International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.23, NO.1, WINTER 1992

Special Issue:

The Farm Machinery Industry in Japan and Research Activities, Part II

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

WE KNOW RICE!!

Since 1896

SATAKE CORPORATION

Ueno Hirokoji Bldg, Ueno 1-19-10, Taito-ku, Tokyo, Japan
Telex No. 265-5993 Cable Address: SAHIKO, TOKYO
Tel. 03-3835-3111 Fax. 03-3832-4503

CONTRIBUTORS WANTED

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

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

VALIANT TEA HARVESTER

MCT10

A Dependable Way of Making Tea Harvesting a Lot Easier

Features

- Picks Best Quality Leaves
- Simple Operation; High Efficiency; Economy
- Uuique Design; Sturdy Construction; Long Life
- Simple Design and Easy Operation
- Crawler Type; Good Maneuverability

MST-E2

Features

- Picks Best Quality Leaves with High Efficiency
- Unique Design; Long Life
- Simple and Easy Operation
- Self-propelling; Labor-saving

MATSUMOTO KIKO CO.,LTD

Head Office: 9325, MAKINOUCHI, EI-CHO, IBUSUKI-GUN, KAGOSHIMA-PREF:JAPAN
TEL.0993(36)1161 FAX.0993(36)2829

International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.23, NO.1, WINTER 1992

Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

Editorial, Advertising and Circulation Headquarters
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101, Japan

FARM MACHINERY INDUSTRIAL RESEARCH CORP.
SHIN-NORIN Building
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101 Japan
Printed in Japan

This is the 74th issue since the issue, Spring of 1971

EDITORIAL

Appropriate Agricultural Technology

Appropriate agricultural technology is a recurring issue among aid-givers, academicians, policy-makers and elsewhere in both developed and developing economics. It derives from the basic concept that in order for a certain technology to qualify as appropriate for a given setting, it has to be technologically feasible, economically viable and duplicable, hence be acceptable to end-users under existing local conditions.

This means that the scientists/engineers who developed the technology should be fully able to demonstrate its feasibility; the technicians should prove its duplicability; and the economists should probe its viability or economic effects. Only when these preconditions are met will the technology "sell" or become acceptable to the policy-makers, financial institutions, private entrepreneurs and most of all, to the target end-users, i.e., the farmers.

Agricultural mechanization is one such technology that is equally a recurring issue among the exponents of agricultural progress, the AMA very much included. As a matter of fact, we editorialized in a recent issue of AMA the significance of two eye-opener articles in that issue which provided empirical evidence on the economic effects, feasibility and acceptability of farm mechanization in two separate countries at almost the same time frame. The message was simply that tractorization need not necessarily displace human and/or animal labor in farming. In effect, those two case reports cited that agricultural mechanization is an idea whose time has come because it fits the local conditions and that, therefore, it is an appropriate agricultural technology.

A similar study in the present issue of AMA is reported by four Chinese professors/researchers from Shejiang Agricultural University in South China wherein they found that "...The conditions for agricultural production can be improved if the farming operations are mechanized. Mechanization plays an important role in timely operations of farm work and securing the productivity of crops under unfavourable weather conditions." They also stressed that "...with the development of rural enterprises (through the introduction and acceptance of farm mechanization and improvements in grain post-harvest technologies), more labor was required by the enterprises and other sidelines."

Simply put, the China study highlights the fact that for China and Chinese farmers, agricultural mechanization is an appropriate agricultural technology which when fully practised in the entire country, the Chinese farmer will soon be exporting farm products in large scale, hence help narrow the gap in food production and consumption in many countries of the world, particularly in alleviating the hardship in countries where 15 to 20 million people, mostly children, die of starvation every year as FAO reported recently.

Taking advantage of this opportunity, the AMA staff wishes to extend to everyone Happy Holidays as 1991 comes to a close and 1992 is ushered in!

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January, 1992

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 23, No. 1, Winter 1992

Yoshisuke Kishida	13	Editorial
C. Murugaboopathi, M. Tomita, E. Yamaji, S. Koide	15	New Rice Growing System to Increase Labor Productivity in Japan
R.N. Sharma	20	Indian Standards on Oil Milling Industry
C.P. Gupta, Totok Herwanto	23	Design and Development of a Direct Paddy Seeder
Muhammad Farooq, Abdul Majid, S. Iqbal Ahmad	28	Developments in Mechanical Planting of Sugarcane
L. Peipp, E. Maehnert	33	Development of A Technical Solution to Cassava Harvesting Problem
Aziz Ozmerzi, Ibrahim Cilingir	37	Use of Colorimetric Technique in Determining Surface Coverage in Spraying
Marilou B. Montemayor	39	Cotton and Weed Seedling Emergence as Affected by Seedbed Preparation
Abdul Razzaq, Ch. Bashir Ahmad, Ch. Bashir Ahmad Sabir	42	A Comparative Study of Partial vs Complete Mechanized Harvesting and Threshing of Wheat
J.C. Igbeka, M. Jory, D. Griffon	45	Selective Mechanization for Cassava Processing
Kassim Skultab, Anthony K. Thompson	51	Design for A Night Ventilated Onion Store for the Tropics
S.N. Asoegwu	56	Growth and Productivity of Egusi-melon as Affected by Tillage Depth
A. Kaloyanov, Ch. Petkov, Il. Rousev	61	Mechanization of Vegetable Growing in Bulgaria
R.K. Bansal, O. El Gharras, J.H. Hamilton	65	Performance of Draft Animals at Work in Morocco: Draftability and Power Output
M.A. Khan	71	Farm Mechanization in Rajasthan in India
Farm Machinery Industrial Research Corp.	74	The Present State of Farm Machinery Industry
Takeo Yamaguchi	78	General Outline of the Research Activities of Tropical Agriculture Research Center
Osamu Kitani	83	An Introduction to the Department of Agricultural Engineering Faculty of Agriculture, The University of Tokyo
Jyunichi Yonemura	87	Agricultural Mechanization Program at the Tokyo University of Agriculture and Technology
Makoto Hoki	90	Introduction to Department of Bioproduction and Machinery, Mie University
Jun Sakai	93	The Agricultural Machinery Industry after World War II in Japan
Shin-Norinsha Co., Ltd.	103	Main Products of Agricultural Machinery Manufacturers in Japan

News 108
Book Review 109

* * *

Co-operating Editors 110
Back Issues 112

New Rice Growing System to Increase Labor Productivity in Japan

by
C. Murugaboopathi
Post-Doctorate Research Associate
Biological and Agric. Eng. Dept.
North Carolina State Univ.
Raleigh, U.S.A.

M. Tomita
Prof.
Agric. Eng. Dept.
Univ. of Utsunomiya
Utsunomiya-shi, Japan

E. Yamaji
Assoc. Prof.
Agric. Eng. Dept.
Univ. of Tokyo
Tokyo, Japan

S. Koide
Institute of Agriculture and
Forestry Engineering
Univ. of Tsukuba
Tsukuba-shi, Japan

Abstract

In order to increase the labor productivity in rice growing, a new system called "Large-sized Paddy Field Using Direct Seeding Supported by Subsurface Irrigation (LFDSSI) System" was developed in Japan. The concept, problems and prospect of this new system is described in this paper.

Introduction

Compared to the western agriculture, Asian rice cultivation is generally considered as labor intensive, and especially in a labor scarce country like Japan with only 8% of the total population engaged in agriculture (FAO, 1986). The main target in rice cultivation is to reduce the labor input and increase labor productivity. The labor cost of rice cultivation in Japan is 46 times that of U.S.A. (Tsujii, 1988) which clearly indicates the necessity to reduce the labor input in rice growing.

Development Towards Increasing the Labor Productivity

In Japan, the total population employed in agriculture decreased from 26% to 8% between 1965 and 1985 (FAO, 1986). The drastic reduction in agricultural population was due to the movement of labor population from agriculture sector to non-agricultural sectors. However, the labor input in rice growing has also been decreasing steadily over the century, and labor input fell by about 75% over the period from 278 man-days per ha in 1874 to 68 man-days per ha in 1985 (Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan, 1988). As shown in **Table 1**, the decrease in labor input during the last 30 years is very high compared to the decrease in the previous 80 years, which is mainly due to the introduction of mechanization in land preparation, harvest and post-harvest operations (**Table 2**). And during this period, the introduction of herbicides reduced the labor input for weeding.

New techniques like shifting from medium-sized machinery to large-sized machinery by enlarging the plot size should be developed in order to reduce the labor input. **Table 3** shows the change in power used for different farming operations in Japan. It will be shown that more mechanization is possible by introducing the LFDSSI system since the farming operations like plowing will be done by large-sized tractor and seeding will be done by direct seeding machinery. **Fig. 1** shows the machinery used for land consolidation with respect to increase in plot size. When the plot size is increased, it becomes necessary to introduce laser-controlled bulldozer so as to achieve the precise field leveling.

Concept of LFDSSI System

The concept of the LFDSSI system is shown in **Fig. 2**. In Japan, up until 1970, most of the rice

This paper is a contribution from the University of Tokyo, Japan.

Table 1 Rice Labor Input in man-days, Japan, 1870—1985

Year	Rice yield (t/ha)	Labor input man-days/ha	Labor productivity kg/man-day
1874	2.36	278	8.49
1880	2.53	275	9.20
1890	2.60	271	9.60
1900	2.87	267	10.75
1910	3.08	251	12.27
1920	3.94	235	16.77
1930	3.92	211	18.58
1940	3.74	206	18.16
1950	4.13	256	16.13
1960	4.99	214	23.31
1970	5.64	146	38.63
1980*	6.06	80	75.75
1985*	6.22	68	91.47

Source: Bray, (1986), The Rice economies, T.J. Press Ltd, Padstow, pp154.
*- Ministry of Agriculture, Forestry and Fisheries (1988), Production cost for rice and wheat, pp239.

Table 2 Labor Required for Different Farming Operations, Japan

Type of operation	1960	1965	1970	1975	1980	1985
Seed preparation	0.7	0.6	0.7	0.5	0.6	0.5
Nursery growth	9.2	7.8	7.4	6.6	6.5	6.1
Puddling and land preparation	17.0	14.4	11.4	9.2	8.1	6.8
Transplanting	26.5	24.5	23.4	12.5	8.5	7.3
Fertilizer application	8.6	6.7	6.6	4.8	4.1	3.8
Weedicide application	26.7	20.8	16.0	11.1	8.2	6.3
Water management	22.1	12.0	10.8	9.9	9.5	9.2
Harvest and threshing	57.4	47.6	35.5	21.8	14.7	11.2
Drying and hulling	5.8	6.8	6.0	5.1	4.2	3.3
Total labor consumed	172.9	141.0	117.8	81.5	64.4	54.5

Source: MAFF, (1988), Production cost for rice and wheat, pp.239.

Table 3 Change in Power for Paddy Cultivation at Different Periods, Japan

Operation	Ancient period	Recent period	Present period	LFDSSI (Future)
Seeding solidation	man power	man power	bull-dozer	Laser-controlled bulldozer
Seeding	man power	man power	transplanter	direct seeding machine
Ploughing	man power	animal power	tractor	big size tractor
Water storage	nature, man power	nautre, pump	nature, pump	nature, pump
Puddling	man power	animal power	tractor	—
Fertilizer and Herbicide	man power	man power	sprayer and duster	sprayer and duster
Irrigation	man power	man power	auto irrigator	subsurface drain pipes
Drainage	nature	nature	subsurface drain pipes	subsurface drain pipes
Harvest	man power	man power	combine	large-sized combine
Plot size and shape	small and irregular	small and regular	medium and regular	large-sized and regular shape

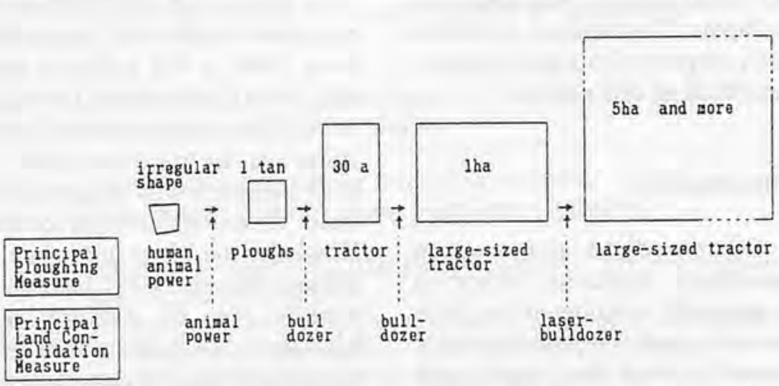


Fig. 1 Tendency towards enlargement of plot size and change in machinery used for land consolidation.

planting was done manually which used a great deal of manual labor. In order to reduce the labor input, rice transplanters were introduced and since then they have been widely adopted. Although rice planting was mechanized using mechanical transplanters, it is still a labor intensive one since the operations like preparation of nursery bed, cultivation of seedlings, arrangement of seedlings in transplanter and transplanting in main field requires much labor. Hence direct seeding seems the only alternative to solving this problem. In Japan the area planted by direct seeding in 1980 was 17 433ha (Nakamura, 1983) which was only 1% of the total rice growing area. In 1974, there was around 3% of the rice growing area planted by direct seeding but because of the development of high efficiency transplanters, this area was reduced to 1%. But recently, the direct seeding machines developed also perform very well with high efficiency similar to transplanting machines and hence the area under direct seeding need to be increased so as to increase the labor productivity.

Labor saving is possible by enlarging the plot size also since big machineries can be used for various farming operations, which ultimately will reduce the labor input. But when the plot size is enlarged, precise field level is very important in order to keep the surface drainage efficient. Precise field leveling can be achieved by using the laser-controlled bulldozer.

Maintaining the homogeneous water condition in the field throughout the crop growth is important in increasing or keeping the yield. Homogeneous water distribution depends upon precise field level. When water is applied by subsurface irrigation system the water table rises uniformly throughout the field and if a precise field level can be achieved, the homogeneous distribution of water table is possible.

The following three possibilities were arrived at in order to achieve the objective of LFDSSI: 1) direct

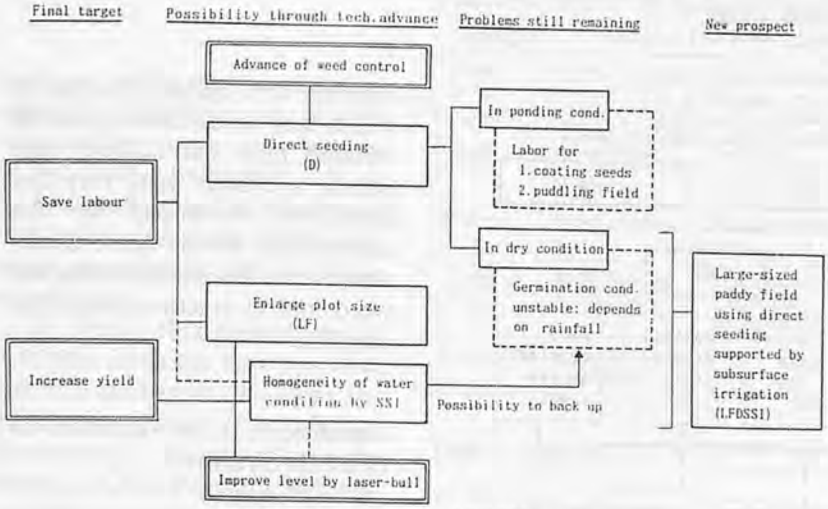


Fig. 2 Prospect for new LFDSSI system.

seeding; 2) enlarging the plot size; and 3) maintaining homogeneity of water condition by using subsurface irrigation.

Direct seeding can be done in three ways: i) by broadcasting technique using broadcasting equipment; ii) using direct seeding machine attached with tractor; and iii) using helicopter attached with seed drilling equipment.

Direct seeding by broadcasting technique may reduce the labor input but the uniformity of seed distribution in the field is a big problem which ultimately will reduce the yield. Hence broadcasting technique is not the best solution to reduce labor requirement.

Direct seeding using helicopter may reduce the labor input for seeding operation although this technique has the following problems: i) The area to be planted should be relatively large and the seed distribution may not be uniform. The helicopter flies at a height of 10-12m and if there is wind, the seeds will not be distributed evenly; ii) The seeds need to be coated before seeding which again requires labor; and iii) The farmer cannot be a part of the seeding operation and he only has to hire a helicopter and hence his labor is wasted during seeding. The cost of hiring helicopter will increase the production cost.

Considering the above problems, it seems that the helicopter seeding is not an optimum way of increasing the labor productivity. In Japan, this can be considered as the next stage of development after solving the problems mentioned above. Hence direct seeding using a special seeding machine may be considered as a better alternative.

Direct seeding using seeding machine can be done under two types of field conditions: 1) ponding condition and ii) dry condition. If direct seeding is done in ponding condition, there is a main problem of labor required for coating the seeds with calpur dust and for puddling the field. Hence direct seeding in ponding condition may not be the best way of achieving the target. Instead, direct seeding in dry condition using a special seeding machine is a better alternative.

When direct seeding is done in dry condition the germination of the seeds mainly depends upon the rainfall during the initial one month of the growing period. If there is no sufficient rainfall the seeds will die which is the reason for the poor popularization of direct seeding. On the other hand, if the water is supplied using surface irrigation system, the seeds will likewise die because of over supply of water. Hence, in order to solve this problem a new concept of supplying soil water using subsurface irrigation is introduced. By using subsurface irrigation system, the water table can be raised to desired level and then the required amount of soil moisture can be supplied.

Therefore, large-sized paddy field using direct seeding supported by subsurface irrigation (LFDSSI) system has been arrived to achieve this target.

Problems of LFDSSI System

Three new techniques introduced in LFDSSI system are: i) large-sized field (LF); ii) direct seeding (D); iii) subsurface irrigation (SSI). Each technique by itself have problems and when they combine with the other techniques they will breed new problems (**Fig. 3**). All the problems discussed below were analyzed in order to determine the practical adaptability of this LFDSSI system to other locations.

Precise Field Level in Large-sized Paddy Field

As discussed earlier, a large-sized field has the main problem of maintaining the precise field leveling. After introducing the laser bulldozer leveling, the field can be leveled only to a particular limit and a 100% precise field leveling is not possible in a large-sized field. Hence the degree of field level necessary for the LFDSSI system should be decided.

Uniform Distribution of Water in LFDSSI

Paddy yield mainly depends upon the uniform distribution of water throughout the field. Especially during the germination stage, the budding growth mainly depends upon the uniform distribution of soil moisture which depends upon the level of field surface.

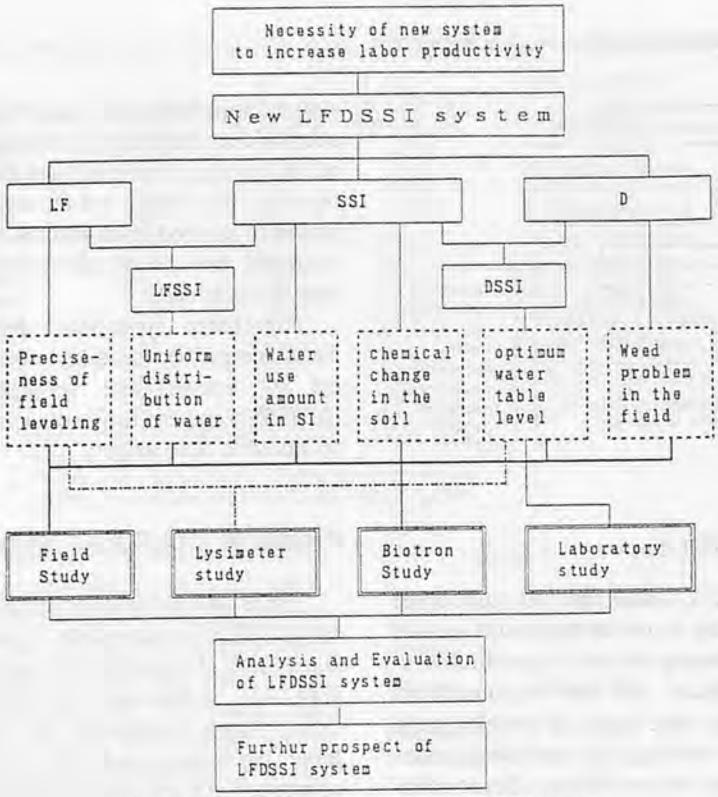


Fig. 3 Problems to be realized in LFDSSI system.

Water Use in Subsurface Irrigation

The quantity of water that is used in subsurface irrigation needs to be determined. If the water consumption for the subsurface irrigation is very high compared to surface irrigation system then this system may not be advantageous in water scarce locations. Hence the quantity of water used in subsurface irrigation system at different stages of the crop growth should be determined beforehand.

Changes in Chemical Condition of Soil Under Subsurface Irrigation System

In surface irrigation system, water is applied from top of the ground surface and oxygen in this water mixes with the chemicals and the organic matter in the soil-water mixture and form new aerobic biosystem. In the process, harmful chemicals that may form will be leached out under optimum percolation and drainage condition. On the other hand, in subsurface irrigation system, water is applied from the bottom and hence the change in chemical condition of the soil may be different from that of the surface irrigation system. Hence the change in chemical condition of the soil under subsurface irrigation system should be clarified.

Optimum Water Table Level in LFDSSI

Using subsurface irrigation system, the water table is raised up to a particular level and then supplied by capillary action. But the optimum depth of water table up to which the water table needs to raise should be decided. In the LFDSSI system, the size of the field is large and hence based on the field level the water table depth should be decided.

Weed Problem in Direct Seeded Field

In transplanted field, the weeds may die because of the puddling operation and most of the small weeds do not survive in ponding condition. But in direct seeded field the weeds may emerge because of the difference in moisture distribution. The type of weeds may be different from the wetland type and dryland type weeds, and there were very few herbicides developed for the unsaturated soil moisture condition. Hence this weed problem and weed control practices need to be clarified.

Conditions to be Satisfied for LFDSSI System

The above problems were analyzed by the following studies (Murugaboopathi, 1989);

1) Field Study—This study was carried out in two large-sized plots of size 2.5 ha and 1.7 ha in Kakurai, Chiba Prefecture, Japan;

2) Lysimeter Study—This study was carried out in a small plot of size 6 × 1.1 m;

3) Laboratory Study—This study was carried out in the laboratory; and

4) Biotron Study—This study was carried out inside the biotron with day time temperature of 30°C and night time temperature of 25°C.

With the above studies the problems of the LFDSSI system were analyzed and it was found that the following conditions should be satisfied to successfully implement the LFDSSI system to other locations (**Table 4**).

1) Direct seeding can be supported by subsurface irrigation system and the optimum water table depth at which sufficient amount of soil moisture can be supplied is 15 to 25 cm. The pF at this range is 0.75 to 1.50.

2) Maintaining water table in the field at a particular level in large-sized field depends on the field level which should be precise to the limit of ±5 cm.

3) Change in chemical condition of the soil was analyzed and it was determined that the soil system which contains microor-

ganisms influence the chemical changes more of the soil than the irrigation or the drainage system. It was further found that subsurface irrigation can be substituted for surface irrigation under optimum percolation and drainage conditions.

4) Weeds that emerge in the LFDSSI fields are both wet-land and dry-land types and using the herbicides DCPA Propanil and Promaerine, these weeds can be killed. DCPA Propanil has high inhibitory activity on the reaction of photosynthesis of weed plants (Matsunaka, 1983) and it effectively controls annual weeds. Promaerine controls the perennial weeds. And the remaining weeds will disappear by keeping the field in ponding condition after 3 weeks.

5) The quantity of water use in the LFDSSI field with the permanent water table at around 1 m level, was less than 15 mm/day during the germination period. During the other periods it ranged between 15 and 25 mm/day. In Japan, the quantity of water requirement is usually 5-10 mm/day for ill-drained fields; about 15-30 mm/day in imperfectly drained fields; 30-100 mm/day for leaky fields (IRRI, 1987). The water requirement for the LFDSSI field falls within this range for the full period of crop growth. The average quantity of water use for the full growing period was 17.5 mm/ day and falls within the category of well-drained fields which means that LFDSSI field has optimum water requirement with optimum drainage. Hence, it can be concluded that subsurface irrigation can be substituted for surface irrigation from the view point of water use.

Moreover, by using an automatic controlled subsurface irrigation system, the labor required can be minimized and by this system the water table can be controlled at any level above or below the ground. Hence this automatic controlled subsurface system facilitates effective water management during the germination and other stages of crop growth.

Table 4 Conditions to Be Realized for LFDSSI System and Evaluation of Fields A and B

Technique	Problem	Conditions	Evaluation of fields A and B
① LF	Precise field level	Under ponding condition ±5 cm	A field = ±5 cm B field = ±5 cm
② SSI	Change in chemical condition	Optimum percolation and drainage	No harmful effect
	Water use	15 ~ 30 mm/day	13 ~ 25 mm/day
③ D	Weed problem	Weedicide + ponding condition	Weeds were killed
① and ②	Uniform water distribution	Difference in water table rise within the field should be within 1 day	In fields A and B difference was within 12 hrs
② and ③	Optimum water table level	−15 ~ −25 cm	In field seed germination was by SSI and rain

Table 5 Labor Required for LFDSSI and MFTSI System

Type of operation	Field A (1987)		Field B (1988)		LFDSSI system >>3ha*	MFTSI system** average
	2.5 ha	per 10 a	1.7 ha	per 10 a	per 10a	per 10 a
Seed preparation	12	0.48	8	0.47	0.5	0.5
Nursery growth	—	—	—	—	6.6	6.0
Land preparation	48	1.92	32	1.88	3.4	6.5
Transplanting	—	—	—	—	5.9	7.2
Seeding	24	0.96	16	0.94	—	—
Fertilizer application	24	0.96	16	0.94	2.0	3.6
Weedicide application	72	2.88	48	2.82	4.6	5.7
Water management	200[a]	8.00	136[b]	3.00	6.5	8.9
Harvest and threshing	40	1.60	32	1.88	5.7	10.6
Drying and hulling	80	3.20	54	3.20	2.3	3.2
Total	500	20.0	342	15.1	37.5	52.2
Transport and others-10%	50	2.0	34	1.5	***	***
Grand total	550	22.0	376	16.6	37.5	52.2
Labor saved		30.2		35.6	14.7	0.0

a A field with manually controlled SSI, b B field with Automatic controlld SSI.
* Farmers holding more than 3 ha of land, Average - National Average.
** Ref: MAFF, (1988), Production cost of rice and wheat, pp.239.
*** Transport and others already added in individual operation.

Conclusions

The new rice growing system called "Large-sized paddy Field using Direct Seeding Supported by Subsurface Irrigation (LFDSSI) system" was developed in order to increase the labor productivity. The problems of this LFDSSI system were analyzed.

The yield benefit between LFDSSI system and Medium-sized Paddy Field using Transplanting supported by Surface Irrigation (MFTSI) system is almost similar. However, by using LFDSSI system the labor that can be saved is as much as 300 h/ha (**Table 5**).

The total production cost in LFDSSI field was only 10,000 yen/ 60 kg of rice, whereas the national average in 1988 was 19 734 yen/60 kg, which means that by using this LFDSSI system the production cost can be reduced to about half of the national average. The LFDSSI system can be considered as an important new prospect in reducing the production cost and increasing the labor productivity.

(Continued on Page 22)

Indian Standards on Oil Milling Industry

by
R.N. Sharma
Bureau of Indian Standards
New Delhi, India

Introduction

Oils are necessary ingredients in the human diet. They are concentrated source of energy and provide more than double, the energy furnished by either protein or carbohydrates per unit weight. The consumption of the edible oils in India is far below the average requirement of about 14 kg per capita per year. It has been estimated that nearly 5.4 million tons of the oil is needed presently whereas availability is about 3.2 million ton. In order to meet the existing gap between the availability and the requirement, import of oils worth Rs.3884 crores was made during the years 1981-86. This has put strain on the foreign exchange balance of the country.

In order to minimize the import and to increase the availability of the oil, concerted efforts are being made by the Government and a Technology Mission has been set up under the direction of the Prime Minister in 1986. The mission has fixed a target of 16 to 18 million tons of oilseads and 4.4 to 5 million tons of oil by 1989-90. It also envisages production of 26 million tons of oilseeds and 8 million tons of oil by the year 2000. The efforts of the mission have started giving results in the form of enhanced production of oilseeds. It is estimated that during the current year (1988-1989) 15.5 million ton of supply of oilseeds is likely to be produced in the country compared to 11.4 million tons, an average production during 1980-85. This would result in the extraction of more oil thereby cutting the importation.

Though increase in production of the oilseeds is one of the important means of producing more oil, the availability of oil can also be increased through improvements and modernization in oil milling technology. Pathak, et al have observed in a study conducted in the Punjab that the average recovery of the oil in mechanical extraction was 73% except in the case of cotton seed for which it was only 60%. They also observed that the use of improved technology in mechanical extraction can yield a further increase in the oil recovery from major oilseeds by about 10% and solvent extraction can yield a further increase of 27.7% in the recovery of the oil from the same source. A combination of improved mechanical extraction and solvent extraction can, therfore, increase the recovery from conventional oilseeds by about 33%.

Using manual and animal-drawn oil extraction equipment, oil can be extracted in the villages and the resulting cake fed to cattle. However, with the passage of time, it has developed fairly as an important industrial activity. Traditional oil "ghanies" are fast disappearing and the power ghanies as well as capital intensive oil expellers, hydraulic presses and solvent extraction equipment are replacing two traditional ghanies.

Standardization Efforts

Emphasis on popularization of the oil milling as an industrial activity has resulted in the growth of an indigenous industry to cater to the increasing needs of the country. However, as observed from the studies conducted, the industry needs to be modernized in order to improve oil recovery. A number of the technological and economic factors would contribute in the modernization. One of the major technological inputs is quality improvement of the equipment and system used in the industry for which standards are the necessary adjunct. Moreover, a shift from traditional system to modernized system calls for an integrated, coordinated and rational approach which can be achieved through the process of standardization and quality control.

The Bureau of Indian Standards (BIS) formerly known as the Indian Standards Institution (ISI) is an apex, national body for the formulation of Indian Standards and certification of products conforming to the relevant standards. Standardization in the oil milling machinery was started in the Bureau in the early 1960s. Some of the important standards developed in this field are highlighted below:

Glossary of Terms Relating to

Oil Expellers—The IS:4596-1968 has been published on the subject covering the definitions of terms used in oil expeller trade, with a view to eliminating ambiguity and confusion arising from individual interpretation of terms used in this industry.

Method of Test for Evaluation of Performance of Oil Expellers—The necessary step towards standardization of the expeller is to standardize the methodology of various characteristics that determine the performance of the equipment. With a view to providing freedom to the manufacturer in the design of expellers, only two factors, namely; quality of cake and power consumption have been considered adequate to determine the performance. IS: 5223-1969 has been published on the subject which coveres in detail the methodology for determining these two characteristics. The standard also stipulates the maximum power consumption at no load and the oil content in residual cake with respect to groundnut and mustard seeds.

Specifications for Single Barrel Oil Expellers—IS:5224 on the subject was first published in 1969 and was revised in 1974 specifying the material of construction for various components; hardness for the cage bars, worms and collars; functional design details; capacity and corresponding power requirements. The capacity has been defined as the quantity of groundnut kernels crushed per day of 24 h in two crushings and having 6 to 8% oil in oil cake after two crushings. A list of the other relevant Indian standards as well as the information to be given in the certificate by the manufacturer to the purchaser at the time of supplying oil expellers has also been indicated.

Recommended Sizes and Capacities of Single Chamber Oil Expeller—IS:10341-1983 has been brought out to facilitate the purchase and selecting the capacities and corresponding sizes for various parameters of the chamber, main gear, quill worm gear and for the kettle.

Oil Seed Kettles—IS:12047-1987 has been published covering the design aspect of the shell, material of construction, capacity, constructional details, installations and testing of horizontal type of kettles.

Power "ghani"—As stated earlier, animal-drawn ghanies which have been in use traditionally are being replaced by the power ghanies, since they have better extraction capacity compared to the traditional ones. A draft Indian standard on the subject has been prepared indicating the material of construction of various components, hardness for some of the components, construction details, performance and other requirements.

Related Subjects—A number of standards which are of the direct interest to the expeller industry, particularly covering the sampling of oilseeds, method of test of oilseeds, grading of various oilseeds for milling purposes as well as hadling and storage conditions of the oilseeds have also been brought out by the Bureau. A list of these standards is given in Annexure I. Standards on groundnut decorticator and cotton delinter are also under formulation.

The panel on Oil Milling Machinery functioning under the Agricultural Produce Milling

Annexure I

Code/year	Title
IS: 3579-1965	Method of test for oilseeds
IS: 4115-1967	Methods for sampling of oilseeds
IS: 4427-1967	Grading for groundnut kernels for oil milling and for table use
IS: 4428-1967	Grading for mustard seeds for oil milling
IS: 4429-1967	Grading for sesame seeds for oil milling
IS: 4617-1968	Grading for linseed for oil milling
IS: 4618-1968	Grading for castor seeds for oil milling
IS: 4619-1968	Grading for MAHUA kernels for oil milling
IS: 4620-1968	Grading for cottonseeds for oil milling
IS: 5292-1969	Grading for safflower seeds for oil milling
IS: 5293-1969	Grading for niger seeds for oil milling
IS: 5294-1969	Grading for KUSUM seeds for oil milling
IS: 5686-1970	Code of practice for handling and storage of oilseeds
IS: 6220-1971	Grading of copra for table use and for oil milling
IS: 7787-1975	Grading for NEEM kernel and depulped NEEM seeds for oil milling
IS: 7797-1975	Grading for soyabeans for oil milling
IS: 7798-1975	Grading for soyabeans for oil milling
IS: 8428-1977	Grading for KARANJA seeds for oil milling
IS: 8443-1977	Grading for tobacco seeds for oil milling
IS: 8557-1977	Grading for KOKUM kernels for oil milling
IS: 8882-1978	Grading for KHAKN fat for oil milling
IS: 8882-1978	Grading
IS: 9993-1981	Grading for DHUPA kernels for oil milling
IS:10006-1981	Grading for NAHOR kernels for oil milling
IS:11068-1984	Criteria for edibility of oils and fats
IS:11476-1985	Glossary of terms relating to oils and fats

Machinery Sectional Committee of the Bureau has included in its programme of work the subjects like vertical type oilseed cookers and solvent oil extraction euipment and systems for formulations for national standards. The work on these subjects will be taken up in the near future.

Implementation and Certification

Implementation means adoption and application of standards in all activities of industry and trade. The full benefit of standardization could be reaped only when standards are supplied in every sphere of activity.

In order to ensure that standards are acceptable to all, care is taken to consult the industrialists, technologists, scientists, government agencies and various testing authorities in order to safeguard the interest of all concerned taking into account, at the same time, the corresponding international standards in other countries for particular items. It would, therefore, be appreciated that standards are implemented to the fullest possible extent. Problems faced in the adoption of standards should be communicated to the Bureau for taking corrective action and to update the standards.

For the benefit of the consumer, the Bureau operates its certification marks scheme which provides third party guarantee of the quality of the product in conformity with the relevant Indian Standard. Any manufacturer with the requisite production and testing facilities may apply for a licence under the scheme. The certifiction marks scheme is operated on a voluntery basis, i.e., only those manufacturers who desire to bring their products under certification get in touch with the Bureau. However, the purchasers/consumers, especially in the organized sector, can play an effective role in influencing the manufacturers to produce the products in conformity with the standards and to obtain Standard Mark.

Conclusion

For accelerating self-reliance on edible oils and to stop the import of the oil, concerted and coordinated efforts are being made to bridge the technology gap in the oilseed production and processing by the government in the form of a Technology Mission. Improving the extraction capabilities, among others, is one of the targets set forth by the Mission. The standards are instruments for improving the quality of the product. It would be appreciated if the published standards are implemented by the industry to reap the full benefits of standardization in terms of assurance of quality, minimization of wastage, reduction in cost, rationalization of variety, ensuring interchangeability and increasing production. ■■

(Continued from page 19)

New Rice Growing System to Labor Productivity in Japan

REFERENCES

1. Bray, F. 1986. The rice economies technology and development in Asian societies, T.J. Press Ltd, Padstow, p.154.
2. FAO production year book. 1986. vol.40, pp24-27
3. IRRI. 1987. Physical measurements in flooded rice soils, IRRI, p.36.
4. Matsunaka, S. 1983. Evolution of rice weed control practices and research: World perspective, in 'Weed control in rice', IRRI, pp5-18
5. Ministry of Agriculture, Forestry and Fisheries, Japan 1988. Production cost for rice and wheat (Japanese), pp238-239.
6. Murugaboopathi, C. 1989. Study on large-sized paddy field using direct seeding supported by subsurface irrigation system, 253pp., PhD thesis, The University of Tokyo, Tokyo, Japan.
7. Nakamura, Y. 1983. Direct seeding in ponding condition (Japanese), Ie no Hikari Kyokai, Japan, p.17.
8. Tsujii, H. 1988. World rice war (Japanese), Ie no Hikari Kyokai, Japan, P.127. ■■

Design and Development of a Direct Paddy Seeder

by

C.P. Gupta
Prof.
Agric. and Food Eng. Div.
Asian Institute of Technology
Bangkok, Thailand

Totok Herwanto
Lecturer
Agric. Eng. Dept.
Padjadjaran University
Bandung, Indonesia

Abstract

To overcome high human stress and drudgery in transplanting operation, a direct paddy seeder to match a two-wheel tractor was designed and developed. The seeder has a working width of 2 m and 8 rows. For each row, there is a seed hopper, a 6 fluted seed metering roller and a double disc furrow-opener. Two lugged driving wheels rotate the metering rollers mounted over a common shaft. Each flute in a metering roller can pick up 3 to 5 paddy seeds and place them in a furrow through seed guide at desired depth of 2 to 7 cm. The seeder is provided with a foot-operated clutch to disengage the metering mechanism and a canopy to protect the operator from direct sunlight. It has a field capacity of about 0.5 ha/h at forward speed of 0.81 m/sec and field efficiency of 78%. The seed rate is 15 to 20 kg/ha. Damage due to metering mechanism is nil for soaked seeds and 3% for pre-germinated seeds.

Introduction

Direct seeding and transplanting are two general methods for planting rice. The primary difference between the two methods is that in the transplanting method, seedlings are first raised in the seedbed before they are planted in the main field whereas in direct seeding, the seed is sown directly in the main field either by broadcast or row-seeding in wet or dry field.

Drill seeding in dry soil makes the use of mechanical seed-drills feasible. It improves soil structure since puddling is minimized. Lower labour cost is the major advantage of direct seeding. The method eliminates seedbed preparation, care of seedlings in the seedbed, pulling seedlings, and hauling and transplanting operations. The savings in labour may substantially reduce production cost, particularly in areas where labour cost is high. Also directly seeded rice may mature 7 to 10 days earlier than transplanted rice. This saving in time is important, especially where multiple cropping pattern is used.

Weeding is a problem if broadcast seeding is used. The weeding problem is less in row seeding because it allows the use of mechanical weeders. This is true, especially in countries where chemical weed control is not yet widely. practiced due perhaps to the fact that herbicides are too expensive for the ordinary farmer. Direct seeded rice also have a greater tendency to lodge than transplanted rice because roots of directly seeded rice develop poorly and anchorage is poor.

IRRI and UPCA researchers are of the opinion that there are no significances in yields of transplanted or directly seeded rice if good management practices are used with each method. The problem in direct seeding is to devise suitable methods which would reduce labour cost further and minimize rat and bird infestation on germinating seeds.

Literature Review

Navasero (1969) designed and tested a paddy seeder with two-step metering mechanism. The first step was to meter a large quantity of seeds from the hopper and the second step was to distribute the metered seeds to the individual rows. One hectare required 4.9 man-h with this 8 row seeder as compared to 199 man-h for manual transplanting. Khan (1975) developed a 6-row paddy seeder at IRRI for seeding pregerminated seeds. The planting by this seeder was 20 times faster than manual transplanting. Srivastava, et al (1986) also developed a pregerminated paddy seeder. Tiwari and Datta (1983) developed a wetland seeder, capable of sowing 6 seeds per hill at a hill-to-hill spacing of 16.0 cm. The average seed rate was 43.2 kg/ha for paddy at field capacity of 0.08 ha/h. From ergonomical consideration this two-row machine could be comfortably operated by one-man. Singh et al (1983) developed a six-row IRRI — Pantnagar bullock-drawn paddy seeder which required 1 443 man-h/ha for all the agricultural operators whereas transplanting methods required

1 682 man-h/ha. The maturity of the crop was advanced 10 days in the bullock-drawn treatment.

Yoshiaki Nakamura et al (1983) reported a new DSSP (direct seeding with coated rice in submerged paddy) system. It requires rice drilling equipment, coating machine and chemicals necessary for preparation of rice seeds and pyrazolate herbicide for initial weed control. Thirty-three percent of the rice growers reported 0.5 t/ha of increase in yield compared with the transplanting cultivation. Rice seeds are coated with calper dust containing 75% calcium peroxide and 25% plaster of Paris. Seeding depth should be about 1 cm. Sledge type seeding machine with roll type feeding device of seeds is recommended for DSSP system. Srivastava and Panwar (1988) reported 2-5 mm as the optimum sprout length for sowing pregerminated paddy in puddled soil.

Objectives

The main objective was to design, develop, fabricate and test a direct seeding machine, attached to a two-wheel tractor, in dry soil. The design of machine should be based on ergonomic considerations to make it comfortable to the operator. The planted rice seeds should achieve an acceptable germination percentage, using local rice variety under Thailand conditions.

Design and Development

The direct paddy seeder (Figs. 1, 2, 3) has the following components: (i) canopy, (ii) canopy frame, (iii) operator seat, (iv) main frame, (v) seed hopper, (vi) driving wheel, (vii) clutch assembly, (viii) transportation wheel, (ix) transportation wheel frame, (x) double disc furrow opener, (xi) metering roller shaft, (xii) seed metering roller, (xiii) lifting mechanism for furrow openers, and (xiv) seed tubes.

Fig. 1 AIT direct paddy seeder, side view.

Fig. 2 AIT direct paddy seeder, back view.

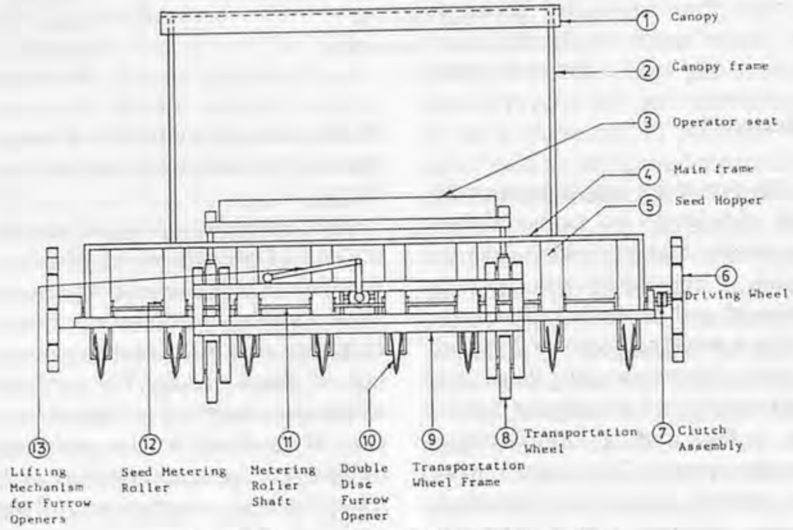


Fig. 3 Diagram of AIT direct paddy seeder.

The seeder was designed for eight rows with inter-row spacing of 25 cm commonly for rice. The total working width of the seeder is 2 m. The seed tube was designed to convey the seeds along a path which is approximately a parabola. The hopper was designed for filling seeds twice per hectare. The hopper consists of 8 boxes. The volume of one box is equal to

$$V = \frac{SR}{n \times Z \times BD}$$

$$= \frac{30 \text{ kg}}{2 \times 8 \times 0.57 \text{ kg/l}}$$

$$= 3.29 \text{ litres} \quad \ldots\ldots\ldots\ldots (1)$$

where v is volume of one box, SR is seed rate per hectare (30 kg/ha), n is number of refillings per ha (2), Z is number of rows (8), and BD is bulk density of seeds (0.57 kg/l).

The dimension of each hopper box is 40 cm high, 10 cm wide and 15 cm long (**Fig. 4**). The material of hopper is MS plate 1.6 mm thick. Designed capacity of each hopper is 4.08 litres which is enough to cover seed on 1/16 ha. According to the physical properties of rice seed, the minimum angle of repose for emptying is 31 degrees. The angle of the hopper box was 80 degrees for free flow of seeds.

The seed-metering roller (**Fig. 5**) is made of PVC circular pipe to reduce weight as well as friction between seed and surface of metering roller. Its diameter and width are 70 mm and 140 mm, respectively. The metering roller consists of 6 flutes, each having length of 15 mm, width of 8 mm and depth of 4 mm.

As the seeds are oriented randomly in the flute, each flute can pick up 3-5 seeds at a time. The average volume of each seed of

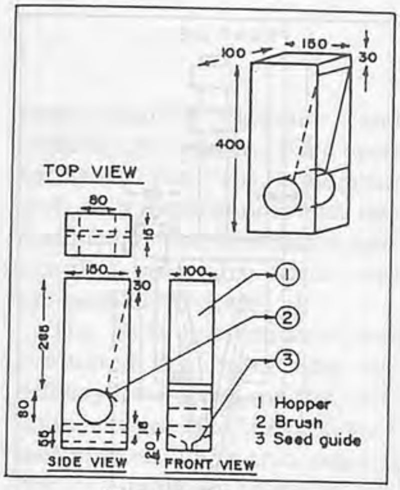


Fig. 4 Seed hopper.

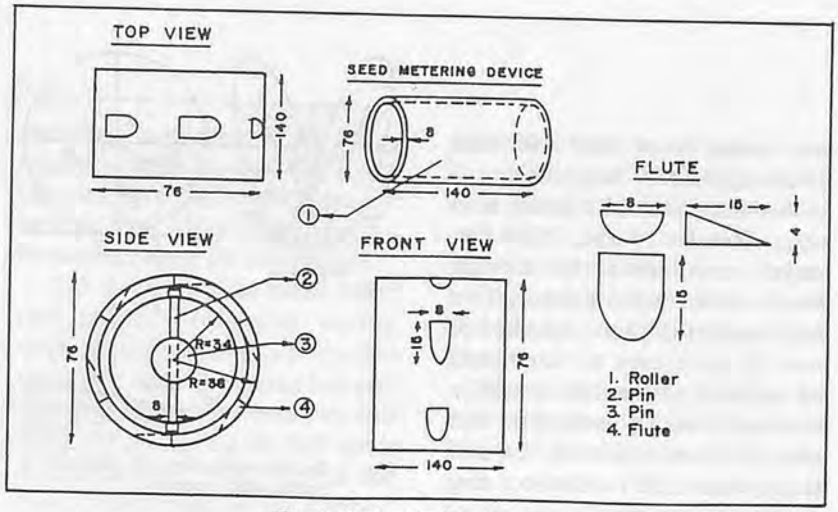


Fig. 5 Seed metering roller.

rice variety (Suphanburi 60) was equal to 22.58 cubic mm.

The seed guide (**Fig. 6**) is made of MS plate 1.6 mm thick. Its function is to help the seed fall down in the furrow. Dimensions of seed guide are 15 mm thick, 70 mm long and 50 mm deep.

The diameter of driving wheel was determined by the distance of dropping hill. The common dropping distance between consecutive hills is 25 cm, and the number of flutes in each metering roller is 6.

$$\text{Since} \quad \frac{D_2}{D_1} = \frac{a}{t} \quad \ldots\ldots\ldots (2)$$

where D_2 is diameter of ground wheel, D_1 is diameter of seed metering roller (7 cm), a is distance of hill dropping (25 cm). Therefore, t, the distance between consecutive flutes is $\pi D_1/6 = \pi \times 7/6 = 3.66$ cm, and D_2 is $25 \times 7/3.66 = 47.77$ cm.

The diameter of the driving wheel was taken as 50 cm. Each driving wheel was made of MS plate (50 × 1 570 × 5 mm). To obtain higher traction, 8 lugs were attached to each driving wheel. Each lug was made from MS plate of dimensions (50 × 50 × 5 mm).

The seed rate requirement (weight of seeds per hectare) SR is given by the formula.

$$SR = \frac{10{,}000}{W \times S_2} \times \frac{1}{(1 - S)} \times W_{1R} \quad \ldots\ldots (3)$$

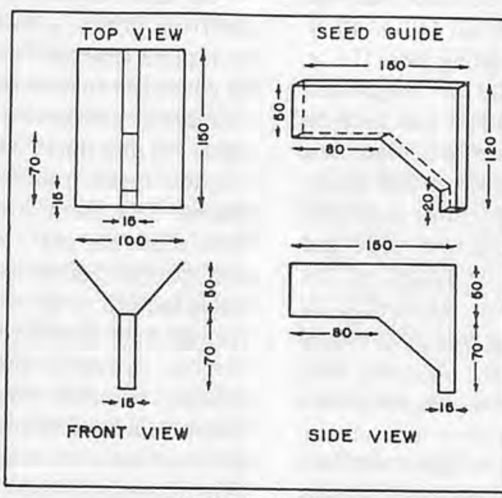


Fig. 6 Seed guide.

where W is working width (2 m), S_2 is circumference of ground wheel, S is slip expressed in fraction, W_{1R} is weight of seeds fallen for one rotation of driving wheel $= (Z \times a \times b) \times q/1\,000 = 6 \times 5 \times 8/1\,000 \times 35.2 = 8.45$ g, Z is number of flutes (6), a is number of grains per hill (5), b is number of rows (8), q is weight of 1 000 grains (35.2 g), and

$$SR = \frac{10{,}000}{2 \times 1.57} \times \frac{1}{(1 - 0.1)} \times 8.45 \text{ g/ha}$$
$$= 29{,}900 \text{ g/ha}$$
$$= 30 \text{ kg/ha}$$

The diameter of the double disc furrow openers (**Fig. 7**) was calculated by the formula:

$$D = \frac{S}{(1 - \text{Sin}^{\alpha})\,\text{Sin}\beta/2} \quad \ldots (4)$$

where S is the required width of furrow (1 cm), $^{\alpha}$ is angle of the point of contact of discs in relation to horizontal axis (30°), β is angle at which the discs are inclined to each other (10°)

$$D = \frac{1}{(1 - 0.5) \times 0.087}$$
$$= 22.95 \text{ cm}$$

The double disc furrow opener (**Fig. 8**) is made from MS plate 4.76 mm thick, diameter 23 cm and supported by a shank. The shank was made of 2.54 cm long circular steel pipe of 19 mm diameter. To reduce friction, roller bearings of dia. 12.7 mm were used. The house of bearing was made from steel 100 mm diametter and 10 mm thick.

