units 1970	kW 1970	units 1980	kW 1980
human	1.9 million	94,960	2.0 million	98,490
bullocks	1.4million	514,500	1.0 million	367,500
tractors	25 thousand	404,250	230 thousand	3,719,100
total		1,013,710		4,185,090
energy kW/ha		0.26		1.07

During the same decade an increase of the number of energised tubewells (diesel engines, electric motors) is estimated from 66,000 to 300,000.

(These estimates were mae in 1970; they have now to be changed because of the energy crisis, as well as the Land Ceiling Act.)

Over 80% of the farm land in the Punjab is now irrigated. For this 200.000 pumpsets are used, a large part of them is powered by diesel engines and electric motors. This type of mechanization is a good example of employment creative mechanization.

In the Punjab there are more than 400 small scale farm machinery industries, one of them is a tractor plant with a planned production of 20,000 of 15 kW four wheel tractors designed for 6-12 ha farming. The industries have an annual output of thousands of threshers, seed drills and other equipment. The raw materials and components for the equipment, like engines, belts, bearings are all manufactured in India. The farm machinery industry is able to deliver the whole range of equipment required by the farmer both for bullock and tractor operations. There is a close cooperation between the industries and the Punjab Agricultural University and other design and testing centres in the area.

Remarkable in India is also the extensive work done in standardization of farm machinery manufacturing, and important source of information and aid for the industry.

Another interesting example of India is the manufacturing and service organization of the leading multinationals in agricultural machinery. It produces medium size tractors that were popular for many years in Europe and America and have shown a good reliability. An extensive network of maintenance and spare parts shops has been set up to cover the needs of the users.

On the African continent is a well known farm machinery manufacturer located in Senegal. With the aid of the farm machinery industry in Europe it has developed a whole range of drawn equipment to be used by small farmers in Africa. An efficient type of this equipment is a multipurpose frame on which alternative components can be mounted either for tillage, seeding or harvesting of the crop. It has much common with the German "Vielzweckgerät" widely used during the first half of this century in European small farming.

Because of the low density of the tractor and machinery population and lack of experience of the buyers the maintenance and spare part service is usually the Achilles heel of the mechanization in the developing countries, while especially by unexperience of the driver extra trouble and machinecracks occur.

Planning the mechanization one should pay much attention to these aspects. Four points are essential:

- **limitation** of types and makes;
- **application** of standardized materials, manufacturing techniques and components;
- **cooperation** between the manufactures and the government in setting up and maintaining regional and national Farm Mechanization Training Centres where both managers, drivers and mechanics can be trained. Also in developing projects, like irrigation and land settlement schemes such centres are **essential** for development.

  Examples are the training centres in Colombia and Surinam. Also in the Netherlands the training of future farmers at these centres is a fixed rule;
- **organization** of the tractor and machinery use.

  For small farming individual mechanization is usually not an economic issue. Cooperation —as it also has been developed in the industrial countries—is essential to achieve the benefits of mechanization. There are several systems of cooperation; one that has the best result is the private custom work business, although there are also good examples of centrally organized cooperative machine stations.

Much emphasis should be laid upon **education** and **training** in agricultural mechanization at the various levels of education and training.

University level

In many countries the educational facilities both in theoretical as well as practical training are still limited, although remarkable progress is noticeable. Both in the training of engineers and agriculturists mechanization of agriculture needs much attention.

In the establishment and the strengthening of the staff and institutions the international organizations and the universities in the industrial countries have many joint cooperative programs. An example is a UNESCO-project in India in which our University as well as Japanese and USA Universities are engaged.

At a UNIDO meeting in the Philippines in 1973 it was recoommended that the training should be directed to the immediate needs of the country and much practical exercises should be included. Training on university level is required to provide for the required engineers and agriculturists for functions in design, testing, industrial famanagement, farm mamagement, research, teaching and advisory work and other related subjects.

Level of technicians and farmers

The facilities for these training should also have elements of theory and practice, however with emphasis on practical exercises in mechanic shops and in practical farm fields.

In Surinam in a scheme of small and large scale rice farming it is practice that the trainees fulfill all mechanized operations during a production cycle, from land improvement to storage and drying. Plans for such a regional centre are on their way in West Africa.

Conclusion

In concluding this paper it may be emphasized that the development of the agricultural equipment industry is to be considered as an essential element of country development. As the increase of food production is a major concern the world over it is also evident that agriculture in the developing counties should have a first priority to share the limited energy resources of our world.

Only through an increase of energy supply the farmers in these parts of the world can really contribute to an increased food production and economic and social improvements.

Agriculture in the industrializing countries is characterized with small holdings, low farm income and low labour costs.

Mechanization of this type of agriculture will only be succesful through the development of appropriate machine designs which will meet the needs of the small farmers and which can be manufactured economically with available low volume production methods and black-smith type technology.

The systems of mechanization of agriculture in the developing countries cannot be an imitation of the mechanization in the industrial world although much of the experiences can be profitably used.

From the forecasts of the development of the world tractor population it is clear that the expansion of farm machinery manufacturing in the future will be concentrated in the developing countries.

Therefore joint ventures and other ways of sharing interests and knowledge and experiences should be recommended.

Essential is also the transfer of capacities and experiences on all levels of agricultural mechanization training from the industrialized world to the industrializing countries.

Regional and national committees and centres for development of mechanization strategies and acting as information centres on agricultural mechanization should be considered.

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Mechanization of Agriculture in Relation to Development in Developing Countries

by
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"Mechanization Technology for Tropical Agriculture" is an article written by Mr. A.U. Khan in the spring issue, 1975, of Agricultural Mechanization in Asia. I quote from this article:

> "…The author believes that the slow pace of agri. mechanization in the tropical regions is due to the inadequacy of the available mechanization technologies to meet the overall requirements of the small farmers in the tropics. It seems reasonable to content that the tropical regions must develop their own mechanization technologies to suit their agricultural, economic, social and industrial conditions …"

I suppose this expresses the thinking, or may be the "ideology" of the writer. The question is, is this the reason behind the slow progress and will the suggested solution be the answer to the problems of agriculture, economy, sociology in developing countries generally and particularly in Asia?

I believe that the writer and myself have both the same goal in mind: to raise the living standard of the rural (agri.) population, who form the backbone of these countries. I hope I do not sound assumptions, but I believe there exists a road; it is a difficult one. I doubt however wether the writer is on the right path which leads on to such a road.

I intend to explain fully what I have in mind. But before that, I would like to write down a few formulas which are generally accepted all over the world:

a. the time of the "Workshop Production" has passed, it can no longer compete with "Industrial Production".

b. what the poor need is not a little more money, which if distributed, would only spur inflation, which ordinary works to their dis-advantage. What the poor need are fundamental changes in the conditions under which they are living and working.

c. mechanization of agriculture (which ever form it takes) is only one stone in the process of building a strong foundation, based on which, the living standard of the rural (agri.) population and the economic situation of the country can be improved.

I believe the three formulas are self-explanatory. But let me give a few short explanations.

The terms "Workshop and Industrial Production" apply equally to any and all products, including agriculture. A person having at his disposal primitive (workshop) implements can only produce as much as he is physically able to. As a "one-man-operation" he could increase his production by acquiring improved, modern, more complicated implements. With the extremely high cost of capital all over the world and specially so in developing countries, it is doubtful wether he could increase his net income to any extend. More likely, he is prone to become a "slave" to his investment. The picture will look totally different if conditions would be changed in such a way, which would enable

Photo.1. Maayan Zwi. The Kibbuz (village) is on the Carmel Mountain, overlooking the plaine up to the Mediterrenean Sea. Below are the fruit plantations and the fish ponds. The field crops are to the right of the picture, not included.

Photo.2. Maayan Zwi. A one-row sugar beet harvester which was bought as a standard machine but completely re-constructed and adapted to local conditions, lifting-cleaning-loading onto truck.

him to produce by himself what he and a number of his neighbours used to produce. The neighbours, may be, assisting him part-time, but spending most of their time producing other products.

The two last formulas (b&c) are inter-connected. Will the direction outlined by the writer (A.U. Khan) lead to the fundamental change in the situation of the poor? On the other hand, what are the other stones which will form the sound foundation on which an improved living condition and standard can be erected? I fully respect the effort to improve and develop implements for small scale farming, to improve the standard of living of these people. However, I doubt wether the enormous effort invested will bring the looked for results. I agree that some results may be achieved to-day and may be to-morrow. But what about 5, 10 or 20 years hence? Will the small fields (which will probably become still smaller, by sub-dividing them amongst additional sons) still be able to support the increased population? Will his suggested method be able to utilize to the fullest the potential of the farmers (who are usually inteligent, but lack education) and utilize the physical potential of the countries, to feed the increasing population of these countries? What are the "other stones" which will form the sound foundation and will lead to a fundamental change: first and foremost education; gradual and planned change of the traditional farm and village structure; planning and follow-up of agricultura production; agricultural processing; organized purchasing and marketing; organized services (extension, irrigation water, machinery, etc.); the creation of additional income sources, etc. etc. Although I am the last person to minimize the importance of agricultural mechanization, I doubt wether a significant step forward can be made without the additional operations, as mentioned above.

But to make all this more clear, let me give you some examples of my own experience from here and some other developing countries.

When I first came to the village (Kibbuz), where I have been living for the last 30 years, the whole labour force worked in agriculture. We worked very hard and could hardly support ourselves. We actually lived on a sub-subsistance level. To-day, not quite 40% of the labour force works in agriculture due to full mechanization; production, on the same size area as 30 years ago, has risen several hundred percent. Aproximately 5% are employed in services to agriculture: irrigation water supply, building-adapting-maintaining machinery. The rest of the labour force is employed in industry; the majority here in the village, a few others in a large agricultural processing plant belong to all the villages of the district. I suppose I can leave it to your imagination how much our living standard has risen.

And now let me take you back 21 years. In 1954 I was asked by the government of Burma to assist in the introduction of agricultural mechanization. Before the war Burma used to be one of the largest rice producing and exporting countries in the Far East. Almost 9 years after the war, Burma was still suffering from a tremendous draft-animal shortage, could not get its rice production going and therefore thought of mechanization. It took me some time till I found out what it means to grow paddy. The first step was the construction of a Central Workship and a Training Centre, to train maintenance and operating personnel. The next step was trying to find the most suitable machinery. Large wheel tractors (from US-Point Four) were useless, they just bogged down. We acquired some smaller 4-wheel tractors and later on 2-wheel walking tractors. We constructed skeleton wheels and then got down to improve some indigenous implements, so that they could be pulled by the tractors. The major problem was how to operate the equipment: owner-operated, contracting, renting, leasing? Fields were from 0,1 to 0,3 Ha, spread all around the village. Even worse, a family did not have all his fields together in one place, but individually, spread all over the area. It was obvious that under these conditions it was impossible to achieve the hoped for results.

I was then asked by the Burmese Ministry of Defense to assist in developing very large areas to settle soldiers after their release from the army. All these soldiers came from villages, but to send them back to these villages would mean a reduction in their living standard. The developed area was devided into large fields which could be fully mechanized: for field crops and planting of orchards. Also large scale live-stock growing was initiated: poultry and dairy cattle. Processing plants were planned: dairy, rice mill, canning, etc. Besides working, everybody took part in the running and operation of the project. Every man received a salary for each day spent at work, compatible to his former army pay. The net profit (less labour and other inputs) from all the products were going to be devided amongst all the members of the village, which naturally acted as incentive not only to work, but to put his whole soul into that work. I do not want to go into details regarding financing and investment, but I believe that this was one exellent form of development investment, from all points of view.

After this example I would like to return once more to the traditional village. Its cropping area was devided into hundreds and thousands of small plots. I do not believe that I exaggerate if I state that from 20 to 30 % of the total area was occupied by bunds. If only half that area could be utilized for cropping, it would mean a rise of income and production from 10 to 20%. It would also mean that the fields could be worked mechanically, in a most economic way. Almost all the area was mono-cropped: rice. Very large areas had the potential of doppel-cropping: rice plus vegetables, groundnuts, pulses, feed-grain, green-fodder, etc. This would facilitate other agricultural branches, like livestock, processing, etc. Farmers were occupied in working their small plots, which were spread all over the area; in treating and handling their grain and selling it. Each one selling his small amount of rice, each one dealing with numerous merchants, wild competition, and in many cases being swindled out of his proper earnings. Double-cropping plus additional agricultural branches was feasible if the farmers could be freed to a certain extend from their present occupations. This would mean, first of all, re-devision of the whole village area into sizeable fields, which could be worked economically. Let the farmer buy the services he requires at self-cost and at controlled prices: irrigation water, mechanization, purchasing and marketing, etc. These services to be organized by one village or in cooperation with any number of villages. Let the farmers concentrate all their efforts on the growing of crops and livestock.

In 1967 I was employed as a Consulting Engineer in a very large development project in Iran. My job was to build up and organize an Agricultural Machinery Service Co. (none-profit). The purpose of the Co. was to develope large agricultural tracts for cropping and to render all machinery services in the already cropped areas of the villages. I do not intend to give details of this particular task, although it may be an interesting subject in itself, but to describe in short the whole project.

The "Project" was situated in a district which covered an area of aproximately 6,000km². The project was staged in two steps. The first one was the drawing up of a "Feasability Report" by a limited crew of specialists. This report covered the then present conditions of aproximately 20,000 families living in 250 villages. It stated all the social conditions and physical resources of the district, as well as the co-relation of the district to the country as a whole. Based on these facts, an overall plan was drawn up which checked the Feasability of each and every item: education, social services, social constraints, availability of labour, soil & water, water supply, evaluation of crop and livestock profitability, purchasing & maketing, marketing demand farecast, supply of capital, etc. etc. In short, the plan aspired to offer all the farmers in these villages the means to achieve a raised and more or less uniform income, due to raised production. Naturally, the physical conditions in each and every village differed, and to achieve this goal, with all details, was left to the long-range plan. This plan was presented to the government and after detailed discussions was aproved.

The next step was to draw up a long-term plan, which naturally also had to deal with the ways and means to implement the plan. The government formed a Development Authority for the district, in which all the government departments concerned were

Photo.3. Iran. Large-scale comprehensive development project. Land Cultivation Service Co., Central Workshop & Head Office.

Photo.4. Iran. As Photo.3. The finishing stages of the construction of an irrigation water storage reservoir.

represented, combining in its organization all the means to implement the development plan. The Authority was devided in to different departments, each of which covered a special subject:

Finance: salaries for the employees, loans for farm and village level, financing items of the development plan, operating the loan received from an international institution, etc.

Social Services: edcation, home economy, health, etc.

Planning: overall plan for the area as a whole and detailed planning for each village, follow-up.

Agriculture: crops, livestock, orchards, entmology, vetenary services, research, extension service, etc.

Irrigation Planning: detailed planning for irrigation.

Cooperatives: agriculture, processing, services, etc.

Water Supply Service Co.: none-profit, development of water sources, supply of water for irrigation & human consumption.

Supply & Marketing Service Co.: none-profit, purchasing & distribution of all farm inputs, processing of some of the inputs, i.e. seed sorting & treatment, feed mixing, Marketing of all the farm products, including sorting and packing, milk & cheese processing, fruit cold storage, etc.

Machinery Service Co.: none-profit, development of cropping areas, levelling & grading of cropping areas for irrigation, construction of irrigation water reservoirs & laterals, development of new orchards, all machinery work in already developed fields, transportation of inputs & crops, maintenance of equipment, building & adaption of equipment, research, etc.

A large amount of key and managing personnel was concentrated within the Authority, all specialists within their own sphere. It may well be that in the beginning there was a certain amount of over-employment. But taking into consideration that all the personnel went through a certain training process, this was, from a national point of view, a most positive investment. The number of key personnel was gradually reduced.

A considerable number of (farm) local population was employed in the Service Cos., in a number of development projects (building & construction) and a number of small enterprises cropped up.

In the following is a short description of the implementation of part of the "Plan": the agricultural plan.

Process of village development: all villages were classified, the classifaction depending on the physical conditions. The composition of the agricultural plan was based on the classifiaction and gave the relation of the different branches: fieldcrops-orchards-livestock.

Location of development area: survey of existing fields, area to be developed, re-allocation of the whole area.

Water supply: survey of existing sources: surface and wells. Planning of additional sources: surface and wells.

Agricultural Plan: detailed farm plan, based on village classification. Cropping, orchards, livestock. Surveying and mapping.

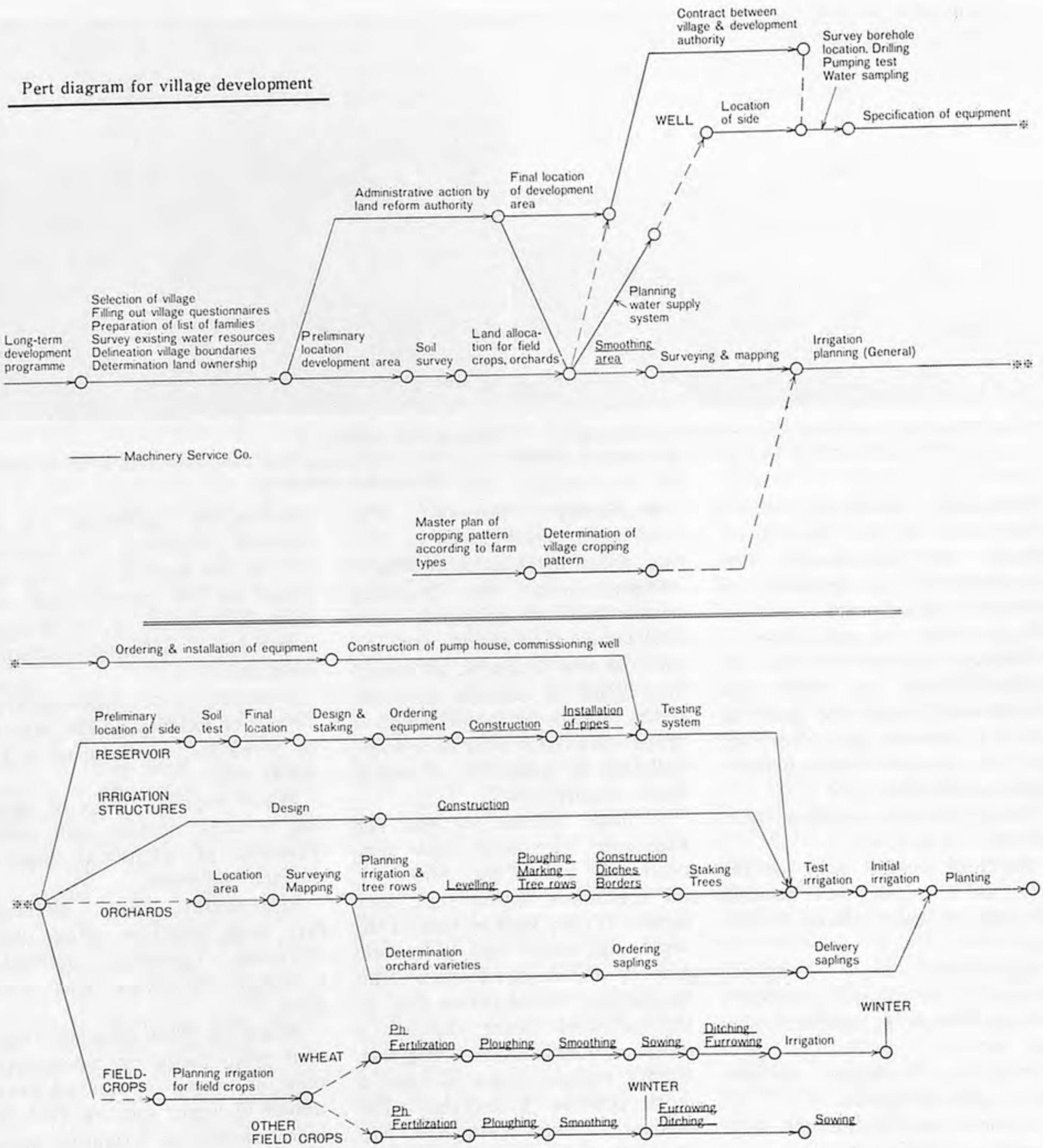
Irrigation Plan: detailed irrigation plan, based on agricultural plan, drawn up on planned availability of water sources. Plan for water reservoirs, irrigation water laterals, levelling and grading of fields.

Land preparation: levelling and tilling and all operations for field crops. Preparations for planting of orchards.

Time Table: an annual plan is drawn up one year ahead of implementation, based on long-range plan. An example (reconstructed from memory) for one village is following herewith. No dates have been inserted.

Fields were layed out in very

Pert diagram for village development



large long blocks, the width of which was controlled by the length of the irrigation furrows. Along side the fields was the irrigation channel and the field itself was allocated (devided) to a number of families, depending on the size. This facilitaded large-scale mechanization in the fields.

Naturally, the Machinery Service Co. was the main implementation facility in the whole project. As the Co. was gradually buit up over a number of years, it had at its disposal exellent personnel, well trained in the field of management, maintenance and operation. Also, a very good service organization backed up the whole operation: central workshop, mobile repair teams, supervision, etc. All the personnel underwent continous training: theoretical during out-of-season, in-the-field during the season. All development machinery operations were financed by a long-term international loan, at very favourable conditions. Its repayment was included in the land rent. Machinery charges for development were on the market level. This left a certain surplus above the expenses, which could be debited to the agricultural operations, charges for which were therefore very low.

