International specialized medium for agricultural mechanization in developing countries

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.XII, NO.1, WINTER 1981

FARM MACHINERY INDUSTRIAL RESEARCH CORP.


ISEKI

Sharing Prosperity Through Agriculture

Agriculture is a vital industry since it sustains life itself.

Recently, the problem of food resources has become increasingly important to most countries. In particular, Japan has been especially concerned with the problem of providing food for its people since it has historically depended on the importation of food to meet its needs. It has long been Japan's dream to be self-sufficient in providing food for its people.

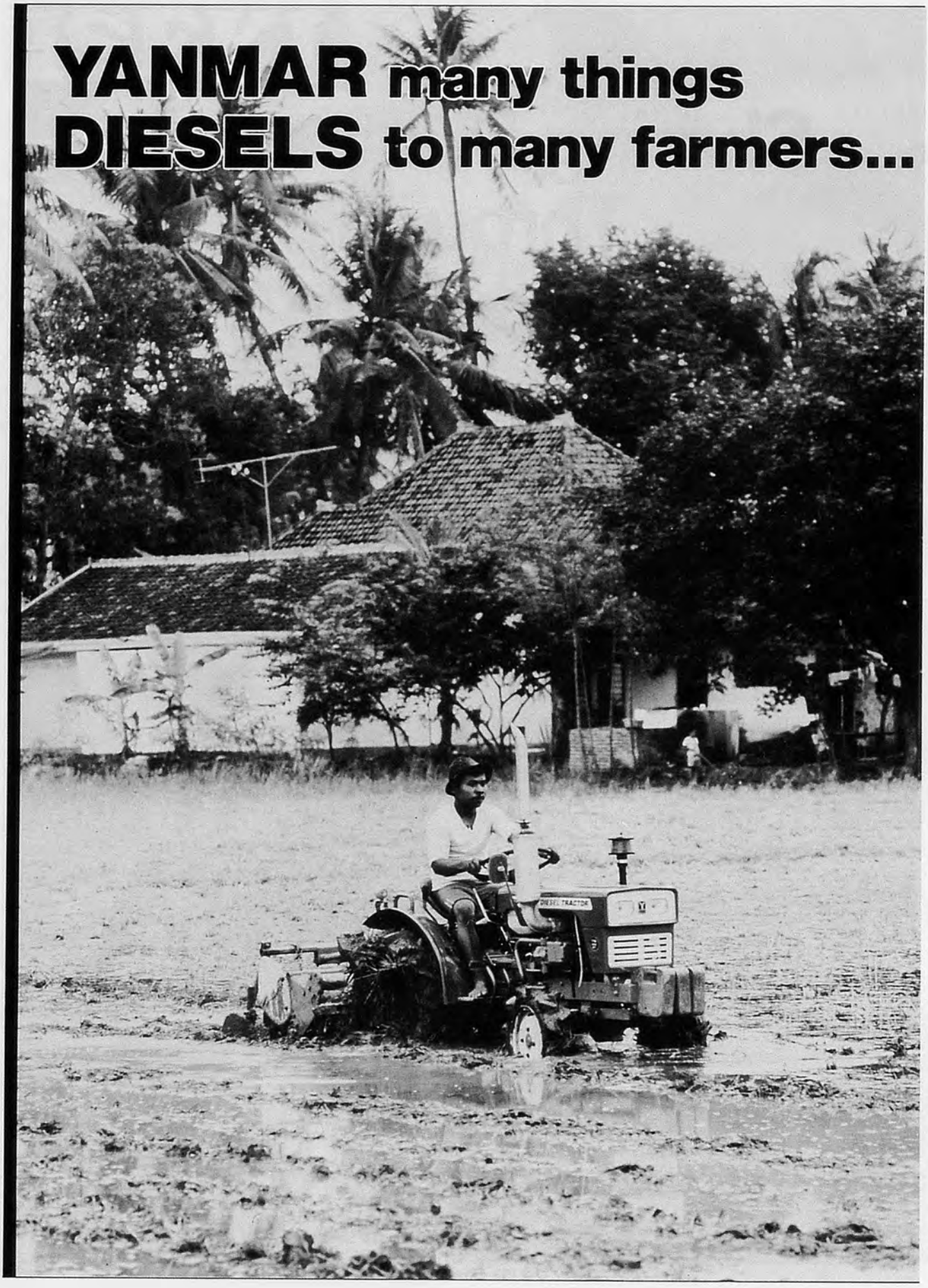
Iseki is proud of the products and the factories that have made this revolution in farming possible. Iseki tractors, tillers, rice transplanters and combine-harvesters have changed the face of farming not only in Japan, but in other countries throughout the world. Iseki products are well known and accepted everywhere. And Iseki continues to make every effort to meet farmers' needs in mechanizing farm operations — from soil preparation, barley cropping, upland field cropping to dairy farming.

In view of the recent anxieties concerned with food production, Iseki pledges itself to promoting the happiness and prosperity of agricultural people by intensifying its efforts and further developing its technological skill so as to promote agriculture on a global scale.



ISEKI & CO., LTD.

Foreign Affairs Division
3-6, Kioi-cho, Chiyoda-ku, Tokyo, 102 Japan
Cable Address: ISEKIRICE TOKYO
Telex: 232-2752, 232-2753 Phone: (03) 238-5245~5260


YANMAR many things
DIESELS to many farmers...

but always the heartbeat of the land

The day of the diesel is here.
Whether serving long hours in the paddies, or pumping life-giving water to the land, the Yanmar diesel is now the prime mover of agricultural progress.
The rugged power of a Yanmar diesel has become symbolic of the new age of agricultural mechanization.
As a faithful friend of the farmer, Yanmar equipment is ready to run through jobs all around the farm-plowing, puddling, harrowing, fertilizing, harvesting, mowing and irrigating
With economy a top priority everywhere, the Yanmar diesel gives more productive power from every drop of fuel. It works hard and long without complaint in all conditions, because it is built from the down-to-earth realities of Asian agriculture.
That's why, wherever serving, Yanmar diesels represent a big step forward for agricultural development.
And with the machine, Yanmar has the men. Local experts trained to make introducing and looking after our machinery easy and efficient for the farmer.

In Asia, diesels are now the heartbeat of the land, and Yanmar has its finger on the pulse.



Model **YM** series
15~33HP



Model **TS(C)** series
4~18HP

Today is the Day of the Diesel.....

YANMAR DIESEL ENGINE

YANMAR DIESEL ENGINE CO.,LTD.
1-1, 2-chome, Yaesu, Chuo-ku, Tokyo 104, Japan
Cable: YANMAR TOKYO Telex: 0222-2310, 0222-473

SUMITHION
SUMICIDIN

SUMISCLEX
Neo-Pynamin

SUMITHION & SUMICIDIN

TO CONTRIBUTE to World Food Production and Improve World Environmental Hygiene



SUMITOMO CHEMICAL offers you a variety of potent and low-toxic pesticides.

SUMITHION, now well accepted at home and abroad, comes close to being a universal insecticide. SUMITHION, an organophsphorous insecticide, is murderous on insects but low toxic to man and animals, being used by rice farmers, fruit and vegetable growers and tea and coffee planters all over the world. SUMITHION, is also used to control vectors of communicable diseases such as mosquitoes, houseflies, bedbugs, lice and fleas.

SUMICIDIN and SUMISCLEX are the latest additions to Sumitomo's line of business, which signify the advent of a new pesticide era.

SUMICIDIN is a pyrethroid-like insecticide, quite powerful with appropriate duration of residual effect and stable in sunlight. SUMICIDIN has made a great sensation especially among vegetable growers and cotton cultivators in the world since its commercialization in 1977 due to the increase of yield and prolonged spray intervals.

SUMISCLEX came into being in 1977 as a fungicide especially for the control of Botrytis on grapes. SUMISCLEX is very effective to grape Botrytis Disease resistant to the conventional fungicides.

Sumitomo also offer you some pyrethroids for household use, among which is NEO-PYNAMIN . Aerosolers are completely satisfied with the quick knockdown effect of NEO-PYNAMIN against houseflies, mosquitoes and other household insects. It offers the same advantage as pyrethrins: extremely low toxic to man and animals.

For further information write: Pesticides Division.

SUMITOMO CHEMICAL CO., LTD.

15, 5-chome, Kitahama, Higashi-ku, Osaka, Japan.
Cable Address: CHEMISUMIT OSAKA

International specialized medium for agricultural mechanization in developing countries

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.XII, NO.1, WINTER 1981

Edited by

YOSHISUKE KISHIDA

Published quarterly by

The Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

Yoshisuke Kishida, Publisher & Chief Editor
Yoshikuni Kishida, Advisory Director
Morio Kamijo, Advisor

Contributing Editors and Cooperators
Bala, Bilash Kanti (Bangladesh)
Mazed, M.A. (Bangladesh)
Gurung, Manbahadur (Bhutan)
Pedersen, T.Touggaard (Denmark)
Hanna, George B. (Egypt)
Chandra, Satish (Fiji)
Michael, A.M. (India)
Soepardjo, Siswadhi (Indonesia)
Pellizzi, Giuseppe (Italy)
Sakai, Jun (Japan)
Snobar, Bassan A. (Jordan)
Chung, Chang Joo (Korea Rep.)
Andreou, Paris (Lebanon)
Bardaie, Muhamad Zohadie (Malaysia)
Saxena, Naresh Chandra (Malaysia)
Shrestha, Bala Krishna (Nepal)
Moens, Adrian (Netherlands)
Choudhury, Md. Shahansha-ud-Din (Nigeria)
Mittal, Jitendra P. (Nigeria)
Odigboh, E.U. (Nigeria)
Devrajani, Bherulal T. (Pakistan)
Ilyas, Mohammad (Pakistan)
Mughal, A.A. (Pakistan)
Lantin, Reynaldo M. (Philippines)
Lee, Chul Choo (Philippines)
Venturina, Ricardo P. (Philippines)
Kandiah, Arumugam (Sri Lanka)
Abdoun, Abdien Hassan (Sudan)
Bedri, Mohamed A. (Sudan)
Peng, Tien-song (Taiwan)
Singh, Gajendra (Thailand)
Kilgour, John (U.K.)
Chancellor, William J. (U.S.A.)
Esmay, Merle L. (U.S.A.)

EDITORIAL STAFF
(Tel. 03/291-5718)
Yoshisuke Kishida, Chief Editor
Kensuke Sakurai, Managing Editor
Yoshinori Sasaki, Assistant Editor
Noriyuki Muramatsu, Assistant Editor

ADVERTISING
(Tel. 03/291-3672)
Kuniharu Ikeda, Manager (Head Office)
Shuji Kobayashi, Manager (Branch Office)
Advertising Rate : 250 thousand yen per a page

CIRCULATION
(Tel. 03/291-5718)
Soichiro Fukutomi, Manager
Editorial, Advertising and Circulation Headquarters,
7,2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101 Japan

Copyright © 1981 by
FARM MACHINERY INDUSTRIAL RESEARCH CORP.
SHIN-NORIN Building
7,2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo, 101 Japan
Printed in Japan

This is the 30 issue since the issue, Spring of 1971.

Editorial

AMA's Second Decade Begins

From all of us to all of you, A PROSPEROUS NEW YEAR!

Exactly a decade ago this month, the AMA's maiden issue was published under the name "Agricultural Mechanization in Southeast Asia". It is remembered vividly how difficult it was to pool resources then, i.e., finances, articles for publication, editorial work, and printer's time, in preparing for the initial issue that was to stand the test of time. The AMA made it and has since enjoyed the encouragement and support that it continues to receive from subscribers, co-editors, engineers, scientists, educators, government officials, businessmen, advertisement sponsors and all those interested in the cause of agricultural mechanization in the developing countries. And that was 10 years ago: a decade that witnessed the growth of the AMA in coverage, readership, friendship and its humble contributions to the promotion of farm mechanization – first, in the Southeast Asia region, and, gradually in much of Asia, Africa, Latin America and North America.

It was in the light of this encouraging past decade of the AMA that the preceding (Autumn, 1980) issue announced that beginning with the present issue, the acronym AMA will henceforth mean "Agricultural Mechanization in Asia, Africa and Latin America."

The decade of the 70s saw farm mechanization making an impact and gaining a firm foothold in many underdeveloped and developing nations. However, the decade of the 80s heralds some degree of apprehension if statistics are to be believed. For instance, the 1980 IBRD World Development Report underscores the widening disparity in economic growth beween the developed and developing countries, i.e., per capita GNP in advanced industrial countries averaged about US$7,600 in contrast with US$176 only in low-income and oil-importing countries. For another, population increase in less-developed and developing countries continues to literally eat up available food supply the production of which, in comparison, does not increase as much. Add to this the fact that the global supply of fossil fuels threatens to diminish markedly, hence to be costlier than ever.

These negative signs that darken the economic horizon of the 80s tell us in no uncertain terms that more than ever before, it is imperative that i) governments of underdeveloped and developing countries must redouble their efforts at stemming the tide of hunger and poverty; ii) the advanced countries, on the other hand, need to develop a more forward-looking attitude towards the problems of the third world; and iii) research efforts must proceed unabatedly in developing economical and renewable sources of energy.

The AMA, for its part, has a high resolve to face its second decade with a stronger determination to improve on its past decade's performance of promoting the cause of farm mechanization. This is because the AMA believes that farm mechanization is a vital key in opening up new frontiers in agricultural productivity. And this determination derives strength from the continuing support that its readers, subscribers and contributors provide it.

The AMA management wishes to take this opportunity to acknowledge in grateful appreciation to the kind support and cooperation of all concerned in seeing it grow and develop over the past decade.

Yoshisuke Kishida
Chief Editor

January, 1981
Tokyo

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. XII, No.1, Winter, 1981

Yoshisuke Kishida	9	Editorial
Jehangir K. Khattak Abdur Rashid S.U. Khan Kermit E. Larsen Riaz A. Khattak	11	Effect of Land Levelling and Irrigation on Wheat Yield
Bherulal T. Devrajani	15	Influence of Farm Machines on Crop Production Efficiency
S. Chandra A.P. Sharma	19	Experiments on Cassava Production Technologies in Fiji
Madhu S. Singh	22	Design, Development and Testing of an Animal-Drawn Harvester
Sheruddin Bukhari Bherulal T. Devrajani	25	Farm Mechanization Research Evaluation in Pakistan
Sarath Ilangantileke Allan Phillips Merle Esmay	29	Post Rice Production Field Losses
Jatindra Nath Samajpati Md. Shawkat Ali Sheikh Md. Siddiqur Rahman	39	Paddy Post Harvest Technology in Bangladesh
B.K. Huang M.N. Özisik M. Toksoy	47	Development of Greenhouse Solar Drying for Farm Crops and Processed Products
Din-sue Fon	53	Stationary Flat-Bed Rice Drier and Two-Way Airflow Drying Method
Subhash S. Arora Kulbir Singh Malhotra	57	Potential of Sugarcane as Alternative Energy Source in India
S. Tiwary T.P. Ojha	60	Performance of Boilerless Parboiling System
Jinnat Ara Begum	63	Food Processing and Preservation for Rural Women in Bangladesh
S.C. Chowdhry B.V. Ramana Rao P. Sharma	66	Performance of Low-Cost Sail-Wing Windmill
Md. Daulat Hussain Md. Faroque Ahmed	69	Population Growth and Food Supply in Bangladesh
News	75	
New Products	78	

★ ★ ★

Index to Advertisers 68
A Note to AMA Contributors 81
Co-operating Editors 82
Back Issues 84

Effect of Land Levelling and Irrigation on Wheat Yield

by

Jehangir K. Khattak
Associate Professor & Chairman
Department of Soil Science
Faculty of Agriculture
University of Peshawar
NWFP, Pakistan

Kermit E. Larsen
USAID Advisor
On-Farm Water Management Project
Peshawar, Pakistan

Abdur Rashid
Assistant Professor
Department of Soil Science
Faculty of Agriculture
University of Peshawar
NWFP, Pakistan

Riaz A. Khattak
Lecturer
Department of Soil Science
Faculty of Agriculture
University of Peshawar
NWFP, Pakistan

S.U. Khan
Deputy Director
On-Farm Water Management Project
Peshawar, Pakistan

Abstract

The effect of land levelling and application of fertilizers/manures was studied on the physico-chemical properties of soil, water use and yield of wheat. Three combinations of fertilizer-cum-manure; NP, NP + farm yard manure and NP + green manure (Susbina aculeata) were applied in cut, fill and unlevelled land. A decrease of organic matter, total nitrogen, available phosphorous and exchangeable potassium occured in the cut position, while in the fill portion these parameters were unaffected. Levelling significantly increased phosphorous, exchangeable potassium and the infiltration capacity of soil. A saving of 34 to 47 % irrigation water was recorded and attributed to levelling.

Introduction

Irrigated agriculture is the mainstay of Pakistan's economy which shares over 43 % in GNP. Out of 19.24 million ha of cultivated land only 4.54 million ha are unirrigated. Water is one of the major limiting factors in increasing agricultural production. To meet the overall increasing demand ground water resources are being exploited and so far more than 1.5 million tube wells have been commissioned throughout the country. The river supply is irregular and water delivered is less than the consumptive use of recommended cropping intensity which is further aggravated by the arid conditions of the country. About 90 % of the irrigated land is not precisely levelled ranging in uneven surface topography (±5 to ±25 cm) resulting in 30 to 50 % water loss. This suggests the need to develop cultivation techniques that help minimise on-farm-water losses. One of the most effective water saving techniques is precision land levelling that allows irrigation water to spread as evenly as possible over the field surface.

This study was undertaken to determine the physical effects attributable to precision land levelling associated with organic and inorganic fertilizers/manure application on crop yield and physico-chemical conditions of soil under Peshawar areas. The findings of this study could be applied to arid-zone irrigated agriculture of the world.

Material and Methods

The research was conducted in nearly level, old pleistocene piedmont alluvium area of Peshawar Valley. The site soil (Typic Ustochrepts) had been homogenized deeply with increasing trend clay and lime contents having a slightly developed hard pan due to repeated cultivation at the same depth. The soil was strongly calcareous and non-saline with a pH of 7.9. A thorough survey of one hectare field was done as suggested by Twitty (10) in a grid system of 20 x 20 m. Elevations were recorded by planimeter and a 2 cm contour map was developed which indicated the roughness of field at ±65 cm. An area of 0.21 ha was left unlevelled with ±35 cm unevenness and 0.63 ha was selected for precision land levelling. In the latter case a total volume of cut was calculated to 316 cu.m with a cut-fill ratio of 1.30. After precision land levelling operations with scraper and land plane, it was finally checked when the elevations of the high and low points ranged between ±2 cm. The precisely levelled area was left as such into cut and fill portions.

The main plots; un-levelled, cut and fill portions were laid out into nine subplots each (10 x 15 m each) for manuring/fertilizing trials. Manures/fertilizers were NP as Nitrophos, NP + green manure and NP + farm yard manure (FYM 12 t/ha), where NP was in the ratio of 130.57 kg/ha. The experiment was laid out in a split plot design with three replications. After uniform irrigation of the whole area at sowing of dhancha (June 19), three composite soil samples of 0-30 cm depth were collected from the three main plots and were analyzed for physico-chemical properties using the methods given by Black (3). Infiltration capacity of soil was determined by cylinder infiltrometer as described by Howard et al (7). Two measured irrigations were given to "dhancha" and it was buried into the soil followed by an irrigation. One month before sowing of wheat crop, well rotten cattle manure was spread and mixed with soil, and at sowing of wheat (cultivar pavon) in November, a basal dose of NP was applied to all 27 subplots. A total of six irrigations were applied. Irrigation water saving was determined using 20 cm cut throat flume as suggested by Warryam et al (11) and the following formula was used:

Water saved (%) = (Depth at unlevelled field – Depth at levelled field) x100/ Depth at unlevelled field

An area of one square meter per sub-plot was for germination and tiller counts. The field was monitored till crop harvest and yield data of wheat grain and straw were collected. Soil samples of 0-30 cm depth were also collected from each sub-plot and analyzed for soil fertility assessment, bulk density and infiltration.

Results and Discussion

Irrigation water saving – An equal number of irrigation was applied to both the unlevelled and precisely levelled plots (**Table 1**). It was observed that during three irrigation, unlevelled plots consumed water depths of 3.86 cm, 3.34 cm and 2.39 cm of water while levelled plots consumed 2.06 cm, 2.21 cm and 2.11 cm or an average saving of 39.20 % water. These findings are in agreement with Ali, et al (2) and Cox (4) who also reported similar results.

Germination – Levelling has significant effect on germination. Farm yard manure and green manure increased the germination in the cut-portion (**Table 2**). The mean values for the fill-portion and unlevelled plots were 48 and 43 %, respectively, as against 72 % germination in the cut-portion. The highest germination percentage of 78 was recorded for green manured cut-portions and the lowest of 40 % for green manured unlevelled plot. The low germination in the fill as compacted to the cut-portion might be due to over pulverization or disturbance of soil structure. Excess moisture, deeper placement of seed, decreased oxygen supply and heavy soil covering on emerging seedling could also reduce germination. But these soil must be rich in organic matter. This condition could be improved in subsequent crop seasons through natural soil settlement and good soil management practices.

Tillering – Precision levelling and better manuring/fertilizing had significant effect on the number of tillers separately as independent factors as well as the interaction between the two was also significant (**Table 2**). Farm yard manure increased the number of tillers significantly over the other two combinations. Cut and fill portions

Table 1. Effect of Land Levelling on Depth of Watering and Percent Saving in Irrigation Water

Irrigations	Observations	Unlevelled plots	Levelled plots	Water saved (%)
I	Area irrigated (ha)	0.190	0.344	
	Time taken (hrs)	2.00	1.42	46.6
	Stream flow (cm/h)	0.90	1.22	
	Depth (cm)	3.86	2.06	
II	Area irrigated (ha)	0.170	0.312	
	Time takens (hrs)	1.42	1.35	
	Stream flow (cm/h)	0.96	1.23	33.8
	Depth (cm)	3.34	2.21	
III	Area irrigated (ha)	0.170	0.312	
	Time taken (hr)	1.32	1.17	
	Stream flow (cm/h)	1.07	1.38	37.8
	Depth (cm)	3.39	2.11	

Table 2. Effect of Levelling and Manuring on Germination and Tillering Capacity of Wheat

Levelling/ manuring	Germination percent				Tillering counts			
	Un-levelled	Cut-portion	Fill-portion	Mean	Un-levelled	Cut-portion	Fill-portion	Mean
Control (NP)	40	68	45	51	690	835	964	829
NP + FYM	49	72	45	55	721	1,110	1,004	945
NP + G.M.	40	78	53	54	615	888	1,025	843
Mean	43	72	48	–	675	944	998	–
	LSD				LSD			
	P 0.05		P 0.01		P 0.05		P 0.01	
Levelling	12		20		258		429	
Manuring	NS		NS		77		108	
Interaction	NS		NS		133		187	

enhanced the tillering capacity significantly as compared to unlevelled plots. Maximum mean value of 1110 was observed in respect of the cut-portion with FYM and minimum of 670 for unmanured plots of unlevelled portion. Beneficial effects of levelling and manuring on plant tillering was due to better growth conditions provided by these attributes as indicated by Robertson and Gardner (9).

Grain yield – Better levelling increased the grain yield significantly, whereas, the interaction between manuring/fertilizing and levelling was not significant (**Table 3**). Yield data indicated significant increase for levelled portions over unlevelled portions. Mean values for NP, NP + FYM and NP + G.M. reveal that there was no significant difference in case of manurial treatments. The results further showed that the higher yield at the cut-portion more than the fill-portion might be due to lodging and loosely settled soil particles holding more water and high fertility inducing vegetative growth. This effect is confirmed by the straw yield which was higher in the fill-portion than the cut portion. Similar beneficial effects of levelling on wheat grain yield were reported by Johnson et al (8).

Straw yield – Levelling showed significant effect on the straw yield of wheat while the interaction between levelling and manuring was not significant (**Table 3**). This shows that more vegetative growth occured due to additional application of organic manure. The yield data indicated 60 percent more yield for levelled plots than unlevelled plots. It also showed that the straw yield instead of grain yield of the fill-portion was higher than the cut portion. This supports the assumption of low grain yield for the fill-portion. The highest mean value of 11,647 kg/ha was noted for the fill-portion with farm yard manure against the minimum of 6,856 kg/ha for the unlevelled and unmanured plots. The grain and straw yields were in conformity with the findings of Hanif et al (6), Ali et al (1) and Cox (4).