A shaft, made of circular steel pipe, diameter 19 mm, 2 250 mm length, connected the driving wheel to the metering rotor. Two dog clutches (90 mm, number of teeth 9) were used to disconnect the rotation of the drive wheel to the shaft, two key ways (100 mm long, 3.2 mm wide and 6.4 mm deep) were used to connect dog clutches to the shaft.

The frame of operator seat was made from angle bar (40 × 40 × 5) mm and the spring steel (11 × 63 × 5) mm, 100 cm length and 40 cm width which was used to reduce vibration of machine. The seat was made of wood and foam. Dimensions of operator seat were 100 cm long, 450 mm wide and 25 mm high. The frame of the operator seat was supported by circular steel pipe (dia 19 mm and length 130 mm). Circular steel pipe was welded to the main frame.

The function of ground wheel is to support the machine during transport as well as to adjust the depth of planting in the field. Both ground wheels are located in the rear part of the machine. To connect both wheels to the frame were used two 450 mm angle bars (40 × 40 × 5) mm and shaft for this wheel was made from circular pipe of diameter 12.7 mm and 14 cm length were used.

To reduce the exposure of operator to direct sunlight in the field, a shade made from plastic 1 000 mm width and 1 500 mm length was used. To adjust the depth of planting in the field as well as to adjust for transport, an adjusting screw (dia 31.75 mm and length 50 cm) was used as lifting mechanism. A lever made of round bar (dia 19 mm and length 500 mm) was used to rotate the screw. The adjusting screw was connected to the main frame and ground wheel frame by welding.

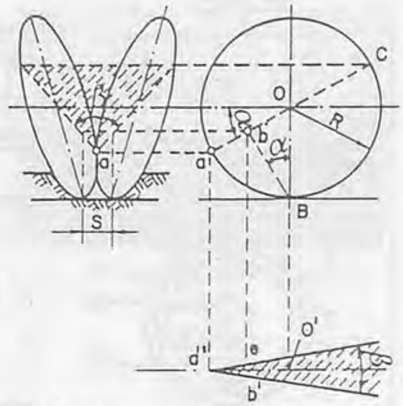


Fig. 7 Relative position of disks in a double-disk opener.

To save the feet of the operator from injury, a shield made of m.s. plate 1.60 mm thick was used to cover the furrow openers. The clutch was also covered by a G.I. sheet 1.6 mm thick. There are two frames: main frame and hopper frame. The main frame is made from angle bar (40 × 40 × 5) mm and hopper frame is made from angle bar (25 × 25 × 5) mm. The frames were joined together. The furrow openers, shaft, driving wheels, ground wheels, clutch, clutch pedal and lifting mechanism were attached to the mainframe. The pillow blocks of diameter 19 mm were used to connect the shaft to the mainframe at its left, middle and right. The main frame is attached at one hitch point to the two-wheel tractor.

Materials and Methods

The following laboratory performance tests were conducted: (i) test of metering mechanism, (ii) germination test, (iii) distribution test.

Test of Metering Mechanism

The driving wheels were jacked up and the metering rollers were rotated by turning wheels 20 revolutions. The delivery rate per hectare was calculated knowing the weight of seeds discharged from the delivery tube during 20 revolutions, row spacing and the distance for seeder to move in 20

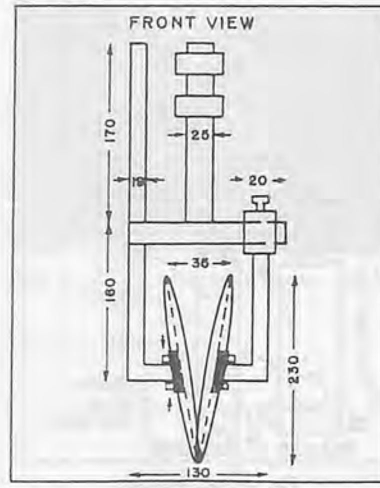


Fig. 8 Front view of double-disk furrow opener.

revolutions. In total, four tests with seeds filled to full, three fourths, half and one-fourth of hopper capacity with four replications were carried out.

Germination Test

This test was conducted by keeping 100 seeds on filter paper soaked with water in a petri dish. After 3 to 4 days, the germinated seeds were counted to determine the percentage of germination.

Seed Distribution Test

This test was conducted to determine the number of seeds per meter length of row, distance of seeds per hill, width of seed inter-rows, and pattern of distribution. The seeder was operated on the greased plastic sheet spread over the floor. This test was conducted with two replications for two types of seed metering devices meant for dry and pregerminated seeds.

Field Performance Test

The field performance test was conducted to obtain actual data on overall machine performance, operating accuracy, work capacity, field conditions and field efficiency.

The fields were prepared to create an optimum condition for germination. The fields were ploughed by disc plough, harrowed by disc harrow, and three times tilled by rotavator, and levelled by leveller. Field performance test was conducted with two replications and two treatments. The treatments were planting with dry seeds and pre-germinated seeds.

The field performance was evaluated by measuring the delivery rate, row spacing, distance between hills, population of seed planted in unit area, population of established plants in unit area, ratio of established plants to seed planted, depth of planting, slippage, ease in handling and operation, soil moisture content, bulk density of soil and core index.

Work Rate and Labour Requirement

Work rate and labour requirements were calculated by measuring the actual average travelling speed, actual operating horus, time spent for turning at headland, time spent for supply of seed, time spent for adjustment of machine, time spent for machine trouble, working capacity (ha/h), field efficiency, required number of workers and man-hours, fuel consumption, pull and draft, and power required.

Results and Discussion

A Kubota two-wheel tractor was used to pull the seeder. The double clutch in the two wheel tractor and the seeder could help during operation. It was very easy to turn the seeder at the end of row/head land.

The field capacity of the seeder was about 0.5 ha/h. The third gear was used to operate the seeder with average velocity 0.8 m/sec. The average slip in the driving wheels was about 11%; and average field efficiency was about 78 percent.

The driving wheels with eight lugs on each wheel rotated the metering mechanism and flutes during operation, and the flutes can pick up 3 to 5 seeds from the hopper and place down in the furrow through the seed guide.

The hopper can be easily filled and refilled with seed during operation. One hectare needed two times to refill the seed hopper. The delivery rate per hectares was about 15.27 kg/ha for full seeds in the hopper, 14.81 kg/ha for three fourth seeds in the hopper, 14.96 kg/ha for half seeds in the hopper and 15.57 kg/ha for one-fourth seeds in hopper.

The damage on seeds due to metering mechanism was negligible for soaked seeds and the average germination was about 93 percent after passing through the hopper and for pregerminated seeds, the average germination was 96% after passing through the hopper and 98% before passing through the hopper.

The double-disc type furrow opener could place the seed at the desired depth (2 to 7 cm) along eight straight lines in the row with inter-row spacing of 25 cm. The double disc furrow opener could reduce the draft requirement in the field due to the use of roller bearings which reduce friction during rotation.

The average number of seeds per hill was about 3.78 at first gear, 4.59 seeds at second gear and 4.03 at third gear. The average distance between hills was about 26.8 cm at first gear, 23.5 cm at second gear and 24.9 cm at third gear. The average row spacing was about 23.7 cm at first gear, 22.90 at second gear, and 22.5 cm at third gear. The average number of seeds per meter length of row was about 15.8 at first gear, 16.4 at second gear and 15.10 at third gear.

The number of established plants per meter length of row was about 13, with row spacing 24.2 cm, hill distance 27.2 cm, number of plants to number of seeds sown in unit area was about 80 percent.

It cost Baht 7,377 for material and Baht 1,575 for labour to fabricate the seeder. The manufacturing price was about Baht 13,000 and selling price Baht 16,000.

The total cost of planting by AIT direct paddy seeder was Baht 214 per hectare, and the break-even point for AIT direct paddy seeder was about 3 to 4 hectares.

REFERENCES

Khan, A.U. 1975. International Rice Research Institute, Annual Report, Los Banos, Philippines.

Nastier, C. Navacero. 1969. A row seeder for lowland rice soils. Saturday Seminar (IRRI), September 6, 1969. International Rice Research Institute.

Singh, R.D., Bhagwan Singh and K.N. Singh. 1983. Evaluation of IRRI Pantnagar bullock-drawn, six row paddy seeder. Agricultural Mechanization in Asia, Africà and Latin America 14(3): 15-20.

Srivastava, A.P., M.S. Kalra and A.K. Wadhwa. 1986. Performance evaluation of pregerminated paddy. Journal Agricultural Engineering, ISAE. 23(1): 1-6.

Srivastava, A.P. and J.S. Panwar. 1988. Optimum sprout length for sowing pregerminated paddy seed in puddled soil. Agricultural Mechanization in Asia, Africa and Latin America 19(3): 43-46.

Tiwari, V.K. and R.K. Datta. 1983. Development of wetland seeder from mechanical and ergonomical consideratoin. Agricultural Mechanization in Asia, Africa and Latin America 14(3): 21-27.

Yoshiaki Nakamura, Haruhiko Murase and Sakae Shibusawa. (1983). Direct seeding with coated rice in submerged paddy field (1) Agricultural Mechanization in Asia Africa, and Latin America 14(3): 11-14.

Developments in Mechanical Planting of Sugarcane

by
Muhammad Farooq
Farm Machinery Institute
National Agric. Res. Centre
Islamabad, Pakistan

Abdul Majid
Farm Machinery Institute
National Agric. Res. Centre
Islamabad, Pakistan

S. Iqbal Ahmad
Farm Machinery Institute
National Agric. Res. Centre
Islamabad, Pakistan

Introduction

In the Middle Ages sugar was a luxury in Western Europe, used mainly in exotic sweets and in pharmaceutical preparations. But today it is an important ingredient of human diet all over the world. It is one of the leading staples in the international commerce despite the fact that it is produced in over 69 countries throughout the temperate and tropical regions (1). In 1965 cane shared 70% of the world sugar production as its yield per hectare was much higher than beet (1). Average yields of sugar from cane in Java (Indonesia) were 15.2 tons per hectare against 4.0 tons per hectare from beets in Belgium and Czechoslovakia, and 3.1 tons in France (1).

Sugarcane is propagated by the cuttings of stalk with at least two buds, called sets instead of the seeds produced in the tassel. Precision planting is adopted for sugarcane in almost all the cane growing countries. Seed rates vary enormously in different growing areas (1). Planting of sugarcane essentially consists of opening a furrow, laying the sets in the bottom of the furrow and covering them with a blanket of soil. These operations are modified to suit the varying agro-climatic conditions in different parts of the world. Under certain conditions cane is planted in shallow furrows, others under deep furrows; in some cases it is planted at the bottom of the furrow, in others at the top of the ridge or bed. In certain regions the furrows are spaced closer together than in others. Where the cane is for the most part rainfed, the furrows are filled up completely and the field is levelled after planting while in irrigated areas furrows are partially filled and water is applied in the furrows. Most of the time the dry leaves are removed from the stalk. It is claimed that the cleaned seed assures a satisfactory stand and it helps in keeping certain diseases such as leaf scald, ratoon stunning and cholorotic streak under control but uncleaned seed is also used in some areas (1). Cleaning of seed cane shares 84% of the labour required for seed preparation (194 man-h/ha). It can be eliminated if uncleaned seed is successfully used (2). Transplanting of pregerminated buds has also been investigated in Hawaii, but due to very high costs, its feasibility is very doubtful (1).

Need for Mechanization of Sugarcane Planting

Planting or sowing creates foundation for a crop and plays a crucial role in its growth and yield. Its importance is accentuated for sugarcane as it is cultivated more than once and as it is a yearly crop. Time of planting takes a larger share of the effects of planting on the plant growth. Late planting of sugarcane has been reported as one of the reasons for low yields in Pakistan by Fasihi, Parc and Qureshi (3, 4, 5). Timely planting has also been emphasised in some other countries (6, 7). Both the rising labour charges and timely non-availability cause delay in planting (8, 9) and demand for its mechanization.

Historical View of Developments in Mechanical Planting

Uichanco (8), reports that the Australian sugar industry was forced to fully mechanize field operations from planting to harvesting with rapid development in the 1960s because of labour scarcity and its escalating costs. They have demonstrated that increased efficiency through mechanization enable them to weather periods of low world sugar prices and reap enormous windfall profits during times of high prices.

In Kerr's words (9) the impetus for the Australian sugar industry to invest and adopt labour saving machinery as well as efficient farming methods was provided by higher labour costs in the industry. Australia pioneered the development of the first commercially successful harvesting machine in the 1950s and has been in the forefront of mechanized cane growing ever since. Australian cane grower's innovative approach to farm cultivation, harvesting and transport problems has enabled them to work on problem areas which traditionally involved a heavy reliance on outside farm labour. For years, the planting operation has been one of the industry's major labour problems despite the development of tractor-drawn machines able to plant unstripped cane. A major breakthrough was the successful development of automatic billet planting machines which virtually made planting a one man operation.

Similar views about the progress of mechanical sugarcane planting in Queensland, Australia has been reported by Cyril (10). He cited cane planting as a labour intensive operation. Using traditional methods, the yardstick for work done per unit of labour was 0.4 ha planted per day. The first attempt to change the planting methods was quick detrashing of the planting material by the use of a scotch stripper followed by mechanical stripper with a system of rollers to detrash the stalk. The development of the speedy planter came later. This machine needed two men to feed the planting material but covered the ground at a much faster rate. It was followed by the development of a trash planter which could handle untrashed cane without any difficulty. It still maintained a fast ground speed with two persons feeding. The latest innovation of the time is the automatic billet planter.

Clive (11) stated a different story of the development of mechanical sugarcane planting in Australia. He said that the specialist-designed machinery has made a major contribution. Names like Hodge and Milne come readily to mind, both designers of early cutter planters. In fact the Hodge cutter planter was considered so important on national basis during World War II that it felt full weight of Federal Government Emergency Legislation which brought into being such undemocratic but necessary legislation as the Manpower Act. As part of this wide reaching legislation, owners of Hodge cutter planters were obliged to hire them out regardless to their cane growers who did not own this labour saving machine. The rate of hire was fixed by the Price Fixing Tribunal, a body emerged as a result of the same war time legislation. The then Prime Minister, Robert Gordon Menzies, when introducing the legislation said, "This is a wholesale invasion of privacy I have no doubt, it is preferable, however, to a wholesale invasion of the British Empire."

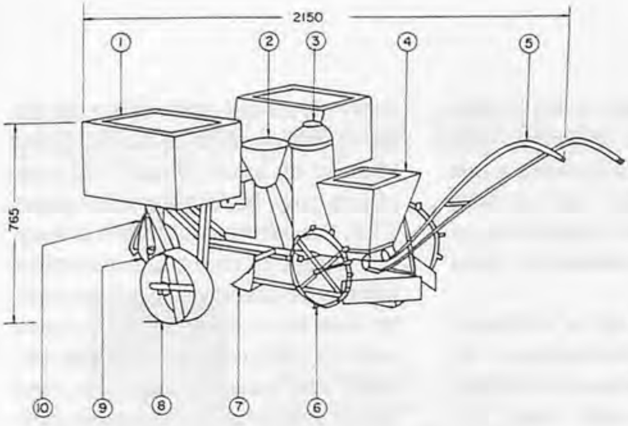
Clayton (12) reported that sugarcane has been planted by hand in most of the sugarcane growing areas of Florida until the development of labour shortage during World War II. At that time conveyors were put into use to move the cane stalks to the workers for planting. It was found that short pieces of cane were much easier to distribute than long crooked stalks. As a result cane has been planted in short pieces in some areas for several years. These short pieces are quite often cut by hand, transported to the field and planted by hand. Since 7-10 tons of sets must be distributed to plant 1 ha, the labour required is a large percentage of the total production labour. A conveyor bottom wagon was introduced later to move cane to the workers who walk behind the wagon, pick the seed pieces and drop to the furrow bottoms. Certain other approaches later on resulted in different types of conveyors.

Mechanical Planting Systems

The mechanical planters developed so far can be classified as billet (set) planters, cutter planters or wholestalk planters.

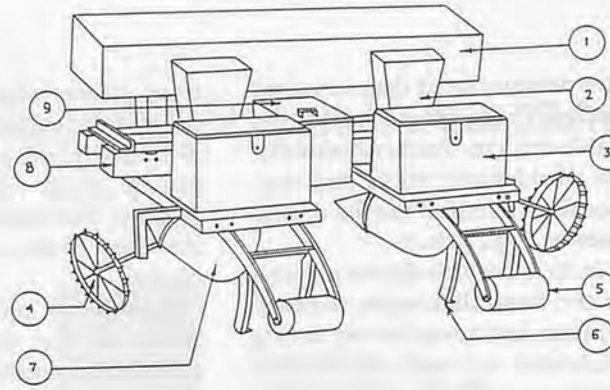
Semi-automatic Billet (Set) Planters

These are animal- or tractor-drawn planting units. The development of animal drawn planters is reported in India (13). These planters are single row attachments to a carriage (**Fig. 1**). Animal-drawn planters function similarly as tractor-drawn planters. These planters have been equipped with various types of set dropping mechanisms. The simplest were developed in India, Cuba, Hawaii and South Africa (14). In these planters the sets are picked from hopper manually and are either dropped directly to the furrow bottom or they are transferred with the help of chutes (**Figs. 2 and 3**). A very simple rota-drum semi-automatic sugarcane planter (15) was developed in India. This is equipped with vertical rotating drums with 12 vertical seed compartments in each drum. The sets are filled in these compartments manually which are carried along by the rotating drum. When a set comes above the opening provided at the stationary drum bottom, it falls into the



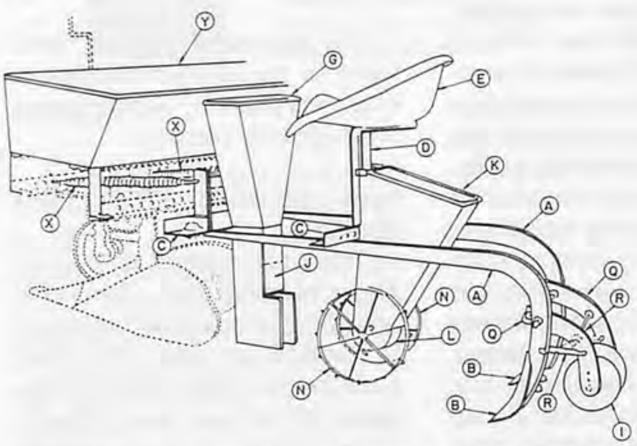
(1) Seed box
(2) Seed chute
(3) Insecticide tank
(4) Fertilizer container
(5) Handle
(6) Fertilizer agitator drive wheel
(7) Share point
(8) Rear wheel
(9) Castor wheel
(10) Tow hook

Fig. 1 Sugarcane planter.



1. SEED HOPPER
2. SEED CHUTE
3. FERTILIZER BOX CUM SEAT
4. LUGGED LAND WHEEL
5. TAMPING ROLLER
6. CULTIVATOR TINE
7. RIDGER BODY
8. FRAME
9. INSECTICIDE TANK

Fig. 2 Semi-automatic sugarcane planter.



A = standard rigid cultivator shank, B = reversible shovel, C = angle iron cross member, D = bracket for seat, E = seat, G = seed chute, I = tamping roller, K = fertilizer hopper, L = dispenser, N = driving wheel, O = bracket for tamping roller, R = tension spring, Y = sheet metal through

Fig. 3 Details of the I.I.S.R. tractor-drawn sugarcane planter.

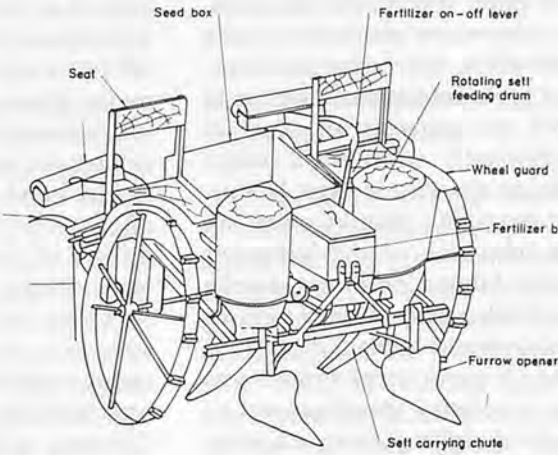


Fig. 4 Two-row tractor-drawn mounted type semi-automatic sugarcane planter.

chute which leads it to the furrow bottom (**Fig. 4**).

In Florida, workers walk behind a conveyor bottom wagon, pick the cane pieces and drop them in the furrow. Bottom conveyor moves cane to the rear of wagon for workers. Some of the conveyors have been located on wagons so that the workers could distribute the cane pieces on to the conveyor which, in turn, discharges them into the open furrow. Other devices used have been equipped with various chain attachments or mechanical fingers which grip the cane and meter onto conveyors or into the furrows (12).

Mayeux (16) described a semi-mechanical sugarcane planter which consisted of two-wheel cart with a central planting chute. The sets are fed manually to the chute where a feeder operated by Geneva drive meter them to the furrow bottom. The planter-replanter developed in Australia (17) is equipped with seed bins having live floor conveyor. The seed bin conveyor moves seed pieces to crewmen who shift them to another small conveyor. This conveyor drops the seed down a chute and into the furrow.

The work capacity of these machines is limited by the speed of the persons feeding cane sets. As every individual has different feeding speed, the machines moving at the same speed can result in different seed rates and levels of sets distribution. These machines are also not reliable for seed rate and distribution as many individuals are not reliable workers. Sets should be free of dry leaves for better results.

Automatic Billet Planters

Sets cut to more or less uniform length are used by these machines. The sets may be cut manually or mechanically. These machines mainly consist of metering units, seed chutes, fertilizer applicators, covering and pressing devices.

Generally, two types of metering techniques are used in such machines, finger wheel or chain type. Only the planter developed in India (18) used finger wheels with the assistance of regimenting rollers (**Fig. 5**). Sets loaded in a hopper are pushed by pushers to finger wheel which pick them up. Regimenting rollers over the finger wheel and rotating in opposite directions take back extra sets. Finger wheels drop these sets to the chute.

In the chain type metering mechanisms, developed in United States and Australia (**Fig. 6**), sets are dropped in small numbers to smaller bins by wagons having conveyor beds. The second conveyors pick these sets from the small bins and feed them to other conveyors or chutes. Extra sets are either taken back from these chains by spring loaded flaps or flow down due to higher slope of the chain. Chutes align and transfer these sets to the furrow bottom (19, 20, 21).

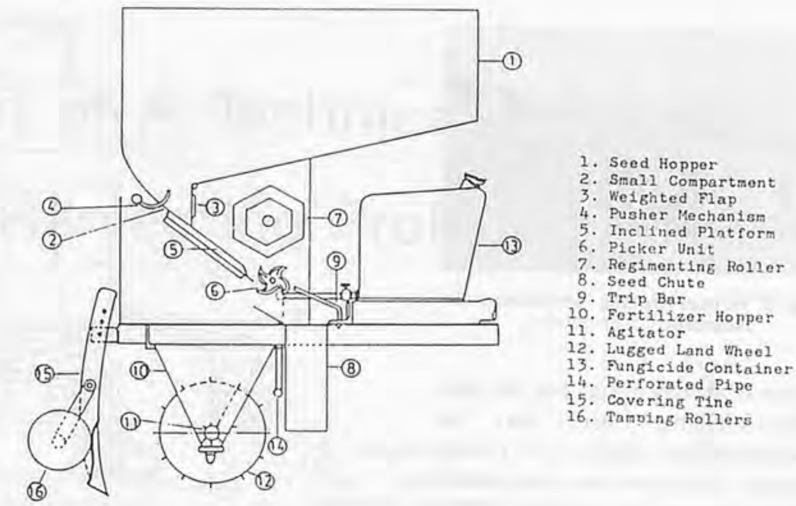


Fig. 5 Automatic sugarcane set planter.

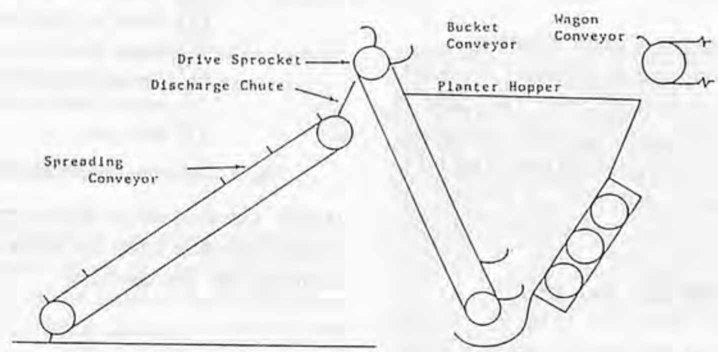


Fig. 6 Chain type metering device for metering cane.

Semi-automatic Cutter Planters

The whole cane stalk is fed to these machines manually. The machine cuts it into pieces and places them at the furrow bottom. Cane is fed to these machines horizontally or vertically. In horizontal feeding machines, the length of cane may be along the direction of forward travel or perpendicular to the direction of travel (**Fig. 7**). Different types of feeding and cutting/metering systems are used in these machines. The rate and distribution of cane seed in these machines is controlled through cutting rate and style in relation to forward speed.

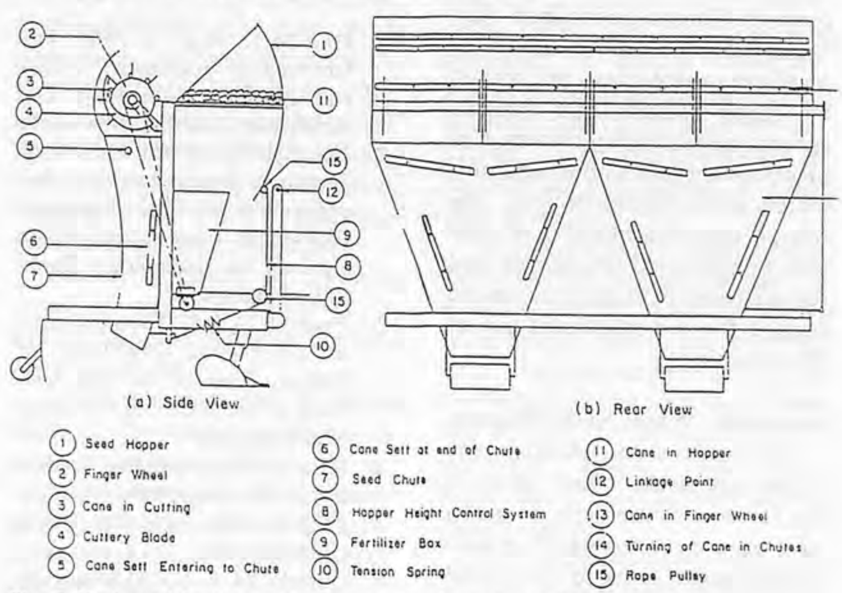


Fig. 7 Horizontal feeding semi-automatic sugarcane cutter planter.

In horizontal feeding machines and with cane perpendicular to the direction of travel, the finger wheels press the cane against the stationary blades which cut it into pieces (22). In other horizontal feeding machines cane parallel to the travel direction is fed to the rollers. The cutters which are fixed in upper and lower rollers coincide and cut the cane (23).

In vertical feeding machines, cane falls freely (24) (**Fig. 8**) or it is pushed by the rollers to the cutting units (25). In free fall, the length of sets has a greater variation at different speeds. Sometimes the crewmen have to hold the cane. Feed through rollers

Fig. 8 Vertical feeding semi-automatic sugarcane cutter planter.

gives relatively equal size of sets. The cutting units may be reciprocating cutters or rotary cutters. The cutters may be ground wheel driven or tractor PTO operated.

Automatic Cutter Planters

This type of planters are loaded with whole cane. The cane is fed to the cutting units automatically which cut it to pieces and discharge to furrows. A planter of this type (2) uses inclined hopper in which the cane is loaded horizontally and parallel to the travel direction **(Fig. 9)**. Canes move to the bottom due to gravity. Pushers at the hopper bottom push the cane to an inclined platform. Canes roll to the end of this platform where these are picked by finger wheels and pressed against the stationary cutters. Cut pieces drop to the chutes and ultimately to the furrow bottom. The rate of seed placement is in relation to the speed of pushers and forward speed. Straight canes are needed for the successful use of this machine.

Automatic Whole Stalk Planters

In whole stalk planters the whole cane stalk is laid down in the furrow. Some type of grabs have been designed which snatch it at one point, move to the desired location and leave the cane. The grabs are opened by a cam and closed by a spring. A planter used two grabs mounted on a rotating bar 180 degrees apart (16). Another machine used a planting arm with cam-actuated grabs suspended over the rear of seed trailer. Ground wheel driven grabs snatch the cane from the mass and drop to the furrow (16).

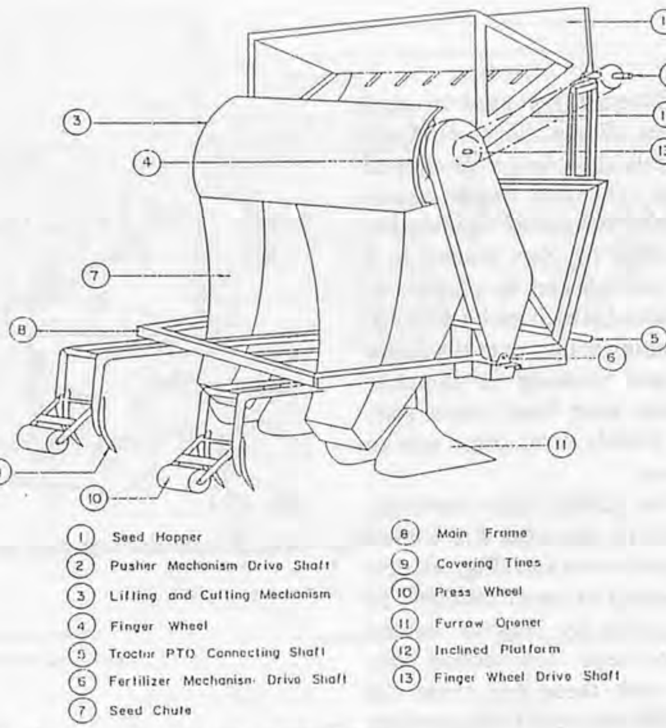


Fig. 9 Automatic sugarcane cutter planter.

REFERENCES

1. Humbert, R.P, (1968) The Growing of Sugarcane, revised ed. Elsevier Publishing Co, Amsterdam, London, New York.
2. Farooq, M, (1985) Field Performance Evaluation and Improvement of FMI Sugarcane Planter, M. Engg. Thesis, Asian Institute of Technology, Bangkok, Thailand.
3. Fasihi, S.D, (1978) Some Aspects of Sugarcane Problems of Punjab, Proc. of the 15th Ann. Con. of the Pak. Soc. of Sugar Technologists.
4. Parc, (1979) Sugarcane Production: Recommendations for 1979-80, Pak. Agri. Res. Council, Islamabad.
5. Qureshi, M.A. (1978) Some Suggestions to Increase Sugar Production in Pakistan, Proc. of the 15th Ann. Con. of the Pak. Soc. of Sugar Technologists.
6. Singh, K., Prasad. S.R. and M. Alam, (1983) Improving the yield of Late Planted Sugarcane, Indian Farming, Vol. 32 (11).
7. Kira, M.T. and H. El-Sherif, (1972) Effects of Date of Planting on Chilo Agamemnon Bles in Sugarcane in UAR, Proc. of the 14th Congress of the Int. Soc. of Sugarcane Technologists held at Louisiana.
8. Uichanco, E.A. (1981) The Australian Sugarcane Cultural System: A Fully Mechanised, High Yield, High Efficience Way to Produce Sugar, AMA, Summer, 1981.
9. Kerr, W.P. (1979) Automatic Billet Planting in Australia, Producer's Review, March, 1979.
10. Cyril, M.A. (1978) Tests Show Billet Planter Sound But Can Be Improved, Cane Growers Quarterly Bulletin, Vol. 41.
11. Clive, M. (1977) Automatic Planting, Producer's Review, November, 1977.
12. Clayton, J.E. (1973) Experiments With Metering Devices For Planting Short-length Sugarcane, Hawaiian Sugar technologist's Reports.
13. RNAM, (1980) Regional Catalog of Agricultural Implements, Regional Network for Agricultural Machinery, Philippines.

(Continued on page 36)

Development of A Technical Solution to Cassava Harvesting Problem

by
L. Peipp
Head, Dept. of Agric. Machinery
Institute of Tropical Agriculture
Karl Marx University
Leipzig, Germany

E. Maehnert
Dept. of Agric. Machinery
Institue of Tropical Agriculture
karl Marx university
Leipzig, Germany

Abstract

Cassava is among the most extensively cultivated root crops. At present increasing attention is being given to this plant. A much-neglected peasent crop only a few decades ago, it has developed into a raw material supplier for the steadily increasing domestic and foreign markets.

The traditional way of producing cassava roots in many places no longer meet the current requirements. Above all, a technical solution to root harvesting, which is physically hard work and at the same time the most time-consuming process among the various stages of production, is called for.

After the elaboration of the agrophysical parameters on the basis of extensive investigations in Cuba, the requirements of functional elements had been determined under the extremely difficult natural conditions there, which resulted in the decision to utilize a variant for this process different from those known so far. The procedure is that the root cluster is loosened by cutting the soil underneath with simultaneous lifting of the cluster by grasping the stalk and pulling it out. The results of the tests carried out in the laboratory and the field confirmed, even under harsh conditions, the expected advances.

Introduction

Cassava is the most important representative of root and tuber crops in the tropics. According to FAO (1986) cassava is grown on an area of 14.2 million ha. Since 1960 the volume of production has increased 240%. The plant is of paramount importance because of its compartively high starch content, its high yield potential which has so far not been fully utilized, its drought resistance and its suitability for soils which are not conductive to paddy cultivation.

The development of cassava from a peasant crop to a widespread cash is due to the following factors:

i) The urbanization of large parts of the rural population in cassava growing countries;

ii) Decreasing financial means, to buy wheat abroad and, therefore, to substitute wheat flour for cassava starch;

iii) World-wide extension of the feedstuff industry increasingly marking the use of cassava products.

Cassava-growing countries responded to this trend. There is a noticeable boost of state-owned, cooperative and private enterprises and trading organizations to buy, sell and process cassava roots and tapioca. At the same time, changes are to be observed in the choice of varieties, in the agronomic measures taken, including a seasonably staggered cultivation and a territorial concentration of the cultivation areas.

Industrial plants of different sizes for the production of starch, chips, pellets and other products appeared in several countries. Plants processing from 50 to 300 t of fresh cassava roots per day are known. In the mid-1970s 44% of the annual production of roots were processed.

In contrast to the industrialized processing of the roots the harvest is still carried out almost exclusively by hand. Changes are becoming more and more apparent. It is the harvesting of the root that raises the greatest problem because it requires about 180 man-hours/hectore and is tremendously back breaking.

The mechanization of the harvesting process has the following aims:

i) Lowering of the overall production costs;

ii) Increase of labour productivity;

iii) Elimination of the physical load;

iv) Decrease in the root losses and damage; and

v) A steady supply of roots for the buyer.

Cassava Root Harvester

Up to the present time there is a marked lack of any specific cassava-root harvester. The machines that have became known so far are either still in the pilot stage or are being employed in very small numbers under easier harvesting conditions. Though manual uprooting is still predominant, there are mainly three harvesting variants:

1. Simple loosening tools to facilitate the manual extraction of the roots (ploughs, CIAT-tool etc.). These loosen the root cluster in the soil.
2. Diggers separating the soil from the roots. Similar to the potato-harvester, they lift the soil together with the roots on to chain-belts or swing-sieves.
3. Implements and machines extracting the root cluster from the unloosened soil.

All these solutions help to reduce losses and the required labour. Depending on local conditions various kinds of shortages cropped up, such as insufficient sturdiness, when the comparatively heavy soil is handled, as well as losses and damage due to the pressure exerted by the tools.

Though the plant is suited for extraction from the hard soil, losses arise because roots get broken or remain in the soil. The characteristic of all these procedures is a comparatively high power input, especially if heavy soils are prevalent.

The development of our own prototype of cassava harvester proceeds from the conditions found in Cuba as represented in **Table 1.** The data on the plant **(Table 2)** refer exclusively to the variety Señorita. The crop population is 14 300 plants per ha with a distance of 90 cm between rows, and 11 100 plants per ha with a distance of 140 cm. The mean yield is 20.5 t/ha and 22.9 t/ha, respectively. The cluster space geometry of the plants is of special importance for the dimensions of the machine. It is that which distinguishes cassava from other tuber crops. The depth of the cluster may be 60 cm. The maximum of the frequency of root depth is 35 cm **(Fig. 1)**. To attain a 95% harvest of the roots the tool has to penetrate the soil up to a depth of 45 cm with a row distance of 140 cm and up to 50 cm with 90 cm. As regards the frequency of the root cluster width the greater value is to be attributed to the greater width **(Fig. 2)**. The root shape is predominantly cylindrical to conical. The difference in the number of roots is negligible. The yield difference is due to greater foot length.

Table 1 Local Conditions in Cuba[1)]

Place	Soil type	Moisture[2)] (%)	Plant age (month)	Distance betw. rows (cm)	Proportion of weeds (t/ha)	Proportion of stones
Melena des Sur	red ferrallitic soil	21.5	13	140	7.5	no
Vinales	red ferrallitic soil	22.0	12	140	8.0	low incidence
Batabano	red ferrallitic soil	20.0	12	90	6.5	no
St. Clara	tropical brown soil	23.0	13	90	10.5	low incidence

1) Cultivation is invariably done on ridges.
2) Date is the mean obtained during the period of investigation.

Table 2 Selected Parameters

Item		Distance between rows = 90 cm			Distance between rows = 140 cm		
		$\bar{x}$	δ	Xmax	$\bar{x}$	δ	Xmax
Number of roots per plant		7.1	3.1	15	5.9	2.5	13
Length of roots	(mm)	222	90	580	530	153	790
Diameter of roots	(mm)[1)]	48.0	8.5	75	45.7	7.2	56
Individual root weight	(g)	336	225	1504	441	251	900
Root weight per plant	(kg)	2.26	1.24	7.34	2.71	1.20	5.80
Diameter of stalk	(mm)[2)]	24.7	4.7	39.0	33.1	8.20	49.0
Height of frist branching of stalks	(m)	1.11	0.48	—	0.76	0.41	—
Pulling power requirement	(N)	986	240	1550	1439	533	2450

1) measured as maximum diameter. 2) measured at a height of 30 cm above soil.

Under the given conditions, 55% of the plants grow only one stalk whereas 10% grow more than two stalks. With an increasing number of stalks their diameter decreases. At a height of 30 cm above the soil 18% of the stalks with a row distance of 140 cm branch off whereas only 7% do so with 90 cm. **Fig. 3** shows to which extent stalks leave the line in 10, 20 and 30 cm above the ground.

The height of the ridge is 12 to 20 cm after a 12 months' vegetation period. Investigations in the field show, that the stalk can stand a pulling power of 2450 N at an approximate height of 30 cm. But the danger arises when roots are torn off with large portions remaining in the soil. To extract 95% of the plants at a row distance of 90 cm from the hard soil, as found in Cuba, 1500 N are necessary as against 2400 N at 140 cm.

The procedures employed in the harvest of roots are: i) digging; ii) pulling; iii) combined digging and

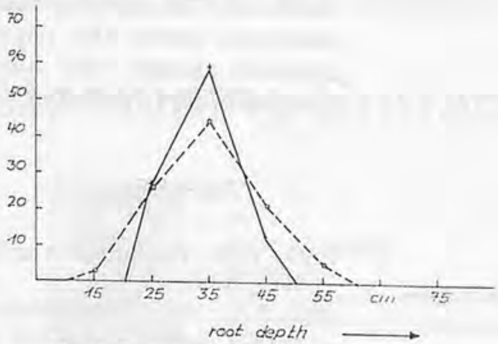


Fig. 1 Frequency polygon of root depth.

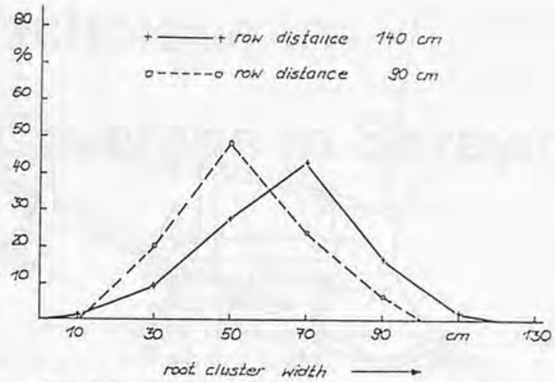


Fig. 2 Frequency polygon of root cluster width.

pulling.

The first variant requires the moving of huge volume of soil with all related technical disadvantages. At a digging depth of 40 cm, about 80% of all root clusters are included. The weight loss is only 1.6% at this depth. Analogous investigations show that the working width of the digger should not be less than 80 cm. Considering practical harvesting conditions (plants growing out of line, skill of driver) a working width of 100 cm is recommended. In this case the proportion of roots is only 0.2%. This way of digging is confined to light sandy soils (**Table 3**).

The second variant, the pulling procedure, results in root losses and damage on medium and heavy soils. Aware of fact that the effectiveness of the first and second variants is restricted, we give preference to the combined digging and pulling procedure. **Fig. 4** shows the layout of the solution which is to be introducted here.

1. The digging unit with
   —frame, attached to the tractor by way of a three-point-linkage system (1)
   —share (2)
2. The pulling unit linked to the frame (1) by means of
   —frame (3)
   —guide element (4)
   —pulling belts (5)

The test was conducted under extremely hard conditions drawn by 20 kN-tractors. The harvesting of the roots with machine is preceded by the cutting of stalks at a height of about 30 cm above the soil and by the removing of the trash. The machine cuts the soil beneath the cluster, loosens it and at the same time lifts it by 20 cm.

This is immediately followed by the pulling process caused by grasping the stalks between belts with an incline of 20 to 30 degrees with the latter lifting the roots from the soil and depositing them on to the surface of the field. The machine leaves the field smooth and the soil loosened to a remarkable depth.

Moreover, this machine has the following advantages.

a) The deadweight of the machine can increase the available traction of the tractor;
b) It can be adapted to different row distances;
c) The convex mould-board attached to the share breaks up the soil so as to loosen the soil

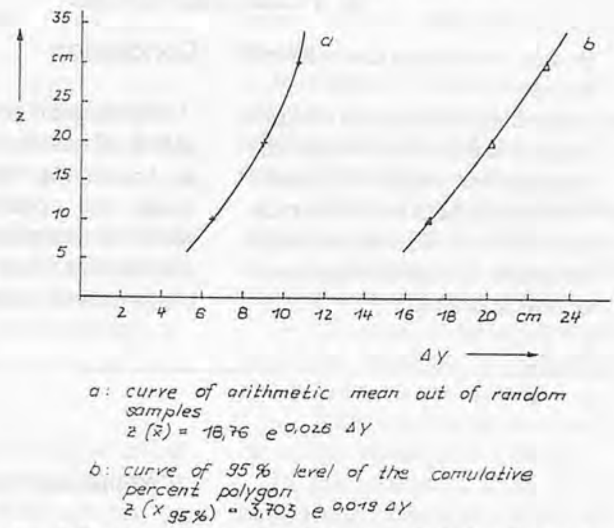


Fig. 3 Position of stalks out of the theoretical plant line xy (z—height above ground level).

Table 3 Requirements of Machine in Different Harvesting Procedures

Item	Digging	Pulling	Digging and Pulling
Working depth	40 cm	—	40 cm
Working width	100 cm	—	100 cm
Weight to be lifted	(4...6).10^3 t/ha	65...125 t/ha	65...125 t/ha
Root: Soil-rate	0.2%	0...15%	8...15%
Soil resistance	15 kN	—	15 kN
Required pulling power	—	1.0...2.5 kN	0.8 kN

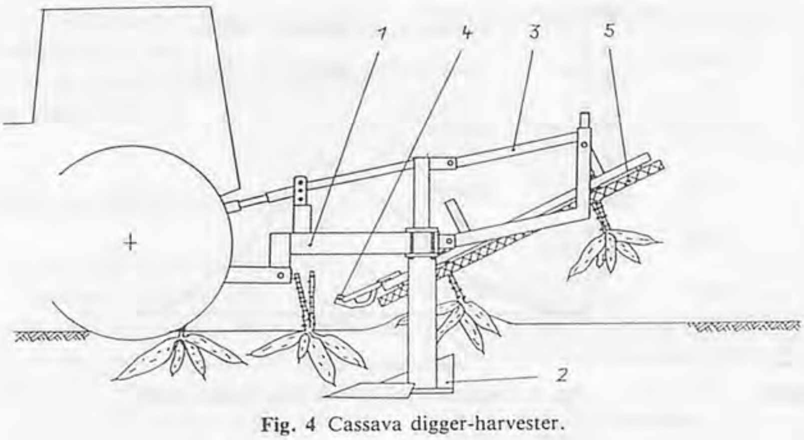


Fig. 4 Cassava digger-harvester.

evenly, preventing damage and losses;

d) According to the given circumstances it is possible to use the digging unit separately; and

e) The hydraulic drive of the pulling unit allows for an easy adoption to the driving-speed of the machine.

Conclusion

The present trend of the utilization of cassava calls for rational harvesting procedures, also under the conditions of heavy soils. The combined digging and pulling technique makes it possible to harvest with minimum losses and under favorable ergonomic conditions. The harvester that we developed meets the required demands under the above-mentioned hard conditions.

REFERENCES

FAO, 1986. Production Yearbook 1985, Rome.

Diaz, R.O. 1977. Characteristics of world's cassava production with emphasis on Latain America. CIAT, Cali.

Odigboh, H.: Ahmed, S.F. 1982. A cassava harvester: Design analysis and prototype development, AMA 12 Nr. 3.

Van Der Sar, T. 1979. Hand operated cassava harvester, AMA 10 Nr. 1.

CIAT, 1987. Highlights. Cassava Newsletter, Cali. ■■

(Continued from page 32)

Development in Mechanical Planting of Sugarcane

14. *Memon, R.G. (1968) IISR Tractor-Drawn Sugarcane Planter, ISST Proc. of 13th Congress, Taiwan.*

15. *Shukla, L.N., Verma, S.R. and A Singh, (1978) Development of a semi-automatic Tractor-Drawn Rota-drum Sugarcane Planter, Journal of Agri. Engg. Vol. 15, No. 4.*

16. *Mayeux, M.M. and B.J. Cochran, (1971) Sugarcane Planter Mechanisms, Trans. of ASAE, Vol. 14.*

17. *Trenholme, C.J., Progress Report On Planter-replanter Designed specifically for Drip Irrigation Field, Wailuku Sugar Company.*

18. Srivastava, N.S.L. and R.G. Memon, (1972) The IISR Automatic Tractor-Drawn Sugarcane Planter, Journal of Agri. Engg., Vol. 9, No. 1.

19. Eiland, B.R. and J.E. Clayton, (1975) Development of Singulation System for Planting Sugarcane in Florida, Presented at the 1975 Winter Meeting of American Soc. of Agri. Engineers, Chicago, Illinois.

20. Cameco Billet and Wholestalk Planters, a leaflet from Cane Machinery and Engg. Co. Inc. Louisiana, USA.

21. (1975) Automatic Cane Planter Works Smoothly in Tweed District, Australian Sugar Journal, December, 1975.

22. Khalid, M., Aslam, M. and S.I. Ahmad, (1984) Design of FMI Sugarcane Planter, Paper Presented at the 5th Ann. Con. of Pak. Soc. of Agri. Engineers, May 24-25.

23. B-33 Cane Planter, Leaflet from ONEL.

24. Yasin, M., Chaudhary, A.S. and M.A. Farooq, (1985) AMRI Sugarcane Planter, Paper Prepared for 6th Ann. Con. of Pak. Soc. of Agri. Engineers.

25. Sugarcane Planter — PMC 181, Leaflet from Gard Pere Et Fils, 30500 Potelieres, France. ■■

Use of Colorimetric Technique in Determining Surface Coverage in Spraying

by
Aziz Ozmerzi
Assoc. Prof.
Farm Mechanization Dept.
Agricultural Faculty, Akdeniz University
Antalya, Turkey

Ibrahim Cilingir
Asst. Prof.
Farm Mechanization Dept.
Agricultural Faculty, Ankara University
Ankara, Turkey

Introduction

Nowadays, chemical pest control is widely used in the crop protection. In terms of quality and quantity in crop protection, appropriate effectiveness can be provided when the chemicals are properly selected and properly applied on the surface of the plants. This application depends directly on the effective use of sprayers and pest control need not cause environmental pollution.