Photo.5. Iran. As Photo.3.
Opening up beds and irrigation furrows for spring planting (sugar beet).

Photo.6. Iran. As Photo.3.
High yielding wheat. Newly introduced strain.

Summary

I believe the three examples outlined, show the direction of thought I had in mind.

Burma: introduction of mechanization of agriculture on a national scale could not attain the expected "break through" as soon as it met the traditinal farm and village structure, without the support of a basic and overall development effort. On the other hand, well planned settlement on a modern basis showed an anticipated result, although on a comparative small scale (at that stage).

Israel: large scale mechanization, backed by all the means and facilities of modern planned agriculture, attained the looked for "break through"; increasing agricultural production by many hundred percent, freeing a large percent of labour, formerly employed in agriculture, to shift to industry or any other form of production.

Iran: concentrated a very large amount of the nationally available skilled personnel in one comperatively small district to implement a "Master Plan" which could serve as a trial and training project for the whole country. Large scale mechanization, backed by all the modern components of agriculture, is bringing a whole district, within a reasonale time, from a sub-subsistence economy to a reasonable living standard. Freeing a part of the population to cultivate additional, formerly barren areas, work in processing plants to raise the returns on agricultural products, in industry, services, etc. In short, raise the production of the whole district, to the benefit of its population and the country as a whole.

Conclusions

Having worked myself in a number of mechanization schemes in different countries, having participated in a number of development projects in developing countries and having read quite a number of reports, I come to the conclusions:

a. That for mechanization in agriculture to succeed, there is a need for changed relations between man and land, creating the possibilities and incentives for man to produce more and more effectively. Without fundamental land reform this strive seems to be ineffectual.

b. That a large part of the effort and money invested into the development of the different sections of mechanization do not attain the hoped for results, unless they are connected with an overall and comprehensive development scheme and effort.

c. That national mechanization and development schemes usually bog down and do not attain the hoped for results, for the lack of sufficient trained personnel, who can be spread over the whole country and implement such schemes.

It seems to me that the example from Israel may show perhaps the final goal, but the example from Iran most probably gives an idea of what "The Road" may look like, the road of which I have talked at the beginning of these lines. I believe that we will probably all agree that the major restriction of a developing country to advance, is its limited number of skilled and trained personnel. It seems therefore reasonable to concentrate a large percent of that personnel in LKE district and use that district as an "Incubator", both for the creation of ideas and plans and their implementation and train personnel in each and every section. This will form the basis to spread the programme over the whole country. Within such a scheme, mechanization can play the major role and attain the hoped for results. ■ ■

Mobility Equations for Pneumatic Tire Performance in Soft Clay Soils

by
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Mobility in saturated rice fields is important for water leveling, wetland preparation, combining, and hauling of the harvested grain from the fields. It is also important to the military when their operations occur in a rice producing region such as South East Asia. In this paper, the military research is utilized for peaceful and hopefully productive purposes as an example of the value of spin-off which occurs from the support of basic research. The basic research was reported by Dean R. Freitag (2) as his Ph.D. Dissertation for Auburn University and also as a technical report by the U.S. Army Engineer Waterways Experiment Station (WES) Corps of Engineers, Vicksburg, Mississippi.

Freitag derived dimensionless terms but did not give any equations. Turnage (6) used dimensionless prediction terms to describe off-road wheeled vehicle performance and gave equations. Melzer (4) used dimensionless terms to predict power requirements for wheels operating in fine-grained soils. Both Turnage and Melzer used the WES "clay mobility number" Nc as the basic prediction term in their equations. Additional constants were added to fit the curves and no discussion of the model used was given to explain their equations. Bernacki, Haman, and Kanafojski (1) gave a model and equations for the reaction of a wheel or tire with soil. Their model assisted in the initial approach to analyzing data for this paper. Data from Robinson, Smith, and Richardson (5) were used to test the authors' prediction equations after the equations were derived and in final form as reported in this paper. Other references, especially Gill (3), were read and have influenced the author; but the cited references are the major sources.

Definition of Terms

The reader is referred Freitag (2) for his definition of terms. The author has used the following symbols for all terms used in this paper and derived equations:

D = Diameter = outside inflated but unloaded tire diameter in inches.

B = Section width = maximum outside width of the cross section of the inflated but unloaded tire. This is in inches and is about the same as the nominal tire section designation 23.1″ in the 23.1″ × 26″ tire size.

C = Cone index, psi, the force per unit area required to penetrate a soil normal to its surface at 72 inches per minute with a 30 degree right circular cone of 0.5 square inch area. This is an average value for the zero to six inch layer in this paper.

W = Wheel load in pounds on a single wheel.

F = Tire deflection in inches. F is computed from Freitag's tables. $F = (\delta/h) * h$.

Z = Tire sinkage in inches. The depth which the tire penetrates the soil relative to the original soil surface. Z is computed from Freitage's table $Z = (Z/D) * D$.

Rr = Rolling resistance in pounds of pull necessary to tow the wheel with zero torque at the axle. Rr is computed from Freitag's tables $Rr = (RT/W) * W$.

P = Net traction in pounds of pull at the maximum pull point or at the 20 percent slip pull point as an equivalent value. P is computed from Freitag's tables P/W by $P = (P/W) * W$.

T = Torque input at the axle in

inch-pounds. T is computed from Freitag's tables T= (Ω/DW) *D*W.

Experimental Data

The reader is referred to Freitag (2) for a complete discussion of the facilities and materials used to develop his experimental data and to ref. (2) **Tables 1, 6, 7. 8, 9, and 10** for the reported results of tests. The tests were conducted in the facilities of the Army Mobility Research Branch, Mobility and Experimental Division, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. These facilities permit single wheels to be tested dynamically under various conditions of speed, load, and soil resistance. Taken as a whole, the facilities occupy a position in wheel soil systems studies analogous to that of a wind tunnel in aerodynamics research. The single-wheel dynameter was used with four basic test tires. Dimensions of the basic test tires are given in **Table 1.**

The soil was a cohesive, alluvial clay soil obtained from flood plain deposists of the Mississippi River near Vicksburg, Mississippi. This soil had a liquid limit of 70 percent, a plastic limit of 25 percent and a plasticity index of 45 percent. Different degrees of soil consistency were obtained by preparing the soil at different water contents, by blending the dry powdered soil with water in a pug mill, and by computing the soil-water mixture so that about 95 percent of the void space was filled with water. In the compacted condition the soil's resistance to displacement was considered independent of the normal pressure on the shear surface. The soil mass would then react as if the shear strength had only a cohesive component and there was no angle of internal friction. This was essentially true as verified by Triaxial compression tests on the soil with cone index values of 24, 41, and 79 psi. Soil cohesion (c) was found to be 1.6, 2.1, and 5.2 psi and the angle of internal friction (ϕ) was found to be 0 to 3 degrees or essentially zero for the range. **Table 2** gives estimated values of C, p, and s at maximum shear stress from the circles shown in Figure 11, Page 54 of Freitag's report (2).

Cone index C was constant with depth from 0 to 14 inches. Average cone index of the top 6 inches was used to measure soil consistency since it was simple in concept and easy to measure without extracting samples. The rate of penetration of the cone penetrometer was measured at 72 inches per minute. Resistance to cone penetration was also tested at other rates. Resistance to penetration increased as the rate of penetration increased. The relation was found to be parabolic with less increase in resistance at higher rates. This rate-dependent soil property was called "spissitude".

A complete pull-slip relation for a test tire in a test soil was measured in a single run of the dynamometer system. Force in pounds necessary to pull the towed wheel was measured at the zero torque point. All other dependent parameters were measured at a controlled-slip value. When no clearly defined maximum occurred on a pull-slip curve, the pull at 20 percent slip was considered a reasonable equivalent of maximum pull.

Analysis of Experimental Data

Conversion of Data

Freitag (2) reported the results of 123 tests in clay with the four basic test tires. His tables gave dimensional values for C and W and dimensionless terms for combinations of parameters. These dimensionless terms were multiplied by section height h, weight W, and/or diameter D to convert them back to dimesioned parameters of deflection F, sinkage Z, rolling resistance Rr, net traction P, and torque T. The converted values of the 123 tests are given in **Table 3, 4, 5, and 6**

Table 1. Dimensions of basic test tires from Freitag's report

Nominal size	Diameter inches d	Section width, inches b	Section height, inches h
9.00—14	28.3	8.3	6.4
4.00—7	14.1	4.2	3.1
4.00—20	28.0	4.2	3.2
6.00—16	28.3	6.6	5.3

Table 2. Triaxial test results for clay from figure 11 of Freitag's report

Cone index psi C	Pressure psi p	Observed shear s psi	Computed shear-psi s1	s2
24	1.4	1.3	1.2	1.7
23	4.5	1.6	1.2	1.7
24	10.6	1.7	1.5	1.7
24	16.5	1.6	1.7	1.7
41	2.3	2.3	2.6	2.9
41	5.2	2.3	2.6	2.9
41	11.7	2.7	2.8	2.9
40	18.0	2.8	2.9	2.9
79	5.2	5.4	5.6	5.7
79	8.8	6.0	5.7	5.7
79	14.5	6.0	5.8	5.7
79	21.2	6.2	6.0	5.7
79	21.2	5.8	6.0	5.7

s1=0.66+0.77*C+0.0287*P;
Prob, T 0.0037, 0.0001, 0.0314
R-square=0.986, C.V.=7.25, Std Dev=0.25, Mean=3.52
s2=.0718*C;
Prob, T 0.0001
R-square=0.992, C.V.=10.6
Std Dev=0.37, Mean=3.52

Table 3. Results of tests in clay with 9.00-14 tire

Tire diameter inch (D) 1	Tire width inch (B) 2	Cone index psi (C) 3	Wheel load pounds (W) 4	Deflection of tire inch (F) 5	Tire sinkage inch (Z) 6	Towed force pounds (RR) 7	Maximum traction pounds (P) 8	Maximum torque in-lbs (T) 9	Test no. 10
28.3	8.3	16.	226.	0.96	0.70	6.	98.	1426.	297
28.3	8.3	17.	428.	0.96	1.61	68.	93.	2095.	298
28.3	8.3	17.	427.	1.60	1.64	47.	108.	2115.	299
28.3	8.3	15.	824.	1.60	3.99	330.	−89.	3451.	300
28.3	8.3	14.	617.	0.96	2.79	186.	45.	2864.	301
28.3	8.3	49.	440.	0.96	0.29	0.	260.	3462.	303
28.3	8.3	29.	227.	0.96	0.24	0.	146.	1940.	304
28.3	8.3	28.	456.	0.96	0.48	0.	152.	2323.	305
28.3	8.3	27.	645.	0.96	1.36	72.	179.	3103.	306
28.3	8.3	29.	857.	0.96	1.67	145.	135.	3468.	307
28.3	8.3	51.	238.	0.96	0.0	0.	259.	3105.	308
28.3	8.3	32.	446.	1.60	0.34	22.	272.	3408.	310
28.3	8.3	34.	860.	1.60	1.11	66.	241.	4332.	311
28.3	8.3	51.	441.	1.60	0.25	0.	429.	5654.	312
28.3	8.3	52.	650.	0.96	0.62	33.	351.	5298.	313
28.3	8.3	41.	445.	2.24	0.01	33.	402.	5503.	390
28.3	8.3	24.	447.	2.24	0.38	17.	312.	4225.	408
28.3	8.3	23.	649.	2.24	0.80	39.	237.	3765.	409
28.3	8.3	52.	447.	2.24	0.14	10.	479.	6325.	410
28.3	8.3	52.	674.	2.24	0.36	20.	585.	8126.	411
28.3	8.3	39.	656.	2.24	0.47	24.	385.	5272.	412
28.3	8.3	40.	878.	2.24	0.18	32.	377.	5491.	413
28.3	8.3	57.	872.	2.24	0.26	12.	621.	8489.	415
28.3	8.3	25.	860.	2.24	1.42	78.	156.	3359.	416
28.3	8.3	24.	230.	2.24	0.19	7.	238.	3346.	417
28.3	8.3	55.	872.	0.96	1.12	88.	260.	5034.	418

Table 4. Results of tests in clay with 4.00-7 tire

Tire diameter inch (D) 1	Tire width inch (B) 2	Cone index psi (C) 3	Wheel load pounds (W) 4	Deflection of tire inch (F) 5	Tire sinkage inch (Z) 6	Towed force pounds (RR) 7	Maximum traction pounds (P) 8	Maximum torque in-lbs (T) 9	Test no. 10
14.1	4.2	49.	111.	0.46	0.28	0.	73.	480.	363
14.1	4.2	42.	114.	0.78	0.10	0.	111.	696.	364
14.1	4.2	43.	235.	0.46	0.42	20.	53.	517.	365
14.1	4.2	60.	101.	0.78	0.10	10.	79.	612.	366
14.1	4.2	60.	219.	0.78	0.34	10.	91.	686.	367
14.1	4.2	42.	101.	0.46	0.09	0.	41.	289.	368
14.1	4.2	40.	234.	0.78	0.49	11.	105.	732.	370
14.1	4.2	25.	100.	0.46	0.65	0.	25.	217.	371
14.1	4.2	25.	102.	0.78	0.27	0.	38.	227.	372
14.1	4.2	37.	343.	0.46	1.16	69.	52.	851.	373
14.1	4.2	41.	336.	0.78	0.92	38.	66.	758.	374
14.1	4.2	42.	440.	0.46	1.23	92.	41.	937.	375
14.1	4.2	38.	437.	0.78	1.46	115.	−19.	924.	376
14.1	4.2	38.	445.	1.08	1.15	88.	27.	816.	377
14.1	4.2	33.	215.	1.08	0.61	21.	88.	685.	378
14.1	4.2	34.	325.	1.08	1.12	71.	60.	802.	379
14.1	4.2	67.	337.	0.46	0.64	47.	101.	922.	380
14.1	4.2	64.	223.	0.46	0.40	18.	88.	720.	383
14.1	4.2	64.	343.	0.78	0.46	32.	127.	1035.	384
14.1	4.2	66.	451.	0.46	0.98	69.	97.	1132.	385
14.1	4.2	64.	451.	0.78	0.82	47.	133.	1215.	386
14.1	4.2	62.	229.	1.08	0.27	18.	200.	1298.	387
14.1	4.2	61.	337.	1.08	0.39	20.	202.	1402.	388
14.1	4.2	67.	451.	1.08	0.59	32.	200.	1634.	389

of this paper. The results of only 115 tests were used in the statistical analysis. Six tests had missing values and two tests were dropped as doubtful. The eight tests not used are lined through in the tables.

Statistical Analysis

Data from **Tables 3, 4, 5, and 6** were analyzed at the LSU Computer Research Center by the regression procedure of the Statistical Analysis System of North Carolina State University (SAS) which permits easy and rapid testing of model equations for statistical evaluation of fit. More than 300 models of equations were tested by regression procedure. Almost all regression equations were highly significant with statistical probabilities of F and T of .0001 and R-squares over 0.80. Statistical analysis under these conditions can only servé as a guide in selecting and refining models to obtain simpler models which best fit the measured data and which give some insight into the soil-tire interaction. Intercepts were tested and dropped if not significantly different from zero at a probability of T at .0001.

The Cone-Soil Model

The WES 30-degree cone penetrometer (**Fig. 1**) is simple compared to the tire and should be examined to support the building of a tire model. The 0.5 square inch base area BA of the penetrometer never contacts the soil. All cone-soil contact must occur on the cone lateral surface area LA. The cone lateral surface area LA is related to the BA by the relation

$$LA = BA/\sin(15) = 0.5/\sin(15) = 1.93185 \text{ sq. in.}$$

The cone shape and method of penetration assures that all the cone lateral surface area is in equal contact. The cone index C in psi by definition is

$$C = W/BA = W/0.5 \text{ sq. in.} = 2W \text{ psi.}$$

The unit parallel force FL per unit cone lateral surface area is

$$FL = (W/\cos(15))/LA = (0.5 \cdot C/\cos(15))/(0.5/\sin(15)) \text{ psi.}$$

$$FL = C \cdot \tan(15) \text{ psi} = 0.268 \cdot C \text{ psi.}$$

This unit lateral force Fl is composed of forces normal to the lateral surface FN and vertical

Table 5. Results of tests in clay with 4.00-14 tire

Tire diameter inch (D) 1	Tire width inch (B) 2	Cone index psi (C) 3	Wheel load pounds (W) 4	Deflection of tire inch (F) 5	Tire sinkage inch (Z) 6	Towed force pounds (RR) 7	Maximum traction pounds (D) 8	Maximum torque in-lbs (T) 9	Test no. 10
28.0	4.2	21.	205.	0.48	1.19	12.	44.	959.	269
28.0	4.2	23.	206.	0.80	0.58	5.	80.	1223.	270
28.0	4.2	18.	407.	0.48	2.53	100.	49.	2006.	271
28.0	4.2	18.	388.	0.80	2.24	83.	45.	1901.	272
28.0	4.2	45.	444.	0.48	0.67	26.	151.	2387.	273
28.0	4.2	47.	442.	0.80	0.42	0.	188.	2661.	274
28.0	4.2	48.	219.	0.48	0.53	0.	122.	1631.	275
28.0	4.2	51.	233.	0.80	0.20	0.	182.	2362.	276
28.0	4.2	44.	209.	1.12	0.20	0.	227.	2762.	277
28.0	4.2	46.	428.	1.12	0.62	0.	272.	3727.	278
28.0	4.2	33.	219.	0.48	0.51	9.	77.	1220.	279
28.0	4.2	34.	221.	0.80	0.45	0.	107.	1337.	280
28.0	4.2	44.	648.	0.80	0.90	62.	182.	3193.	281
28.0	4.2	43.	645.	1.12	0.83	33.	183.	3052.	282
28.0	4.2	30.	235.	1.12	0.43	0.	138.	1750.	283
28.0	4.2	30.	457.	1.12	1.00	32.	139.	2329.	284
28.0	4.2	56.	706.	1.12	0.85	43.	203.	3341.	285
28.0	4.2	51.	628.	0.48	1.24	73.	170.	3200.	286
28.0	4.2	31.	456.	0.48	1.29	59.	114.	2234.	287
28.0	4.2	31.	461.	0.80	1.36	47.	114.	2375.	288
28.0	4.2	20.	230.	1.12	0.59	0.	94.	1404.	289
28.0	4.2	36.	655.	0.80	1.38	92.	168.	3485.	291
28.0	4.2	33.	659.	1.12	1.19	52.	169.	3137.	292
28.0	4.2	56.	639.	1.12	0.82	31.	164.	2899.	293
28.0	4.2	54.	629.	1.12	0.47	23.	226.	3135.	294
28.0	4.2	19.	426.	1.12	2.00	55.	85.	2171.	295
28.0	4.2	47.	658.	1.44	0.75	33.	235.	3851.	400
28.0	4.2	48.	314.	0.26	0.67	17.	98.	1829.	401
28.0	4.2	22.	308.	0.26	1.51	61.	72.	1880.	402
28.0	4.2	21.	648.	1.44	2.45	155.	−2.	2631.	403

to the base surface FV.

FN = FL*Tan (15) = C*Tan (15) *Tan (15) = 0.0718*C psi.

FV = (FL/Cos (15))* C = 0.277*C psi.

The cone index may now be compared to the triaxial shear test reported for the test soils. The relationship of shear stress (s), cohesion(c), and index for the three values of (C) were reported by Freitag for lowstrength, medium-strengh, and high-strength conditions with

C—values Cone—index = 24, 41, and 79 psi.

(c)—values cohesion = 1.6, 2.1—2.6 and 5.2 psi at zero applied stress.

(ϕ)—friction angle = 0, 0—3, and 3 degrees.

Note : that computed values of FN closely approximates the (c)—values of cohesion.

FN = 0.0718*C which would give the following values of FN—force normal to cone = 1.7, 2.9, and 5.7 psi.

These data would indicate that the failure shear stress (s) in the test clay was the same as the cone lateral surface normal unit force FN, while the apparent supporting unit vertical force on the cone was FV per unit of lateral area.

Data in **Table 2** are estimated values of C, p, and s at maximum shear stress from the Mohr circles in Figure 11 page 54 of Freitag's report (2). These data were used in regression analysis. The best regression equation was

sl = −0.66 + .077*C + 0.029* p;

R—Square = 0.986, Std dev. = 0.255, and s Mean = 3.52 for a C.V. of 7.25 percent.

The intercept −0.66 had a probability T of .0037, the coefficient C had a probability T of .0001, and the coefficient p had a probability T of .0314.

A second regression equation with no intercept and no p term gave an equation of

s2 = 0.0718*C; with a C.V. of 10.63 percent and a R—Square of 0.992.

The value 0.0718 is equal to the value FN = 0.0718*C previously estimated for the force normal to the cone. The normal for FN on the cone in cohesive soils is apparently the cohesive value and shear value for the soil.