Table 3. Effect of Levelling and Manuring on Grain and Straw Yields of Wheat

Levelling/ manuring	Grain yield (kg/ha)				Straw yield (kg/ha)			
	Un-levelled	Cut-portion	Fill-portion	Mean	Un-levelled	Cut-portion	Fill-portion	Mean
Control (NP)	3,655	3,826	4,012	3,831	6,856	9,347	10,577	8,926
NP + FYM	3,712	9,565	4,233	4,169	7,500	10,767	11,647	9,971
NP + G.M.	3,769	4,432	4,340	4,180	7,708	10,606	13,191	10,501
Mean	3,712	4,274	4,195	–	7,354	1,040	11,805	–
	LSD				LSD			
	P 0.05		P 0.01		P 0.05		P 0.01	
Levelling	339		563		1,432		2,375	
Manuring	NS		NS		NS		NS	
Interaction	NS		NS		NS		NS	

Effects of Levelling on Soil Properties

Composite soil samples (0-30 cm) collected from three main plots; unlevelled, cut-portion and fill-portion were analysed for physico-chemical properties (**Table 4**). The data indicated a little effect of levelling on soil texture, lime, total soluble salts and pH, especially for the unlevelled plots and fill-portion due to homogenized profile of test series. In the cut-portion, on account of removal of fertile surface soil, organic matter, total nitrogen, available phosphorous and exchangeable potash contents of the soil decreased. Whereas in the unlevelled and fill-portions, these values were affected only slightly. Bulk density increased in the cut-portion but decreased in the fill-portion.

Deep chiselling of the cut-portion and shifting of loose soil material of granular structure from cut- to fill-areas resulted in increased infiltration capacity of soil in precision levelling. Similar results were reported by Hanif et al (6), Ali et al (1) and (2) and Robertson and Gardner (9).

Effect of Levelling and Manuring on Soil Fertility, Bulk Density and Infiltration Rate

After the wheat was harvested, soil samples collected from 27 subplots were analyzed for organic matter, total nitrogen, available phosphorous, exchangeable potash, bulk density and infiltration (**Table 5-7**). The analysis indicates that the addition of organic manures increased organic matter, available phosphorous, total nitrogen and

Table 4. Effect of Levelling on Physico-Chemical Characteristics of Soil

Characteristics	Units	Unlevelled	Cut-portion	Fill-portion
Organic matter	%	0.70	0.60	0.71
Total nitrogen	%	0.09	0.08	0.09
Available phosphorous	ppm	10.69	6.76	9.49
Exchangeable potassium	ppm	190.50	137.00	189.00
Bulk density	gm/cc	1.63	1.73	1.49
Sand	%	24.90	23.00	23.00
Silt	%	44.50	40.50	45.00
Clay	%	31.60	36.50	32.00
Soil texture	–	clay loam	clay loam	clay loam
Infiltration rate	cm/hr	1.06	1.21	1.36
Lime	%	12.30	14.94	12.80
Total soluble salts	%	0.02	0.02	0.02
pH	–	7.90	8.00	7.90

Table 5. Effect of Levelling and Manuring on Organic Matter and Total Nitrogen of Soil

Levelling/ manuring	Organic matter (%)				Total nitrogen (%)			
	Un-levelled	Cut-portion	Fill-portion	Mean	Un-levelled	Cut-portion	Fill-poriton	Mean
Control (NP)	0.65	0.56	0.65	0.62	0.08	0.07	0.08	0.07
NP + FYM	0.80	0.78	0.90	0.82	0.10	0.08	0.09	0.09
NP + G.M.	0.83	0.84	1.03	0.90	0.90	0.09	0.11	0.09
Mean	0.76	0.72	0.86	–	0.09	0.08	0.09	–
	LSD				LSD			
	P 0.05		P 0.01		P 0.05		P 0.01	
Levelling	NS		NS		NS		NS	
Manuring	NS		NS		NS		NS	
Interaction	NS		NS		NS		NS	

Table 6. Effect of Levelling and Manuring on Available Phosphorous and Exchangeable Potash

Levelling/ manuring	Available phosphorous (ppm)				Exchangeable potash (ppm)			
	Un-levelled	Cut-portion	Fill-portion	Mean	Un-levelled	Cut-portion	Fill-portion	Mean
Control (NP)	8.29	6.33	8.29	7.63	179.50	135.00	188.00	167.50
NP + FYM	8.95	7.31	10.48	8.91	184.50	140.50	196.00	173.66
NP + G.M.	9.16	7.32	10.58	9.04	196.00	146.50	207.00	183.16
Mean	8.80	6.98	9.78	–	166.66	140.66	197.00	–
	LSD				LSD			
	P 0.05		P 0.01		P 0.05		P 0.01	
Levelling	1.08		1.72		42.36		NS	
Manuring	NS		NS		NS		NS	
Interaction	NS		NS		NS		NS	

Table 7. Effect of Levelling and Manuring on Bulk Density and Infiltration Rate

Levelling/ manuring	Bulk density (gm/cc)				Infiltraction rate (cm/h)			
	Un-levelled	Cut-portion	Fill-portion	Mean	Un-levelled	Cut-portion	Fill-portion	Mean
Control (NP)	1.73	1.65	1.58	1.65	1.06	1.21	1.36	1.21
NP + FYM	1.62	1.61	1.56	1.56	1.59	1.12	1.27	1.36
NP + G.M.	1.61	1.62	1.55	1.59	1.16	1.32	1.45	1.31
Mean	1.65	1.62	1.56	–	1.11	1.26	1.39	–
	LSD				LSD			
	P 0.05		P 0.01		P 0.05		P 0.01	
Levelling	NS		NS		NS		NS	
Manuring	NS		NS		NS		NS	
Interaction	NS		NS		NS		NS	

exchangeable potash and maximum beneficial effects were noted in case of NP + G.M. treatment, but these results were not statistically significant. This might be due to the contribution of nutrient elements and organic matter by farm yard manure and green manure which improved soil fertility better than the application of nitrophos. Infiltration capacity increased with organic manuring while bulk density decreased due to increased pore space.

Precision land levelling significantly increased the infiltration capacity. A maximum value of 1.39 cm/hr was noted in fill-portion where bulk density decreased and 1.56 gm/cc was the value of fill-portion. Removal of fertile surface soil from the cut-portion due to precision levelling resulted in a decrease of soil fertility in terms of organic matter, total nitrogen, available phosphorous and exchangeable potash. Whereas, organic matter, available phosphorous and exchangeable potash were high in the fill-portion as compared to the unlevelled plots. These results were in conformity with Cox and Aslam (5) and Robertson and Gardener (9).

Conclusion and Recommendations

A decrease in organic matter, total nitrogen, available phosphorus and exchangeable potassium occured in the cut-portion. In the fill-portion these parameters were unaffected. Precision levelling significantly increased the infiltration rate and enhanced the grain and straw yield of wheat. Some 34 to 47 % irrigation water was saved due to precision levelling in the field. It is, therefore, recommended that farmers should level their fields so that the water thus saved could be utilized for increasing crop areas, yields and overall crop production.

REFERENCES

1. Ali, A., Clyma, W. and Early, A.C. Improved Water and Land Use Management Through Precision Land Levelling; Proc. Inter. Conf., Waterlogging and Salinity, Lahore, Dept. of Civil Engg., Engg. & Tech. Univ., Oct. 13-17, 1975.
2. Ali, A., Clyma, W. and Ashraf, M. Irrigation Practices for Traditional and Precision Levelled Fields in Pakistan; CENTO Panel Meeting on the Optimum Use of Water in Agriculture, NIAB, Faisalabad, p. 27-28, 1975.
3. Black, C.A. Methods of Soil Analysis; Part I and II, ASA, Inc. Madison, Wisconson, U.S.A., 1965.
4. Cox, P.M. Water Management Monthly Report; CSU. Water Management Programme, p. 3, 1976.
5. Cox, P.M. and Alam, M.M. Precision Land Levelling and Its Effect on Soil Fertility and Productivity; p. 4, 1977.

(Continued on page 18)

Influence of Farm Machines on Crop Production Efficiency



by
Bherulal T. Devrajani
Principal Investigator
Sind Agricultural University
Tandojam, Pakistan

Introduction

In virtually all developing countries the issue of agricultural mechanization is controversial. Pakistan is surely no exception. Many experts, particularly economists, feel that higher initial outlays and fear of displacement of farm labour, and small farm sizes do not suggest machine use in Pakistan agriculture. However, tractors and farm machines have positively contributed to the production of crops.

Farm machines have been adopted on a certain number of progressive farms without prior planning. No research results were reported before on machine use in agriculture particularly in Sind. The efficiency of mechanization in this province is still based on doubts and hypotheses. Therefore, research in the field of farm mechanization is very essential for decision making and to determine the feasibility as to whether mechanized cultivation at varying degree permit efficiency in labour productivity and increase crop yields as compared to traditional farming. Before recommending a machine singly or in combination, it is necessary to evaluate its efficiency through objective analysis.

The study was based on three major criteria: machine efficiency, irrigation efficiency, and economic efficiency. It was undertaken to determine the suitability of farm machinery in the cultivation of major crops under different types of soil. It aims to study the use, functions and efficiency of machines on pre-sowing, sowing, post-sowing and harvesting operations. The study also includes the effects of size and make of a particular machine for use on small holdings. It appraises the economic efficiency of various machines competing in the production of wheat, cotton and sugarcane crops with emphasis on quality of operations resulting in higher production coefficients. Thus, it covers both engineering and economic aspects of crop production.

The Survey Phase

During the survey phase, the study was confined to tractor farms and traditional farms. A sample of 50 tractor and 25 traditional farms was selected from five districts (Tharparkar, Sanghar, Hyderabad, Nawabshah and Sukkur). The sample criteria were variations in machines and tractors available and ability of growers to respond in providing data. The selection of traditional farms represented traditional methods of cultivation with similar types of soils and irrigation facilities.

The selected farms were visited frequently to collect data. The data were checked through multiple

This paper relates to Project PK-ARS-8 (Fg-Pa-225) implemented in Sind Agriculture University, Tandojam under Cooperative USDA/PARC (PL-480) program. Dr. James L. Butler, Research Leader, Coastal Plain Experiment Station, Tifton, Georgia is the cooperating scientist. It is a pioneering research in Sind, particularly in the field of mechanization management. The project was implemented on January 1, 1974 initially for five years with Mr. M. Toaha Qureshi as Principal Investigator. Originally, the project was negotiated to undertake the study by controlled experimentation, but Mr. Qureshi revised its plan and conducted research through survey methods. After three years, the cooperating scientist strongly objected the deviation in plan. Thus USDA/FERRO authorities visited the Sind Agriculture University, Tandojam in October 1976. By that time Mr. Qureshi had joined the ARC and rerevised the plan of experimental work with the author as Principal Investigator extending the duration of the project to 3½ more years for completion by June 1982.

question series. Recall investigations were also made for computing field efficiency and machine performance. The time, number of operations and work quality were measured physically to estimate the various aspects of machine use efficiency. For analyzing the production function of wheat and cotton, the farms were grouped as follows: small farms, below 200 acres; medium farms, 201 to 500 acres; and large farms, above 500 acres. The sugarcane farms were grouped differently: small farms, below 100 acres; medium farms, 101 to 200 acres; and large farms, above 200 acres.

The results based on two years data of these crops are summarized under four heads: appraisal of mechanization, wheat production, cotton production and sugarcane production.

Appraisal of Mechanization

Agriculture in much of Pakistan has since been dependent on bullock power and indigenous implements. It has remained up to subsistence level transforming to commercial level in the production of rice, wheat, cotton and sugarcane. Farm power and machinery are introduced on progressive farms, but bullocks are not uncommon even on tractor farms. Diversified share-cropping system of farming is practiced. There is no proper zoning of crops to specialize according to soil type and climate. The use of physical inputs is almost similar for both progressive and traditional farms but not in cultural practices, hence different productivity levels.

In general, farmers like to mechanize their farms, but the machines are priced beyond their means. The lack of machine, spare parts, repair and service facilities, are major problems. Hence, tractor use is almost confined to pre-sowing operations and transportation.

The climate in Sind is not uniform. The monsoon rains are scanty and do not supplement irrigation. However, unexpected showers cause floods and damage the summer crops. Thus, climate has much influence on timeliness of operations.

Land use in Sind indicates that on 45 % of the total land area (of 30.8 million acres) plowing by bullocks is used. About 51 % of the total area lies under hillocks and sand dunes with potential for development. Some 4 % is forest. Therefore, farm land expansion depends on the development and intensive cultivation through tractor use. Some 34 % of the cropped area was planted to wheat, 23 % to cotton, 4 % to sugarcane, and the rest to other crops.

Irrigation water scarcity is a limiting factor. The limited public and private tubewells supplement irrigation in sweet water zones only. Canal irrigation provides water to 45 % of the farm areas in the "Rabi" season and 27 % in the "Kharif". Heavy water losses in conveyance and on-farm application deplete the available water supply. The lands are not properly levelled which need improvement to increase irrigation efficiency, water saving, uniform crop stand, and easy machine traffic.

The soils are not homogenous, even on the same farm. Soil types are important in the mechanization of operations. Water-logging and salinity/alkalinity deteriorate soil fertility and a large area goes out of cultivation every year. Machine use can reclaim these soils to some extent.

Farm size influences the efficiency of mechanization as it is relatively easy to achieve economy of scale on large farms. Most farm machines have short-season use which is further affected by farm size. Machines and tractors cannot be scaled down much in terms of per acre investment due to operational requirements. The prevalence of small holdings is another factor that affects machine efficiency. Losses of 10 to 15 % crop areas are attributed to bunds and on-farm irrigation facilities. However, the operational size of farms in Sind is sufficiently large for mechanization.

The well-to-do farmers in the province accepted tractors in the 60s majority of which were 55 hp in size. Farmers own tractors without consideration of both sizes of tractor and the farm. The average tractor horsepower was 0.17 per acre supplemented by 0.05 bullock power per acre as against 0.07 bullock horsepower per acre on traditional farms.

The use and functions of tractors varied from farm to farm depending on the operations mechanized, area operated and pressure of work. There was no complete mechanization even where facilities were available. The degree of mechanization was such that some field operations were carried out partially by bullocks and partially by tractors. The ultimate aim of using tillage machines was measured in terms of depth of work and precision of work done. The machines ensured considerably better work.

Machine capacity and efficiency was calculated for every machine. There was a difference between calculated and actual labour use, causing expected displacement, but in practice there was no labour displacement felt at certain peak periods. The energy requirement in the form of diesel oil per acre was about 10 gallons. Custom work, if at all available, was more expensive as compared to unit owning and operating costs of tractor cultivation.

Wheat Production

Increased wheat production is

dependent on HYV seeds, suitable soil, optimum fertilizer use, proper irrigation, plant protection, agronomic practices and timeliness of operations. Climate and pests also affect production. Cultural operations through machines enhance yields as do the depth of plow, number of passes, quality of work, levelling and sowing at proper time and depth for proper germination, plant population and weed control. Harvesting at proper time reduces grain losses. Under normal cropping intensity, wheat is mostly cultivated on wheat lands of the preceding year.

Wheat involves average cost of Rs.637.94 per acre on tractor farms as against Rs.657.64 on traditional farms. The breakdown of costs on tractor farms are Rs.121.90 on land, Rs.130.03 on labour, and Rs.386.01 on capital inputs as against Rs.101.93 on land, Rs.304.62 on labour and Rs.251.09 as capital on bullock farms. The overall cost of production on traditional farms was higher than tractor farms involving more labour inputs and less capital inputs.

Tractor farms produced 32.24 maunds of grains and 26.56 maunds of straw as against 22.44 maunds of grains and 20.91 maunds of straw per acre on bullock farms. The physical productivity of grains and straw was 43.67 % and 27.02 % higher on tractor farms as compared to traditional farms. The progressive growers earned at 42.52 % more as compared to traditional growers. Machine use saved both time and cost.

The input-output ratio on tractor farms was 1:2.19 as against 1:1.49 on traditional farms. The progressive growers earned an additional profit of Rs.0.70 on per rupee expense or 43 % more after increasing the volume of inputs by 3 % in the form of machines.

Cotton Production

The production of cotton is dependent on edaphological and environmental conditions coupled with the use of physical inputs. HYV seed, optimum plant population, proper fertilizers, plant protection, proper irrigation, plant protection, improved cultural practices and picking at proper times enhance cotton production.

Cotton is a deep-rooted crop. For successful root development and healthy nourishment, a well drained friable soil is essential, especially at the early stages of plant growth. The tillage operations should ensure desireable depth, proper crumbling and friability of hard and sticky soils. Land levelling is important because cotton is susceptible to standing water. Cotton crop requires heavy weeding and interculture operations.

Cotton production costs Rs.672.66 per acre including Rs.126.52 on land, Rs.211.36 on labour, Rs.334.78 as capital inputs on mechanized farms as against a total of Rs.661.62 on traditional farms, sharing Rs.108.46 on land, Rs.348.81 on labour and Rs.204.35 on capital. The cost of production per acre of cotton on tractor farms was higher.

The progressive cotton growers had an average yield of 17.06 maunds of seed cotton per acre as against 13.48 maunds on traditional farms. The yield on tractor farms was 26.56 % higher. The input-output ratio on tractor farms was 1:2.56 as against 1:2.05 on traditional farms after increasing the volume of inputs by 16.16%. Time-cost analysis reveals that the machine use had significant effect on production and saved Rs.26.64 per acre for the various field operations substituting labour.

Sugarcane Production

Sugarcane is grown on all types of soil as an annual as well as perennial crop. It gives a plant crop and two ratoon crops. Ratoon crop yields less but competes with the main crop in terms of net returns. Sugarcane is fibre rooted, but deep penetrating plant, thus requiring good quality tilth. It is sown in rows of 2.5 feet to 3 feet apart.

The production function involves inputs of Rs.1,520.17 per acre on tractor farms as against Rs.1,440.57 on traditional farms. The cost on tractor farms included Rs.213.62 on land, Rs.373.61 on labour and Rs.932.95 on capital inputs as against Rs.210.47 on land, Rs.633.23 on labour and Rs.596.88 as capital on traditional farms. The yield of cane on tractor farms was 33.77% higher.

The input-output ratio on tractor farms was 1:3.25 as against 1:2.57 on traditional farms. Progressive growers earned an added income of Rs.0.68 on per rupee expense and earned 33.57 % more after increasing the volume of inputs by 6.62 %. The machine contribution in sugarcane production was also highly significant.

Mechanized cultivation though, expensive in terms of initial costs, was more efficient than conventional farming. Thus, it is suggested that various field operations be standardized through experimentation. For this purpose it was recommended that tractors and farm machinery be manufactured in the country at lower cost.

The Experimental Phase

After the revision of the plan of work from survey methods to experimentation in the end of 1976, four experiments were conducted as follows:

Experiment 1—Comparison of tractor blade and land plane (Primary tillage with disc plow and tandem harrow).

Experiment 2—Comparison of

efficiency of drilling/broadcast of seed and fertilizers.

Experiment 3—Effect of degree of mechanization on cost and yield.

Experiment 4—Grain losses in mechanized/traditional harvesting and threshing of wheat.

These experiments are being tried on wheat, cotton and sugarcane crops, the objectives of the study being the same as in the survey phase. Experiments 1 and 2 are for all these crops, experiment 3 is for cotton and sugarcane, while experiment 4 is only for wheat. Results of two crop cycles of cotton and one cycle each of wheat and sugarcane crops have been reported in the annual report for the current year. The interim results of two cotton crops and one year each of wheat and sugarcane are also presented.

Cotton Experiments

In experiment 1, disc plow + land plane required less water, gave more depth of plow, required more time and fuel, involved average man-animal hours, costed heavier on machines, and ranked first in production as well as in net returns. Disc plow + tractor blade ranked second. In experiment 2, the most efficient combination was drilling of both seed and fertilizers and so was in traditional trials. Whereas, in experiment 3, the highest yield and returns were directly proportional to the degree of mechanization because machines saved time, reduced man-animal labour and enhanced unit production. Statistically, the disc plow + land plane was significantly different from the tandem harrow + tractor blade combination and the tandem disc harrow + land plane but not the disc plow + tractor blade. Similarly, in experiment 2, seed drilled + fertilizer drilled was significantly different from seed broadcast + fertilizer broadcast, but not from seed drilled + fertilizer broadcast. While in experiment 3, pre-harvest mechanization was significantly different from pre-sowing mechanization, but not till-sowing mechanization.

Sugarcane Experiments

In experiment 1, the results were almost in conformity to cotton with the exception that the tandem harrow + land plane combination which ranked second. Experiment 2 was fully in conformity with the cotton results and so was in experiment 3. Statistically the combination of disc plow + land plane was significantly different from the tandem harrow + tractor blade, but not the other two combinations in experiment 1. There was no significant difference in treatments in experiment 2 and so was in experiment 3.

Wheat experiments

In experiment 1, disc plow + land plane saved water, but ranked second to the combination of tandem harrow + land plane which was the most efficient. In experiment 2, in machine trials drilling of both seed and fertilizers gave highest yield and returns, but in traditional trials, the drilling of fertilizers had no effect. Statistically, in experiment 1, the tandem harrow + land plane was significantly different from tandem harrow + tractor blade and disc plow + tractor blade combinations but not disc plow + land plane. While in experiment 2, drilling of both seed and fertilizers was significantly different from broadcast methods, but not from seed drilled + fertilizer broadcast. In experiment 4, the harvesting/threshing of wheat indicated efficiency of 96.95% for combines, 90.71% for thresher, and 84.41% for manual methods recording the grain losses of 3.05%, 9.29% and 15.59%, respectively. ■■

Effect of Land Levelling and Irrigation

(Continued from page 14)

6. Hanif, M., Ali, F., Early, A.C. and Kemper, W. Improved Soil Water and Crop Management for Increased Crop Production; Water Management Series No. 2, pp. 12, 22, 1976.
7. Howard, R.H., Donnan, W.W., Phellan, J.T and Shockley, D.G. The Use of Cylinder Infiltrometer to Determine the Intake Characteristics of Irrigated Soils, USDA-ARS, Washington, D.C. p. 44-47, 1956.
8. Johnson, S.H., Hussain, M., Khan, Z.S., Ali, B and Y.Y. Chaudhry, I.H. The Economics of Precision Land Levelling in Pakistan; Proc. Water Management for Agri., ENGRO Seminar, p. 132-143, 1977.
9. Robertson, D.W. and Gardner, H. Restoring Fertility to Land Where Levelling Operations Have Removed the Top Soil and Left Raw Sub-soil Exposed; Proc., ASST, pp. 27-33 & 44, 1964.
10. Twitty, K. and Kaulvik, P. Guide for Precision Land Levelling in Pakistan; USAID, Islamabad, 1975.
11. Waryam, A.M., Clyma, W. and Early, A.C. Installation and Use of Gut-throat Flume for Water Measurements; Tech. Bull. CSU, Lahore, 1975. ■■

Experiments on Cassava Production Technologies in Fiji



by
S. Chandra
Assistant Director of Agriculture (Research)
Department of Agriculture
Koronivia Research Station
P. O. Box 77, Nausori, Fiji



A. P. Sharma
Indian Aid Agricultural Engineer
Department of Agriculture
Koronivia Research Station
P. O. Box 77, Nausori, Fiji

Abstract

Cassava (*Manihot esculenta* Crantz) is an important staple crop in the developing nations of the tropical world. The production of this crop is extremely labour intensive. Research is being conducted in many countries to develop suitable mechanization systems in cassava. In Fiji three production technologies; namely traditional, animal and tractor based systems of production were recently assessed in the field. These production technologies are evaluated in terms of biological, economic and energetic measures. Finally, some general policy implications are drawn from the results of this study.

Introduction

Cassava is one of the most important staple food crops of the low income, indigenous populations of the tropical world. Cassava, taro, yams and sweet potatoes probably form the staple diet of 550 million inhabitants in the developing nations (Chandra, 1979a). In Fiji these four root crops account for 51% of the average daily kJ requirements of an adult indigenous Fijian (Chandra, 1979b). Of this cassava supplies almost 31% of the kJ's.

Present cassava production systems throughout the world are extremely labour intensive. These systems are almost wholly based on manual labour for harvesting. Presently considerable research is being undertaken in different countries to find less labour consuming methods of harvesting cassava. Usually these have involved the evaluation of low or appropriate technology in the cassava growing developing nations. Many of these technologies have involved the design and development of simple tractor-drawn harvesters. In Fiji such a tractor-drawn cassava harvester has recently been evaluated in the field (Sharma, 1978).

The purpose of this paper is to report the results of three cassava production technologies in Fiji. These technologies are: (a) traditional ; (b) animal ; and (c) tractor based systems of production. The present system of cassava production in Fiji is described. This is followed by an account of the experimental designs used and the results obtained. Biological, economic and energetics measures are then used to evaluate the three systems of production. Finally some general policy conclusions are drawn from the results of this study.