In order to evaluate the effectiveness of a sprayer, at first it is necessary to determine the pulverization characteristics of the sprayer such as the average drop diameter, drop size uniformity, drop density and degree of spray coverage. Some methods are still used for these determination. In a research carried out with turbo-sprayer, the colorimetric method has been applied. This paper shows how the colorimetric method is applied in determining the surface coverage.

The colorimetric method is fast and sensitive and gives more economic working opportunity than other methods. In this method, the colored compound at the given concentration is used as spraying liquid. The washing water being collected off the sample surfaces is measured with colorimeter or spectrophotometer. From these measurements, the quantity of the spraying liquid on the unit area can be calculated.

Determination of Volume of Spraying Liquid per Unit Area by the Colorimeter

The calculation of this method and the way in which this method is applied may be divided into sampling and measurement of samples.

Sampling

The glass plates of 20 × 20 cm size are suitable for the sampling surface. These plates are put on the private stalls in the given rows along the spraying width of the sprayer. The height, number and position of the sampling surface are selected according to the experiment to be carried out.

The colour collecting on the glass is washed with pressured water and washing water is collected in a tube. For this washing, 5-15 ml of water is enough.

Measurement of Samples

The measurement of the concentration for colour can be done by means of colorimeter or spectrophotometer. It is satisfactory that the spectrophotometer has a sensitivity of 1 ppm.

At first the spectrophotometer is calibrated zero by using pure water before the measurements. It is necessary that the spectrophotometer is calibrated with standard series whose concentration is known.

In respect of measuring the sensitivity, the colour used on the colorimetric method must have same properties as follows:

— It must be properly disolved in water and must be transparent.

— It need not leave any residue when it is mixed with water.

— The washing water obtained from the washing of sampling plates must be transparent.

— After it is dissolved in water its colour should not change.

In this research, dust colour having the properties mentioned above was used and it is called ACILLAN CROSEIN M007. This colour gave satisfactory results.

The colour concentration of spraying water used in the experiments was 1 g/l (1000 ppm). This concentration was determined to be satisfactory for precision measuring.

When preparing the standard series, the amount of coloured compound which will fall on the surface of a glass plate must be considered. The amount of the compound is calculated from the theoretical application rate. The spectrophotometer was set to measure the range which the coloured compound would be able to fall on to a glass plate.

In this study, a substance of 10 ml was taken off from the spraying compound by a pipe and this was put in a glass balloon of 100 ml. Then the glass balloon was filled with water such that the coloured compound of 100 ppm was obtained. Then water whose amount varied from 1 ml to 12 ml was taken off from this concentration. Each sample was put in a glass balloon of 100 ml and these balloons were filled with water. Therefore, a series whose concentration varied from 1 ppm to 12 ppm was prepared.

Measuring of Standard Series and Samples Obtained

The wave length of 510 (nm) was selected for measuring on the spectrophotometer. This wave length is suitable only for the ACILIAN CROSEIN M007 of 1 g/l. The instrument was made zero by using pure water. After making zero, the calibration factors were determiend for the standard series prepared earlier.

The washing water would be in different colours depending on the amount of the coloured compound falling on the glass. In order to measure the washing water, samples are collected in tubes and diluted from 25 ml to 250 ml. After this process the indicating factor of the washing water is determined on the spectrophotometer.

Evaluation of Measurements

The colour concentration of samples is calculated by comparing them with the reading of standard series. The concentration reading for standard series are (X) and for samples (Y). The calculated correlation factor (r) between (X) and (Y) is 0.99934 and the regression equation for (X) and (Y) is

$$Y = 0.07999\ X - 0.002$$

This equation is shown in **Fig. 1**. This regression factor 0.002 can be omitted as it is very small. $1/m = X/Y$ is called slope factor (S.F.).

S.F. = $1/m = X/Y$ = (Concentration as being ppm)/(Reading on spectrophotometer)

After determining the S.F. of standard series, samples are measured on the spectrophotometer and when readings are multiplied by the S.F., the concentration of samples is obtained.

The amount of colour in the sample must be determined because water of a given volume was added to the samples according to the colour concentration of samples.

If there is 1 mg colour per 1000 ml, the concentration is 1 ppm or if there is 0.25 colour per 250 ml, the concentration is also 1 ppm. Here 1 mg or 0.25 mg is called extent of dilution. For example, if the concentration of a sample being diluted to 25 ml is 1.68 ppm, the amount of colour is

$$X = \frac{1.68 \times 0.025}{1}$$

$$= 0.04 \text{ mg}$$

In this study, as the glass plate of 20 × 20 cm was used as sample surface, this quantity of the colour in the diluted samples which was obtained in washing this plate is the quality of colour which falls on the surface of 20 × 20 cm (400 cm^2). When this is defined as the value of spraying coverage, the spraying coverage is (mg/400 cm^2). In the experiments, the concentration of spraying liquid was 0.1 g/1%. Therefore, 1 ml of this water includes 1 mg colour. The amount in mg of colour obtained after measurement is equal to the amount in ml of spraying liquid falling on the glass plates. Hence, the value of spraying coverage is 1 mg/400 cm^2 or it is defined as (ml/400 cm^2).

The value of spraying coverage in terms of application rate can be shown thus:

$$1 \text{ ml}/400 \text{ cm}^2$$

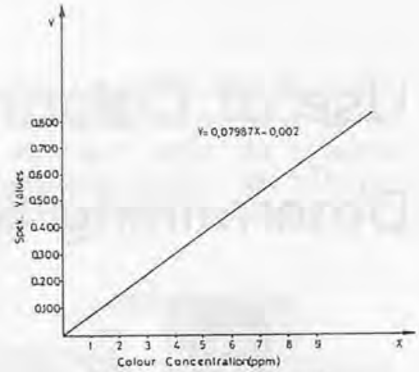


Fig. 1 Calibration curve.

$$= (1 \text{ ml}/400 \text{ cm}^2) \times (1 \text{ l}/1000\text{ml}) \times (1\,000\,000 \text{ cm}^2/1 \text{ da})$$

$$= 25\ \frac{1}{\text{da}}$$

When the value of spraying coverage is multiplied by 25, the application rate can be found. This value provides an opportunity to compare with the theoretical application rate of sprayers.

In this study and in which this method was applied, it was determined that this method was an easy, economical and sensitive method. A graphic presentation obtained in the study conducted is shown in **Fig. 1**.

REFERENCES

Cilingir, I., 1983. Seker Pancarı Tarımsal Savasında Turbo Atomüzörlerin Ilâçlama Karakteristikleri ve Is Basarıları Üzerinde Bir Arastırma. Yayınlanmamıs Doktora Tezi, Ankara, 172 s.

Sharp, R.B., 1974. Spray Deposit Measurement by Fluorescence Pestic. Soi. 5. NIAE, Bedford.

Speelman, L., 1971. A Fluorescent Tracer Technique for Determination of the Liquid Distribution of Field Crop Sprayers. J. Agric. Engag. Res. 16 (3), London.

Vogel, A.I., 1961. A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, Chapter XI (X), London. S. 738-746.

Yates, W.E. and Akesson, N.B., 1963. Fluorescent Tracers for Quantitative Microresidue Analysis. Transaction of the ASAE, Michigan. ■■

Cotton and Weed Seedling Emergence as Affected by Seedbed Preparation

by
Marilou B. Montemayor
Agric. Engineer
Central Cotton Research Institute
Old Shujabad Road
Multan, Pakistan

Abstract

Five methods (treatments) of seedbed preparation with different kinds of tillage implements and combination of implements, each requiring different number of tractor trips over the field, T1: Flexible-tine Cultivator (twice), T2: Rotavator (once) + Cultivator with *sohaga* (once), T3: Roterra (once), T4: Cultivator with sohaga (thrice) (Conventional Method), and T5: Disk Harrow (twice) + Cultivator with sohaga (once) were tested as to their effect on cottonseedling (*Gossypium hirsutum*) and weed emergence, and soil bulk density. The soil clod size distribution is described in percent passing each size of sieve mesh. The objective was to find a method of seedbed preparation requiring a minimum number of tractor trips over the field in order to minimize machinery wheel traffic and to reduce the labour required during seedbed preparation. Using Duncan's multiple range technique in analysis, there was no observed significant difference in cotton seedling emergence among other treatments except between T1 and T5 ($p < 0.05$). The former gave the least and the latter the highest seedling emergence which was not different from the rest of the treatments. There was no significant difference on weed emergence ($p < 0.05$). Therefore, it is concluded that treatment T3 which prepares a seedbed in a single run and does not require labour is an appropriate alternate method for seedbed preparation. It was also observed that tractor and planter wheel traffic during planting operation contributed to severe weed emergence.

Introduction

The cultivator (MF-38 Tiller) of 9, 11, and 13 tines is the most widely used tillage implement in Pakistan, both for primary and secondary tillages. However, gradually over the years some secondary tillage implements have been introduced and are now also popularly used by many cotton farmers, not primarily for seedbed preparation but for shredding and incorporating crop residues and green manuring crop into the soil. These implements are the Rotavator and the off-set disk harrow.

The cultivator is the least expensive tillage implement available, has a low power requirement, is simple and produces a soil reaction similar to that of the traditional animal-drawn plough. These are probably the reasons as to its popularity. However, one of its major drawbacks is the repeated number of runs, ranging from at least three to 10 times it has to make in order to prepare a seedbed of the desired tilth. Moreover, it cannot be used without the wooden plank accessory called "sohaga" which further requires two men to sit on it during field operations (**Fig. 1**). It does not seem to be realized by farmers that repeated number of tractor runs over the same field can possibly have detrimental effects on the soil structure caused by tractor wheel traffic.

Since the Rotavator and the disk harrow have now established their utility with many farmers, it would be worthwhile to investigate their performance in seedbed preparation as well, along with other newly acquired secondary tillage implements, in order to investigate the possibility of reducing the number of tractor runs without sacrificing seedling emergence while keeping energy expended at the minimum practically feasible. The type of seedbed preparation should also eliminate or reduce weed germination.

Review of Literature

There seems to be a dearth of literature regarding the influence of seedbed preparation on seedling emergence in Pakistan. Sheikh (2),

Fig. 1 Conventional method of seedbed preparation using cultivator with sohaga.

in his comparison of three implements for seedbed preparation, namely; Disk Plough, Disk Harrow and Field Cultivator found that the Disk Harrow and Field Cultivator gave statistically more emergence of wheat seedlings than the Disk Plough. His experiment showed that bulk density (g/cc) of 1.25 (Disk Harrow) and 1.33 (Field Cultivator) gave better emergence than 1.15 (Disk Plough). Soil shear strength of the Disk Harrow was lowest while the Cultivator was highest, with Disk Plough in between the two. Emergence exerted by the seedlings were minimum for Disk Harrow than with Field Cultivator.

Materials and Methods

The experiment was conducted at the Central Cotton Research Institute, Multan, Pakistan. The soil type was silt-loam. The irrigation system was flood-level basin.

Primary tillage before the pre-plant irrigation called "rouni" for all treatments was done with two runs of the Cultivator, each perpendicular to each other, followed by levelling after which the pre-plant irrigation of 110 mm (4 in.) was applied. When the field reached the moisture level optimum for tillage called "wattar", seedbed preparation of the five treatments were performed in a layout of randomized block design with three replications.

The plot size was 6.1 m × 54.9 m. Seeding was done using the Gaspardo SA480 four-row planter at a depth of 6.35 cm, row distance of 76 cm, and set at the seeding rate of 40 kg/ha on 15.6.1987. The cotton (Gossypium hirsutum) variety was NIAB-78 with a laboratory germination rate of 80%.

Table 1 Effect of Seedbed Preparation on Plant and Soil Factors

Treatment	No. of runs	Energy kW-h/ha	Emergence plants/m	Weed pop./ $0.75m^2$	Bulk density g/cc	Tilled layer depth cm
T1 Flexible-tine cultivator	2	14.5*	8.55a	x 70.00a y 29.33b	1.33a	9.9
T2 Rotavator + Cultivator with Sohaga	1,1	46*	10.00ab	x 83.67a y 39.00b	1.19b	12.0
T3 Roterra	1	31**	10.89ab	x 62.67a y 34.67b	1.38a	9.9
T4 Cultivator with Sohaga	3	22*	10.11ab	x 75.67a y 44.67b	1.24b	12.6
T5 Disk harrow + Cultivator with Sohaga	2,1	27*	12.45b	x 72.33a y 25.67b	1.32a	12.9

Note: a,b—Figures designated by the same letter are not significant at $p \leq 0.05$, Duncan's Multiple Range Test; x—wheel trafficked; y—non-wheel trafficked; *—Reference (1); **—From implement manual.

Comparing the Roterra and the Rotavator (both are rotary tillers), the tines of the former rotate on a vertical axis while the blades of the latter rotate on a horizontal axis. The Roterra can only prepare a seedbed but cannot incorporate crop residues into the soil as the Rotavator. However, with the same width-of-cut (1.5 m), the Roterra can be operated by tractors of 26 to 33.6 kW (35 to 45 hp) engine power, while the Rotavator would at least require a tractor of 47 kW (63 hp) engine power.

A single run of Cultivator-Sohaga was required after the use of both the Rotavator and the Disk Harrow in order to eliminate slight depressions and ridges created between implement widths-of-cut.

The makes and models of the different implements used are as follows:

Flexible-tine Cultivator, MF-137
Rotavator, Howard E.70
Roterra, Lely
Cultivator, MF-38
Disk Harrow, MF-34.

Results and Discussion

Seedling Emergence

Except between treatments T1 and T5 ($p < 0.05$) there was no significant difference in seedling emergence among other treatments (**Table 1**).

Weed Emergence

The weed encountered during this study was *Trianthema monogyna* (common name "Itsit") which is one of the major problems encountered in cotton production. The weed emerges rapidly on compacted soil surface resulting from rain and tractor or machinery wheel traffic.

The statistical analysis reveals that there was no difference between treatments (**Table 1**) but there was a significant difference between inter-rows ($p < 0.05$), i.e., alternating inter-rows which have been subjected to tractor and planter wheel traffic, and the rest of the inter-rows which were free from wheel traffic. Inter-rows subjected to wheel traffic (50% of inter-rows) had, on the average, 111% more weeds than those which were not subjected to wheel traffic (the other 50% of the inter-rows). Therefore, it is recommended that seeders, particularly the two- and four-rows, must be fitted with some tool in order to eliminate machinery wheel tracks during the seeding operation.

Soil Clod Size Distribution

Sampling was done four days after seedbed preparation, by pushing a metal cylinder of 28 cm diameter into the tilled layer and the soil was collected by hand. The samples were then passed through sieves of diameter 6.35, 12.7, 25.4, 38.1 and 50.8 mm, weighed and the percentages calculated. Significant differences were observed in clod sizes 6 to 13 mm and 25 to 38 mm which showed that T1 Flexible-tine Cultivator produced the coarsest and T2 Rotavator + Cultivator with sohaga produced the finest seedbeds. The average cumulative percentage passing through each sieve diameter for each treatment is illustrated in **Fig. 2**. The higher the curve, the greater is the percentage of smaller clods. The detailed data is in **Table 2**.

Significant correlation between emergence and percent by weight of clods was observed for sizes less than 6 mm, 6 to 13 mm, and above 50 mm **(Table 2)**.

The Rotavator which has a high energy requirement compared to other treatments and produced the finest seedbed did not result in better emergence. Therefore, the soil break-up produced by treatments T3, T4 and T5 with their corresponding bulk densities may be considered optimum for cotton. The average of the cumulative percentage for each diameter-size of these three treatments would be as shown in **Table 3**.

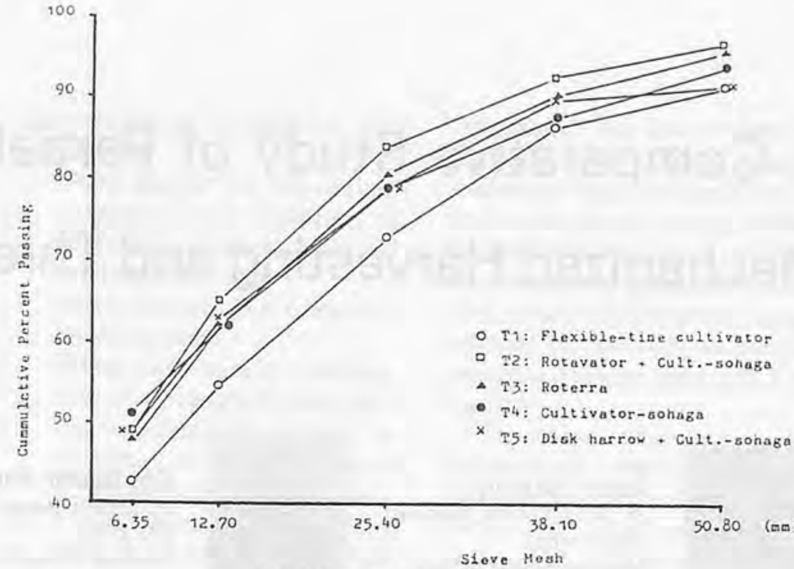


Fig. 2 Soil clod size distribution.

Table 2 Soil Clod Size Distribution in Percent

Treatment	Size, mm					
	less 6	6 to 13	13 to 25	25 to 38	38 to 50	above 50
T1 Flexible-tine Cultivator	43.62a	11.24c	17.33a	14.77a	5.08a	8.01a
T2 Rotavator + Cultivator with Sohaga	49.07a	16.36a	18.67a	9.07b	4.03a	2.8a
T3 Roterra	48.05a	14.29ab	18.9a	9.42b	4.92a	4.42a
T4 Cultivator with Sohaga	48.75a	12.89bc	17.78a	8.79b	5.81a	5.98a
T5 Disk harrow + Cultivator with Sohaga	49.3a	13.06bc	16.13a	10.51b	2.48a	8.52a
Transformation	—	sqrt (x)	sqrt (x)	sqrt (x + .5)	sqrt (x + .5)	sqrt (x + .5)
Corr. Coef., 5% t = .514	.621 S	.581 S	.274 NS	.501 NS	.261 NS	.575 S
Regression curve*	Cubic	Cubic	Quadratic	Quadratic	Quadratic	Cubic

Note: a, b—Figures designated by same letter are not significant at $p \leq 0.05$, Duncan's Multiple Range Test; *—x = percent by weight clods; Y = emergence, plants/m.

Bulk Density

Sampling was done by the Core Method using a sampling cylinder of 10 cm diameter × 13 cm height.

Bulk density, although significantly different ($p < 0.05$) to each other did not show any trend corresponding to that of seedling emergence **(Table 1)**. It can, therefore, be concluded that bulk density in the range of 1.19 to 1.38 g/cc is favourable for cotton seedling emergence and differences in emergence within this range may be caused by other factors.

The high bulk density of T1 and T3 may probably be due to their shallow tilled layer while the sampling was done to a depth of 13 mm. Bulk density of untilled soil was 1.44 g/cc.

Table 3 Average Cumulative Percent Clods Passing for Each Size of Sieve Mesh of Treatments T3, T4 and T5

Sieve diameter (mm)	Cumulative % Passing
50.80	93.92
38.10	89.52
25.40	79.95
12.70	62.12
6.35	49.45

Recommendations

1. To avoid excessive wheel traffic, the Roterra which prepares a seedbed in a single trip, does not require labour, and has an energy requirement less than that of a Rotavator, would be an ideal machine for seedbed preparation.
2. The Rotavator and the Disk Harrow may also be used in seedbed preparation, rather than using them only for incorporating of crop residues and green manure.
3. The flexible-tine Cultivator is not recommended for seedbed preparation.

REFERENCES

1. Hunt, D. 1973. Farm Power and Machinery Management. Iowa State University Press, Iowa.
2. Sheikh, M.S. 1977. "Effects of different tillage practices on soil characteristics and emergence of wheat seedlings under irrigated crop conditions." Mechanization of Irrigated Crop Production, (Proceedings). FAO, Rome. ■■

A Comparative Study of Partial vs Complete Mechanized Harvesting and Threshing of Wheat

by
Abdul Razzaq
Sr. Subject Matter Specialist
(Engineering)
Adaptive Research Farm
Sheikhupura, Pakistan

Ch. Bashir Ahmad
Sr. Subject Matter Specialist
(FM & FE)
Adaptive Research Farm
Sheikhupura, Pakistan

Ch. Bashir Ahmad Sabir
Director of Adaptive Research
Lahore, Pakistan

Abstract

The study was undertaken to investigate and evaluate the comparative economic benefits of partial and complete mechanized wheat harvesting and threshing practices. Manual harvesting plus mechanical threshing was compared with self-propelled and tractor-drawn combines deployed for harvesting wheat crop. It was established that the use of combine registered higher wheat yield than manual harvesting plus mechanical threshing. Also, complete mechanized wheat harvesting and threshing system proved more economical as compared to the partial mechanized technique currently practised in large scale in the country.

Introduction

Wheat is a major food crop in Pakistan. It is grown in large areas. The total areas planted to wheat in Pakistan increased from almost 4 million ha in 1947-48 to over 7 million ha in 1985-1986 **(Table 1)**.

Wheat crop is harvested, threshed and winnowed by the following three methods in Pakistan:

Conventional system — All operations are done by manual and bullock labour. This practice was very common up to the 1960s but is nearly obsolete now.

Partial mechanized system — Two systems are practised: (a) harvesting by manual labour and threshing and winnowing by mechanical thresher, and (b) harvesting by mechanical harvester, manual gathering and threshing and winnowing by mechanical thresher. The use of mechanical thresher is very common and about 80% wheat crop has been estimated being threshed in this manner (Kango, 1984).

Complete mechanized system — All the operations from harvesting to winnowing are performed one at a time by a single machine, i.e., combine.

Tractor-drawn combines made a good impression during the 1970s and early 1980s. However, self-propelled combine is becoming popular now due to its high capacity and versatility. Many private enterprises have started custom hire services with fleets of self-propelled combines. All combines introduced commercially in Pakistan are conventional, Western type. Combines inherit a drawback in that they do not turn out wheat straw in the form, contrary to other methods, which can be used readily as animal feed, locally, known as "bhoosa." In spite of this, the use of combine harvester is popular due to timeliness and its ability to cope with changing weather conditions.

Table 1 Wheat Area in Pakistan

Year	Area (million ha)
1947-48	3.954
1955-56	4.521
1965-66	5.155
1975-76	6.111
1981-82	7.223
1982-83	7.398
1985-86	7.403

Source: Economic Survey of Pakistan, 1985-86.

This study was undertaken to evaluate harvesting of wheat crop by manual labour plus mechanical threshing under partial mechanized system in comparison with all operations by combine under complete mechanized method.

Review of Literature

A study was carried out at the Agricultural University, Tandojam, Pakistan to determine comparative grain losses in mechanized vs traditional harvesting and threshing of wheat. Three systems of harvesting, viz; combine, manual harvesting plus mechanical threshing and manual harvesting plus bullock threshing were studied. As a result of the study, Kango (1984) reported 3.6% loss in grain and no recovery of straw with combine, 10.58 and 19% grain losses with manual harvesting, plus mechanical threshing and manual harvesting, plus bullock threshing, respectively. The Fauji Foundations Corporation (1987) also indicated grain losses to the tune of 11-15% with manual harvesting plus mechanical threshing of wheat in their Mobile Farm Extension Services Project.

Methodology

The study was conducted during the wheat season of 1985-86 and 1986-87 under the Adaptive Research in Sheikhupura, Pakistan. A survey was done to collect information from farmers and machinery owners. Under partial mechanized wheat harvesting system, 75 farmers were interviewed in total caring utmost that the samples are quite representative of the various segments of the farming community in the district. Data regarding the charges being paid by them for manual harvesting, gathering, mechanical threshing of wheat crop and labour engaged on thresher were collected along with threshing output, average yield per acre and price of bhoosa. Similarly, under complete mechanized harvesting system, 10 combine owners and 26 farmers who owned combines were interviewed. Statistical data on the charges claimed by combine owners and charges paid by farmers were obtained. During the survey, all the farmers interviewed reported that combine harvesting gave 80-160 kg/acre higher yield than manual harvesting plus mechanical threshing of wheat but comparative quantified data were not available. However, 6 farmers had harvested their wheat crop with both methods under study. Cost analysis of both methods were based on the estimated following assumptions:

1. Hired labour for harvesting, gathering and feeding to thresher under partial mechanized system.
2. Hired thresher and tractor.
3. Hired combine.
4. Wheat yield/acre = 1 200 kg.
5. Loss of wheat grain under partial mechanized system = 10.58%, i.e., the lowest figure as reported by Kango (1984).
6. Rate of wheat = Rs. 80/40 kg.
7. Weight of "bhoosa" = weight of wheat grains.

Results and Discussion

Partial Mechanized Method

Labour charges — Labour charges paid by farmers for various wheat harvesting and threshing operations were paid by farmers to labour engaged for harvesting, bundle making and gathering of bundles at the farm.

Further, all farmers responded that 5 men were required for smooth working on thresher with an average threshing output of 6 000 kg during a shift of 10 h. This labour was also responsible for filling in wheat grains in sacks, loading of bags for transportation and unloading in stores. **Table 2** further indicates that all the farmers paid wheat grain (in kind) of 20 kg/man shift as labour charges engaged for working on thresher and their average yield was 1 200 kg/acre.

Threshing charges — The charges paid by farmers to hired thresher and tractor for threshing their wheat crop ranged from Rs. 4.50 to Rs. 5.75/40 kg unit, or an average of Rs. 5. Majority of the farmers (59 out of 75) interviewed paid Rs. 5/40 kg unit. Farmers paid wheat grain at an average rate of 5 kg/40 kg to the owners of tractors and threshers.

Price of bhoosa — The prices at which bhoosa was sold by farmers ranged from Rs. 7.25 to Rs. 9.00 per 40 kg units, or an average of Rs. 80. Majority of the farmers were paid Rs. 7.25/40 kg unit.

Cost analysis — On the basis of the preceding data and the assumptions illustrated under methodology, an analysis was undertaken to determine the cost

Table 2 Labour Charges for Various Operations of Wheat Harvesting and Threshing

Harvesting and gathering of wheat		Labour engaged for working on thresher				
No. of farmers interviewed	Charges paid (kg/acre)	No. of farmers interviewed	No. of labourers engaged for a shift of 10 h	Threshing output per shift (kg)	Charges /man shift (kg)	Average yield (kg/acre)
20	110	8	5	5 600-6 100	20	1 440
45	120	40	5	4 800-6 000	20	1 240
10	130	20	5	5 800-6 600	20	1 080
		7	5	6 000-6 800	20	1 040
Average	120		5	6 000	20	1 200

Table 3 Breakdown of Harvesting and Threshing Costs

Item	Cost/acre (Rs.)
Manual harvesting and hathering @ 120 kg/acre	240
Threshing charges:	
a) Hired thresher and tractor @ 5 kg/40 kg	300
b) Hired labour, 5 men/shift of 10 hours @ 20 kg per man shift for threshing capacity of 6 000 kg per shift.	40
Loss factor @ 10.58% of wheat yield	254
Total charges =	834
Minus cost of 1 200 kg bhoosa @ Rs. 8/40 kg	240
Net cost	594

incurred in harvesting and threshing of wheat under the partial mechanized system

Complete Mechanized System

Hiring charges of combines — **Table 4** shows the charges claimed by the combine owners and the charges paid by farmers who hired combines for getting their wheat crop harvested. Charges paid by farmers are considered more authentic. The difference in the charges of tractor-drawn combines is that for Chinese-made machine, labour is required to harvest wheat crop from the sides of fields up to the width of its cutting blade to initiate working and, therefore, its charges are less. In the case of the JF tractor-drawn combine, no manual harvesting is needed as the cutting blade is swivelled in front of the tractor, hence its charges are higher. However, the highest charges indicated by farmers will be considered in subsequent computations.

Comparative yields — Wheat yields obtained with both systems under similar conditions are shown in **Table 5**, prepared from data collected from the farmers who harvested wheat crop manually and threshed it by mechanical thresher and used combine at their farms as well.

As the table shows, there is not much difference in the use of a complete mechanized harvesting, on one hand, and on the other, partial mechanized system of harvesting being a yield of 34 kg/acre and 31.5 kg/acre, respectively.

Cost analysis — Considering the above results and the assumptions cited in the methodology, a cost analysis was made and the comparison is shown in **Table 6**.

Table 4 Charges for Wheat Harvesting with Combines

Type of combines	Charges claimed by combine owners		Charges paid by farmers		
	No. of combine owners interviewed	Charges (Rs./acre)	No. of farmers interviewed	Charges (Rs./acre) Self-propelled combine	Tractor-drawn combine
John Deer, 4.3 m	2	350	19	350	—
(Self propelled)	1	400	5	—	—
Claus, 4.3 m	1	375	2	—	—
(Self propelled)	1	350	—	—	—
MF, 4.3 m	1	350	—	—	—
(Self propelled)					
Laverda 4.3 m	2	350	—	—	—
(Self propelled)					
JF, 2.1 m	1	350	—	—	300
(Tractor drawn)					
Chinese, 2.4 m	1	300	—	—	250
(Tractor drawn)					

Table 5 Wheat Yields Obtained with Partial vs Complete Mechanized Harvesting Systems

No. of farmers interviewed	Total area of wheat (acres)	Yield with complete mechanized system		Yield with partial mechanized system	
		Area harvested with combine (acres)	Yield (kg/acre)	Area harvested manually and threshed with thresher (acre)	Yield (kg/acre)
1	37	27	36	10	33.50
1	56	50	30	6	27.00
1	35	22	38	13	36.00
1	75	60	28	15	25.00
1	43	20	33	23	30.75
1	51	32	39	19	36.75
	Average:		34		31.50

Table 6 Cost per Acre in the Use of Self-propelled Combine and Tractor-drawn Combine

Item	Cost/acre (Rs.) Self propelled	Tractor drawn
1. Combine charges	Rs. 350	Rs. 300
2. Cost of 1 200 kg bhoosa (not made by combine) @ Rs. 8/40 kg	240	240
Total charges	590	540
Minus the cost of excess wheat yield @ 100 kg/acre	200	200
Net cost	Rs. 390	Rs. 340

Conclusion

The use of combine results in higher wheat yield compared to manual harvesting plus mechanical threshing.

Complete mechanized wheat harvesting system is more economical than partial mechanized method. Net cost per acre for harvesting and threshing of wheat with self-propelled combine was Rs. 390, for tractor-drawn combine, Rs. 340 and for manual harvesting plus mechanical threshing, Rs. 594 under prevailing conditions.

REFERENCES

Finance Dept.; Govt. of Pakistan. Economic Survey of Pakistan, 1985-86.

Kango, A.M.H. 1984. The Pakistan Times, October 20, 1984, p.8.

Fauji Foundation Corporation, 1987. The Mobile Farm Extension services Project, Clause No. 1.2.1■■

Selective Mechanization for Cassava Processing

by
J.C. Igbeka
Dept. of Agric. Eng.
University of Ibadan
Ibadan, Nigeria

M. Jory
Centre d'Etude et d'Expérimentation
en Méchanisation Agricole et en Technologie
Alimentaire (CEEMAT/CIRAD),
73, rue Jean-François Breton,
34000 Montpellier, France

D. Griffon
Centre d'Etude et d'Expérimentation
en Mécanisation Agricole et en Technologie
Alimentaire (CEEMAT/CIRAD),
73, rue Jean-François Breton,
34000 Montpellier, France

Abstract

An appraisal of the existing and prototype machines for the mechanization of *gari* processing from cassava was undertaken by the authors, vis-à-vis the traditional methods. It was found that, though some of the machines were operative and produced comparatively good products, their costs and technology were out of reach of the average gari producer in West Africa. Also, some of the traditional methods were found to be functional and with some modifications increased productivity. A selective appropriate mechanization was, therefore, proposed where the peeling and frying (with modified structure) operations are carried out manually, while internal combustion engine-operated machines were proposed for the grating, pulverization and sieving operations.

Introduction

Gari, a granular food product from cassava, is one of the main sources of carbohydrate for more than 80% of the inhabitants of the West African subregion. It is normally eaten in different forms. In Nigeria, Benin, Togo and some parts of Cameroon, it is consumed either soaked in cold water with sugar or salt added and taken with coconut, peanut, fish, beans porridge or in the form of paste made with hot water and eaten with vegetable sauce. It could simply be mixed with cooked beans with palm oil added as is eaten in Togo.

Traditional Method of Processing

The traditional process of producing gari from cassava is basically the same in the subregion. It involves the following unit operations: peeling, washing, grating, fermenting, and dewatering (pressing), pulverizing and sieving, and frying. **Fig. 1** shows a typical flow chart of these operations.

Peeling is normally done manually by women and teenage girls, using kitchen knives. The rate could be as high as 350 kg per day of 8 hours per person. The rate and the quality of peeling improve with experience. After the cassava tubers have been peeled, they are washed and made ready for grating. Grating is done on a metal sheet (aluminium or galvanized iron) with holes punched with nail, making one surface rough and the other smooth. Grating is done on the rough surface by pressing the tuber on it and making a back-and-forth movement. The reduced cassava which is in the form of pulp pass through the holes and the surface into a container under.

This is one of the most difficult manual operations in the traditional gari processing. In some cases, operators have had their fingers chipped off by the sharp rough surface.

The grated or milled cassava pulp which is in the form of mash, is then put into a bag of either woven cloth or hessian, tied and put under heavy compressive pressure, for dewatering. This is achieved by placing the bag of pulp between two flat wooden surfaces and compressing by tying together the ends of the wooden platform and adding weights. It is left for 2-4 days during which time fermentation of the pulp takes place. This fermentation is very necessary to reduce the cyanide

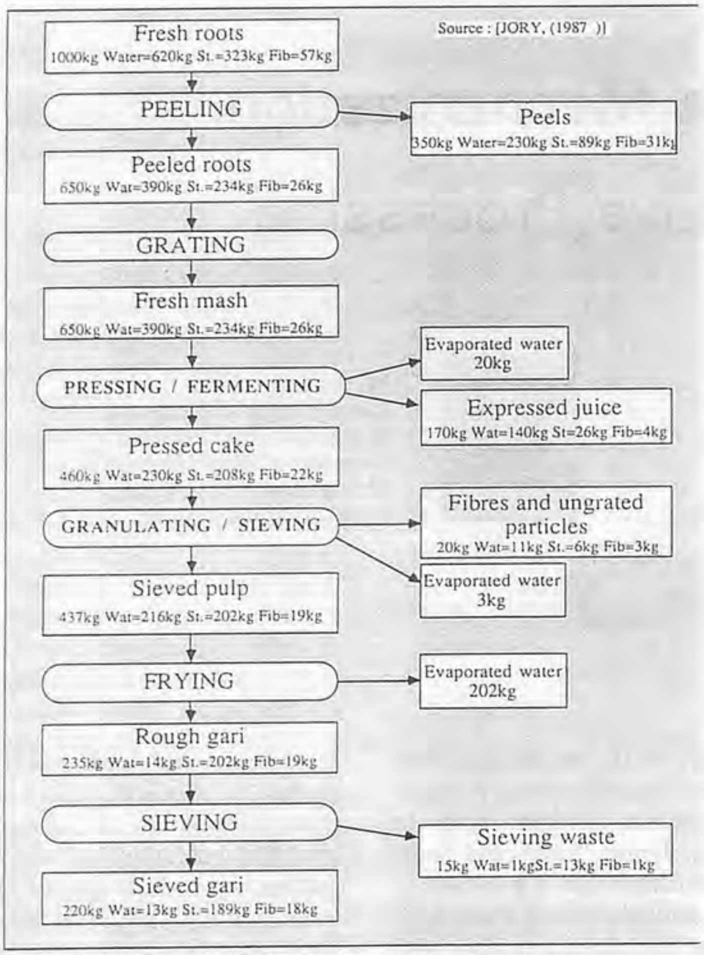


Fig. 1 Traditional gari processing flow chart.

content of the product (Chuzel and Griffon, 1987). After the pulp has been dewatered and fermented, it becomes lumpy and with a characteristic fermented odour. The lumps are broken with hand and then sifted in a sieve locally made from palm frond ribs or wire mesh. The product is granular and with about 50-60% moisture content (wet basis). The final stage of frying is done in a locally constructed oven or ordinary fireplace using a big circular frying pan. The process of gari frying, normally referred to as *garification*, involves simultaneous cooking and dehydration. The final product should be crisp and cooked. The main hazard in this operation is the smoke that gets into the operators' eyes.

Need for Mechanization

Some aspects of the traditional method of gari processing have been found to be time-consuming and sometimes hazardous to the health of the operator. Also, the traditional method does not lend itself to uniform quality products. It has been found that quality differed from one operator to the other and even with the same operator, quality was different from one batch to the other. For example, the degree of fineness of the pulp depends on the coarseness or fineness of the punched holes of the grater.

With some aspects of the traditional method, it may be very difficult to increase productivity as some of the operations will form bottlenecks. For example, the grating operation which is time consuming with inherent hazard will be a bottleneck in any attempt to increase production. Therefore, the need for mechanization cannot be over-emphasized.

Mechanization is mainly the use of mechanical means to reduce human effort, improve timeliness and quality of various operations in an attempt to increase the quality of the product and the production efficiency (Stout et al, 1970). Considering mechanization in this context, the question will be: How far can we mechanize and what level of mechanization is adequate for different operations of gari processing?

Requirements for Mechanization

To answer the above question, it is pertinent to look into some of the basic factors that should be considered during mechanization. The three basic ones are technical, economic and social considerations.

When proposing a machine for a particular use, the technical skill or know-how of the users should be considered. A quick survey of the West African region reveals that most of the gari producing population is illiterate with very low technical skill. The purpose of mechanization will be defeated if hi-tech machines that need very skilled personnel to operate and maintain are recommended for them. Machines that can be maintained and, if possible, fabricated by the local craftsmen should be recommended. Therefore, the technology should be appropriate.

The economic level of the people is a very important consideration when proposing machines for fabrication. The average income per capita per year of the farmers in the West African region is estimated to be about $300 (Igbeka, 1983), which puts their productivity in the world's bottom one-third. Therefore, any machine proposed or recommended for such farmers must be inexpensive with cheap spare parts. Also, it must be strong to withstand the type of rough handling and storage it is likely to receive. Many machines are introduced in developing countries without considering the social implications to the users. In Africa, there are clear-cut division of labour according to the sexes. There are some operations specifically meant for the women folk. For example, gari frying is never done by men so also cassava peeling. It is usually assumed that operation of heavy motorized machine is for men while small motorized machines for grinding maize, beans or pepper could be operated by both sexes. Therefore, in recommending any machine for the processing of gari, it must be borne in mind that in the rural areas of most West African countries, gari production is mainly a woman's job with the man only sometimes helping in the high energy requirement operations.

Our aim in this paper, therefore, is to take each unit operation in the gari production process, survey all advances and developments made in its mechanization vis-à-vis the traditional method and come up with a proposition of the appropriate machine for that operation. It is possible that it may not be necessary to use motorized machine in some operations, but only to improve on the traditional method by designing better and more functional tool or infrastructure. This is called selective appropriate mechanization (Igbeka, 1986).

Peeling Operation

Almost all processing of cassava tubers into one food or the other requires peeling. This is because a major proportion of the toxic cyanide content in cassava is contained in the peel. Different researchers and industries have come up with different prototype models of mechanical peeling machines. Some of them are continuous types and requires cutting the tuber into smaller sections or pieces while others are of the batch type and operate with the full tuber lengths. Odigboh (1985) presents two types of cassava peelers, one continuous and the other batch. The continuous type operates only with cassava roots cut into 100 mm long pieces and introduced lengthwise through a feed channel. He claims a peeling efficiency of 95% at 135 kg/h. On the other hand, his batch type operates with full cassava tubers mixed with some inert abrasive materials rotated in a drum at 40 rpm. He claims uniform and thorough peeling at about 180 kg/h.

Igbeka (1985), recommended the use of abrasive belt in a continuous cassava peeler. It operates with cut tuber slices and requires that the slices be near circular in shape. This same method was also reported earlier by Ezekwe (1975). In France, Bertin Ltd has built a cassava peeling machine (Martin, 1985). Its capacity is claimed to be 350 kg/h of tuber. The tuber is first sliced into four equal longitudinal quarters in a slicing machine and each slice is introduced, with the peel side up, into the peeling machine. CEEMAT is also working on this machine (Jory, 1989) and claims a lower capacity (about 200 kg/h).

A critical appraisal of all these existing machines reveals the technology involved in producing them is very high and requires very high-skilled personnel to maintain them, even though their operation is simple. Also, the costs of these machines are exorbitant and out of reach of the average gari producers in West Africa. They may be adequate for a large scale gari producer but the number of this category of farmers in West Africa is very small.

In the light of the above appraisal and realizing that cassava peeling offers the rural women the forum and opportunity of meeting and exchanging views, we propose that manual peeling be adopted. This should be done on "task" basis, that is payment rate on quantity of peeled tubers and not on the time spent. Also, this payment rate must depend on the size of the roots, taking in account that small tubers take far longer time to peel than big ones. An average of root weight can be estimated on a 100 kg sample by counting the tubers. For example, in order to compensate the peeling duration of an average 300 g root batch, the price per kg of peeled tubers could be twice the price of a 600 g root batch.

Grating or Rasping Operation

There exist now various versions of mechanical graters that are powered either by electric motors or small internal combustion engines. In Nigeria, the local artisans and craftsmen can fabricate the motorized mechanical graters. Most of them are made of rotating solid wooden drum wrapped with serrated or punched metal plate, with a concave that opens into an exit chute. More durable drums have been constructed by different categories of artisans. In Ghana, grating is done with a horizontal rotating roughened disc held in place by a vertical shaft. Also, these are easily constructed by the local artisans and craftsmen. In Togo, a CEEMAT-design rasper is used. It is made of a series of hack-saw blades fixed at intervals on a high quality nylon rotating drum. Such a drum, as it is well equilibrated, permits to reach a high rotating speed and thus a very fine mash. This machine can be equipped with either an electric or a petrol engine. The cost, therefore, is quite high for the average local

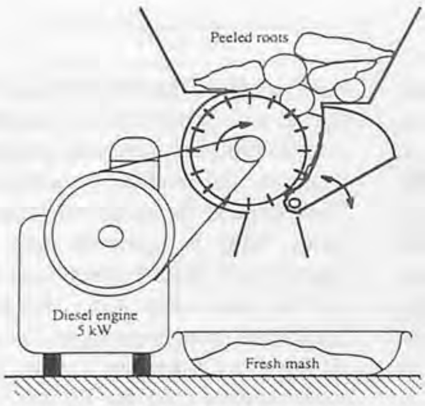


Fig. 2 Saw-blade drum grater.

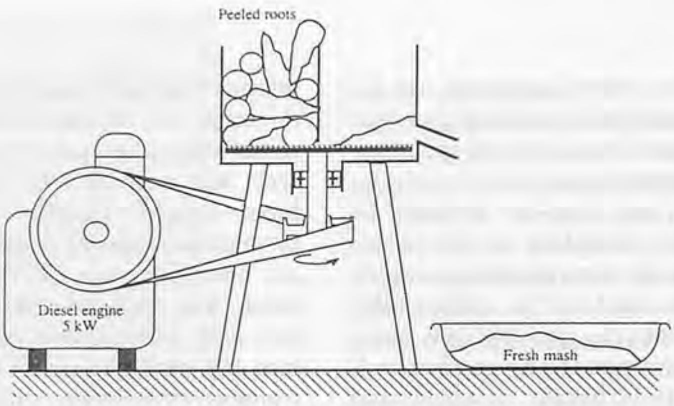


Fig. 3 Vertical shaft plate grater.

gari producer. The traditional manual method of grating has been earlier found to be hazardous and time econsuming. We, therefore, believe that this operation needs to be mechanized. In suggesting the best type of machine for this operation we have appraised the existing ones and propose two types used in Nigeria and Ghana. The sketches of the two are shown in **Figs. 2** and **3**. It should be noted that a special care should be brought in the fabrication and balancing of the drum in order to maintain a high rotating speed (about 3000 rpm for a 200 mm diameter drum).

Fermenting and Dewatering Operation

Fermentation is a very important aspect of the gari processing as this helps to reduce the cyanide content of the final product (Chuzel and Griffon, 1987). It also gives the product the characteristic odour.

In the traditional method the two processes of fermentation and dewatering are accomplished simultaneously. But some work done by CEEMAT (Jory, 1987) showed that marginal lower cyanide level was obtained by fermenting the mash before dewatering than when both occured simultaneously. Separate fermentation needs the use of a stronger pressing equipment which eliminates as much water as possible during a 30-minute pressing stage than during a 2 or 3-day fermentation under pressure. Thus, only one station is necessary to press successively several bags of mash instead of one station for each 50 kg bag by the traditional method. Such powerful mechanical pressing or dewatering devices have been fabricated by different researchers and countries. In Nigeria, a mechanism that improves upon the traditional method is in use. It is called the "hydraulic jack" mechanism (Igbeka, 1986). The bags of wet mash are heaped (2 to 3 bags) between two wooden platforms and then slowly compressed with the hydraulic jack. This mechanism can easily be constructed by local artisans. Usually, when the jack is not in use, it is rented out to other users or local craftsmen. The mechanism is so simple and easy that it is usually operated by a teenage boy.

CEEMAT, in conjunction with Gauthier Ltd. in France has fabricated a continuous pressing machine. The machine makes use of cassava mash already fermented with substantial amount of juice drained per gravity during fermentation. It is comprised of a smooth stainless steel rolling drum that presses the mash against a very fine mesh nylon conveyor belt. The juice is collected below the belt while the pressed cassava cake is continuously released at the other end. This design is very good especially for a full-scale continuous system but it is inadequate for a small scale batch gari producer. Its cost is also quite high and it can only be used where there is electricity. This makes it out of reach for the average gari producer in West Africa. In the light of the above appraisal, we propose the use of the hydraulic jack mechanism with a provision for collecting the juice which has high starch content. **Figure 4** shows the sketch of the mechanism.

Pulverizing and Sifting Operations

In the traditional way, these two operations are carried out simultaneously and manually. This process is very tedious, slow and quite unhygenic, due to possible contamination by the operator's hand.

Some mechanical machines are available for these operations. Most of them operate on the same principle. Odigboh and Ahmed (1982a) designed a prototype machine which accepts lumps of fermented and dewatered gari mash, cuts them up into small pieces by a cake breaker and delivers the pieces, by a belt conveyor, onto a reciprocating sieve for sifting. The machine could handle 125 kg of mash per hour. This machine when produced will be quite expensive as the material of constructions are not cheap. Also, the output is not worth the investment.

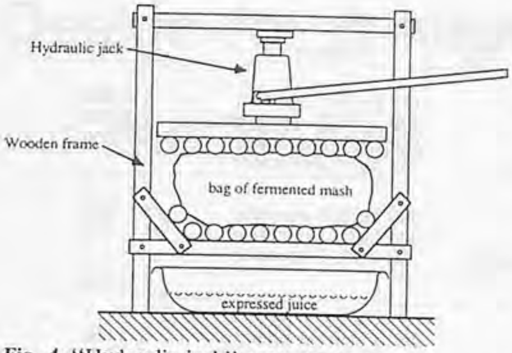


Fig. 4 "Hydraulic jack" press structure.

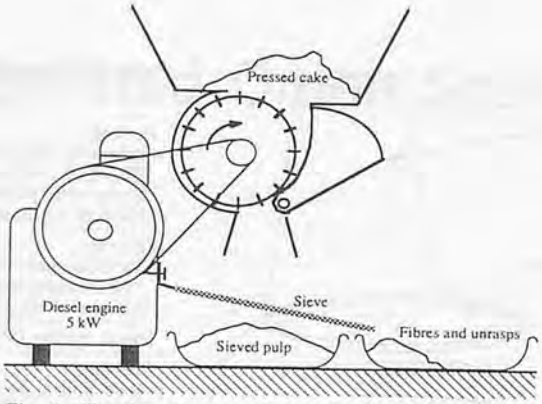


Fig. 5 Vibrating sieve coupled to the diesel engine.

CEEMAT and Gauthier Ltd. have produced, as part of their continuous flow cassava processing unit, a cassava cake pulverizer and sieve. The cake, coming from the press, is delivered into the cake pulverizer which is more of a rotating serrated drum. The pulverized cake, now in granules, falls directly into a vibrating sieve that has provision for declogging the sieve. This design eliminates the use of a belt conveyor but lends itself only for a continuous flow system. Also, it uses two electric motors making it difficult for rural use.

There is need to mechanize these two operations as the traditional method has been found to be inadequate for a uniform quality product. The drum type of cassava grater has the same features as the cake pulverizer and hence can perform that function. There is no use for a rural dweller who owns a grater to invest again in a pulverizer. We, therefore, propose that the grater be used for pulverizing the dewatered cake with a vibrating sieve added immediately below the exit chute for sifting. The sieve will be coupled to the same internal combustion engine used for grating and will undergo its vibrations. A typical proposed sieve is shown in **Fig. 5**.

Frying Operation (Garification)

Garification which is the term used to describe gari frying is a very complex operation. It involves simultaneous cooking and dehydration which is accomplished by manual turning and crushing of the sifted mash in a hot open cast iron or "terracotta" pan, made from baked and glazed clay.