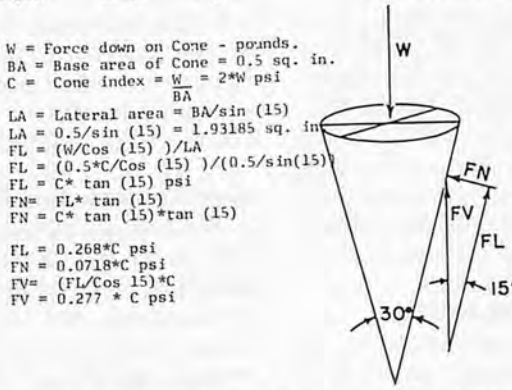

Fig.1. Force distribution on a 30-degree cone penetrometer

The Tire-Soil Model

As stated before, the cone penetrometer is simple to model compared with pneumatic tires. However, many tire models may be stated and tested to gradually converage on a model that approximates the measured results. The best model found to date by the author for Freitag's data is reported in this paper. This should not imply that it is the correct model for all tires or other test data. This model is reported due to lack of time and data to test other models. Other

Table 6. Results of tests in clay with 6.00-16 tire

Tire diameter inch	Tire width inch	Cone index psi	Wheel load pounds	Deflection of tire inch	Tire sinkage inch	Towed force pounds	Maximum traction pounds	Maximum torque in-lbs	Test no.
(D)	(B)	(C)	(W)	(F)	(Z)	(RR)	(P)	(T)	
1	2	3	4	5	6	7	8	9	10
28.3	6.6	20.	243.	1.32	0.43	6.	113.	1644.	322
28.3	6.6	19.	241.	0.80	0.53	13.	83.	1419.	321
28.3	6.6	64.	231.	0.80	0.09	0.	161.	2190.	323
28.3	6.6	60.	239.	1.32	0.04	0.	229.	3754.	324
28.3	6.6	22.	439.	0.80	1.78	51.	69.	2087.	325
28.3	6.6	21.	438.	1.32	1.62	33.	77.	1958.	326
28.3	6.6	21.	629.	0.80	2.77	136.	−22.	2813.	327
28.3	6.6	21.	645.	1.32	2.55	115.	9.	2702.	328
28.3	6.6	39.	236.	0.80	0.24	0.	166.	2197.	329
28.3	6.6	41.	237.	1.32	0.28	0.	262.	3568.	330
28.3	6.6	19.	231.	1.86	0.67	10.	184.	2327.	331
28.3	6.6	20.	445.	1.86	1.10	16.	167.	2468.	332
28.3	6.6	20.	653.	1.86	1.43	35.	150.	2754.	333
28.3	6.6	21.	828.	0.80	2.99	225.	−8.	2976.	334
28.3	6.6	20.	848.	1.32	3.47	256.	−36.	3048.	335
28.3	6.6	20.	847.	1.86	2.76	184.	28.	3116.	336
28.3	6.6	21.	847.	1.32	3.28	235.	−45.	3404.	337
28.3	6.6	22.	683.	1.32	2.18	127.	41.	2667.	338
28.3	6.6	40.	676.	0.80	1.14	66.	169.	3367.	339
28.3	6.6	36.	658.	1.32	0.77	33.	195.	3557.	340
28.3	6.6	37.	677.	1.86	0.61	10.	324.	4675.	341
28.3	6.6	36.	239.	1.86	0.31	0.	332.	4058.	342
28.3	6.6	38.	460.	1.86	0.48	0.	324.	4374.	343
28.3	6.6	39.	891.	0.80	1.56	148.	134.	3631.	344
28.3	6.6	39.	887.	1.32	1.38	98.	179.	3916.	345
28.3	6.6	41.	886.	1.86	0.96	32.	285.	4513.	346
28.3	6.6	58.	455.	0.80	0.30	0.	231.	3090.	351
28.3	6.6	51.	657.	1.32	0.55	14.	330.	4574.	354
28.3	6.6	52.	235.	1.86	0.16	0.	356.	4622.	355
28.3	6.6	53.	443.	1.86	0.28	0.	422.	5566.	356
28.3	6.6	48.	455.	1.32	0.32	0.	330.	4558.	357
28.3	6.6	52.	876.	0.80	1.05	91.	215.	4413.	359
28.3	6.6	51.	864.	1.32	0.67	45.	271.	4450.	360
28.3	6.6	48.	844.	1.86	0.58	22.	411.	6138.	361
28.3	6.6	48.	710.	1.32	0.71	21.	285.	4220.	362

Table 7. Prediction equations for tire-soil relations from Freitag's data.

No.	Equation formulas 1/	Units	Range of values low	mean	high	Std. dev.	Coef. var.	R-square
1	H1=3.81*W/(C*2.*PI*RM)+0.644;	inch	0.55	2.07	5.59	0.39	18.9	0.83
2	H2=3.57*W/(C*2.*PI*RM)+0.638*F;	inch	0.55	2.07	5.59	0.23	11.1	0.990
3	Z3=3.57*W/(C*2.*PI*RM)−0.362*F;	inch	0.00	0.93	3.99	0.23	24.9	0.965
4	T4=1.00*P*RT+1.35*W*Z;	in-lb	217	2778	8489	207	7.4	0.996
5	T5=.0649*C*ZA*RT+0.0928*C*FA*RT	in-lb	217	2778	8489	381	13.7	0.986
6	T6=.0608*C*ZA3*RT2+.095*C*FA*RT2;	in-lb	217	2778	8489	396	14.2	0.985
7	P7=1.00*T/RT−1.34*W*Z;	lbs	−89	168	621	16.8	10.0	0.994
8	P8=0.0687*C*ZA+0.0925*C*FA −1.414*W*Z/RT;	lbs	−89	168	621	33.9	20.2	0.975
9	P9=0.0677*C*ZA3+0.0952*C*FA −1.46*W*Z3/RT2;	lbs	−89	168	621	33.6	20.0	0.975
10	RR10=0.00264*C*FA+1.12*W*Z/RT −0.208*W*F/RT;	lbs	0	46	330	13.0	28.2	0.971
11	RR11=0.00916*C*FA+1.32*W*Z3/RT2 −0.611*W*F/RT2;	lbs	0	46	330	15.7	34.2	0.957
12	C12=9.33*T/(HA*RT)+1.20*W/HA;	psi	14	38.4	67	5.2	13.4	0.984
13	C13=11.6*T/(HA*RT);	psi	14	38.4	67	5.8	15.2	0.980

1/ Defined values: H = F + Z; RT = sqrt (R*(R−H)). RM = sqrt (D*B)/2;
HA = 2.*PI*RM*H; FA = 2.*PI*RM*F;
RT2 = sqrt (R* (R−H2));

persons should test this model on their data and cooperate to derive better, more accurate, and more universal prediction equations. Data should be reported in table so that others may analyze the data and formulate models. In this manner we can advance more rapidly.

Assumptions for model

1. The tire-soil surfaces are assumed to interact at all times to maintain an equilibrium condition.

2. The basic forces on the wheel and tire are weight W, net traction P, and torque T; the forces must act through the cap of tire surface area in contact wit the soil to maintain the equilibrium conditions.

3. a) The cap of tire surface area may be approximated by an equation similar to the equation for the surface area of a cap of a speere **Figure 2** where the sperical cap surface area = SA = 2.*PI*R*H.

b) An approximate equation for the surface area of a cap on a torus shaped pneumatic tire may be based on the geometric mean of two spheres with radii of D/2 and B/2.

HA = PI *H*SQRT (D*B) = 2*PI*RM*H;

where H = F + Z ≦ B/2 and

RM = 1/2*SQRT (D*B); is the geometric mean radius of a distorted sphere. This equation is useful for its simplicity and has given the best fit for all models tested.

4. The cap of the tire-soil surface area for deflection F is constant for any weight W and tire pressure if the soil cone-index C and traction T are held constant. If the weight W, torque T, and net traction P change to exceed soil conditions, the excess ground pressure is brought to equilibrium by a change in sinkage Z. (See Freitag Figure 9. Sample oscillograph trace).

5. The effective torque radius is the geometric mean of the radius and the deflection plus sinkage value H.

RT = SQRT (R*(R−H)) ;

Mobility Prediction Equations

The real usefulness of the tire-soil model will depend upon the possibility of developing equations which fit the measured data, which are dimensionally correct, and which show potential in extrapolation to predict tire-

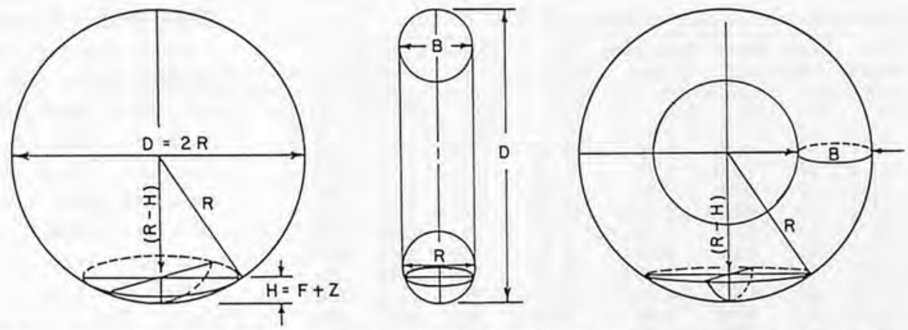

Fig.2. Spherical cap for sphere with radius R and height H and torus with diameter B and exterior diameter D.

soil relations for other combinations of soft clay soils and pneumatic tires.

Table 7 lists the equations which seem to best fit the measured data. The R-square, coefficient of variation, standard deviation, low, mean, and high values are all given for each equation. The intercept is given where significant with probability T > •001. Suppressing the intercept causes a major increase in the R-square without a corresponding decrease in the standard deviation from the regression line. For this reason the standard deviation is probably a better guide to the precision of the estimate. The best standard deviation for the estimated values of Z and F were in the order of magnitude of 0.23 inch, net traction or pull P in the order of magnitude of 17 to 34 pounds, and rolling resistance Rr from 13 to 16 and the cone-index C was about 5 psi. The actual precision of measurement of data under dynamic conditions was not given but errors in the measurements obviously are reflected in the standard deviation from the regression line for the predicted values estimated by the equations. The width of the band from the line in which the points are scattered is equal over the range from the low to the high values. This equal spread about the regression line would indicate that there was a corresponding equal error in measurement of the original data over the entire range. This error is about 5 percent of the range. The use of dimensions for P, T, Rr, and Z increases the R-square over the range of values as it gives weight to the values according to magnitude. The use of dimensionless values often results in the greatest magnitude being given to the smaller value. This is particularly true in the ratios P/W, T/W, etc. Any error in measurement would have greater effect on the dimensionless values. These errors are partially overcome by the magnitude of the range in the dimensional equations and give greater confidence for the larger values. This approach is encouraging since the smaller values in all cases should approach zero and the real interest is in extrapolation of values to larger tires and loads.

Discussion of Prediction Equations

The prediction equations derived from the data in **tables 3, 4, and 5** are listed in **table 7.** These equations are in the form for use in the SAS program, for ease of typing, and for reference. The defined values are as footnoted at the bottom of the table. Diameter D, width B, weight W, and deflection F are used as known values. B and D are used to compute the geometric mean spherical radius RM. Deflection area FA is computed from the equation of a spherical cap with radius RM. Sinkage Z3, sikage area ZA3, and mean torque radius RT2 are computed for an assumed or measured value of cone index C. Torque T6, net traction or pull P9, and rolling resistance Rr11 are computed from the values of Z3. Cone index C13 may be computed by assuming values of T and Z. Note that for C13 the reciprocal of the coefficient $1/11.6=0.0862$. The value. 0.0862•C is an estimate of shear when the tire area HA is sheared by the torque T by torque radius RT. The coefficients .0608 to .095 in equations T5, T6, P8, and P9 are also estimates of shear values which indicate that the cone index C is a fair measure of shear. The use of a spherical wheel under a torque load should be tested in an effort to estimate shear more accurately.

The predicted values and measured values were plotted to observe the deviation over the entire range. In general the deviation from the regression line was less at the extreme low and high values and greatest around the mean value. The standard deviation divided by the range is about 5 percent which is probably somewhere in the order of magnitude of the accuracy of the measuring devices used. Data different from the data used in the derivation must be used to evaluate the prediction equations.

Table 8. Rolling resistance tests in clay with an 11.00-20, 12 PR tire.

Test no.	Tire diameter inch (D)	Tire width inch (B)	Cone index psi (C)	Wheel load pounds (W)	Deflection of tires inch (F)	Tire sinkage inch (Z3)	Towed force pounds (RR)	Computed towed force pounds (RR11)	(RR11a)
1	41.2	11.4	57	4500	1.56	7.72	1048	2755	888
1A	41.2	11.4	44	4500	1.56	10.16	1156	4173	1192
2	41.2	11.4	44	4500	2.21	9.92	1102	4031	1101
2A	41.2	11.4	43	4500	2.21	10.17	1103	4204	1140
3	41.2	11.4	50	4500	4.99	7.63	594	2498	498
3A	41.2	11.4	44	4500	4.99	8.92	594	3372	667
4	41.2	11.4	45	4500	4.00	9.04	810	3449	798
4A	41.2	11.4	47	4500	4.00	8.59	738	3148	736
4B	41.2	11.4	42	4500	4.00	9.79	904	4007	914
5	41.2	11.4	45	3000	1.12	·6.58	693	1501	557
5A	41.2	11.4	48	3000	1.12	6.15	648	1374	537
6	41.2	11.4	42	3000	1.75	6.86	651	1550	528
7	41.2	11.4	41	3000	2.74	6.68	396	1438	447
8	41.2	11.4	43	3000	2.12	6.55	483	1434	485
8A	41.2	11.4	45	3000	2.12	6.23	408	1335	469
9	41.2	11.4	44	1500	0.50	3.40	180	365	288
10	41.2	11.4	44	1500	0.87	3.26	160	334	272
11	41.2	11.4	43	1500	1.18	3.23	128	318	257

RR11=0.00916*C*FA+1.32*W*Z3/RT2−0.611*W*F/RT2;
RR=0.263*R11; R-square=0.945, C. V. =26.6
Std. Dev.=173, RR Mean=650.
RR low=128, RRhigh=1156
RR=RR11a=0.0691*C*FA+0.351*W*Z3/RT2−0.387*W*F/RT2; R-square=0.983, C.V.=15.6, Std. Dev.=101

Evaluation of the Prediction Equations

Tests with 11.00—20 tire

Data from 18 towed tests in clay were used by Freitag to evaluate his analysis. These values were independent of the data used to develop the prediction equations and are given in **Table 8.** The rolling resistance values predicted by eqation RR11 were greater than the measured values over the entire range, however, the coefficient 0.263 reduced the values of R11 to a fair estimate with standard deviation of 173 pounds over the range.

The individual factors C*FA, W*Z3/RT2, and W*F/RT2 were used to derive a regression equation RR11a which gave an excellant fit over the range. The model of the equation is stable but the coefficients are not would be the conclusion for this evaluation. The difference in soils, number of tire plys, and the almost constant cone index C are factors which could explain the change of coefficients.

Tests with a log skidder

Data from 12 tests of a log skidder were reported by Robinson, Smith, and Richardson (5) for rolling resistance and maximum traction. These were field tests on a full scale tractor in a wooded area. **Table 9** summarizes the reported values and the predicted values from the prediction equations. The maximum pull is predicted well by equation P9. The rolling resistance is not predicted so well by equation RR11 unless an intercept of 794 pounds is included. This intercept would account for transmission and bearing internal resistance. One pavement test of rolling resistance indicated that RR on pavement was from about 500 pounds for the low vehicle weight of 16,495 pounds. The RR of the loaded vehicle at 20,870 pounds would have been higher possibly 630 pounds.

The results of this evaluation is encouraging on the potential to predict traction P and rolling resistance RR on full scale equipment under field conditions.

Conclusion and Recommendations

The individual factors C*FA, W*Z3/RT2, and W*F/RT2 were stable for the original data and

Table 9. Rolling resistance and traction tests on a rubber-tired log skidder compared with predicted values.

Test no.	Cone index psi (C)	Wheel load front pounds (WF)	Wheel load rear pounds (WR)	Tire defection front inches (FF)	Tire defection rear inches (FR)	Tire sinkage front inches (Z3F)	Tire sinkage rear inches (Z3R)	Maximum Pull measured pounds (P)	Maximum Pull predicted pounds (P9a)	Rolling resistance measured pounds (RR)	Rolling resistance predictions pounds (RR11a)
10	74	5318	2930	3.01	1.67	1.06	0.58	10,320	9123	1200	1236
12	47	5318	2930	3.01	1.67	2.30	1.26	3,300	6103	1600	1643
14	45	5318	2930	3.01	1.67	2.45	1.34	5,000	5835	1600	1706
16	95	5318	2930	3.01	1.67	0.58	0.32	9,680	11,114	1200	1173
18	64	5318	2930	3.01	1.67	1.39	0.76	8,500	8096	1400	1323
4	69	4795	5640	2.55	3.13	1.15	1.30	10,120	10,391	1200	1419
6	34	4795	5640	2.55	3.13	3.30	3.83	5,000	4399	2750	2941
9	74	4795	5640	2.55	3.13	1.01	1.14	13,200	11,035	1600	1352
11	47	4795	5640	2.55	3.13	2.13	2.46	3,900	7113	2400	2029
13	45	4795	5640	2.55	3.13	2.27	2.61	6,200	6754	2400	2127
15	95	4795	5640	2.55	3.13	0.58	0.64	12,700	13,546	1200	1210
17	60	4795	5640	2.55	3.13	1.47	1.68	11,700	9159	1200	1591

D=62.5 inches; B=23.2 inches
P9a=0.984*P9; R-square=0.964, C. V.=21.46
Std. Dev =1781 P mean=8302
Intercept not significant.
RR11a=794+0.807*RR11; R-square=0.844, C. V.=14.02
Std. dev=231, RR mean=1646
Intercept significant at probability of T 0.0001.

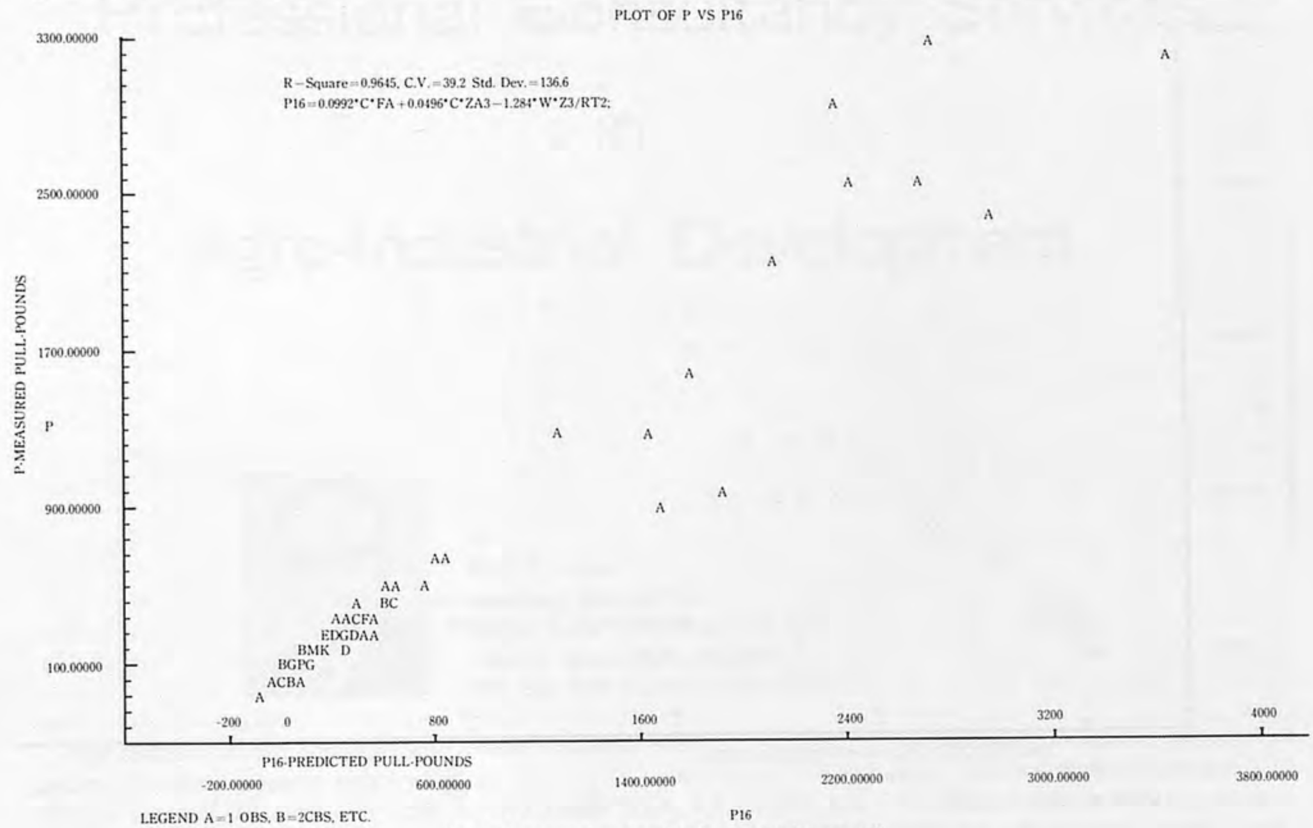

Fig.3. Measured vs predicted net traction or pull

also for the 11.00—20 and 23.1—26 tires. These additional data were included in a combined statistical analysis to derive prediction equations for the greater range for pull and rolling resistance.