Present Production Systems

In Fiji cassava is mainly grown in subsistence and semi-subsistence situations. The plot sizes are small, usually ranging between 0.1 and 0.2 ha. The crop is grown on all soils in all the three major climatic zones; the wet, intermediate and dry zones. The main varieties are "Vulatolu", "Yabia Damu", "Sokobale" and "Merelista", with a growing season length of 8 to 10 months. Cassava is planted and harvested throughout the year. There are two major systems of production. In a semi-subsistence situation on flat, arable land cassava is planted in rows. After several ploughings and harrowings the ground is prepared into 15-20 cm high ridges with a row space of about 1 m. The planting material is the stem of the plant which is cut into 30 cm setts. These setts are poked into the ridges to a depth of 10 cm and at spacings of 30 cm. In a purely subsistence context or on hilly land cassava is grown on mounds. Clusters of four to five setts are used on each mound which may be 1.5 m apart between centres. Weeding is done two to three times in the first three months and by this stage the crop forms a sufficiently dense canopy to block out sunlight and therefore check weed growth. The crop is lifted out

by forks and the tubers are cut from the roots by cane knives. The tubers are large and individual tubers often weigh over 1 kg. For home use a few plants are harvested as needed. Tubers destined for the market are often bagged for transport or put in coconut frond baskets. Cassava has no serious diseases or pests in Fiji. The average annual yield is about 9 t/ha. Total annual production in Fiji could be about 35,000 t (Casley, 1969). A germplasm collection, containing 28 varieties, is maintained at Koronivia Research Station in southeast Viti Levu.

The present production system of cassava relies heavily on manual labour for almost all tasks. A very large percentage of labour is used in the harvesting task. This is illustrated in Figs. 1 and 2 which are based on empirical farm survey data collected in 1971 from nine Fijian farms in the Naduri Village in the Sigatoka Valley in southeast Viti Levu, Fiji. Cassava is the main crop grown on these farms, the other crops being sweet potatoes, broom corn, maize, water melon and vegetables. The total area of cassava on the nine farms was 6.40 ha, giving a mean plot size of 0.71 ha per farm. Labour use represented in the two figures averaged 465 man-hours/ha/year for yield of 12 t/ha of cassava.

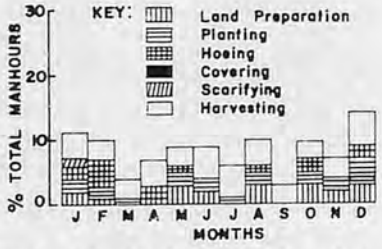


Fig. 1 Monthly labour use, by task, in cassava production

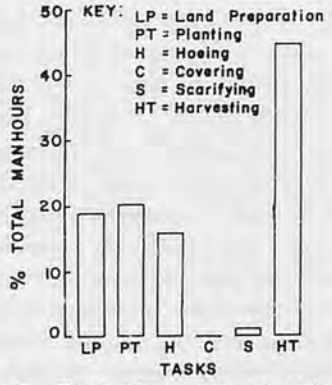


Fig. 2 Total labour use, by task, in cassava production

Experimental Designs

The experiments on traditional, animal and tractor production technologies of cassava were carried out between 1977-1978 on farmers fields in southeast Viti Levu. Annual rainfall in this area is 3,250 mm. The rainfall is distributed fairly uniformly, although the dry season from May to October obtains only 35 % of the total. The soils on which the experiments were conducted are the flat alluvial soils of the Rewa Series (Twyford and Wright, 1965). The soil texture was sandy loam to sandy clay loam.

Based on comprehensive farm interviews three farmers were selected within a short distance of each other. The selection criteria was based on the farmers' interest in the study and access to farms from the Kornivia Research Station, the central location of this study. All three production technologies were evaluated at each of the three farms, thereby giving three replicates to each production system. The plot sizes of the traditional, animal and tractor based systems of production were 0.4 ha, 0.2 ha and 0.4 ha, respectively.

The traditional and animal systems of production involved initial disc ploughing by a medium-sized (35-50 hp) tractor and all subsequent ploughing and harrrowing by bullocks. The planting of cassava setts was done manually after ridging by bullock-drawn ridger. Fertilizer application and weed control were done manually. The crop was harvested manually using forks.

The tractor system of production involved disc ploughing and disc harrowing for land preparation using a medium-sized tractor. Ridging of soil was done by tractor and the cassava setts were hand-planted. Fertilizer application and weed control operations were done manually. The crop was harvested using a tractor-drawn cassava harvester described earlier (Sharma, 1978).

Throughout the study the man-hours used for each task and the cost of each operation were recorded at site. This data was later tabulated under four headings: (a) land preparation; (b) planting; (c) fertilizer application and weed control; and (d) harvesting.

The three cassava production technologies were evaluated using three measures: (a) biological; (b) economic, and (c) energetics. The biological measure was the yield of cassava per ha. The economic measure* was the gross margin per ha. The energetics measure was the efficiency ratio "E" (the ratio between the amount of food energy produced and the amount of energy expended to produce the commodity) (Black, 1971). Specifically, in this case E is the edible yield of cassava expressed in kJ and divided by the kJ of energy expended by man, draught animals and tractor fuel to attain that yield. In the above definition the photosynthetic energy utilized by the cassava plant is not included. The higher the E of a crop the more efficient that crop is in the energetics efficiency with which it uses resources to produce food under a cropping system of a given technology. Recently considerable work has been done on the energetics of crop production in Fiji which have been reported by Chandra, 1979; and Chandra and Sharma, 1979.

*All values are expressed in Fiji dollars as of July, 1980 when $F 1.00 = $US 1.25 = Yen 277.

Discussion of Results

The results of the study are presented in **Tables 1** and **2**. **Table 1** shows the labour requirements and the costs of the three cassava production technologies while **Table 2** shows the results of the economic analysis.

As expected, **Table 1** shows that the traditional and animal production systems of cassava are extremely labour intensive, needing 788 and 883 man-hours per ha. On the other hand, the tractor production system only needs 248 man-hours per ha. In terms of production costs, including labour, the tractor production system is only about half as expensive as the traditional and animal systems.

In terms of biological yield the tractor production system had the highest output, although there is only a slight variation in yield between the three production systems. The higher yield of the tractor production system is probably due to better preparation of tilth during the land preparation stage which subsequently arrested some of the weed growth in this system compared to the other two.

The economics of production in **Table 2** shows that the tractor production system gives the highest gross margin which is about 60% greater than that obtained in the traditional and animal production systems. Most of this variation is accounted for by the higher labour costs in the latter two systems. In terms of other crops grown in this region, such as rice, sweet potatoes, vegetables and maize, the gross margin generated per ha of cassava compared with any of the three production systems is extremely favourable. The major constraint to large quantities of production would be the limited demand for cassava in the urban markets.

The high E's of the traditional (82.4) and animal production (80.2) systems indicate that the returns to energy expenditure are high, indicating an efficient staple food crop production system. On the other hand, the tractor production system (4.2) uses a large amount of energy to produce a unit of food. For the developing nations of the tropical world where cassava is a staple food crop this aspect will be particularly vital because of the escalating fossil fuel prices. In terms of energy needed to produce a unit of food there may be a good reason to shift production technologies based on tractors more towards animal and traditional production systems.

Table 1. Labour Requirements and Costs of Cassava Production/ha

Operation	Unit	Traditional	Animal	Tractor
Land preparation	Manhours	110	113	14
	Cost ($)	157	160	96
Planting	Manhours	80	88	47
	Cost ($)	32	36	29
Weed control and fertilizer application	Manhours	171	184	92
	Cost ($)	129	135	90
Harvesting	Manhours	427	498	95
	Cost ($)	207	226	97

Table 2. Economics of Cassava Production/ha

Item	Traditional	Animal	Tractor
Yield (mt)	24	25	27
Gross value at farm ($)	2,112	2,200	2,376
Production costs ($)	525	557	312
Labour costs ($)	394	442	156
Gross margin ($)	1,193	1,201	1,908

Conclusions

Three cassava production technologies were evaluated in Fiji: the traditional, animal and tractor based systems of production. The traditional and animal production systems are extremely labour intensive and incur the highest production costs. The highest gross margin per ha from cassava was obtained in the tractor production system. However, the tractor production system is very inefficient in terms of energy use per unit of food produced. In the long term the developing nations of the tropical world, where cassava is a staple food crop and where fossil fuels are becoming extremely expensive, will have to review each production technology to suit their national goals.

REFERENCES

1. Black, J.N. (1971) Energy relations in crop production – A preliminary survey. *Proc. Assoc. Appl. Biol.* 67: 272-278.
2. Casley, D.J.L. (1969) *Report on the census of agriculture*, 1968. Legislative Council Paper No. 28 of 1969, Govt. Printer, Suva; 137p.
3. Chandra, S. (1979a) Root crops in Fiji. Part 1: Production, marketing and consumption patterns. *Fiji Agric. J. 41* : 73-85.
4. Chandra, S. (1979b) Energetics of crop production in Fiji. *Agricultural Mechanization in Asia 10*, 3 : 19-24.
5. Chandra, S. and A.P. Sharma (1979) Current status of agricultural mechanization in Fiji. *Agricultural Mechanization in Asia. 10*, 3 : 28-32.
6. Sharma, A.P. (1978) Studies on the mechanized harvesting of cassava. *Fiji Agri. J.40* : 59-61.
7. Twyford, I.T. and A.C.S. Wright (1965) *The soil resources of the Fiji islands.* Government of Fiji, Suva; 2 vols., 570p. ■■

Design, Development and Testing of an Animal-Drawn Harvester



by
Madhu S. Singh
Egerton College
Njoro, Kenya

Introduction

Harvesting of major crops is done with hand sickle in India, despite of all its deficiencies, in the absence of improved harvesting machines. Manual harvesting is tedius and requires about 150 to 175 man-hours/ha to harvest a wheat crop. Due to increased shortage of agricultural labour during the peak seasons, farmers have to face great difficulties in timely harvesting of their crops. The combine harvesters which have replaced nearly all the harvesting machines in western countries, do not seem to be acceptable to Indian farmers due to prohibitive initial cost and requirement of large size plots for operation. Also these combines are not provided with the parts for making bhusa which is a valuable cattle feed. Although some work has been done to develop animal-drawn harvesting machines (Verma, 1970 and Verma and Bhatnagar, 1970) based on the design of horse-drawn American reaper but due to complicated design and relatively high draft requirement, these models could not become popular with the Indian farmers. Thus there is an urgent need to develop an *animal-drawn harvester which should be simple in construction* and draft requirement should be low enough to be operated by a pair of average-sized bullocks. This paper deals with design, development and testing of an animal-drawn harvester suitable for Indian conditions.

Design Consideration

The knife of a harvester performs a complicated motion consisting of a translation motion together with the machine and reciprocating motion relative to the machine. The reciprocating motion of the knife, with the crank rotating uniformly, is directed perpendicular to the line of travel of machine and presented by a simple harmonic motion which is defined by second order differential equation as

$$d^2x/dt^2 = -w^2x \quad \ldots\ldots(1)$$

where d^2x/dt^2 : acceleration of the knife moving along the x-axis
x: position coordinate
w: angular velocity of the crank

It follows that the relative movement of the knife can be taken to be the movement of the crank pin projection corresponding to the circumferential travel of crank pin. Thus knife stroke can be considered as

$$s = 2r \quad \ldots\ldots(2)$$

where s = knife stroke
r: crank radius

The knife speed is variable and varies from zero to maximum within one revolution of the crank. Average value of the knife speed is expressed as

$$Vav = s/60 = 4rn/60 = rn/15 \quad \ldots\ldots(3)$$

where n: crank speed (rpm)

For the harvester whose knife is driven from the ground wheel, the rpm of the ground wheel Nw, at given forward travel speed Vm and wheel diameter D, can be computed as

$$Nw = 60Vm/D(1-E) \quad \ldots\ldots(4)$$

where E: slip coefficient for ground wheel

Constructional Details

The harvester was designed and fabricated (Singh 1978) to be oper-

ated by a pair of bullocks. Pneumatic tractive wheels of size 6-16, which are commonly available in the market, were selected for the harvester. Power to the cutter bar from the ground wheel is transmitted through gears and V-belt. Forward speed of 1.5 km/hr was considered as desired linear speed of the machine as it is the average working speed of the bullocks. A rectangular frame of 80 cm x 65 cm was fabricated to support the gear box, crank and cutter bar assembly. Considering 860 strokes per min as the recommended speed of the cutter bar, the crank speed will be 430 rpm. Thus the design speed ratio of the ground wheel to crank will be 1:43. Two sets of pinion and gears with circular pitch of 0.753 cm and having 15 and 61 teeth, respectively, were used to provide speed multiplication ratio of 16 in two steps of 4 each. For engaging and disengaging the gears a jaw clutch was fabricated. The remaining speed ratio of 2.78 was provided by a V-belt. A crank was designed and mounted on the front of the frame to provide stroke length of 7.5 cm. A reel having reel index of 1.5 and 30 cm radius was designed and mounted on the frame with quick provision of horizontal and vertical adjustment. The collecting trough was fabricated from galvanized iron sheet of 20 gauge for the collection of the cut material. The complete prototype of the harvester is shown in **Fig. 1**.

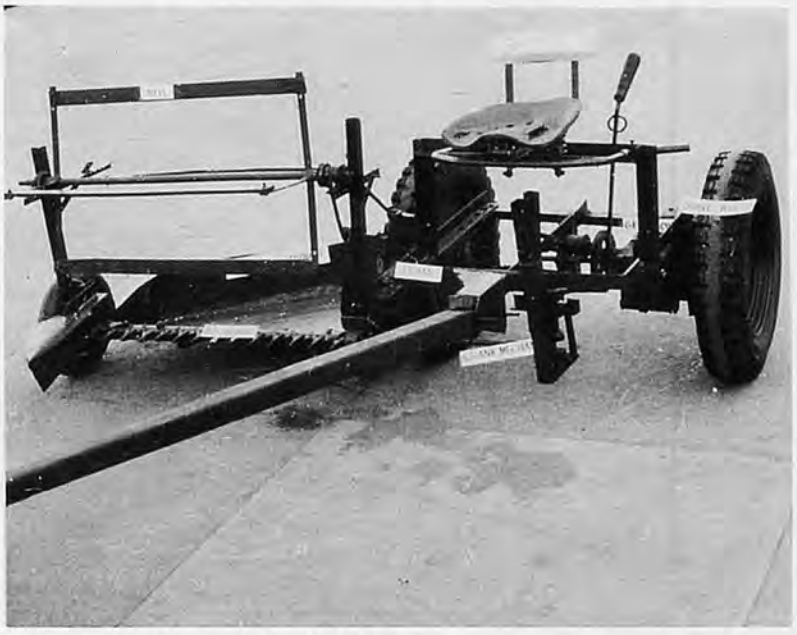


Fig. 1 The complete prototype of the harvester

Laboratory and Field Tests

The experiment was conducted to determine the power requirement for harvesting wheat variety HP 1162 at different forward speeds and plant densities. Speeds of the operation for the test were 1.5, 2.0 and 2.5 km/hr. These speeds were obtained by rotating the drive wheel 10, 13 and 16 rpm, respectively, with the help of a speed reduction unit powered by a 1.5 kw electric motor. Load variations were achieved by keeping plant densities 200, 300, 400 and 500 plants/m^2 with the help of a specially fabricated frame for simulating various crop densities during the test. The power requirement for harvesting the crop was computed by summing the power requirement to pull the reaper on wheat stubble field at no load. The power requirement to cut the crop was recorded by watt-meter at 10, 13 and 16 rpm of the drive wheel. Five replications were done for each speed and plant density. The data were analysed using multiple regression technique on DT 12 digital computer.

The harvester was tested for harvesting wheat and paddy crops at the University Crop Research Centre during May and October 1977. During the test the crop was cut and collected in the collecting trough properly as the cutter bar and other components of the harvester operated smoothly.

Results and Discussion

Effect of Speed on Power Requirement – **Table 1** shows the power requirement for harvesting wheat crop at different forward speeds and plant densities. The result is plotted in **Fig. 2** which indicates that the power requirement increased linearly with an increase in the forward speed. At lower speed of 1.5 km/hr, the power requirement was 583.2 watts at plant density of 200 plants/m^2. At higher speed of 2.5 km/hr power requirement increased to 978.7 watts at the same plant density. This increase in power requirement may be attributed to greater feed rate caused by increased forward speed.

Table. 1. Power Requirement for Harvesting Wheat at Different Speeds and Plant Densities.

Unit : watt

Crop density, Plants/m^2	Forward speed, km/hr		
	1.5	2.0	2.5
200	565.1	756.5	968.9
300	639.1	826.5	1,035.9
400	664.1	866.5	1,079.9
500	749.1	926.5	1,143.9

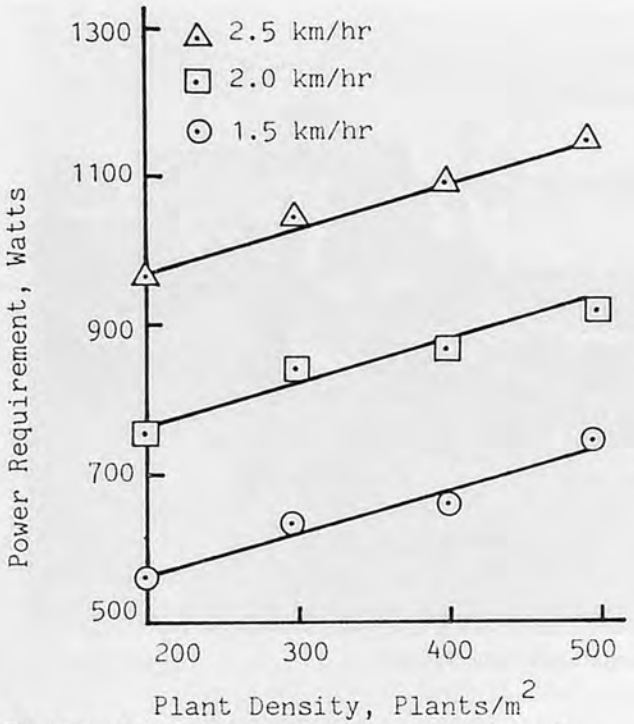


Fig. 2 Power requirement for harvesting wheat at different forward speeds and plant densities

Kepner (1952) also observed that any increase in forward speed increased the feed rate.

Effect of plant density on power requirement is shown in **Fig. 2**. It is evident that the power requirement increased linearly with increase in the plant density. **Table 1** indicates that for lower plant density of 200 plants/m^2 the power requirement is 565.1 watts at speed of 1.5 km/hr. The power requirement increased to 749.1 watts at higher plant density of 500 plants/m^2 at the same forward speed. Any increase in plant density increased the feed rate which resulted in higher power requirement. This result is in agreement with that of Loty and Singh (1975) who concluded that the cutting force increased with the increase in plant density.

From **Table 1** it is observed that the power requirement of the harvester at the forward speed of 2.0 and 2.5 km/hr are 827.8 and 978.7 watts, respectively, was greater than the power available for a pair of average size bullocks (746 watts) at the plant density of 200 plants/m^2. However at the forward speed of 1.5 km/hr, the power requirement was reasonably well within 1 hp for the plant density range of 200 to 400 plants/m^2. Plant density of 500 plants/m^2 required 749.1 watts which was higher than the available power of 746 watts.

Thus it is clear that the harvester has to be operated at forward speed up to 1.5 km/hr and plant density range of 200 to 400 plants/m^2. However, the plant density of 500 plants/m^2 is not common in the field. Therefore, the harvester can be operated continuously for longer periods at normal load of bullocks.

From the data generated a model was developed by multiple regression technique correlating the forward speed, plant density and power requirement. Thus the power requirement in watt to harvest wheat crop is given as

$$P = -32.294 + 368.828S + 0.493D$$

where S: forward speed, km/hr

D: plant density, plants/m^2

The standard error of the estimates of the regression coefficient are 8.36 and 0.031 for speed and crop density, respectively. The overall standard error of the estimate is 11.78. Goodness of the fit is 0.9 and t values were 48.17 and 18.51 for speed and crop density respectively. The coefficient of speed and plant density are significant at 0.01 level of significance. The model has been plotted in **Fig. 2**. It is evident that the forward speed and plant density both affect the power requirement.

REFERENCES

1. Kepner R.A. 1952. Analysis of the cutting action of a mower. Agricultural Engineer. 33(6): 693.
2. Lotey J.S. and Singh C.P. 1975. Studies on cutting force requirements and shattering losses incurred in harvesting of wheat. J. Agricultural Engineering 12 (3-4): 10.
3. Singh, M.S. 1978. Development of a bullock operated harvester. M. Tech. (FPM) thesis submitted to Govind Ballav Plant, University of Agriculture and Technology, Pantnagar (Unpublished).
4. Verma S.W. 1970. Bullock drawn reaper for wheat harvesting. Indian Farming 19 (11):25.
5. Verma S.R. and Bhatnagar A.P., 1970. Bullock drawn reaper with engine-operated cutter bar. Indian Farming. 19 (11):29. ■■

Farm Mechanization Research Evaluation in Pakistan



by
Sheruddin Bukhari
Assistant Professor



Bherulal T. Devrajani
Senior Agricultural Research
Engineer and Principal Investigator

Sind Agricultural University, Tandojam, Sind, Pakistan

Introduction

Pakistan, an agricultural country, holds 19.09 million hectares of cultivable land. The country's 73.43 million population possesses a little over quarter hectare of land per capita. The increasing demand for food and fibre makes agriculture the most important sector of national economy sharing about 34.5 percent to the Gross National Product employing more than 70 percent of the population resulting in very low per capita income. The main factors responsible for food deficits and poor agriculture involve population explosion, less than deserved attention on agriculture, lack of modern production techniques, shortage of essential inputs, and lack of advisory services for farmers (1).

Farm Mechanization

One of the important modern technologies is farm mechanization. Machine technology is progressing with slow speed, the manufacture of farm machinery is getting setbacks, and problems arise in the development and design of farm machines due to diversified farming and unstandardized farm operations. The operational efficiency of the existing farm machines need to be examined from the view point of macro as well as micro angles. The machines are bound to save labour, maintain timeliness of operations, ensure higher yields, and best quality of field work and products. The proper introduction of machine technology based on quality and performance of machines is important for the shift of agriculture from traditional farming to mechanized cultivation and thus overcoming food shortage and to help improve the entire sector.

Farm mechanization allows easiness of the optimization of cultural practices such as tillage, seeding, cultivating, fertilizing, plant protection, harvesting and disposal. Timeliness through mechanized operations minimizes crop losses of adverse weather. It must be accepted that the production cost per hectare or per unit product has been reduced due to modern technologies where applied. The most important of these is the increased production capability a worker can command with the use of work and drudgery at increased enhanced income opportunities in addition to eliminating the burden of work and drudgery at increased labour productivity keeping abreast of seasonal work, particularly at the peak work load periods of labour shortage even in the most economically accepted cost.

The change from man-animal labour to tractor power is essential to saving the fodder areas required to feed these animals and to devote such land to other crops of higher priority. One bullock's fodder requirement takes away the equivalent of land required for feeding two humans (3). The farms in Pakistan have employed about 16.55 million draft animals (4), which therefore, take away the equivalent of land required for feeding 33.1 million people. It will be wise to use such lands for milk and meat animals to raise animal products or to produce more food when draft animals can be replaced effectively by power machines. Also, a farmer becomes at least three times effective when he is seated on a tractor (2).

This paper relates to the findings of research on tractor and bullock farms in Hyderabad district of Sind. The study was based on the comparative information gathered from 20 tractor farms and eight traditional farms. The objective of the study was to determine the suitability and effectiveness of tractor drawn machines as compared to conventional farming.