Several designs of both batch and continuous flow gari fryers have been reported. Igbeka and Akinbolade (1986) developed a continuous flow fryer that simulated the traditional method of pressing, scraping and turning of the mash in a long cylindrical open trough. It gave a very good product but the construction was too complicated and cost too high for the average gari producer. Odigboh and Ahmed (1982b) designed a prototype fryer which operated with the same principle as that of Igbeka and Akinbolade. They had provision for it to be powered either by an electric motor or manually. This design, like the first, is quite complicated as it requires a lot of precision in positioning the wooden paddles and designing the metering device that regulates the mash intake into the fryer. It is not possible for such a machine to be fabricated by the local artisans but only by big industries thus making it very expensive.

On the other hand, efforts have been made to improve on the traditional method of frying by eliminating the hazards involved like smoke and heat affecting the operator. The Rural Agro-Industrial Development Scheme (R.A.I.D.S.) of the Nigerian Federal Department of Agriculture and Rural Development, has come up with improved gari frying structures that increased the output, eliminate smoke and heat for the operator and produce good quality product. It is a long rectangular shallow frying pan, seated on a specially constructed furnace with chimney. Usually, there are two women, at both ends of the pan. One woman can assume the first stage of cooking then transfer the mash to her partner who will assume the second stage. Igbeka (1987) also developed a similar structure which makes use of coal as heat source. The International Institute for Tropical Agriculture (I.I.T.A.) at Ibadan (Nigeria) is working on one-woman fryer structure with smoke and heat eliminated from the operator. It makes use of dense rice husk or wood shavings.

After appraising these existing mechanical and improved traditional fryers, we came to the conclusion that the improved traditional fryers will be most adequate for the rural gari producer. The structure can be constructed by the producer and what is needed to be purchased is the pan. One of such structures is sketched in **Fig. 6**.

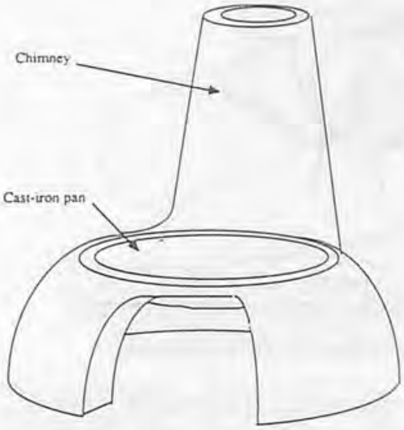


Fig. 6 Proposed structure for traditional gari frying.

Conclusion

Some aspects of the traditional processing of gari are tedious, time-consuming and sometimes hazardous to the operator. Therefore, there is the necessity to mechanize or improve on these operations. A critical appraisal of the available machines for mechanized gari processing revealed that some of them are very sophisticated and expensive for the typical rural gari producer in West Africa. On the other hand, there are some cheap and simple machines that can be constructed by the local artisans. The propositions, therefore, made in this paper, include the good, functional and cheap machines and structures that can easily be fabricated and constructed by the local artisan. These are for the grating, dewatering and fermenting, pulverizing and sifting and frying operations. **Table 1** shows our estimated comparative costs of some of the machines and those proposed in this paper.

Table 1 Estimated Comparative Costs of Some of the Machines

Operation	Capacity	Cost
Peeling		
Abrasive belt continuous peeler	135 kg/h-1 operator	$ 8 000
BERTIN continuous peeler	200 kg/h-2 operators	$18 000
Drum type peeler	180 kg/h-1 operator	$ 3 000
Manual method (recommended)	45 kg/h-1 operator	—
Grating		
Vertical shaft rotative plate	1 000 kg/h-1 operator	$ 600
"Saw-blade drum" type	1 000 kg/h-1 operator	$ 500
Manual method (not recommended)	20 kg/h-1 operator	—
Diesel engine (for the grater)		$ 1 000
Pressing		
Belt continuous press	300 kg/h-0.5 operator	$ 3 000
"Hydraulic jack" (recommended)	300 kg/h-0.5 operator	$ 120
"Rope type" pressing mechanism	300 kg/h-0.5 operator	$ 80
Traditional method	200 kg/batch-200 kg of stones to handle	—
Grating and Sieving		
Grater and reciprocating sieve	180 kg/h-0.5 operator	$ 1 500
Vibrating sieve coupled to the diesel engine (recommended)	200 kg/h-0.5 operator	$ 100
Manual method	100 kg/h-1 operator	—

REFERENCES

Chuzel, G. and Griffon, D., 1987, Le gari, un ptofuiy ytsfiyionnrl grtmrnyŕ à base de manioc. Aspects fermentation-détoxication. Doc. CEEMAT.

Ezekwe, G.O., 1975, Cassava peeling: possibilities of using an abrasive belt. Nigerian Journal of Engineering and Technology, 1 (2): 86-99.

Igbeka, J.C. and Akinbolade, J.A., 1986, The development of a continuous flow gari fryer. Proc. Int. Conf. on Energy Food Production and Post-Harvest Technology in Africa, Nairobi, ANSTI-UNESCO, Vol 7: 246-256.

Igbeka, J.C., 1983, Selecting and adapting farm machinery to rural conditions. Journal of Agricultural Mechanization in Asia, Africa and Latin America (A.M.A.), Tokyo, 14 (3): 45-48, 51.

Igbeka, J.C., 1985, Mechanization of tuber (cassava) peeling. Proc. Int. Symposium on Mechanization of Harvesting and Subsequent Processing of Agricultural Products in Tropical African and the Manufacturing of Relevant Agricultural Implements, Yaounde, CIGR III, 410-422.

Igbeka, J.C., 1986, Partial mechanization of some operations in a rural family farm industry. Proc. Congress of Int. Committee of Work Study and Labour Management in Agriculture (CIOSTA), Stuttgart, CIGR III, 363-369.

Igbeka, J.C., 1987, Personal communication

Jory, M., 1987, Transformation du manioc en gari au Togo, Rapport de stage. Doc. CEEMAT.

Jory, M., 1989, Personal communication

Martin, J.F., 1985, L'éplucheuse de manioc SMA 350. Proc. Int. Symposium on Mechanization of Harvesting and Subsequent Processing of Agricultural Products in Tropical Africa and the Manufacturing of Relevant Agricultural Implements, Yaounde, CIGR III, 423-428.

Odigboh, E.U. and Ahmed, S.F., 1982(a), A Machine for pulverizing and sifting mash. NIJOTECH.

Odigboh, E.U. and Ahmed, S.F., (1982b), Design of a continuous process frying machine. Proc. Nigerian Society of Agricultural Engineers, 6 (1): 65-75.

Odigboh, E.U., 1985, Prototype machines for small medium scale harvesting and processing of cassava. Proc. Int. Symposium on Mechanization of Harvesting and Subsequent Processing of Agricultural Products in Tropical Africa and the Manufacturing of Relevant Agricultural Implements, Yaounde, CIGR III, 323-338.

Stout, B.A., Kline, C.K., Green, D.A.G. and Donahue, R.L., 1970, Agricultural mechanization in equatorial Africa. A.S.A.E. paper 70-113.

Design for A Night Ventilated Onion Store for the Tropics

by
Kassim Skultab
Silsoe College
Cranfield Institute of Technology
Silsoe, Bedford MK45 4DT
U.K.

Anthony K. Thompson
Silsoe College
Cranfield Institute of Technology
Silsoe, Bedford MK45 4DT
U.K.

Abstract

A pilot scale store was designed and built using the principle of night ventilation to cool the crop. The purpose of the store was to provide a simple way of extending the market availability of onions which could be used by small scale farmers in the tropics. Various design parameters were considered, including ventilation method and rate, insulation levels and structural requirements. A store was built and tested in simulated tropical conditions. Results indicate that fairly even temperatures can be maintained in the store, being very close to the theoretical levels previously recommended for high temperature storage of onions. Further recommendations are made for subsequent studies, but the design described in this paper is suitable for construction and direct application by farmers.

Introduction

Bulb onions (*Allium cepa L.*) are a major crop throughout the world. Of the estimated annual world production of some 23 million tonnes, 55% are produced in less developed countries, mainly in the tropics (FAO, 1985). Onion cropping is seasonal while demand tends to be constant. The better way of supplying this constant demand is to store the bulbs in a fresh state.

Simple storage technology has been developed over many decades, mainly for small scale on-farm storage. These techniques have been described for Sudan, Korea, Jamaica and Britain by Thompson (1986a). In many other tropical countries bulbs are simply placed in bags and stored in the shade. A general estimate of storage losses of onions in developing countries was given as 16 to 35% (NAS, 1978). In a study in the Sudan up to 60% of onions were lost during storage for five months (Musa et al, 1973). In a study of commercial post harvest losses in Paraguay during 1983 it was found that 48% of harvested onions were lost before they reached the consumer (Thompson, 1986b). In South Yemen annual onion production between 1980 and 1983 varied between 2 769 and 5 726 tonnes and the post harvest losses between 26 and 34% (Thompson, 1985).

The problem of post-harvest losses of onions in the tropics is so acute that refrigerated stores are increasingly being constructed to hold onions at 0°C and 70% RH. This technology is expensive, but it can reduce post harvest losses to very low levels (Thompson et al, 1972).

An intermediate technology method for onion storage was described in Britain (Bleasdale and Thompson, 1967) which used night ventilation to replace refrigeration to cool the onions. This storage technique might have application in the tropics because of the unusual storage physiology of onions. Sprouting of onions is delayed at 0°C and at 28°C and above (Ward, 1976; Thompson et al, 1972). Respiration and weight loss are affected by temperature and tend to be lowest at 0°C, the rate increasing rapidly to a maximum at 10 to 15°C then dropping progressively to around 25 to 30°C then rising again (Karmarker and Joshi, 1941; Ward and Rucker, 1976; Stow, 1975). The main problem of storage of onions at 25 to 30°C compared with storage at 0°C is rotting. There appears to be little evidence of differences in cultivar resistance to rotting. In a study of 20 cultivars, Stow (1975) found that at 26°C Rijusburger AC72751, which is a disease-resistant cultivar, had 28% rotting

Acknowledgements: The authors wish to thank the following members of staff of Silsoe College for their help and advice during this project — M.L.A. Bascombe, J. Robinson, K.S. Channa, S.D. Ferguson, R. Canham and J. Brice.

bulbs after 9 months' storage. Other cultivars had higher or equal levels.

In a study carried out in the Sudan (Stow, J.R. and Thompson, A.K. unpublished report; Silvis and Thompson, 1974) a night ventilated store was constructed and compared with a simple traditional store for onions. During 5 months' storage, losses in the ventilated store were 42% compared to 57% in the traditional store. The average maximum temperature during that period in the two stores was 33.1°C in the ventilated store and 36.1°C in the traditional store.

This paper describes experiments in order to determine whether it might be possible to improve the design of night ventilated stores for onions in the tropics.

Materials and Methods

A night ventilated store was designed and constructed to contain a minimum of 500 kg of onions. The size was used for experimental purposes to establish principles for a larger store. It was sited in a heated glasshouse at Silsoe College so that tropical conditions could be simulated. The internal dimensions of the store were 0.702 m wide × 0.688 m long × 2.02 m high **(Fig. 1)**. The main frame was made of hollow square sectional welded steel pipe. Three sizes of pipe were used — 25 × 25 × 2 mm; 20 × 20 × 2 mm and 25 × 50 × 2.5 mm **(Figs. 2 and 3)**. The plenum chamber at the bottom of the store was 40 cm high and the onions were supported on the same hollow sectional pipe (20 × 20 × 2 mm) used in the main frame and placed at 116 mm intervals. Just before the onions were loaded this was covered with a hessian sack to increase the pressure in the plenum chamber and thus help air distribution.

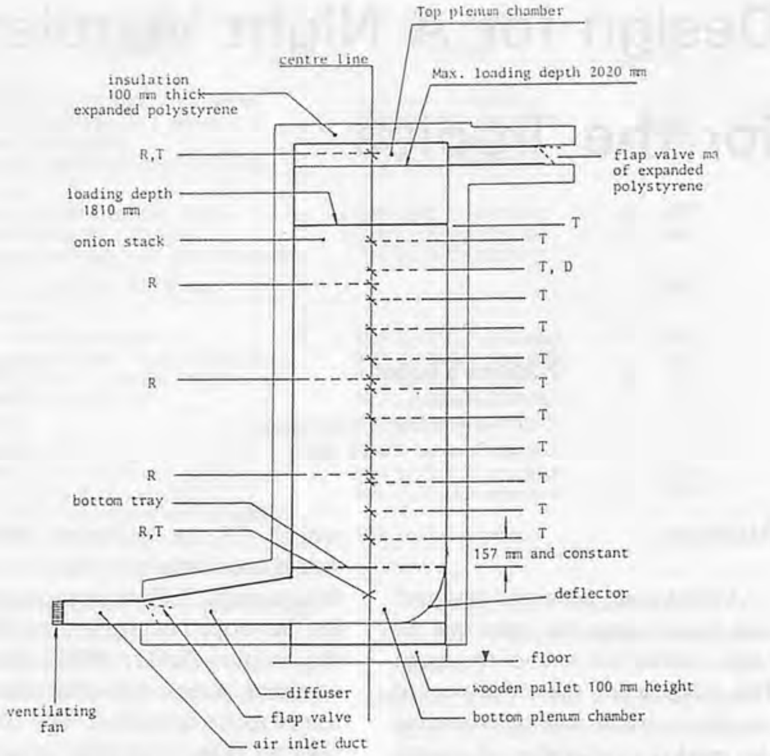


Fig. 1 Schematic diagram of the night ventilated store. R: humidity probe; T: temperature probe; D: differential thermostat.

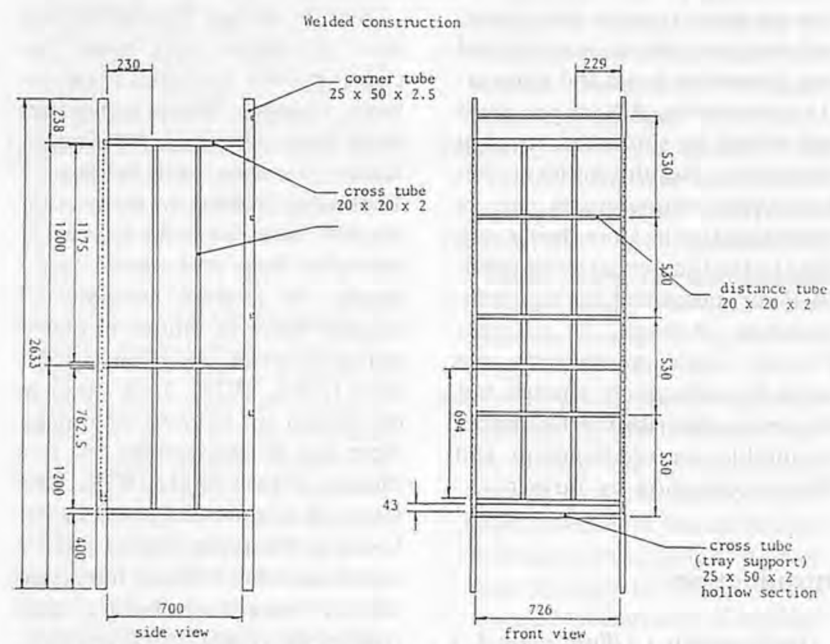


Fig. 2 Main frame assembly of the night ventilated store. All dimensions are in mm. Third angle projection.

Twelve mm thick plywood panels were screwed to the metal frame on three sides and the top **(Fig. 3)**. On the fourth side four doors were constructed, one above the other, and closed with suitcase catches **(Fig. 4)**. Inside the doors two metal upright bars were fixed in which a series of wooden slats

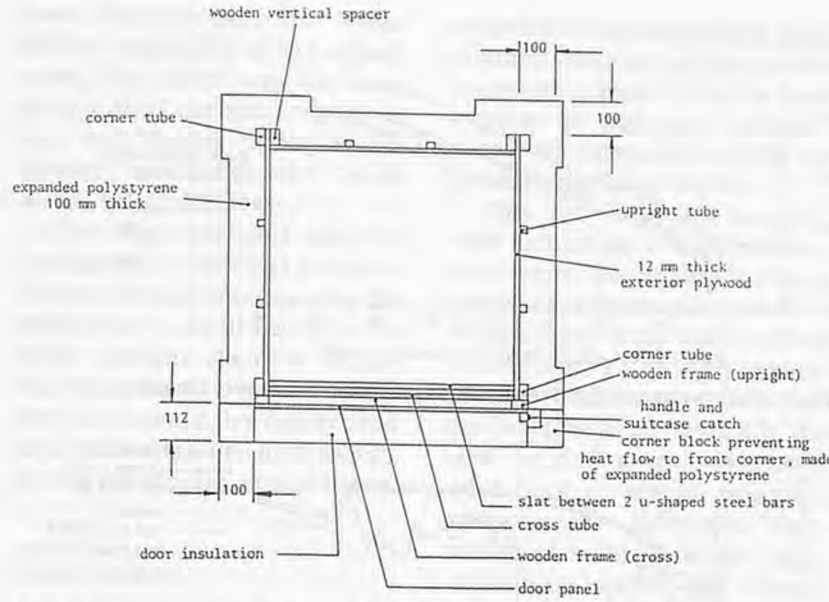


Fig. 3 Cross-section of the night ventilated store horizontally cut at the centre. Dimensions are in mm.

Fig. 4 Front view of completed store before filling.

Fig. 5 Side view of store showing fan inlet.

could be slotted as the store was filled.

The sotre was insulated on the outside using expanded polystyrene. The theoretical basis for the thickness of insulation was calculated on an outside temperature of 30°C and a maximum allowable rise in stack temperature of 2°C during the day. The structure was covered with aluminium foil **(Fig. 4)**, which gave a theoretical sol-air temperature of 34.8°C.

On this basis and, including the insulation value of the 12 mm of plywood, an insulation level of 104 mm of expanded polystyrene was required, but in fact 100 mm thickness was used because this was a standard available thickness. If the store was constructed by a small scale farmer in the tropics, materials like coir fibre or rice hulls could be used for insulation instead.

The stack was ventilated by

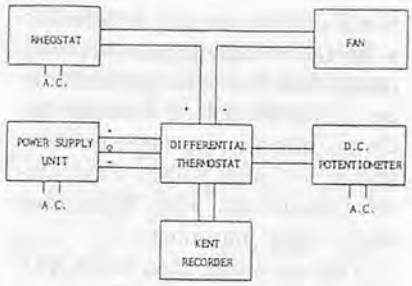


Fig. 6 Diagram of the differential thermostat wiring.

forcing air from the outside by a forward curved centrifugal fan (Airflow Developments Ltd. Model 45CTL with a capacity of 135 Watts) **(Fig. 5)**. The fan speed was detected by a stroboscope and controlled by a rheostat (Lande Lyons Ltd.). If the fan outlet went directly into the plenum chamber, kinetic energy would be dissipated as heat, noise or vibration. A tapering channel was, therefore, constructed between the fan and the plenum chamber to overcome this problem (Pankhurst, 1968). In order to help achieve an even flow through the stack of onions a deflector plate was put opposite the air inlet in the plenum chamber. The air, after passing through the onions emerged in a plenum chamber above the stack and vented to the outside via an outlet duct **(Fig. 1)**.

In order to use ambient air for ventilation only when its temperature was lower than the onion stack temperature, a differential thermostat was constructed and installed **(Fig. 6)**. The differential temperature was set at 2°C so that when the outside air temperature was 2°C lower than the stack temperature the ventilating fan was switched on. When the outside temperature was less than 2°C below the stack temperature the fan was switched off.

The temperature, humidity, pressure and air flow in the empty store were monitored using thermocouples attached to a Kent recorder (George Kent Ltd.), relative humidity sensors attached to a portable data logger M1600L (Microdata Ltd.), an anemotherm air meter model 60 (Anemostat Corporation), a portable air flow testing set mark 4 (Air Flow Developments Ltd., High Wycombe) and U-tube manometers.

The store was then filled with 500 kg of Keepwell (Davisons) onions. These had been harvested two weeks previously, topped and dried at 30°C and graded so the average diameter was 63 mm. The bulbs were loaded into the store to a depth of 1.81 m. Measurements were made of the air flow, temperature and humidity, both outside and at various points within the store **(Fig. 1)**.

Results and Discussion

At a depth of stack of 60 cm there was a need for only a low static pressure at the fan outlet to achieve the required flow rate. Although there was a general trend for this to increase with increasing depth of onion bulbs the difference over the range of 90 to 180 cm varied very little **(Fig. 7)**.

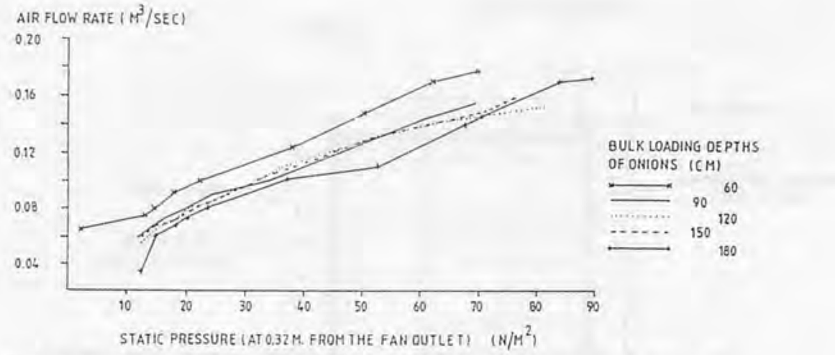


Fig. 7 Static pressure and airflow for different depth of onions in the store.

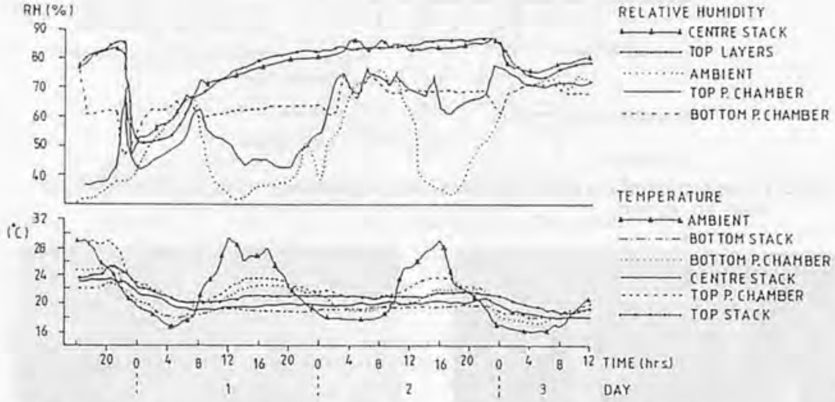


Fig. 8 Temperature and relative humidity changes during the experiment.

The actual static pressures in the store full of onions at a flow rate of 0.02175 m/s was less than 10 Nm. This contrasts with the recommendation cited by Bunting (1986) and Anon (1985) of 375 Nm or 250 Nm, respectively. One factor possibly contributing to this discrepancy is the depth of onions in the stack; 1.81 m compared with 3 m cited by Anon and 4 M by Bunting.

Also, the onions uused in the present study had been topped and size graded to remove small bulbs thus facilitating air movement. However, this is not confirmed by the bulk density figures which were 1.74 t in the present study, compared with 2.25 to 2.5 t cited by Anon (1985) or 1.90 tonne for dry topped onions (Bunting 1986).

The ambient temperature inside the glasshouse did not reach the hypothetical tropical conditions predicted for this study which were 30°C. However, the store reduced wide diurnal temperature fluctuation and, at times, the stack temperature was up to 9°C less than the outer ambient temperature.

The store insulation performed satisfactorily. In one study where the maximum outside temperature reached 29°C the maximum temperature in the centre of the onion stack was 21.5°C **(Fig. 8)** and the increase in temperature of the onions during the day was a maximum of only 1.3°C.

There was a temperature gradient through the stack with the higher temperature at the top. This gradient varied with ambient temperature conditions between about 1.1°C on a dull day to 2.0°C on a sunny day. Where onions are stored by this method in stacks of 3 or 4 m high this temperature gradient could be even higher and could affect the storage life of the bulbs.

A major problem with this store was humidity. While the ambient humidity fluctuated from 30 to almost 80% RH, the humidity within the stack remained much higher, generally within levels between 70 and 80%. When the differential thermostat was in use the fan was switched on at just before midnight and off again at about 8 a.m. This coincided with the period of highest ambient humidity.

General recommendations for humidity in onion stores are in the order of 70 to 75% RH (Thompson et al 1972) and where levels of 80% RH occur onions may begin to grow roots and rot. However, the onions used in the experiment were freshly harvested and had been dried for only two weeks before being used in the experiment. The necks were not completely dried out and it could be that with further drying before storage, stack humidity levels would have been lower.

The store was used only for storing bulbs which had previously been dried. However, with the addition of a small heater in the lower plenum chamber freshly harvested onions could be loaded into the store and thoroughly dried at a continuous high air flow rate before the storage period began.

Conclusions

Although the studies highlight some of the difficulties of designing non-refrigerated stores for the tropics, the current study illustrates that some environmental control can be achieved. The atmosphere inside the store was modified and produced conditions close to those which have been shown to be suitable for high temperature storage of onions.

However, the conditions within the store are affected by ambient conditions, but for long or medium term storage of crops like onions, it might be possible to site the store in a place where more or less the right conditions will prevail. It may also be necessary to occasionally ventilate the store during the day in order to reduce the humidity. This point needs further study. Further control might be achieved by a combination of a differential thermostat and ordinary thermostat.

This type of store could be modified for storage of other commodities, both in the tropics and temperate climates. For the later it might be necessary to incorporate an evaporative cooler to provide additional cooling.

This study evaluated the principle and design of a night ventilated store. Its application in a commercial situation is most likely on a small scale basis in third world countries. In such circumstances local materials would probably be used, especially for store insulation with perhaps a time clock or manual switching replacing the differential thermostat. On this basis the only equipment which the farmer would need to buy is a fan. The one used in the study cost only £25.

REFERENCES

Anon (1985). Vegetable Storage. Farm Electric Handbook, Electricity Council, Farm Electric Centre, Stoneleigh, UK. 38 pp.

Bleasdale, J.K.A. and Thompson, R. (1967). Annual Report of the National Vegetable Research Station, Wellesbourne. p.50.

Bunting, M.E. (1986). Potato/onion store management. Journal Farm Building Association. 35, 18-23.

FAO (1986). Production Year Book for 1985, Food and Agriculture Organization of the United Nations. 330 pp.

Karmarkar, D.V. and Joshi, B.M. (1941). Investigation on the storage of onions. Indian J. Agric. Sci. 11, 82-94.

Musa, S.K., Habish, H.A., Abdulla, A.A. and Adlan, A.B. (1973). Problems of onion storage in the Sudan. Tropical Science, 15, 319-327.

National Academy of Science (1978). Post harvest losses in developing countries. NAS, Washington D.C., U.S.A.

Pankhurst, R.C. (1968). Wind tunnel technique, Sir Isaac Pitman & Sons Ltd. UK. 49-62.

Silvis, H. and Thompson, A.K. (1974). Onion shortage in the Sudan. Report of the Food and Agriculture Organization of the United Nations. AGON.SUD 70/543. pp.6.

Stow, J.R. (1975). Effects of humidity on losses of bulb onions (*Allium cepa*) stored at high temperature. Experiment Agriculture 11. 81-87.

Thompson, A.K. (1975). Post harvest losses of bananas, onions and potatoes in P.D.R. Yemen. Contract Services Report CO485. Tropical Development Research Institute, UK. pp.41.

Thompson, A.K. (1986a). Storage. In Pest Control in Tropical Onions. Tropical Development Research Institute, UK. p.85-96.

Thompson, A.K. (1986b). Report on a visit to advise on the establishment of a post harvest technology laboratory at the National Agronomy Institute, Paraguay. Report Tropical Development and Research Institute, R1352R, pp.44.

Thompson, A.K., Booth, R.H. and Proctor, Felicity J. (1972). Onion storage in the tropics. Tropical Science, 14. 19-34.

Ward, C.M. and Tucker, W.G. (1976). Respiration of maleic hydrazide treated and untreated onion bulbs during storage. Ann.Appl. Biol, 82, 135-141.

Ward, C.M (1976). The influence of temperature on weight loss from stored onion bulbs due to dessication, respiration and sprouting. Ann.Appl.Biol. 83, 149-155. ■■

Growth and Productivity of Egusi-melon as Affected by Tillage Depth

by
S.N. Asoegwu
Dept. of Agric. Eng.
Federal Univ. of Technology
P.M.B. 1526
Owerri, Nigeria

Abstract

Field experiments were carried out on a sandy loam soil during 1981-82 to determine the effects of tillage depths: 0, 10, 15, and 20 cm on the yield and yield components of egusi-melon on an Alfisol. The depth were achieved by adding dead weights on the loading frame of a tandem disc harrow in such a way that the weight was symmetrically distributed over the discs.

All measured root parameters were higher in the 15-20 cm tillage depth than in no-tillage-root length per unit area (56-72%), total root surface area (25-28%), mean root diameter (3.6-10.7%) and root length density (45.4-53.5%). While the soil bulk density and penetration resistance decreased with the depth of tillage, the penetration resistance also decreased with days after sowing (DAS) and the bulk density increased with DAS. The total porosity increased with tillage depth and decreased with DAS.

The number and weight of fruits and dry seed weight increased with tillage depth. These were increased by 69%, 60.5% and 62.2%, respectively, by 20 cm tillage depth over zero tillage. Also, the ratio of dry seed weight to fresh fruit weight is about 2%.

Acknowledgement: The author acknowledges the technical assistance of O. Ibitoye and A. Pasheun and is grateful to the Director of the National Horticultural Research Institute, Ibadan for providing facilities for the study and for permission to publish the report.

Introduction

Egusi-melon (*Colocynthus citrullus L.*) is native to West Africa and belongs to the Cucurbitaceae family. It is a monoecious annual herbaceous climber widely grown in tropical Africa for the edible seeds. The seeds are used in soups and other delicacies as "ogbala ati" (Ibo). Egusi-melon is an integral part of Nigeria's traditional farming system. In the south, it is usually grown as an intercrop with staple food crops like yams, cassava, cocoyam, maize, etc. (Atu and Ogbuji, 1986; Asoegwu, 1987). In the north it is grown with sorghum, millet, etc.

Sole crop production of egusi-melon is not common but the increasing demand for vegetable oil for industrial use may soon promote large-scale sole crop production of egusi-melon (Nihort, 1986). The oil content of this crop is between 45% and 55% and can be extracted by relatively simple means (Adegbalugbe, 1986). Research on the production aspects of local vegetables, including egusi-melon, has been on a limited scale (Tindall, 1977). The crop, like water melon (*Citrullus lunatus*), can grow on almost any soil type that is well drained, warm and fairly productive (McCollum, 1975). However, it thrives best on newly cleared, sandy-loam soils that are rich in humus, fertile, well drained and slightly acidic.

Mechanical tillage manipulates the soil to provide soil conditions favourable for growth. The seedbed or rootbed should, among other things, provide adequate air capacity and exchange within the soil; reduce soil resistance to root penetration and optimize soil temperature. These could be achieved by breaking the soil to finer size particles using rotary tillage equipment. McCreary and Nichols (1956) having studied the effects of disc geometry on soil factors concluded that packing of the soil by discs and penetration is governed by the same group of factors. And weight was found to be the most important factor in penetration. However, soil-engaging implements can cause soil compaction which increase bulk density and decrease porosity and permeability to air and water flow (Davies et al., 1973). In addition, growth and elongation of the root systems of most annual crops into deeper regions of the soil profile may be impeded (Babalola and Lal, 1977). Thus increased mechanization is viewed with concern since the resulting compaction significantly retard the performance of various crops (Soane et al., 1982; Kayombo and Lal, 1986). An earlier study with this crop (Asoegwu, 1987) has shown that no tillage system was inferior to other tillage systems in terms of yield and growth. And using only the harrow for mechanically preparing the seedbed may be beneficial since Cooper (1971) has stated that disc harrow reduced compaction of soil to the depth of operation but compacted the soil immediately below the depth of penetration. Also, using only the harrow may reduce the total power required if conventional tillage system were adopted. However, the ability of roots to penetrate compacted soils appears to result from a combination of high root-growth pressure (Zimmeran and Kardos, 1961) and small root diameter (Kashirad et al., 1967) which egusi-melon has.

The root system development of several vegetable crops have been reported to be affected more by soil conditions than by the root growth pattern specific for the crops (Portas, 1973). And since the crop is shallow-rooted, the objective of this study is to investigate the appropriate tillage depth required for optimum production of this crop by minimum tillage system (harrowing once to various depths).

Materials and Methods

The experiment was conducted at the vegetable farm of the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. The experimental site was a newly cleared area, about 0.2 ha, with no previous cropping. The predominant soil series is Egbeda-Iwo association and is classified as an Alfisol (Oxic Paleustalf) according to soil taxonomy, (1975). The soil texture is sandy-loam with a gravelly region at 30-55 cm depth. The pH = 6.2 and the humus content is high. The sand silt and clay contents are 70.3%, 17.6% and 12.1%, respectively, and the soil is well drained.

The tillage depth treatments were achieved using a single pass. The harrow whose total weight was 750 kg had 26 discs spaced 0.2 m, with a 20° gang angle and 2.5 m width of cut. Each disc is 52 cm in diameter with a concavity of 4.5 cm and weight 20 kg. Power for operating the harrow was provided by a 62 kW (85 hp) tractor and the speed of operation varied between 2.96-3.65 km/h throughout the tillage operations. Tractor front weights (25 kg each) were placed securedly on the harrow frame. Total front weights of 0 kg, 150 kg and 300 kg were used to achieve 10 cm, 15 cm, and 20 cm depths. For each weight, five replications were made in a completely randomized block design. Each plot size measured 5 m wide and 30 m long. A no-tillage treatment (5 m × 30 m) replicated 5 times was included to serve as a control. The no-tillage plots were treated with paraquat (1-1' dimethyl-4, 4'-bipyridylium ion) at the rate of 0.5 kg a.i/ha for weed control one week prior to seeding. Depth of tillage was measured at different points in each plot after each tillage treatment and found to be 10.0 ± 0.33 cm, 15.0 ± 0.45 cm, and 20.0 ± 1.09 cm, respectively.

After seedbed preparation, egusi-melon seeds were sown by hand at three seeds per hill at a 2 m × 2 m spacing. After emergence and establishment of the plants, they were thinned to one plant per hill with a population of 30 plants per plot. Fertilizer use consisted of 50 kg/ha NPK: 15: 15: 15 applied at 4 weeks after sowing. Planting was done on 6 September, 1981 (second season), 2 April (first season) and 5 September (second season), 1982.

Soil bulk density and total porosity were measured by the core (85 mm high and 50 mm diameter) method and analyzed by procedures in Black et al, 1965. Soil strength (penetration resistance) was measured using a CL 200 pocket penetrometer. All these were made on soils taken at the 0-10 cm depth and at 3, 32 and 95 days after sowing (DAS). The same core sizes were used for excavating soil for root length analysis at harvest using the Drew and Saker (1980) procedure. The mean root diameter and total root surface area were calculated according to Adepetu and Akapa (1977).

Fruits were harvested by hand at about 3 months after sowing using 20 middle plants in each plot for yield analysis. The harvested fruits were counted, weighed and graded into three diameter sizes — S_1, > 14 cm; S_2, 11-14 cm; S_3, < 11 cm and processed for dry seeds as discussed in an earlier report (Asoegwu, 1987). Yield data were analysed and presented while weather data during the seasons were obtained from a meteorological station about 300 m away from the experimental site.

Results and Discussion

During the three growing seasons, soil moisture was adequate during the early growth of the plants since rainfall was higher than open air (**Table 1**). While rainfall increased as crop growth progressed in the first season, it decreased in the second season. The reverse is the case for open air evaporation. Even though evaporation was higher than rainfall in the second season, it had no significant effect on yield.

Table 1 Growing Season Rainfall, Open Pan Evaporation and Air Temperature at NIHORT, Ibadan

Second Season 1981	September	October	November	Total
Rainfall (mm)	149.5	69.5	38.5	257.5
Open Pan evap. (mm)	98	107	139	344
Mean air temp. (°C)	25.6	26.5	27.2	—
First Season 1982	**April**	**May**	**June**	**Total**
Rainfall (mm)	136.9	187.0	230.2	554.1
Open Pan evap. (mm)	95	68	52	215
Meanair temp. (°C)	27.3	26.8	26.1	—
Second Season 1982	**September**	**October**	**November**	**Total**
Rainfall (mm)	65.6	111.5	19.7	196.8
Open pan evap. (mm)	86	120	133	339
Mean air temp. (°C)	26.1	27.2	27.8	—

Soil Physical Properties

Bulk density, total porosity and soil penetration resistance in the 0-10 cm depth were measured at 3, 32, and 95 DAS during the three growing seasons **(Table 2)**.

Bulk density — For all tillage depth treatments, bulk density increased with DAS in the 0-10 cm soil depth. This may be due to raindrop impact. Also, the depth of tillage (TD) decreased soil bulk density due to the loosening of soil by tillage operations using rotary discs. The decrease amounted to between 3.9% and 10.7% at 3 DAS, 3.8% and 8.8% at 32 DAS and 4.6% and 7.9% at 95 DAS. At harvest (95 DAS), bulk density was not significantly affected by TD apparently due to the surface cover provided by the leaves and tendrils of the crop. There was no significant difference between bulk density at 32 DAS and 95 DAS because raindrop impact may have recompacted the soil at about 4 weeks after tillage operations.

Penetration resistance — This, as measured at 0-10 cm depth, decreased with increasing TD and DAS. The no-tilled plots had penetration resistance between 2.0% and 17.8% higher than in the tilled plots. At 3 DAS and 32 DAS, penetration resistance was not significantly different at 0-10 cm depth. Even though penetration resistance generally decreased with DAS and with TD, the values for the 15-20 cm depth were not significantly different from each other. The low values of 120-124 kPa recorded from the 15 cm and 20 cm TD at harvest may be due to the combined effects of high root volume in these treatments **(Table 3)** and foliage cover of soil surface during growth which may have reduced compaction due to raindrops. The high values (140-150 kPa) recorded for penetration resistance at the 10 cm depth confirms the fact that soil-engaging implements compact the soils immediately below the depth of operation.

Total porosity — The TD significantly increased porosity compared to no-tillage by 7.1%-11.9% at 3 DAS. At 32 DAS, total porosity was reduced in all treatments due probably to raindrop impact. At 95 DAS, there were increases in porosity in all the tilled plots due to increased root volume and foliage during growth and the reduced soil moisture at harvest due to reduced rainfall and increased open air evaporation, especially in the second seasons. For no-tillage, porosity decreased further at 95 DAS, while there was no significant difference between 10 cm and 15 cm TD treatments. For the 20 cm TD, there was significant increase of about 7.4% in porosity when compared to the 15 cm TD for 32 DAS and 95 DAS.

Crop Response

Root growth — TD increased root length per unit area by 72.1% and 56.2% in the 15 cm and 20 cm TD, respectively, over zero tillage depth. The mean root diameter was not significantly affected by TD **(Table 3)**. It seems most of the roots were concentrated in the 15-20 cm depth due probably to better aeration, more soil pulverization and reduced mechanical impedance. Deeper and easier proliferation of roots in the 15-20 cm depth increased total root surface area, which itself is a function of total root length and root diameter, and provided greater soil volume for the egusi-melon root system to exploit. Reduction in root length per unit area in the 0-10 cm depth may have resulted from the inability of the root to penetrate the compacted soil immediately below the depth of operation (Cooper, 1971), due to the weak root system of egusi-melon. Also, the high root density at the 15-20 cm depth confirms the findings of Kashirad, et al (1967) that root penetration may be due to small root diameter. Barber (1971) has shown that roots develop more extensively in tilled soils than in no-till soils. The more root length per unit area and more root density in the 15 cm TD seem to indicate that the range of

Table 2 Effects of Tillage Depth on Soil Bulk Density (Mg/m^3) Penetration Resistance (kPa) and Total Porosity (%, v/v) in the 0-100 mm Depth during Second Season of 1982

Tillage depth (cm)	Soil bulk density			Penetration resistance			Total porosity		
	3 DAS	32 DAS	95 DAS	3 DAS	32 DAS	95 DAS	3 DAS	32 DAS	95 DAS
0	1.34a[1]	1.36a	1.37a	154a	150a	146a	52 b	48 c	46 c
10	1.29b	1.31b	1.31b	150a	147a	140b	58 a	50 c	54 b
15	1.25c	1.28bc	1.30b	136b	133b	124c	56 a	53 b	54 b
20	1.21d	1.25c	1.27b	135b	133b	120c	59 a	57 a	58 a

[1] Means within the same column which are followed by the same letter do not differ significantly at the 5% level of probability (Duncan's Multiple Range Test).

Table 3 Effect of Tillage Depth on Egusi-melon Root at Harvest (95 DAS)

Tillage depth (cm)	Root length per unit area L_A (m/m^2)	Total root surface area per plant (m^2)	Mean root diameter ($\times 10^{-3}$m)	Root length density (m/m^{-3})
0	850C[1)]	3.2b	2.8a	346b
10	972C	2.8b	2.6a	365b
15	1 463a	4.0a	3.1a	531a
20	1 328b	4.1a	2.9a	503a

1) Same as in Table 2.

Table 4 Average Yield of Egusi-melon due to Tillage Depth

Tillage depth (cm)	Fruit weight (t/ha)	Number of fruits ($\times 10^3$/ha)	Dry seeds weight (kg/ha)	Dry seeds weight / Fruit weight (t/t)
0	18.7C[1]	3.8C	388.4d	0.0208a
10	21.6C	4.5C	420.6c	0.0195a
15	26.2b	5.4b	594.4b	0.0227a
20	31.6a	6.1a	629.8a	0.0199a

1 Same as in Table 2.

Table 5 Yield of Egusi-melon by Fruit Size due to Tillage Depth

Tillage depth (cm)	No. of fruits ($\times 10^2$/ha)			Weight of dry seeds (kg/ha)		
	S_1[1)]	S_2	S_3	S_1	S_2	S_3
0	9c[2)]	12b	17b	122.2b	115.0d	151.2b
10	11b	13b	21b	134.1b	146.7c	139.8b
15	10bc	16a	28a	169.3a	262.6b	162.5b
20	13a	17a	31a	121.5b	278.8a	229.5a

1) $S_1 > 14$ cm; 14 cm $> S_2$ 11 cm; $S_3 < 11$ cm
2) Same as in Table 2.

the effective root depth of egusi-melon is 15 cm and that this is a shallow-rooted crop. Also, the minimum root surface area required in an optimal root environment for this crop seems to be 4.0 m^2.

Fruit and seed yield — In **Table 4**, the number of fruits, fruit weight, and dry seed weight were all significantly increased by tillage depth. The increases ranged from 15.5-69.0%, 18.4-60.5%, and 8.3-62.2%, respectively, for tilled over no-tillage treatments. Fruit number and fruit weight per ha were not significantly affected by 0 cm and 10 cm tillage depths. Average yield was consistentlly higher in the 20 cm tillage depth. The ratio of dry seeds weight to fruit weight was not influenced by tillage depth and was about 2%.

Table 5 shows the yield of egusi-melon by size. In all treatments, there were more small-sized fruits (S_3) which contributed 44-52% of fruits produced per hectare while S_1 and S_2 contributed 18-24% and 28-32%, respectively. Lesser larged-sized fruits were produced in all treatments, with the 20 cm tillage depth having the highest numbers of fruit in all size ranges.

In terms of dry seed, S_2 fruits produced higher weights than S_1 and S_3 in all tilled plots. The 20 cm tillage depth produced the highest dry seed weights of 278.8 and 229.5 kg/ha in the S_2 and S_3 size groups, respectively. Zero to 15 cm tillage depth treatments did not influence dry seed weight in S_3 but had significant effects in S_2. Over all tillage depths, the fruit sizes contributed dry seed weights by 26.9%, 39.5% and 33.6% for S_1, S_2 and S_3, respectively. Also, S_1 and S_2 produced heavy number of seeds per fruits. This indication becomes important when consideration is being given as to how to increase fruits size of the egusi-melon by genetic or agronomic means. Even though tillage depth increased seed weight by promoting root growth, it seems that with the highest root development at the 15 cm tillage depth, this becomes the optimum tillage depth for egusi-melon.

Effects of soil properties on root growth and dry seed yield — Root length per unit area ($/mm^2$) (Y_1) and dry seed yield (kg/ha) (Y_2) were individually regresssed with soil bulk density (Mg/m^3) (X_1), penetration resistance (kPa) (X_2) and total porosity (%, v/v) (X_3) on the 0-100 mm depth. The regression equations for root length and dry seed yield on the soil properties are shown below:

$$Y_1 = 6644.86 - 4156.46X_1; \quad r = -0.65^{**} \qquad (1)$$

$$Y_1 = 3887.69 - 20.36X_2; \quad r = -0.80^{**} \qquad (2)$$

$$Y_1 = -571.56 + 33.23X_3; \quad r = 0.68^{**} \qquad (3)$$

$$Y_2 = 2172.09 - 1267.65X_1; \quad r = -0.56^{**} \qquad (4)$$

$$Y_2 = 1505.18 - 7.52X_2; \quad r = -0.84^{**} \qquad (5)$$

$$Y_2 = 50.38 - 8.64X_3; \quad r = 0.50^{*} \qquad (6)$$

Equations (1), (2) and (3) show that soil physical properties are a major determinant of root growth in Alfisols (Hulugalle and Lal, 1986) for egusi-melon. While increasing bulk density and penetration resistance decreases root growth, increased total porosity enhances root development. Equations (4), (5) and (6) also show the same soil properties having similar effects on dry seed yield. Efforts geared towards manipulating these soil properties are important in improving yield of egusi-melon.

Conclusions

(1) Tillage depth decreased soil bulk density which increased with days after sowing (DAS) due probably to raindrop impact.

(2) Low values of penetration resistance recorded at harvest may have been due to the combined effects of high root volume at the 15-20 cm tillage depth and foliage cover of the soil surface during growth.

(3) Tillage depth increased total porosity at 3 DAS. This was reduced as growth progressed but at harvest increased root volume increased total porosity in all tilled plots.
(4) Most of the egusi-melon roots seem to be concentrated at the 15-20 cm tillage depth, indicating that the effective root depth for this shallow-rooted crop is 15 cm. The minimum root surface area required for an optimal root environment seems to be 4.0 m^2.
(5) Average fruit yield was consistently higher in the 20 cm tillage depth than in other treatments. Also, the small-sized (S_3) fruits were greater in number in all treatments.
(6) Medium-sized (S_2) fruits produced higher dry seed weights than S_1 and S_3 in all tilled treatments. Average over all tillage depths, the fruit sizes contributed dry seed weights by 26.9%, 39.5% and 33.6% for S_1, S_2 and S_3, respectively. Also, S_1 and S_2 produced heavier dry seeds per number of fruits than S_3.

REFERENCES

Adebalugbe, T., 1986. Processing edible oil from agricultural product. Research Magazine, 1: 19-20.

Adepetu, J.A. and Akapa, L.K., 1977. Root growth and nutrient uptake characteristics of some cowpea varieties. Agron. J., 69: 940-943.

Asoegwu, S.N., 1987. Comparison of tillage system for the production of egusi-melon (Colocynthus citrullus L.) and Okra (Abelmoschus esculentus L.) in Eastern Nigeria Crop Res. (Hort. Res.), 27: 77-90.

Atu, U.G. and Ogbuji, R.O., 1986. Root-knot nematode problems with intercropped yam (Dioscorea rotundata), phytoprotection 67: 35-38.

Babalola, O. and Lal, R., 1977. Subsoil gravel horizon and maize root growth. 1. Gravel concentrations and bulk density effects. Plant soil, 46: 337-346.

Barber, S.A., 1971. Effects of tillage practice on corn (Zea mays L.) root distribution in morphology. Agron J., 63: 724-726.

Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E., and Clark, F. E., 1965. Methods of Soil Analysis, Part I, pp. 299-314; 374-390. Am. Soc. Agric., Madison, Wisconsin.

Cooper, A.W., 1971. Effects of tillage on soil compaction In: Compaction of agricultural soils. Monograph I. Am. Soc. Agric. Engineers. St. Joseph, Michigan, P. 315-364.

Davies, D.D., Finney, J.B. and Richardson, S.J., 1973. Relative effects of tractor weight and wheel slip in causing soil compaction. J. Soil Sci., 24: 399-409.

Drew, M.C. and Saker, L.R., 1980. Assessment of a rapid method using soil cores for estimating the amount and distribution of crop roots in the field. Plant soil, 55: 297-305.

Hulugalle, N.R. and Lal, R., 1986. Root growth of maize in a compacted gravelly tropical Alfisol as affected by rotation with woody perennial. Field Crops Res., 13: 34-44.

Kashirad, A.J., Fiskell, G.A., Carlisle, V.M. and Hutton, C.E., 1967. Tillage pan characterization of selected coastal soils. Soil Sci. Soc. Amer. Proc., 31: 534-541.

Kayombo, B. and Lal, R., 1986. Effects of soil compaction by rolling on soil structure and development of maize in no-till and disc ploughing systems on a tropical Alfisol. Soil Tillage Res., 7: 117-134.

McCollum, J.P., 1975. Producing Vegetable Crops, 2nd ed. The Interstate Printers & Publishers, Inc. Danville, Illinois, pp. 493-505.

McGreary, W.P. and Nichols, M.L., 1956. The geometry of discs and soil relationship. Agric. Engr., 37: 808-812.

NIHORT, 1986. Advances in fruit and vegetable research at National Horticultural Research Institute (NIHORT) Ibadan — a commemorative publication, p.20.