Pull-combined equation

P16 = 0.0992*C*FA + 0.0496*C*ZA3 − 1.284*W*Z3/RT2;

Prob, T or B values 0.0001 0.0029 0.0002

R-square = 0.9645, C.V. = 39.2, Std. Dev. = 136.6,

Range of values

low	mean	high
−89	348	3300

Figure 3, shows a plot of the values for measured pull P Vs. predicted pull, P 16. The coefficient 0.0496 for the sinkage area is one-half of the coefficient 0.0992 for the deflection area. This would indicate that the entire deflection contact area is in contact with the soil while only one-half of the sinkge area is in contact with the soil. The shape of the tire reinforces this conclusion. The coefficient −1.284 for the W*Z3/RT2 indicates that is the main rolling resistance factor at maximum pull. The intercept was not significantly different from zero.

Rolling resistance-combined equation

RR16 = 0.0155*C*FA +1.11*W*Z3/RT2−0.484* W*F/RT2;

with Prob., T of B values 0.0001 0.0001 0.0001

R-square = 0.975, C.V. = 30.6, Std. Dev. = 46.3

Range of values

low	mean	high
0	151	1156

Figure 4 shows a plot of the values for measured rolling resistance RR Vs. predicted rolling resistance RR16 for all values. The coefficient 1.11 and factor W*Z3/RT2 explains the major portion of the rolling resistance. Surface contact area coefficient 0.0155 and factor C*FA accounts for additional rolling resistance while the coefficient−0.484 and factor W*F/RT2 indicates that this deflection component reduces rolling resistance slightly. The intercept for the combined data was not significantly different from zero. The higher values, however, show a trend that would indicate a positive a intercept.

Recommendations

1. The prediction equations P16 and RR16 should be tested on other data and the individual factors C*FA, C*ZA3, W*Z3/RT2, and W*F/RT2 should be included in regression models for the other data and combined data to continue the development of the prediction equations over a wider range of conditions.
2. Additional effort should be

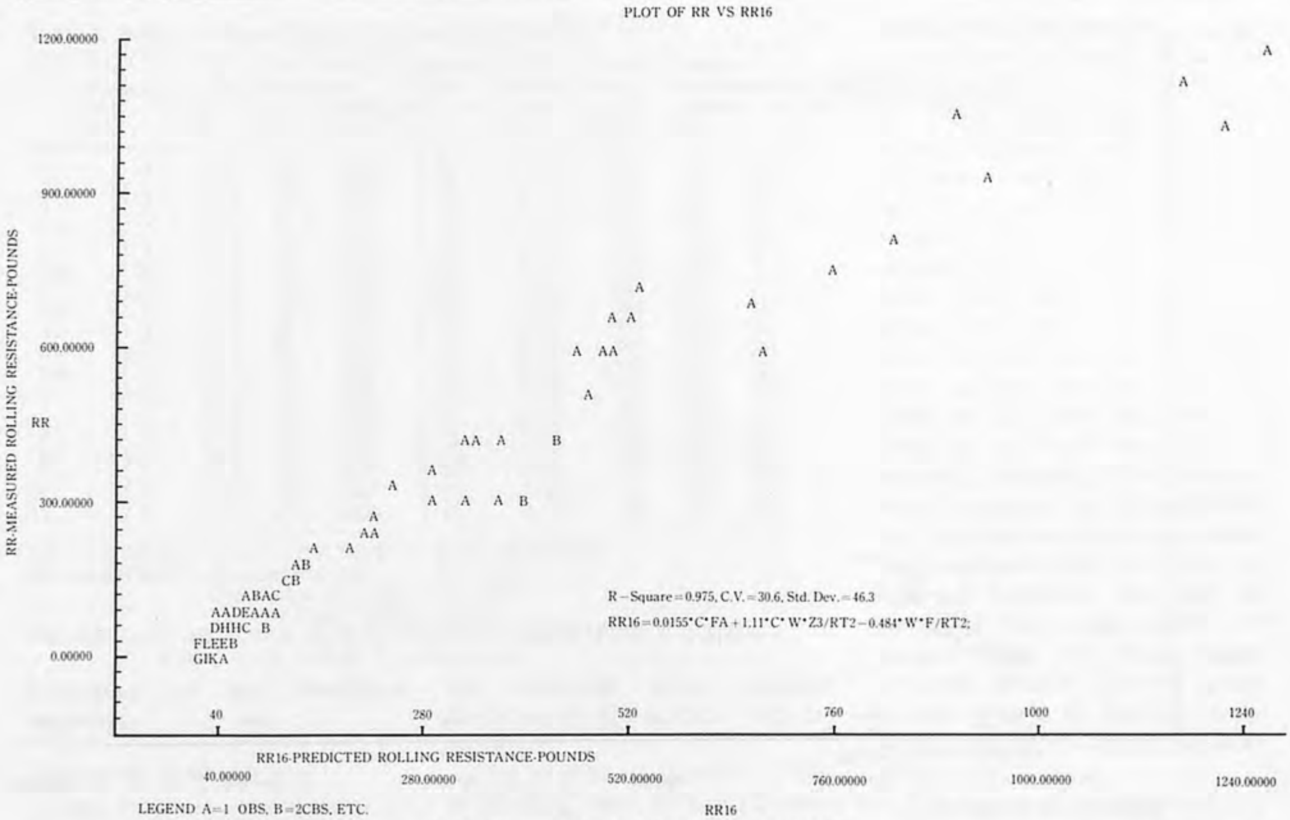

Fig.4. Measured vs predicted rolling resistance.

directed to the solution of the contact area of the deflected surface cap area and sinkage surface cap area of pneumatic tires. The use of the finite element computational procedure should be more accurate and reduce the variability. The coefficients 0.638*F and −0.362*F for equations H2 and Z3 are probably values 2/PI and 2/P1−1 to correct for the distortion in the deflection cap area.

3. Spherical radial tires or balls should be tested (a) to secure more accurate data, (b) to possibly establish a shear measuring device to replace or supplement the cone penetrometor in soft clay soils, and (c) to possibly develop more effective and economical radial tires of mobility in soft clay soils.
4. The rate-dependent soil property defined as "spissitude" should be investigated to predict shear or "viscosity" changes with rate of shear.

Conclusion

I personally belive that the development of accurate prediction equations for pneumatic tires on plastic clay soils will be possible and that equations P16 and RR16 are useful but primitive prototypes.

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Professional Consultancy Services in Agro-Industrial Development

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Agriculture is our biggest industry. In fact, in many ways we should treat it as such. We can usefully apply several good practices and norms which have been in use in the industry. In the context of the current situation, there is special emphasis increasing agricultural production and development in the agro sector. All possible avenues have to be harnessed to accelerate the pace of this development.

In the engineering industry, Consultancy Services are now an established practice; some good examples are—the technical services required by the steel plants and those in production engineering including plan, lay-outs, capacity utilization, etc. Professional technical consultancy services are now beginning to be available in the country in the Agro-industrial sector. It is hoped that such services will gain a similar standing as in the engieneering industry. Consultancy services in the Agro-industrial field will have to break some new ground.

AGRO-INDUSTRY

To begin with, let us set out the scope of the Agro-industry, the main beneficiary from the consultancy services. The industry can be divided into two parts—the inputs and the outputs. The agricultural inputs mainly include farm equipment, seeds, fertilizers a d pesticides. The farm equipment industry is now well developed in the country. In addition to meeting domestic requirements, they are active in exports too. The industry covers a wide range of items including tractors, agricultural machinery power tillers, combines, trailers, engines, motors, pumps, sprinkler irrigation, plant protection equipment hand-tools, bullock-carts and animal drawn implements. The industry dealing with agricultural outputs covers handling, storage and processing of agricultural produce.

Consultancy services to the Agro-industry can provide effective marketing and management support, which in many cases is so much needed. Marketing support covers the entire gamut of operations including assessment of demand, development of markets and products, preparation of marketing plans, comprehensive plan for dealership operations, techno-economic studies, technological forecasting, executive searching and development, negotiations on franchise/collaboration/salescon tracts. Then, there are always the special studies in problem areas of high priority, tailored to individual needs. There are good prospects for the Agro-industry in the field of exports, in particular to developing countries in South America, Africa. Middle East and the Far East. Export markets require to be carefully developed in a well organised manner.

SMALL-SCALE INDUSTRIES

The Agro-sector is largely served by small-scale industries. Though the medium scale and the large-scale industries can, to an extent, organize their own help, the importance of consuitancy services to the small-scale indus-

Photo.1. Power Tiller Assembley Line in Indian agricultural machine factory.

tries need not be over-emphasized. Marketing to-day is a very weak area for them. Experience shows that the small-scale entrepreneur is to organize technical skills and good quality production. It is primarily in the field of marketing that he faces serious difficulties which, of course were not anticipated earlier. The industry does not merely require a report from the Consultant on particular aspect of the operations; what will really benefit the industry is preparation of an action plan and its implementation. Consultancy services ought to be encouraged on a sustained i.e., retainer basis.

It is a fallacy that the small-scale entrepreneur finds it difficult to afford professional consultancy services. In fact, if he needs it, he can afford it; results will be in much greater proportion than the investment. Moreover, a number of small-scale entrepreneurs can get together and utilize the consultancy services on a time sharing basis and the general overheads and expenses can be spread over on a number of units.

AGRO-INDUSTRIES CORPORATIONS

In almost every State, we have an Agro-Industries Corporation in the State Sector; some of them are also called the Agro-Industries Development Corporations. The Corporations have now been operating for a few years. Perhaps, it is time to take stock of the experience gained mainly with a view to charting out an accelerated action programme for their role in the present emergency. The Corporation being a business organization is expected to be more result oriented and can participate more effectively in execution of agro-industial development plans. It is suggested that there should be a Federation of the AICs at the Central level to assist them in many of the common problem areas. The scope of activities which can be organized by the federal body can itself form the subject of a separate write-up. For brevity's sake, suffice it will be to stress the importance of pooling of the experience and sharing of the facilities created throughout the country.

The AICs can develop good fraternal trading arrangements among themselves. To conserve resources, duplication should be avoided. Some element of specialisation can be introduced by identifying the strength of each Corporation. Each Corporation can undertake projects though primarily for the benefit of the State, but can also advantageously serve the neighbouring States. The AICs have an important contribution to make in fields like development of Agro industries, accelerating the pace of farm mechanization and organizing Agro services for the farmer, not only providing him with essential inputs but by also assisting him in his operations through custom work, hiring etc.

AGRO-SERVICE CENTRES

A large number of agro-service centres nave now been established during recent years. The centres will continue to require guidance and supporting services. With special emphasis on servicing of small farmers, such centres attain great significance. The farmer must be provided with essential inputs at the place of use in good time and in quantities required. He also require assistance in farm operations as well as post-harvest handling of his produce. Custom work on farm operations and hiring of equipment have to be organized on business lines.

Two factors are very important for the success of the Centres—the experience of the entrepreneur and logistics. It is a wrong as umption that a fresh graduate with three months of training can be transformed into an entrepreneur. Business of this nature requires tactful handling and calls for lot of business acumen and experience. It is, therefore, important that to begin with a nuclei of service centres should be opened under the proper supervision of experienced entrepreneurs. Fresh graduates can work at these Centres not for three months only, but for sufficiently long time so that they are exposed to the finer elements of business. Logistics too have to be properly organsised; these include training (mainly of craftsmen—operators and mechanics), availability of fuels and lubricants finance, etc. Though we have done reasonably well in spreading farm mechanization but the pace can be much faster if we are able to organize logistics.

Photo.2. Ridging with locally manufactured power tiller.

FINANCING INSTITUTIONS

For over 7 years, the nationalised banks have now been active in an organised manner in agricultural financing. It is time to take stock of the situation and lay down proper guide-lines so the agricultural finance will be more result oriented and can even be made use of for influencing agricultural production in the direction desired. Aggregate credit requirements of the agro-sector cannot be met and, therefore, priorities have to be properly determined.

The scope of services required by such Institutions include preparation and appraisal of projects, evaluation of programmers, special studies in problem areas, in-depth investigations with a view to improving recovery and suggesting future course of action, effective co-ordination with input suppliers and borrowers, studies relating to profile of rural borrowers agro-industries and small-scale industries, studies for revival of sick units/accounts, executive searching and development, special projects in collaboration with agencies like World Bank and Asian Development Bank. Though in some areas such services are being organized by ARC, AFC, State Bank and other nationalised banks, but there is room to organize better and faster to cope up with the responsibilities now entrusted to the agricuitural financing institutions. It is not enough to recruit fresh technical graduates or draw on the services of retired personnel. In view of the magnitude and the national importance of the impact of such programmes, the subject requires greater attention in all seriousness. Banks have a proud record, and rightly so, of investing crores of rupees every year in the agro-sector. But proper servicing of these accounts has now become urgent and important.

FARM FUELS

There are now three large-scale public sector Oil Corporations—professional petroleum marketeers with a great tradition, rich experience and wealth of knowledge to serve the farmer more effectively. The Corporations are Indian Oil, Hindustan Petroleum and IBP. It is estimated that farm fuels and lubricants now account for an annual procurement valued at about Rs. 500 crores. Such a sizeable market does require greater attention at the hands of these national Corporations.

The annual report of one of the three Companies does make a mention of farm fuel centres which is a welcome beginning; but lot has to be done provide the farmer with efficient fuel services. He must receive fuels and lubricants unadulterated, in quan ities required at his point of use well in time. He requires technical guidance on proper storage and use of fuels. There are a number of makes of tractors and farm machinery now indigenously made. Lubrication charts and guides on these equipment must be freely available. The Oil Corporations both here and overseas have a good tradition to provide the consumers with efficient service as also technical guidance. The training aids here have to be specially developed suit our local needs. There is a need for organizing a Farm Fuel Advisory

Service with a view to making available to the farmer all the services which in all fairness he is entitled to from fuel marketeers.

Petrol pumps have played an important role in development of the road transport industry in India. Similarly, they can be made to play a still more effective role in Agro-industrial development. A petrol pump can serve as an important base for Agro services. During the season, 24-hour service can be made available to the farmer. Essential agricultural inputs can be marketed through these petrol pumps. Better penetration of the rural markets through petrol pumps can be achieved; a farmer can come to rely on a pertrol pump as a friend in need.

INSURANCE

We now have two public sector Insurance Corporations which too can organize several useful services for the farmer. They are the Life Insurance Corporation of India and the General Insurance Corporation. With the current tractor population of about two lakhs and the annual demand of about 30,000, it is estimated that the premium in case of tractors alone is around Rs. 2 crores a year. There is room for improving the under-writing services to the farmer. Crop insurance and live-stock insurance have received some attention.

Can we think in terms of a package policy to cover farm equipment like a tractor from factory to the farm for a period of say one year from the date of manufacture? Today, the tractor is covered by as many as six policies during its journey from the factory to the farm. Obviously the farmer pays for all stages of this premium directly or indirectly. Looking from another angle, can we have a composite policy to cover the tractor, the owner and the operator? Now that nationalised banks are investing lot of money on farm equipment, its insurance assumes greater importance.

To cover the risk adequately, insurance companies in other countries spearhead safety campaigns. We have yet to make a start in farm safety. With greater use of chemicals on the farm and spread of mechanization, hazards are growing. Safety consciousness has to be aroused, proper training aids, particularly audio-visual, have to be developed; we must train a cadre of trainers so that training can be multiplied on a mass scale.

EDUCATIONAL AND RESEARCH INSTITUTION

There are now nuclei of Agricultural Universities in the country who must equip themselves well to meet the pressures on them. In the realm of Consultancy there can be a two-way traffic with these institutions. They need assistance in teaching, research and extension to be more practical and result oriented. They require to develop an effective co-ordination with the industry, government and the farmer. They require to be equipped with high quality trainers and updated faculty (updating is a regular process). On the other hand, the seats of learning can organize and support consultancy services at the grass root level, Agro Service Centres, Training Institutes Centres, preparation of training media, aids and publications. The Institution can develop and establish models of various useful agencies such as Agro Service Centre, Training Centre, Farm Products Processing Centre, etc., keeping in view the regional needs.

PUBLIC TRUSTS

Vast acreages of agricultural land are available with Public Trusts including Gaushalas all over the country. These lands must be put to productive use. Institutions like Gaushalas need not subsist on sustained charity and doles. If they can prepare plans for development of their agricultural land bring it under cultivation, raise resources through banks for the inputs required and go into commercial agriculture themselves, they will generate their own income. All they will require is a one time donation to get started, but no recurring alms. Couple of institutions who have come to me have already implemented these suggestions and are now running a commercial agricultural venture—not for making profits but for generating funds for public service and financing their own expansion programmes of community service.

Agriculture is a vast subject, the scope becomes still wider when we use the term Agro Industry. An attempt has been made in this write-up to identify some important beneficiaries and the areas in which help can be drawn from professional technical consultancy sbuvices. We have dealt only with a few agencies and some important areas requiring high priority. Neither of the lists is exhaustive. Organizing consultancy for our own Agro services will greatly assist in Agro industrial development. Moreover, we are in a position to make these consultancy services available to developing countries where our knowledge and experience is more relavant and does put us at some advantage. In the context of the need to raise agricultural production and the productivity, organizing professional technical consultancy services in the Agro sector will make a significant contribution. ■ ■

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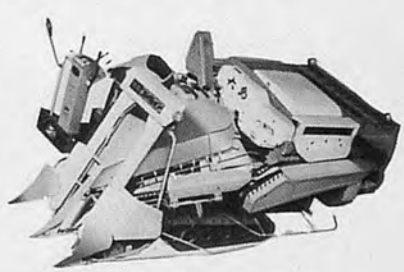

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  Efficiency=60～90minutes/10ares
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  Cutting wide=800mm 2～3row cutting
  Efficiency=40～70minutes/10ares
- model RC-901
  Engine=11～15HP
  Cutting wide=900mm 3row cutting
  Efficiency=40～70minutes/10ares
- model RC-902D
  Engine=15HP
  Cutting wide=900mm 3row cutting
  Efficiency=40～60minutes/10ares
- model RD-1000
  Engine=11～13HP
  Cutting wide=800mm 2～3row cutting
  Efficiency=40～60minutes/10ares
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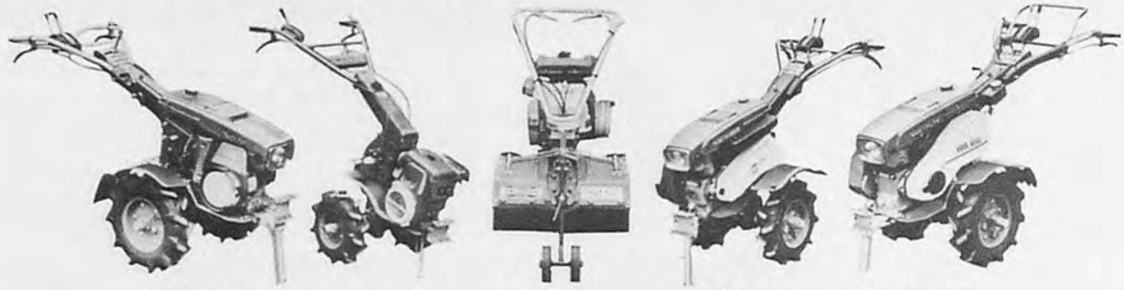

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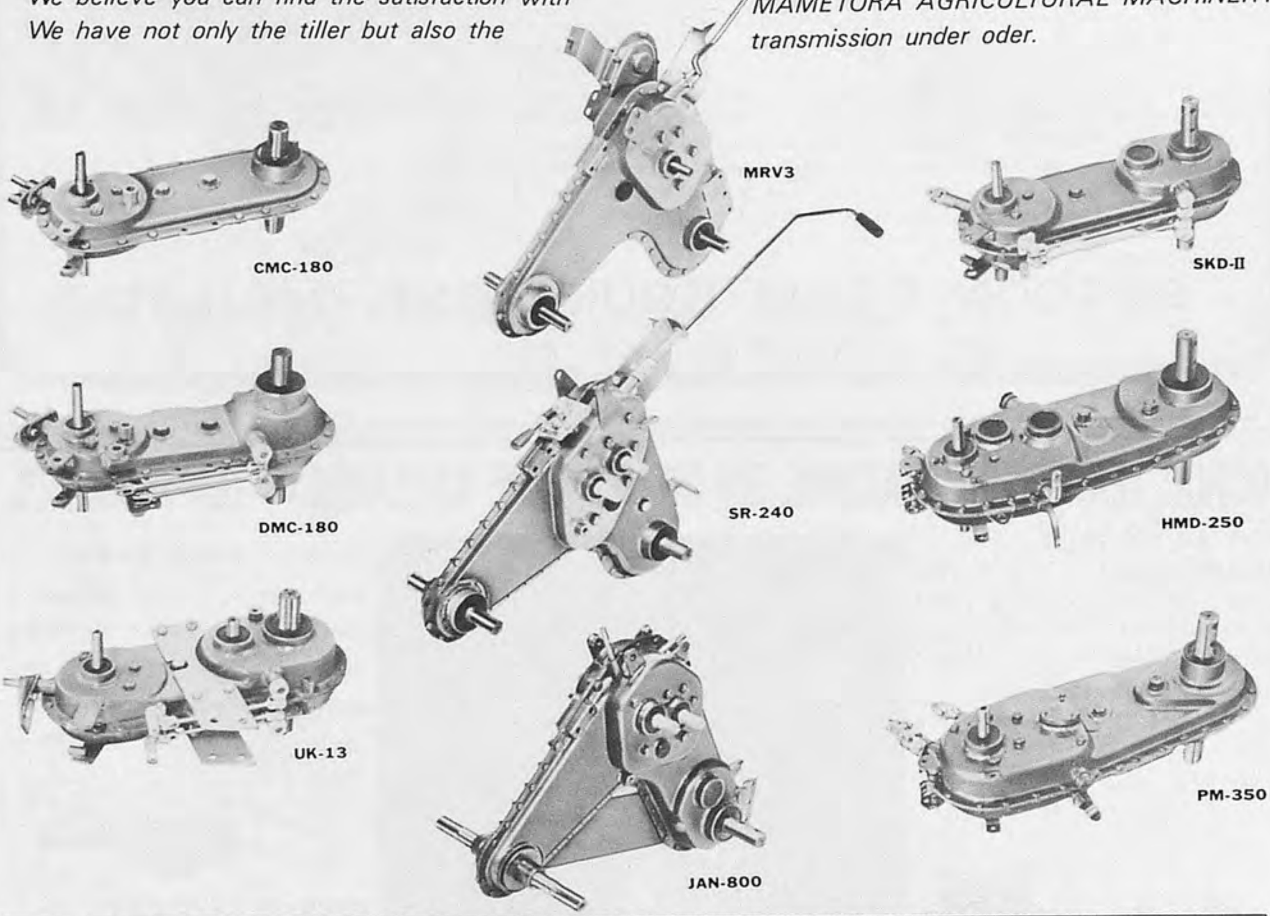

Model		MC-80	MCF-130K	CMC-180	DMC-180	DMC-II	SKD-18	SKD-II	SKD-III	HMD-250	PM-350	UK-13	MH-750	MT-40
Applications(PS)		1·8~2·5	2·0~3·5	3·0~4·5	3·0~4·5	3·0~4·5	3·0~4·5	4·5~6·0	4·5~6·0	5·0~7·0	6·0~8·0	3·0~4·5	3·0~4·5	3·0~4·5
Shifiting Stages		F1	F1, R1	F2, R1	F2, R1	F3, R1	F2, R1	F2, R1	F3, R1	F4, R2	F6,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

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Quick,easy soil salinity measurements

One of the more important chores in the life of an agricultural water manager in the proper management and treatment of saline soils is getting accurate information of the concentration and extent of soluble salts in such soils.