Plate 1 Tandem disk harrow used to crush and bury the trash of sugarcane after harvest



Plate 2 Tandem disk harrow used to plow and clod crush



Plate 3 Spiketooth wooden log used for clod crushing in heavy soils

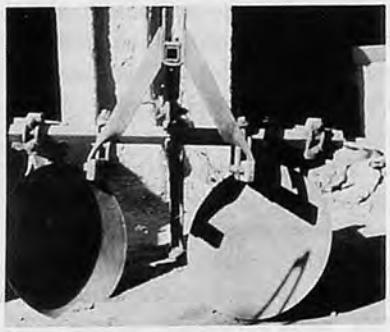


Plate 4 Single pair border disks used for making check bunds



Plate 5 Double pair border disks used for making check bunds



Plate 6 Cultivator used to open soil for seed bed



Plate 7 Cotton planter

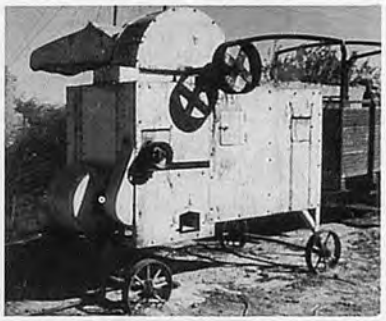


Plate 8 Tractor P.T.O.-operated wheat thresher



Plate 9 Tandem disk harrow used to thresh wheat



Plate 10 Bullock-thresh manual cleaning of wheat

Evaluation Result

Before analysing mechanization status, it was imperative to record cropping pattern to assess machine use (**Table 1**). The availability of tractor drawn implements showed that the tillage operations on these farms were almost mechanized at different levels, machines like plows and levellers constituted 69.5 percent. **Table 2** shows the number of tractor operated and bullock-drawn implements available on tractor versus bullock farms in four subdistricts of the area.

The tractors used on the selected farms ranged from 45 to 65 horsepower with the majority of 55 (75.6%) and a few of even 75 horsepower. The horsepower per hectare was not uniform. A farmer owned different makes and models of tractors with different horsepower ratings. The average horsepower per hectare on tractor farms was 0.73 including bullock power of 0.05, considering one draft animal equivalent to 0.4 horsepower (4). Whereas, on selected bullock farms, the draft animals were almost used for tillage operations and the average horsepower per hectare was 0.16 which surely indicated shortage of power input.

The use of tractors varied from farm to farm. Though the major

field operations were carried out by tractors but even then a considerable number of bullocks was still available on these farms. The tractor work hours required for different field operations depended on the resource availability, area operated, work load, nature of work and cropping intensity. The pattern of work hours used investigated on tractor-cum-bullock farms compared to non-tractor farms is shown in **Table 3**. The survey indicated that almost all the implements on tractor farms were used for longer hours to be expected in a year which could be assigned under normal farm size conditions with the exception of some machines worked for less hours due largely to the size of farm under specified crop and seasonal work nature not allowing to perform more than one job or due to restricted use in a crop for not being multipurpose. But the importance is that of economically employing available machine resources at optimum level maintaining the quality of work and the timeliness of operations. The extent of tractorization and degree of mechanization are presented in **Table 4**.

The farmers were inclined to adopt power machines but the use was not up to the mark assigning reasons of varied nature coming in the way slowing the rate of use. These problems were mostly of social, economical and technical in nature.

Table 1. Cropping Pattern

Rabi (Winter Crops)			Kharif (Summer Crops)		
Crops	Cropped Area (ha)	Percent	Crops	Cropped Area (ha)	Percent
Tractor Farms					
Wheat	1,382.01	29.32	Cotton	871.29	18.48
Sugarcane	862.79	18.50	Rice	321.73	6.82
Oilseeds	85.79	1.82	Sugarcane	405.09	8.60
Vegetables	16.19	0.34	Oilseeds	50.18	1.06
Garden	91.86	1.95	Vegetables	12.55	0.27
Fodder	173.21	3.67	Garden	91.86	1.95
Other crops	254.14	5.40	Fodder	102.39	2.17
			Other crops	40.06	0.85
Total	2,865.99	–		1,895.15	–
Fallow	1,847.40	–		2,818.24	–
Intensity	–	60.00		–	40.20
Bullock Farms					
Wheat	51.80	28.55	Cotton	25.09	13.84
Sugarcane	7.28	4.00	Rice	8.50	4.58
Oilseeds	3.64	2.01	Sugarcane	0.81	0.45
Vegetables	3.24	1.76	Vegetables	–	–
Garden	2.43	1.32	Oilseeds	1.21	0.70
Fodder	21.85	12.05	Garden	2.43	1.32
Other crops	7.28	4.10	Fodder	10.12	5.58
Total	97.52	–		48.16	–
Fallow	83.77	–		133.13	–
Intensity	–	53.79		–	26.57

Table 2. Farm Size, Power and Machinery Information

Group	Farms Studied	Farm Holdings (ha)	Tractor Farms: Tractor Implements			Tractor Farms: Bullock Implements		Tractor Farms: Horse-power per Hectare			Traditional Farms: Farm Holdings (ha)	Traditional Farms: Bullock Implements		Traditional Farms: Bullock hp/ha
			Pre-sowing (No.)	sowing (No.)	Harve-sting. (No.)	Pre-sowing (No.)	Sowing (No.)	Tractor	Bullock	Total		Pre-sowing (No.)	Sowing (No.)	
I	1	42	5	–	–	–	–	2.35	–	2.350				
	2	57	9	–	1	15	6	1.91	0.097	2.007	26	12	5	0.15
	3	121	4	–	–	28	8	0.91	0.079	0.989	30	17	5	0.16
	4	154	5	2	1	32	9	0.76	0.099	0.859				
	5	283	10	1	1	–	–	0.86	–	0.860				
II	1	113	5	–	–	45	26	0.97	0.098	1.068				
	2	182	10	1	1	–	–	0.98	–	0.980	15	10	2	0.16
	3	263	8	–	1	–	–	0.63	–	0.630	33	18	8	0.17
	4	324	10	–	1	58	20	0.68	0.091	0.771				
	5	346	16	2	1	–	–	0.91	–	0.910				
III	1	219	10	2	1	50	14	0.50	0.091	0.591				
	2	243	6	2	1	63	18	0.41	0.082	0.492	13	10	3	0.19
	3	324	11	2	1	56	8	0.65	0.074	0.724	19	11	4	0.17
	4	404	9	2	1	136	42	0.41	0.888	0.498				
	5	647	20	4	1	–	–	0.63	–	0.630				
IV	1	121	4	–	–	37	12	0.53	0.092	0.622				
	2	152	5	1	1	56	20	0.66	0.094	0.754	16	9	3	0.15
	3	182	7	2	1	66	29	0.60	0.101	0.701	30	21	7	0.16
	4	233	9	–	1	75	28	0.43	0.096	0.526				
	5	283	14	3	1	–	–	0.61	–	0.610				
Average		–	178	24	16	717	240	0.68	0.05	0.75	–	108	37	0.16

Table 3. Tractor, Bullock and Man Work Hours Per Hectare

(Unit: Hours/Hectare)

Crops Sown	Tractor Farms												Traditional Farms							
	Work									Total Work			Work						Total Work	
	Pre-sowing			Sow-ing			Harvesting/ Threshing						Pre-sowing		Sow-ing		Harvesting/ Threshing			
	Trac-tor	Bul-lock	Man	Trac-tor	Bul-lock	Man	Trac-tor	Bul-lock	Man	Trac-tor	Bul-lock	Man	Bul-lock	Man	Bul-lock	Man	Bul-lock	Man	Bul-lock	Man
Wheat	9	11	30	2	1	1	3	6	61	14	18	92	141	184	3	4	67	163	213	351
Sugarcane	16	10	52	1	4	29	–	–	326	17	10	407	190	360	21	37	–	321	211	718
Cotton	11	26	50	1	1	1	–	–	222	12	27	273	153	194	4	4	–	227	157	425
Rice	11	12	28	–	–	94	–	17	104	11	29	226	177	224	–	78	69	157	246	459
Oilseeds	7	9	31	–	3	7	–	62	158	7	74	196	111	150	1	3	66	166	178	319
Fodder	8	15	37	–	–	2	–	–	–	8	15	39	124	162	–	2	–	62	124	226
Vegetables	7	25	67	–	–	5	–	–	71	7	25	143	123	223	–	21	–	82	123	326
Garden	6	–	18	–	–	–	–	–	58	6	–	76	80	115	–	–	–	–	80	115
Other crops	7	5	11	–	–	1	–	–	73	7	5	85	121	159	–	9	–	–	121	168

Table 4. Extent and Degree of Mechanization

Farm Machines	Tractor Farms				Operations Mechanized (%)		
	Quantity Owned (unit)	Percent of Machines Owned	Total Work Hours	Percent of Total Work Hours	Tractor	Bullock	Man
Pre-sowing machines	178	81.65	62,229	87.33	58.48	13.48	28.04
Sowing machines	24	11.01	4,039	5.66	44.92	26.97	18.11
Harvesting machines	16	7.34	4,998	7.01	41.73	5.57	52.70

Conclusion

The farmers generally lacked the know-how in the field of machinery management to optimize field operations and were not fully aware of modern methods. The cropping intensity could be increased by adopting power machines and the land areas could be better utilized for enhanced unit production.

The tractors and tillage machines were utilized for a good number of hours compared to the expected yearly work hours had there been standard farm sizes related to implement widths and power units available. The majority of the tractors was of 55 horsepower. The horsepower per hectare was not uniform which averaged 0.73, including bullock horsepower of 0.05 per hectare on tractor farms.

To cultivate one hectare of land on tractor farms, an average of 9.77 tractor-work-hours supplemented by 22.4 bullock-work-hours and 170.81 man-work-hours were utilized. While one hectare of land on bullock farms used 162.32 bullock-work-hours and 344.18 man-work-hours thereby substituting 14.32 bullock-hours and 17.75 man-hours per hectare per horsepower. The man-animal labour in crop production can effectively and economically be replaced by tractor power which ensures; time saving, cost saving, yield take-off and quality of products.

REFERENCES

1. Azam, K. M. An Economic Analysis of Problems of Farm Mechanization; Trade and Industry, 9(7): 696, 1969.
2. Lees, A. B. Farm Machinery, Faber and Faber Ltd. London, 23-33.
3. Suri, M. M. Agricultural Mechanization in India; Proceedings of the International Agricultural Machinery Workshop, The IRRI Philippines, 33-42, 1978.
4. Yoshisuke Kishida, How to Promote the Mechanization for Small Farms in Asia? 78, 1978.

■■

Post Rice Production Field Losses

by
Sarath Ilangantileke
Faculty Member
Department of Agricultural Engineering
University of Peradeniya
Peradeniya, Sri Lanka

Allan Phillips
FAO Agricultural Engineering Advisor
in Chile



Merle Esmay
Professor of Agricultural Engineering
Michigan State University
East Lansing, Michigan
U S A

PART I MEASURED LOSSES IN SRI LANKA

Introduction

The loss of rice, after it has been grown and matured, reduce the farmers' financial returns. The farmers' capability to become a viable part of the economic community of a developing country is thus diminished. Post production losses also reduce the total amount of food available to the consumers of a country. Improved rice varieties, fertilizers, plant protection, water control and cultural practices have increased yields appreciably in many countries. The high post production losses from many traditional practices unfortunately nullify full realization of the increased yields.

Most Sri Lankan farmers have realized increased rice yields with the introduction of the new higher yielding varieties. Post production rice losses have, however, been estimated to be as high as 25 to 30 % (Wimberly, 1974). **Fig.** 1 shows what an estimated loss of 20 % means to Sri Lanka, as compared to total production and imports. Any post production loss reduction would reduce import requirements. A one-third reduction of losses would save over 100,000 metric tons of imported rice and the necessary foreign currency reserves.

Appropriate post rice production methods and associated technology are as important as the production phase. Improper harvesting, handling, threshing, processing, storage and marketing operations produce losses in rice quality and quantity. Factors contributing to losses in the field and off the field are numerous and vary with differing economical, technical and environmental conditions. Reliable measurements of post rice production losses in less developed countries have been limited.

The post rice production system of operations as shown by **Fig. 2** is divided into the in-field and off-field subsystems. The rice producer is generally responsible for the in-field operations. The producers are still using traditional in-field practices in most less developed countries while there have been significant technological improvements in off-farm processing, transporting, storing and marketing.

This research study was therefore focused towards the in-field post rice production subsystem of operations. Special emphasis was directed towards the development of a reliable data base for losses that occur during the pre-harvest, harvest, handling and threshing operations. In a second phase of this research study the field measurements were used to verify a system model for simulating losses from alternative combinations of technology and conditions. This paper covers the in-field loss measurement phase.

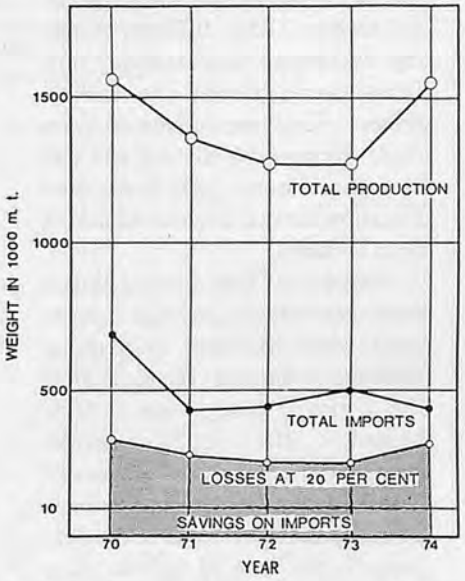


Fig. 1 The significance of post production rice losses in Sri Lanka (Losses amount to the equivalent of one-half of the imports)

Note: This field research was made possible through a doctoral internship to Sarath Ilangantileke from the Food Institute of East-West Center at Honolulu, Hawaii. Part I of this paper was presented at ASAE Meeting in Winnipeg, Canada, June 1979, Paper No. 79-5060.

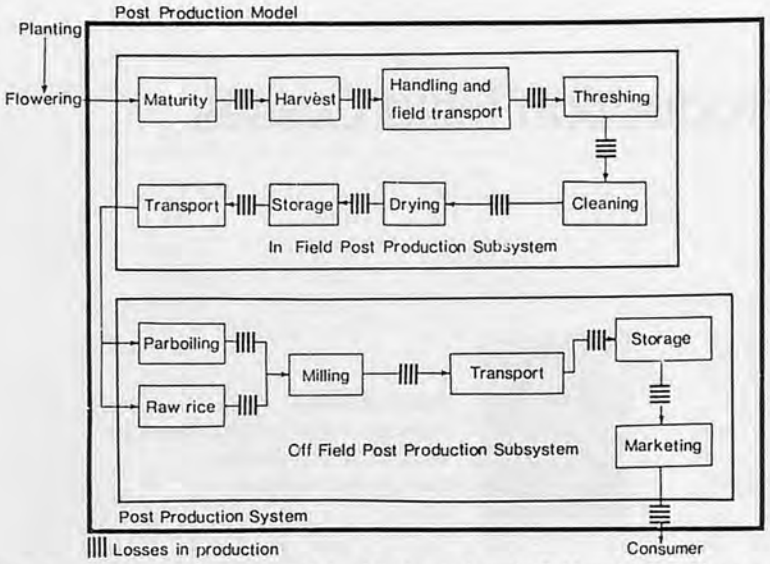


Fig. 2 A post production model with the various in-field and off-field operations in which losses occur

Methodology

The field measurements of post rice production losses were necessarily location specific and somewhat selective in order to include the range of rice varieties, growing conditions and post production methods and technologies desired. The five popular rice varieties, BG 94-1, BG 34-8, BG 11-11, BG 90-2 and H-4 were included. The choice of varieties was made within the framework of what farmers preferred for certain growing seasons. Four different threshing operations were studied, thus farms were selected to include these. Field measurements were made during both the dry and wet cropping seasons. All farms used irrigation for rice production during both seasons.

Pre-harvest and *harvest losses* were measured on one square meter plots when harvested at four-day intervals beginning 16 days after the rice crop was 50 % headed. The 50 % headed time, even though a judgement determination, is the most reliable maturity index available in the field prior to the time of harvest. One hundred and forty five one square meter plots were randomly selected on each of the farms studied. There were two farms included for each rice variety.

Transport handling losses were measured during the movement of the harvested stalk rice paddy on the heads of carriers to the threshing sites. For measurement purposes, each bundle of stalk paddy was loosely wrapped with polyethylene sheets to collect the fallen kernels. The measured transport distances averaged about 300 m.

Threshing losses were measured during four different types of operations. The threshing methods included: (1) a pair of buffalos treading on a caked mud floor; (2) a 35 hp tractor circling on a floor covered with a large jute sheet; (3) an Iseki self-feed mechanical threshing machine; and (4) a foot-pedal drum-type thresher. The pedal thresher was used in the field where the grain was harvested so stalk paddy transport losses were eliminated. Measured grain losses included unthreshed grain, wind losses and drum losses. Threshing operations were also timed.

Results and Discussion

The field measurement data for the two seasons and five varieties were analyzed with linear and polynomial regression techniques. The statistical package 'Shazam' was used for the analysis. Harvest date beyond 50 percent heading was used as an independent variable against bird and rodent damage, pre-harvest losses, post-harvest losses, transport losses and broken kernels for the four threshing methods. A polynomial regression was also performed using grain moisture content as a dependent variable against the independent harvest date variable.

The grain moisture content of the five varieties studied decreased with time beginning 16 days after 50 percent heading occurred. Grain moisture was measured on all varieties at 8 a.m. and 2 p.m. on the scheduled harvest dates. Polynomial regression equations for the average daily moisture content of each of the five varieties are shown by **Fig. 3** at the four-day interval harvest dates.

Two moisture reduction patterns are in evidence among the five rice varieties. The two varieties that lost moisture the fastest after the 16th day beyond 50 percent heading were BG 94-1 and BG 34-8. These were the dry season varieties while the other three were wet season varieties. The moisture loss patterns for the three wet season varieties were quite similar. It appeared that the seasonal moisture variation of the grain in the standing crop was greater than the variation between varieties.

Sun-checked grain kernels increased continuously with delay in the harvesting date and as the grain moisture content of the standing crop decreased. Sun checked kernels are defined as those that had evidence of a fissure across the width of the kernel. Samples were taken at all harvest dates. The kernel husks were removed and observations made for fissures. **Fig. 4** shows that the sun-checking increased quite linearly although at a different rate for each variety as the harvest date was delayed. A wet season variety, BG 11-11,

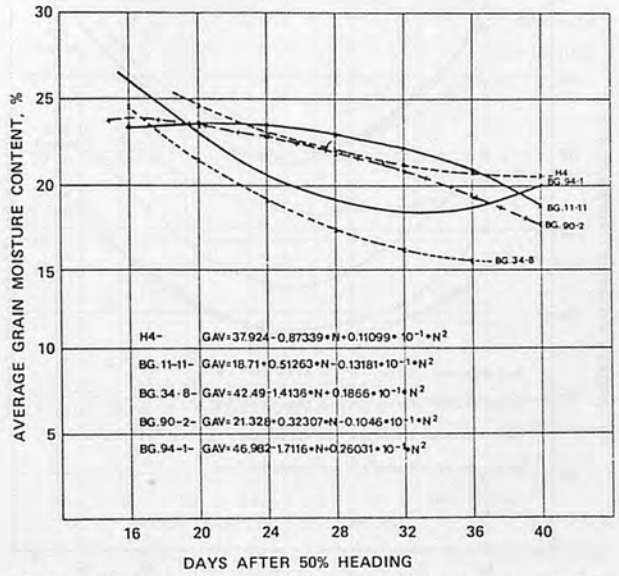


Fig. 3 The variation of grain moisture content as compared to time of harvest

	BG 34-8		BG 11-11		BG 94-1		BG 90-2		H4	
N=	20	36	20	36	20	36	20	36	20	36
4.3	12.8	29.1	9.1	19.8	5.9	12.6	5.2	10.7	2.6	9.9
4.4	13.1	32.3	13.3	37.0	6.0	32.7	4.7	21.3	2.2	13.3
4.5	8.6	31.9	9.3	27.3	4.9	9.7	5.4	12.4	3.4	10.5
4.6	28.0	45.4	25.1	63.7	33.3	50.2	20.2	36.4	10.7	27.7
	62.5	138.7	56.8	147.8	50.1	105.2	35.5	80.8	18.9	61.4

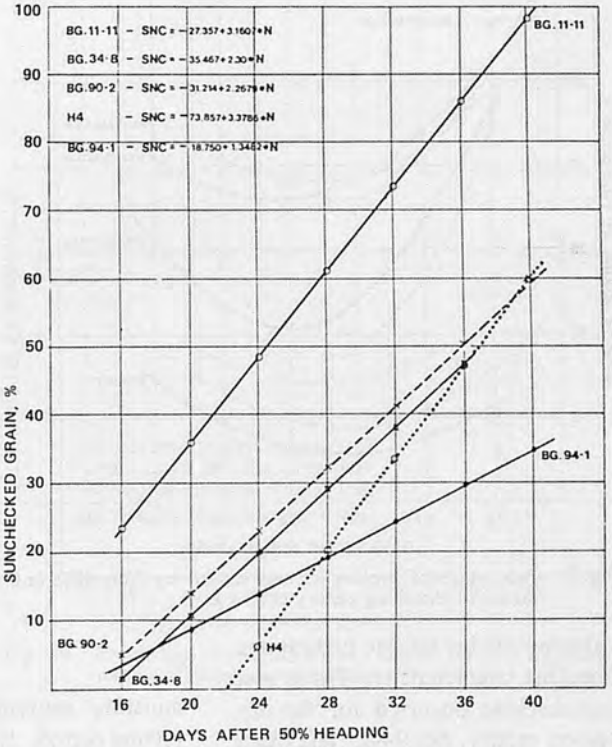


Fig. 4 Percentage of sun-checked grain as affected by time of harvest

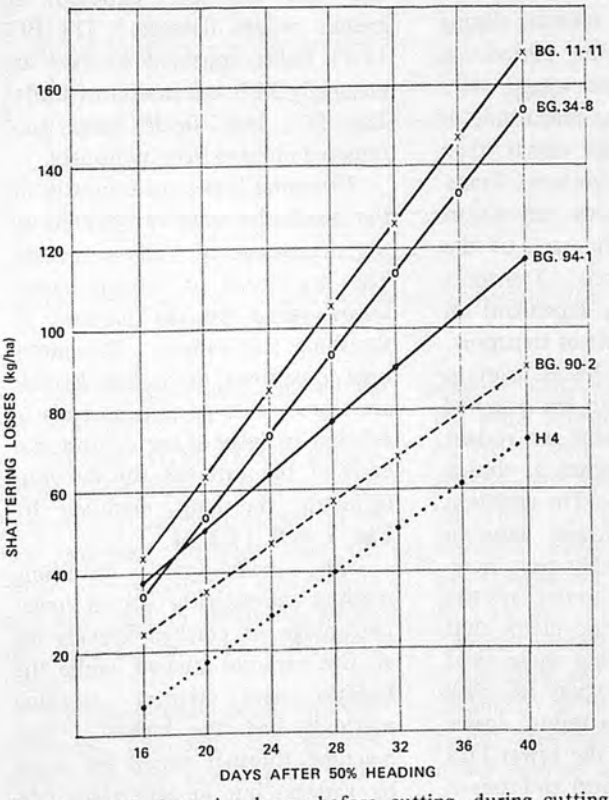


Fig. 5 Total shattering losses before cutting, during cutting, bundling and transport

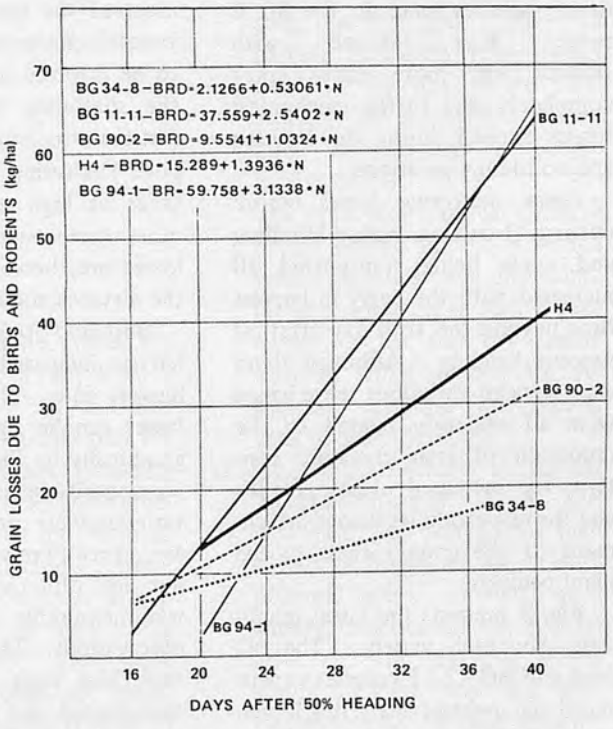


Fig. 6 Grain losses from birds and rodents as related to time of harvest

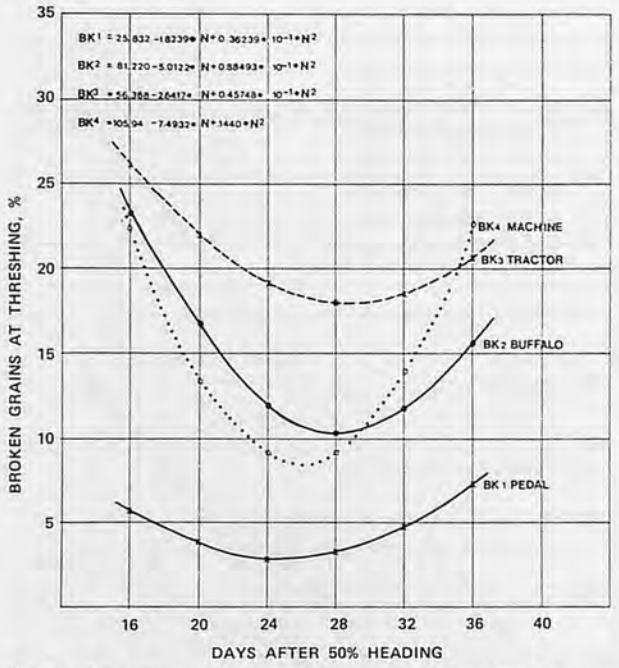


Fig. 7 Percentage of broken kernels caused by four different means of threshing variety BG 34-8

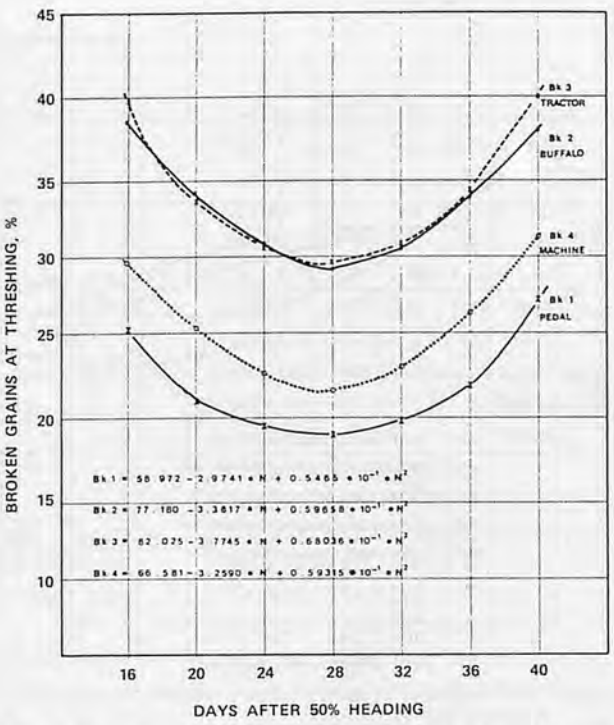


Fig. 8 Percentage of broken kernels caused by four different means of threshing variety BG 11-11

experienced by far the highest sun checking characteristic. The lowest sun-checking occurred for the dry season variety, BG 94-1. The other three varieties were grouped in between. The most vulnerable variety for sun-checking had nearly all of its kernels checked when harvested on the 40th day after 50 percent heading while the other varieties were in the 50 % range. Rice kernels with fissures will more easily crack completely due to the mechanical forces applied during the husking and polishing operations.