Portas, C.A.M., 1973. Development of root system during the growth of some vegetable crops. Plant and soil, 39: 507-518.

Soane, B.D., Dickson, J.W. and Campbell, D.J., 1982. Compaction by agricultural vehicles: a review III. Incidence and control of compaction in crop production. Soil Tillage Res., 2: 3-36.

Soil Taxonomy, 1975. A basic system of soil classification for making and interpreting soil surveys. Agric. Handbook No. 436, SCS-USDA, U.S. Government Printing Office, Washington, D.C.

Tindall, H.D., 1977. Vegetable Crops In (Leakey, C.L.A. and Wills, J.B. eds.) Food Crops of the Lowland Tropics. Oxford University Press, Oxford, p. 101-126.

Zimmer, R.P. and Kardos, L.T., 1961. Effect of bulk density on root growth. Soil Sci., 91: 280-288.

■■

Mechanization of Vegetable Growing in Bulgaria

by
A. Kaloyanov
Prof., Agric. Mechanization
Dept. Land Regulation
Higher Institute of Agriculture and
Civil Engineering
Sofia, Bulgaria

Ch. Petkov
Senior Res. Associate
Scientific Secretary
Institute of Mechanization and
Electrification of Agriculture
Sofia, Bulgaria

Il. Rousev
Assoc. Prof.
Director, State Testing Center
Plovid, Bulgaria

Abstract

The present paper examines the peculiarities of the technology applied in vegetable growing and the possibilities of mechanizing the processes and operations comprising it. With nearly all the vegetable crops accepted is the bed-furrow soil surface used in two variants, with corresponding machines, bed-and-furrow openers, being developed for that purpose. Brief information is adduced about some of the machines particularly designed for vegetable growing, as well as results of tests of vegetable-crop harvesting machines. Finally, an exemplary technological complex of machines is shown, intended for industrial production of tomatoes for processing.

Introduction

The climatic-and-soil conditions in Bulgaria are favourable for growing most of the vegetable crops such as tomatoes, pepper, onion, carrots, cabbage, green peas, green beans, eggplant, radishes, lettuce, etc. Therefore, vegetable growing is an important branch of Bulgarian agriculture providing vegetables for domestic market as well as for export.

Bulgarian vegetable growing occupies about 3% of the total arable land, and ensures 10-12% of the plant-breeding produce, consuming 17-18% of the labour employed. This necessitates the usage of machines for mechanization of the branch.

To increase vegetable production and to improve its efficiency, the State stimulates its modernization and implementation of scientific-and-technical achievements. For that purpose, near the town of Plovdiv the Maritsa Market Gardening Research Institute has been established and charged with the tasks to create new promising vegetable cultivars, to develop new technologies for their growing, and to render assistance to the farms implementing those technologies. The Institute is in co-operation with the Research Institute of Mechanization and Electrification of Agriculture in the field of making new machines for vegetable growing.

The agrarian reform carried out in Bulgaria during the past 3-4 decades was expressed in establishing different collective forms (co-operative, state and mixed) of management, providing a possibility of realizing specialization and concentration of the crops on broader areas, and of using process-mechanizing machines of higher productivity. Nowadays, about 60% of the vegetable produce comes from these farms.

Peculiarities of Vegetable-growing Technology

On the basis of existing traditions and recent experience the bed-furrow soil surface is accepted and recommended as the unified base of the technology of growing almost all vegetable crops, and is applied in two variants **(Fig. 1)**: a) beds with ridges turning into high, even beds

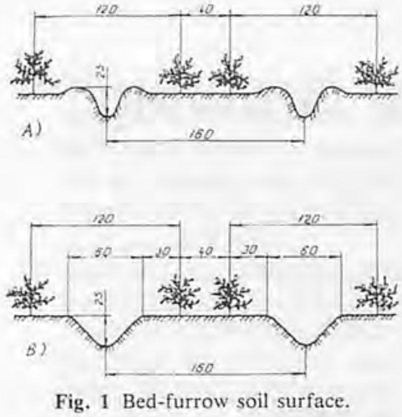


Fig. 1 Bed-furrow soil surface.

during the period of vegetation, and b) high, even rotary-tilled beds. Vegetable-crop growing on bed-furrow soil surface is more suitable for the biological requirements of these crops, and, facilitates gravity irrigation and mechanization of all successive procedures.

To form bed-furrow soil surface according to the first variant, use is made of the ЛУГ-4.8 universal garden bedder, having passive working elements, and in the second variant, the ЛФ-4.8 rotary bedder, capable of applying mineral fertilizers and herbicides, and of sowing vegetable seeds simultaneously with soil profiling.

In smaller orchards, vegetables may be grown on even, as well as on bed-furrow soil surface, with smaller modifications of the bedders being used.

Usually, the beginning of the vegetable-growing technology is the principal summer-and-autumn cultivation, including the following: stubble breaking by means of either share plough or disc harrow at a depth of 12-15 cm, regularly making the areas even with the aid of levellers, spreading manure and mineral fertilizers, ploughing at a depth of 30 cm and autumnal furrowing, with the beds being roughly formed, to be finally made in spring by means of the ЛФ-4.8 bedder. Provided that the areas are tilled in summer, deep loosening should be carried out instead of deep ploughing.

During spring additional pre-sowing soil tillage should be performed, including the following procedures: harrowing and final forming of the beds prepared in autumn, while the remaining areas should be subjected to routine levelling along with tillage, loosening with cutting, bedding and compacting with the aid of disc rollers.

Sowing is an important process related to vegetable growing. In Bulgaria the following two modes of sowing vegetable crops are established: a) through planting out, and b) through directly sowing the seeds. The first mode is performed manually or by using seeding transplanters where workers supply the plants to the seeding apparatus. This mode consumes a greater amount of labour. The second one is carried out with seeders designed for precision one-grain or pocket sowing, without thinning being required.

After their emergence, care for the plants consists in hoeing, top-dressing, spraying with pesticides against diseases and pests, and weed control. These are being carried out with machines and in terms in conformity with the requirements to the individual vegetable crops.

In its final stage, i.e., harvesting, the technology is crop-differentiated because of the great variety of the products obtained, and the specificity of the process of harvesting.

Tractors and Cultivating Machines

Two periods related to the mechanization of Bulgarian vegetable-growing may be pointed out. The first period comprises the years 1961-1975, and is characterized by mass implementation of the class 0.6 Bulgarian self-propelled chassis СШ-22, and a set of machines intended to be operated with, having 2.8-3.2 m working width. The period coincides with the establishment of co-operative farms in the country, within whose frames the enlarged orchards and single-purpose brigades for their management have been organized. As a result of the mechanization implemented, the labour consumption per 100 kg of produce being 2.44 man hours in 1960 fell down to 1.87 man hours towards 1970.

The second period commenced in 1976 and continues to the present time. It coincides with the introduction of higher-duty tractors in agriculture. The TK-80 class 1.4 tractor became the basic machine ensuring a possibility of using machines of a greater working with and of working at higher speeds in vegetable-growing branch. On this basis, vegetable-growing is switched over to a new generation of agricultural machines having a working width of 4.8 m, and, thus, productivity is increased by 1.5-1.7 times as compared to the earlier equipment. The new machines also have the advantage of simultaneously tilling three complete beds as compared to one whole and two-half-beds before, and, thus, the difficulties related to boundary-bed tillage are avoided.

In the present state of vegetable-growing, TK-80 tractors are the principal power sources and the collective farms prefer these machines. Agricultural machines of a 4.8 m working width corresponding to the bed-furrow soil surface accepted as a technological base in the country, are manufactured in Bulgaria. **Table 1** briefly shows basic information about the more important machines belonging to the above-mentioned group.

The higher-duty T-150K type of tractors (imported from the USSR) are used for more severe procedures such as levelling, deep

Table 1 Special Machines Used in Vegetable Growing

Name of machine	Trade mark	Working width (m)	Working speed (km/h)	Output (ha/h)
Wheeled tractor	ТК-80	—	0.4-9.0	—
Bed-furrow maker	БЛ-4.8	4.8	5.0	2.0
Bed toothed harrow	БЗЛ-4.8	4.8	7.0	2.8
Bedder	ЛУГ-4.8М	4.8	5.0	2.5
Cutting bedder	ЛФ-4.8	4.8	5.0	2.0
Precision sowing seeder	СПН-4.8	4.8	0.4	0.8-2.5
Seedling transplanter	МРЗ-4.8	4.8	0.4-1.2	0.2-0.4
Seed-onion seeder	МСЛ-15/18	4.8	2.5	0.9
Bed tiller	КЛ-4.8	4.8	5.0	2.0
Hoeing vegetable tiller	КОЗ-4.8	4.8	5.0	2.0
Tomato clipping machine	МОДР-4.8	4.8	2.5	2.5-4.0
Herbicidal plant	УХЛ-8М	4.8	4-8	1.5-2.0

loosening, autumnal deep ploughing, combined performance of severe operations, etc., and these are equipped with the heavier machines.

The private-farm mechanization is lagging behind because of the following reasons: sectors of small-size, variety of crops grown there, limited financial resources not allowing the farmers to buy tractors and necessary sets of machines, lack of modifications corresponding to the different sizes of the farms, etc. Therefore, when some of the more difficult to carry out and of short-term operations are required, the farmers make use of the services rendered by the co-operative farms and the state machine-and-tractor stations.

To satisfy the requirements of the private farms of small-sized equipments in the country, two modifications of the classes 0.6 and 0.2 light tractos are manufactured, fitted with small cutters, tillers, ploughs and trailers. Such small-sized equipment are imported from abroad as well. The piece-work application and land renting for long-term management in recent years increased the interest to the small-sized facilities offered.

Along with the above-mentioned vegetable-growing machines, different equipment for soil tillage, sowing, fertilizer spreader, plant protection, levelling, transportation, etc. are also used in this branch, being of universal purpose and employed in other agricultural branches, as well. According to the types, their number amounts to about 40, most of which are manufactured in the country and others are imported.

Harvesting Machines

Vegetable-growing mechanization encounters the greatest difficulties in harvesting due to the specificity of the processes of gathering related to the individual vegetable crops, and to the great variety of the products / fruits / obtained, some of which cannot be machine-processed hence require the employment of different harvesting technologies.

In cases of unevenly ripening vegetables requiring repeated selective harvesting or intended for fresh consumption, mass gathering in wooden crates, small boxes, baskets, buckets and other packings is applied. Here, use is also made of the so-called semi-mechanized vegetable harvesting when the processes of loading, transportation and unloading are mechanized by using pallets, box-pallets, containers and tractor fork lifters.

The harvest of evenly ripening vegetables intended for processing use different kinds of machines and combines offering a possibility of applying two basic harvesting technologies: single-phase and double-phase.

The first successes are achieved in the harvest of green orchard peas for canning, this being a crop threatened with extinction because of the great amount of labour consumed in harvesting. Two technologies are approved and applied to harvest this crop: single-phase using the BK-3 self-propelled combines (Hungarian made) and Herbort-461 (West German made), transportation being carried out with TK-80 tractor and P-8.5C trailer, and double-phase harvesting when, the PAE-3.6 (Hungary) windrowers, as well as the Bulgarian ЖСБ-4.2 perform mowing, and, then, harvesting is carried out by means of the Hungarian ВНБЦ tractor-hauled combine, the transportation means being the same.

In the harvesting of green beans the single-phase technology has proved to be of the highest results, and it is recommended to carry it out using the ФЗБ-combines (Hungarian made) and ГБ-2700 (manufactured by FMC, USA) while transportation should be performed by means of the P-8. 5C trailer.

Trials have been carried out for 10-15 years, to mechanize tomato harvesting, these being the principal vegetable crop in the country. For that purpose, special tomato cultivars were imported from California, USA, manifesting even ripening and being suitable for mechanized harvesting. The recent comparative tomato-combine testing carried out at the State Testing Center, Plovdiv, covered the following 5 marks of combines: DK-3, Bulgarian test model, ПБ-Ф, model of the Hungarian firm Hodgen, CKT-2A from the USSR, FMC-5500 TE from the USA and Guarezzi, Italy. The results of the tests show that almost all machines harvest 86% up to 93% of the yield, but allow losses of between 9% up to 17%, and damages 13% up to 23% of the fruits. These values are beyond those required and permitted in the corresponding world and

Bulgarian standard limits. The CKT-2A tomato combine is suggested for use to harvest tomatoes intended for processing.

On the basis of similar investigations, the following harvesting machines are specified and recommended: E-804 (GDR made) and YKM-2 (USSR made) single-harvesting combines for head cabbage; the EM-11 single-row and E-825 double-row combines (GDR made) and MMT-1 single-row (USSR made) one for carrot harvesting; and onion - the single - and double-phase harvesting machines ЛКП-1.8 (USSR), РЛ-1500 and ДЛ-1500 (FRG) and AMAK-Ф2 (Holland).

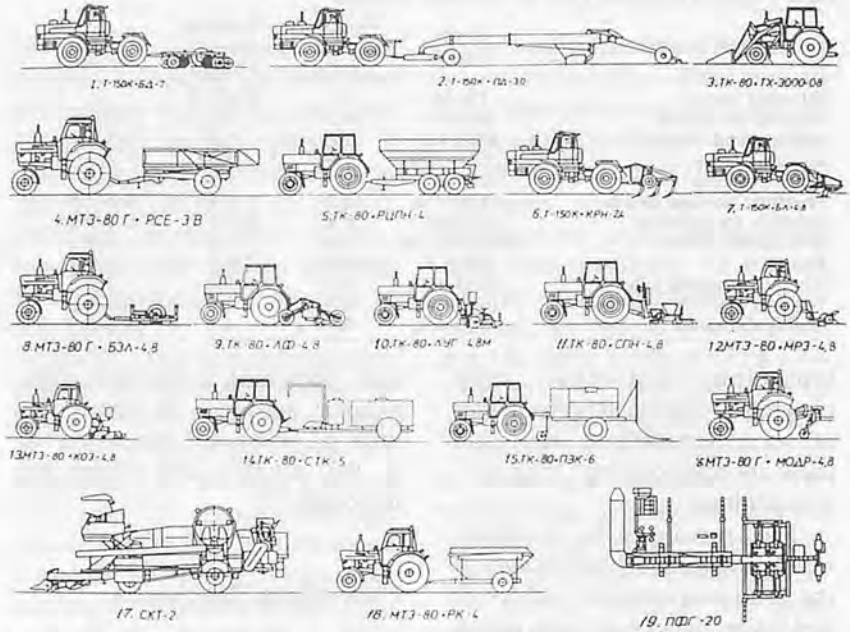


Fig. 2 Technological complex of machines for industrial production of tomatoes for processing.

Industrial Technologies and Technological Complexes of Machines

It is typical for vegetable-growing at the present stage that machines are introduced not only individually highly productive but complete process lines and technological complexes of machines (TCM), as well, ensuring complex mechanization of the processes related to the production of different vegetables. This is achieved on the basis of scientifically substantiated technologies and of employing new, modern machines manufactured in the country and imported from abroad. First rank are those farms where concentration and specialization of production are realized on enlarged areas, and complex mechanization is implemented being integrated with produce processing enterprises. Such industrial technologies are applied in the production of green peas, green beans, onion and carrots. TCM intended for tomatoes and cabbage are gradually put into practice.

Fig. 2 shows an example of technological complex of machines designed for industrial processing of Californian tomato cultivars suitable for mechanized growing and harvesting. It includes the following operations and units:

1. Stubble disking with T-150K (higher-power tractor) and БД-7 disc harrow.
2. Routine operating levelling with T-150K tractor and longbase ПД-3.0 leveller.
3. Loading of mineral fertilizers with TK-80 tractor and TX-3000-08 front loader.
4. Transportation of mineral fertilizers and charging of fertilizer spreader with the aid of MT3-80r tractor and PCE-3B high-lifting self-unloading trailer.
5. Mineral fertilizer spreading with TK-80 and centrifugal РЦПН-4 spreader.
6. Deep soil loosening with T-150K and KPH-2.4 deep scarifier.
7. Autumn rough bedding with T-150K and БЛ-4.8 furrow-and-bed maker.
8. Spring harrowing of beds using MT380 and 63Л-4.8 harrow.
9. Spring bedding with TK-80 and ЛФ-4.8 bedder.
10. Spring bedding with TK-80 and ЛУГ-4.8M
11. Sowing of seeds by means of TK-80 and СПН-4.8 seeder.
12. Transplanting seedlings with MT3-80 and M3P-4.8 seedling transplanter.
13. Hoeing by means of MT3-80 and KO3-4.8 soil tiller.
14. Preparation of pesticide solution with TK-80 and mobile CTK-51 mixer.
15. Spraying seedlings with TK-80 and П3К-6 sprayer.
16. Clipping tomato plants with MT3-80 and the MODP-4.8 machine.
17. Tomato harvesting with the CRN-2A tomato combine.
18. Transportation of tomatoes with MT3-80 and PK-4 container-trailer.
19. Primary processing (sorting out) of tomatoes at the handling station with РФГ-20 process line (Hungarian make).

By implementing such a TCM for tomato growing on area of 100-200 ha, labour consumption may be reduced by 10-15 times as compared with the traditional practices.

(Continued on page 70)

Performance of Draft Animals at Work in Morocco: Draftability and Power Output

by
R.K. Bansal
Centre Regional de la Recherche Agronomique
B.P. 290, Settat
Morocco

O. El Gharras
Centre Regional de la Recherche Agronomique
B.P. 290, Settat
Morocco

J.H. Hamilton
Centre Regional de la Recherche Agronomique
B.P. 290, Settat
Morocco

Abstract

In Morocco, horses, mules, donkeys, and camels are used for draft purposes, as single animals and in teams often made of two different types of animals. Performance of single animals and teams (1) a horse and a donkey; (2) a horse and a mule; and (3) a camel and a donkey was studied in plowing for 1 h with 3 types of plows. The horse and mule, working as single animals, produced an average draft force of 795 N and 923 N (30% and 20% of their body weights), respectively, and their power output was 978 W. A single, female camel produced 568 N average draft force (13.8% of its body weight) and 591 W power output. In contrast, the teams of horse and donkey and horse and mule, produced almost the same power output as that of single animals. Single animals were tired and needed rest after working for 1 h, but teams had the capacity to work longer. Differences in natural walking speeds and stepping rates of small and large animals cause additional stress when they are teamed together.

Acknowledgements: The authors acknowledge Drs. S. Beniamlih, A. Georouali, J. Hossaini, M. Oukessou, and R. Zinefilali, all from IAV Hassan II, Robat, Morocco; Messrs M.E.R. Paice, D.H.O'Neill, and D.C. Kemp from AFRC Engineering, Silsoe, U.K.; and Dr. B. Boulanouar from CRRA, Settat, Morocco, who participated and contributed in the project. This study was done as a part of USAID Project No. 608-0136.

Introduction

In Morocco draft animals play a very important role in agriculture. They are used extensively for tillage, sowing, inter-row weeding, and transportation. It has been estimated that up to 70% of the 7.4 million ha cultivated in Morocco is tilled by tractors (Roussaky and Jenane, 1982). The highest level of mechanization is for wheat and barley in the areas accessible to tractors and combine harvesters (Primov et al., 1987) because it saves time, labor and is often cheaper. But on farms in the hilly regions inaccessible to tractors, and on most small farms on the plains, draft animals are used for tillage and successive operations, even for wheat and barley. For other crops, such as maize, faba beans, chickpea, and lentil grown in the plains, tillage is often done by tractors. But other operations of ridge-and-furrow making, sowing, and inter-row weeding are mostly accomplished by using draft animals (Bansal and El Gharras 1987).

Draft animals offer a high potential for farming in Morocco: they represent approximately 561,000 kW of highly verstaile energy readily available to farmers (Bansal and El Gharras, 1987; MARA 1983). This potential can be best realized by improving the efficiency and work output from draft animals to achieve better quality and timeliness of farm operations.

An interesting feature of draft-animal use in Morocco is that different types of animals are paired in teams. Almost all possible combinations of horse, donkey, mule, and camel are used to make teams of two animals work together. The common implements used with draft animals are single-bottom moldboard plow ("charrue Marocaine"), wooden country plow ("araire"), peg tooth harrow, and tine harrow. The potential of multi-row seed drills and animal-drawn multipurpose wheeled tool carriers (WTC) for dryland farming is being investigated by the Centre Regional de la Recharche Agronomique (CRRA), Settat (Bansal and El Gharras 1987). The working methods, draft, and power requirements of these equipment are different from those of conventional types. However, published information on draftability, power output, and physiological response of animals working in different teams is not available yet.

A project was carried out at CRRA in 1987, in collaboration with AFRC Institute of Engineering Research (AFRC Engineering), UK, and Institute Agronomique et Veterinaire Hassan II (IAV Hassan II), Morocco, to study the performance of draft animals. The specific objectives of the project were to study (1) the draftability, power output, and endurance of different combinations of draft animals; (2) draft and power requirement of selected implements; and (3) effect of different levels of load on the physiological response. This paper contains results related to objectives 1 and 2.

Materials and Method

Experiments were conducted at a research station at Sidi El Aydi, near Settat, Morocco, on well levelled Vertisol fields. One female camel, 2 donkeys, and one horse were acquired from a nearby weekly animal market. A pair of mules was already on the station. All animals had training and had worked before.

The animals were given practice for about a month with the implements, prior to the experiments. During this period, problems related to harnesses, attaching implements, and fitting of sensors were resolved. Harnesses were chosen from the conventional ones used by farmers, so that harness type was not a variable in the study. Similarly, the best possible arrangements with respect to traces, draw pole, and single- and double-trees were made for attaching implements to the harnesses of the concerned animals. The horse and the mules were fitted with collar harnesses and chest bands when they were pulling the WTC, to properly support the draw pole. There was no need for a collar harness when they pulled a moldboard plow drawn by a chain. The donkeys worked only with chest bands even when they were in a team with a larger animal. On some occasions, collar harnesses were tried on donkeys teamed with a horse or a camel, to support the draw pole of the WTC. However, this arrangement was not satisfactory because the collars did not fit well on donkeys. The camel was fitted with a wide, cushioned neck strap to which the traces were fastened.

During the practice period, general health and body weight of all the animals was monitored. For those losing or gaining weight, the ration of barley was adjusted accordingly. The camel received 5 kg, horse and mules 4 kg each, and donkeys 2 kg each of barley every day. The straw quantity was unlimited up to an extent that the overnight leftover in the manger was minimum. The physical measures of the animals are given in **Table 1.**

For recording data in the field, a computerized instrumentation developed by AFRC Engineering, UK, was used. This system works with a series of sensors fitted to animals and to the implement (O'Neill et al. 1987). It records 8 parameters, 5 on the animals and 3 on the implement. The animal parameters recorded are heart, breathing and stepping rates, and body temperature of one animal and the stepping rate of the second Animal. The variables recorded on the implement are draft (horizontal component of pull force, N), angle of pull (deg), and distance travelled (m). The program for data logging calculates and stores automatically values for speed (m/s), energy expended (kJ), and power output (W) of the animals, using instant values for draft and distance travelled with respect to real time.

In addition to data secured on the computerized system, certain physiological parameters on animals were recorded by clinical methods every time, before and soon after work. These parameters were rectal temperature, heart rate, respiration rate, blood concentration of glucose, protein, potassium, sodium, and haematocrite (Beniamlih et al. 1987).

Table 1 Physical Measures of the Animals Tested

Animal				Height of			
Identification	Type	Age (years)	Body weight (kg)	Wither (m)	Rear leg hinge (buttocks) (m)	Front knee (m)	Rear knee (m)
2	Mule	4	460	1.43	1.40	0.80	0.85
3	Mule	12	315	1.48	1.50	0.87	0.95
4	Horse	4	270	1.37	1.33	0.81	0.90
5	Donkey	4	180	1.15	1.18	0.69	0.73
6	Donkey	4	170	1.14	1.22	0.71	0.78
7	Camel	4	419	1.76	1.68	1.14	1.03

Table 2 Details of Environmental Factors from 8 to 15 November 1987, Sidi El Aydi, Morocco.

	Range	Mean	CV (%)
Minimum temperature, (°C)	7-13	9.3	23.9
Maximum temperature, (°C)	18-23	21.6	8.0
Relative humidity, (%)			
at 0700 h	41-89	75.3	17.8
at 1400 h	52-82	70.9	15.1
at 1800 h	35-82	70.1	23.0
Soil moisture (% g/g)	25.7-26.8	26.2	2.9

Field tests were done during 8-15 November 1987. **Table 2** contains details on the environmental factors during that week and the moisture content of the soil where the tests were done. The field used was large enough to provide 100-m straight test runs. In the first few passes before data logging, the working of the plow was set by making adjustments wherever needed to avoid excessive load on animals. At the same time, the radar (used for sensing distance pulses) was calibrated and system tested. Data was then logged for 2 min. The computer was then disconnected from the sensors, and the animals continued to work normally. After 20 min, it was connected again and data was logged for approximately 2 min. In this way, in about 1 h work data was logged at four intervals, i.e., for 2 min at the beginning of the work, and at 20, 40, and 60 min from the beginning.

Treatments

Tests were conducted with 4 combinations (teams) of animals and 3 single animals for plowing, using 3 types of plows, as follows:

Animals teams

1. Horse and donkey
2. Horse and mule
3. Camel and donkey
4. Pair of donkeys
5. Single horse
6. Single mule
7. Single camel

Implements

1. Moldboard plow (Charrue Marocaine)
2. Wheeled tool carrier (WTC) with a 22-cm moldboard plow
3. Country plow (araire)

The single-bottom moldboard plow made in Morocco is about 20 cm wide, and is drawn from a single- or double-tree by a chain. They cannot be attached to single animals. Thus, the pair of donkeys and single animals were tested with a moldboard plow (Charrue Marocaine) only. A 2-week schedule was drawn up, allowing 1/2 day's work to each combination of animals and implements. But 1 week was lost due to rains and problems with the data logger. The testing program was restricted to one replicate. Despite this, a large amount of data was gathered (9 to 13 data points per second for each variable) and the time-series nature of data logging maintained the validity of our results.

Results and Discussion

Single Animals

Data for single animals show that the horse developed an average draft of 795 N (81 kg) during continuous work for 1 h **(Table 3)**, which was 30% of its body weight. The mule weighing 460 kg gave an average draft force equivalent to 20% of its body weight. The female camel produced 568 N (58 kg) draft force, which works out to 13.8% of its body weight. The draftability of animals is often taken as 10-15% of their body weights (Hopfen 1969). Tolaine and Roston (1958) reported average tractive effort of horses in Brazil to be 10-12% of their body weight. The draft potential of mules weighing 350-500 kg was earlier reported as 50 to 60 kg (Hopfen 1969).

Figures in **Table 4** show that power output of a single horse and a single mule was equal at 978 W (1.31 hp), but the camel it was 591 W (0.79 hp). The output from the horse and the mule was higher because they worked only for 1 h. Continuous working for longer time migh have lowered their walking speed and, consequently, the power output. Another aspect is that most data seen in the literature comes from experiments done with two or more animals working in a team where efficiency of individual animals depends upon the draft and power requirement of the implement.

Teams of Animals

It was generally observed that single animals were tired after 1 h of work with the moldboard plow. The horse and the mule, in particular, were observed to be sweating and breathing hard and had to be rested after 1 h. In contrast, when working in a team, both animals were confortable and maintained uniform speed and high power

Table 3 Average Draft Force (N) Applied by Different Teams of Animals to Pull 3 Types of Implements

Item	Minutes from beginning of work				Mean	SE (±)
	0	20	40	60		
Moldboard plow						
Horse and donkey	ND*	830	776	762	790	20.7
Horse and mule	ND	856	851	864	857	3.8
Camel and donkey	673	851	861	ND	795	61.1
Pair of donkeys	542	726	ND	ND	634	51.2
Single horse	741	814	831	ND	795	27.6
Single mule	ND	938	908	ND	923	15.0
Single camel	462	674	ND	ND	568	76.5
Wheelded tool carrier with a moldboard plow						
Horse and donkey	494	856	837	ND	729	117.8
Horse and mule	833	773	ND	ND	803	30.1
Camel and donkey	ND	630	683	ND	657	26.6
Country plow						
Horse and donkey	590	703	463	787	636	70.3
Horse and mule	554	481	457	770	565	71.2
Hose and donkey	ND	639	461	ND	550	89.3

*ND = Not determined.

Table 4 Average Walking Speed (m/s) and Power Output (W) of Animals for Three Types of Implements

Items	Minutes from the beginning of work				Average working speed*	SE (±)	Average power output (W)
	0	20	40	60			
Moldboard plow							
Horse and donkey	ND	1.00	0.81	0.91	0.90	0.05	711
Horse and mule	ND	1.18	1.12	1.13	1.14	0.02	977
Camel and donkeys	1.32	1.05	1.03	ND	1.04	0.01	827
Pair of Donkeys	1.38	0.83	ND	ND	0.83		602
Single horse	1.44	1.23	1.23	ND	1.23		978
Single mule	ND	0.97	1.15	ND	1.06	0.09	978
Single camel	1.27	1.04	ND	ND	1.04		591
Wheeled tool carrier with moldboard plow							
Horse and donkey	1.15	ND	1.13	ND	1.13		824
Horse and mule	1.33	ND	ND	ND	—		1068
Camel and donkey	ND	0.88	0.95	ND	0.92	0.03	604
Country plow							
Horse and donkey	1.12	1.07	1.22	1.19	1.16	0.04	738
Horse and mule	1.27	0.99	1.19	1.16	1.11	0.06	627
Camel and donkey	1.03	0.92	0.93	ND	0.92		506

*Average walking speed is the average of observations from 20 minutes onwards.
ND = Not determined.

output with the moldboard plow. The combination of a camel and a donkey pulling a moldboard plow shows that the donkey contributed significantly to the total power output of 827 W. For some reason, the power output from this team was low for both the WTC and the country plow. One possible explanation is that the moldboard plow drawn by a chain was easy to attach to the doubletree. But the beams of the WTC and the country plow posed harnessing problems. It appeared that the team-up of a camel with a donkey is inappropriate for working with an implement drawn through a beam, because of the differences in their heights and stepping distances.

Draft and power output of team-up animals were observed to be lower than those of individual animals working independently. In the horse and mule team, the mule used was lighter (315 kg) and older (12 years). This team produced a draft of 857 N for the moldboard plow, 803 N for the WTC, and 565 N for the country plow. The power output was 977 W for the moldboard plow, and 627 W for the country plow (**Table 4**). Thus the horse and mule together produced only about 7% higher draft than the draft produced by the horse alone (795 N). Moreover, the power output of this team was similar to that of a single horse or the younger mule for pulling the same implement. Thus, the horse in a team with a mule was working at about 50% of its potential capacity.

A similar trend can be seen for other teams involving the donkey. The pulling capacity of a donkey can be estimated from the working of a team. A team of 2 donkeys gave 634 N average draft and 602 W power output (**Tables 3** and**4**). Assuming that both donkeys made equal efforts, then the draft and power output of one are 317 N and 301 W, respectively. On an individual animal basis, the draft and power output of the horse and donkey team worked out to be 1112 N and 1279 W, and that of the camel and donkey team are 885 N and 892 W, for a moldboard plow. The horse and donkey team recorded 790 N average draft and 711 W average power output for pulling the same implement. Similarly, the camel and donkey team showed 795 N average draft and 827 W average power output. These results indicate that, on the basis of power output, the horse and donkey team worked at 56% and the camel and donkey team at 93% of their potential capacities.

The effect of different levels of power output of the 3 teams can be seen as an important factor determining the endurance of these animals for continuous work and the need for rest. For example, the horse and mule team, working at about 50% of its potential capacity, would have experienced less fatigue than the horse and donkey team operating at 56% capacity, and still less than the camel and donkey team working to 96% capacity. Thus, for pulling a moldboard plow, a camel and donkey team would have needed more frequent rests than the other teams.

Draft and Power Requirement of Implements

When animals are teamed up, particularly large ones such as a horse and a mule, the draft produced appears to be very much dependent on the draft requirement of the implement. For example, the moldboard plow seems to have an average draft requirement in the range of 790 N to 923 N for normal working, which also determined the pull force applied by the animals. For single camel and the pair of donkeys, this plow was set to work shallower or take lesser width of cut so that these animals could pull it. The wheeled tool carrier with attached plow recorded the highest average draft of 803 N. The country plow's draft requirement was the least, averaging between 550 N and 636 N. Thus it can be concluded that the moldboard plow had the highest draft requirement, followed by the WTC and the country plow, which needed the lowest draft. In other words, the country plow is good only for small animals or combinations of one small and one large animal (such as a donkey with a horse). On the other hand, the moldboard plow and the WTC fitted with a moldboard plow are better suited to a team of large animals such as 2 mules, 2 horses, or a combination of a horse and

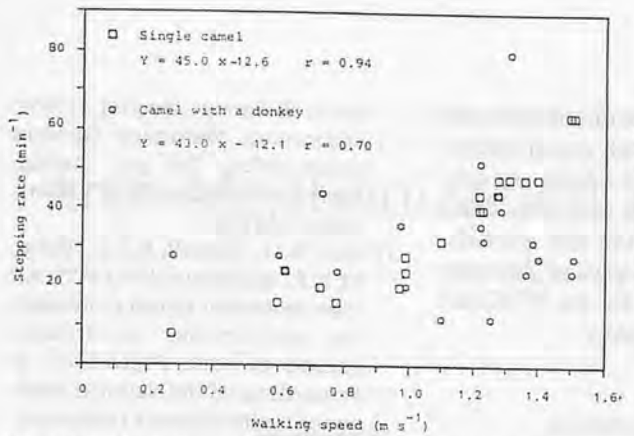


Fig. 1 Stepping rate vs walking speed of a camel working independently and in team with a donkey.

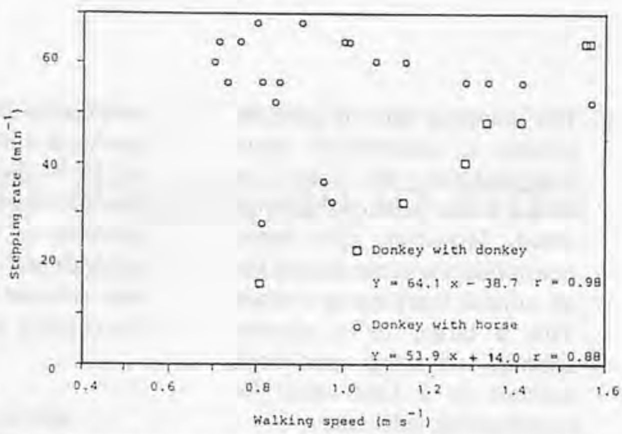


Fig. 2 Stepping rate vs walking speed of a doneky with other donkey and with a horse.

a mule, because of relatively higher draft and power requirements.

Walking Speeds

Results on walking speeds (**Table 4**) show that animals walked faster or slower in a team, depending upon the walking speed of their companion. For example, the horse working alone with a moldboard plow registered an average speed of 1.23 m/s (leaving out the starting figure of 1.44 m/s). The horse slowed down to 0.90 m/s when it worked with a donkey, and to 1.14 m/s with a mule, for pulling the same implement. On the contrary, the donkey and the mule which registered individual speed at 0.83 m/s and a.06 m/s, had to walk faster to keep pace with the horse. A camel had to slow down from 1.04 m/s to 0.92 m/s in team with a donkey for pulling a WTC or the country plow, and the donkey had to walk faster. This represents an additional stress on the smaller animal (donkey) and the slower animal (mule) when they are teamed up with a faster (horse) or a larger (camel) animal.

Stepping Rate vs Walking Speed

The stress factor on animals in team with a larger or a smaller animal can also be seen from the relationship between their stepping rate and speed. **Fig. 1** shows the effect of walking speed on the stepping rate of a camel pulling the moldboard plow alone, and in a team with a donkey. For a single working, this relationship is almost linear (r = 0.94). But in a team with a donkey, the stepping rate of the camel was not proportionate to its speed (r = 0.70), which shows that the latter lost walking rhythn. **Fig. 2** shows similar results for a donkey, first in team with another donkey and then with a horse. Clearly, the stepping rate and speed of a donkey in team with a similar-sized animal have a good correlation (r = 0.98). But when working with a horse to draw the same implement, the stepping rate and speed of a donkey showed a lower correlation (r = 0.88). The teaming of a large animal with a small animal adversely affects their stepping rate, which may pose some difficulties to both animals.

The effect of draft on speed is not clear from **Table 4**. The horse and donkey team showed improvement in speed from 0.90 m/s to 1.13 m/s when the draft force was reduced from 790 N to 729 N. But the trend was reversed for the camel and donkey team, where apparently speed fell from 1.04 m/s to 0.92 m/s as draft fell from 795 N to 657 N. Our data are probably inadequate to arrive at a conclusion in this respect.

Finally, as expected, most animals registered higher speeds at the beginning of work and slowed down within the first 20 min as they settled into the work. However, further fall in speed was not observed after 20 min of work, even for single animals who were visibly tired. Further work is needed to study this aspect. In calculating power output (**Table 4**), speeds registered at the beginning of work have been excluded.

Conclusions

The main conclusions of the study are as follows:

1. A team of a horse and a mule produced nearly the same or slightly less draft force and power output as was produced by a single horse pulling a moldboard plow. Singly, these animals appeared nearly exhausted after 1 h of work. The main effect of teaming up was on capability of animals to sustain loads, which determines work duration and the need for rest.
2. In general, at the beginning of work, all animals showed a high speed but slowed down within 20 min. It was found that small (donkey) and slow (mule) animals had to walk faster than their own natural rhythm when harnessed with faster (horse) and large (camel) animals. This factor could have put additional stress on them.

3. The stepping rate of animals pulling a moldboard plow independently was found to have a linear relationship with speed. However, this linear relationship was not found for an animal working in a team with a larger or a smaller animal, indicating that both animals in a team may be experiencing difficulty.
4. The country plow appeared to be suitable for small animals (a pair of donkeys) or a combination of a small animal with a large animal, such as a donkey with a horse, because of its low draft and power requirements. On the other hand, the moldboard plow and the wheeled tool carrier fitted with a moldboard plow are better suited to a team of large animals because of relatively high draft and power requirements.
5. Harnessing the camel and donkey team to an implement drawn by a beam remains to be resolved satisfactorily. This team worked well with moldboard plow drawn by a chain attached to the double-tree and produced a high power output of 827 W. But because of harness problems and poor compatibility of the two animals, the draft and speed of this team were reduced for the WTC and the country plow.

REFERENCES

Bansal, R.K. and El Gharras O. (1987). A report on small farm mechanization project 1986-87. 46pp. BP 290, Settat, Morocco: Centre Regional de la Recharche Agronomique. (Limited distribution).

Beniamlih, S.; Gerouali, A.; Hossaini, J.; Oukessou, M.; and Zinefilali, R. (1987). Etude sur les performances des animaux de trait dans la station INRA de Settat. 12 pp. Rabat, Morocco: Department de physiologie Animale et Therapeutique, Institut Agronomique et Vedterinaire Hassan II. (Limited distribution).

Hopfen, H.J. (1969). Farm implements for arid and tropical regions. No. 91. Rome, Italy: FAO.

MARA (Ministers de l'Agriculture et de la Reforme Agraire) (1983). Agriculture Marocaine Donnees Essentielles. 55 pp. Rabat, Morrocco: Direction de la Vulgarisation MARA.

O'Neill, D.H.; Howell, P.J.L.; Paice, M.E.R; and Kemp, D. (1987). An instrumentation system to measure the performance of draught animals at work. Pages 53-72 in Proceedings of the National Seminar on Animal Energy Utilization. Bhopal, India: Central Institute of Agricultural Engineering.

Primov, G.O.; Said, I.; and Herzenni, A. (1987). Crop production in Abda (Morocco). A study report. 64 pp. BP 290, Settat, Morocco: Centre Regional de la Recharche Agronomique. (Limited distribution).

Roussaky, A., and Jennane C. (1982) Contribution a l'etude de la distribution et de l'utilization des tracteurs agricoles. Diploma in Engineering thesis, 86 pp. Rabat, Morocco: Institut Agronomique et Veterinaire Hassan II.

Tolaine, O.; and Roston, P.J. (1958). Les animaux et l'effect de traction. Brazil (state) Divisao de Macanizacao Agricola. Boletim: 163-172. San Paulo, Brazil. ■■

(Continued from page 64)

Mechanization of Vegetable Growing in Bulgaria

REFERENCES

1. *Zaikov, A.; G. Panchaliev and N. Kolev. Technological complexes of machines for harvesting green beans. Mehaniz. sel. stop. No. 6, 1988.*
2. *Zaikov, A. Harvesting and post-harvesting processing of carrots. Ovoshtar., gradinar. i konservna prom., No. 5, 1985.*
3. *Zaikov, A. Mechanized harvesting and post-harvesting processing of head cabbage. Mehaniz. sel. stop.,* No. 2, 1988.
4. Zaikov, A. and G. Panchaliev. Industrial production of onion. Mehaniz. sel. stop., No. 3, 1986.
5. Kaloyanov, A.; G. Jejev and D. Atanasov. A study on the mechanized harvesting of orchard peas for canning. Scientific works of the G. Dimitrov HIA, vol. 17, 1965.
6. Koumanov B. and D. Kostov. Mechanization of production processes and increasing the quality of vegetables. Mezhdounar. selstop. spisanie, No. 3, 1985.
7. Mihov, A. et al. Industrial technologies in vegetable growing. Chr. G. Danov, Plovdiv, 1982.
8. Petkov, Ch. Technological complex of machines for vegetable production. Mehaniz. sel. stop., No. 5, 1988.
9. Todorov, K. KO3-4.8 hoeing tiller. Mehaniz. na sel. stop. No. 3, 1986. ■■

Farm Mechanization in Rajasthan in India

by
M.A. Khan
Senior Scientist
Central Arid Zone Res. Inst.
Jodhpur, Rajasthan
India

Abstract

The use of tractors and farm machines have positive contribution to agricultural production. In Rajasthan, farm mechanization started in the 1940s but gained momentum only in the post-green revolution era (1966-67). In 1988, about 87 000 tractors were on farms as compared with only 15 in 1945. In just 16 years (1972-1988) the population of tractors, tillage implements, mechanical seeders, pump sets and power threshers increased by about 7, 6, 40, 10 and 25 times, respectively.

Introduction

Rajasthan is the second largest state (in area) of India located between 23°03' and 30°12' North latitude, 69°30' and 78°17' East longitude. The state has an area of 342 239 km^2 which is 10.74% of the total geographical area of the country. The population of the state is 43.8 millions and density 128 persons per km^2. About 70% of the state population are engaged in agriculture. The total area under cultivation is 18.4 million ha of which 3.3 million ha are irrigated (17.9% of total cultivated area). The average annual rainfall is 570 mm mostly received between the middle of June and end of September. Major summer crops are millet, jowar, maize, pulses, cotton, rice, vegetable etc., while winter crops are wheat, barley, pulses, oil seeds, vegetable, etc. **(Table 1)**.

Farm Mechanization

Farm mechanization has positive relation with farm productivity; firstly through timeliness of field operation and, secondly, through good quality work. In Rajasthan where farming is predominantly rainfed and climatological resources are unfavourable, farmers are left with less time for field operations. Also, since farmers fields are widely scattered, much time and energy are being lost in movement. Mechanization, therefore, has a high place in such area.

Farm mechanization in Rajasthan started in the 1940s when some progressive farmers moved little forward to test improved agricultural machines and the results were very encouraging. Since then continuous efforts are being made to mechanize agriculture thus reducing human drudgery. In the last four decades, particularly in the post-green revolution period, tractors and other farm machines have multiplied many times over—testifying thereby a progressive in trend towards farm mechanization.

Table 1 Area Planted to Various Crops, 1989-90 (Unit: 1 000 ha)

Crop	Area	Percentage
Millet	4 928	24.61
Jowar	827	4.13
Maize	944	4.71
Rice	179	0.90
Cotton	434	2.16
Sugarcane	16	0.08
Wheat	1 650	8.24
Barley	214	1.07
Pulses	2 409	14.53
Oil seeds	2 220	11.08
Other crops	1 284	6.41
Total	15 605	77.92
Fallow	4 422	22.08

Source: Unpublished report, 1989-90. Board of Revenue, Govt. of Rajasthan.

Tractors

Tractorization in Rajasthan is mostly oriented to intensification of agriculture and to break the labour peak arising from development in technology in dynamic context. The tractor population in 1945 and 1951 was 15 and 504 units, respectively. The increase in tractor population was faster since 1966-67 when the green revolution campaign was launched. In 1966 about 4 000 tractors were on farms which increased to about 12 000 in 1972, 25 000 in 1977, 55 000 in 1983 and 87 000 in 1988 **(Table 2)**. Tractor population from 1966 to 1988 (22 years), therefore, has

Table 2 Population Trend of Tractors and Draft Animals

Year	Tractors (Unit)	Draft Animals	
		Head (000')	Equivalent Horse Power (000' HP)
1945	15	3 051	1 716
1951	506	3 589	1 964
1956	1 274	4 078	2 257
1961	3 196	4 510	2 471
1966	4 195	4 610	2 523
1972	12 157	4 516	2 511
1977	24 768	4 642	2 582
1983	54 668	4 338	2 450
1988	86 904	4 031	2 277

Table 3 Population of Agricultural Machinery in Rajasthan (Unit; Number)

Machinery	1945	1951	1956	1961	1966	1972	1977	1983	1988
Tractor	15	506	1 274	3 196	4 195	12 157	24 768	54 668	86 904
Mouldboard and Disc plough	—	—	—	—	—	6 483	12 695	25 790	41 199
Disc harrow	—	—	—	—	—	6 250	10 883	22 768	37 212
Cultivator	—	—	—	—	—	12 214	22 322	41 648	57 299
Leveller and scraper	—	—	—	—	—	1 871	4 790	12 603	20 754
Seed drill	—	—	—	—	—	924	4 027	31 126	36 622
Seed planter	—	—	—	—	—	442	1 025	764	2 482
Oil engine with pump	110	1 268	1 317	2 464	7 252	37 094	85 513	226 370	371 113
Electric pump	143	333	342	477	4 954	35 843	82 918	205 909	255 725
Sprayer and duster	—	—	—	—	2 523	4 670	7 754	14 608	36 466
Power Thresher	—	—	—	—	—	1 130	5 317	22 214	28 683
Maize sheller	—	—	—	—	—	32	66	439	923
Combine harvester	—	—	—	—	—	—	37	1 599	4 681

Source: 1. Indian Livestock Census, 1951, Directorate of Economics and Statistics, Govt. of India, New Delhi.
2. Report on Livestock Census of Rajasthan, Govt. of Rajasthan, Ajmer.

increased about 21 times. With the tractor population increase, the number of draft animals since 1966 experienced a decreasing trend except during 1977 when there was slight increase over the 1972 population.

Contrary to the common belief that tractors are only suitable for big farmers, it is quite interesting to observe that a large number of tractors are being used (on hire basis) by the marginal and small farmers. This is due to the fact that many of the marginal and small farmers are unable to maintain draft animals since cropping is limited to 3-4 months in a year.

Ploughs, Harrows and Cultivators

Tilling the field is essential for creating favourable soil condition for seed germination and plant growth. The age old wooden plough gives low and poor quality work output. With the introduction of tractors in farming improved matching tillage implements such as, plough, harrow, cultivators, etc. were brought in use. In 1988, over 41 000 ploughs (mould board and disc), 37 000 disc harrows and 57 000 cultivators were in use in the state **(Table 3)**. Many manufacturers are engaged in producing these implements locally.

Seeders

With the introduction of high yield seed varieties and inorganic fertilizer, the value of mechanical seeder has increased. Mechanical drills offer advantage by way of ensuring desired application rate, uniform distribution and correct placement of seed and fertilizer, beside having relatively higher work output thus increasing farm productivity. In 1972, only about 900 units of power-operated drills were on farms which increased to about 37 000 units in 1988 **(Table 3)**. In addition, there are about 475 000 units of animal-operated drills on farms at the present time.

Seed planters are still not popular and their use is limited to some big private farms or government farms only.

Pump Sets

The dependence of agriculture on monsoon and its consequent vulnerability has been recognized from the earliest time. Pump sets were introduced during the British rule in India to lift water from dug wells and surface reservoirs for irrigation. Thereafter, there has been continuous increase in its population. Oil engine and electrical pumps have multiplied 10 times and 7 times, respectively, in just 16 years (1972-1988) **(Table 3)** resulting in increased cropping intensity and higher grain production.

With the proposed plan to introduce electricity to all the remaining villages by the end of this century the choice will shift in favour of electrical pump sets. The large use of electrical pump sets may bring revolution in irrigation in the state.

Sprayers and Dusters

With the application of new technology plant protection measures have become inescapable. There are three types of sprayers and dusters in use; (i) hand operated; (ii) foot operated and (iii) power operated. In 1988, about 36 500 units of sprayers and dusters (all type) were on farms compared with only 2 500 units in 1966 **(Table 3)**.

Threshers and Harvesters

Power threshers being highly efficient and with higher work output have gained wide acceptance among local farmers. Threshers are driven either by gasoline engine or electric motor, mostly in the range of 3 to 7.5 hp. Tractors are also used as prime mover. In 1988, over 28 000 threshers were owned by local farmers which was more than 25 times higher compared with the 1972 figure **(Table 3)**. Besides some big manufacturers, small scale industries and some trained village artisans are engaged in manufacturing threshers locally.

Combine harvesters were introduced during the 1970s for testing purpose only. Soon after they were adopted by State Government farms and some big private farms. In 1988, about 4 700 combine harvesters were on farms. Though the combine harvester has added advantage of harvesting and threshing its scope is limited to big farms only. Small farmers do not accept the machine due to its high initial cost and requirement of large-sized plots for operation.