Eyeballing crops and soils in such areas is not enough since salinity may reduce crop yields by as much as 25 percent without visible symptoms.

ARS researchers at the U.S. Salinity Laboratory, Riverside, Calif., have developed two devices that may make life just a bit easier for those charged with keeping salinity down to manageable levels. The devices may one day play a part in reducing or preventing farm income losses from salinity as well as aid in preventing environmental pollution.

Fig.1. Using a new four-electrode device, scients are able to make quick, easy soil salinity measurements in the field. Soil scientist Robert J. Prather adjusts a meter used to measure the resistance of electrical flow between the inner pair of electrodes (PN-4108)

Both devices are adaptations of earth resistivity techniques that have been in use for years by geophysicists to determine depths to subsurface strata and ore bodies. The technique involves the measurement of resistance between electrodes placed on the soil surface.

To date, the reliable diagnosis of salinity has required tests on soil samples that are brought into the laboratory, although less precise measurements may be made in the field with portable field kits.

Even with portable kits, the time and effort required for such procedures are comsiderable because of the numerous samples that must be taken throughout the field and at varying dephs in the profile.

Further, to evaluate the effects or success of various management programs and treatments, it is desirable to monitor soil salinity levels periodically.

It all boils down to present methods taking too much time, effort, and money. For those reasons, a method for determining soil salinity directly in the field without recourse to sampling and analysis should be invaluable both for practical and research applications.

Soil scientist James D. Rhoades and chemist Rebert D. Ingvalson have measured soil salinity in the field with a device which relates soil electrical conductivity (EC) to soil salinity.

Soil EC measurements are

Fig.2. Researchers at Riverside have also developed a single-probe device for taking spot readings of salinity. That device has the four electrodes inlaid in a single shaft (the four metal rings in the photo above, PN-4109), which can be inserted in a standard soil sampler hole (below, PN-4110)

made using four electrodes, equally spaced along a straight line, insterted a few centimeters into the soil surface. Electrical current is passed through the outer pair of electrodes. The current flows through the soil via electrolyte conduction. Resistance to this current flow is measured between the inner pair of electrodes with a resistance meter. Precalibration of the meter relates resistance to soil salinity.

For a given soil type, researchers are able to correlate soil conductivity with soil salinity when such measurements are made at a constant water content. For the study, Dr. Rhoades used field capacity—the moisture content of the soil a day or two after a rain or irrigation treatment—as the water constant because that constant is easily reproducible and available.

A major benefit of the technique is its ability to measure average salinity in a relatively large volume of soil. Depth or volume of the sample can be regulated by increasing of decreasing the spacing between electrodes.

Since plants respond to the salinity of the large soil mass in which their roots grow, the four-probe device lends itself to practical salinity measurements.

Soil salinity is typically highly variable from. spot-to-spot in the field; hence, many soil samples would have to be analyzed in a laboratory to come up with similar readings that take only moments with the EC technique.

Among benefits of the method are:

The lack of need of taking soil samples or making analytical determinations.

The speed and simplicity of the measurement.

The low cost of the required equipment.

The portability and suitability for diagnosis, survey work, or monitoring of salinity.

Dr. Rhoades in cooperation with ARS soil scientist Ardell D. Halvorson, Sidney, Mont., used the four-probe device to survey and map areas of low, medium, and high salinity with good results in their regional studies of saline seeps. Ordinarily such a project would involve time-consuming soil sampling and expensive laboratory analysis.

Since there are times when precise information on soil salinity distribution within the root-zone is needed, Dr. Rhoades in cooperation with Jan van Schilfgaarde, Director of the Salinity Laboratory, only recently developed a four-electrode probe that gives "spot" readings of salinity rather than the large volume readings of the initial device.

The newer four-electrode probe works on the same principle except the electrodes are inlaid in a single shaft so that the probe can be inserted to the desired depth in a hole made with a standard soil sampler. The leads from the electrodes are inside the probe's shaft and exit out the handle to a resistance meter. The shaft is slightly tapered so that firm contact of all four electrodes is achieved upon insertion in the soil.

Studies continue to evaluate the use of the technique at differing water contents under field conditions. Dr. Rhoades is developing a salinity monitoring program in cooperation with local Soil Conservation Service and Bureau of Reclamation personnel in the Wellton-Mohawk Valley of Arizona, involving the new devices to detect any ercessive increases in soil salinity that may result from underirrigation or changes in irrigation procedures. Methods for ascertaining the status of salinity reclamation are being developed in the Imperial Valley by Dr. Rhoades and soil scientist Malek Kaddah employing these same devices.

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by U.S.Department of Agriculture (Agricultural Research, Oct. 1975, Vol. 24, No.4)

Projects approved

$10.5 MILLION TOWARD ECONOMIC AND SOCIAL DEVELOPMENT

A total of 10 projects for social and economic development in 10 countries was approved by the Executive Director of WFP in the period April-June, 1975. The total cost to the Programme is almost $10.5 million.

BOLIVIA

Road improvement in Santa Cruz

Bolivia, the poorest country in Latin America, can, it is believed, advance substantially if the almost empty lowlands are opened up and developed—most of the population lives in the high, harsh, unproductive area of the Altiplano.

Fewer than five hundred thousand of the country's five million inhabitants live in the 390000 km^2 of the Province of Santa Cruz. Their annual per caput income is less than $50, infant mortality is around 50 percent before the age of five and the level of illiteracy estimated to be above 60 percent.

The area is almost unexploited, but has been found to be suitable for growing cotton, rice and sugar cane and for raising cattle. But its agricultural potential cannot be developed until its 1420 kilometres of roads have been rehabilitated.

WFP aid, at a total cost of $1.3 million has been approved to feed 3000 voluntary road workers for 200 days a year over three years.

COSTA RICA

Help to small subsistence farmers

Despite an annual economic growth rate of 8.5 percent since 1960, conditions for the poorest 20 percent of the population —which earns 5 percent of the total income—have improved only slightly.

With the help of a $31 million grant from USAID, the Government has launched an inter-agency programme which covers agricultural services, agricultural education, credit, cooperatives, marketing, land tenure, community organization and municipal development.

Among the Government's main objectives in the scheme is to bring subsistence farmers into the mainstream of modern life by increasing their living standards through the adoption of modern technology. As an incentive to nearly 5000 of these farmers to change from subsistence agriculture (yucca and cereals produced by primitive techniques) to a modern deversified agriculture efficiently producing basic grains, horticulture and fruits, WFP will supply food aid on a rotating basis for four years at a total cost of $1.3 million. The food will sustain them while their land is being reconverted and until such time as they begin to reap the benefits from their new crops.

THE GAMBIA

School feeding and nutritional education

The Programme has assisted the Government since 1971 with a country-wide school feeding programme aimed at increasing school attendance, providing a balanced diet to children and youth in all institutions, promoting nutritional education and hygiene and, indirectly limiting the exodus of young people from villages to towns.

The project has had encouraging results and is well known and popular throughout the country. It has awakened the interest of parents to the extent that many now contribute to it in kind and, sometimes, even in cash.

Because of its success and taking into account the country's difficult financial position, the project has been expanded to include 930 boarders and 21,000 pupils at day schools. In addition, 10 percent of the beneficiaries (2,200) will receive a daily ration during two months of holidays in return for maintaining school gardens and farms. Total cost to WFP : $1,323,000.

GUATEMALA

Rural development through self-help

About 60 percent of the people in this Central American country are employed in agriculture, mainly of the subsistence type. With a high rate of population growth (3.1 percent annually) the demand for employment is increasing rapidly, particularly in the towns.

The Government is giving increasing attention to economic and social improvement in the rural areas to create a higher level of employment, and it has given high priority to infrastructure, health and social programmes in these areas.

The Programme is to give assistance to projects for the construction of 20 rural water supply systems, 12 wells, 100 latrines, 32 health centres, three municipal markets, improvement of 100 houses, establishment of vegetable gardens, construction of ten small irrigation systems, construction of three large water supply systems; construction and improvement of 100 rural schools and ten sports fields; construction and maintenance of 200 kilometeres of 40 feeder roads and ten other infrastructure works.

The total cost to WFP is $1.9 million.

GUINEA

Feeding in hospitals and health centres

Despite Government efforts in the field of health—about 10 percent of the budgetary expenditure is devoted to this sector—much remains to be done.

WFP assistance was requested in order to improve the diet of patients in the hospitals and health centres which would result in a quicker recovery of patients.

The total number of patients who will receive food under the Programme's agreement with the Government for aid at a total cost of $1.2 million for three years is estimated at 5,400 a year in 32 hospitals throughout the country. In addition, 200 students of the National Secondary School of Public Health and university students will receive food aid during their practical training courses at the hospitals.

GUINEA-BISSAU

Returning refugees to receive aid

Some 100,000 refugees from neighbouring countries were expected to have resettled in their previous villages by July. WFP is to provide rations for them for 200 days at a total cost of $1.3 million until their first crops are harvested at the end of the year.

INDIA

Food for children in drough area

Unprecedented drought conditions prevailed in the State of Bihar throughout 1974 resulting in considerable loss of crops and a grave food shortage throughout the State.

To counteract malnutrition and physical disorders which have resulted among children following the drought, the Programme is to feed 185,000 primary school children for 90 days at a total cost of $800,000.

SRI LANKA

Aid for primary schoolchildren

Faced with insufficient foreign exchange to import all the food required, the Government has asked donors to assist them in a holding operation to enable a special feeding scheme for primary schoolchildren to continue for 12 months. CARE (Cooperative for American Relief Everywhere), has been operating in Sri Lanka for 17 years but, in line with USAID policy, it has gradually reduced the number of beneficiaries from 2 million in 1972 to a proposed 800,000 from July 1, 1975. Because of the drought the Government has asked CARE to postpone the proposed reduction of food assistance to 200,000 children for a year and at the same time has requested WFP aid.

The Programme has responded by giving food aid at a total cost of $481,000 to provide the ingredients for a high-protein biscuit, manufactured locally, which will supplement the children's normal diet.

WESTERN SAMOA

Malnourished children to be helped

Agriculture is given prominence in Western Samoa's second Five Year Plan, but until the Government's targets for development are realized there are many children suffering from protein malnutrition—as high as 8.4 percent among children under the age of five.

Among projects to raise nutrition standards—all backed by WFP, UNDP/FAO and the Asian Development Bank—is one for pigs and poultry, the stocking of 50,000 acres of bush highlands with beef cattle, a dairy development project and one for fisheries development.

The Programme has allocated food aid for three years at a total cost of $1.3 million. ■ ■

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by FAO(World Food Programme News July-September 1975)

IRRI names two new rice varieties

Two new rice varieties—IR32 and IR34—have been named by the International Rice Research Institute. Both varieties are broadly resistant to insects and diseases and have special characteristics that adapt them to regions where other IRRI varieties are not suited.

IR32 matures in 140 to 145 days—later than other IRRI varieties. The semidwarf rice may be particularly suited for certain rainfed areas where farmers grow only one crop. In these areas, late maturity is desirable so that famers can harvest and dry the crop after the monsoon rains. In typhoon zones, later-maturing crops may escape storm damage.

Because IR34 is intermediate in height (120-130 cm), it may be suited for rainfed regions or areas where the water becomes too deep for semidwarfs during the monsoon season. Farmers in Malaysia, Indonesia, and other countries often prefer such intermediate-statured rice varieties.

IR32 and IR34 yield about like other IRRI varieties. In the 1975 dry season, IR32 yielded about 5.6 tons per hectare; IR34 yielded 5.9t/ha.

IR32 and IR34 are resistant to the widespread brown planthopper, and to tungro and grassy stunt virus diseases.

Both are also resistant to bacterial blight and green leafhoppers and at least moderately resistant to blast.

IR32's genetic resistance to brown planthoppers stems from a different gene than that of other resistant varieties, IR26, IR28, IR29, and IR30. It carries the recessive gene (bph 2).

Similarly, both IR32 and IR34 are thought to carry different genes for green leafhopper resist-

Table 1. Resistance ratings of IRRI varieties*

Variety	Diseases				Insects				Soil problems			
	Blast	Bacterial blight	Grassy stunt	Tungro	Green leaf-hopper	Brown plant-hopper	Stem borer	Gall midge**	Alkali injury	Salt injury	Zinc deficiency	Phosphorus deficiency
IR8	MR	S	S	S	R	S	MS	S	S	MR	S	MR
IR5	S	S	S	S	R	S	S	S	S	MR	R	MR
IR20	MR	R	S	R	R	S	MR	S	S	MR	R	R
IR22	S	R	S	S	S	S	S	S	S	S	S	MR
IR24	S	S	S	MR	R	S	S	S	MR	MR	S	MR
IR26	MR	R	MS	R	R	R	MR	S	MR	MR	S	R
IR28	R	R	R	R	R	R	MR	S	MR	MR	R	R
IR29	R	R	R	R	R	R	MR	S	S	MS	R	R
IR30	MS	R	R	R	R	R	MR	S	MR	MR	R	MR
IR32	MR	R	R	R	R	R	MR	R	S	—	—	—
IR34	R	R	R	R	R	R	MR	S	S	S	R	R

R = resistant MR = moderately resistant MS = moderately susceptible S = susceptible
*Rated in the Philippines. **Rated in India.

Table 2. Major characteristics of varieties named by IRRI

Character	IR8	IR5	IR20	IR22	IR24	IR26	IR28	IR29	IR30	IR32	IR34
Growth duration											
Dry season (Dec. seeding)	125 days	135 days	120 days	115 days	125 days	130 days	105 days	115 days	106 days	140 days	120 days
Wet season (June seeding)	130 days	145 days	135 days	130 days	125 days	130 days	105 days	115 days	109 days	145 days	125 days
Sensitive to photoperiod	no	weakly	weakly	weakly	no	no	no	no	no	no	no
Grain											
Length	medium	medium	medium	long	long	medium	long	medium	medium	long	long
Width	bold	bold	slender	slender	slender	slender	slender	slender	slender	slender	slender
Appearance	some white belly	some white belly	translucent	translucent	translucent	translucent	translucent	opaque	translucent	translucent	some white belly
Head rice recovery	low	moderate	high	high	high	high	high	high	high	high	high
Amylose content	high	high	moderately high	high	low	high	high	waxy	high	high	high
Gel consistency	high	low	medium	high	low	medium-low	high	low	low	low	high
Gelatinization temperature	low	intermediate	intermediate	low	low	low	low	low	intermediate	low	low
Seed dormancy	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	moderate	high
Seedling vigor	very good	very good	very good	good	good	good	good	very good	very good	very good	very good
Height	90-105 cm	130-140 cm	110-115 cm	95-105 cm	100-110 cm	100-110 cm	100-110 cm	90-100 cm	95-105 cm	100-110 cm	120-130 cm
Tillering ability	high	high	high	high	moderate	high	moderate	high	high	high	high
Lodging	resistant	moderately resistant	moderately resistant	resistant	resistant	moderately resistant	moderately resistant	moderately resistant	moderately resistant	resistant	moderately resistant

ance.

The increased genetic diversity lessens the danger of new insect biotypes multiplying that can survive on and attack resistant varieties.

IR32 is moderately resistant to the stem borer (about like IR20). IR34 is slightly less resistant than IR20.

IR32 was found resistant to the gall midge by scientists at the Central Rice Research Institute (CRRI), Cuttack, India.

IR32 has long, slender grains with excellent appearance. It has a high amylose content and soft gel consistency, which may make it desirable for consumers in areas such as Indonesia and the Philippines.

IR34 is a high amylose type with long, slender grains. Because of its hard gel consistency, its eating quality may be somewhat less desirable than that of IR32.

IR34 was found to be tolerant of zincdeficient soils in greenhouse tests at IRRI.

IR32 was previously known by its experimental line number, IR2070-747-6-3-2. It is a progeny of the cross $IR20^2$/Oryza nivara//CR94-13.

IR34 was previously known as the experimental line IR2061-213-2-17. It is a progeny of the cross $Peta^3$/Taichung Native 1//Gam Pai 15/4/IR-8/Tadukan//$TKM6^2$/TNI///$IR24^4$/O. nivara.

Before releasing the two new varieties, scientists at IRRI and in national programs studied yield data and insect and disease reactions from tests at experiment stations and in farmers' fields in the Philippines, Bangladesh, India, Thailand, and several other countries.—T.R.H.

by The International Rice Research Institute (The IRRI Reporter 4/75)

New wheat provides valuable protein

If the new hard red winter wheat variety Lancota were grown on all of Nebraska's wheat acreage, it would provide about 100 million more pounds of valuable protein each year than present varieties do.

Best of all, says ARS agronomist Virgil A. Johnson, the protein is in that portion of the wheat grain that is made into white flour, so it will not be lost in the milling process.

Lancota is a result of a cooperative effort begun more than 20 years ago by ARS and the Nebraska Agricultural Experiment Station, Lincoln, to improve the nutritional value of wheat by breeding. Dr. Johnson predicts that its development may be only the first step in genetic engineering to make wheat a more nutritious food (AGR. RES., March 1974, pp. 6-7).

Eventually, this research may contribute significantly to the nutritional status of about a third of the world's people who depend upon wheat as a major source of calories and protein.

The new wheat is a selection from a cross made in 1965 of an Atlas 66-Comanche breeding line and the variety Lancer. It derives its higher grain protein content from Atlas 66, a soft wheat carrying genes for high protein from the South American variety Frondoso.

Lancota is the first hard winter wheat variety adapted to the Great Plains with the potential for high yields of grain possessing 10 to 20 percent more protein than ordinary wheat varieties. The additional protein will cost consumers and farmers little or nothing, Dr. Johnson points out, because it is built into the wheat plant. And it does not depend upon the use of additional nitrogen fertilizer.

Like any other new variety, Lancota must initially gain farmer acceptance on the basis of its agronomic qualities, Dr. Johnson explains. Farmers presently have limited market incentive to grow a higher protein variety, but they may plant it if it equals or excels currently grown varieties in yield, disease resistance, and other field characteristics.

Lancota has qualities in addition to its high protein potential that may make it attractive to farmers, millers, and bakers, he says.

It has been consistently superior to its male parent, Lancer, in yield and equal or better in bushel weight in performance tests. It is similar to Lancer in field appearance and stem-rust reaction but much superior in resistance to leaf rust and Septoria leaf blotch. Like Lancer, it is medium in maturity but is somewhat less winterhardy.

The new variety has excellent milling and baking qualities. It is medium in dough mixing time, has good mixing tolerance, and excellent loaf volume potential.