Grain shattering losses before cutting, at cutting, during bundling and while being transported all increased with the delay in harvest time beyond the 16th day after 50 percent heading. Although there were varietal variations these losses were all evidently related to the reduction of grain moisture content, the increased plant maturity and the associated weakened attachment of the grain kernels to the plant pedicels.

Fig. 5 presents the losses graphically for each variety. The BG 34-8 and BG 11-11 varieties experienced the greatest shattering losses. The BG 34-8 was a dry season variety with the lowest grain moisture content during the harvesting period. It might be expected that shattering losses would then be the highest of the five varieties. The BG 11-11 variety was, however, a wet-season variety and its grain moisture content stayed the highest of the five varieties during most of the harvesting period. A varietal characteristic would seem to be involved in the magnitude of the shattering losses rather than just grain moisture content. Transport shattering losses ran about twice as high as for each of the other three operations. Transport losses are, however, dependent on the distance and mode of transport.

Bird and rodent losses prior to harvest increased with the delay of harvest date. The bird and rodent losses can be significant as shown graphically by **Fig. 6**. The variation in magnitude of losses between varieties were probably not, however, directly related to the varieties nor any other specific factor that was measurable during these field observations. The variety BG 34-8 that had high shattering losses experienced one of the lower bird and rodent losses. Bird and rodent losses can be attributable to a number of external factors such as (1) bird and rodent infestation in the area; (2) presence of houses and humans; and (3) lodging of plants. In these observations the variety H-4 lodged at the grain filling stage and was therefore exposed to greater rodent damage. The BG 11-11 fields appeared to have an unusually high infestation of birds. The BG 34-8 fields were surrounded more closely by houses.

Threshing losses were mostly of the qualitative type as reflected by the percentage of broken kernels. The magnitude of broken kernel losses varied by the method of threshing and variety. The measured quantities of broken kernels are shown on a percentage basis in relation to delay of harvest time for each of the varieties for the four different threshing methods by **Figs. 7, 8, 9, 10 & 11.**

The pedal-drum threshing method consistently had a lower percentage of cracked kernels for all five varieties studied, while the buffalo and tractor treading methods had the highest. The machine thresher varied for some by variety, but in general its percentage of cracked kernels was in

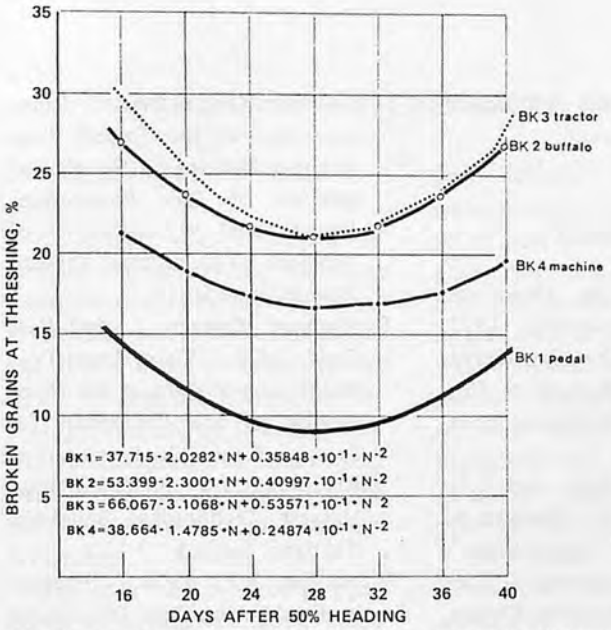


Fig. 9 Percentage of broken kernels caused by four different means of threshing variety BG 90-2

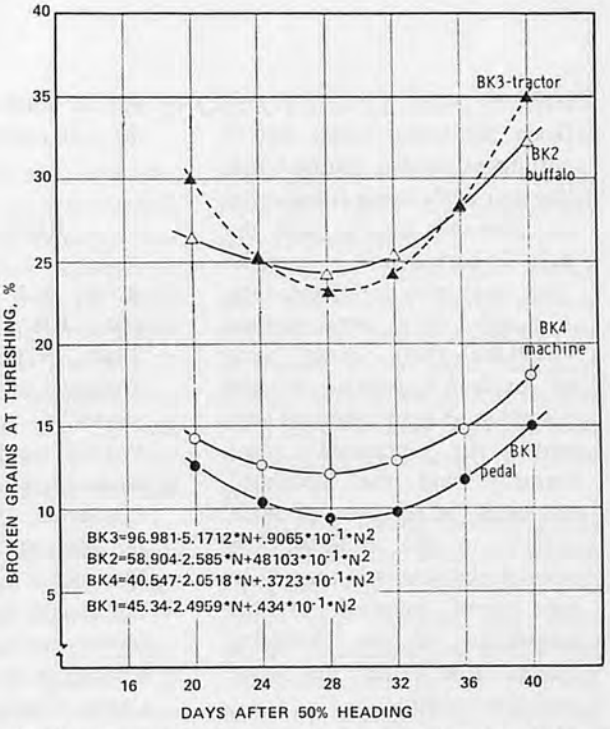


Fig. 10 Percentage of broken kernels caused by four different means of threshing variety H-4

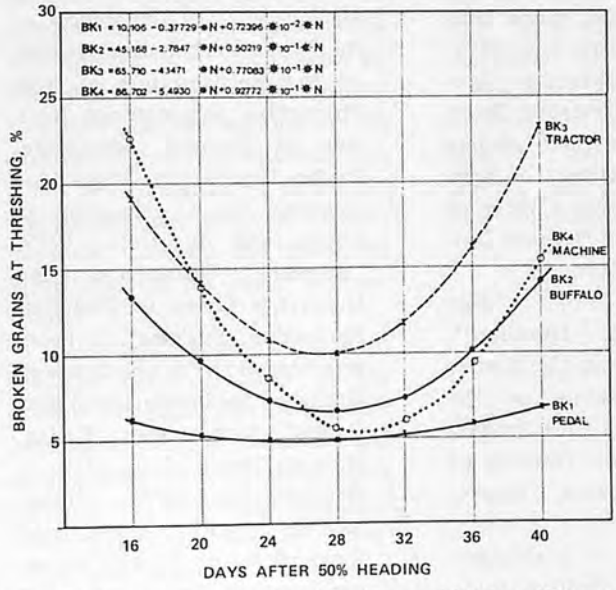


Fig. 11 Percentage of broken kernels caused by four different means of threshing variety 94-1

the middle range as compared to the other three.

The BG 11-11 variety experienced appreciably higher percentages of cracked kernels for all of the threshing methods than the other four varieties. This variety was also high in shattering losses, sun checking and bird and rodent losses.

The foot-pedal drum thresher evidently provided the gentlest impact on the rice kernels while still accomplishing the task of separating the grain from the stalks. Cracked kernel losses for the pedal thresher ran only from 5 to 10 % with four of the five varieties and about double that for the fifth. The other threshing methods caused cracked kernel percentages as high as the 30 to 40 % range. The foot pedal thresher represents a lesser investment than any of the other three threshing methods. Also, stalk paddy transport losses are eliminated because threshing is done in the field where the stalk paddy is cut.

Conclusions

The following conclusions are based upon the Sri Lanka field measurements and analysis:

1. The moisture content of the stalk paddy grain prior to harvest decreased from about 24 % at 16 days after 50 % heading to somewhere below 20 % at 40 days depending on the variety.
2. The grain moisture loss patterns before harvest for the three wet season varieties were quite similar and appreciably higher than those for the two dry season varieties, which implied that the seasonal variation was greater than between varieties.
3. Grain sun-checking at harvest increased linearly as the harvest date was delayed for each variety although at appreciably different rates. A wet season variety experienced the highest level of sun checking which would indicate that this phenomenon may be more dependent on varietal characteristics than the grain moisture content

level.

4. Grain shattering losses before cutting, at cutting, during bundling and while being transported all increased linearly with the delay in harvest time beyond the 16th day after 50 % heading. Although there were varietal variations these losses were all evidently related to the reduction of grain moisture content, the increased plant maturity and the associated weakened attachment of grain kernels to the pedicels. A varietal characteristic seemed to have been involved in the magnitude of the shattering losses rather than just grain moisture content.
5. Bird and rodent losses prior to harvest increased linearly with the delay in the harvesting date. Some varietal differences were recorded. However, the magnitude of such losses were attributable mainly to the external factors of bird and rodent infestation, the presence of houses and humans, and the degree of plant lodging.
6. Threshing losses were mostly qualitative and measured by the percentage of broken kernels. The pedal-drum threshing method consistently showed the lowest percentage of cracked kernels for the five varieties studied, while the buffalo and tractor treading methods had the highest levels.
7. Cracked kernel losses for the pedal thresher ran only from 5 to 10 % with four of the five varieties and about double that for the fifth. The other threshing methods caused cracked kernel percentages as high as 30 to 40 %.
8. The foot pedal thresher represents a lesser investment than any of the other three threshing methods. Also, the stalk paddy transporting losses are eliminated by pedal threshing as it can be done in the field where the stalk paddy is cut.

REFERENCES

1. Arora, V.K., S.M. Henderson and T.H. Burkhardt, 1973. "Rice Drying Cracking Versus Thermal and Mechanical Properties". ASAE Transactions. Vol. 16, No. 2.
2. Bhattacharyya, K.K. and B.N. Chatterjee, 1977. "Studies on the Maturity of Rice Grains". The RPEC Reporter. Rice Processing Engineering Center, Indian Institute of Technology, Kharagpur, Vol. 3(1).
3. Chung, Chang Joo, Whoa Seng Kang and Chong Ho Lee, 1977. "Determining Optimum Timing of Paddy Harvesting Based on Grain Loss and Milling Quality". Department of Agricultural Engineering, College of Agriculture, Seoul National University, Suwon, Korea.
4. Curfs, H.P.F., 1974. "Rice Harvesting and Threshing". Paper presented at the Expert Consultation Meeting on the Mechanization of Rice Production. International Institute of Tropical Agriculture, Ibadan, Nigeria.
5. Esmay, M.L., Soemangat, Eriyatno and A. Phillips, 1979. "Rice Postproduction Technology in the Tropics". East-West Center, University of Hawaii Press, Honolulu, Hawaii.
6. Ilangantileke, Sarath G., 1978. "In-Field Post Production Losses on Small Farms in Sri Lanka". A paper presented at the workshop on Grain Post Harvest Technology, Department of Agriculture, Royal Thai Government and S.E. Asian Cooperative Post-Harvest Research and Development Program, Bangkok, Thailand, January 10-12.
7. Jacobi, B., 1974. "Some Aspects of Rice Harvesting and Threshing Operations in Orissa". Paper presented at the Expert Consultation Meeting on the Mechanization of Rice Production, International Institute of Tropical Agriculture, Ibadan, Nigeria, June 10-14.
8. Maranan, Celerina L. and Bart Duff, 1978. "Farm Level Post Production System in the Bicol Region of the Philippines (A Progress Report)". Presented at the Workshop on Grain Post Harvest Technology, Bangkok, Thailand, January 10-12.
9. Nichols, F.E., 1974. "Factors in Establishing Test Procedures Under Local Conditions for Harvesting and Threshing Machinery". In the Report of the Expert Consultation Meeting on the Mechanization of Rice Production, International Institute of Tropical Agriculture, Ibadan, Nigeria, June 10-14.
10. Toquero, Z., C. Maranan, L. Ebron and B. Duff, 1977. "Assessing Quantitative and Qualitative Losses in Rice Post Production Systems". Paper presented at the Action Oriented Workshop for Prevention of Post Harvest Rice Losses, Kedha, Malaysia, March 12-30, 1978.
11. Wanders, A.A., 1974. "International and Coordinated Research Project on Rice Mechanization – GP4/1 TE INT 43(NET) Rice Harvesting and Threshing". Paper presented at the Expert Consultation Meeting on the Mechanization of Rice Production, International Institute of Tropical Agriculture, Ibadan, Nigeria, June 10-14.
12. Wimberly, J.E., 1975. "Ford Foundation International Rice Research Institute, Post Production Projects in India and Sri Lanka". Presented at a Planning Meeting on Post Harvest Crop Protection, East-West Food Institute, Honolulu, Hawaii.

PART II A SYSTEMS MODEL OF POST RICE PRODUCTION LOSSES

Development of the Model

A model was developed to simulate the rice cutting, bundling, transport and threshing operations at the farm level. A weather model was incorporated to simulate the effect of rainfall patterns on the post production operations. Post rice production operation losses were simulated based upon the field loss measurements made in Sri Lanka.

The post rice production operations of cutting, bundling, transporting and threshing are described in rates of hectares per hour. The integral of the rate over some time interval gives area covered by the operation. The Euler's formula was used for the solution of the differential equations of this model. The Euler approach, by its simplicity but still with adequate solution accuracy, reduced the time and effort required for model development.

The model inputs consisted of maturity dates, described as the number of days after 50 percent heading; and known shattering and lodging characteristics based upon variety. The harvesting, bundling, transporting and threshing operations were simulated for a given land area. The delay effects simulated by weather and labor models were introduced. The model was designed to begin harvesting an average field size of 0.94 ha on the 16th day after 50 % heading, and on each fourth day afterwards up to 40 days after 50% heading.

The number of days required to complete the post production operations for the given area and the losses accumulated varied with the operational delays caused by weather and labor shortages. The model output consisted of grain losses, rain days, labor used and the total period of days required. Four different threshing methods were simulated for each simulated set of post harvest operations. The post rice production subsystem model is shown by **Fig. 12**. The model delayed cutting while there was simulated rain or less than 5 laborers available. Preharvest losses were based upon the time of beginning the harvest plus the delay in completing the harvest after 50 % heading.

The Labor Model. The labor subroutine assumed that labor availability followed a Gaussian or normal distribution. The model delayed the cutting operation if there were less than 5 laborers available.

The Rain Model. The occurrence of rain or no rain was simulated by the model of Jones, Colwick and Threadquill (1972). The subroutine was formulated from 20 years of rainfall records from the Maha Illuppalama dry zone research station.

Harvesting Operations. When labor and weather conditions were satisfied the cutting operation was performed for an eight hour day. A hand cutting rate of 0.013 ha/hr/labor unit was used. An extra labor requirement was inserted for lodged grain.

After harvesting, the stalk paddy was left in the field for drying. After one day of drying the stalk paddy was bundled and transported. No limitations were placed on labor availability for the bundling and transporting operations. The labor model generated data were supplemented by family labor. Removal of the stalk paddy from the field was assumed as a priority operation. Therefore any available labor was used. The available labor

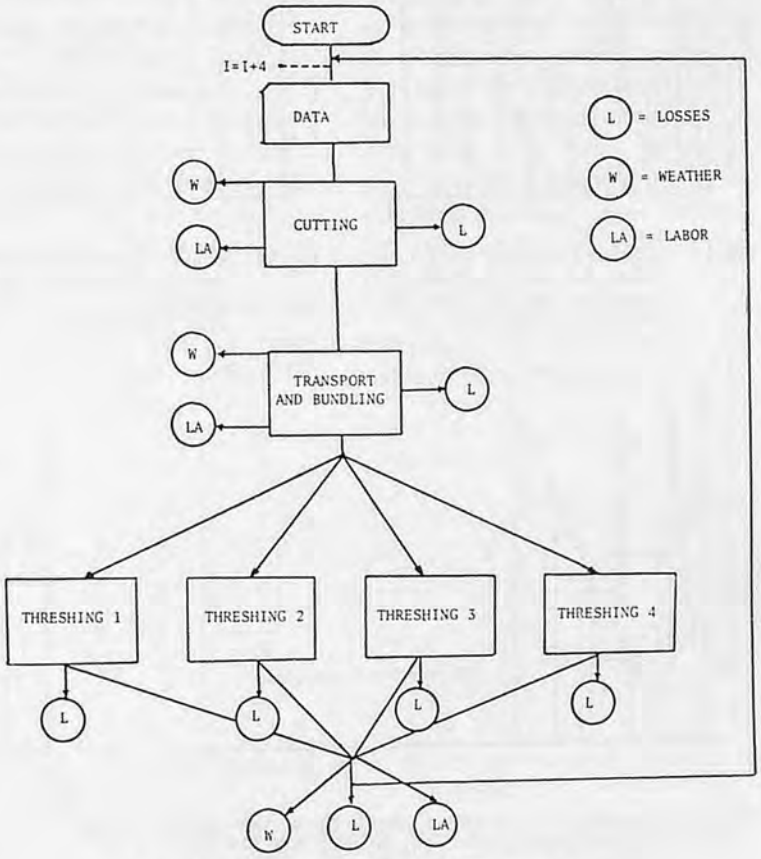


Fig. 12 The post production farm level model

was split two-thirds for transporting and one-third for bundling. Bundling and transporting losses were imposed by the model based upon the previously made in-field measurements.

Threshing Models were developed for four different threshing methods: a) pedal; b) buffalo; c) tractor treading; and d) machine. The pedal threshing was done in the field while the other three methods required the transport of the stalk paddy bundles to a central threshing floor. Threshing rates and losses were based upon previous field measurements. One advantage of the machine threshing was that the stationary thresher was assumed to be under shelter, and threshing could be carried out regardless of weather conditions.

Simulation Results

The harvesting operations for one variety BG 11-11, were simulated for 0.94 ha units as starting every fourth day on and after the 16th day after 50% heading. When the harvest began on the 16th day, 11 days were required to complete all operations of cutting, bundling, transporting and threshing with the pedal thresher (see **Fig. 13**). The resulting simulated threshing operation stretched over a period of 7 days. Two rain days prevented any threshing from taking place. The two earlier rain days did not prevent bundling and transporting. However, the pedal threshing was then done off the field. Available labor is shown by **Fig. 14** and harvesting losses are shown by **Fig. 15**. The unavailability or labor did not cause any delays in the harvesting operations. Total losses were relatively light at 43 kg/ha.

Although the harvesting operations were simulated beginning every 4th day after 50 percent heading, only three are included for illustration purposes in this paper (16th, 28th and 40th day). The harvesting operation beginning on the 28th day represents one taking place under quite ideal conditions (see **Fig. 16**). No rainy days were encountered and 9 labor units were available for harvesting (see **Fig. 17**). Thus all harvesting operations were completed early on the 6th day. The grain losses associated with the different harvesting operations are illustrated in **Fig. 18**. Note that losses nearly doubled for the harvest beginning on the 28th day as compared to the 16th day even though there was no rain delay nor transport losses.

The latest harvesting schedule, simulated as beginning on the 40th

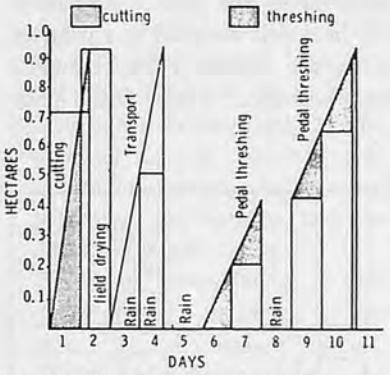


Fig. 13 Simulated rice harvesting operations for variety BG-11-11 beginning on the 16th day after 50% heading

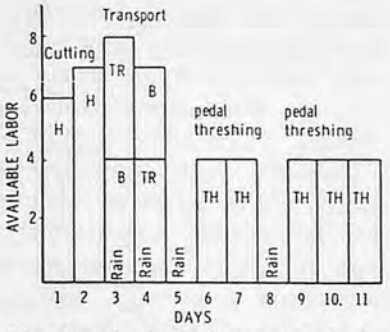


Fig. 14 Simulated labor availability for the rice harvesting operations beginning on the 16th day after 50% heading

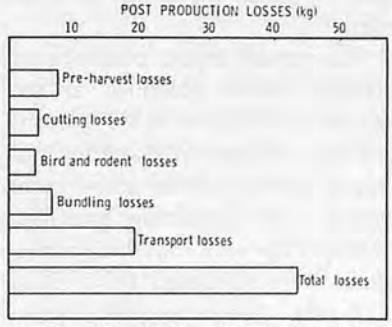


Fig. 15 Simulated harvesting losses when operations started on the 16th day after 50% heading

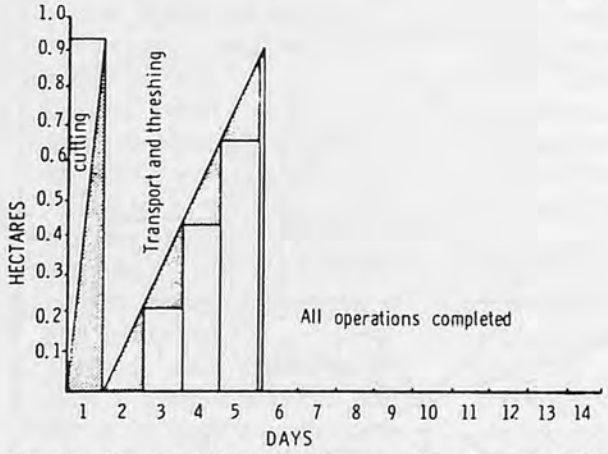


Fig. 16 Simulated rice harvesting operations for variety BG 11-11 beginning on the 28th day after 50% heading

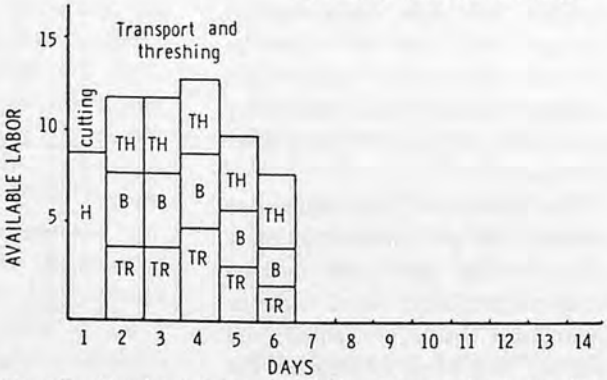


Fig. 17 Simulated labor availability for the rice harvesting operations beginning on the 28th day after 50% heading

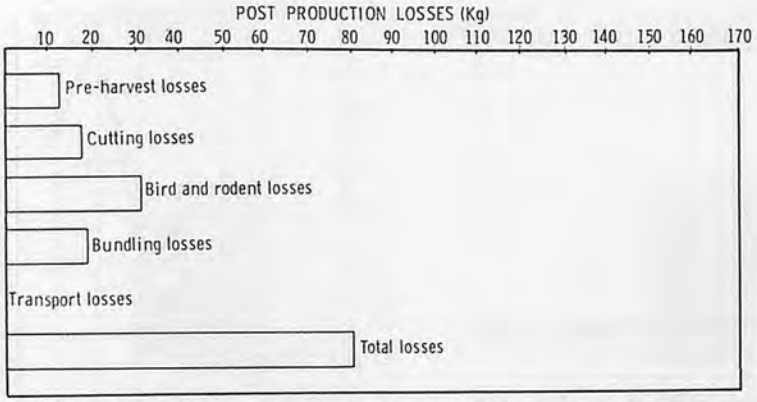


Fig. 18 Simulated harvesting losses when operations started on the 28th day after 50% harvesting

day after 50 percent heading, covered a period of 14 days and is illustrated by **Fig. 19**. Not only was this harvest very late in getting started but one week of rain was encountered during the harvesting operations. Only five units of labor were available the first day so not all of the cutting was completed (see **Fig. 20**). Bundling and transport were carried out on the second day even though it rained. No further operations were possible until the 9th day.