Measures for Promoting Farm Mechanization

Popularization of farm machines is an essential component of farm mechanization. Various state extension agencies and other organizations are engaged in popularising new technology through display, demonstration, training and audio-visual aids. The State Department of Agriculture and Cooperation is the nodal agency responsible for large scale popularization of newly developed and proven machines in Rajasthan.

Loans

All the 28 nationalized banks, State Cooperative Bank, Regional Rural Bank and other similar financial institutions provide loans to farmers for the purchase of tractors and farm equipment against the mortgage of land. The banks also provide indirect finance to farmers through the rural development programmes and credit societies.

Training Facilities

Proper education and training for farmers is essential for the adoption of new technology. Farmers Training Centres, Farmers' Science Centres and other similar organizations are involved in imparting training to farmers on various aspects of farm mechanization beside the use of improved seed and fertilizer.

Constraints in Farm Mechanization

The major constraints in farm mechanization is financial resources of farmers. Majority of state farmers are marginal and small having limited financial resources. The farmers get credit facilities from banks and credit societies for the purchase of agricultural machinery. But the procedure in obtaining credit from these agencies is time-consuming and complicated to follow. The government has realized this problem and is now taking steps to simplify the procedure for credit application.

Repair and maintenance of tractors and equipment is another constraint in farm mechanization. Most of the service centres are based in cities and big towns and farmers have to travel long distances to get to these facilities. Sometimes spare parts are not available and farmers have to wait many days. There is, therefore, real need for better sale and service facilities in the rural areas.

Conclusion

In the last four decades, farm mechanization in Rajasthan has gone a long way. The development was faster in the post-green revolution period testifying much progress in agricultural productivity. The provision of training facilities has helped in generating awareness among farmers on positive role of farm mechanization in agriculture.

REFERENCES

1. Board of Revenue, Govt. of Rajasthan, Ajmer (Unpublished Report, 1989-90).
2. Census of India — Rajasthan, Govt. of India, New Delhi 1991.
3. Indian Agriculture in brief. Sixteenth edition, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation.
4. Indian livestock Census, 1951. Directorate of Economics and Statistics, Govt. of India, New Delhi, Vol. II, Page 265.
5. Livestock Census of Rajasthan, Govt. of Rajasthan. Ajmer 1956-1988.
6. NCAER, 1981. Implication of tractorization on farm employment, productivity and income. Report NCAER, New Delhi.
7. Statistical Abstract, 1982. Directorate of Economics and Statistics, Govt. of Rajasthan, Jaipur.
8. Statistical Outlines, 1984. Directorate of Economics and Statistics, Govt. of Rajasthan, Jaipur. ■■

The Present State of Farm Machinery Industry

by
Farm Machinery Industrial Research Corp.
7, 2-chome, Kanda Nishikicho,
Chiyoda-ku, Tokyo, 101 Japan

Outlook of Agriculture

Trend of Agriculture

Agricultural production in 1989 increased 1.7% over the previous year.

The plowland of rice field in 1990 decreased 23,000 ha to 2,074,000 ha. The crops were 10,499,000 t, which showed an increase over the preceding year. The crops of wheat decreased 4% over the previous year to 1,297,000 t. Soybean resulted in the yield of 220,000 t, which showed a decrease over the preceding year.

Imports of agricultural products amounted to $26.5 billion in 1989, which showed 12.6% of the total imports. In 1990, imports of agricultural products increased 1.6% over the preceding year.

Farming population in 1990 decreased 2.6% over the preceding year to 4,080,000 persons. In addition to this, those over the age of sixty-five are on the increase. It is the immediate problem to maintain agricultural successors.

Farm houses are continuously decreasing to 3,835,000 farm houses in 1991. Of all these farm houses, those of full time farmers are only 473,000 houses.

Farm income in 1990 increased 15%, compared with the preceding year. The ratio of farming income to the total income is only 14%.

Agricltural investment in 1990 increased 4% over the preceding year. The investment in agricultural machinery increased 8%, which showed ¥199,000 per house.

In Japan, food life has become rich since the 1970's. On the other hand, rice crop, oranges, milk and eggs were overproduced. Food industry has developed and imports of agricultural products showed a sharp increase.

Japanese agriculture is requested to reduce the production cost and to produce the high quality, various agricultural products which consumers are asking for. It has come to be a matter of concern to improve the relation between global environment and agriculture.

Trend of Farm Mechanization

Agricultural mechanization in Japan has remarkably progressed in the field of low land rice, chief crop, in a short period since 1955. Thus, continuous system of low land rice has completed. 98% of rice crop is transplanted and 99% of rice crop is havested by farm machinery in 1990. As to rice crop, working hours per 10 a decreased to 43.8 hours — they were 117.8 hours in 1970.

In recent years farm machinery for rice crop is developed to be larger-sized, higher-efficient and more commonly used. In addition, farm machinery for field crops and livestock farming is being developed and improved, which has been lagged behind so far. Whatever the types it may be, farm machinery is being improved from various points such as performance, safety and cost reduction.

Followings are the number of popularization of farm machinery as of Jan. 1, 1991: riding tractor amounted to 1,966,000 units; walking tractor 1,765,000; rice transplanter 1,904,000; head feed combine 1,169,000 (belonging to farmers who are selling agricultural products) **(Table 1** and **Fig. 1)**.

Shipments of major farm machinery in the domestic market in 1990 are as follows: riding tractor reached 96,000 units; riding tractor 206,000; transplanter

Table 1 Major Farm Machinery on Farm

Unit: Thousand

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1985	2,579	1,854	1,993	2,151		1,518	1,109	1,473
1986	2,554	1,834	2,098	—	—	—	1,150	—
1987	2,682	1,904	2,179	—	—	1,275	1,201	1,378
1988	2,674	1,985	2,199	1,408	1,674	—	1,244	—
1989	2,654	2,049	2,205	—	—	—	1,258	—
1990	2,185	2,142	1,983	1,871		1,298	1,215	1,282
1991	1,765	1,966	1,904	—	—	—	1,169	—

Source: "Statistical Yearbook of Ministry of Agriculture, Forestry & Fisheries" by the Ministry of Agriculture, Forestry & Fisheries and Other datas.

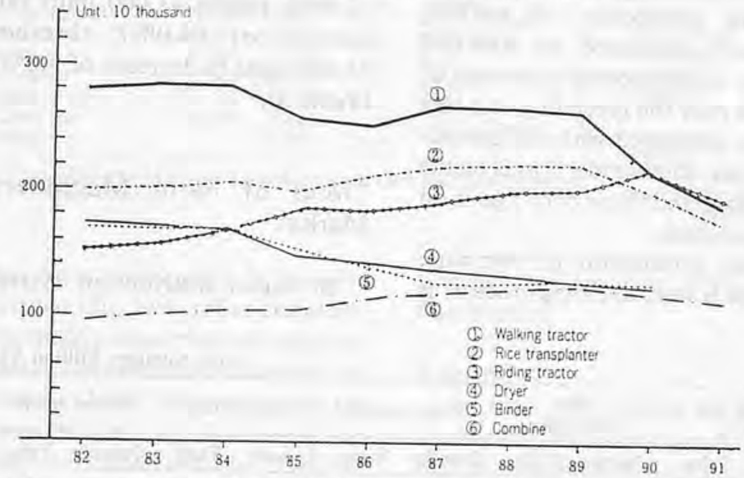


Fig. 8 Selected farm machinery on farm.

Table 2 Shipment of Major Farm Machinery

Unit: Number

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1985	195,589	103,859	126,967	128,353	136,970	49,908	95,676	78,304
1986	184,005	109,101	122,441	132,447	133,479	52,234	88,997	74,636
1987	184,885	90,940	101,942	140,635	123,674	44,746	79,278	66,662
1988	213,941	90,261	84,531	144,705	108,958	39,950	66,618	59,666
1989	214,806	89,676	88,444	168,232	110,969	36,789	65,046	58,614
1990	205,944	95,691	89,139	183,820	107,229	37,117	65,247	51,954

Source: "Survey of Shipment of Agricultural Machinery" by the Ministry of Agr., Forestry & Fisheries.

89,000; power reaper 37,000; combine 65,000; dryer 52,000; huller 44,000(**Table 2**).

Recently there is a larger demand for used farm machinery. In 1989 the rate of used machinery in the distributing amount is as follows: riding tractor forms 43%; transplanter 34%; combine 35%.

Measure of Farm Mechanization

The budget of agricultural, forestry and fishery for 1991 amounted to ¥3,265.8 billion, which shows an increase of 4.6% compared with the preceding year.

The budget of agricultural and forestry is mainly compiled, laying emphasis on the following respect: to reduce production cost; to produce agricultural crops in response to the trend of the demand; to promote researches for the increase in the additional value of agricultural products; to preserve the environment on the earth; to reinforce international cooperation; and to make mountainous districts lively.

Enterprises for agricultural mechanization are incorporated into measures which aim at giving life to agriculture and rural districts, enlarging the scale of leading farmers who assume the responsibility of agricultural production, making the most of high-technology and information, promoting agriculture among hills and chief producing districts for high productivity.

In the introduction and use of farm machinery, it is most important to reduce production cost under the rational use of high-performance farm machinery, to popularize simple farm machinery equipped with fundamental function and at a low price, to make an efficient use of used farm machinery and to prevent accidents in farm working.

Movement of Farm Machinery Industry

The output of farm machinery, which increased sharply in 1973 and 74, amounted to ¥659.0 billion. But it decreased sharply to ¥536.7 billion in 1978 because farmers were unwilling to invest money in machinery under the popularization of rice crop machinery and under the policy of reducing the acres for rice planting.

Except for ¥627.3 billion in 1980, since 1978 the output remained about ¥500 billion p.a. The output has a gradual increase to ¥633.8 billion in 1984, ¥667.8 billion in 1985 and to ¥674.3 billion in 1986. Because international markets are developed and high value-added products are developed. In spite of these increasing tendency, in 1987 the output decreased ¥500.0 billion again. Since then, it remained about ¥550.0 billion.

Though other industries are showing signs of prosperity, the farm machinery industry is depressed. Japanese farm machinery manufacturers are striving for making their business market active by stirring up new demand for farm machinery, produce for other industries as subcontractors, finding a market in other industries except for farm machinery. Now, we are more and more shorthanded. It urged to improve working hours, wages and working environment.

Trend of Farm Machinery Production

In 1990 the amount of farm machinery production was ¥585.6 billion, which increased by 5.8% over the preceding year. This increase was resulted from the fact that domestic supply and exports were slightly improving.

Production of major farm machinery is as follows: riding tractor decreased by 1.0% over the preceding year to 156,000 units. By sizes, those under 20 ps amounts to 71,000 units, those from 20 to 30 ps 59,000 units and those over 30 ps 26,000 units.

The production of walking tractor amounted to 269,000 units, which showed a decrease of 2.4% over the preceding year. By sizes, compared with the preceding year, those under 5 ps is on the decrease and those over 5 ps is on the increase.

The production of combine, which is next to riding tractor, is 69,000 units. This is an increase of 6.5% over the preceding year.

Followings are the production of other types of farm machinery: rice transplanter amounts to 91,000 units (an increase of 4.0% over the preceding year); grain dryer 59,000 units (an increase of 6.7%); bush cleaner 1,603,000 units (a decrease of 5.1%); huller 60,000 units (an increase of 26.4%); binder 43,000 units (an increase of 14.0%); thresher 23,000 units (a decrease of 5.0%) **(Table 3)**.

Trend of Farm Machinery Market

In Japan distribution system

Table 3 Yearly Production of Farm Machinery

Unit: Number, Million Yen

Year	Farm machinery total		Riding type tractor		Walking type tractor		Rice transplanter		Power sprayer		Power duster		Blower sprayer	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1985	—	667,895	209,652	247,100	278,581	41,398	132,909	53,835	170,968	10,479	222,877	7,755	7,200	8,361
1986	—	647,265	209,078	254,010	268,307	37,026	134,433	64,541	157,774	9,754	184,132	6,374	7,121	9,535
1987	—	585,810	179,884	215,379	276,286	38,778	92,861	50,181	144,734	8,396	165,241	6,028	6,231	8,296
1988	—	549,854	172,761	209,278	276,684	37,644	81,022	43,554	181,805	9,851	161,763	5,999	8,696	9,958
1989	—	553,368	157,544	197,947	275,629	38,735	87,615	46,337	184,098	10,015	156,802	5,845	9,901	9,400
1990	—	585,561	115,939	198,557	269,027	38,248	91,141	52,462	220,528	12,339	149,789	5,575	9,565	9,514
(1991)	—	608,500	148,000	201,600	258,000	38,600	92,000	55,600	205,000	11,800	158,000	6,000	8,800	12,200

Year	Grain reaper		Brush cutter		Power thresher		Grain combine		Rice husker		Dryer		Grain polisher	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1985	51,061	12,274	1,350,990	24,573	42,901	15,163	102,593	157,222	80,231	19,661	76,571	42,634	75,314	3,843
1986	55,587	13,777	1,496,433	27,191	41,295	15,246	93,080	150,188	72,000	19,060	73,798	44,590	66,891	3,537
1987	45,867	10,292	1,421,007	24,569	29,126	10,430	78,656	131,265	57,087	16,300	65,378	44,192	61,367	3,083
1988	41,204	9,313	1,546,010	26,160	24,811	8,900	64,412	117,132	49,866	13,137	58,097	37,649	58,982	2,932
1989	37,291	8,841	1,689,181	28,501	23,835	9,005	64,789	127,309	47,478	13,900	55,537	35,244	61,298	3,223
1990	42,502	11,110	1,601,652	25,798	22,634	9,118	68,993	138,396	60,004	18,332	59,269	39,990	58,500	4,871
(1991)	38,000	9,600	1,650,000	27,900	19,400	7,800	70,000	148,200	60,000	19,000	58,000	43,200	63,000	5,800

Source: "Survey of Status of Machinery, Production" by the Ministry of Interntional Trade and Industry. Data by Japan Agr. Machinery Manufacturers' Assn. and Land Internal Combustion Engine Manufacturer's Assen.

Note: Data for 1991 are forecast by Farm Machinery Industrial Research Corp.

Table 4 Farm Equipment Distributor and Sales Value

Unit: Million yen

Year	No. of retailers (1)	Employes	Annual sales value (2)	Inventory	Square meters of shop m^2	Annual sales value (2)/(1)
1976.5	8,417	43,819	811,535	199,672	740,785	96.4
1979.6	9,257	48,548	1,007,298	159,772	898,854	108.8
1982.6	10,084	49,081	1,018,983	164,269	1,005,546	101.0
1985.6	9,142	43,921	946,507	144,837	985,453	103.5
1988.6	9,444	45,952	1,015,304	159,798	923,726	107.5

Source: Ministry of International Trade and Industry.

Table 5 Handling of Farm Equipment by Agricultural Cooperative Association (1989 Business Year)

Unit: Million yen

Business year	Total number of coops. surveyed	Purchase in this term	Of which purchased through affiliated organs	Amount of supply and handling
1985	4,242	345,606	268,640	378,441
1986	4,194	351,484	275,591	383,023
1987	4,117	333,131	260,530	364,716
1988	3,976	337,970	259,915	379,709
1989	3,717	308,833	237,383	340,989

Source: "Statistics on Agricultural Cooperatives—1989 business year—" by the Ministry of Agriculture, Forestry & Fisheries.

Table 6 Export of Farm Equipment 1990

Unit: FOB Million Yen

Year	Unit	Value	Ratio	Major destinations
1985		190,305		
1986		150,792		
1987		135,354		
1988		130,492		
1989		131,042		
1990		132,757	100.0	U.S.A., Korea, France
Power tiller	52,925	4,024	3.0	France
Wheel tractor	65,413	50,293	37.9	U.S.A.
Power sprayer	37,883	1,509	1.1	Iran, Taiwan, U.S.A. Thailand
Duster	16,097	407	0.3	Thailand
Lawn mower	158,954	15,263	11.5	U.S.A., France
Brush cutter	1,030,092	23,775	17.5	Italy, U.S.A.
Mower	37,481	2,088	1.6	U.S.A.
Combine	5,956	10,833	8.2	Korea
Blade, knife	—	2,177	1.6	U.S.A.
Chain saw	195,079	4,446	3.3	U.S.A., France
Other		17,942	13.6	

Source: Ministry of Finance. Totaled by Japan Farm Machinery Manufactuer's Assn.

Table 7 Import of Farm Equipment 1990

Unit: CIF Million Yen

Year	Unit	Value	Ratio	Exporters
1985		15,303		
1986		17,425		
1987		20,949		
1988		23,095		
1989		27,245		
1990		33,205	100.0	W. Germany, U.K., U.S.A.
Wheel tractor	4,150	13,774	41.5	U.K., W. Germany
Pest control machine	1,082,430	1,355	4.1	U.S.A.
Lawn mower	35,818	2,621	7.9	U.S.A.
Mower	9,060	1,086	3.3	France, Netherlands
Hay making machine	3,423	1,761	5.3	W. Germany, Netherlands, France
Bayler	1,521	2,306	6.9	U.S.A., France
Combine	154	1,994	6.0	Belgium, W. Germany
Chain saw	41,245	1,610	4.8	W. Germany, Sweden
Other		6,698	20.2	

Source: Ministry of Finance. Totaled by Japan Farm Machinery Manufactuer's Assn.

for farm machinery is roughly divided into two major channels: the traders concerned and Agricultural Cooperative Association. As of June, 1988, the retail shops for farm machinery, including the traders concerened and Agricultural Cooperative Association were recorded to be about 9,400, the employees amounted to be about 46,000 persons, and the annual sales amounted to be ¥1,015 billion **(Table 4)**.

According to the governmental survey by Ministry of Agriculture, Forestly and Fishery, the total sales by Agricultural Cooperative Association reached 341.0 billion in 1989 **(Table 5)**.

Under the declining demand for farm machinery, the farm machinery distribution industry is making efforts to expand facilities and technique, and to rationalize the management. Now, it is urgent necessity that working environment should be consolidated to maintain manpower because labor shortage has become more serious.

Export and Import of Farm Machinery

Export

In 1990 the exports of farm machinery amounted to ¥1,328 billion, which showed an increase of 1.3% over the preceding year. The ratio of the exports to the total amounts ¥585.6 billion of the production ended in 22.7%.

Seeing from the shipments, those for the North America and Europe is on the decrease over the preceding year, while those for Asia, Central and South America and Oceania is on the increase. The exports for the United States, the largest market, reached ¥48.8 billion and the amount forms 37% of the total exports.

As for the types of farm machinery, tractor was chiefly exported. 156,000 tractors were produced in 1990. Of the tractors 65,000 units were exported, which amounted to ¥56.1 billion. Seeing by sizes, the exported tractors under 30 ps amounted to 51,000, those from 30 ps to 50 ps were 12,000, those more than 50 ps were 3,000 units.

Major farm machinery, next to tractor, is bush cleaner. The total exports were 1,030,000 units and ¥23.8 billion **(Table 6)**.

The export of farm machinery in Japan has shown no remarkable fluctuation for four years running. Money is positively invested in foreign countries. Much more companies are making efforts to tie up technically with companies on the spot, to establish factories and expand the trading and production base.

Import

In 1990 the imports of farm machinery amounted to ¥33.2 billion, which means an increase of 22% over the preceding year.

Followings are the major imported farm machinery: tractors amounted to 4,150 units (those more than 70 ps were 3,096 units of all the tractors); chainsaw were 41,000 units **(Table 7)**. ■■

General Outline of the Research Activities of Tropical Agriculture Research Center

by
Takeo Yamaguchi
Director
Research Division II
Tropical Agriculture Research Center
1-2, Owashi, Tsukuba
305 Japan

Introduction

For most of the developing countries located in the tropics and subtropics which have to overcome the difficulties associated with population increase and low national income, the promotion of agriculture is a prerequisite for their social and economic development. They are thus placing great hopes on the industrialized and developed countries for cooperation in the field of agricultural technology.

On the other hand, nowadays, due to the growing interdependence among countries for agricultural and forestry natural resources, agricultural and forestry activities cannot be conceived any longer on a national scale solely. In particular, to ignore the potential of agricultural and forestry resources in the tropics and subtropics would preclude any progress in the future.

However, the technology which can contribute to the development of agriculture in the tropics and subtropics cannt be automatically transferred under its present form by the developed countries or simply modified. What is needed, is to design new techniques adapted to the conditions prevailing in these regions.

In particular, recently, there has been a growing awareness in Japan of the need to tackle the "North South Problem" and to solve the trade frictions with the international community. As a result, it has become increasingly important for Japan to extend assistance to the developing countries in the field of agricultural technology in placing emphasis on the tropical and subtropical regions. To meet such objectives, research requirements have tended to increase both in quantity and quality and great hopes are being placed on the Tropical Agriculture Research Center (referred to as TARC) which is the only organization in Japan in charge of research in the field of agricultural technology overseas.

Role and Characteristics of the TARC

The Center was established with the following objective: "to carry out research and surveys for the development of technologies pertaining to agriculture, forestry and animal husbandry in Japan and overseas".

Three types of research activities are being carried out to meet these objectives:

1. Research required for the development of techniques pertaining to agriculture and forestry in the tropics and in the subtropics.
2. Research relating to the development of technologies which may contribute to broaden spectrum of research in agriculture and forestry in Japan along with raising the level of research.
3. Collection, coordination and dissemination of information relevant to the technology and activities related to agriculture and forestry in the tropics and subtropics.

The Center is one of the 29 research institutes affiliated with the Ministry of Agriculture, Forestry and Fisheries (referred to as MAFF) of Japan. Unlike the other institutes which carry out research primarily related to domestic agriculture, the Center is involved

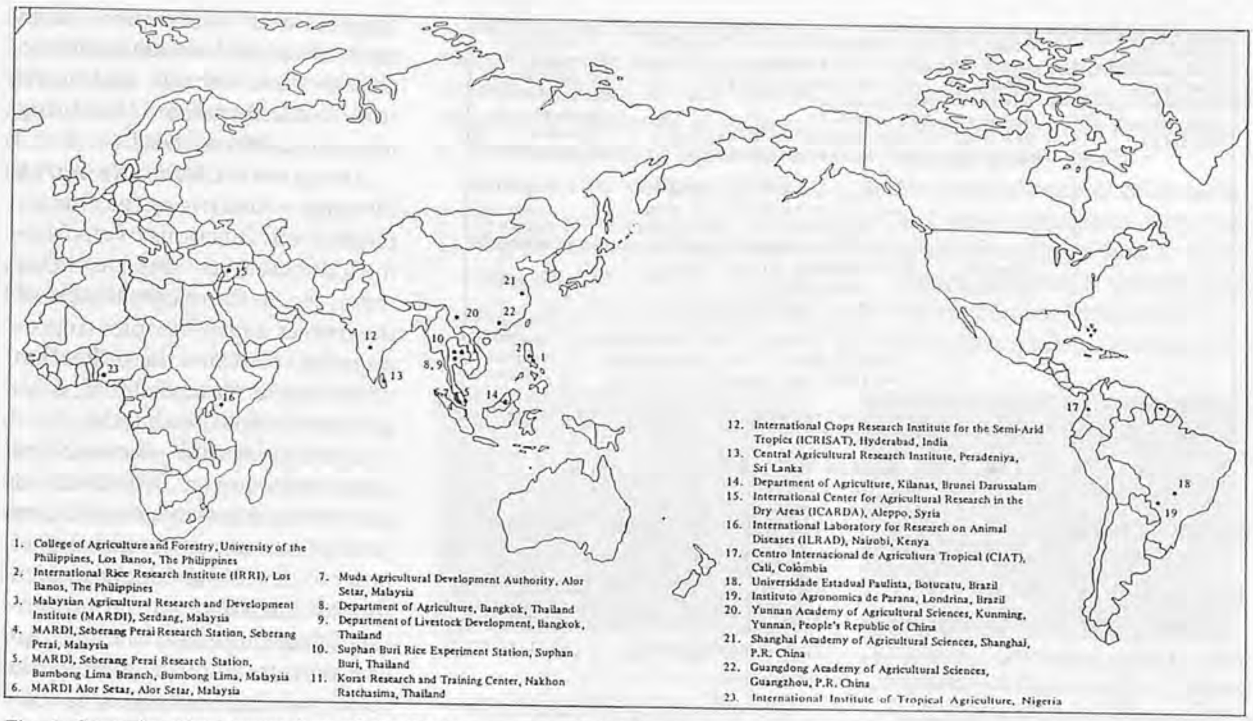


Fig. 1 Countries where researchers of the Center are presently being sent on long-term assignments.

in research in agricultural technology, with the exception of fisheries, overseas, in particular in the countries located in the tropical and subtropical regions. The responsibilities of the Center consist of sending researchers overseas, invitation of overseas researchers and research administrators to Japan and exchanging, collecting, coordinating and disseminating information on the research activities mentioned above.

Development of the Center Since Its Foundation

April 1966 A unit in charge of the development of technological research pertaining to tropical agriculture was created by the Secretariat of the Agriculture, Forestry and Fisheries Research Council of the MAFF. The activities of this unit consisted of sending researchers overseas, carrying out surveys abroad and gathering data and information.

June 1967 The unit was upgraded to an office which, in addition to the activities mentioned above, became in charge of the organization of international symposia on tropical agricultural research and of the invitation of overseas research administrators to Japan.

June 1970 The Tropical Agriculture Research Center was established in Tokyo (General Affairs Section, Accounting Section, Planning Division, Research Division) and started functioning as a research institute affiliated with MAFF. At the same time, the construction of the Okinawa Branch of the Center in Ishigaki Island was initiated.

November 1972 Construction of research facilities in Tsukuba Science City.

April 1974 Creation of the position of General Research Coordinator.

April 1975 Construction of the main research building and of the attached facilities in Tsukuba is almost completed. Construction of the Okinawa Branch is completed.

July 1975 Creation of the Second Research Division.

June 1977 Transfer to Tsukuba.

December 1983 Transfer to larger facilities in the Tsukuba area due to the expansion of the Center's activities. The Planning Division is upgraded to the Division of Planning and Coordination.

April 1985 Creation of the Division for Research Information

May 1987 Creation of the Eco-Physiology Research Division.

October 1988 Creation of the Marginal Land Research Division.

April 1991 Creation of the Administration Division.

Organization and Research Activities of the Center

Organization

The organization of the Center

Tropical Agriculture Research Center (Director General)	— Planning and Coordination Division	7 members
	— Administration Division	19 members
	— Research Information Division	14 members
	— Research Division I	30 members
	— Research Division II	10 members
	— Eco-Physiology Research Division	16 members
	— Marginal Land Research Division	11 members
— Okinawa Branch 32 members	—General Affairs Section	6 members
	—Crop Introduction and Cultivation Laboratory	4 members
	—Crop Breeding Laboratory	2 members
	—Tropical Fruit Tree Laboratory	3 members
	—Rapid Generation Advance Laboratory	2 members
	—Crop Protection Laboratory	4 members
	—Soil Fertility Laboratory	2 members
	—Field Management Section	8 members

Total number: 141 members (102 researchers). April 13, 1991.

Fig. 2 Organization of the center.

is outline in **Fig. 2**.

Activities of the Center

Planning and Coordination Division—Three sections: Planning Section, Coordination Section, International Relation Section.

Planning of the research project; arrangements for the dispatching of researchers overseas; liaison and coordination with the organization concerned in Japan and overseas; organization of the international symposia; invitation of research administrators and counterpart researchers.

Research Information Division—This Division consists of the Library and Documentation Section and 6 research coordinators for information. The activities of the Division include the collection, compilation, analysis and distribution of literature and information pertaining to tropical agriculture. Occasionally the members of the Division carry out surveys overseas.

Research Division I—The researchers from this Division conduct studies on subject matters required for the development of techniques covering a wide range of fields, such as crop breeding, cultivation, physiology, ecology and protection in the tropics; soil management; etc.

Research Division II—Systematization of the techniques required for farm, management after analysing the results obtained by the researchers of the first Division; comprehensive studies for the development of agricultural activities.

Eco-Physiology Research Division—Analysis of specific physiological mechanisms of plants in the tropics and subtropics, with emphasis placed on adaptation to adverse environments and nutrition mechanisms involving microorganism activity.

Marginal Land Research Division—Analysis of the characteristics and functions of environmental resources such as land, water, etc. in the marginal areas of the tropics and subtropics to promote and improve the utilization of these areas for agriculture, forestry and animal husbandry.

Okinawa Branch—Research on crop improvement, methods of cultivation, soil management, crop protection, etc. is carried out in order to develop techniques which should contribute to the promotion of agriculture in the subtropical zone to stabilize production under a definite system. It is considered that the results of these studies could serve as a link to the

Fig. 3 Rice planting area in Peninsula Malaysia.

research pursued overseas and could be a means of transferring technology to the subtropical areas, including the Nansei-Shoto (Rhykyu Islands) in Japan as well as to the tropical zone.

Activities Relating to Farm Mechanization

The Muda irrigation scheme which is Malaysia's largest rice double cropping project covers a flat, coastal, alluvial plain of about 100,000 ha in surface area straddling the States of Kedah and Perlis in the north-western part of Peninsular Malaysia.

To promote the development of the Muda irrigation scheme in alleviating various constraints, TARC has been cooperating with Muda Agricultural Development Authority (MADA) by undertaking joint surveys and studies and by providing a number of research scientists specialized in rice agronomy, agricultural engineering, farm mechanization and farm management and agricultural economics. On the other hand, TARC has also cooperated with the Malaysian Agricultural Research and Development Institute (MARDI) by undertaking joint studies on rice breeding of resistant varieties for tungro virus disease and control of pest and diseases associated with the promotion of rice double cropping and by providing a number of research scientists such as rice breeders, entromologiests, plant pathologists and weed scientists.

These joint surveys and studies have involved a multidisciplinary approach for the establishment of an elaborated infrastructure, the adoption of complex agronomic practices to use as efficiently as possible the inputs available as well as concerted efforts to foster the understanding and cooperation of the rural communities.

On the other hand, TARC has undertaken some specific research projects relating to rice double cropping in Malaysia as follows:

1. Mechanization of rice cultivation in the tropics. (1973-1977).
2. Mechanization of farm operations in the paddy growing areas of the tropics. (1978-1982).
3. Promotion of rice double cropping through rationalization of system water management and farming systems in the lowland tropics. (1983-1987)
4. Methods of control of diseases and pests associated with the promotion of rice double cropping in the tropics. (1985-1989)
5. Promotion of rice double cropping through direct seeding cul-

Fig. 4 Overview of the Muda irrigation scheme from the Kedah peak, Season: early February, 1985, Fallow period of dry season.

Fig. 5 Overview of the Muda irrigation scheme from the airplane, Season: early December, 1990, Planting period of second crop.

Fig. 6 Pedu dam, irrigation water was released to the river.

Fig. 7 Building of the Muda Agricultural Development Authority (MADA)—the central plot—.

Fig. 8 Transplanter.

Fig. 9 Rice planted by transplanter.

Fig. 10 Rice harvested by big combine harvester.

Fig. 11 Rice harvested by big combine harvester.

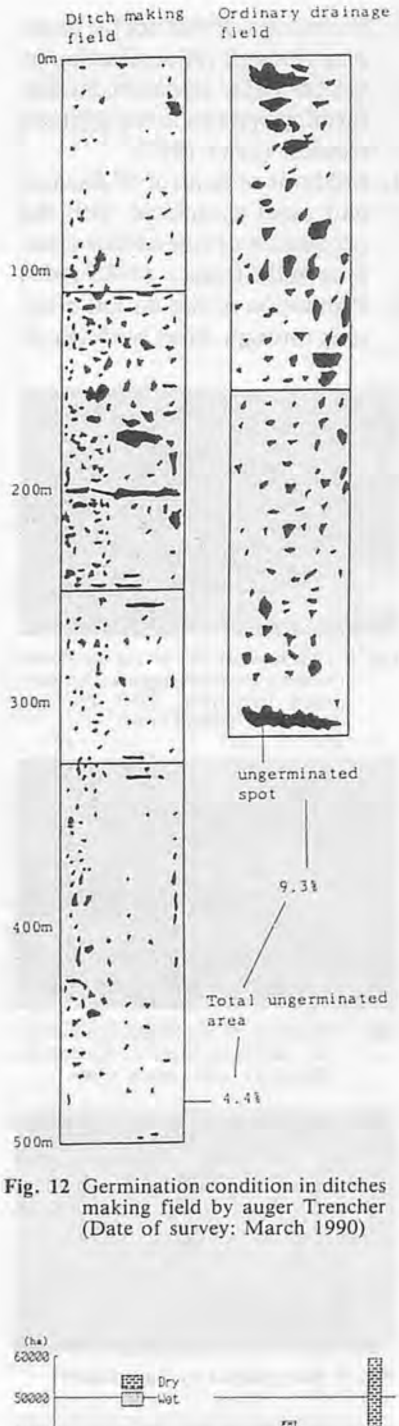


Fig. 12 Germination condition in ditches making field by auger Trencher (Date of survey: March 1990)

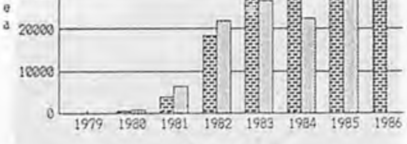


Fig. 13 Trend of direct seeding in the Muda area.

ture in the tropics. (1988-1992)

Highlights of the collaborative research relating to the rice research programs in Malaysia during the period from 1967 to 1989 are as follows:

Farm mechanization—Trials on the development of rice transplanters and harvesters adaptable to the Muda area were carried out initially by the farm mechanization team. In the transplanting operation, the four-row walking type transplanter was found to display a high performance. The final model of the head-feeding combine harvester with combined use of a shallow tilling drive harrow is suitable for the operation, as it is associated with minimal grain loss under the soft ground conditions of the Muda area. However, compared with the large combine harvester, the efficiency, economy and durability are inferior. The farm mechanization team carried out trials for the development of a series of attachments for tractors, including several types of cage wheels, float-strakes and both chopping and rotary types of drive harrows. These instruments were highly effective for land preparation in the Muda area.

Throughout the studies on farm mechanization, the results obtained suggested that the introduction or simple modification of the technology adopted in temperate countries was not compatible with the conditions prevailling in the Muda area. It was also deemed important to combine harmoniously "software" fields such as plant breeding, methods of cultivation and fertilization, control of pests and diseases, farm mechanization and management with "hardware" components such as construction of irrigation and drainage facilities and farm roads as well as field consolidation.

System water management and farming systems—In the Muda irrigation area, a yield increase per unit area of about 24% was achieved during the 14 years period since the beginning of the double cropping practice through the introduction of higher-yielding varieties and the application of large amounts of fertilizer. However, after the double cropping practice spread to the whole area, the yield became extremely unstable mainly due to the insufficient supply of irrigation water and severe occurrence of rice tungro disease associated with year-round cultivation with erratic schedules caused by the low canal density, the labor shortage and the farmers' attitude to scheduled cropping, as well as heavy application of fertilizer.

To overcome the yield instability a new double cropping system based on transplanting cultivation involving a complete fallow period to be implemented over the wholoe Muda area during the dry season was proposed. It was eventually recognized that for the implementation of this double cropping system, water management in an irrigation system with reservoir should function effectively from the water source to the terminal lots.

Rice double cropping through direct seeding culture—Recently, direct seeding culture has been disseminated to more than 60% of the rice-producing area of the Muda area. Since 1988, TARC and MADA have been carrying out studies on the promotion of rice double cropping through direct seeding culture. ■■

INQUIRY and REQUEST to AMA

Please let us know your need. We shall promptly reply them. Inquire on any catalog listed in the advertisement in this issue. We shall try our best to serve you. We welcome articles of interest to agricultural mechanization.

Fill in the reverse side of this card and send us by sealed letter.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7-2 Kanda Nishikicho Chiyoda-ku Tokyo-Japan 101

ADVERTISED PRODUCTS INQUIRY

Product	Advertiser	Vol., No., Page

EDITORIAL REQUEST TO AMA

Your Name :

Address :

Occupation :

SUBSCRIPTION/ORDER FORM

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (AMA)

Issued Quarterly

Subscription Rate (includes surface mail postage)

Annual (4 issues) ------------ ¥.6,000
Single copy ------------ ¥.1,700

Back Issues (1971−75, ¥.2,000 per copy)
(1976−77, ¥.1,200 per copy)
(1978−80, ¥.1,500 per copy)

★Spring, 1971	☐Vol.7 No.2, Spring, 1976	★Vol.9 No.4, Autumn, 1978
★Vol.2 Autumn, 1971	☐Vol.7 No.3, Summer, 1976	☐Vol.10 No.1, Winter, 1979
☐Vol.3 No.1, 1972	☐Vol.7 No.4, Autumn, 1976	☐Vol.10 No.2, Spring, 1979
☐Vol.3 No.2, Summer, 1972	☐Vol.8 No.1, Winter, 1977	☐Vol.10 No.3, Summer, 1979
★Vol.4 No.1, Spring, 1973	☐Vol.8 No.2, Spring, 1977	☐Vol.10 No.4, Autumn, 1979
☐Vol.4 No.2, Autumn, 1973	☐Vol.8 No.3, Summer, 1977	★Vol.11 No.1, Winter, 1980
★Vol.5 No.1, Summer, 1974	☐Vol.8 No.4, Autumn, 1977	★Vol.11 No.2, Spring, 1980
☐Vol.6 No.1, Spring, 1975	☐Vol.9 No.1, Winter, 1978	☐Vol.11 No.3, Summer, 1980
★Vol.6 No.2, Autumn, 1975	☐Vol.9 No.2, Spring, 1978	☐Vol.11 No.4, Autumn, 1980
☐Vol.7 No.1, Winter, 1976	★Vol.9 No.3, Summer, 1978	★: Indicates issues out of stock.

☐ **Abstract and Index, 1971-80 (Special Issue, 1983)**

(Check issues and number of copies you wish to order)

Back Issues from 1981, ¥.1,700 per copy (Vol. 12 No. 1 and No. 4 are out of stock)
Abstract and Index, Special Issue, 1983, ¥2,000 per copy.

Vol. ____ No. ____, 19 ____, ____ copy/copies

(check one)

☐ Please invoice me/us

☐ I/We enclose remittance for ¥ ________

****

Name: ____________________

Firm: ____________________

Position: ____________________

Address: ____________________

(block letters)

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7, 2-chome, Kanda Nishikicho, Chiyoda-ku,
Tokyo 101 Japan
Tel. (03)-291-3671~4, 5718

STAMP

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7, 2-CHOME, KANDA NISHIKICHO, CHIYODA-KU

TOKYO, 101 JAPAN

1st FOLD HERE

2nd FOLD HERE

An Introduction to the Department of Agricultural Engineering Faculty of Agriculture, The University of Tokyo

by
Osamu Kitani
Professor
Department of Agricultural Engineering
Faculty of Agriculture, University of Tokyo
Yayoi 1-1-1, Bunkyo-ku, Tokyo
113 Japan

Outline of the University of Tokyo

The University of Tokyo was established in 1877 as the first national university in Japan. It offers courses in essentially all academic disciplines on both undergraduate and graduate levels providing research facilities for these disciplines. The University has a faculty of approximately 2,200 professors, associate professors and lecturers, and a total student enrollment of about 21,700. There are more than 1,500 students from abroad, and about 1,300 foreign scholars come to the University for short or extended visit. The University is known for the excellence of its faculty and students; namely of its graduates are and have always been leaders in the government, in business and in the academic word.

The University organization consists of the College of Arts and Sciences, nine Faculties and a Graduate school with eleven divisions. The nine Faculties are Law, Economics, Letters, Education, Engineering, Science, Agriculture, Medicine and Pharmaceutical Sciences. The University operates the twelve Institutes such as the Institute of Applied Microbiology, the Ocean Research Institutional and others. The main campus of the University is located in Hongo, Bunkyo-ku, Tokyo; it occupies about fifty-six hectars of the former Kaga Yashiki, the Tokyo estate of a major feudal load.

Faculty of Agriculture

The Faculty of Agriculture consists of eight Departments together with the affiliated Institutions as well as a Faculty Library. The Faculty is located in Yayoi campus adjacent to Hongo, occupying an area of twelve hectars. The eight Departments are Agrobiology, Agricultural Chemistry, Forestry, Forest Products, Fisheries, Agricultural Economics, Veterinary Medical Science, and Agricultural Engineering, and each Department offers a course for Master's and Doctoral programs in the Graduate School of Agricultural Sciences. The Institutions are Experimental Farm, University Forests, Animal Husbandry Experimental Station, Veterinary Hospital, Fisheries Laboratory, Experimental Station for Landscape Plants, Radioisotope Center and Biotechnology Research Laboratory which offers another course of the graduate program. All these Institutions and research facilities work closely with their related departments and graduate courses. Many of the faculty members associated with these institutes engage in graduate school teaching and supervise graduate students studying towards an advanced degree.

Recent data concerning the Faculty and both under- and graduate students are indicated in **Table 1** to **5**.

Table 1 Composition of Personnel

Dean	1
Professors	64
Associate professors	72
Lecturers (Full-time)	13
Lecturers (Part-time)	71
Instructors	153
Administrative Personnel and others	309
Total	683

Table 2 Total Number Holding Bachelor's Degree, Master's Degree and Doctor's Degree
(as of May 1, 1989)

Bachelor's Degree	7175
Master's Degree	2307
Doctor's Degree	1126
Doctor's Degree	1799*2

*2: Number of those who have not been in the graduate school but have completed doctoral works.

Table 3 Enrollment of Students
(as of December 1, 1989)

	Under graduates	Post Graduate		Foreign Research Students
		Master's program	Doctor's program	
Agrobiology	74	41 (5)	32 (13)	7
Agricultural Chemistry	159	109 (10)	99 (27)	8
Forestry	47	28 (2)	8 (3)	3
Fisheries	37	35 (5)	40 (25)	2
Agricultural Economics	66	16 (11)	21 (12)	7
Agricultural Engineering	48 (1)	22 (4)	15 (5)	1
Veterinary Medicine & Animal Sciences	108 (1)	0 (0)	59 (12)	2
Forest products	58	33 (2)	14 (5)	2
Course of Biotechnology*1	—	36 (3)	10 (4)	1
Total	597 (2)	320 (38)	298 (106)	33

*1: Graduate Course only. ( ): Number of foreign students.

Table 4 Field Chosen by Japanese Students after Their Graduation
(April, 1986 ~ March, 1989)

	Undergraduates	Post Graduates	
		Master's program	Doctor's program
Graduate School	361	163	—
Private Company	280	157	37
Governmental Institution	47	27	7
Educational Profession	5	6	15
Others	26	7	69
Total	719	360	128

Department of Agricultural Engineering

In Japan the systematic research and education of agricultural engineering initiated in the Department of Agronomy, the University of Tokyo in 1911. The Department of Agricultural Engineering was established in 1925, and at present it consists of six laboratories with 24 teaching staffs; namely 6 professors, 6 associate professors, 1 lecturer and 11 instructors.

About 30 undergraduate students are enrolling into the Department every year. The first two years of undergraduate studies are devoted to general education and introductory lectures in specialized subject at the College of Arts and Science. In addition, students are required to take certain subjects stipulated by the Department of their choice. These are to be taken in the last of the four semesters spent in the College, by which time they know general and fundamental aspects on Agricultural Engineering. In 1991 35 graduate students, including 10 from abroad, are studying in the graduate program.

The laboratories and their major research activities are introduced as follows:

Laboratory of Land Reclamation, Conservation and Rural Engineering—The laboratory covers the field of land reclamation, improvement and conservation, including researches on its physical properties and on techniques of rural planning, especially land use planning from the viewpoint of farmland conservation. Some research projects which have been carried out in the recent years are a) physical properties of organic soil, b) reconstruction of paddy field for multi-purpose use, c) farmland irrigation system, d) remote sensing of farm land.

Laboratory of Agricultural Water Engineering—The laboratory has been mainly dealing with irrigation and drainage. It develops fundamental theories and applies them to actual projects. The activity of the laboratory has been expanded greatly in recent years to include more comprehensive studies concerning water. These new activities include social, regional and simulation-analytic aspects. The current research topics are a) optimization of water resources reservoirs, b) effect of urbanization on river systems, c) unsteady phenomena occurring in the control of water conduits and so on.

Table 5 Number of Foreign Students Who Got Degrees
(April, 1986 ~ March, 1989)

Master's Degree	50
Doctor's Degree	68
Doctor's Degree	14*3

*3 Number of those who have not been in the graduate school but have completed doctral works.

Laboratory of Soil Physics and Soil Hydrology—The laboratory studies flow and storage of water, chemical materials and energy through the soil, and how the soil mass as a whole changes. The purpose of our work is to determine desirable conditions of soils for agricultural use. The current research topics are a) water circulation of agrofields, b) heat transport in the fields, c) eco-environmental system evaluation in the agro-fields, d) soil erosion and protection, e) soil solute transport mechanisms, f) Soil physics and mechanics.

Laboratory of Environmental Engineering—The laboratory is engaged in investigations of methods, facilities and analyses of environmental control of plants in order to attain more successful and effective production. Techniques in protected cultivation such as utilization of heat pumps, storing solar energy in soil for energy saving and application of new covering materials are studied through computer simulations as well as experiments. Application of recent progresses in computer science and biotechnology to agriculture is also important subject. Expert systems for disease diagnosis and tissue cell culture systems for nurseries have been developed, and experiments on the plant factory have been continued for seeking optimal environment of the crops. Micrometeorological effects of urban parks are also investigated theoretically and experimentally.

Laboratory of Agricultural Power, Energy and Machinery—Research and development of farm power and machinery as well as devices and facilities related to bioproduction is the main aim of this laboratory. Mechanization planning and energy analysis as a software of machinery systems is also studied. The main research projects carried out in this laboratory are a) automation and robotics of field machinery and devices, b) soil dynamics and tillage and c) energy analysis and development for new power.

Laboratory of Postharvest Technology—The laboratory covers both fields of postharvest technology and food process engineering. The main research projects carried out in recent years are a) plant design and management of the postharvest facilities for agricultural products, b) systems development for CA storage as well as ripening of fresh fruits and vegetables applying advanced technologies developed in computer and material sciences. c) theoretical and experimental studies on thermal unit operations such as drying of rough rice, vacuum cooling of leafy vegetables, backing of white bread and freeze drying of food materials, and d) developments of ·measuring and analysis methods for physical properties of biomaterials.

Research Activities in Agricultural Machinery and Processing

The following research activities have been carried out in the two laboratories related to agricultural machinery and processing engineering. Laboratory of Agricultural Power, Energy and Machinery:

(a-1) Development of field robot for plant protection and weed control.
(a-2) Robotics for biotechnological process; especially for tissue culture.
(a-3) Moisture control of crops my means of ultrasonic sensors.
(a-4) Ultrasonic sensing of field surface conditions.
(a-5) Image processing of soil clod distribution and plants.
(b-1) Double blades tillage for low energy tillage operations.
(b-2) Selection of minimum tillage tools by means of artificial intelligence.
(b-3) Power and energy reduction of vibratory tillage by frequency control.
(c-1) Studies on Stirling cycle engine for biomass combustion heat.
(c-2) Development of up-flow type biomass pyrolysis gasifier.
(c-3) Solar Rankine cycle for irrigation pumping.
(c-4) Energy analysis of agricultural production and biomass conversion.
(d-1) Studies on small-scale farm mechanization.

Laboratory of Postharvest Technology;

(a-1) Development of planning methods for the rational operation and management of packaging plants of horticultural products.
(a-2) Assessment of actual operational conditions and improvement instructions for the country elevators and other rice processing facilities.
(a-3) Performance characteristics measurements of advanced sorting machines.
(a-4) Development of inspection/sorting machines for rough rices with image analyzer.
(b-1) Storage and ripening of kiwifruits and pear "La France".
(b-2) Automation of artificial banana ripening process by fuzzy theory.
(b-3) Development of CA-storage system with gas separation membrane.
(b-4) Separation of microcystis by electro- and dissolved air floatation.
(c-1) Transport phenomena during vacuum cooling of vegetables.
(c-2) Vacuum drying of silkworm cocoons.
(c-3) Energy analysis in the production of foods.
(c-4) Energy recycling in bread baking processes.
(c-5) Simulation model on heat and mass transfer and sur-

face color change during baking process of white bread.
(c-6) Freeze-drying characteristics of beef and coffee solutions.
(d-1) Automatic measurement system of transport properties of food samples undergoing sublimation dehydration.
(d-2) Rheological characteristics measurement of white bread.
(d-3) Prediction of structural parameters and flow of water vapor of food.

Foreign Students and Scholars Today

In 1991 there are about 150 foreign graduate students in the Graduate School of Agricultural Sciences, and 10 from foreign countries such as Indonesia, China, Brazil, Sri Lanka are studying as graduate students in the Department of Agricultural Engineering. Other more than 10 foreign scholars are staying in the Department as visiting research fellows, foreign research students or trainees of the Japan International Cooperation Agency (JICA).

Foreign students are accepted by the Department as Foreign Research Student (FRS) or as Foreign Graduate Students. The former status is for the study of a specific subject having no direct connection with any degree program while the latter is to either Master's degree or Doctorate. However, the applicant for a foreign Graduate Student in Master's or Doctor's course usually become at first the FRS preparing for the entrance examination of the courses. During this period of about 6 months the applicant can also attend an intensive course of Japanese language offered by the Foreign Student Center of the University in Hongo campus.

The applicant for Master's or Doctor's course is required to have a Bachelor's or Master's degree, respectively. It takes at least two years to complete the program of Master course and three years for Doctoral.