The Nebraska, South Dakota, Kansas, and Texas Agricultural Experiment Stations and ARS joined in the release of Lancota. Limited quantities of certified seed should be available for 1976 planting.

by U.S.Department of Agriculture (Agricultural Research, Oct. 1975, Vol. 24, No.4)

Edouard Saouma of Lebanon elected Director-General of FAO

Photo.1. Mr. Edouard Saouma of Lebanon, was elected Director-General of the United Nations Food and Agriculture Organization (FAO) by an overwhelming majority, receiving 121 votes at the 18th Session of the FAO Conference.

Rome, November 10-- Mr. Edouard Saouma of Lebanon, a senior official of the Food and Agriculture Organization of the United Nations (FAO) since 1962, today was appointed Director-General of the Organization by its governing Conferenece.

Mr. Saouma, 49, received 121 votes out of 125 valid votes cast on the second ballot this afternoon by delegates to the Conference. Five other candidates withdrew after the first ballot, on which Mr. Saouma received an overwhelming lead of 62 votes when 66 were needed for election.

The new Director-General will begin his six-year term of office on January 1, 1976, succeeding Dr. A.H. Boerma, of The Netherlands, who has headed FAO since January 1, 1968.

Mr. Saouma, at present Director of the FAO Land and Water Development Division and Chairman of the Interdepartmental Working Group on Natural Resources and the Human Environment, will become FAO's sixth Director-General and the second from a developing country.

From 1962 to 1965 Mr. Saouma was Regional Representative for the western zone of Asia and the Far East at New Delhi, after which he became Director of the Land and Water Development Division at FAO headquarters.

Previous to his service with FAO Mr. Saouma held a number of senior positions with Lebanese agricultural academic and research institutions and with the Lebanese government. From 1955 to 1962 he participated in all sessions of the FAO Conference and Council as delegate of Lebanon. On 13 October 1970 he was nominated Minister of Agriculture of Lebanon.

Born November 6, 1926, in Beirut, Mr. Saouma is married and has three children. He received a degree in agricultural chemistry from St. Joseph's University School of Engineering, Beirut, in 1949, and the degree of Ingenieur Agronome from the National School of Agronomy of Montpellier, France, in 1952.

Mr. Saouma is fluent in Arabic, English, French and Spanish.

Photo.2. Rome, 8 November 1975-Opening of the 18th Biennial Session of FAO's Governing Conference.

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T.T. Pedersen


G. Pellizzi


B.K. Shrestha


R.P. Venturina

IRRI Publications

FIELD OPERATIONS, MACHINERY AND IMPLEMENTS

Irrigation and irrigation equipment

1. Thougtawee, N. "Measurement of Evapotranspiration and Water Losses in Flooded Fields." Research project conducted under the supervision of Mr. L. Johnson.
2. Johnson, L. 1963. "The Relative Importance of Evaporation, Transpiration, Percolation and Seepage in Flooded Rice Culture." Seminar paper, April 25.
3. Johnson, L. 1965. "Traction Problems on Flooded Rice Soils." Paper presented at the Annual Meeting of the American Society of Agricultural Engineers, University of Georgia, June 20-23.
4. Johnson, L. 1965. "Irrigation of Rice." Saturday seminar paper, August 21.
5. Casem, E. 1966. "Soil Depth Effects on Rice under Lowland Conditions." Paper presented at the Annual Convention of the Philippine Society of Agricultural Engineers, Manila, May 6.
6. Johnson, L. 1967. "Water Use and Management." Saturday seminar paper, September 9.
7. Samuel, J., F. Nichols and S.E. Roy. 1974. "Design of a Centrifugal-Jet Pump Combination—a New Approach for Rice Irrigation and Drainage." Paper presented at the Annual Convention of the Philippine Society of Agricultural Engineers, Manila, April.
8. Samuel, J. 1974. "Development of a Jet Flow Pump." Saturday seminar paper, August 24.
9. Samuel, J., G. Salazar and V. Cueno. 1974. "Lift Irrigation for Rice Production." Saturday seminar paper, August 24.
10. Samuel, J. 1974. "The Jet-Flow Pump." Handout sheet.

Tillage

1. Johnson, L. 1963. "Report on料the Conference on Agricultural Engineering Aspects of Rice Production." International Rice Commission Newsletter. Vol. 7 No. 3, September (reprint).
2. Casem, E. 1965. "Tillage Studies at IRRI." Saturday seminar paper, August 26.
3. Johnson, L. 1967. "Land Preparation." Saturday seminar paper, September 2.
4. Cabanos, P. 1970. "Mobility Studies in Wetland." Saturday seminar paper, August 22.
5. Koike, M. 1970. "Dynamic Analysis of Rotary Tillage." Terminal research report.
6. Gee-Clough, D. 1974. "Characteristics of Single Lugs, Typical of Cage Wheel Lugs, in Wet and Dry Soils." Paper presented at the Annual Convention of the Philippins Society of Agricultural Engineers Manila, April.
7. Orcino, N. and B. Duff. 1974. "Experimental Results from Alternative Systems of Land Preparation." Saturday seminar paper, July 27.
8. Gee-Clough, D. and W. Chancellor. 1974. "Pull and Lift Characteristics of Single Lugs on Rigid Wheels in Wet Rice Soils. "Paper presented at the 1974 Winter Meeting of the American Society of Agricultural Engineers, Chicago, December 10-13.

Fertilization

1. Nanalo, A. 1966. "Anhydrous Ammonia Applications for Lowland Rice." Saturday seminar paper, April 23.
2. Casem, E. 1968. "Fertilizers and Fertilizer Applicators for Lowland Rice." Saturday seminar paper, September 14.
3. Navasero, N. 1974. "Equipment for Application of Agricultural Chemicals." Saturday seminar paper, August 31.
4. Navasero, N. 1975. "Deep-Placement Chemical Applicators for Lowland Rice." Paper presented at the 6th Annual Scientific Meeting of the Crop Science Society of the Philippines, Bacolod City, May 8-10, and at the Annual Convention of the Philippine Society of Agricultural Engineers, Manila, May 15-16.
5. Navasero, N. 1975. "Deep--Placement Chemical Applicators for Lowland Rice." Saturday seminar paper, July 19.

Planting

1. Reyes, R. 1966. "Plant Spacing in Direct Row-Seeded and Square-Hill Transplanted Rice." Paper presented at the Convention of the Philippine Society Agricultural Engineers, Manila, May 6.
2. Navasero, N. 1969. "A Row Seeder for Lowland Rice Soils." Saturday seminar paper, September 6.
3. IRRI. 1970. "Fast Seeder." The IRRI Reporter, Vol. 6 No. 2.

4. Wikramanayake, V.E.A. 1971. "Direct Seeding and Transplanting of Rice." Paper presented at the International Rice Research Conference, IRRI, April 19-20.
5. Agricultural Engineering Dept. 1971. Row Seeder Manual.
6. Padolina, C. and F. Nichols. 1972. "Methods of Seeding and Transplanting of Rice." Saturday seminar paper, August 19.

Pest control.

1. Takenaga, T. 1971. "Technical Problems in Mechanization of Pest Control." Institute of Agricultural Machinery, Omiya, Japan (reprint).

Weeding

1. Navasero, N. 1968. "Mechanized Weeding in Wetland." Paper presented at a joint UPCA-IRRI seminar, September 30.
2. Navasero, N. and A.U. Khan. 1969. "Use of Mechanical Power for Rotary Weeding." Paper presented at the Convention of the Philippine Society of Agricultural Engineers, IRRI.
3. Navasero, N. and A.U. Khan. 1970. "Use of Mechanical Power for Rotary Weeding." PANS. Vol. 16 No. 1 (Reprint).
4. IRRI. 1970. "Power Weeder for Paddies." The IRRI Reporter, Vol. 6 No. 2.

POST-HARVEST OPERATIONS

Harvesting and threshing

1. Casem, E. 1967. "Harvesting and Threshing." Saturday seminar paper, September 9.
2. IRRI. 1967. "Lightweight Paddy Thresher." The IRRI Reporter. Vol. 6 No. 3.
3. Casem, E. and A.U. Khan. 1969. "Physical Properties of the Rice Plant and Paddy." Saturday seminar paper, August 23.
4. Khan, A.U. 1971. "Harvesting and Threshing of Paddy." Paper presented at the International Rice Research Conference, IRRI, April 19-21. Paper No. 71-05.
5. Agricultural Engineering Dept. 1971. Table Thresher Manual.
6. Khan, A.U. 1972. "New Harvesting and Threshing Equipment for Small Tropical Farms." Paper presented at the IAMFE Third International Conference on the Mechanization of Field Experiments, Brno, Czechoslovakia, July 10-15.
7. Ramos, B., J. Policarpio and F. Nichols. 1973. "Harvesting and Threshing Equipment Development at IRRI." Saturday seminar paper, June 23.
8. Samson, B. and B. Duff. 1973. "The Pattern and Magnitude of Field Grain Losses in Paddy Production." Saturday seminar paper, July 7.
9. Agricultural Engineering Dept. 1975. Axial Flow Thresher Manual.

General papers on rice milling and processing

1. Khan, A.U. and V.E.A. Wikramanayake. 1971. "A Laboratory Test Tube Rice Miller." Agricultural Engineering Dept. Paper No.71-08.
2. Van Ruiten, Harry. 1971. "Recent Developments in the Rice Milling Industry of the Philippines. "Paper presented at the International Rice Research Conference, IRRI, April 19-21. Agricultural Engineering Dept. Paper No.71-09.
3. Khan, A.U. 1971. "Rotary Grain Cleaner for Tropical Countries." Handout sheet.
4. Wimberly, J. 1972. "Review of Storage and Processing of Rice in Asia." Agricultural Engineering Paper No. 72-01.
5. Khan, A.U. 1972. "Rice Drying and Processing Equipment for Southeast Asia." Paper presented at the ASAE Summer Meeting; Hot Springs, Arkansas, June 27-30. ASAE Paper No. 72-339.
6. Agricultural Engineering Department 1972. Grain Cleaner Manual.
7. Agricultural Engineering Dept. 1972. Bibliography of Drying and Processing Studies in Southeast Asia.
8. Duff, B. and I. Estioko. 1972. "Establishing Design Criteria for Improved Rice Milling Technologies." Saturday seminar paper, August 26.
9. Duff, B. 1972. "A Note on Economies of Size in Rice Milling Systems." Paper prepared for the UPCA/UNDP/FAO Seminar Workshop of the Philippine Grain Centrals Association. UPCA/UNDP Project on Training of Technicians for the Grain Industries, Manila, August.
10 Agricultural Engineering Dept. 1972. References on Grain Loss Studies.
11. Z. Toquero, B. Duff, T. Anden and Y. Hayami. 1975. "Estimating the Elasticities of Home Consumption and Marketable Surplus for a Subsistence Crop: Rice in the Philippines." Agricultural Engineering Dept. Paper No. 75-02.
12. Arboleda, J. 1975. "Impro-

vement of the Kiskisan Rice Mill." Saturday seminar paper, July 5.
13. Ramos, B. 1975. "Manufacture and Performance of Paddy Threshers in the Philippines." Saturday seminar paper, July 12.
14. Toquero, Z. and B. Duff. 1975. "Technical and Economic Factors Affecting the Efficiency of Mechanization in Rice Post-Production Systems." Saturday seminar paper, July 26.

Drying

1. Amilhussin, A., A. Manalo and A.U. Khan. 1970. "Accelerated Drying of Paddy." Saturday seminar paper, September 5.
2. IRRI. 1970. "Drying Paradox: Wet is Better." The IRRI Reporter Vol. 6 No. 2.
3. Manalo, A., A. Amilhussin and A. U. Khan. 1970. "Drying Chemically Treated Paddy to Break Dormancy." Saturday seminar paper, Sept. 5.
4. Manalo, A. 1970. "Design Data on Counterflow Drying of Rice." Paper presented at the Seminar-Workshop on Grain Processing. University of the Philippines College of Agriculture, December 7-10.
5. Manalo, A. 1970. "Paddy Drying Research at IRRI." Paper presented at the Annual Convention of the Philippine Society of Agricultural Engineers, UPCA, December 11-12.
6. Manalo, A. 1971. "Rice Hulls as Fuel for Drying Paddy." Saturday seminar paper, September 11.
7. Manalo, A., J. Arboleda and A.U. Khan. 1972. "Drying and Processing Research at IRRI." Saturday seminar paper, August 12.
8. Manalo, A. 1973. "A Low-Cost Grain Dryer." Paper presented at the Annual Convention of the Philippine Society of Agricultural Engineers, Manila, January 25-26.
9. Arboleda, J. 1973. "Accelerated Conduction Drying of Paddy." Paper presented at the Annual Convention of the Philippine Society of Agricultural Engineers, Manila, January 25-26.
10. Arboleda, J. and A. Manalo. 1973. "Paddy Drying." Handout sheet for the Agricultural Engineering Session of the Rice Production Training and Research Program, IRRI.
11. Khan, A., A. Amilhussin, J. Arboleda, A. Manalo and W. Chancellor. 1973. "Accelerated Drying of Rice Using Heat Conduction Media." Paper presented at the Annual Meeting of the American Society of Agricultural Engineers, Lexington, Kentucky, June 17-20.
12. Arboleda, J., A. Manalo, A. Khan. 1973. "Accelerated Drying of Paddy." International Symposium on Preservation of Wet Harvested Grains, Institute National de la Pecherche Agronomique, Paris, March 5-10.

MECHANIZATION IN AGRICULTURE AND ECONOMIC DEVELOPMENT

1. Johnson, L. 1963. "Power Requirements in Rice Production." Paper presented at the Conference on Agricultural Engineering Aspects of Rice Production, August 11-17.
2. Johnson, L. 1964. "Mechanization of Philippine Farms." Paper presented at the Second Irrigation Institute Conference, May 29.
3. Johnson, L. 1964. "Mechanization to Improve the Standard of Living in Tropical Rice-Growing Areas." Presented at the ASAE Winter Meeting, New Orleans, Louisiana, December 8-11.
4. Johnson, L. 1965. "Mechanization to Improve the Agriculture of Developing Countries." Presented at the Annual Meeting of the Indian Society of Agricultural Engineers, New Delhi, November 11.
5. Johnson, L. 1966. "Is Mechanization Possible Where Rice Is King?" Agricultural Engineering, Vol. 37, No. 3
6. IRRI. 1966. "Labor and Procedure for the Pedal Thresher." Technical Paper No.2, September.
7. Casem, E. O. and E. Ruiz, 1967. "An Analysis of Rice Farm Operations in Central Luzon" Presented at the Annual Convention of the Philippine Society of Agricultural Engineers, May.
8. Johnson, L. 1967. "Mechanization of Rice in Tropical Areas." Thursday Seminar Paper, May 25.
9. Khan, A. U. 1968. "Agricultural Machinery Research and Development at the International Rice Research Institute." Paper presented at the meeting of the Japanese Society of Agricultural Machinery, Kyoto, Japan, April 6-8.
10. Khan, A. U. 1968. "Agricultural Machinery Research and Development at the International Rice Research Institute." Paper presented at the Fifth Session of the International Rice Commission Working Party on the Agri-

cultural Engineering Aspects of Rice Production, Storage and Processing, Kandy, Ceylon, September 5-9.
11. Khan, A. U. 1969. "Agricultural Machinery Development Program at the International Rice Research Institute." Paper presented at the VII International Congress of Agricultural Engineers, Baden-Baden, West Germany, October 6-12.
12. Khan, A. U. 1969. "Position Paper on Agricultural Engineering Research in the Philippines." Presented at the Advisory Committee on Agricultural Research Meeting, National Science Development Board, Manila, August 28.
13. Khan, A. U. 1970. "Mechanization Research for Tropical Agriculture." Paper presented at the Annual Meeting of the American Society of Agricultural Engineers, Minneapolis, July 8-10. ASAE Paper no. 70-114.
14. Khan., A. U. 1970. "Machanizing the Tropical Farm." Agricultural Engineering. Vol. 51, No. 11 (Reprint).
15. Khan, A. U. 1971. "Equipment for Mechanized Tropical Agriculture." Paper presented at the seminar on the Mechanization of Agriculture in West Africa, Bambey, Senegal, January 25-29. Agricultural Engineering Departtment Paper No. 71-02.
16. Khan, A.U. 1971. "Agricultural Machinery Development at the International Rice Research Institute." Paper presented at the seminar on Mechanization of Rice Production and Processing, Paramaribo, Surinam, September 27-October 2. Agricultural Engineering Department Paper No. 71-07.
17. Khan, A. U. 1971. "Present and Future Development of the Mechanization of Rice Production." Paper presented at the seminar on Mechanization of Rice Production and Processing Paramaribo, Surinam, September 27-October 2. Agricultural Engineering Department Paper No. 71-06.
18. Khan, A. U. 1971. "Machinery Development for Tropical Agriculture." Agricultural Mechanization in South East Asia. Spring.
19. Khan, A. U. 1972. "Agricultural Mechanization: The Tropical Farmer's Dilemma." World Crops. Vol. 24
20. Duff, B. 1972. "Design, Development and Extension of Small-Scale Agricultural Equipment." Paper presented at the Seminar on Farm Mechanization in Southeast Asia, November 27-December 2, A/D/Ç and MADA, Penang, Malaysia.
21. Khan, A. U. 1972. "New Agricultural Equipment from the International Rice Research Institute." Agricultural Mechanization in Asia. Vol. 3.
22. Khan, A. U. 1972. New Machinery for Tropical Agriculture." Paper presented at the International Conference on Tropical and Sub-Tropical Agriculture, Honolulu, American Society of Agricultural Engineers, April 11-13.
23. Khan, A. U. and B. Duff. 1972. "Agricultural Mechanization Technology Development at the International Rice Research Institute." Paper presented at the seminar on Priorities for Research on Innovating and Adapting Technologies for Asian Development, Woodrow Wilson School, Princeton University, New Jersey, September 20-23, and at the conference on Technology, Employment and Development, CAMS, Penang, Malaysia, January 3-5, 1973.
24. Khan, A. U. and J. Policarpio. 1972. "Mechanization Thchnology for Small Tropical Farms." Saturday seminar Paper, September 2.
25. Policarpio, J. 1973. "Power Tiller and Tractor Development at IRRI." Paper presented at the Annual Convention of the Philippine Society of Agricultural Engineers, Manila, January 25-26.
26. Khan, A. U. 1973. "Appropriate Technologies: Do We Transfer, Adapt, or Develop?" Paper presented at the Ford Foundation Seminar on Technology and Employment, New Delhi, India, March 21-24.
27. Khan, A. U. 1974. "Appropriate Mechanical Technology for Developing Countries." Paper presented at the AAAS Symposium on "How Can Technology in the United States and Developed Countries be directed towards Helping Developing Technologies in the Less Developed Countries?", San Francisco, March.
28. Khan, A. U. 1974. "Mechanization Technology for Tropical Agriculture." Paper presented to the Study Group on Low-Cost Technology and Rural Industrialization, OECD, Paris, September 17-20.
29. Khan, A. U. 1975. "University Research and Industrial Research in the LDC." Paper presented at the 1975 Annual

Meeting of the American Society of Engineering Education, Fort Collins, Colorado, June 16-19.

ECONOMICS OF MECHANIZATION

Mechanization and Employment

1. Johnson, L. 1963. "More Farm Power for More Days of Farm Production per Year." Paper presented at the First National Convention of Pump Irrigators sponsored by the National Federation of Pump Irrigation Associations, Manila Hotel, January 23.
2. Johnson, S., E. U. Quintana and L. Johnson. 1967. "Mechanization of Rice Production." Pappr presented at the Seminar Workshop on the Economics of Rice Production. IRRI, December 8-9.
3. Johnson, S. 1968. "Performance and Economics of Use of Small Equipment in Tropical Monsoon Countries: The Case of the Philippines." Paper presented at the Annual Meeting of the Japanese Society of Agricultural Machinery, Kyoto, Japan, April 6-8
4. Orcino, N. 1970. "Economic Aspects of Hand Tractor Ownership and Operation." Saturday Seminar Paper, September 22.
5. Duff, B. 1971. The Impact of Improved Varieties and Agricultural Mechanization on the Labor Force Absorption Problem in West Pakistan." Tables and charts. Thursday .Seminar Paper, February 25
6. Duff, B. and N. Orcino. 1971. "Economic Research in the Department of Agricultural Engineering." Saturday Seminar Paper, August 21.
7. Crisostomo, C., W. H. Myers, T. Paris, B. Duff and R. Barker. 1971. "The New Rice Technology and Labor Absorption in Philippine Agriculture." The Malayan Economic Review. Vol. X VI (Reprint).
8. Duff, B. 1971. "Economics of Mechanizing Large versus Small Farms in West Pakistan." Paper presented at the International Rice Conference, IRRI, April 19-21.
9. Barker, R., W. H. Myers, C. M. Crisostomo and B. Duff 1972. "Employment and Technological Change in Philippine Agriculture." International Labour Review. Vol. 106.
10. Duff, B. 1972. "Mechanization and Employment in Philippine Agriculture: Some Empircal Evidence." Paper presented at the Seventh Session of the IRC Working Party on Agricultural Engineering Aspects of Rice Production, Processing and Storage, November 3-6, Bangkok.
11. Estioko, I. 1972. "CB: IBRD Farm Mechanization Credit Program: Philippines." Paper presented at the Seminar on Farm Mechanization in Southeast Asia, November 27—December 2, A/D/C and MADA, Penang, Malaysia.
12. Orcino, N. 1972. "Economic Aspects of Hand Tractor Ownership and Operation." Paper presented at the Seminar on Farm Mechanization in Southeast Asia, November 27—December 2, A/D/C and MADA, Penang, Malaysia.
13. Orcino, N. and B. Duff. 1973. "Technical and Economic Characteristics of Tractor Contract Operations in Central Luzon." Saturday seminar paper, June 30.