By the 40th day when this most delayed simulated harvesting operation took place sun-checked grain was simulated at 99 %. It will be noted from **Fig. 21** that total field losses were simulated to be 230 kg. This was nearly triple the simulated losses of 43 kg for the earliest harvesting operation carried out at 16 days after 50 % heading.

The harvesting operations were also simulated for the other threshing methods of buffalo treading, tractor treading, and machine. **Fig. 22** illustrates the simulated percentages of broken grain resulting from the various threshing methods, and the average moisture content for the different harvest dates. It will be noted that both the tractor and buffalo threshing operations caused the highest percentage of broken grain. The pedal thresher broke the least grain at all moisture content levels. The most optimum time of harvest for minimum threshing losses was the 28th day after 50 % heading. This would be when the moisture content was 22-23 % wet basis.

Simulated total grain losses for the in-field post production operations are illustrated by **Fig. 23**. Total grain losses increased quite consistently with delay in time of harvest from 16 to 40 days after 50 % heading. Total grain losses with the pedal thresher were less than for the other threshing methods when the threshing could be done in the field in order to eliminate transportation losses. If, however, rain interrupted the cutting operation, the stalk paddy was transported to the threshing center. Simulated rain delays occurred when harvesting was done with the pedal thresher at 16, 20, 32 and 40 days after 50 % heading.

Rain delays during harvesting as simulated by the model, were shown to be critical. Rain extended the harvesting period to 14 days at one time while the 0.94 ha was once harvested in 6 days with no rain delay. The pedal threshing operation was simulated under optimum conditions at 36 days after 50 % and reduced losses to less than half of that shown for the other three methods. The other three threshing methods all experienced rain delays at 36 days after 50 % heading. At 40 days after 50 % heading the pedal threshing method was delayed by rain while the other three methods were not.

The simulation results show the complex interdependence of weather, labor availability, delay in

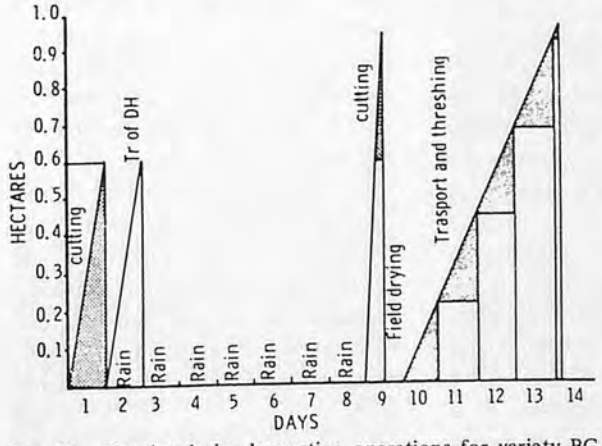


Fig. 19 Simulated rice harvesting operations for variety BG 11-11 beginning on the 40th day after 50% heading

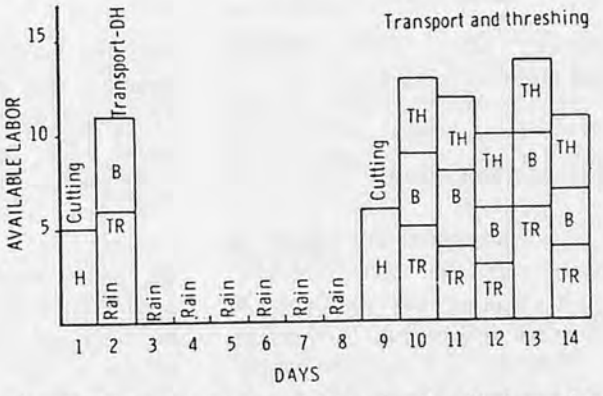


Fig. 20 Simulated labor availability for the rice harvesting operations beginning on the 40th day after 50% heading

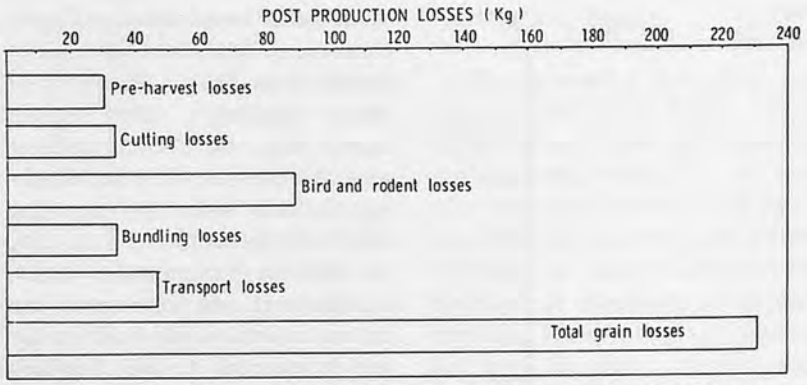


Fig. 21 Simulated harvesting losses when operations started on the 40th day after 50% harvesting

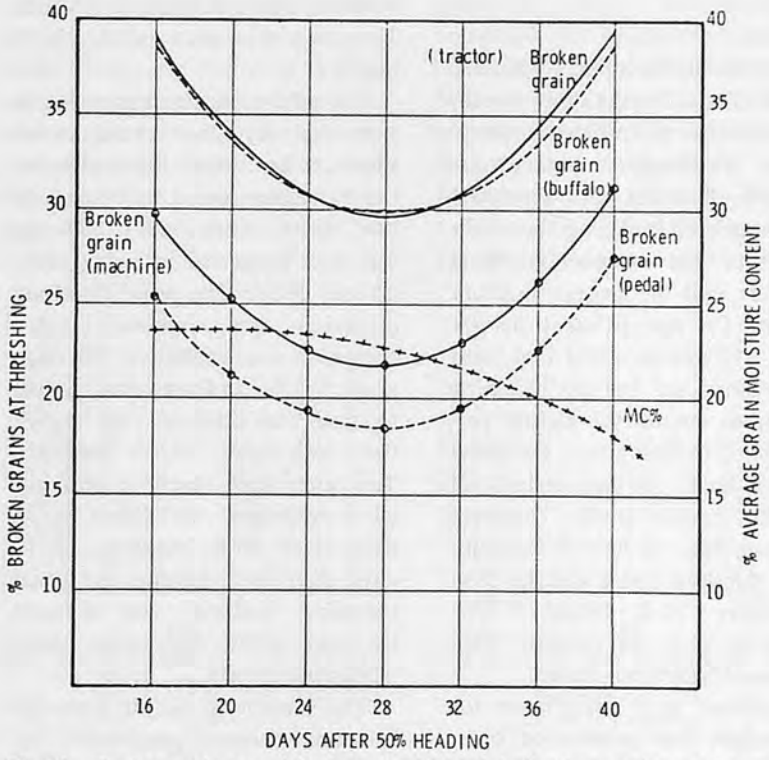


Fig. 22 Broken grain caused by four threshing methods when carried out from 16 to 40 days after 50% heading and the moisture content at time of harvest

cutting after 50% heading and threshing technology.

Recommendations

1. Rice harvesting should be done near the 28th day after 50% heading has occurred. At this time broken grain by threshing is minimized and total post production losses are in the middle range.

2. The foot pedal drum thresher is strongly recommended over the buffalo treading, tractor treading and machine threshing. The pedal drum thresher cracked about 12% less grain than the two treading methods and 3 to 4% less than the machine thresher. Pedal drum threshing in the paddy field eliminates transporting the stalk paddy to a threshing floor and the associated losses of 40 to 100 kg per ha. The foot pedal drum thresher is a simple, low-cost appropriate means of threshing stalk paddy in the field immediately after cutting to minimize field drying and transporting losses.

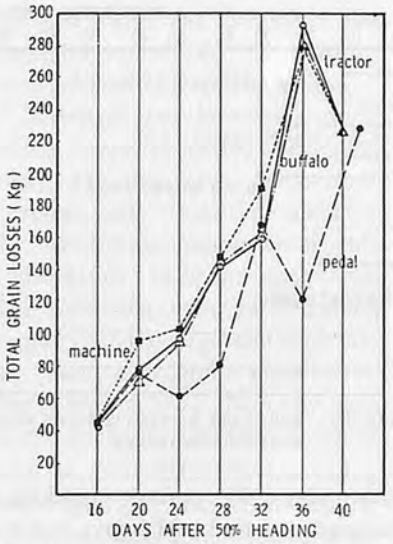


Fig. 23 Simulated total grain losses for the in-field post production operations as carried out from 16 to 40 days after 50% heading

3. The labor model indicated that sickle cutting of the paddy at the optimum harvesting time was possible. Sufficient labor was thus available without undue constraints or shortages. Labor availability can, of course, vary with time and place so the labor model coefficients must be revised accordingly for specific simulation studies. Replacement of hand cutting with a machine is particularly difficult as there are few viable intermediate type machines available. Technology for mechanical harvesting thus shifts to the quite sophisticated and expensive self-propelled binders and combine harvesters which are not feasible at this time in many countries.

4. Simulation modeling should be used in planning rice production programs. The feasibility of various post production technology packages can be analyzed in order to compare alternative technology, minimize losses and utilize available labor. ■■

Paddy Post Harvest Technology in Bangladesh





by
Jatindra Nath Samajpati
Head

Md. Shawkat Ali Sheikh
Lecturer

Md. Siddiqur Rahman
Assistant Professor
Department of Agricultural Engineering and Basic Engineering, Bangladesh Agricultural University, Mymensingh, Bangladesh

Abstract

In this paper attempts have been made to give an account of the production and the post-harvest processes of paddy that are currently followed in Bangladesh. All the processes like harvesting, threshing, parboiling, drying and storing are very premitive and time consuming. In every stage there is the possibility of grain loss due to various causes and hence the post-harvest losses of paddy in Bangladesh is estimated to be as high as 22 percent. This quantitative and qualitative losses can be reduced by improved threshing, drying and storage facilities at the farm level.

Introduction

Bangladesh is an agricultural country and rice is the staple food of the 82.7 million people. The country is a food-deficit and every year it becomes necessary to import rice and other cereals at the expense of valuable foreign exchange. The import of cereals may range from 10 to 13% of the total domestic production (Islam, 1977). Due to primitive harvesting and conservation methods the post-harvest losses lies between 8 and 22% (Bala, 78). Although paddy fields of Bangladesh are considered naturally fertile, the average yield is 1.5 m.t./ha which is one of the lowest in the world.

Bangladesh produces four rice crops in a calendar year. Although these four crops cannot be grown in the same land, in some areas the individual farmer can grow two to three crops on the same land. The average crop intensity for rice is 1.48 (Monthly Statical Bulletin of Bangladesh, January, 1977). The total area and percentage of cultivable lands are shown in **Table 1**. Of the four types of rice, Aman is the major crop and grows mainly in upland, transplanted in July – August and harvested in November – December. Aus and Boro are two other crops. Aus is a rainy season crop and is broadcast in lowland in the months of April – May and harvested in July – August. Boro is a dry season crop and traditionally grown in lowlands. **Table 2** may be regarded as the representative production of different types of paddy in Bangladesh.

In order to cope with the food crisis, high yielding varieties have been developed in research institutes in the country. The improved high yielding varieties, specially IR-8, can be grown all year round provided irrigation facilities are available. The production, import and price of paddy are shown in **Table 3**.

Harvesting

In most areas of Bangladesh, the paddy is left standing in the field for sundrying so that its moisture content is between 20 – 28%. Harvesting time is determined by the experience of the farmers and is done by hand with sickle (**Fig. 1**). The harvested paddy in most cases is stacked for a few days before threshing.

Both harvesting and threshing methods affect the quality and yield of paddy. Harvesting of Aman paddy takes place in dry weather and the farmers are very busy during this period of harvesting and threshing. If the paddy is overmature, shattering occurs, cracking develops in the grain and some of the grains fall in the field and lost during cutting and transporting. The reaping of paddy is shown in **Fig. 2**.

Threshing

The farmers thresh paddy immediately after harvested or they stack the paddy bundles and thresh at a favourable time. Sometimes threshing is done 10 – 15 days

Table 1. Land Utilization Statistics of Bangladesh by Districts 1974–75 and 1975–76

(Area in '000' acres)

District	Total Area	Net Available for Cultivation		Forest		Cultivable Waste		Current Fallows		Cropped Area									
										Single		Double		Triple		Net		Total	
		1974–75	1975–76	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76
Dacca	1,845	398	398	65	65	9	9	124	162	779	752	372	362	98	96	1,249	1,210	1,818	1,763
Kisheregani*	1,372	309	310	3	3	48	47	102	29	445	466	422	463	43	54	911	983	1,419	1,554
Mymenshingh	1,866	282	282	65	64	17	17	125	86	505	509	784	815	88	93	1,377	1,416	2,336	2,416
Tangail	833	78	78	113	113	20	20	14	23	293	189	218	216	96	94	607	599	1,017	1,003
Faridpur	1,724	442	443	–	–	5	5	81	80	566	667	426	426	104	104	1,196	1,197	1,831	1,832
Chittagong	1,731	319	320	518	519	40	39	106	118	439	431	268	265	40	40	747	736	1,095	1,081
Chit. Hill Tracts	3,260	67	92	3,001	2,969	10	14	7	10	83	84	81	82	9	9	173	175	273	276
Noakhali	1,187	157	157	5	5	72	71	134	38	499	510	257	315	65	90	820	916	1,207	1,412
Comilla	1,660	257	266	2	2	14	11	238	151	725	593	400	554	25	82	1,150	1,230	1,600	1,949
Sylhet	3,062	825	826	197	197	139	138	151	85	1,305	1,226	407	540	38	60	1,750	1,816	2,233	2,477
Rajshahi	2,339	500	502	7	7	74	72	86	79	1,247	1,249	344	347	80	82	1,671	1,678	2,174	2,188
Dinajpur	1,670	294	295	24	24	63	62	174	183	727	726	293	288	96	92	1,116	1,105	1,600	1,577
Rangpur	2,371	520	521	5	5	86	85	115	62	529	531	971	999	146	169	1,645	1,698	2,908	3,035
Bogra	961	215	215	–	–	2	1	27	28	396	395	262	261	61	60	718	716	1,101	1,097
Pabna	1,201	232	233	–	–	1	1	151	85	481	496	266	298	70	89	817	883	1,224	1,359
Khulna	2,977	447	447	1,426	1,426	6	6	126	75	780	811	175	187	17	26	973	1,024	1,182	1,262
Barisal	1,669	448	449	13	13	25	25	35	20	775	776	221	234	151	153	1,147	1,163	1,671	1,702
Patuakhali	1,045	305	305	22	26	15	15	65	48	493	498	137	142	8	10	638	650	789	811
Jessore	1,630	340	340	–	–	23	23	22	63	888	835	322	332	35	38	1,245	1,205	1,637	1,613
Kushtia	877	141	142	–	–	22	1	129	166	426	416	173	143	9	8	609	568	801	728
Total	35,280	6,576	6,622	5,466	5,438	670	662	2,002	1,591	12,481	12,250	6,799	7,269	1,279	1,449	20,559	20,968	29,916	31,135

* Kishoreganj and Netrokona Sub-divisions of Mymensingh district are considered as a separate agricultural district and named as Kishoreganj district.
Source: Bangladesh Bureau of Statistics. (1978).

Table 2. Percent-Wise Seasonal Distribution of Paddy, Acreage and Production

Crop Type	Area %	Production %
Aman	58	59
Aus	33	25
Bore	9	16

Source: Andersen and Hoberg (1974).

Table 3. Production, Import and Price of Paddy

Year	Production (1000m.t.)	Import (1000m.t.)	Average Retail Price (Dacca) Rice-boiled Medium Taka/Seer*
1973–74	11,720	86	–
1974–75	11,109	264	6.79
1975–76	12,561	396	4.06
1976–77	11,600	196	3.51

* One seer equals 933.1459 grams, one Taka equals 0.065 dollar (U.S.).
Source: Monthly Statistical Bulletin of Bangladesh, Vol. IV, No-1 and 9, 1977.

Fig. 1 Sickle for paddy

Fig. 2 Reaping of paddy

after harvest. Delay in threshing of stacked paddy often results in qualitative and quantitative losses due to warm and moist conditions inside the stack.

Threshing is mostly done by treading the paddy bundles with bullocks (**Fig. 3**). Hand beating of paddy bundles over a log or table is also practiced to a limited extent. Although mechanical threshing is very rare in Bangladesh, pedal threshers are used in Comilla and some other districts. This type of mechanical threshing reduces



Fig. 3 Bullocks tread paddy stacks

Table 4. Output of Different Threshers

Type of Threshing	Horse-Power	Output (kg/hour)
Hand Beating	–	17–20
Trading with Bullocks	–	140
Pedal Thresher	–	40–54
Table Thresher (engine powered)	3	207
Drum Thresher (Engine Powered)	4	250

Source: Campbell, (1976).



Fig. 4 Parboiling of rice

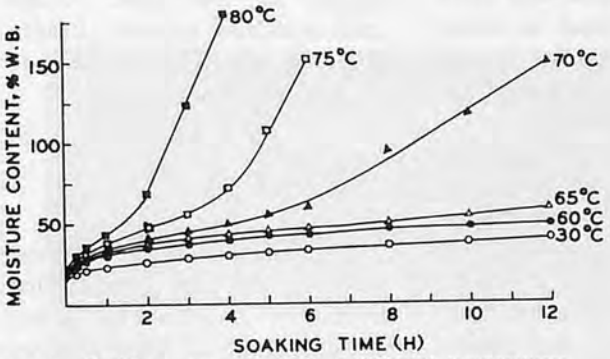


Fig. 5 Soaking curves for IR8 at different temperatures. Source: Ali et al, 1976.

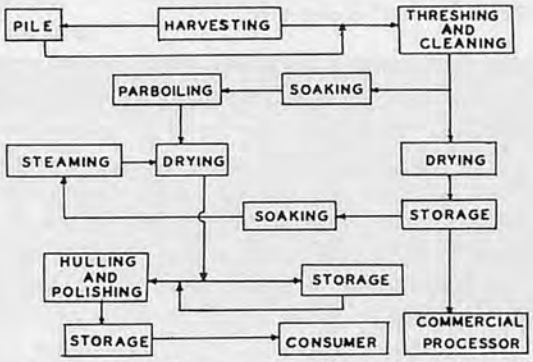


Fig. 6 Flow diagram of traditional harvesting and conservation of paddy in Bangladesh

labour requirement and improves the quality of paddy. A comparative statement of the output of these traditional methods and mechanical threshing is shown in **Table 4.**

Parboiling

Parboiling is locally known as 'siddha' and has since been widely practiced in Bangladesh (**Fig. 4**). During this process a slightly irreversible swelling and fusion of starch granules occures that changes the starch from crystalline form to an amorphous one. If the paddy is sufficiently dry, it is necessary to soak the paddy in water in which process the voids in the paddy are filled with water and the starch granules swell. It reduces the parboiling time and improves the quality of rice. **Fig. 5** shows the relation of moisture content with soaking time of IR-8 paddy.

In Bangladesh, farmers usually parboil paddy just after threshing and cleaning. They parboil only those quantities which are needed for family consumption during that particular season. Paddy for seed, cakes, special rice-dishes and surplus paddy for sale, are dried and stored. However if needed, farmers may parboil paddy out of the stored grain. Accordingly parboiling methods can be grouped into two categories: parboiling of fresh threshed and clean paddy or parboiling of dried and stored paddy (**Fig. 6**).

Dried stored paddy (moisture content 12 - 14%) is soaked in water for 24 - 28 hours then steamed and dried following almost the same procedure as mentioned for parboiling fresh threshed paddy.

Drying and Hulling

After threshing and cleaning, paddy is dried for the removal of moisture from rough rice because the moisture content of rough rice at harvest may vary from 18 to 30%. Drying is necessary in order to prevent destructive metabolism and decomposition and to inhibit microbial growth and prevent insect development.

Insect development is enhanced at high moisture content (above 14%). In fact, little or no insect activity occurs in cereal grains at moisture content below 10% (Brooker et al, 1974).

At present sundrying is widely practised throughout Bangladesh in all seasons. Farmers dry both parboiled paddy and rough rice in the farm yard or in the home yard. The paddy is spreaded in the farm yard in the dry season. In the rainy season it becomes difficult to dry the paddy in the sun due to incessant rain and high relative humidity. The farmers spread paddy on mats made of woven bamboo and then stir the paddy repeatedly. After a few hour's sun heating, they heap the paddy in a cold place to save the rice from cracking due to excessive heating. Farmers generally determine the moisture content of dried paddy by treading the paddy under feet or by biting. Although most of the paddy grown in Bangladesh are being dried in sun, the government has started some



Fig. 7 "Dhaki" in operation

pilot-scale dryer with the technical and financial support from some foreign agencies.

The parboiled dried paddy is then hulled by the farmers using locally made husking machine known as 'dhaki' (Fig. 7). In many cases hulling is done in the power driven hulling machines.

Storage

Storage of paddy is necessary for longer or shorter period immediately after drying. Optimum storage conditions should protect paddy from unfavourable weather conditions, insects, rodents, fungi, mites etc., both from quantitative and qualitative point of view.

Farm level storage in Bangladesh is a function of cropping pattern, consumption requirement, price and labour payment. Majority of the farmers have the optimum storage period of 3 – 4 months and storage period determines the loss level.

Storage structures in Bangladesh are mostly traditional at the farmer level. Farmers store parboiled or rough rice and seed paddy in various types of structures: "gola", "dole", earthen containers, oil drums and gunny bags.

Gola – These are outdoor structures made of bamboo splits and generally circular in shape with thatched roof. Indoor "golas" are barrel shaped and smaller in capacity.

Dole – This type of structures are circular or oval in shape and made of woven bamboo, plastered with mud and cowdung. These are generally kept on a raised platform.

Earthen containers – Earthen structures like "matka", "kuthi", jar etc. are made of clay and available in local markets. These are mostly used for storing seed paddy and rice.

Oil drums – These steel structures are generally used for storing seed paddy. In many cases, people use these to store rice needed for their own consumption.

Gunny bags – These bags are used for storing paddy by most farmers. Government organizations also store food grains in different go downs in these bags.

In addition to the above traditional structures, government organizations have modern storage structures in different districts of Bangladesh.

Paddy Losses in Different Stages

Losses in paddy start in the field as rodents, insects and birds cause sometimes serious damage. During threshing and drying of paddy the losses that occur are not negligible. In Bangladesh the paddy losses have been reported to be as high as 22%, of which 20% is lost in commercial storage. Table 5 shows the percentage distribution and their causes of post harvest losses of paddy of some Asian countries, including Bangladesh.

The major losses of paddy in Bangladesh are caused by rodents, insects and fungi during storage. Lack of knowledge on the part of farmers in food grain storage leads to all these types of damages. The total loss is proportional to the total production of paddy.