The applicant for the Graduate school is recommended to contact with a head of laboratory to ensure the possibility and procedure to be accepted in the graduate course of Agricultural Engineering, discussing his/her research subject and schedule in Japan and then should submit several document to the Japanese Embassy in his/her home country in order to receive a certificate and a student visa which are valied for staying in Japan. An application form for obtaining the Japanese Government (MONBUSYO) Scholarship is also available at the Japanese Embassy, and its selection procedure is also arranged by the Japanese Embassy in cooperating with the Government of his/her home country. Since 1991 the Graduate School of Agricultural Sciences has started to offer the Special Doctoral Program in Agricultural Development supported by MONBUSYO Scholarship, and by this program two graduate students have been accepted in the course of Agricultural Engineering.

For the convenience to get the information for studying in the Department of Agricultural Engineering, the list of supervising professors and address of the Department are presented as follows:

Prof. Toshio TABUCHI*: Land Reclamation, Conservation, and Rural Engineering
Prof. Hiroyasu SHIMURA: Agricultural Water Engineering
Prof. Masashi NAKANO**: Soil Physics and Soil Hydrology
Prof. Tadashi TAKAKURA: Environmental Engineering
Prof. Osamu KITANI: Farm Power, Energy and Machinery
Prof. Hiroshi MORISHIMA: Postharvest Technology
*Head of the Department,
**Chairman of the Graduate course

Address: Department of Agricultural Engineering
Faculty of Agriculture
The University of Tokyo
Yayoi 1-1-1, Bunkyo-ku, Tokyo 113, Japan ■■

Agricultural Mechanization Program at the Tokyo University of Agriculture and Technology

by
Jyunichi Yonemura
Professor Emeritus,
Tokyo University of Agriculture and Technology
3-5-8, Saiwai-cho, Fuchu City,
183 Japan

Introduction

The Fuchu campus of the Tokyo University of Agriculture and Technology, a.k.a. Tokyo Noko University in Tokyo, is located some 25 km west of Tokyo. It is conveniently accessible from Tokyo via the J.R. Line train system for about an hour's ride. This campus houses the Agriculture Faculty whereas the Technology Faculty is housed on another campus at Koganei.

The Fuchu campus which is the focus of the present paper, is surrounded by residential areas. The shady trees and the experimental farms on the campus provide an ideal atmosphere for learning.

The discussion that follows briefly reviews the Faculty of Agriculture and foreign students in the University with agricultural mechanization being the main focus.

The University at a Glance

The Tokyo University of Agriculture and Technology was established in 1949 as one of the national universities. Under the National School Establishment Law of Japan, the Tokyo College of Agriculture and Forestry and the Tokyo Textile College were merged into a Tokyo University of Agriculture and Technology after many changes in the name and the university system.

The origin of the two colleges that gave birth to the University can be traced back to the Meiji Era, the forerunners of which were chartered by the Japanese Ministry of Home Affairs in 1872.

In 1985 the doctoral degree in agricultural science under the United Graduate School was established through the cooperation three agriculture faculties of Ibaraki University, Utsunomiya University and the Tokyo University of Agriculture and Technology.

One of the educational aims of the University is not only to breathe into the minds of its students the technical skills in agriculture and technology but also to prepare and encourage them to play active parts in their specialization or expertise anywhere in the world that they find themselves in after they leave the portals of the university.

As of May 11, 1991, the University had a total of 701 teaching and administrative staff, including the President. There were 165 professors, 15 associate professors, 3 assistant professors, 105 research associates and 276 administrative staff.

During the same date (May 1, 1991), there were 5,111 students enrolled and about 5 percent of which (254) were students from foreign countries. The undergraduate students numbered 4,169 (791 of which were foreign students); 864 graduate students (145 of which were foreign students); and 78 research/special students (30 which were foreign students).

The Faculty of Agriculture

When the University was established in 1949, it started with three departments under the Faculty of Agriculture, namely: Agriculture, Forestry and Veterinary Medicine. But as science and technology developed, the three departments were reorganized into six, namely: Agricultural Chemistry, Agricultural Engineering, Sericulture, Plant Protection, Forest Products and Environmental Science and Conservation with a total of 51 chairs. The graduate degrees such as master and doctor courses were established in 1965 and 1985, respectively.

By 1990, the Faculty of Agriculture was reorganized again into four main departments with a total of 62 chairs: Agricultural Production, Applied Biological Science, Environmental Science and Natural Resources and Veterinary Medicine. The purposes of the reorganization were: i) to strengthen and reinforce the basic sciences in order to be responsive to the needs of advances in biotechnology, environmental science and information science; and ii) to create a new outlook in education and research systems. In addition, the enrichment of the curricula was an effort to meet the demands of foreign students, particularly the graduate students, whose numbers keep increasing each year.

Agricultural Machinery

The discipline of Agricultural Machinery is composed of two chairs, namely: Farm Machinery and Agricultural Processing and Farm Tractor and Farm Power. These two chairs were originally organized with the Department of Agricultural Engineering with three other chairs, namely: Irrigation and Drainage, Agricultural Land Engineering, and Agricultural Structure Engineering until the year 1989. The Department of Agricultural Machinery of the University is well known, particularly in the field of transplanting machinery and soils and safety in farm work operations.

Research which leads to social needs such as quality improvement of agricultural products and the prevention of vibration and noise from the farm machineries has been promoted in recent years.

Because of the high reputation that the agricultural machinery discipline enjoys world-wide, foreign students are attracted to come to the University.

The latest change in the University has been the renaming of the Faculty of Agriculture into Environmental Control and Farm Machinery and System Engineering of Environment without changing the number of chairs and staff.

In order to correspond to such change, emphasis is now placed on: i) Practical Use and Conservation of Water Resources; ii) Area Plan for Better Habitation and Better Living Conditions; and iii) Safe and Efficient Use of Automation and Systems.

Thus the Department of Agricultural Engineering now belongs to the Environmental Engineering Course of the Department of Environment and Resources.

The Chair of Agricultural Machinery and Mechanization

In view of the recent changes in the Faculty of Agriculture, a redirection in research undertaking at the University now is facing the promotion of new research project on the following subjects:

1. Minimizing Vibration and Noise of Agricultural Machines
2. Development of Information Systems for Agricultural Products
3. Development of Efficient-Use for Agricultural Products
4. Development of Man-Machinery System for Agricultural Products
5. Development of Harm Prevention for Animals

The Chair of Environment Control and Farm Machinery

This is a new chair that replaced recently the earlier chair on Agricultural Implements with the aim of covering a wider scope of study. The present emphases on research for this chair focus on:

1. Tiller/cultivator and soil as a fundamental factor in production and environment;
2. Automatic transplanting devices for vegetable seedlings

Fig. 1 .Fuchu campus aerial view.

and necessary nursery apparatus;
3. Environmental control for fresh products in the process of storage and transport;
4. Hydroponics in combination with aquaculture; and
5. Management system for wasted food and utilization of livestock excrement.

International Exchange Program

The University has a long history of international exchange activities with foreign institutions of higher learning. At the present time, seven sister universities have exisiting ties with the Tokyo University of Agriculture and Technology as follows:

1. Ahen University, Germany
2. Paulista University, Brazil
3. Shanghia University of Machinery, People's Republic of China
4. Sekko University of Agriculture, People's Republic of China
5. Beijing University of Technology, People's Republic of China
6. Nanking University of Forestry, People's Republic of China
7. Chulalongkorn University, Thailand

Proof of the on-going relationship with foreign universities, foreign students continue to be attracted to the University as a result of which an International Exchange Hall, including a dormitory on the campus has been constructed recently. Also, a strong advisory system has been introduced lately on the campus in an effort to help foreign students in obtaining a good orientation as they enroll.

Foreign Students

As mentioned earlier, there were 254 foreign students enrolled in the University as of May 1, 1991 representing 25 countries. **Fig. 3** shows the breakdown of these students as follows: People's Republic of China, 117; Republic of Korea, 31; Republic of China, 26; Indonesia, 22; Malaysia, 11; Thailand, 6; Mongolia, 4; Iran, 3; and other countries, 13.

The Faculty of Technology seems to attract more foreign students as it had 268 of them in May compared with 86 at the Faculty of Agriculture. In the latter, however, the majority are in the graduate school.

In terms of financial background, 58 of these students receive scholarship grants from the Japanese government; 77 of them finance their own studies. A few of these foreign students stay with their families who are expatriates in Japan.

A breakdown of the foreign students at the Faculty of Agriculture as of May 1, 1991 is shown in **Table 1**.

Table 1 Distribution of Foreign Students, Faculty of Agriculture (Unit: number)

Classification	Scholar*	Scholar**	Own Pay
Researcher	3	—	7
Undergraduate	2	1	11
Masteral degree	10	4	12
Doctoral degree	18	5	13
Total	33	10	43

* Japanese government grant.
** Grants from other sources.

Of the 12 foreign graduate students in the field of Agricultural Machinery, 8 are doing their masteral degrees and come from the Republic of China, Republic of Korea, Indonesia, Bulgaria, Vietnam, Nigeria and Thailand. On the other hand, the 4 doing their doctoral degrees come from the Republic of China, Republic of Korea and Iran. ■■

Introduction to Department of Bioproduction and Machinery, Mie University

by
Makoto Hoki
Professor
Department of Bioproduction and Machinery
Faculty of Bioresources, Mie University
1515, Kamihama-cho, Tsu
514 Japan

Introduction

Mie University is one of the national universities financially supported by the Government of Japan. The university campus is situated in Tsu City located 50km Southwest of Nagoya. It is convenient place to reach in 50 minutes by the Kintetsu Railways from Nagoya.

The Department of Bioproduction and Machinery is one of the six departments under the Faculty of Bioresources. The Faculty of Bioresources, named newly in 1987, is based upon the former two traditional Faculties of Agriculture and Fishery. Thus the new Faculty of Bioresources has actually more than 70 years of tradition in its academic and professional activities.

Department of Bioproduction and Machinery

The Department of Bioproduction and Machinery was formerly known as the Department of Agricultural Machinery. Recent advancement of biotechnologies and electronics has been producing notable changes on production, processing and energy in bioproduction systems.

The Department of Bioproduction and Machinery is designed to deal with this new field to meet the future requirements for bioproduc tion and environmental systems. The emphasis of the department's research programs is on high engineering technologies to be applied in the areas of bioresources, environment and energy.

Research Fields

The research fields in the department consist of the following five laboratories.

Laboratory of Agriculture and Fishery Machinery

Research topics:

i. Fundamental research on a plate movement and soil reaction
ii. Model analysis of machine frames
iii. Vibration analysis and protection
iv. Position controls of hillside tractor
v. Soil-machine interface for terrain vehicles.

Laboratory of Power and Energy

Research topics:

i. Dynamic balancing of coupled behicle
ii. Electro-magnetic seeding
iii. Quality evaluation of agricultural produts
iv. Harvesting and processing of high moisture rice
v. Environmental study for grain storage
vi. Steering conrol of transplanter.

Laboratory of Processing Machinery

Research topics:

i. Grain drying by solar energy
ii. Development of plant factory
iii. Testing quality of rice
iv. Heat and mass transfer of agricultural materials
v. Color studies of agricultural materials.

Laboratory of Systems Control

Research topics:

i. Biomass gasification system for small power plant
ii. Study of PTO driven disk tiller
iii. Appropriate technologies in the developing countries
iv. Algae production and control systems
v. Study of 4 wheel drive and steering controls
vi. Tractor control by voice recognition under noise.

Laboratory of Biological Information Engineering

Research topics:

i. Quality evaluation of food products
ii. Study of coffee extraction
iii. Thermal properties of food
iv. Non-contacting measurement of plant growth
v. Electric potential of plant surface
vi. Measuring system for transpiration and photosynthesis of plant leaves

Each laboratory consists of 2-3 professors of particular expertise.

Bioproduction System Research Institute

The institute, formerly called the Institute of Tractor Research and Testing, is located 9 km Northwest of the Mie University main campus and consists a part of the Mie University Experiment Station.

The facilities include power and machinery shops and electric dynamometer for various power measurements. Grass covered courses with specific slopes for testing hillside tractors and equipments are available in addition to a standard concrete testing course. Solar drying facilities and a sawdust gasifier for small power plant are also located in the Institute. Also quiet and remote environment allows to conduct specific studies for noise analysis, voice recognition and related subjects of human safety.

The Institute is operated by the faculty of the Department of Bioproduction and Machinery jointly with the staff of the experiment station. The other research and field testings occasionally conducted include studies of direct seeding of coated rice seeds, studies of tractor axial loads during front-loader operations, studies of tire properties related to side slippage and tractor position sensing.

The research activities in the institute together with the department research summaries are covered in the Annual Report of Bioproduction System Research Institute and available upon request.

Academic Programs

The Faculty of Bioresources provides programs leading to the degrees of Bachelor of Science, Master of Science and Doctor of Philosophy.

Undergraduate Programs

Mie University is operated on the system of two semesters per year. One semester consists of about 15 weeks. Four years are required to complete the undergraduate courses.

The main courses provided by the department are: applied mathematics; applied physics; applied mechanics; numerical analysis; farm machinery; process engineering; power machinery; systems control; biological measurement engineering; machine design and drawing; computer programming; technical English; energy utilization; processing machinery; physical properties of agricultural materials; material science; introduction to electrical engineering; applied electronics and machinery; information engineering; transport phenomena; behicle engineering; agricultural mechanization.

Student Laboratory for Bioproduction Machinery is required for the all students. This laboratory course is offered once a week for two semesters. Each laboratory provide a specific experimental theme as follows:

i. Soil compaction measurements
ii. Automatic measurements of temperature
iii. Shearing tests of soil
iv. Ultrasonic measurements of solid materials
v. Tensile and compression tests of metals
vi. Measurements of thermal properties
vii. Drying of rough rice
viii. Force measurements by strain gage
ix. Tractor noise measurements
x. Profile analysis by image processing

Students are required to collect, process and analyze the data to prepare a short weekly report for each laboratory.

Students Practice for Bioproduction Machinery is also required for the all students. The 12 specific practice courses are provided for exposing students to current high technologies for instrumentation and data acquisition systems as well as machinery operation and shop practices. The student practices are offered once a week for two semesters with the specific themes listed below:

i. Basic computer graphics
ii. Machining practices
iii. Operation of measuring instruments
iv. Welding practices
v. Basic computer simulation
vi. Tractor driving practices
vii. Data processing by computer
viii. Construction of electronic circuit
ix. Basic handling of agricultural products
x. Instrumentation for thermal measurements
xi. Measurements and processing of time series data
xii. Tractor tillage practices

The student practice courses are conducted mostly using the departmental facilities on campus and the Bioproduction System Research Institute in the experiment station of Mie University.

Graduate Programs

Graduate study leading to Master's and Doctoral degrees in the Bioproduction and Machinery provides the discipline for advanced studies and research in an engineering field related to the biological materials, energy and environment.

The following courses are offered:

Advanced Agricultural and Fishery Machinery

Advanced Material Science for Machinery

Seminar in Agricultural Machinery

Advanced Process Engineering

Advanced Thermal Engineering

Seminar in Process Engineering

Advanced Power Machinery

Advanced Energy Utilization

Seminar in Power and Energy

Advanced Systems Control

Applied Control Engineering

Seminar in Systems Control

Advanced Biological Measurements

Advanced Physical Properties

Seminar in Biological Information Engineering

Advanced Research in Bioproduction Machinery

Advanced Process Engineering for Biological Materials

Advanced Engineering for Applied Energy

Advanced Measurement for Biological Masses

For an admission to the Masters of Science programs, a Bachelor of Science degree is required in the equivalent undergraduate fields. A Master of Science degree is required for consideration for admission to the Doctoral program.

The candidate must conduct original research on a problem in a specific engineering field and prepare a dissertation of acceptable quality and a publishable technical article.

Overseas Students

The number of overseas students is increasing at the Mie University in any area. Those who want to enroll to the Mie University are advised to obtain the scholarship from the either their own Government, from Monbusho of Japanese Government or from any funding agency before submitting official application form. It is also strongly recommended to have a good command of spoken Japanese before entering the university.

International Programs

Exchange Program

Mie University has various international programs. Official exchange agreements were made with Michigan State University in 1983, Jiangsu Institute of Technology (China) in 1986 and Chiang Mai Univerrsity (Thailand) in 1988. Various levels of student and faculty exchange have been in progress between these universities.

Joint Research Project

The Department of Bioproduction and Machinery carries international research projects of specific areas in cooperation with the other related department of Mie University. These research projects have been implemented with selected academic institutions and univesities in overseas.

With the Department of Agricultural Engineering of the Michigan State University, U.S.A., a study of PTO driven disk tiller was conducted during 1983-1989 under the sponsorship of Toyosha Company, Osaka.

A field study on the conventional farm tools and the evolution of farming systems in Southeast Asia was conducted jointly with the universities in some Asian countries. This was under the scientific research founds of Japanese Ministry of Education, Science and Culture. The cooperating universities were Kasetsart University, Chulalongkorn University, Khon Kaen University, Chiang University in Thailand, Agricultural University of Malaysia and Bogor University in Indonesia. This five year project was completed in 1989.

A new joint research on farming systems and its development in Southeast Asia is to start in 1992 under the scientific research funds of Japanese Ministry of Education, Science and Culture. Chiang Mai University, Majo Institute of Agriculture, University of Rangsit, Chulalongkorn University and the Asian Institute of Technology will be the cooperating institutes for this 3 year project. ■■

— from a controlled economy to a free market economy —

The Agricultural Machinery Industry after World War II in Japan

by
Jun Sakai
Professor
Department of Agricultural Engineering
Kyushu University
Hakozaki, Higashi-ku, Fukuoka
812 Japan

Abstract

Many agricultural machinery factories in Japan were destroyed during World War II, and had to be reconstructed after the war. Moreover, one of the major problems in Japan after the war was how to shift from the "controlled economy" under the militaristic government in wartime to "free market economy" under the democratic government after the war. This paper describes the kinds of confusion and problems prevalent in the society and the agricultural machinery industry after the war, how the government tried to resolve them by what kinds of political decisions, how the production, sales and post-sales service networks of a free market economy were established through the transitional control system after the war and what was done in the 1950s and the 1960s to achieve further development in the 1970s and the 1980s.

There were many dramatic events, and the author summarized them, most of which were told and edited by the late President Yoshikuni Kishida of Shin-norinsha Co., Ltd. in his books.[1,2,3]

Concept of Agricultural Mechanization after the War[9,10,11]

In Japan, a shift from human and animal powered agriculture to mechanized agriculture commenced around 1955 about ten years after World War II. Hence, Japan's agriculture has been mechanized only within the last thirty five years since 1955 as shown in **Fig. 1**.

These years can be divided into three terms. The first ten years from 1945 to 1955 were spent for the reconstruction of agriculture and the farm machinery industry. In this term, "agricultural land reformation" as a national project was completely implemented, resulting in the disappearance of farm tenants in Japan. All farmers became landed farmers, and the farming was done mainly by human and animal power on small family farms.

Meantime, the problem on the farm machinery industry was how to shift from the controlled system under the militaristic government in wartime to the democratic free market one under the government after the war. The old system was dissolved and new manufacturing and sales systems suitable to Japanese agriculture were established within several years.

The next fifteen years from 1955 to 1970 constitute the term of initial farm mechanization mainly with walking tractors and power threshers. Because of a nationwide diffusion of walking tractors in this term, draft cattles were replaced by milk and beef ones, and the use of animal power ceased completely within fifteen years. This has not happened in any other country in the world. However, the transplantation and harvest of paddy rice were still done by manual operation. For

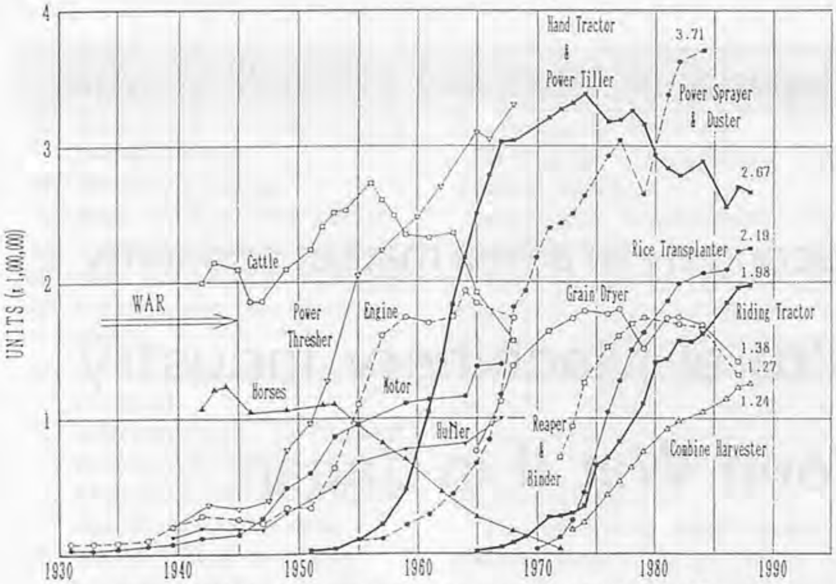


Fig. 1 Diffusion trends of major farm machinery in Japan.[11]

the farm machinery industry it was the age for a modern mechanical industry of mass production to supersede conventional technology.

The twenty years from 1970 to 1990 constitute the term of diffusion of riding tractors, paddy transplanters and combine harvesters. Japanese agriculture was fully mechanized by developing a variety of farm machinery.

The amazing development of agricultural machinery and diffusion of farm mechanization in Japan was realized through a miraculous development of the agricultural machinery industry.

The first step leading to the success of such a miraculous development, from 1955 to the 1980s, of agricultural machinery and mechanization suitable to Japanese paddy field conditions consisting of small family farms, was taken in 1945, just after the end of World War II as follows:

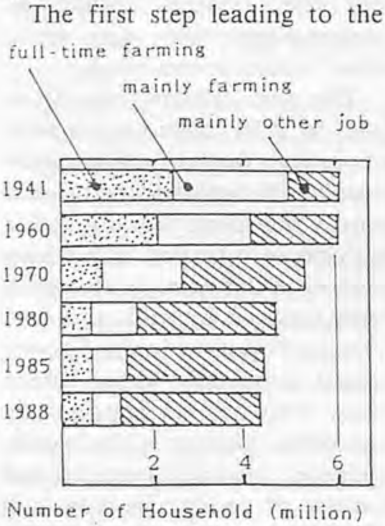


Fig. 2 Total number of family farms.[11]

Farming and the Farm Machinery Industry just after the War

When the war came to an end, the Japanese nation was faced with many serious problems. All industries, main cities and towns had been destroyed by bombing attacks, and two million soldiers and seven million Japanese refugees started to arrive back home from many Asian countries. Japan's total population in 1945 was about 72 million. There were 6 million small family farms as shown in **Fig. 2**, and about 40% of the total economically active population were farmers as shown in **Fig. 3**.

The most important matter for the Japanese, in confusion after the end of the war, was to eat and to produce food. On the other hand, there was an extremely short supply of farm tools and machines to use for their agriculture and gardening.

General agricultural field works in Japan at that time, the 1940s, were performed by human and animal power without tractors. The main farm tools, equipment and machinery at that time were only hoes, shovels, animal plows and saddles, manual paddy weeders, hand sprayers, sickles, carts, grain threshers, grain hullers, rice polishers, grain mills, straw-rope and straw-mat making machines, small farm engines, electric motors and so forth.

Thus, there were only several big factories producing agricultural machinery such as paddy grain threshers and processing machinery lead by Iseki company, etc., plows and other field equipments by Matsuyama, Takakita and Toyosha company, etc. and farm engines by Kubota and Yanmar company, etc.

All factories and industries producing tools or machinery were under the strict control of the

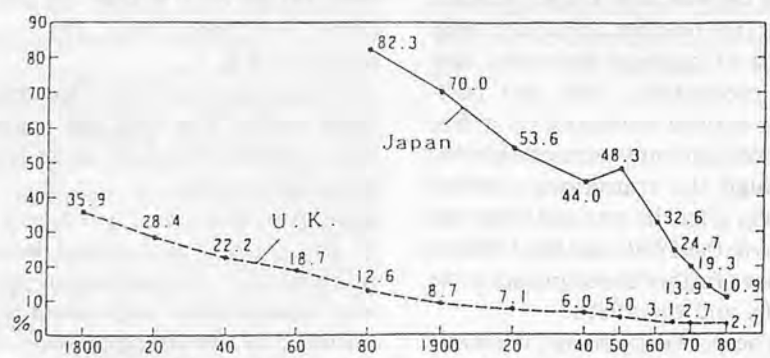


Fig. 3 Percent of farmers' population to economically active population.[11]

militaristic government during the war. Many farm machinery manufacturers had to join some munitions industry. At the end of World War II, Japan had a serious problem of the lack of farm products because of the shortage of chemicals, fertilizer and farm implements. For example in April, 1945, although the government ordered the farm machinery factories to produce 350,000 manual hoes within a year, they could not achieve it because of the lack of raw materials supplied by the government.

When the war was over, the traditional farm machinery industry had to be reconstructed under many difficult conditions. These were lack of raw materials, lack of funds to invest, extremely high rate of economic inflation and the competition among companies which participated from machine industries and began to produce many kinds of farm machines and implements of very poor quality and performance as follows:

Lack of Fund

It is considered that the historical experience of Iseki company, one of the leading farm machinery companies in Japan, especially in the fields of power grain threshers, will show the typical trend of the farm machinery industry after the war.

For example[4], Iseki company, lost all their factories in a bombing attack on Matsuyama City on the 26th of July, 1945, only nineteen days before the end of the war. They had to start again from the beginning. The first thing they had to do was to buy back their products, disassemble them and use them to prepare again drawings of all parts. In the meantime, 150 employees had to find and repair machine tools that survived the bombing attack, and completed their transfer into a rented factory of 717 m^2 floor area in September 1945. They began to temporarily produce hoes, cooking pans, hand mills, stoves and so forth. They also continuously worked to build a wooden factory of 778 m^2 floor area for iron casting, which they completed in January 1946.

At that time, the company had only a little cash and an insurance against war damage of 3,000,000 yen. When the company approached several banks for financial support by offering the insurance as security, the new Japan government declared that the insurance had became void.

However, the managing director of Iseki asked special assistance of the president of a local bank, Shikoku Bank who knew them well. The bank's president decided to loan 500,000 yen to Iseki. Another bank, Kangyo Bank, also approved a loan of 1,000,000 yen to the company in August 1946. Iseki was then abie to start to build a real factory of 4 774 m^2 floor space. At that time, the official retail price of polished rice was 2,000 yen/ton, and the official dollar exchange rate had not been decided yet.

Easy Participation of Other Mechanical Industries

Many factories in other machine industries, mostly those which had been part of the munitions industry in wartime, had to shift into a peacetime industry after the war. To be a manufacturer of farm machinery was thought to be one of the most promising fields in the peacetime industry after the war. It so happened that about 60% of the total number of former munitions factories tried to produce farm machinery without any professional knowledge or technical know-how on farm machinery, or any philosophy about agriculture.

Tens of factories each with more than 100 mechanics suddenly appeared to produce farm tools, equipment and machines within one year, though there had been only five to six factories on this scale producing such products before the war. Problems and confusion in the conventional production and distribution networks of farm machinery were brought about by these new participants, who were effectively invaders from another ministry into the Ministry of Agriculture and Forestry.

In general, the machine industry had been under the control of the Ministry of Munitions in wartime. After the war the Ministry of Munitions was discontinued, and the Ministry of Commerce and Industry, MCI, took over the control of the machine industry in Japan. The agricultural machinery industry, however, was basically and traditionally under the control of the Ministry of Agriculture and Forestry in wartime. It may have been thought that the MCI could not understand the agricultural sector and it would be difficult for them to manage perfect distribution, sales and post-sale-service of agricultural machinery to the farmers.

In wartime, the Ministry of Agriculture and Forestry controlled the supply of raw materials and production in the farm machinery industry and the distribution of products to farmers through a regulatory governmental agency, i.e., the Control Agency of Farm Machinery under the ministry.

This system had to be changed to a democratic one after the war, while there was the problem of rapidly increasing number of factories producing farm machinery outside the traditional agricultural machinery inudstry as follows.

Shift from Militaristic Controlled Economy to Democratic Economy

When the war came to an end, there were no commercial sales networks of a free market economy. The Ministry of Agriculture and Forestry started to control the agricultural machinery industry along with MCI. The government may have thought that it would be quite difficult to shift so suddenly and perfectly to a free economy system, and it would be better to have a transitional period of controlling in a democratic way by means of the cooperatives.

The Ministry of Agriculture and Forestry requested National Association of Agriculture, NAA, to take over the distribution of farm machinery to farmers. They was to be the central organization of the agricultural cooperatives in Japan later on. In the meantime, manufacturers organized the Control Cooperative of Farm Machinery Industry, CCFMI, and the control agency in wartime winded up.

NAA would estimate the total demand of the agriculture cooperatives all over Japan and give CCFMI an order of the necessary number of units of farm machinery. CCFMI took care of all production. The manufacturers had to prepare raw materials by themselves. NAA paid them according to their production reports, and took care of all distribution. This system started in 1946, and became an advance payment system which the factories took advantage of and used to solve their serious funding problems, because NAA collected the money by distributing the agricultural machinery to farmers through agriculture cooperatives, and paid the money to the factories only depending upon the report of the production schedule sent by the factory which had NAA's order.

The shipment of goods from the factory had to be directed to NAA, and NAA undertook to distribute the goods to the farmer through the office of the agricultural cooperatives in every prefecture. The retail prices of major farm machinery were decided by the government as an official prices to the farmer.

All manufacturers of farm machinery had to register their names and to give information about the goods they produced to CCFMI. In 1946, the total number of registered factories had reached about 4,500, of which 965 were factories for grain threshers, 450 for paddy hullers, 550 for rice mills and so forth. However most manufacturers from other machine industries were destined to disappear within several years, which effectively caused traditional farm machinery manufacturers to gain confidence as follows:

Painful Experience

Most of the goods produced by the former munition factories were of extremely poor quality and low performance. They copied only the shape and outside view of things. Though they asked technical questions even to farmers or cooperatives, they could not obtain professional answers on technical know-how. They expected the agricultural experiment stations under the government or in every prefecture to advise them, but most officers could not give correct answers but made only the operation tests on the farm tools and equipments. Most factories continued producing very poor products.

Many farm tools, equipment and machines came to be sold on the black market, because the prices of the goods on the black market were sometimes much higher than the official prices of similar goods. Many urban people in hunger wanted to buy farm tools for their gardening to produce farm produce, and directly visited farmers to buy any food from them, even by the barter system.

The farmers were duty-bound to sell their delivery quota of clean rice to the government. All Japanese had to buy the rice by recording the stamp in their riceration books. However, many farmers came to earn money by selling rice and other farm products on the black market or through black marketeers, and became rich enough to buy farm tools or machines on the black market and not from the NAA network. Although the merchants and people in the black market were sometimes arrested, and their grains were confiscated by the police, black marketeering became usual all over Japan. Actually an honest judge in Nagoya city who had decided never to eat any food from the black market was starved to death.

NAA adopted an advance payment system to the factories which had submitted their manufacturing schedule. However, this system became a source of trouble because of the terrible economic inflation, about 500% in 1946, about 300 to 400% in 1947, and about 250% in 1948 as shown in **Table 1**. The money supply from

Table 1 Infration after the War

	General wholesale price index	Retail price of rice (yen/10 kg)
1942	1.9	3.32
1943	2.0	3.32
1944	2.3	3.32
1945	3.5	6.00
1946	16.3	36.35
1947	48.2	149.60
1948	127.9	357.00
1949	208.8	405.00
1950	246.8	445.00
1951	342.5	620.00
1952	349.2	620.00
1953	351.6	680.00
1954	349.2	765.00
1955	343.0	765.00

(by Japan government)

the central bank was 55.4 billion yen in 1945, 93.3 billion yen in 1946 and 219.1 billion yen in 1947.

Even if the factories tried to buy the raw materials necessary to manufacture a machine after receiving the money from NAA, enough of the material to make the machine could not be bought. In fact, when the goods were produced in a factory, the prices of the goods became so high that they could not be sold at the equivalent of the money already paid by NAA. Thus the manufacturers prefered to sell their products not to NAA at the official price, but directly to farmers or consumers at a much higher price, or even sold the raw materials to black markets.

NAA had paid the money in advance, but could not get enough units of farm machinery to distribute to the farmers. When the total deficit of the goods in stock on the books exceeded 300 million yen, NAA tried to stop the payment to such factories. The surprised manufacturers then requested NAA and the government to pay the price at shipment.

An attempt to solve this problem was made by setting up a special session on farm machinery in the "assessment committee of official prices" in the government, enforced in August 1947, and by properly raising the official price at certain times in a year. The rationing system managed by NAA under the Ministry of Agriculture and Forestry was utilized to give priority of farm machinery distribution to the farmer who had delivered his quota of rice grain to the government.

Rivival of the Commercial Community

Free sales networks of the commercial community had been completely dissolved during wartime, and though only the leading staff among them had been absorbed into the Control Agency of Farm Machine and Equipment under the government, some of the employees had become post-sales service men in the control agency. After the war, the control agency was dissolved, and manufacturers organized a control organization, the Control Cooperative of Farm Machinery Industry, CCFMI, as mentioned above.

When CCFMI and NAA established control management of the production and distribution of farm machinery to farmers after the war, illegal black markets appeared. The original commercial community desired to carry on their free activities not in the black market but in the legal open market outside the rationing system of the cooperatives. Farm machinery manufacturers had also begun to contact the commercial community in an attempt to establish commercial networks of free market economy which would cover the nation.

In January 1947, the commercial community organized the Japan Association of Agricultural Machinery Commerce, JAAMC, and requested government to recognize their free commercial activities for the following reasons:

1 The rationing system managed by only cooperatives under National Association of Agriculture was always behind time in distributing machines.
2 Agricultural machinery appropriate to local conditions is not always distributed.
3 The system provided very poor post-sales service to the farmer.
4 The system could not control the quality and performance of the machinery.
5 Controlled system became a cause of appearing the black market.
6 The prices of some machines were higher than those of the same kind on the black market and so forth.

The government approved their activities as follows:

New Competition System

At that time in 1946 to 1947, the nation was suffering a galloping inflation under the government led by the liberal party, and many labor conflicts stemming from request for higher wage and enough food were occurred all over Japan. As a result, in 1947, the nation elected the Katayama government led by the socialist party.

The Ministry of Agriculture and Forestry wanted to retain the controlled system in distributing all the agricultural machinery, and in December 1947, a new policy was adopted to recognize both the controlled system by NAA and the free dealers' system by the commercial community.

Namely, it is important to note that a new competing function between the cooperative system of rather democratic socialism, and the commercial system of democratic liberalism was established in Japan.

Forty-five of sixty-eight kinds of agricultural machines and equipment became free for sell at official prices. Any group which wanted to deal in agricultural machinery was requested to register in order to be officially recognized. Prefectural cooperatives of agriculture and dealer's associations were registered as wholesale dealers, and commercial people and cooperatives in cities, towns and villages as retail dealers. The ministry issued coupons for purchasing agricultural machinery to both systems depending on their demands, in order to keep controlling the distribution of all agricultural machinery.

This policy was very effective to realize and systematize a new dealers' network of commercial people as a transition structure in the transition period from wartime controlled economy to future free market economy. Moreover to farmers all over Japan, it was very effective to realize better diffusion networks for farm machinery and mechanization with active sales and post-sale service, because the controlled economy of the cooperative system and the free market economy of the commercial system have come to learn each other's good points as well as compete since then.

Each manufacturer made an effort to systematize the sales network consisting of a sole agent and retailer, who were commercial people, for only their brand. It is important to note that this can only be achieved successfully by the trust of commercial people on the product in the free market.

For example, an incredible event happened in December 1948:[4)] the group of special agents of Iseki products prepared about 20 million yen by themselves, and four representatives of the group, handing the money to President Iseki in advance of stocking the products, asked him only to increase the production. The president and Iseki people were deeply impressed by this trust in Iseki products, and swore to work more for agents and farmers.

Competition in the Agricultural Machinery Industry

When the assignment of farm machinery coupons by the government to the cooperatives' and dealers' systems started, new trouble occurred: they accepted 100% of the coupons for tools and machines produced by traditionally famous manufacturers, but refused about 90% of the coupons for the products of manufacturers from wartime machine or munition industries.

The reason was that in 1947 the production of farm machinery by too many factories had already caused a demand-supply gap. There was over-supply of products even on black markets, and the price of poor goods could not be high. The farmer began to purchase only reliable tools, equipment and machines.

Moreover in 1949, the government changed from the cabinet of the socialist party to that of the liberal party. The government had a resolute determination to apply a retrenchment policy with balanced budget, readjustment of subsidies, tax collection enhancement, etc., in order to solve a serious problem of inflation. Japan stepped quickly into a deflated economy, and fell into the first depression after the war.

In a declining economy, the level of capital investment stays low, and the purchasing power of consumers also stays low. Thus, the readjustment or reduction of most companies and the bankruptcy of small- and medium-sized businesses were widely witnessed mainly because of money stringency, and the increasing number of jobless people and labor disputes in an uproar were big social problems. The farmers' demand for agricultural machinery declined also, and most farm machinery companies began to have difficulties because of tight money.

Between 1947 to 1950, competition in the selection of only excellent manufacturers in technology and management occurred in the Japanese farm machinery industry under difficult social conditions. Most manufacturers who had participated easily from other machine industries disappeared quickly between 1946 to 1949, and the total number of factories which had more than 10 factory workers producing farm machinery decreased between 1949 to 1950 as follows:

June 1949:	1 150
Jan. 1950:	795
June 1950:	641

The total number of employees in the agricultural machinery industry decreased also as follows:

June 1949:	43,000
Jan. 1950:	32,000
May 1950:	25,000

In April, the dollar exchange rate was determined to be 360 yen/$. The total production in million yen (million $) of the agricultural machinery industry was as follows:

June 1949:	1,185 (3.29)
Aug. 1949:	1,094 (3.04)
Oct. 1949:	1,247 (3.46)
Dec. 1949:	898 (2.49)
Feb. 1950:	682 (1.89)
April 1950:	638 (1.77)
June 1950:	536 (1.49)

The agricultural machinery industry was still very small and weak in Japan. For example[4)], when Iseki company was successfully progressing around 1948, Mitsubishi company, one of the biggest munition enterprises in wartime, already had difficulty in managing their Kumamoto factory which was producing manual pedal-threshers and power threshers, and asked Iseki company to buy it. The total price was 58.95 million yen ($160,000) for the land of 271,729 m^2 with a factory and an office building of 16,982 m^2, company houses and apartments of 15,635 m^2 including about 200 employees. Iseki bought all of them from Mitsubishi in September 1949, and had to pay 10 million yen within one year and the rest within three years by 1/3 installments each year. The production in the factory began smoothly, when the government applied a deflation policy.

In 1950, a sharp depression started all over Japan, and Iseki came to have a large stock of goods, a delay in the payment of salary in February, a discontinuance of payment of traffic allowance in April, and finally started to discuss a 50% reduction of employees with the employees' union in May. Many of the staff began to believe that the Matsumoto factory would become bankrupt, if the Kumamoto factory was not closed. Three hundred and fourteen of the 986 employees were laid off from the factories.

In the Kumamoto factory, all employees were filled with so much tension because the factory could not pay the increased tax, delayed paying their salaries, and there was a rumor that the factory might be closed. The head of the factory announced that it was a trial by God and that they should do their best at work. All employees agreed to do so, and continued to work hard without any complaint. President Iseki could not declare the closing of the factory, struck by the attitude of the workers under such a difficult circumstance. He announced that he would put off closing the factory until November, if a solution could not be found.

In June 1950, the Korean War broke out, and the economic panic of deflation disappeared quickly from Japan owing to the special procurement of the U.S. army. The Kumamoto factory did not need to be closed, because of the promotion of sales.

Moreover, the government lifted the price control of farm machinery in April and the rationing control of them as well in June, 1950, in order to start a perfect free-sales and competition system. It can be said that the agricultural machinery industry overcame the age of confusion after the war, and stepped into the age of preparing the shift from animal-powered farming to mechanized farming in the later half of the 1950s.

Contribution of Other Machine Industry

The engineers in the agricultural machinery industry must create better mechanisms and performance of the machinery with special ideas and technical know-how in order to be accepted by farmers. They should also create the machines which are durable to the farmer's rough operation and maintenance. Therefore, they should understand farmers, technical and historical trends of their local agriculture and the necessary farming work in each season, soil and plant properties, and so on.

Most companies which participated from other mechanical industries after the war did not have such engineers, and failed to produce farm machinery competitive with traditional agricultural machinery companies, though they could produce excellent weapons of much higher technology in wartime.

However, they had remarkable impact on and contribution to the agricultural machinery industry. These were as follows:

From a historical viewpoint, there were some traditional manufacturers of farm engines. The two typical ones were Kubota company producing kerosene engines, and Yanmar company producing diesel engines. They were producing water-cooled low-speed engines of a horizontal single-cylinder design in the 1940s. Engine speed was several hundred rpm.

In 1947, Mitsubishi company, aircraft engine manufacturer in wartime, started to produce farm engines. This was a high speed air-cooled kerosene engine, which had a great influence on the traditional manufacturers who had been producing only slow-speed water-cooled kerosene engines. The air-cooled engine is much lighter than the water-cooled one. Technical competition in developing a lighter farm engine of higher rotational speed started in Japan.

In 1948 to 1950, Mitsubishi and Kubota companies developed medium speed water-cooled kerosene engines. Several other manufacturers who could not develop medium speed ones gradually disappeared from the market. Yanmar diesel engines had to also compete with Kubota kerosene engines, and between 1950 to 1952 developed the smallest high-speed diesel engine in the world, of only 1.5 to 2 horsepower.

On the other hand, Mitsubishi air-cooled farm engines of both kerosene and gasoline influenced other manufacturers of air-cooled engines. Shibaura engine appeared in 1950, Honda engine in 1954 and Kawasaki engine in 1955 on the market, and this current became an effective cause of the rapid development and diffusion of many kinds of walking tractors in the 1950s to the 1960s as shown in **Fig. 1**.

Walking Tractors and Marketing Competition for Dealer Network[4)~8)]

The development of many farm engines resulted in the increase of competition among engine manufacturers, and traditional farm engine manufacturers had to strengthen their relations with their dealers' network. Moreover, Kubota and Mitsubishi began to produce walking tractors, and their special dealer network came to have exclusive characters compared to other power tiller manufacturers. This was the start of the marketing competition among manufacturers to establish modern sales and service networks in the 1950s to the 1960s, and this expanded competition led some of them to be huge agricultural machinery enterprises in the 1960s to 1970s.

Namely, there were many eager but small manufacturers of walking tractors or unique power tillers in Japan from the 1930s to the 1950s. The performance of their machines was not so practical in paddy fields yet. Due to the insufficient development of the engines mounted on the machines and their technology in general, few farmers accepted them in the first half of the 1950s. They were producing only tractor bodies, and engines were bought by the tractor body manufacturer from specialized engine manufacturers like Kubota and Yanmar, etc., or mounted the engine on the tractor at the dealers of certain engine manufacturers.

There were also many specialized manufacturers of threshers and other farm machines, and they recommended to dealers the brand name and type of engine to be coupled to their machines. The specialized manufacturers of engines and farm machines were collaborating among themselves.

However, in 1947, Kubota company began to produce a power tiller on which a Kubota water-cooled farm engine was mounted, and Mitsubishi started to produce a walking tractor mounted with a Mitsubishi air-cooled kerosene engine in 1948. Their expansion policy caused a critical problem to other agricultural machinery manufacturers, because the other power tiller or walking tractor manufacturers became competitors to engine manufacturers, and the dealer network of a certain engine manufacturer could only deal in the power tiller or walking tractor made by the engine manufacturer. Namely, for example, Kubota dealers wished to conduct sales promotion for Kubota power tillers and not for the ones made by other manufacturers.

Many famous power tiller manufacturers, Fujii company and Takeshita company, etc., and their dealers began to mount Yanmar diesel engines on their tillers.

Some thresher manufacturers became engaged research and development of power tillers, and in 1953, Iseki company and Satoh company etc. began to produce their power tillers, and they also became the competitors to the engine manufacturers who were producing power tillers. At last, conventional local dealers became unable to sell the agricultural machinery of more than one brand name. For example, a Kubota dealer could not deal in Iseki threshers, and an Iseki dealer could not deal in Kubota power tillers.

Since around 1955, Kubota company started a technical and sales tie-up arrangement, OEM supply system, with a selected thresher maufacturer, a huller manufacturer, a sprayer manufacturer, etc., and set up a specialized dealers' network all over Japan. Thus, Kubota dealers network could sell not only Kubota's engines and power tillers but also Kubota's threshers, hullers, sprayers and so forth. They stopped advertising in terms of the few kind agricultural machinery they produced like Kubota farm engines or Kubota power tillers, and started to advertise in terms of Kubota agricultural machinery, which gave an impression of completely satisfying farmers' various demands on agricultural machinery.

Other leading manufacturers, Mitsubishi, Iseki, Yanmar, etc., had also the same policy of preparing all kinds of agricultural machinery of their brand name through tie-up arrangement with other small- and medium-manufacturers, and established new sales and service networks all over Japan.

For example, since around 1960, Yanmar Diesel Co., Ltd. had tie-up arrangements with Takeshita and Fujii company who were the strongest competitors on the power tiller market to Kubota, and with Kyowa company for threshers and post-harvest machinery which was also an excellent competitor to Iseki company, and with New Delta company for sprayers and dusters, etc. Their group established a new company, Yanmar Agricultural Equipment Co., Ltd. and completed a better sales and post-sale service network.

However, the fact was that the real purpose of establishing the stronger sales and service networks was not only the competition among leading agricultural machinery manufacturers, but also the competition between the commercial sector with the agricultural cooperatives as follows:

Competition between Commercial System and Agricultural Cooperatives

One of the important reasons for the establishment of a strong sales and service network, with special dealers dealing in all kinds of agricultural machinery of a given brand name, done by the commercial sector was in order to compete against the strong sales network of agriculture cooperatives for agricultural machinery.

The Japanese government promulgated the Agricultural

Cooperative Society Law in 1947, and National Association of Agriculture, NAA, started to become the National Federation of Agriculture Cooperative Association, NFACA, later on. This federation has been called "Zennoh" in Japanese, which consisted of about 14,000 agricultural cooperatives all over Japan. Zennoh could have a large stock of many kinds of agricultural machinery from any manufacturers and distributed them through the network of their cooperatives all over Japan. The agricultural machinery distributed by Zennoh had to be called Zennoh agricultural machinery.

Zennoh had a duty to introduce better agricultural machinery to the farmers. Thus, Zennoh was very much interested in the inspection or test function as a means of selecting such better agricultural machinery as they desired, and they could utilize governmental subsidies on their agricultural machinery for farm mechanization projects managed by prefectures through agricultural cooperatives.

Their retail prices of goods for farmers could be lower than those of commercial dealers, because Zennoh was originally a system of mutual aid without profit.

Before the dealer network of manufacturers had been established after the war, NAA was a reliable rationing network for the manufacturers, and after the establishment of the commercial community as JAAMC in 1947, Zennoh was also an important sales network for the manufacturers, because the market share of Zennoh was almost 50% of total sales of agricultural machinery from all the manufacturers. Thus, no manufacturers could ignore their demands.

However, Zennoh had one very weak point: a poor function of post-sales service to farmers. The sales section of local cooperative was not so interested in the repair and maintenance of the agricultural machinery that they sold. They did not have a repair service shop, facilities, stock of spare parts, service mechanics, etc.

The manufacturers needed to get all information about the post-sales service, by which they could know the real quality and performance of their own products and initiate advanced research and development design of products for the future. All manufacturers wanted to establish a better sales situation by including a much better and more rapid post-sales service function than those of agricultural cooperatives.

Zennoh began to make an effort to facilitate the same function of post-sales service in local cooperatives as the commercial sector since the 1960s, though they had difficulty in employing mechanics who had professional techniques and knowledge of agricultural machinery on sale.

The farmers had access to the marketing networks of both the commercial and cooperative systems in competition, and this led to a miraculous achievement of agricultural mechanization in the 1950s and the 1960s in Japan.

Investing in R&D Activity by Manufacturers

In 1950, Shibaura air-cooled farm engines appeared on the market. In 1952, Honda company participated in producing high-speed air-cooled farm engines run on gasoline, and in 1955, Kawasaki company also began to sell the same type of farm engines. The reason was that Japan's agriculture of 6 million hectares managed by 6 million family farms had stepped into a farming system mechanized by small walking tractors coupled with unique Japanese plows. The total production volume of such walking tractors of 3 to 6 horsepower, traction type, and rotary power tillers of 7 to 12 horsepower, drive type, became 10 thousand in 1952, 45 thousand in 1955, 130 thousand in 1957, 300 thousand in 1960, rapidly increasing year by year as shown in **Fig. 4**.

In 1959, Honda company began to produce very modern walking tractors powered by 5 horsepower high-speed gasoline engine. This company was already well known as a top manufacturer of motor cycles and was showing very active technical innovations like Sony company. Honda company announced that they would establish Honda R&D Co., Ltd. in order to develop completely all new models of Honda products, and that they would invest 3% of the total annual sales revenue of Honda Motor Co., Ltd. every year to the R&D company.