Comparative Economic Studies of Rice Production and Processing

1. Alicbusan, L. C. 1964. "The Rate of Substitution of ManHours by Animal or Machine Horsepower Hours in Rice Production." August.
2. Barker, R., S. Johnson, N. Alviar and N. Orcino. 1969. "Comparative Economic Analysis of Farm Data on the Use of Carabao and Tractor in Lowland Rice Farming." Paper presented at the Farm Management Seminar with Focus on Mechanization, U.P. Institute of Small-Scale Industries, Manila, February 24—March 1.
3. Johnson, S. 1969. "Terminal Report on the General Engineering and Economic Research Portion of Contract No. AID/csd 834."
4. Toquero, Z. and B. Duff. 1974. "Survey of Post-Production Practices among Rice Farmers in Central Luzon." Saturday seminar paper, September 7.

Economic Aspects of Machinery Manufacturing and Marketing

1. Johnson, L. 1967. "Comments, Definitions, and Personal Opinions to Explain the Tropical Rice Producers' Conditions and Problems of Machinery Manufacture." Project Committee Meeting of Contract No. AID/csd-834.
2. Cabanos, P. 1971. "Jeepney Manufacturing in the Philippines, A Model for Developing the Agricultural Machinery Industry." Agricultural Mechanization in South East Asia, Vol.2 (reprint).

Show Report from Europe

Remarkable Machinery and New Products

by Shin-Norinsha Co., Ltd.

EIMA

The 6th EIMA (Esposizione Internazionale delle Industrie di Macchine per L'Agricoltura) sponsored by UNACOMA (Unione Nazionale Costruttori Macchine Agricole) was held at Bologna in Italy from Dec. 19th to Dec. 23rd in 1975. 670 companies including 125 from overseas exhibited their agricultural machinery, components, spares and accessories.

The show was crowded with 35,000 visitors. As the number of foreign visitors reached to 3,500 and the participant rate of companies increased 10 percent in proportion to that of last year, the sponsor was pleased for the success.

Characteristics of the Exhibition

The most distinctive point in the show was that there were a lot of small-sized machinery for the animal industry, vegetables, fruit trees and rice crops reflecting versatile agriculture in Italy. A large number of small-sized farm working machinery similar to walking power controllers developed by IRRI of Philippines were exhibited. It shows that we can make use of them in the versatile fields of farming such as feedstuff and vegetable production.

As for a tractor, output of boarded engine in majority was considerably large compared to its body. Most of engines with more than 5 h.p. were Diesel engines and for the solution of increasing weight of engine, air cooling was adopted to save cost of fuel and simplify handling. 34 tractor manufacturers participated for the exhibition of walking tractors. 31 manufacturers for wheel tractors and 10 for four wheels drive articulate tractors. With the recent tendency of tractor development, articulated types increased covering a small-sized tractor about 20 h.p..

In Italy, most of manufacturers produce about two or three hundred tractors a year. In spite of the small figure in production, the selling price in Italy seems to be much cheaper than in Japan. The secret of the cheaper price is that there are specialized tractor parts makers and they are in cooperation with tractor manufacturers keeping touch with them. Processing and finishing was not always good. Other exhibited machinery could be said the same thing. However I could see the merit that machinery were devised to improve handling efficiency based on practical use.

As for tillage implement and machinery, I could see a lot of rotaries. There were also various shapes of tillage nail and working constructions. I could admit the result of new technical development in the censor for avoidance of obstacles. We should mark that tillages equipped with them increased.

Though some new combine harvesters were exhibited, I could not find any original points except that there were several varieties of horse power and cutting width. However, to keep an operator in a healthy condition, it was paid attention that adoption of the equipments which sent out the purified air or excluded dust with two fans.

Plenty of working machinery for fodder crop production were exhibited, I could remark the tendency of technical development on the side of lightening an effort for bale conveyance. It has been long since baler was devised to facilitate the transportation of hay, there were working machinery to transfer from two to thirty bales at the same time, or ones, which are now increasing, to carry a big bale.

As for a manure spreader, front spreading type took place instead of rear spreading type which had been once prevalent. Merit of the front spreading type was explained that an operator could have the wide sight at the time of spreading. At the English exhibition, the rear spreading type still occupied the leading place, and it was a good comparison with this Italian Exhibition EIMA.

As for fruit culture, pest control machines equipped with censor to suspend medicine spreading between fruit trees, running work-stand to facilitate the high-place working, pruning scissors for harvesting worked by air pressure, shakers, drawing harvestings for vine and harvesting for small grain fruits were fresh.

☆ ☆ ☆

Tractor

Valpadana 4RM20—24···

Engine : 24HP SAE at 3,000 rpm-Diesel-One cylinder—27HP SAE at 3,000 rpm-Diesel-two cylinders. Clutch : dry, single plate, foot control. Gearbox : 8 speeds of which 6 forward from 1 to 18 km/h and 2 reverse from 1 to 6.5 km/h. Differential : on both axles with double locking, foot control. Traction : four driving wheels. Power take off : number one indipendent at 2 speeds or synchronized with all the speed of the machine, reverse included. Power lift : max. lifting capacity kg. 650. Turning radius : max. 106cm. Weight : without ballasts 700 kg.

(Valpadana s.p.a.)

Power unit for garden

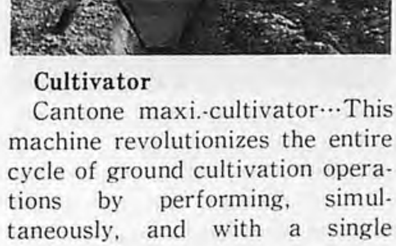
"ALCINO" The all-purpose interchangeable driving unit···For lawn mowing, heage cutting, bush trimming, watering, paint spraying, tyres inflating, hoeying, snow-ploughing etc. Technical data : Two-stroke 48 cc. 2 HP motor, automatic clutch, two-speed gear-box, quick, snap-on mounting, easy self-winding starter.

(Alcegarden s.p.a.)

Rotary ditchers

Dondi mono-doublewheel ditchers···Possibility of effecting the cleaning by only one operation, depositing the removed soil on only one side of the ditch. The digging operation of a new ditch is carried out by several passages according to the depth requirements, to the kind of soil, to the minimum advancement speed of the available tractor and the power of the tractor same. 30° inclination trapezoidal digging section. Coupling to the universal 3 point connection of all wheel tractors and operation with p.t.o. at 540 r.p.m. Operation speed 1,000/1,300 m/h.

(Pietro Dondi & Figli)



Cultivator

Cantone maxi.-cultivator···This machine revolutionizes the entire cycle of ground cultivation operations by performing, simultaneously, and with a single operator, all the various stages : ploughing, harrowing or hoeing, levelling, drainageditching, broadcast and localized fertilizer distribution, weed control and sowing.

Engine : 12 cylinders, 17,000 cc, maximum power 314 BHP air-cooled.

Total weight of machine equipped for wheat and maize cultivation : 9,550 kg.

Working depth : 10-35 cm (max.)

Hoeing-rotors : 780 mm diameter

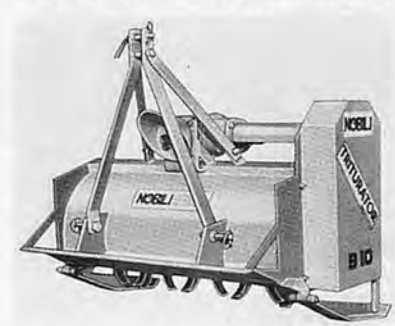
Minimum turning radius with 60—70 HP tractor : 480 meters.

(Cantone Industria macchine Agricole s.p.a.)

Trim-chopper

Triturator B 10···This machine suitable for chopping every fibrous, and also all the branches of the plants after the pruning. The triturator is applyed to the hydraulic powerlift of the tractor and works on its nomal running lines, taking its movement from the power drive. The triturator in its working position skins the ground through two plates, placed laterally, and everything which is in its path as it advances is beaten down by knives and cut to pieces.

Working width : 100cm, depth : 75cm. reccomanded RPM of trac-



tor PTO : 550, minimum power requirements : 20÷25 CV-HP, number of knives : 32, weight (without PTO) : 160kg.

(Nobili s.p.a.)

Digger

Sicma VP10···Gear : provided with 4-speed gear, for standardized power take-off at 540 revolutions, speed revolution 110′—125′—140′—180′, which, on the ground of the tractor advancing, permits to change the speed revolutions. So it is possible both to adjust the unitary production-capacity, and the degree of the ground mincing.

Working width : 242cm, depth : 34cm, power requirements : 40÷90 HP, weight : 840kg.

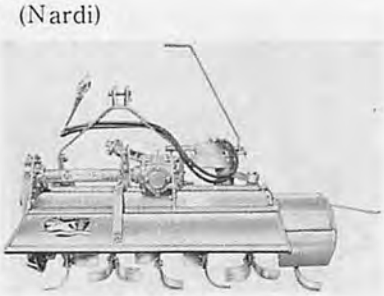
(Sicma)

Rotary hoe

Nardi ZLI/c 140···Ideal for the complete working of vineyards and orchards. This, in fact, perform in a single operation hoeing between rows and between each tree in the row. The lateral displacement and the return of the machine is obtained by a feeler with three adjustments which permits the machine to work at the required distance from the trees. The cover extention on the right hand side of the hoe is shaped specially to prevent any damage to the trees and fruits.

Working width : 140m, HP : 30—45.

(Nardi)



Spray car

Barrow mounted sprayer ···Tank : Made of polyethylene, 15 imp. gals. capacity, complete with filter and cover and mechanical agitator.

Pump : Piston type, oil-bath working, operated by hand ; with unified ball valves made of INOX steel 18/8.

Frame : Steel tube made ; with revolving handles to allow packing in the carriage box.

Wheel : Disk wheel of stamped plate with semipneumatic rubber tyre, with two bushings.

(F. lli Giacomo & Luigi Carpi)

Atomizer/duster

OMA Jumbo TP 45···Designed to perform treatments to all trees and all that plantations where owing to the nature and disposition of plants no machine can be handled.

A gun distributor can instead be set, both in horizontal and vertical position. With distributor vertically positioned, the jet reaches 20 metres approx., while the horizontal position ensures a 25m long jet.

Supplying a delivery of 40 litters/min. at a pressure ranging from 0 to 30 Atm. Absorbed power 28÷30 hp approx.

(OMA)

Rotary manure spreading cart

Spanoiletame. R50···This is specially designed to spread any kind of manure, and also excellent for spreading waste and for transporting fodder.

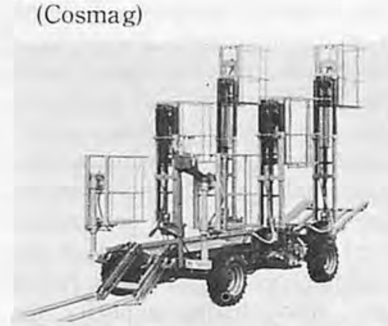
Rotor diameter : 1.20m, Sideboard height : 0.70m, Useful volume : 4.80mc³, Capacity : 5ton, Spreading : lenght up to 6m, track 1.35m, Power required : 25HP, Weight : 1.1ton, Wheels : 2, Tires : 10—00—20.

(Santini Giuseppe & C.-S.N.C.)

Picking machine

Cosmag "SEM 4/6B"···Self propelled fully hydraulic controlled machine for pruning and picking fruits in bins, provided with 6 independent platforms which can turn and raise by hydraulic control, powered front fork to load the bins, traslation of the same on the platform and rear unloading by skib. All mouvements and forward are operated by the hydraulic system which also permit to use shears on all platt forms.

(Cosmag)



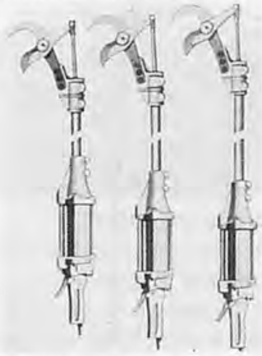
Air compressor and pneumatic shears for cutting

Mod. 14B···Compressor group, with 4-air intake tank, provided with pneumatic circuit breaker

for automatic no-load working, air cleaner and lubricator group. It is applied to the three points of tractor's hydraulic powerlift, which works by power take off. Intaken air 490 l.-700 rpm.

Mod. 19-20-21B···Pneumatic shears for cuttings as far as 50mm with 1-1, 5-2m extension.

(Buratti Ennio & C.)



Collecting machine

Olivia e nocciola 100···This machine thoroughly solves the problem of collecting olives, nuts, chestnuts and almonds. It is applicable to all types of tractors and motorcultivators.

Volume of centrifugal separator : 165 dmc, Collecting surface : 200-300 mq/ph, Tube-length : 5m, Max operating surface : 10m, Intaking-tube diameter : 100mm, Riddles diameter : from 10ϕ to 25mm, Approximative weight : 400kg, Length of the machine : 2.5m, Width of the machine : 1.15m, Inlets : 2m.

(Tonutti s.p.a)

Grafting machine

"Dueffe" Automatic pneumatic-operating portable grafting machine···This machine carry out the grafting operation directly in the field. This easy-to-use grafting machine functions pneumatically and its use in the field is made possible through the assistance of a compressor unit which may be applied to cultivators or tractors of any type.

Maximum cutting diameter : 15mm, Maximam pressure : 10atm, Net weight : 2,250kg.

(Angelo Barison)

Combine harvester

Laverda combine M112···Cutting width 3.10-3.60-4.20m. Cutting height min. 0.04m, max. 1.00m, capability to cut 0.25m below wheels level.

Drum with 8 rasp bars, width 1,040mm, diameter 600mm.

Four straw walkers, length 3.56m with drawer type extension of 0.16m, cleaning area 3.71+0.17 sq.m.

The feed auger delives grain to center of tank and in high position. Capacity of grain tank 2,650 l.

Diesel six cylinders. Power output (Din 70,020) 94HP at 2,200rpm.

Weight with 3.10m table 6,200kg.

(Ditta Pietro Laverda s.p.a.)

Container

G. Menci tractor towed trailermounted container···Perfectely suitable container for carriage and quik einsilage of cereals, maize, fodder, meals, etc. Elevation of the polydirectional unloading archimedean screw from 20° to 90° and orientation at 360°. Single archimedean screw with large capacity : up to 60 tons/hour. Working by means of tractor's p.t.o. and cardan joint.

MG30TC capacity : 5.5m³, 3.5tons.

(G. Menci & Figli s.n.c.)

Beet harvester

Self-moving "Europa"-Bifilar···United yards machine, self-moving, working on two files, executes beet-roots neck-cutting, cleaning, estirpation and picking up. The neck-cutting is made by two indented plates under which two knives are situated. A side-delivery rake puts the collars on two files. The machine can work on 42-55cm distant files. Machine and members movement is produced by a Diesel motor-6 cylinders-4 phases-120 HP-ais-blast cooling. Maximum speed allowed : 20 km/h-working speed 6/10km/h. The daily output on two 50 cm files is about 5/6 Ha in 10 hours of work. Sizes : height mm 3,250, length mm 6,050, breadth mm 2,750, tare kg 5,600.

(P.Barigelli & c.s.p.a)

Mower-cutter loader

Europa self-propelled harvester type 150/TS···This machine can work with any kind of fresh, semi-dry or dry fooders. It has the possibility of using three different harvesting head : corn head ; pick-up, mowing bar.

6 cylinder 140 HP Diesel motor. Hydro-static drive-axial piston pump and motor. Differential-with brakes and epicyclic reduction gears. Steering-hydrau-

lic rear wheel. Max. speed-25km/hr. Cutting-blower-9 blade, 1,350rpm. Cutting length-from 3 to 200mm.

(A. Berni & Figli)

Mower/picker

SANTINI self-moving mower/picker R4500…Designed for high forage mowing, loading, moving and unloading performance with a single operator. Central steering system with power steering allows easy, safe and effortless driving and better visibility both when working and when running on the road. Double blade mowing bar with hydraulic lifting. 45HP Diesel motor. Single dry disk clutch. Automatic bed unloading.

Max. width : 2.15m, max. length : 6.80m, max. height : 3.07m, height w/arches down : 2.75m, bed height : 1.00m, forage capacity : $32m^2$, capacity : 4 ton.

(Giuseppe & C.-S.N.C.)

Bale wagon

E. Pancaldi mod. Unipak 150…For loading, transferring, unloading and piling of bales. Capacity : 144 bales 36×46~126 bales 40×48. Time of loading : 15-20 minutes. Time of uNloading : about 5 minutes. Length of the bales : from 0.90 meters to 1.10 meters. Production : 50-70 Ql/h : variable in conformity with the product and the distance. Tare weight : 3,200kg.

(Ernesto Pancaldi)

Elevator

Caravaggi elevator…High flanked elevator, with double stiffening ribs, made of stamped plate and connections for ensiling.

Pneumatic wheels, adjustable hubs with ball bearings.

By request : a reduction-unit for lifting, with a cardan-joint ; a four-wheeled carriage.

String chain, of special type with plated cast iron sheaves with watertight ball bearings.

(Caravaggi)

Silos frigieri

Silos frigieri mod. S.F./C.…It consists of

a) a rotating mechanical compressor, driven by an explosion engine.

b) a central tube, around which the compressor rotates.

c) a double screw feeding apparatus for the mechanized spreading and levelling of the fodder on the silo. This apparatus is driven by a self-contained explosion engine.

d) a metal band, made up of interchangeable sections, supporting the fodder ; this band is automatically lifted by the compressor.

Construction : all metal, with top quality materials. Axles, pins and gears are mounted on ball bearing.

Working capacity, with the screw feeding and spreading apparatus : approx. 150 to 250q. cut fodder per hour (max. length : 15cm.).

(Silos Frigieri)

Ensiling machine

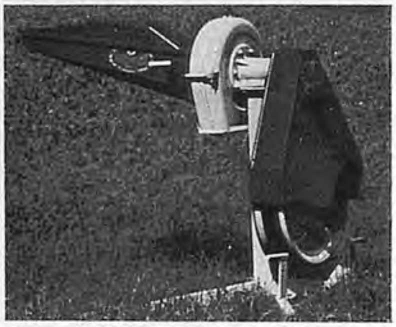
Peruzzo super 100 Universal…For the ensiling of the maize up to an height of 25m. For the ensiling of the integral cut up at waxy state into the vertical silos and earthed horizontal. For grinding dry fodder.

Hourly output : 6,000—10,000kg/h. Needed power : 80-100HP. Maximum prevalence : 25m. Weight : 980kg. appr. Feeding stair with friction and manual release. Grinding group fitted with 150 hardned steel hammers.

(Peruzzo Adriano)

Hammer mill

Vulcano mini…Hammer mill for grinding and ensilage. The finished are wheat, maize, in-



tegral ear, oats, barley, vine-branches, lucerne, hay.

The mini Vulcano can work with knives or hammers or with hammers or knives. It is mounted on a column and has three fastening points for lifting from tractor. It is supplied with four screens and on demand with 30 HP cardanic shaft. On demand also with electric motor.

(Flli Deidone)

ROYAL SMITHFIELD SHOW

The 1975 Royal Smithfield Show was held in Earls Court of London from the 1st to 5th of December, 1975. The 1975 was the significant year when A.E.A., one of the sponsors of this show, celebrated its Centenary and the agricultural machinery exports this year reached £515.2 million (51% growth compared with last year), whcih exceeded the target £500 million from January to October. That's why the show was full of enthusiasm.

The feature of the show

The 1975 was the year of British National Farm Safety Year and the show was the significant chance to sum up the safety promotion movement. From the 1st of September 1977, a tractor without safety cab will be prohibited from using and from the 1st of June 1976, a new tractor must install safety cab of which noise level is under 90 dBa. Therefore, this show became a good opportunity to judge which tractor manufacturers or which cab manufacturers have the best technique.

There were many tractors with quiet cab in the show. Among them, we could find tractors of which noise level was under the indicated value, 90dBa and even some of them were 86 dBa. There were, however, a big difference in the technique among the manufacturers, so we could also find many manufacturers which were trying hard to reach the indicated value. Accompanied the new regulations will become effective in 1976 and 1977, the demand in cab will be increasing. It is uncertain that whether the manufacturers will be able to supply with enough cabs corresponding with the great demand.

The operation of farm working machinery becomes harder owing to fitting up with cab to a tractor, combine and others. As a countermeasure, remotecontrolled farm working machinery will be developed by applying electricity and hydraulic system in future. The manual operation from a window of cab is a present practical way. We found also hitch in the show, by which farm working machinery can easily equip to a tractor.

It was the another feature of this show that the transportation means for straw and hay have developed variously. In England, the farmers who were using big bale became hundreds houses in 1975 and there is a arospect that the demand will increase. But, on the other hand, there are many farmers who are anxious about whether big bale is surely fit for a British weather. So that, various kinds carriers have been developed for small bale or for big bale.