Conclusion

In Bangladesh the post harvest processing methods of paddy that are mostly followed are very primitive and traditional. These processes are crude and time consuming, and result in heavy losses. The important stages of losses are threshing, drying, storage and distribution. Four big modern food silos have been built at Chittagong, Ashugong, Demra and Santahar, where the major portion of food grain is stored. To reduce the post-harvest losses the farmers need to be trained through extension work to increase their knowledge in post harvest technology.

(Continued on page 65)

Table 5. Post-harvest Losses of Paddy in Some Asian Countries.

Country	Situation	Types of loss	Amount	Period	Cause	Comments
Bangladesh	All levels	Weight	8% to 22%	–	Various	Published in proceeding of the Workshop on Appropriate Technology. Feb. 6-8, 1975, Dacca
India	Farm Trader	Weight Germination	15% 8%	Continuing study from 1961-1971	Insects, Vertebrates & fungi.	Samples removed from stores for examination
Indonesia	Farm	Weight	10%	–	Insects, rodents & fungi.	Various farm surveys in collaboration with different agencies
Japan	All Levels	Weight	5%	–	Various	Published in Agricultural Mechanization in Asia, Vol. VII, No. 3.

Source: Bala, B.K. 1978.

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.2 Autumn, 1971
- ☐Vol.3 No.1, 1972
- ☐Vol.3 No.2, Summer, 1972
- ☐Vol.4 No.1, Spring, 1973
- ☐Vol.4 No.2, Autumn, 1973
- ☐Vol.5 No.1, Summer, 1974
- ☐Vol.6 No.1, Spring, 1975
- ☐Vol.6 No.2; Autumn, 1975
- ☐Vol.7 No.1, Winter, 1976
- ☐Vol.7 No.2, Spring, 1976
- ☐Vol.7 No.3, Summer, 1976
- ☐Vol.7 No.4, Autumn, 1976
- ☐Vol.8 No.1, Winter, 1977
- ☐Vol.8 No.2, Spring, 1977
- ☐Vol.8 No.3, Summer, 1977
- ☐Vol.8 No.4, Autumn, 1977
- ☐Vol.9 No.1, Winter, 1978
- ☐Vol.9 No.2, Spring, 1978
- ☐Vol.9 No.3, Summer, 1978
- ☐Vol.9 No.4, Autumn, 1978
- ☐Vol.10 No.1, Winter, 1979
- ☐Vol.10 No.2, Spring, 1979
- ☐Vol.10 No.3, Summer, 1979
- ☐Vol.10 No.4, Autumn, 1979
- ☐Vol.11 No.1, Winter, 1980
- ☐Vol.11 No.2, Spring, 1980
- ☐Vol.11 No.3, Summer, 1980
- ☐Vol.11 No.4, Autumn, 1980

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

Back Issues from 1981, ¥.1,700 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

SUBSCRIPTION/ORDER FORM

AGRICULTURAL MECHANIZATION IN ASIA (AMA)

Issued Quarterly

Subscription Rate(includes surface mail postage)

Annual(4 issues) ----------¥.5,000
Single copy ----------¥.1,500

Back Issues (1971—75, ¥.2,000 per copy)
(1976—77, ¥,1,200 per copy)

☐Spring, 1971	☐Vol.5 No.1, Summer, 1974	☐Vol.7 No.4, Autumn, 1976
☐Autumn, 1971	☐Vol.6 No.1, Spring, 1975	☐Vol.8 No.1, Winter, 1977
☐Vol.3 No.1, 1972	☐Vol.6 No.2, Autumn, 1975	☐Vol.8 No.2, Spring, 1977
☐Vol.3 No.2, Summer, 1972	☐Vol.7 No.1, Winter, 1976	☐Vol.8 No.3, Summer, 1977
☐Vol.4 No.1, Spring, 1973	☐Vol.7 No.2, Spring, 1976	☐Vol.8 No.4, Autumn, 1977
☐Vol.4 No.2, Autumn, 1973	☐Vol.7 No.3, Summer, 1976	

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

Back Issues from 1978, ¥.1,500 per copy

Vol._____No._____,_____197_____,_____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

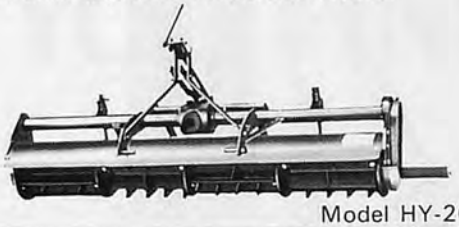
Niplo DRIVE HARROW

- Because of the unique shape of blades, puddling and clod breaking can be completely performed at a time.
- The unique levelling equipment and soil moving system make fields even and smooth.
- It is light enough to keep balance with a tractor even In muddy paddies and easy to handle.
- It requires less power and can harrow widely. It is economical.
- Blades can be easily replaced.
- Model HZ-3300 can be folded both sides by 45 centimeters.
- It produces a fine upper layer and rough lower layer, the ideal soil condition for rice planting.

The universal joint is a standard attachment.



Model HZ-3300



Model HY-201



Model HD-20A

Models	Dimensions (L×W×H)	Weight	Harrowing Width	PS of Tractor required	Rotor R.P.M (PTO540)	3point linkage	Working Speed	Capacity
HY—201	618×2137×952mm	199kg	2000mm	15—25ps	211rpm	Cat. 0.1	2.0–3.0km/h	30～50a/h
HD—20A	950×2400×1160mm	280kg	2300mm	25—35ps	248rpm	Cat. 1	2.5–5.0km/h	40～90a/h
HZ—3300	1050×3670×1100mm	488kg	3330mm	above40ps	278rpm	Cat. 1.2	2.5–5.0km/h	60～130a/h

MATSUYAMA PLOW MFG. CO.,LTD.

2949, Shiokawa, Maruko-machi, Nagano-ken, 386-01 Japan

Kett
MOISTURE METER OF THE WORLD

Proper moisture control earns large profits!



GRAIN MOISTURE METER RICETER MODEL D

COMPUTERIZED GRAIN MOISTURE METER, RICETER MODEL D is an instrument to measure the percentage of moisture content of products. It has been sold more than 400,000 so far in Japan and officially adopted by the Japanese Food Agency. Riceter Model D has been also sold thousands in Southeast Asia including Burma·Taiwan·Thailand·Philippine and Indonesia and Bangladesh.

The Kett Electric Laboratory is an unique manufacturer in the world which has studied and sold the Moisture Meter through more than thirty years.

■MOISTURE METERS FOR·····
GRAIN·WOOD·PAPER·MORTAR
FOOD·FIBER·PULP·etc.

■THICKNESS METERS FOR·····
COATING·PLATING·PAPER·FILM
LINING·etc.

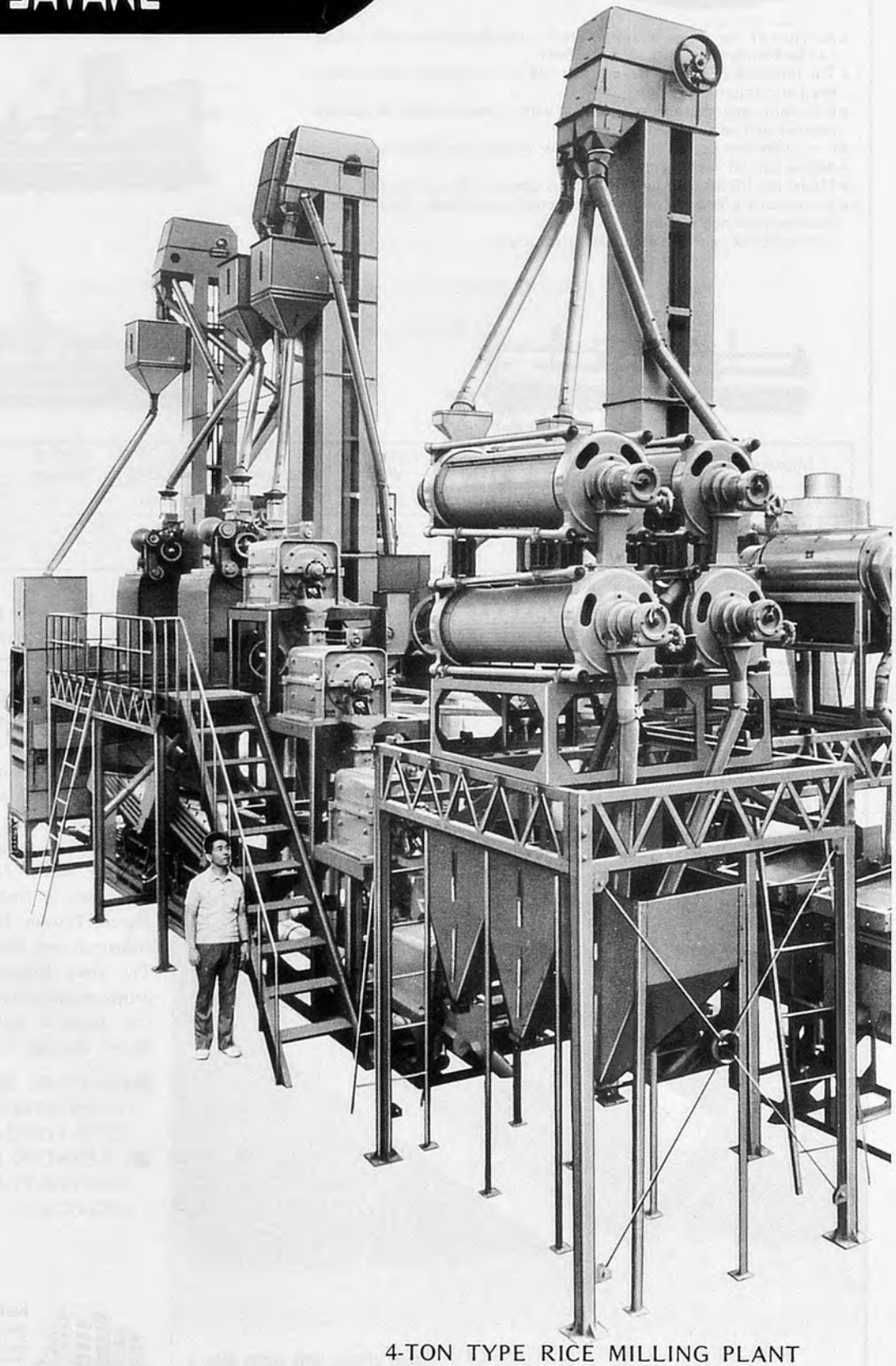


Kett Electric Laboratory
Head Office
8-1, 1-chome, Minami-Magome, Ota-ku, Tokyo, Japan
Cable address: KETTKAGAKU TOKYO
Branch Office
Osaka, Nagoya, Sapporo, Hiroshima

Kett Electric Laboratory

FOREMOST IN THE RICE WORLD

SATAKE



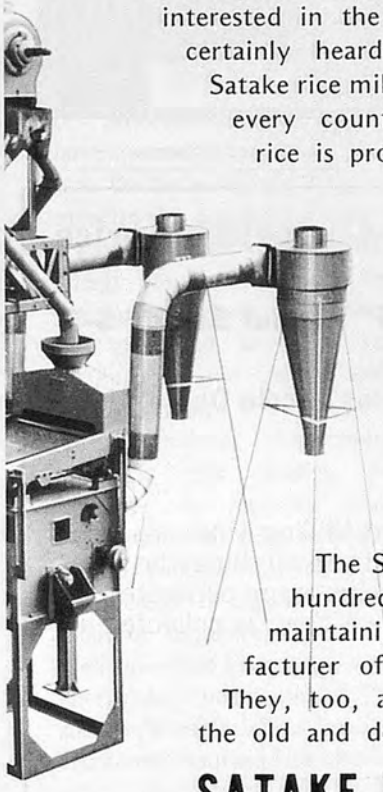
4-TON TYPE RICE MILLING PLANT

WHERE RICE IS, YOU FIND — SATAKE

Satake is a name well known in the broad area of rice processing. Anyone involved, who is interested in the best rice processing, has certainly heard the name "SATAKE". Satake rice mills can be found in virtually every country in the world where rice is produced.



HIROSHIMA PLANT





TOHOKU PLANT

The Satake Group of companies has fifteen hundred employees dedicated to the goal of maintaining Satake as the foremost manufacturer of rice drying and milling machinery. They, too, are always seeking ways to improve the old and develop new products.



HEAD OFFICE

SATAKE ENGINEERING CO., LTD.

UENO HIROKOJI BLDG., UENO 1-19-10, TAITO-KU, TOKYO, JAPAN

Arimitsu Serves World Agriculture With Unique Answers To Basic Needs.


Power Reaper Model ACE-30


Wheelbarrow Power Sprayer Model AT-26H


Electric Portable Power Sprayer Model CS-5AGS


Power Knapsack Mist-Duster Model MD-35DX


Lead Sprayer Model LS-560AMP

Arimitsu offers a wide selection of innovative equipment capable of superior performance. Each quality product incorporates a wealth of exclusive technology and nearly six decades of specialized experience. The diverse Arimitsu product line ranges from handy crop sprayers to high-pressure pumps. All have earned an outstanding reputation for tough reliability with customers in over 60 countries. Extensive R &D enables Arimitsu to create the advances necessary to assure greater efficiency.

Arimitsu—the profitable way to spray, dust, and pump.

Power knapsack mist dusters, Power hand sprayers, Hand dusters, Power reapers, Irrigation pumps, Soil injectors, Power blowers and Sprayer pumps.

ARIMITSU INDUSTRY CO., LTD.

3-21, Fukaekita 2 chome, Higashinari-ku, OSAKA, 537 JAPAN
Telex: 0-529-7257 ARIMIT J Cable: "ARIMITIND" OSAKA Phone: (06) 976-8181

Integrated Rice Husking and Milling Machine with Competitive price



"MARUMASU" Model Super S-3

Single Machine can handle Duplex Jobs

Husking Unit and Milling Unit are Operated each other by Switching the Change Lever. Rice Husks are separated by a Cyclone and Rice Bran is collected in the Container

Specification:

Model Super S-3	
Engine 3.5ps	
Tank Capacity	
Unhusked Rice	18-20kg
Husked Rice	18-20kg
Output per Hour	
Milled Rice	120kg

MARUMASU MACHINERY CO.,LTD.

HEAD OFFICE ADD Kamiichi,Nakaniikawa-gun,Toyama-pref.
Tel. 07647-2-2233

Development of Greenhouse Solar Drying for Farm Crops and Processed Products



by
B.K. Huang
Professor
Biological and Agricultural Engineering Department
North Carolina State University
Raleigh, NC 27650, USA

M.N. Özisik
Professor
Mechanical and Aerospace Department
North Carolina State University
Raleigh, NC 27650, USA

M. Toksoy
Visiting Assistant Professor
Mechanical and Aerospace Department
North Carolina State University
Raleigh, NC 27650, USA

Introduction

In agricultural production system, the drying of various crops following harvest and dehydration of processed products consume large quantities of energy, much of it in the form of fossil fuel heat to increase the drying air temperature. Awareness that the sources of energy are limited to a finite and decreasing reserve of fossil fuels has generated increased activity in pursuing the use of alternate energy sources.

Ever present solar radiation, although not always readily available, is receiving considerable attention as a generally accepted inexhaustible clean energy resource. It is a potential replacement or supplement for the fossil fuels now used in crop drying. Solar energy, as collected near the earth's surface, is essentially a low temperature heat source. This characteristic may limit its use in high temperature drying but may make it ideally suited for the seasonal and low temperature requirements of drying various agricultural crops and processed products. Low temperature drying has been applied to various kinds of grains in most all regions of the United States.

Drying is one of the oldest uses of solar energy. The spreading of the crops on the ground and drying them directly in the sun has been cheaply and successfully employed for many products throughout the world for thousands of years. The practice requires little capital outlay for equipment, but the drying efficiency is low and considerable labor may be involved. It also results in high loss and low quality products contaminated by dirt and insects.

Recently work in solar drying has been devoted in two directions. There has been work in direct drying, wherein the material is exposed to solar radiation, and by energy absorption and air circulation the moisture is vaporized into the atmosphere. In the other method, drying is indirectly accomplished by use of some type of collector, which furnishes hot air to a separate drying unit. Since solar energy is not a constant source of energy due to weather variations, more effective systems are possible in some cases if a supplemental oil, gas, or electric heater is used when the sun is not shining. The addition of supplemental heater unit provides an additional margin of safety in preventing crop spoilage. Both the solar heater and the supplemental heater reduce the operating time of a drying fan considerably resulting in energy savings.

The evolution of on-farm grain drying represents significant advancement in technology, equipment, and management in the past 30 years (Brooker et al., 1978). There has been a tremendous increase in the number of on-farm drying facilities. The available drying methods include in-storage, batch-in-bin, batch, continuous flow, low and high temperature, etc. with or without grain stirring. Many research projects have been conducted in grain drying using air solar collector in conjunction with grain bins (Baker and Shove, 1977; Bakker-Arkem et al., 1977; Calderwood, 1977; Converse et al., 1976; Donald et al., 1978; Foster and Peart, 1976; Kline, 1977; McLendon and Allison, 1978, Morey et al., 1977; Morrison, 1975;

Remark: The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Research Service of the products named, nor criticism of similar ones mentioned.

Acknowledgements: The authors wish to acknowledge the partial sponsorship for the research by the North Carolina Energy Institute, the U.S. Department of Energy, and the U.S. Department of Agriculture.

Peterson and Hellickson, 1976). Significant energy savings have also been achieved in peanut drying (Butler and Troeger, 1977), in burley tobacco curing (Walton et al., 1977), and in bright leaf tobacco curing (Huang et al., 1975; Huang and Bowers, 1976 and 1977; Huang et al., 1979). These studies showed that solar energy could be collected and used but it was essential to design a solar system which was competitive with a conventional unit in price and operating cost.

Today most conventional crop driers are not fully utilized year-round and have a low efficiency from energy point of view. An effective year-round solar-energy utilization has been realized using the greenhouse bulk curing solar system (solar barn), developed by Huang et al. (1975). The system utilizes solar energy as a first priority energy source to cure tobacco in the summer months and to grow greenhouse crops and tobacco seedlings the remainder of the year. An overall 51 percent fuel savings was achieved during the 1978 tobacco curing seasons with the solar barn as compared to a conventional bulk curing barn. During greenhouse mode of operation Klanchoe flowers, cucumbers, tomatoes and tobacco seedlings were successfully grown.

Many tobacco farmers in Southeastern United States also grow peanuts and grains. With the peanut curing season occurring after the tobacco curing season, the peanut curing process should utilize the solar energy and available facilities to save fuel for economical farm operation. The greenhouse solar system can easily be utilized to cure and dry peanuts and grains as well as other agricultural crops by the addition of combination rotary solar collectors and driers (Huang et al., 1979).

The greenhouse solar drying system described in this paper is a multi-purpose structure which includes the capability to effectively utilize solar energy within the structure. It is adapted to control temperature, humidity and other environmental parameters for drying mode for crop and product dehydration, for greenhouse mode for plant production, or for storage mode for storing crops or commodity. This paper presents the basic concept, design and development of the rotary drum solar collector system to be used for drying agricultural crops and processed products by showing experimental results for drying rice, peanuts and vegetables as well as the preliminary simulation studies.

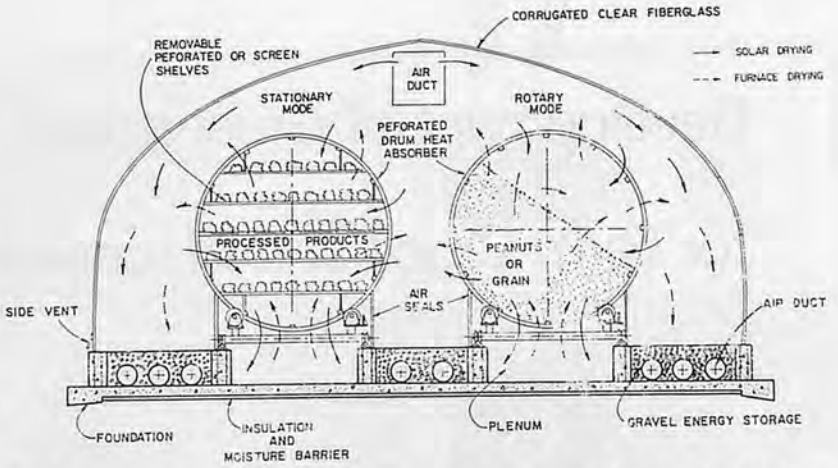


Fig. 1 Greenhouse solar drying system for solar or furnace drying with the drums set for rotary and stationary modes

Greenhouse Rotary Drum Solar Drying System Design and Analysis

The basic concept of the greenhouse solar drying system is illustrated in **Fig. 1**. The rotary drums consisting of structural frames and perforated sheet metal surfaces are set inside the transparent shell structure to form an integrated solar collector system. The system is equipped with an oil or gas furnace and air circulating systems. It can be operated for solar or furnace drying with the drum set for rotary mode for drying grain and peanuts, or set for stationary mode with perforated shelves for dehydrating processed products. During the daytime solar energy is continuously collected by the drum surface to heat the air flowing through the material being dried. The effective heat transfer rate for these porous absorbers is significantly higher than the conventional flat plate absorbers (Khe, 1971). When the solar energy is minimum or not available, the reverse flow furnace drying is performed in conjunction with dehydration and waste heat recovery using the structure and gravel storage system to reduce the energy requirement. For rotary mode periodical agitation is provided to achieve more uniform grain drying and to serve as a grain cleaner. The drum can be designed as stationary unit fixed in the transparent shell structure or as a portable unit to be set on a trailer (**Fig. 2**) for field loading like a conventional grain or peanut wagon. The drum is then rolled from trailer into the structure for solar energy curing and drying. **Fig. 3** shows the greenhouse solar drying system with four units of the combination rotary drum solar collectors and driers, furnace room, and gravel energy storage system. During greenhouse mode of operation the rotating drums serve as a ferris wheel plant production system enhancing the economic feasibility of the system.

The energy flow diagram of the greenhouse solar drying system shown in **Fig. 4** illustrates the energy balance for drying or curing,

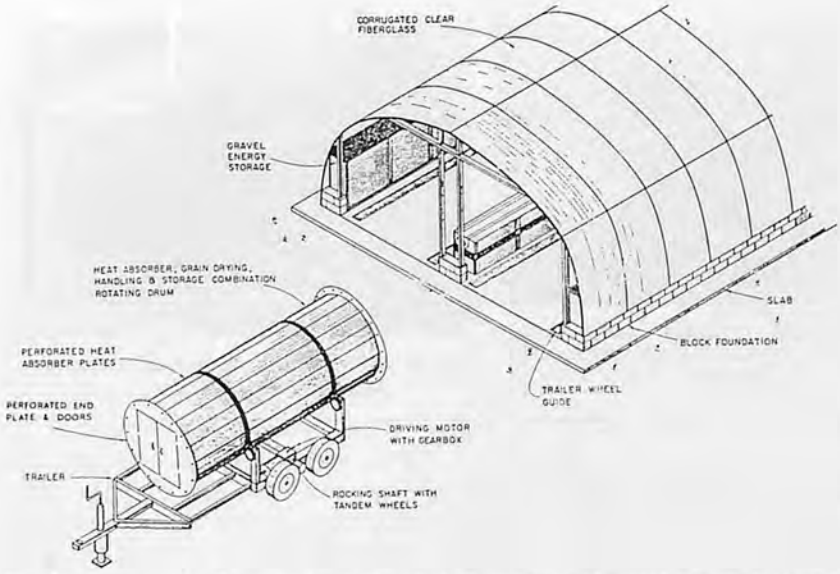


Fig. 2 Rotary solar-drum trailer unit and shell structure of greenhouse solar drying system

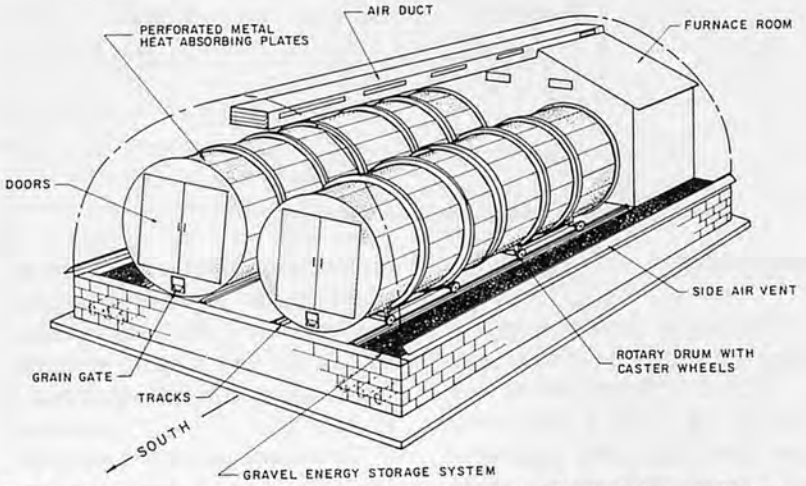


Fig. 3 Greenhouse solar drying system with four units of rotary drum collector-dryers

energy storage, and heat losses. The energy can be supplied by solar heating and/or furnace heating depending on the weather conditions and time of the day, using the basic air flow patterns shown in Fig. 1. Amount of exhaust air, air recycling, dehydration and heat recovery can be controlled by vents and dampers to meet the temperature and moisture requirements by the material to be dried or cured at various stages of drying or curing process, and to maximize the energy utilization. The various radiative, convective, and conductive components of the losses can be minimized by proper design and selection of the construction materials. Since forced convection is used in the curing and drying process accurate control of drying rates under various conditions is of great importance in achieving an efficient high quality drying.