This announcement became a big topic among the machine industry in Japan, and many agricultural machinery companies followed this policy of strengthening their R&D section in order to compete with Honda company, resulting in the very active development of new agricultural machinery including rice trans-

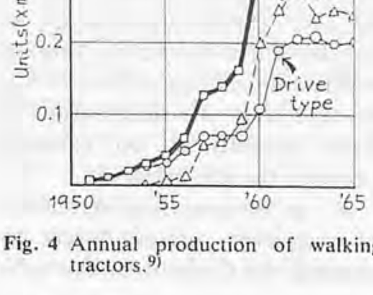


Fig. 4 Annual production of walking tractors.[9]

planters and combine harvesters in the 1960s, which were thought impossible by all Euro-American experts in Asian agriculture.

The author hopes this short report on historical experience in Japan will inspire some good ideas for developing a better agricultural machinery industry and marketing networks for the farmers.

Conclusion

1. When World War II came to an end, one of the major problems in Japanese agricultural machinery industry was not only to reconstruct their factories but also how to shift from "controlled economy" under the militaristic government in wartime to "free market economy" after the war. There was no commercial sales networks of free market economy yet in 1945.

2. There were many other problems such as lack of raw materials, lack of funds to invest, extremely high rate of economic inflation, etc. Traditional farm machinery manufacturers had to compete with many other manufacturers which transfered from the munition industry and began to produce many kinds of farm implements and machines of poor quality and performance.

3. It was quite difficult to shift so suddenly and perfectly to a free economy system, and the government carefully prepared a transitional period of controlling in a democratic way by the cooperatives. In 1946, the Ministry of Agriculture and Forestry requested the central organization of agricultural cooperatives, National Association of Agriculture, NAA, to take over the distribution of farm machinery to farmers through the cooperatives.

4. In the meantime, agricultural machinery manufacturers organized the Control Cooperative of Farm Machinery Industry, CCFMI, instead of a control agency under the government in wartime. The ministry requested CCFMI to take over the production of farm machinery.

5. At the primary stage, NAA paid manufacturers only according to their production schedule, in order to solve their fund problem. Retail prices of major farm machinery were decided by the government as an official prices to the farmers. The manufacturers had to send their products to NAA. At the secondary stage in 1947, NAA changed their advanced payment system to the system of paying at the time of the manufacturer's shipment to NAA, because of galloping infration.

6. In January, 1947, the people who wanted to work in the free commercial field organized Japan Association of Agricultural Machinery Commerce, JAAMC. At the end of 1947, the Ministry of Agriculture and Forestry established a new policy to issue the coupons for purchasing farm machinery to both sales networks of NAA and JAAMC. Namely, a new competing system between the cooperative system of rather democratic socialism and the commercial system of democratic liberalism have been established in Japan, and they have come to learn each other's good points as well as compete since then.

7. It took about 5 years after the end of the war for the retail prices of agricultural machinery to be free. All manufacturers made effort to establish better sales and post-sale service networks and to strengthen their R&D sections in order to develop new agricultural machinery activity.

LITERATURE CITED

1. The Change of Agricultural Machinery Industry, 20 years after the War (1945-1965): edited by Yoshikuni Kishida, Shinnorinsha Co., Ltd., Tokyo, 181 pages' book. 1965
2. One Hundred Years of Agricultural Machinery Industry: edited by Yoshikuni Kishida, Shinnorinsha Co., Ltd., Tokyo, 318 pages' book, 1968
3. Fourty Years' Current of Agricultural Machinery Fields: edited by Yoshikuni Kishida, Shin-norinsha Co., Ltd., Tokyo, 298 pages' book, 1973
4. Sixty Years' History of Iseki Agricultural Machinery, published by Iseki Agricultural Machinery Co, Ltd., Matsuyama, 402 pages' book, 1989
5. Kubota The First Hundred Years, published by Kubota Corporation, Osaka, 378 pages' book, 1990
6. Yasuhiro Fujii: Kokoro-no-hashira, my autobiography for cultivation, Seikisha Publishing Co., Ltd., Tokyo, 136 pages' book, 1974
7. Sixty Two Years of Takeshita Iron Industry Co., Ltd., published by Yosoichi Takeshita, Yanagawa, 281 pages' book, 1976
8. Twenty Years' History of Yanmar Agricultural Equipment Co., Ltd., published by Yanmar Ag'l Eq. Co., Ltd., Osaka, 387 pages' book, 1986
9. Sakai, Jun: Development Currents of Agricultural Machinery for Japanese Rice Cultivation and Farming Structure, AMA, 8(4), 68-78, Farm Machinery Industrial Research Corp., Tokyo, 1977
10. Sakai, Jun: Phongsupasamit, Surin: Kishimoto, Tadashi: Evolutional Steps for Plowing and Tractorization in Japan, AMA, 17(4), 11-19, Farm Machinery Industrial Research Corp., Tokyo, 1986
11. Sakai, Jun: Farming Structures and Trends of Agricultural Mechanization in Japan, — Success, problems and aspirations in the mechanization of Japanese small family farms —, AMA, 21(1), Farm Machinery Industrial Research Corp., Tokyo, 1990

■■

Main Products of Agricultural Machinery Manufacturers in Japan

by
Shin-Norinsha Co., Ltd.
No. 7, 2-chome, Kanda Nishikicho
Chiyoda-ku, Tokyo 101, Japan

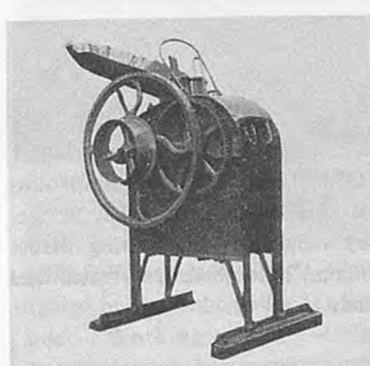
Introduced here are the mainproducts of agricultural machinery manufacturers in Japan with a number of photographs.

The products are developed and improved for both foreign and domestic markets. For further information please refer to the manufacturers contained in the directory.

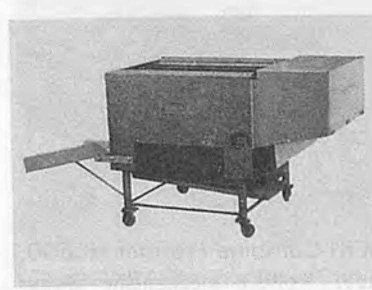
The ARIMITSU Greenhouse Sprayer. Operators safety and labour savings are realized because the equipment operates automatically from a remote location, uniformly spraying micron particle size droplets throughout the greenhouse.

★ ★ ★

BUNMEI Sugarcane Harvester NB-11. The small walking tape harvester.



CHIKUMA Corn Sheller Type 3. Removes kernels from corn-cobs by a short time. Capacity: 750-1, 125kg/h, Power r'd: 1-2 PS, R.P.M.: 300-500, Size in mm: 1,015H x 575W x 1,010L, Weight: Net 90kg Gross 130kg, Shipping meas.: 18 cft.



CHIKUSHIGO Carrot Washing Machine. Nine rolling brushes assure high efficiency. Wide outlet opening helps easy handling. Efficiency: 100kg/3-5min.

★ ★ ★

DAISHIN Engine Pumps "CORAL" Model SCL-50.
Suitable for general purpose pumping, irrigation, water carting in agriculture, water transfer over long distances, public works, etc. Max. total head: 32m (105ft). Suction lift: 8.5m (28ft). Max. capacity: 520ℓ/min. Standard capacity: 15m-210ℓ/mm. Engine power: 3.1-3.5HP.

ISEKI Tractor Landmax T825.
Mounted with 88 HP (5,393cc) Diesel engine. The 6-cylinder, well-balanced engine runs without noise and dynamically performs any type of work.

ISEKI Combine Frontier HL500.
Super Rolling mechanism always controls the position of the body at level by the help of sensors. Working width: 1,650mm-1,700mm (5 row). Engine power: 50HP (2,600cc).

★ ★ ★

KIORITZ U.L.V. Sprayers.
DM-9, DM-3500, DM-4500, DM-5500, PB-4500 has been attached with U.L.V. (Ultra Low Volume) nozzle, Model DMULV-1. These sprayers are used for environmental hygine control such as malaria prevention, etc. as well as general purpose applications.

KOBASHI Rotor KA Series with 4-point auto-hitch. Working width: 220cm. Required tractor horsepower: 50-65.

KOMATSU ZENOAH Reciprocator SGC220DL. Engine: 22.5cc, Dry weight: 6.5kg, Cutting Blade: 230mm, 20-toothed, heat-treated steel blade.

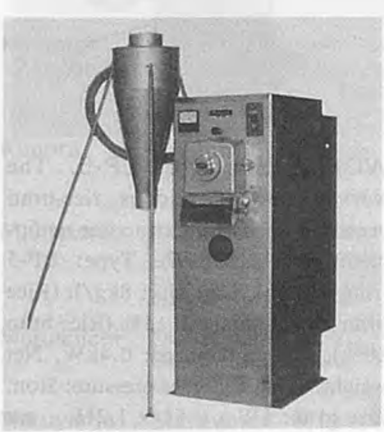
KUBOTA M8580 Tractors. Built to handle a variety of agricultural applications, including field operations, heavy-duty front loader work in barnyards and other farm work. Designed to turn tighter, lift heavier loads, move more material and is everything for peak working efficiency. Has a powerful liquid-cooled direct injection diesel engine with four cylinders and 80 PTO horsepower.

KUBOTA Diesel Tractor B20. A totally new concept in tractor design, the compact Model B20 provides power and versatility for a variety of heavy-duty jobs, including loader, backhoe, and box scraper work, and still retains all the benefits of a compact tractor. Engine (Model D950-A-T): Water-cooled, 3-cylinder, 20hp. Total weight: 930kg

KUBOTA Zero Diameter Turn. Auto Assist Differential, 4WD Front Mower Model FZ2100. Engine: 4 cycle, liquid-cooled diesel, 20hp. Total weight: 680kg

MAMETORA Power Cultivator SRV4V. Wide range use: cultivation to riding, Mounted with 7 PS engine.

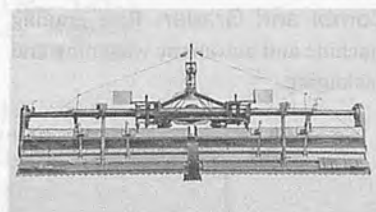
MAMETORA Vegetable Transplanter TP-3V. This machine is available in both pot and soil block in seedling transplanting. Application: all vegetable nursery.

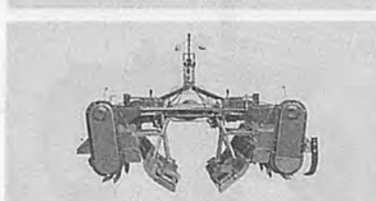


MARUSHICHI Rice Whitening Machine Echo-Star M3. Double jet suction mechanism. Law breakage rate and power. Power: 2.2kW, Capacity: 180-240kg/h.

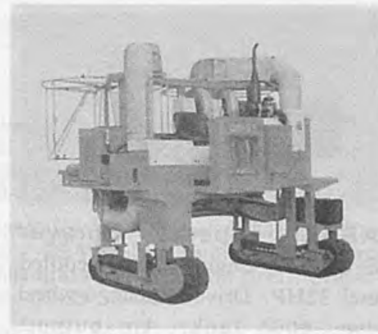
MARUYAMA Portable Power Sprayers MSO55D. Engine: Air-cooled, 2-cycle, output 22.6cc, Pump: Suction capacity 5.1ℓ/mm, max pressure 25kg/cm^2, Weight: 8.5kg.

MATSUMOTO Tea Harvester MST-E2. Simple and easy operation. Self-propelling; Labor-saving. Picks best quality leaves with high efficiency.



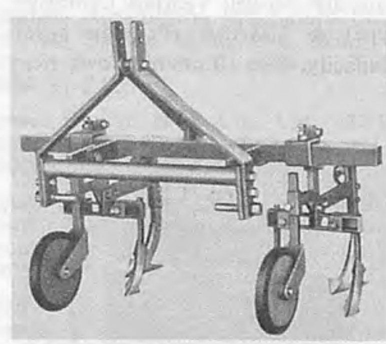


NIPLO Wing Harrow HW-4101B folded by hydraulic power for transport. Working width: 417cm; Required tractor horsepower: over 50.



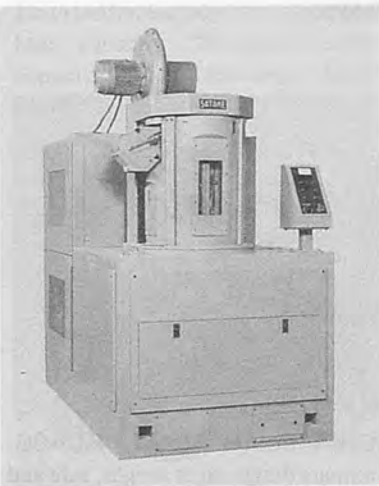
OCHIAI Riding Type Tea Picking Machine OM-25. Full working width cutter bar. Stepless speed control. Water-cooled Diesel engine 28.5PS.

ROBIN Power Rotor PRO400. Compact design, light weight, safe and easy to use. Engine displacement: 121cc (max. 2.8HP/1,800rpm), Weight: 56kg.



SUKIGARA Double Row Cultivator Model TBC. The row width can be controlled easily and quickly by adjusting each bolt at the left and right of tool bar. Row width: 600-900mm. Suitable working speed: 3-5km/h. Power required: 11-20HP.

SASAKI Speed Sprayer RS-660Z. Engine: water-cooled diesel 32HP. Drive system: 6-wheel drive. 600ℓ tank. Air output: 560m³/min. Pump output: 94ℓ/min. Dry weight: 1,220kg.



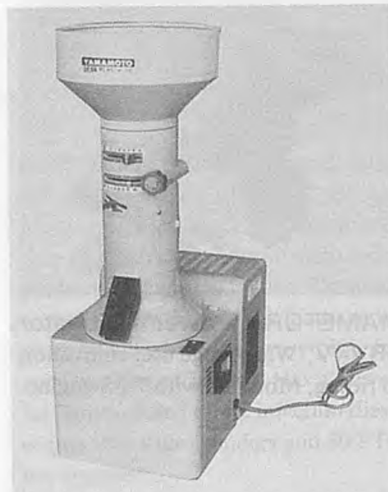
SATAKE New Rice Whiteness, Abrasive and Friction types, have high recovery, uniform & gentle milling, less installation space and high capacity. Model: VRM8A (Abrasive type) & VMA8A (Friction type) Capacity: 8 to 10 mt/hr brown rice

SATAKE Color Sorters with their quality optics and high-grade electronics allow the operator to make efficient separator on the basis of color. Model: GS40AG/AK/AP, GS60AG/AK/AP, GS80AG/AK/AP and CS500B. Major Application: Rice, wheat, coffee, corn, sunflower, beans, spices, etc.

SHIZUOKA's Single Kernel Moisture Tester CTR-800E for rough rice, brown rice, wheat and barley.

TIGER KAWASHIMA Rice Combi and Grader. Rice grading machine and automatic weighting and packaging.

YANMAR Diesel Tractor F97. Engine: vertical, 4-cycle, water-cooled diesel 97HP/2,200rpm. Weight: 2,980kg. Transmission: gear shifting F12xR4. Drive system: 4-wheel drive.



YAMAMOTO Test Whitening Machine VP-30T. Type of milling: vertical. Weight: 24kg. Power required: 0.3kW. Capacity: 30kg/h. Hopper holding capacity: 5kg.

WORLD Squeezer LP-5. The world's first continuous rice-bran vegetable seeds oil extraction qeuipment (SQUEEZERS). Type: LP-5 (ring system), Capacity: 8kg/h (Rice bran 5), Residual oil: 15% (Rice bran 10%), Power required: 0.4kW, Net weight: 90kg, Cylinder pressure: 5ton, Size in m: 1W x 0.5L x 1.2H. ■■

Arimitsu — Arimitsu Industrial Co., Ltd.—7-4, 1-chome, Fukae-kita, Higashinari-ku, Osaka, 537. Tel. 06-973-2010

Bunmei — Bunmei Noki Co., Ltd.—11-4, 1-chome, Korimoto-cho, Kagoshima-city, 890. Tel. 0992-54-5121

Chikuma — Chikuma Farm Machinery Mfg. Co., Ltd.—356, Yoshikawa-koya, Matsumoto-city, Nagano-pref., 399. Tel. 0263-58-2055

Chikushigo — Chikushigo Co., Ltd.—29-3, Ino, Umi-cho, Kasuya-gun, Fukuoka-pref., 811-21. Tel. 092-932-1662

Chikusui — Chikusui Canycom Inc.—90-1, Fukumasu, Yoshii-machi, Ukiha-gun, Fukuoka-pref., 893-13. Tel. 09437-5-2195

Daishin — Daishin Co., Ltd.—3-23-1, Yoyasu-cho, Ogaki-city, 503. Tel. 0584-75-5011

Honda — Honda Motor Co., Ltd.—1-1, 2-chome, Minamiaoyama, Minato-ku, Tokyo, 107. Tel. 03-3423-1111

Iseki — Iseki & Co., Ltd.—3-6, Kioi-cho, Chiyoda-ku, Tokyo, 102. Tel. 03-3238-5265

Kaaz — Kaaz Corporation—387-1, Gomyo, Saidaiji, Okayama-city, Okayama-pref., 704. Tel. 08694-2-1111

Kawasaki — Kawasaki Giken Co., Ltd.—348-1, Kanaya-kawara, Kanaya-cho, Haibara-gun, Shizuoka-pref., 428. Tel. 0547-46-1113

Kioritz — Kioritz Corporation—7-2, Suehirocho 1-chome, Oume-city, Tokyo, 198. Tel. 0428-32-6118

Kobashi — Kobashi Kogyo Co., Ltd.—684, Nakaune, Okayama-city, 701-02. Tel. 0862-98-3111

Komatsu-Zenoah — Komatsu-Zenoah Co., Ltd.—142-1, 2-chome, Sakuragaoka, Higashi-yamato-city, Tokyo, 189. Tel. 0425-61-2141

Kubota — Kubota Corporation—2-47, Shikitsu-Higashi, 1-chome, Naniwa-ku, Osaka, 556-91. Tel. 06-648-2434

Mametora — Mametora Agric. Machinery Co., Ltd.—9-37, 2-chome, Nishi, Okegawa-city, Saitama-pref., 363. Tel. 048-771-1181

Marushichi — Marushichi Co., Ltd.—23-2, 1-chome, Senju, Adachi-ku, Tokyo, 120. Tel. 03-3879-5191

Maruyama — Maruyama Mfg. Co., Inc.—4-15, 3-chome, Uchi-kanda, Chiyoda-ku, Tokyo, 101. Tel. 03-3252-2281

Matsumoto — Matsumoto Kiko Co., Ltd.—9325, Makinouchi, Ei-cho, Ibusuki-gun, Kagoshima-pref., 891-07. Tel. 0993-36-1161

Mitsubishi — Mitsubishi Agricultural Machinery Co., Ltd.—603, Kanda-kaji-cho 3-chome Chiyoda-ku, Tokyo, 101. Tel. 03-3258-0116

Niplo — Matsuyama Plow Mfg. Co., Ltd.—2949, Shiokawa, Maruko-machi, Chiisagata-gun, Nagano-pref., 386-04. Tel. 0268-35-0300

Nozawa — Nozawa Mfg. Co., Ltd.—224-1, Naganuma-cho, Isezaki-city, Gunma-pref., 372. Tel. 0270-32-1315

Ochiai — Ochiai-Shoji Co., Ltd.—58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-pref., 439. Tel. 0537-36-2161

Orec — Orec Co., Ltd.—23-4, Jyojima, Jyojima-cho, Mizuma-gun, Fukuoka-pref., 830-02. Tel. 0942-62-3161

Robin — Fuji Robin Industries Ltd.—35, Ohoka, Numazu-city, Shizuoka-pref., 410. Tel. 0559-63-1111

Sanyo — Sanyo Kiki Co., Ltd.—3858, Shinjyo, Satosho-cho, Asakuchi-gun, Okayama-pref., 719-03. Tel. 08656-4-2871

Sasaki — Sasaki Corp. Ltd.—1-259, Satonosawa, Towada-city, Aomori-pref., 034. Tel. 0176-22-3111

Satake — Satake Engineering Co., Ltd.—2-30, Saijo-nishihonmachi, Higashihiroshima-city, Hiroshima-pref., 724. Tel. 0824-23-3111

Shibaura — Ishikawajima-Shibaura Machinery Co., Ltd.—32-7, 5-chome, Sendagaya, Shibuya-ku, Tokyo, 151. Tel. 03-3358-4211

Shizuoka — Shizuoka Seiki Co., Ltd.—4-1, Yamana-cho, Fukuroi-city, Shizuoka-pref., 437. Tel. 0538-42-3114

Sukigara — Sukigara Agricultural Machinery Co., Ltd.—38, Sairinji, Yahagi-cho, Okazaki-city, Aichi-pref., 444. Tel. 0564-31-2107

Sunwa — Sunwa Sharyo Mfg. Co., Ltd.—571, Negishi, Sayama-city, Saitama-pref., 350-13. Tel. 0429-54-6611

Tiger — Tiger Kawashima Co., Ltd.—4290, Fujioka, Fujioka-cho, Shimotsuga-gun, Tochigi-pref., 349-13. Tel. 0282-62-3001

World — World Seiken Co., Ltd.—11-1, Yamazaki, Ohiro, Tsuruoka-city, Yamagata-pref., 997. Tel. 0235-35-2555

Yamamoto — Yamamoto Co., Ltd.—404, Oinomori, Tendo, Tendo-city, Yamagata-pref., 994. Tel. 0236-53-3411

Yanmar — Yanmar Agricultural Equipment Co., Ltd.—1-32, Chaya-machi, Kita-ku, Osaka-city, 530. Tel. 06-376-6336 ■■

NEWS

Seoul International Exhibition of Machinery, Science & Technology for Agriculture, Fisheries and Livestock (SIEMESTA '92)

November 16-22, 1992
Korea Exhibition Center
Seoul, Korea

SIEMSTA '92 which is organized by Ministry of Agriculture, Forestry & Fisheries and managed by the Korea Farm Machinery and Tool Industry Cooperative, Korea young Prospective Farmers & Fishermen Federation and Korea Exhibition Center (KOEX), is the authorized and sole event in the field of Machinery, Science & Technology for Agriculture, Fisheries and Livestock in Korea.

The mechanization of the agricultural sector is being rapidly promoted due to the sharp decrease and old age of the rural population. The Government plans to enhance the farming mechanization ratio from the present 15% to 80% by 1995, has loaned out US$516 million to the farming sector for their agricultural machinery purchases in 1990, and plans to continuously support farm loans until this goal is accomplished.

Presently, the domestic market size is approximately US$743 million which is a 30% increase over prior year. As the trend in farm mechanization is leaning toward larger vehicle types, the sales of tractors and combines are especially showing over 50% growth, and all heavy machinery are dependent on import. Rending total liberalization in the agricultural and fisheries sector by 1996, mechanization will be accelerated by the Government to improve their productivity.

Concurrent event:

- Technical Symposium for Agriculture, Fisheries & Livestock
- Best Farming Products Contest
- Workshop on using Agriculture Tool & Appliances

For information contact
SIEMSTA '92 Secretariat
Korea Exhibition Center (KOEX)
159 Samsung-dong, Kangnam-gu,
Seoul 135-731, Korea
Tel: (82) (02) 551-1141/2, 1126
Fax: (82) (02) 551-1311, 555-7414

Cashew Nut Processing Plant for Far East

In the face of intense international competition, Lodge Sturtevant has recently received an order for a cashew nut processing plant to be installed near Kendari on the island of Sulawesi, Indonesia. The plant has been designed to process almost 4,000 tonnes of raw nuts a year. The contract includes supervision of erection, plant commissioning and training of local personnel.

The plant to be supplied comprises a number of modules each with its own specific function. These include: grading of the raw nuts, roasting/decortication, kernel drying and vacuum packing of the finished product.

Although there are two products from the cashew tree, the nut and the apple, it is the nut that is the commercially valuable product. It is for this reason that the Lodge Sturtevant system of decortication has been developed to meet the need for a simple, reliable method of removing the kernel from the toxic outer shell of the raw cashew nut.

Raw nuts delivered from the storage facility are first cleaned and graded by size before being conditioned to the correct moisture content for processing. They are then conveyed to the roaster intake where they are roasted in cashew nut shell liquid at a carefully controlled temperature.

During the roasting operation, further cashew nut shell liquid is automatically extracted as a by-product and collected ready for pumping into drums. The liquid is used in the production of plastics, insulating compounds and as a bond in brake linings. Discarded shell is conveyed to collection areas and is subsequently used as a source of energy for the roasting and drying process.

The nuts are then cooled prior to cracking with the broken shells being removed pneumatically. Any nuts which are not fully cracked are automatically recycled until decortication is complete. The final stages of the operation are drying and peeling followed by vacuum packaging of the finished product.

Contact: Maurice Morgan, telephone: 0484 420303
Lodge Sturtevant Ltd.
PO Box B7
Turnbridge
Huddersfield
England HD1 6RB

Useful Farming Practices 1991 Edition

(Japan)

This book is a result of the efforts to collect useful techniques, widely from various parts of the world. From the starting point just until the last edition, we have compiled our "Useful Farming Practices" based on these considerations, and fortunately, the series have been welcomed by a large number of readers who are composed of wide ranges of industrial and social standings; and encouraged by these warm appreciations, we have been able to continue our publication.

In the meanwhile, we have found that there are increasing number of people who are not entirely satisfied by these elementary techniques with limited and easy-to-understand explanations, on the one hand, and there have been a sharp increase in the number of cooperative activities by Japanese researchers and the fruitful results have been accumulated year after year.

Of these fruitful results, there are not a few, that are applicable to other localities with little or no modifications. So we have decided to include some of these results in our new Edition, with the collaboration of these researchers themselves, we have given as much theoretical explanations as possible.

We have also went over the archives of Japanese traditional techniques that had been slowly developed by ancient researchers and peasants in order to cope with lack of inputs and infrastructures.

For the collection, we had extensive cooperation of the Japanese agricultural experts, Japan Oversease Cooperation Volunteers, etc. who are sent to or returned from missions. Without the cooperation of these people, the publication of this book might have been impossible and I should like to express my deep gratitude to them.

Under such a situation, the improvement and extension of agricultural techniques must be the challenges for developing countries, and for our part, we should place the utmost priority on these activities within Japanese international cooperation.

This book will be an useful companion for Japanese experts engaged in agricultural cooperation, and all people working in this field as well.

Size: 22 × 15 cm, pp 223, Vynil cover.

Edited and published by Association for International Cooperation of Agriculture & Forestry 19, Ichiban-cho, Chiyoda-ku, Tokyo 102, Japan.

Rice: Then & Now

(Philippines)

By R.E. Huke and E.H. Huke

Three facts make both strategic and applied research on rice essential during the years ahead: 1) Rice is, and will continue to be, the world's most important food crop; 2) The world agricultural base is faced with possible constriction due to human interference with natural cycles; and 3) World population growth will continue well into the next century.

It is essential for the public to have easily understandable information to help them understand the role of rice in feeding the world.

The wide-ranging introduction to rice was written by Dr. Robert E. Huke, visiting geographer, and Ms. Eleanor H. Huke, visiting cartographer, Dartmouth University, USA.

Size: 28 × 22 cm, pp 44, soft cover. Price HDC US$8.50, LDC US$ 2.00 plus airmail (US$4.00) or surface mail (US$1.00) postage.

Published by Division H, Information Center, IRRI, P.O. Box 933, 1099 Manila, Philippines.

The Farmer as Manager

(U.K.)

By Tony Giles and Malcolm Stansfield

This book is a non-technical text which will be suitable for students of general agriculture and farm management taking courses at colleges and universities, as well as for practising farmers and farm managers. The authors have between them, both practical expertise and academic experience and have provided a clear and stimulating approach.

The focus of the book is on general principles discussed in a qualitative way. Thus while there is coverage of budgeting and financial management, there is equal consideration given to concepts such as setting objectives and decision making and to practical matters such as production and staff management.

The book is a revised edition of a work first published in 1980 by Allen and Unwin. All chapters have been updated and increased attention has been given to topics such as the use of computers, the relevance of the European Community and the Common Agricultural Policy, and to providing up-to-date case studies. The new edition will therefore provide a very readable and jargon-free text.

Contents include: • Setting objectives • Planning • Decision making • Control • Production • Buying and selling • Finance • Staff • Managing the manager • Acquiring information • Priorities.

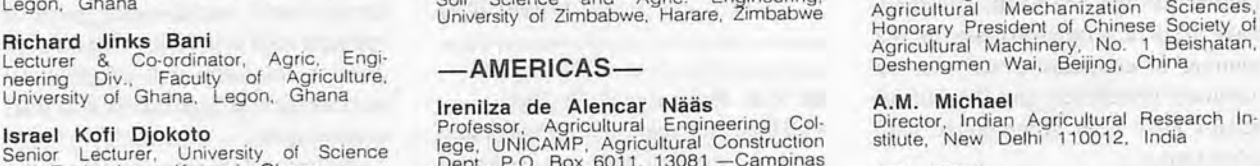
September 1990, 224 pages, Price including postage: £9.95 (US$17.50 Americas only).

Published by C.A.B. International Wallingford, Oxon OX10 8DE United Kingdom. ■■

Co-operating Editors

E A Baryeh | A M Hossay | B S Pathak | D B Ampratwum | R J Bani | I K Djokoto | D K Some | J C Igbeka | E U-Odigboh | K C Oni

N G Kuytembeh | A H Abdoun | A B Saeed | Suya Nath | A I Khatibu | S Tembo | I de A Nääs | A E Ghaly | A A Valenzuela | O Ulloa-Torres



W J Chancellor | M R Goyal | A L Philips | S M Farouk | M A Mazed | Wang Wanjun | A M Michael | J P Mittal | T.P Ojha | S R Verma


Soedjatmiko


M Behroozi-Lar


J Sakai


B A Snobar


C J Chung


C C Lee


I Haffar


M Z Bardaie


E S Eldin


M Afzal


A D Chaudhry


A Q Mughal


R M Lantin


R P Venturina


S Illangantileke


S F Chang


S Phong-supasamit


C Rojanasaroj


G Singh


Y Pinar

Jun Sakai
Professor, Dept. of Agric. Engineering, Faculty of Agriculture, Kyushu University 46-05, Hakozaki, Higashi-ku, Fukuoka 812, Japan

Bassam A. Snobar
Professor & chairman, Plant Production Dept., Faculty of Agriculture, University of Jordan, Amman, Jordan

Chang Joo Chung
Professor, Dept. of Agric. Engineering, College of Agriculture, Seoul National University, Suweon, Korea 170

Chul Choo Lee
Research Professor, Seoul Woman's University, Mailing Adress: Rm. 514 Hyundate Goldentel Bld. 76-3 Kwang Jang Dong Ku, Seoul, Korea

Imad Haffar
Assistant Professor of Agric. Mechanization, Dept. of Soils, Irrigation and Mechanization, Faculty of Agriculture and Food Sciences, American University of Beirut, Beirut, Lebanon

Muhamad Zohadie Bardaie
Associate Professor, Faculty of Engineering, Universiti Pertanian Malaysia, 43400 UPM, Serdang, Selangor, Darul Ehsan, Malaysia

ElTag Seif Eldin
Mailling Address: Dept. of Agric Mechanization, College of Agriculture, P.O. Box 32484, Al-Khod, Sultan Qaboos University, Muscat, Sultanate of Oman

Mohammad Afzal
Senior Engineer (Mechanization Engineer), Farm Machinery Institute, National Agric. Research Centre P.O. NIH, Islamabad, Pakistan

Allah Ditta Chaudhry
Associate Professor & Charman, Dept. of Farm Machinery and Power, Agric. Engineering and Technology, University of Agriculture, Faisalabad, Pakistan

A.Q. Mughal
Professor, Faculty of Agricultural Engineering, Sind Agriculture University, Tandojam, Sind, Pakistan

Reynaldo M. Lantin
Agricultural Machinery Expert, Regional Network for Agricultural Machinery, c/o United Nations Development Programme P.O. Box 7285 ADC Pasay City Metro Manila, Philippines

Ricardo P. Venturina
President & General Manager, Rivelisa publishing House, 215 F, Angeles St. cor Taft Ave. Ext., 1300 Pasay City, Metro Manila, Philippines

S. Illangantileke
Head, Dept. of Agric. Engineering, Faculty of Agriculture, University of Peradeniya, Sri Lanka

Sen-Fuh Chang
Professor, Agric. Machinery Dept. National Taiwan University, Taipei, Taiwan

Surin Phongsupasamit
Associate Professor, Dept. of Mech. Engineering, Faculty of Engineering, Chulalongkorn University, Ban 10330, Thailand

Chanchai Rojanasaroj
Research and Development Engineer, Dept. of Agriculture, Ministry of Agriculture and Cooperatives, Bang-Khen, Bangkok 10900, Thailand

Gajendra Singh
Professor of Agric. Engineering, Div. of Agricultural & Food Engineering, Asian Institute of Technology, GPO 2754, Bangkok 10501, Thailand

Yunus Pinar
Associate Professor, Agric. Engineering Dept., Faculty of Agriculture, University of Ondokuz Mayis, Kurupelit, Samsun, Turkey

—EUROPE—

Anastas Petrov Kaloyanov
Professor & Head, Research Laboratory of Farm Mechanization, Higher Institute of Economics, Sofia, Bulgaria

Henrik Have
Prof. of Agric. Machinery and Mechanization at Institute of Agric. Engineering, Royal Veterinary- and Agricultural University, Agrovej 10 DK2630 Tastrup, Denmark

Giuseppe Pellizzi
Director of the Institute of Agric. Engineering of the University of Milano and Professor of Agric. Machinery and Mechanization, Via G. Celoria, 2-20133 Milano, Italy

Aalbert Anne Wanders
Staff Member, Dept. of Development Cooperation, Netherlands Agricultural Engineering Research Institute (IMAG), Wageningen, Netherlands

John Kilgour
Senior Lecturer in Farm Machinery Design at Silsoe College, Silsoe Campus, Silsoe, Bedford, MK45 4DT, UK ■■


A P Kaloyanov


H Have


G Pellizzi


A A Wanders


J Kilgour

BACK ISSUES

(Vol. 22 No. 1, Winter 1991 ~)

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 22, No. 1, Winter, 1991)

Editorial (Y. Kishida) 13
Development of Load Cell of Tension and Compression Type by Appropriate Technology (Y. Shibata, K. Toyoda) 15
Feasibility of Using Field Plot Machinery in India (B.G. Yadav, R.N.S. Yadav) 21
Testing and Evaluation of Fuel Filters Used on Tractors (A.K. Singh, M.L. Mehta, R. Tiwari) 26
Field Performance Evaluation of Bullock-drawn Puddler (D.N. Sharma, M.L. Jain, S.C.L. Premi) 29
Power Requirements of Tillage Implements (J.M. Baloch, S.N. Mirani, A.N. Mirani, S. Bukhari) 34
Design, Development and Evaluation of Power Tiller-drawn Seed-cum-Fertilizer Drill (A.C. Varshney, C.P. Bohra, S. Narang) 39
Small Power Unit, Equipment and Service Units—Needs, Structures and Problems (L.G. Stoimenov) 42
Development of a Low-cost Weeder for Lowland Paddy (Md. S. Islam, K.A. Haq) 45
Energy Studies in Cropping Systems in Lateritic Soil of Orissa, India (P.K. Mohapatra, P.C. Senapati, D. Satpathy) 49
Rice Post-harvest Practices and Loss Estimates in Bangladesh: Threshing through Sundrying (A.K.M.A. Haque, N.H. Choudhury, M.A. Quasem, J.R. Arboleda) 53
Energetics of Forage Chopping (Y. Jekendra, P. Singh) 59
Mango Harvesting Techniques in Bangladesh (D. Hussain, M. Alam, Md. A. Hussain) 64
Agricultural Mechanization in Rajasthan, India (A.K. Sharma) 69
For Emitters as Evaporative Cooling Devices for Dairy Cow Sheds (A.M. Abdalla, R. Narendran) 73
The Present State of Farm Machinery Industry (F.M.I.R. Corp.) 77
Outline and Activities of National Agriculture Research Center (T. Kuwana) 81
Prospect of Agricultural Machinery Course in Hokkaido University (Hokkaido University) 86
Research and Education of The University of Tsukuba (T. Konaka) 89
Introduction of Agricultural Machinery Laboratory, Department of Agricultural Engineering, Kyushu University (J. Sakai) 91
Japanese Society of Agricultural Machinery (T. Konaka) 96
Activities by Hokkaido Agricultural Machinery Assoc. (N. Murai) 99
Main Products of Agricultural Machinery Manufacturers in Japan (Shin-Norinsha Co., Ltd.) 101

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 22, No. 2, Spring, 1991)

Editorial (Y. Kishida) 7
Design Development and Performance Evaluation of Bullock-drawn, Multipurpose Hoe (R.V. Jadhav, P.A. Turbatmath) 9
Bullock-drawn Roller-type Mould Board Plough for Heavy Soils (S.K. Mohanty, D.K. Das, S.K. Dash) 15
Optimum Combination of Tillage Tools for Seedbed Preparation of Wheat after Paddy Harvest (C.P. Singh, B.S. Panesar) ... 18
Evaluation of Land Preparation Methods in Small Farm Holdings in Northern Sudan (H. Fakki, M. Dawelbait) 23
Traffic Compaction and Tillage Effects on the Performance of Maize in Sandy Loam Soil of Nigeria (K.C. Oni) 27
Standardization and Quality Control of Centrifugal Pumps (Y. Suneja, M.L. Mehta, R. Tiwari, V.A. Patil) 32
Establishment of a Multi-crop Production System with Minimum(O.C. Ademosun).. 35
Effect of Vegetative Cover, Mulching and Planting Time on Some Soil Physical Properties and Soil Loss in Pineapple Plots (S.N. Asoegwu) 39
Tractor Power Utilization on Mechanized Farm (B. Singh, K.N. Singh, T.C. Thakur, A. Kumar) 44
Computer Expert System for Breakdown Diagnostic of Agricultural Tractors (Md. Z. Bardaie, L.K. Leong) 49
Energy Needs and Production of Rural Areas in Punjab, Pakistan(I. Ahmad, S.I. Ahmad, A.W. Zafar) 53
Influence of Timing and Date of Harvest on Wheat Grain Losses (S. Bukhari, K.A. Ibupoto, G.H. Jamro, G. A. Khohro) 56
Mechanized vs Traditional Cultivation of Sugarcane Crop in Pakistan (M. U. Khaskheli, F.M. Rattar, L.A. Jamali, K.A. Ibupoto) 59
Single-row Model II Cassava Harvester (E.U. Odigboh) 63
Reducing Grain Post-harvest Losses (R.J. Bani) 67
Development of Brush-type Ginger Peeling Machine (Y. Ali, G.C. Jain, S.S. Kapdi, Y.C. Agarwal, S. Bhatnagar) 71
Potentials of and Constraints to the Adoption of Agricultural Mechanization Technology in the Middle East Region (I. Haffar, M.H. Ahmed) 74
Estimation of Higher Heating Value of Biomass in Tropical Regions (P. Sirisomboon) 81

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 22, No. 3, Summer, 1991)

Editorial (Y. Kishida) 7
A New Rice Harvesting Technology and its Stripper-feature Machine System (J. Yi Yuan, Du Cheng-hai, Xu Jia-mei) 9
Grain Losses in Wheat Harvested by Tractor Front-mounted Reaper-windrower (S. Bukhari, A. Mughal, J. Malik, A. N. Mirani) 15
Design of a Thresher for Locust Bean (O.A. Ajayi) 21
Performance of Power-operated Groundnut Pod Stripper (A.K. Gol, S.K. Nanda) ... 25
An Experimental Apparatus for Simultaneous Spreading of Plastic Mulch and Drip Irrigation Pipes (I. Haffar, M. Baasiri, M. Marroush) 29
Effects of Four Soil Tillage Methods on Growth of Maize in Zambia (M. Kersten, F. Hack) 34
Development of Low-cost, Hand-operated Planter (T.E. Simalenga, N. Hatibu)....... 39
Agricultural Machinery Testing in India (M. Mehta, V.A. Patil) 42
Laboratory Method for Determining Energy Requirement for Pulverizing Soil Clods (F. Kelemu) 45
Mathematical Model of Rice Huller's Rubber Rolls (S.O. Atolagbe) 49
Development of 4-ton Paddy Dryer (I.K. Djokoto, L.C. Kiamco) 51
Design Development and Testing of Sugarcane Cleaner (L.N. Shukla, I. Singh, N.S. Sandhar) 55
Manufacture of Agricultural Machinery in Chile (E.J. Hetz) 59
Agricultural Inputs, Mechanization and Employment in Turkey (Y. Zeren, A. Isik) ... 63
Farm Mechanization vis-a-vis Human Labour Employment in Punjab Agriculture (R.S. Sidhu, S.S. Grewal) 67
Development and Field Performance of a Chickpea Thresher (M. Anwar, N. Amjad, A. W. Zafar) 73
Draft and Energy Requirements of Agricultural Implements in Semi-arid Regions of Morocco (L.L. Bashford, D. V. Byerly, R.D. Grisso) 79

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 22, No. 4, Autumn, 1991)

Editorial (Y. Kishida) 7
Puddling-type Floating Power Tiller for Small-scale Rice Farms (H.T. Manaligod R.E. Stickney) 9
Portable Computer and Data Logger to Test a Prototype in the Fields (M.R. Mollah) 13
Energy Expenditure Pattern of Power Tiller Operator (K. Kathirvel, T.V. Job, R. Karunanithi, K.R. Swaminathan) 18
Prediction of Field Performance of Wheel Tractors (J.M. Baloch, A.N. Mirani, S. Bukhari) 21
Diesel Engine Performance Tests Using Oil from Jatropha Curcas L (M. Ouedraogo, P.D. Ayers, J.C. Linden) 25
Comparative Performance of Various Implements in Grassy Land (A. Razzaq) 30
A new Design Concept for Animal-drawn Harvester (B.G. Yadav)........................ 33
Optimum Replacement Time of Combine Harvesters (T.N. Mishra, B. Singh, K.N. Singh, D.K. Pathak, P. Reddy) 37
Development of Axial-flow Thresher in Southern Vietnam (P.H. Hien) 42
Design and Development of Straight Through Peg Tooth Type Thresher for Paddy (P. Datt, S.J.K. Annamalai) 47
Effects of Different Cearances between Two Rubber Rolls on Dehusking of Paddy (Md. K. Khan, S.N. Mohanty) 51
Accelerating Design and Performance Test Evaluation of Cross-flow Tempering Drier Using Computer Simulation Model (C.E. Ofoche, T. Abe, Y. Hikida) 54
Drying Fruits and Vegetables with Solar Energy in Egypt (M.A. El-Shiatry, J. Müller, W. Mühlbauer) 61
A Portable Field Recording Device for Draft Measurement (C.D. Durairaj, D.M. Jesudas, R. Karunanithi, K.R. Swaminathan) 65
Effect of Method of Handling Tractor Fuel: Iraqui Countryside Experience (L.H.M. Ali, A.H. Kadhum) 69
Feasibility of Fuel Ethanol from Cane Molasses in Pakistan (I. Ahmad, S.I. Ahmad, M. Afzal) 72
Optimum Utilization of Animal Dungs as Domestic Fuel: A Case Study (D.N. Sharma, N. Sethi, A. Batra, B. Sehgal) .. 75
Frictional and Packing Behavior of Green Coffee Beans (J. A.M. Nkanya, S.A. Thompson) 79

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 23, No. 1, Winter, 1992)
Editorial (Y. Kishida) 13
New Rice Growing System to Increase Labor Productivity in Japan (C. Murugaboopathi, M. Tomita, E. Yamaji, S. Koide) 15
Indian Standards on Oil Milling Industry (R.N. Sharma) 20
Design and Development of a Direct Paddy Seeder (C.P. Gupta, T. Herwanto) 23
Developments in Mechanical Planting of Sugarcane (M. Farooq, A. Majid, S.I. Ahmad) 28
Development of A Technical Solution to Cassava Harvesting Problem (L. Peipp, E. Maehnert) 33
Use of Colorimetric Technique in Determining Surface Coverage in Spraying (A. Ozmerzi, I. Cilingir) 37
Cotton and Weed Seedling Emergence as Affected by Seedbed Preparation (M.B. Montemayor) 39
A Comparative Study of Partial vs Complete Mechanized Harvesting and Threshing of Wheat (A. Razzaq, Ch. B. Ahmad, Ch. B.A. Sabir) 42
Selective Mechanization for Cassava Processing (J.C. Igbeka, M. Jory, D. Griffon) ... 45
Design for A Night Ventilated Onion Store for the Tropics (K. Skultab, A.K. Thompson) 51
Growth and Productivity of Egusi-melon as Affected by Tillage Depth (S.N. Asoegwu) 56
Mechanization of Vegetable Growing in Bulgaria (A. Kaloyanov, Ch. Petkov, Il. Rousev) 61
Performance of Draft Animals at Work in Morocco: Draftability and Power Output (R.K. Bansal, O.El Gharras, J.H. Hamilton) 65
Farm Mechanization in Rajasthan in India (M.A. Khan) 71
The Present State of Farm Machinery Industry (F.M.I.R. Corp.) 74
General Outline of the Research Activities of Tropical Agriculture Research Center (T. Yamaguchi) 78
An Introduction to the Department of Agricultural Engineering Faculty of Agriculture, The University of Tokyo (O. Kitani) 83
Agricultural Mechanization Program at the Tokyo University of Agriculture and Technology (J. Yonemura) 87
Introduction to Department of Bioproduction and Machinery, Mie University (M. Hoki) 90
The Agricultural Machinery Industry after World War II in Japan (J. Sakai) 93
Main Products of Agricultural Machinery Manufacturers in Japan (Shin-Norinsha Co., Ltd.) 103
News 108
Book Review 109

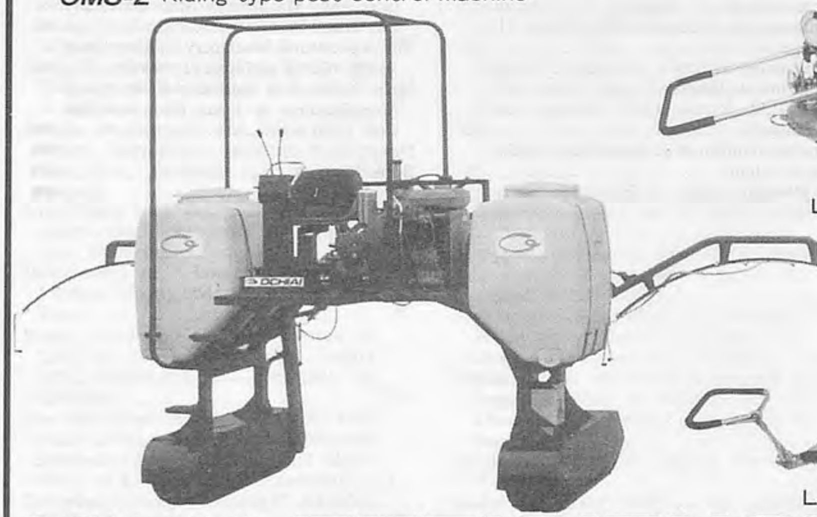
The Updated Version of the AMA Computerized Index Available

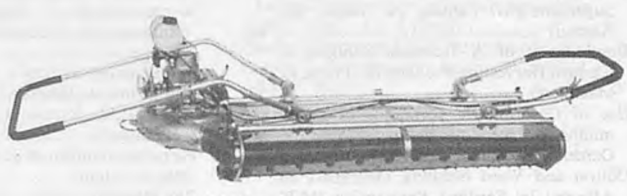
A computerized index of technical articles in *Agricultural Mechanization in Asia, Africa and Latin America* has been compiled for the years 1971 through 1990. Each citation includes truncated versions of the title, first and second authors' names and four keywords. Year, issue and page number of each article are given. The citations along with software for searching the database are all included on a single computer diskette for use with IBM-PC, -XT, -AT or compatible type computers.

Anyone wishing to receive this material may send one formatted. 5 1/4-inch, 360 Kbyte, double-sided, double-density diskette to William Chancellor, Agr. Eng. Dept., Univ. of Calif., Davis, CA 95616, USA. The database and searching software will be copied to that diskette, and it will be returned by airmail along with software documentation. There is no charge. Any special customs or postal designation or specifications required should be stated in the letter of request. Annual updates will be available in the future.

OCHIAIi is the top-ranking tea-leaf piker manufacturer in Japan. OCHIAI's products are used in tea-producing areas worldwide.

OMS-2 Riding type pest control machine





L-SIZED TEA PLUCKER *V-8*

L-SIZED PRUNER *R-8*

HIGH-EFFICIENCY RIDING TYPE SERIES

OM-25 Full-width tea picker

ENGINE PRUNER *E-6*

GUIDE TO OCHIAI

- Succeeded in devising Japan's first automatic tea-leaf picker in 1959.
- Received the Director of the Board of Scientific Technology Award in 1967.
- During the intervening period (1959-1967) obtained a number of patents, as well as receiving a variety of awards and prizes in the domain of science and technology.
- The top-ranking tea-leaf picker and tea-tree trimmer producer, holding 60% of the shares in the same line of business in Japan, surpassing the other manufacturers in sales and product, and leading the related business worlds in its expansion and development.

OCHIAI HAMONO KOGYO CO LTD

OCHIAI-SHOJI CO., LTD.

Head Office: 58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-ken, Japan
Tel. Kikugawa (05373) 6-2161~5 Telex 03965824 STPA J ATTN OCHIAI