In connection with this, a transport vehicle was greatly improved and we saw a fork lift truck which could run on a rough land.

Compared with EIMA Show in Italy which covered a wide display, the Royal Smithfield Show concentrated on big machinery such as a tractor, combine, etc. A tractor trends to become a large size, a front wheel drive tractor, an articulated tractor and to equip with deluxe cab. In a combine, a grain separator has been improved and it is becoming a big size more than one loaded 150 hp engine. In livestock, besides the mentioned development of carrier, a high performance baler and an automatic feeder were remarkably improved. In the management of hay, chemicals for preventing from rottenness during storing and the results of development in adding method were displayed. In meters, a monitor which use for the elevation of accuracy of combine were displayed as well as a moisture meter for grain and hay, etc.

Addition to them, the improved machinery and new typed machinery of grinder, zigzag saw, welder, etc., which are used at dealers, were displayed and appealed very enthusiastically.

☆ ☆ ☆

Tractor

Leyland 262···The Leyland 262 is a new development to meet farmers' demands for more power and improved all-round performance. We are confident that its power and versatility will suit the needs of farmers both large and small, and make it an outright winner in its class. Important features to noto are : Leyland's high torque 4/98 series engine ; a strengthened rear axle ; improved PTO design ; a ten forward and two reverse multi-speed geerbox ; high capacity hydraulics with all the services you need, and tyre equipment to match.

(British Leyland UK Ltd.)

Tractor

County 7600-4···The design of the new model, differs from system of Four Wheel Drive to four equal size wheels by utilising one rear axle casing to take the power from the crown wheel carrier to a conventional front driven axle.

Immediate advantages of this drive system are that it avoids lengthening the tractor wheelbase.

The drive take-off incorporates a manually operated pre-selective clutch for engagement and disengagement of the front axle, which is easily controlled on the move by the driver. Maximum power of the 7600-4 is 97 bhp at 2100 rpm.

(County Commercial Cars Ltd.)

Tractor

International 1046···The 1046 4-wheel drive tractor is qualitybuilt, from engine through to final drive, just as all International tractors are.

The power behind this tractor is modern, high-torque International diesel engines that meet the most advanced requirements.

The safety cab is Isomount mounted to isolate vibration and noise from the operator. Visibility is excellent for all types of operations.

Wheel treads adjust to meet the requirements of varying field and row-crop situations.

(International Harvester Co. of Great Britain Ltd.)

Tractor

New Ford 5600···The new 5600 has a 4 cylinder diesel engine producing 68 bhp at 2100 rpm. 8 speed constant mesh transmission with independent p.t.o and optional 2 speed p.t.o.

Optional Ford Dual Power Inboard wet disc brakes 12×36 rear wheels with 7. 50×16 fronts

Lifting capacity at the ball ends is 3820 lbs.

Hydraulic pump flow is 7.7gpm.

The new Ford 5600 incorprates many of the standard improvements listed for the lower horsepower models.

(Ford Moter Co. Ltd.)

Tractor

John Deere 8430···It is a U.S. built articulated 4 wheel drive twin wheel tractor, powered by a 215 hp SAE, 6-cylinder variable speed, valve-in-head, turbocharged and inter-cooled diesel engine.

The quad range transmission is split up into four ranges providing 16 forward and 4 reverse gears.

It is fitted with an exclusive Sound Gard Body, designed to provide a comfortable working environment and to protect the operator in most accident situations.

(John Deere Ltd.)

Tractor

MF 1505···Massive dimensions of the new 180 hp pivot steer MF 1505 tractor include a height to the top of the cab of nearly 11 ft and overall length of nearly 19 ft. On the luxury cab, the operator can "dial" his own comfort with full air-conditioning forming part of the standard equipment. The armchair-type seating is fully adjustable to suit individual prefereneces. Liberal use of sound-absorbing materials forms an integral part of the high standard of trim and contributes to low sound levels.

(Massey-Ferguson (U.K.) Ltd.)

Tractor cab

David Brown Quiet Cab···This view of the interior of the new David Brown safety cab illust-

rates : the compact instrument layout incorprating the steering colum ; the relocation of manual controls ; and the armchair seating. The maximum noise level is well below the proposed legal limit of 90 decibels, applicable from June 1976.

(David Brown Tractors Ltd.)

Rotavator

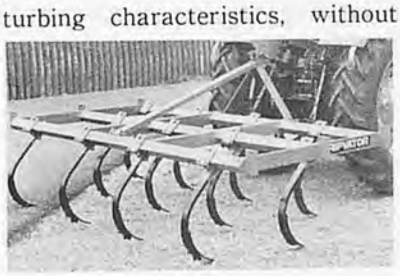
The Howard HA70···HA70 Rotavator is one of a new range of machines with tillage widths from 40″ (102cm) to 80″ (204cm) suitable for tractors up to 50 h.p. An important feature of this machine, which has the Selectatilth gearbox and other Howard characteristics is that it is available with three alternate rotors fitted with standard blades, cultivating blades, or spikes, which can be changed in about 20 minutes in the field.

(Howard Rotavator Co. Ltd.)

Cultivator

Ripvator J-Tine···To the Ripvator spring-tined cultivator range has now been added a J-Tine version, fulfilling a need in the medium cultivations range of machines.

These J-shaped tines have been specially developed by Ripvator to cater for medium duty ripping, general cultivation and preparation of soil for cereals and root crops. They offer excellent penetration with good soil disturbing characteristics, without clogging.



(Watveare Overseas Ltd.)

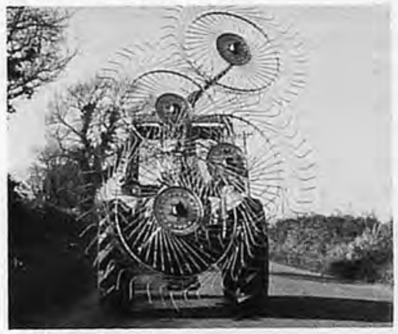
Rakes

The British Lely Superake ···Overlapping rake wheels mounted on heavy duty roller bearings are fitted with high quality spring steel tines with optimum flexibility ensuring fast, clean raking in all conditions, and long troublefree life.

Flexing tines gently turn two 5′ or 6′ swaths at a time, leaving crop lightly inverted and exposing wet crop to sun and wind for fast drying.

Superake fingerwheels tease the crop gently fluffing and turning the swaths, leaving the crop evenly and lightly spread for maximum exposure and drying.

(British Lely Ltd.)



Broadcaster

Agrospread···Designed by fertiliser engineers for the accurate application of fertilisers at rates varying from 1-20 cwts. an acre. Evenness of spread is obtained by a precision method of directing the fertiliser flow on to a constant speed hydraulic spinner. The landwheel driven feed chain controls the application rate an acre independently of tractor speed. This is the ideal machine for distributing bulk fertiliser from a central farm store to the field.

(Hargreaves Fertilisers Ltd.)

Seed Drill

Allis-Chalmers 723···The model 723 drill is a 23 row machine with a sowing width of 8ft. 8in.

The high clearance Suffolk coulters, fitted with replaceable wear shin pieces are spaced at 4½ in. (11.4cm). Large clearance between front and rear row of coulters allows free flow to the soil.

The 23 coulters are maintained in the working position by 3 large tension springs and are lifted by twin hydraulic rams.

With a hopper capacity of over 25 cu. ft. nearly 11 cwt. of wheat or 10 cwt. of barley may be carried.

(Jones Balers Ltd.)

Drill

New Giant Model MF30···With 50 per cent greater output than the existing largest model, a new giant version of the highly successful MF30 drill requires tractors of about 90 hp to make maximum use of its big capacity. It has an overall width of 21 ft 3 in, and is available as a 30 row standard spacing grain and fertiliser combined drill or a 47 row narrow spacing grain-only machine. With all the features of the MF30 for extreme accuracy of seed and fertiliser distribution at operational speeds in excess of 6 mph, MF say that the giant new model is capable of 100 acres a day performances, assuming that farmers are able to organise the necessary fast loading and trans-

port of seed and fertiliser.

(Massey-Ferguson (U.K.) Ltd.)

Combine harvester

Western/Dania D 1600···The Dania D-1600 Combine provides a choice of cutting widths of 10ft or 12ft. The cutting table is readily detachable, and a separate towed carrying trailer is available, if required. A 6 cylinder diesel engine of 100 h.p. (SAE) provides ample power for all harvesting conditions. A large grain tank of 65 bushels is centrally placed for even weight distribution. Particular attention has been paid to operator comfort, with all essential controls at the driver's hand. Hydrostatic Orbitrol steering contributes to easy handling, and an electro-hydraulic cutting height pre-setter provides instant adjustment of the hydropneumatically ballanced cutting table, to save time on turning and manoeuvering.

(Dronningborg Maskinfabrik)

Combine harvester

John Deere 975···The John Deere 975 combine is the largest in the range of new combines introduced by John Deere Limited, Langer, Nottingham. It is powered by a 167hp SAE turbocharged diesel engine and is fitted with the exclusive John Deere cross-shaker. It also has a newly designed operators platform.

(John Deere Ltd.)

Sugar beet harvester

Armer/Salmon 3 in1···Armer-Salmon's latest machine, designed to reduce from three to one, the number of stages involved in beet harvesting, operations, saves both time and cuts costs in terms of the number of operators and machines required. The new three-row harvester lifts and loads over an acre of beet per hour, using just one 70h.p. tractor and one operator.

The 3 IN 1 Sugar Beet Harvester consists of two units which are attached to the same tractor. The topper unit consists of an articulated frame attached to the front of the tractor and a lifter-/cleaner/loader attached to the rear. Both units are equipped with independent automatic row finders.

(Armer Salmon Agricultural Machinery)

Forage harvester

Sperry New Holland 339···The model 339 is a trailed off set 5 foot cut machine, capable of direct cutting, picking up wilted crop, mowing and mulching crop residues.

Primarily designed to accommodate a wide range of tractor sizes and types the Model 339 has an entirely new drive line which is available as original equipment

in 540 or 1000 RPM at no additional charge. The principal feature of this drive line is the 100° gear box which reduces built in power loss, fatigue, and stress by reducing the operating angles through which the universal PTO joints have to work.

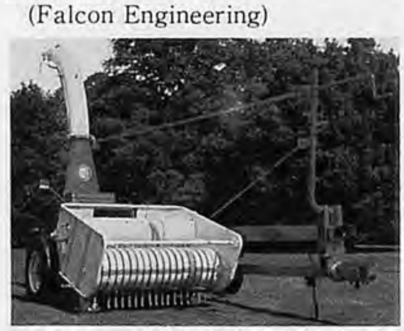
(Sperry New Holland Division, Sperry Rand Ltd.)

Forage harvester

Rivierre-Casalis H500···The unit has been designed to operate with high horse power tractors offering a reversed driving position kit—the purpose being to offer the user all the operational advantages of a self propelled machine.

The machine has the same general demensions as the trailed Standard H500 with a large 24in diameter, 20in wide cylinder, normally equipped with six blades but, for special purposes, the machine can be operated with three or nine knives.

(Falcon Engineering)



Forage harvester

Vicon-Gehl CB 600···Vicon-Gehl CB 600 Forage harvester can be fittedwith an independent power unit, using a Ford type 2715E 6cylinder diesel engine, mounted centrally above the axle, with a 4 belt drive to harvester primary gearbox.

The independent drive is shearbolt protected and provides from 93-106 hp for chopping and blowing.

This arrangement maximises output, as forward speed can be controlled by the twing tractor to exactly match the crop conditions. Ideal for the contractor or for the farmer wishing to obtain high output with only medium tractor.

(Vicon Ltd.)

Wagon

Manns-Gilibert 505···This is a truly multi-purpose machine. Using two spanners it takes at most, only minutes to convert from one use to another.

Out standing features :

1) Heavy duty chains and box-section slats on bed and angle slats on cross conveyer feed ensure complete reliability.

2) Hydraulically operated parallelogram system raises body clear of chassis for turning.

3) Variable speed, forward and reverse control mechanism for bed-feed. Adjustable by lever mounted above drawbar.

(J. Mann and Son Ltd.)

Trailer

Tydraulic···This New Tydraulic, the Tye-Lift, has all the equality of trailers which over the years have earned our reputation.

The advantages of this type of special trailer vary, of course, from farm to farm, depending upon the application. The two main advantages are the ability to tip from a height, to save, for example, restacking of sugar beet with a tractor frontend loader.

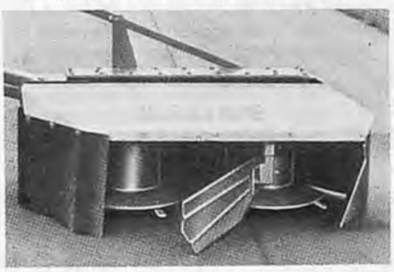
(Tye Trailer Co. Ltd.)

Turbo mower

Krone TM2/165 DI···The TM2/165 DI (5ft 6in) is a three point, fully mounted unit equipped with both Category I and II mounting links. The connecting hitch is an all welded rugged design that enables effortless attachment.

The large diameter rotary drums are driven by a heavy duty drive shaft that is fully encased and continually libricated. No V-belt drive-always constant drum speed. The crop passes between the clearance of the rotaring drums without any clogging or plugging. The knives on the drums are attached in such a way which prevents binding on the knives. The arrangement of the units and new screw make it easy to loosen the bolt even when stone damage or excess wear has occurred.

(Bernard Krone (U.K.) Ltd.)



Chemical filler

All man chemical filler···It is a simple chemical self-filling attachment which cuts out altogether the need for filling by hand.

The operator has only to put a nozzle into the container, turn a valve, and the chemical is sucked into the sprayer.

The chemical filler is an optional extra-costing £31.00 plus VAT-for the Allman Spraymaster Major and 150 models. It is attaches to a new injector type water filling device fitted on both machines—along with a new control giving fingertip on/off, pressure regulation, boom selection and "suck-back" to reduce nozzle drip.

(E. Allman & Co. Ltd.)

Precleaner

Lockwood···A new precleaner for canning potatoes is being introduced of the Royal Smithfield Show by Lockwood Graders (UK) Ltd., Eves Corner, Danbury, Chelmsford, Essex CM 3 4NH.

The machine utilises X-rays to detect stones and clods—which are rejected by 26 pneumatically operated and closely spaced fingers.

The machine, which has a thoughput of about 12 tons per hour, will handle potatoes down to as small as 7/8 in diameter. Labour for the final hand selection has been reduced by at least four people.

(Lockwood Graders (UK) Ltd.)

BACK NUMBERS

◇ ◇ ◇

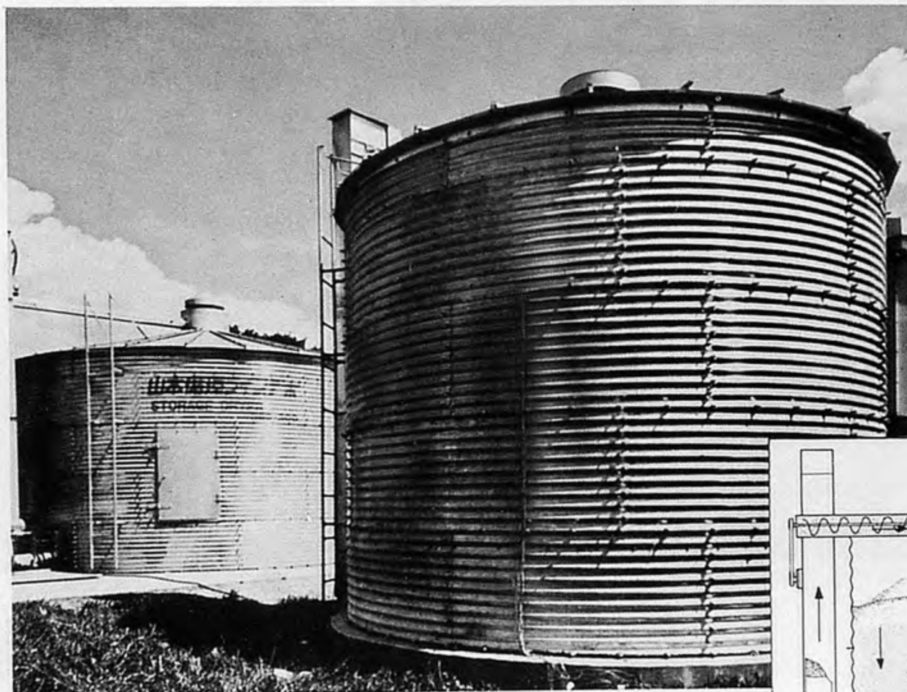
◇ ◇ ◇

INDEX TO ADVERTIZERS

YAMAMOTO: Our machines are the best helpers to you.

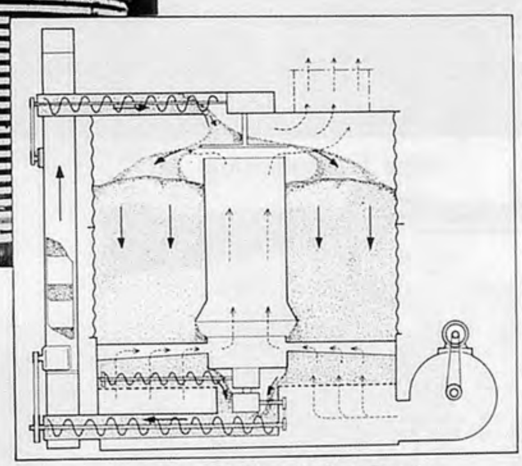
YAMAMOTO RICE DEPOT

Rice harvest depends on right cultivation. As YAMAMOTO RICE DEPOT makes a new dryer system which fits with any regions and enterprises, it perfectly dry and store.



Rice Depot

YAMAMOTO RICE DEPOT can manage any amount up to 8 tons.



Explanation of Circulation Dryer

Specification

Type: SBD-3
Dimention: 4.3m (wibth) × 3.5m (length) × 3.4m (height)
(size of bin: 3m (diameter) × 2.7m (height))
Maximum capacity: 8 ton

YAMAMOTO MFG. CO., LTD.

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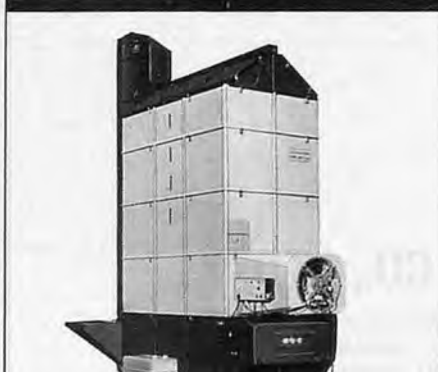
ISEKI's mechanization system for farm works

Rice Transplanting

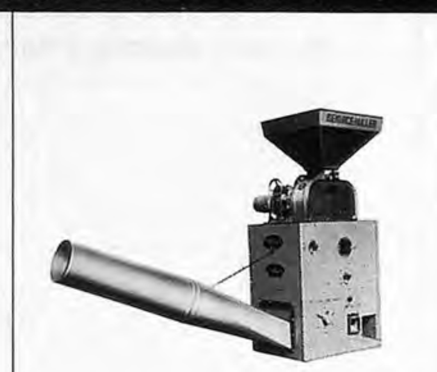
Rice Transplanter

Harvesting (Reaper Binder)



Dryers ITC series

Thresher D series



Rice Huller (all steel type)

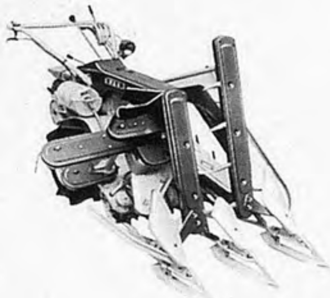
4-wheel
Tractor TS series

Let ISEKI play the main role on your farm today!

Power Tiller KC series

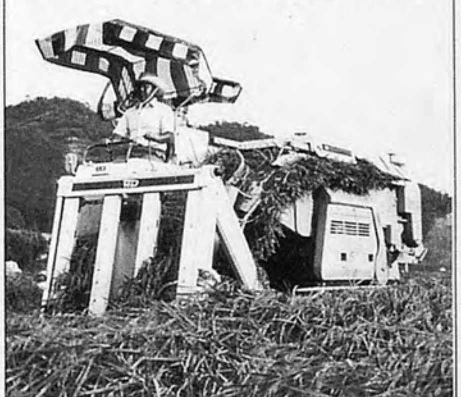
Power Tiller KS series

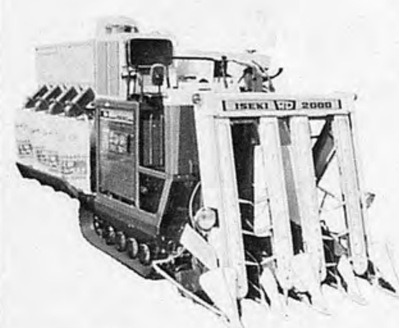
Power Tiller AC series



Reaper Binder RS series

Harvesting (Combine Harvester)





Combine Harvester HD series

Rice Polisher

FARM EQUIPMENT & MACHINERY

ISEKI AGRICULTURAL MACHINERY MFG. CO.,LTD.

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