Various system parameters that affect drying and curing performance include; the air flow rate through solar drum, the outside air humidity and temperature, the solar radiation availability, the heating rate by the furnace, the transmissibility of the greenhouse shell to solar radiation, the absorptivity of inside surface for solar radiation, the mixing of outside air and the exhaust air. Therefore, complete heat transfer analysis of the system is quite involved and requires the inclusion of the effects of each of these factors in the system analysis.

The system performance for

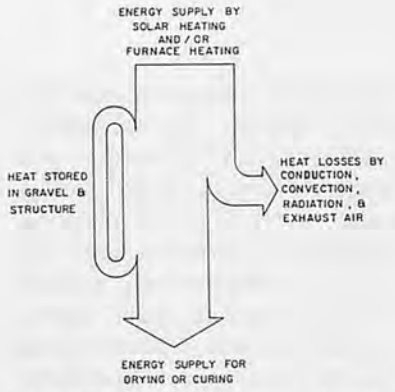


Fig. 4 Energy flow diagram of greenhouse solar drying system

drying can be predicted by writing proper energy balance equations for each system components such as the cover surface, drum surface, floor, and air mass first to determine the inside air temperature. The drying of the grain or other materials can then be determined by writing a transient mass balance equation for the grain contained inside the drums, together with a moisture and temperature balance for the air flowing through the grain mass.

The general procedure for the above analysis has been illustrated by Özisik, Huang and Toksoy (1979) with a specific application to the curing and drying of peanuts by solar energy.

Results and Discussion

Full scale field tests have been performed to test the effectiveness of the solar drying system for the drying of rice, peanuts and vegetables by using both solar and/or furnace heating. Also, preliminary simulation study has been conducted to evaluate the system performance.

Rice and Vegetable Drying

The first rotary drum solar drier was designed for rice drying in 1974. It was constructed and field tested at National Taiwan University, Taipei, Taiwan in 1975. Significant fuel savings and improved grain quality were achieved indicat-

ing that the principle of reversible-flow, agitation, low-temperature solar drying was superior to conventional drying. Solar energy storage, recycling and nighttime dehydration further reduced the energy requirement and resulted in more uniform grain drying. Further tests were conducted using improved version of greenhouse solar drying system with 3-ton solar drum unit shown in **Fig. 5(a)** for rice and vegetable drying*. **Fig. 6** shows the results of both solar and furnace drying of rice conducted in mid-December at Kao-hsiung (latitude 22°42'N). The curve for Test 1 shows that solar drying was performed for 1,770 kg of rice with initial moisture content of 24%. Within 4.5 hours the moisture content of rice was decreased to 18% and drying was discontinued overnight. On the next day drying was performed using furnace due to rainy weather and the moisture content was decreased from 18.5% to 13.5% within 4 hours and 40 minutes. Test 2 was conducted on a rainy day by furnace drying using 1,110 kg of rice with 25% initial moisture content. The curve shows that the moisture content was reduced to 13% within 10 hours.

For vegetable drying test, shredded Chinese cabbage was dehydrated with the same system with a combination of solar and furnace heating. The test was started at 18:30 with furnace drying, continued to 14:00 on the next day (hazy and cloudy). It took about 19.5 hours to dehydrate 487 kg of the cabbage in the rotating drum to the final weight of 47 kg. These results clearly indicate the potential of this drier as an effective system for drying grain and dehydration of vegetables.



Fig. 5a Three-ton solar drum unit used for rice and vegetable drying



Fig. 5b Six-ton solar drum unit used for peanut curing

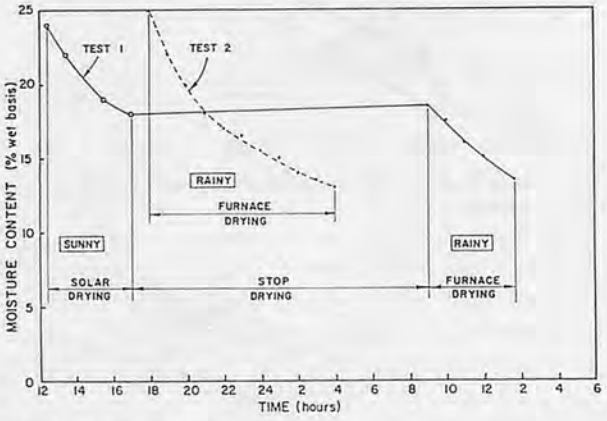


Fig. 6 Solar and furnace drying of rice

Peanut Curing

The full-scale peanut curing was conducted using the system with one 6-ton solar drum unit as illustrated in **Fig. 5(b)**. A rotary solar grain drier unit was engineered with features that provide multi-purpose usage, self contained, high efficiency at lowest possible cost, and was constructed by the Aeroglide Corporation. Four full-scale peanut curing and drying tests were performed using the rotary drier in the greenhouse solar curing system located at the Central Crops Research Station in Clayton, N.C. (latitude 35°41'N).

On October 7, 1978, the first cure was made using 2,722 kg of peanuts having an initial moisture content of about 17%. Drying was performed by forcing hot air from the plenum without the rotation of the drum. Furnace heating was used to supplement the heating during nighttime curing. The temperature was set at 32°C. Once air passed through the peanuts, it was either exhausted through the front shutter or was recirculated. Solar energy stored in the gravel beds supplemented the heat for nighttime drying. At the end of 44 hrs of drying the moisture content was reduced to about 5%.

The second curing test was started on October 17, 1978, using approximately 3,720 kg of peanuts having an initial moisture content of about 26%. The same drying pattern as in the first test was followed. During 60 hrs of operation, the moisture content was reduced to about 7%.

The third set of tests was started on October 19, 1978. Approximately 2,903 kg of peanuts, having an initial moisture content of 18% were used. Drying tests, utilizing the solar energy, were performed with the drum being periodically rotated. The study indicated that the rotation provided sufficient agitation for uniform drying. The angle of repose was about 35°, depending somewhat on the moisture content of the peanuts. The unit as it rotated, also provided gentle cleaning action to clean

* Personal communication with Prof. T.S. Peng, Agricultural Engineering Department, National Taiwan University.

dust, sands and soils in the peanuts. After 3 hazy days of solar drying the moisture content was reduced to about 9.6%.

The fourth set of tests were started on October 24 using approximately 1,542 kg of peanuts having a moisture content of 22.9%. The moisture content was reduced to 15.6% within 4 hours of solar drying in the afternoon. The drying was discontinued at night. On the second day the moisture content was reduced to about 11.5% with 5 hours of solar drying.

The system performance was further evaluated under no-load condition. Fig. 7 shows the curves for total solar radiation and temperatures of solar drum, inlet and outlet air, and gravels on November 2, 1978 with air flow rate of 2.9m^3/s. During the daytime the drum surface temperature was generally maintained over 30°C resulting in an average rise of 10°C in air temperature.

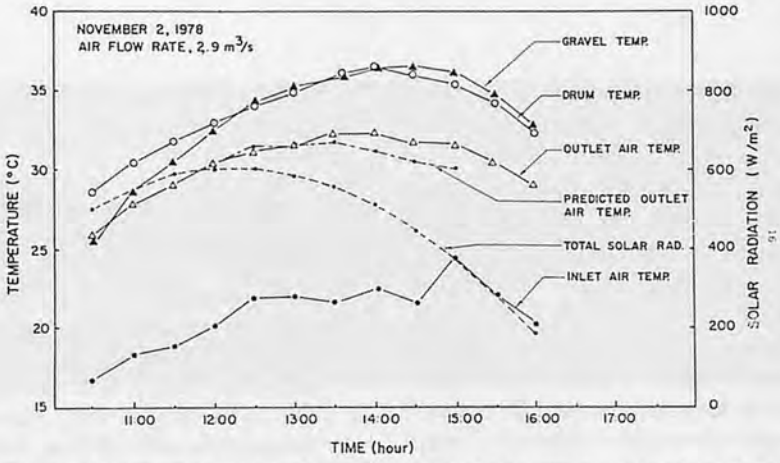


Fig. 7 System performance of greenhouse solar drying system with a 6-ton drum unit under no-load condition

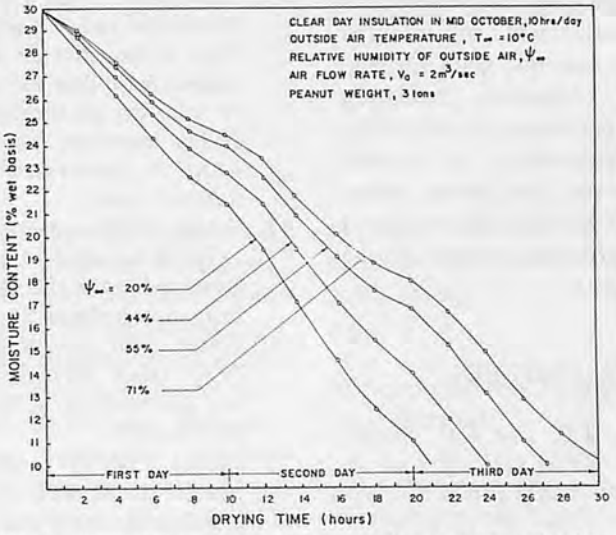


Fig. 8 Simulated system performance of greenhouse solar drying system with a 6-ton drum unit fan solar peanut curing

Systems Modeling and Dynamic Simulation

Systems approach to various mode of operations will streamline every aspect of management while optimizing system performance with multi-level modeling strategies. Dynamic simulation model and computer programs were developed (Özisik, Huang and Toksoy, 1979) for solar energy utilization and system performance studies of the greenhouse solar drying and curing system.

The predicted outlet air temperature curve shown in Fig. 7 illustrates the simulated results of solar heating from 12:00 to 15:00 conform favorably to the measured data. In order to further illustrate the system capability for curing and drying peanuts under various environmental conditions peanut curing was simulated to predict drying times with solar heating under different outside air humidity conditions. The calculations were performed based on ASHRAE solar energy model for a single drum containing 3 tons of peanuts using a solar radiation intensity for a clear day in mid-October. The floor absorptivity for solar radiation was taken as 0.70, outside air temperature 10°C and air flow rate through the drum 2m^3/sec. For the analysis the experimental results by Young and Whitaker (1971) were used to determine the mass diffusion through peanuts. The simulated results (Fig. 8) indicate that the moisture content of peanuts can be reduced from 30% to 10% with 21 to 30 hours of solar drying depending on the humidity of the outside air.

Summary and Conclusion

A multi-purpose greenhouse solar drying system has been developed for the drying and curing of agricultural crops and processed products using both solar and furnace heating. The system utilizes the total structure as an effective solar energy collector by accommodating the specially designed rotary drums which serve as integrated solar heat absorber, crop drier, agitator, transport, and storage.

Full-scale tests have been conducted to study the system design and operating characteristics for rice drying, peanut curing, and

vegetable dehydration. The results have indicated that the systems have performed effectively for both modes of drying and that the principle of reversible flow agitation low-temperature solar drying is superior to conventional drying with increased fuel efficiency and improved grain quality especially for grain with high initial moisture content. The rotary drum provided effective solar energy collection. Solar energy storage, recycling and nighttime dehydration further reduced the energy requirement and resulted in more uniform grain drying. Preliminary computer simulation were also performed to predict the system performance for no-load condition and for peanut curing using solar heating. The simulated results conformed favorably to the measured data.

REFERENCES

1. Baker, J.L. and G.C. Shove. 1977. Solar grain drying in Illinois. ASAE Paper No. 77-3009.
2. Bakker-Arkema, F.W., S. Becker and D.B. Brooker. 1977. Feasibility of solar energy grain drying in Missouri and Michigan. ASAE Paper No.77-3011.
3. Beasley, E.O. and J.W.Dickens. 1963. Engineering research in peanut curing. Tech. Bul. No. 155, North Carolina Agricultural Experiment Station.
4. Bowers, C.G., Jr., B.K. Huang and D.H. Willits. 1976. Improving solar energy collection, storage, and air flow control in greenhouse solar curing barn. ASAE Paper No. 76-3548.
5. Bowers, C.G., B.K. Huang and C.F. Abrams, Jr. 1975. Solar energy utilization in a bulk curing/greenhouse system. ASAE Paper No. 75-3504.
6. Brooker, D.B., B.A. McKenzie and H.K. Johnson. 1978. The present status of on-farm grain drying. ASAE Paper No. 78-3007.
7. Butler, J.L. and J.M. Troeger. 1977. Use of solar energy to cure peanuts. ASAE Paper No. 77-3033.
8. Calderwood, D.L. 1977. Rice drying with solar heat. ASAE Paper No. 77-3003.
9. Converse, H.H., G.H. Foster and D.B. Sauer. 1977. Low temperature grain drying with solar heat. ASAE Paper No. 76-3018.
10. Donald, J., C.B. Ogburn, J. Thompson and D. Laird. 1978. Field demonstration and economic feasibility of the use of solar drying techniques for drying soybeans in Alabama. ASAE Southeast-Southwest Region Paper.
11. Foster, G.H. and R.M. Peart. 1976. Solar grain drying progress and potential. Agric. Information Bulletin No. 401.
12. Foster, G.H. and R.M. Peart. 1976. Grain drying-reflections and perspectives. ASAE Paper No. 76-3005.
13. Glover, J.W. 1977. Mechanical peanut curing. PPG 20, North Carolina State Agricultural Extension Service.
14. Huang, B.K., C.G. Bowers, Jr. and A.H. Nassar. 1979. Greenhouse solar system for bulk curing tobacco and peanuts. Proc. Use of Solar Energy for Crop Drying Conf.
15. Huang, B.K. and C.G. Bowers, Jr. 1977. Solar-energy utilization using greenhouse bulk curing and drying system. Proc. Solar Crop Drying Conf. 117-145.
16. Huang, B.K. and C.G. Bowers, Jr. 1976. Immediate solar-energy utilization using greenhouse bulk curing and drying system. Final Report PTP74-17622. 71 pp.
17. Huang, B.K., C.F. Abrams, Jr., L. L. Coats and C.G. Bowers, Jr. 1975. Development of greenhouse bulk drying systems for solar energy utilization and plantbed mechanization. ASAE Paper No. 75-1018.
18. Husain, A., C.S. Chen and J.T. Clayton. 1973. Simultaneous heat and mass diffusion in biological materials. Jour. Agric. Eng. Res.
19. Khe, C. 1971. Analysis of a matrix solar collector for low temperature applications. Ph. D. Dissertation. University of California, Davis.
20. Kline, G.L. 1977. Solar collectors for low temperature grain drying. ASAE Paper No. 77-3007.
21. McLendon, B.D. and J.M. Allison. 1978. Solar energy utilization in alternate grain drying systems in the Southeast. ASAE Paper No. 78-3013.
22. Morey, R.V., H.A. Cloud, R.J. Gustafson and D.W. Peterson. 1977. Evaluation of the feasibility of solar energy grain drying. ASAE Paper No. 77-3013.
23. Morrison, D.W. 1975. Bare plate solar collector grain drying bin. ASAE Paper No. 75-3513.
24. Özisik, M.N., B.K. Huang and M. Toksoy. 1979. On solar grain drying. Proc. 2nd Miami International Conf. on Alternative Energy Sources.
25. Peterson, W.H. and M.A. Hellickson. 1976. Solar-electric drying of corn in South Dakota. Trans. of ASAE 19 (2):349-353.
26. Walton, L.R., W.H. Henson, Jr., S.G. McNeil, B.F. Parker and J.M. Bunn. 1977. Solar curing facilities for burley tobacco. ASAE Paper No. 77-3002.
27. Willits, D.H., C.G. Bowers, Jr., P.V. Nelson and B.K. Huang. 1976. A solar energy storage system for greenhouse. ASAE Paper No. 76-3507.
28. Young, J.H. and T.B. Whitaker. 1971. Evaluation of the diffusion equation for describing thin-layer drying of peanuts in the hull. Trans. of ASAE 14(2): 309-312. ■■

Stationary Flat-Bed Rice Drier and Two-Way Airflow Drying Method



by
Din-sue Fon
Instructor
Agricultural Engineering Department
National Taiwan University
136 Chou Shan Road, Taipei
Taiwan

Introduction

For several thousand years in China, rice was dried by the stationary bed method—grains spread over the ground for direct sun-drying. In recent years, people have used a grain box with heated air passing upward through the grain layers. This type of stationary-bed drier, also called flat-bed drier, now numbers 16,000 units in Taiwan. Farmers here favor this type of drier mainly because it is simple in construction, easy to set up, and inexpensive. In general, its holding capacity ranges from 800 to 1,500 kg of wet paddy. Each batch of grains needs 12–20 hr to dry through, depending on its initial moisture content and quantity.

Because the wet paddy is kept stationary during the whole flat-bed drying process and heated air of high temperature is often used, significant moisture gradients would form across the grain depth, resulting in extremely different drying effects on the top and bottom layers of grains, which inevitably produce serious crack of grain kernels after drying is completed. It is believed that the kernel cracking phenomenon affects the rice quality and sometimes even renders the whole kernel pulverized in milling. Because of this shortcoming, it is not uncommon that the Food Bureau and Farmers' Associations complain of low paddy quality when collecting the farmer's paddy in lieu of land taxes.

Under this circumstance, farmers who want to purchase rice driers are usually advised to buy the circulating one. However, this suggestion is not always accepted because the circulating drier is costly, too bulky in size, and only suitable to small-kernel grains.

Inspite of the above-mentioned weakness, the flat-bed direr still has unique traits that merit its introduction to the farmers, especially those in the developing countries where small-scale farming is dominant. However, some technical modification should be made to improve its performance.

The objective of this study is to modify the present flat-bed rice driver by applying a two-way airflow drying method in an attempt to reduce the moisture gradients throughout the grain bed and thus solve the rice cracking problem that usually occurs in paddy drying.

Principle of the Two-Way Airflow Method

As shown in **Fig. 1**, heated air is directed into two different paths. One follows the traditional pattern with heated air passing upward through the grain bed; the other runs in an opposite direction with heated air going down through the grain. These two directions can be interchanged every 2 or 3 hrs. In that case, both top and bottom layers of grains will then have the same opportunity of exposure to heated air during the whole drying process. This two-way airflow drying method is possible by simply adding an air direction changing device between the drying box and the axial fan accompanied with a burner.

Fig. 2 shows details of the air direction changing device which can be used for controlling the inlet and outlet ports simultaneously with two linked plates, both of which can be actuated by a lever and stopped tightly at two extreme

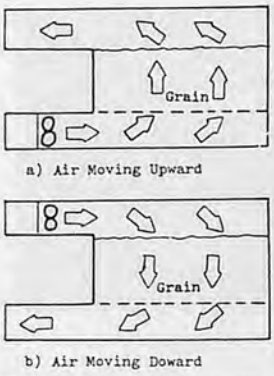


Fig. 1 The two-way airflow drying method

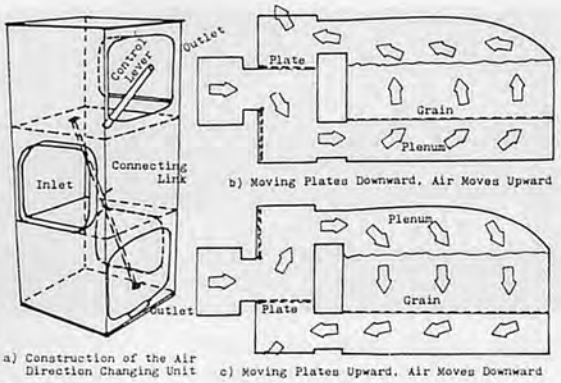


Fig. 2 Construction of the air direction changing unit and its functions

positions. These plates serve as an air duct divider, directing heated air from the burner and exhaust air from the grain mass either upward or downward. Obviously, this method is quite different from the circulating multi-pass drier that constantly consumes lots of energy in grain moving and is also different from the traditional flat-bed drier in which the heated air moves upward through the grain mass.

Besides the air direction changing unit, a piece of vinyl canvas is also used as a top cover of the grain box. This canvas cover can be easily set up simply by inserting a small rubber tube against a U-shaped slot which is attached right on the top edge of the grain box. This can also be done by a quick clamping action if a rigid frame cover is employed instead of vinyl canvas.

Experiments

In order to make sure that this paddy-drying system works well, both laboratory and field tests were conducted in 1979. **Fig. 3** shows the actual appearance of a two-way airflow drier for field tests, and **Fig. 4** is a sketch of the laboratory drying apparatus. Laboratory experiments emphasized the investigation of four factors, including grain depth (45 cm & 30 cm), heated air temperature (45°C & 40°C), direction changing period (every 1–2 hrs), and airflow rate (0.05 & 0.15 CMM/kg of paddy). Each factor was arranged into two levels to examine the effects of both levels on rice quality, temperature changes and moisture behavior during the drying process. Each sample under test ranged from 18 to 25 kg, depending on the grain depth.

The field test was performed three times at Tainan, southern Taiwan, in March 1979 when the first rice crop was being harvested. During the test, the thermostat was set at 45°C and 50°C and air direction changed every 2 hrs. in the daytime and every 3 to 4 hrs. at night.

The test paddy was piled up to 40 cm in depth, which amounts to 1,000 kg in wet weight. The paddy's local name is Pon-lai, a medium-grained variety of the Japonica type.



Fig. 3 A two-way airflow drier

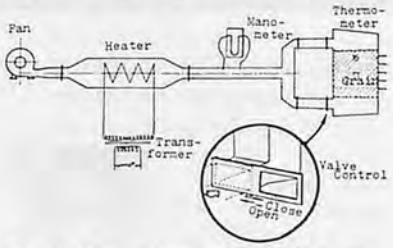


Fig. 4 The laboratory drying apparatus

Discussion

As shown by the experiments, the two-way airflow drying method can help maintain a higher rice quality and achieve the same results as the circulating dryer generally does. **Figs. 5** and **6** show the typical drying curves of each grain layer in both the traditional one-way and the new two-way airflow drier. The latter, especially at the top and bottom, discloses a kind of "staircase" effect during the drying process which can be explained by the tempering and drying actions alternatively in-

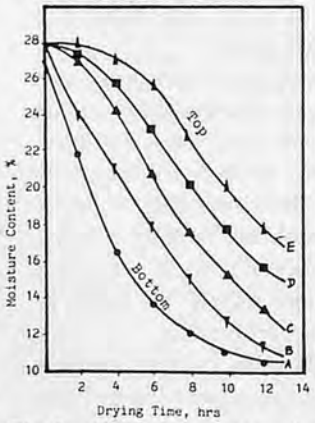


Fig. 5 Moisture curves of grain layers in the stationary one-way drier (45°C, 45cm in depth)

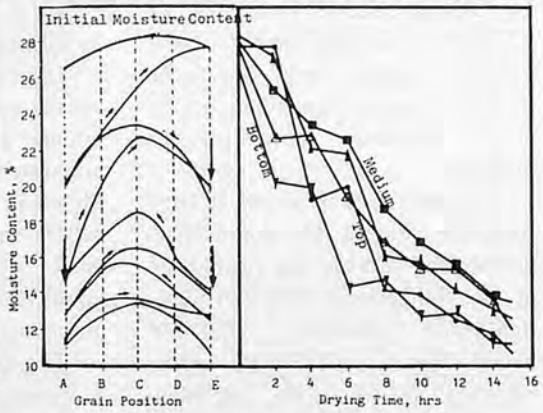


Fig. 6 Moisture curves in the two-way airflow drier (45°C, 45cm in depth, 2-hr reversing period)

volved in this two-way airflow method, and that moisture is removed intermittently either on the upper or the lower part of the whole grain depth. In other words, every grain kernel in the grain box experiences tempering and drying effects, which have long been the characteristics of circulating driers.

Fig. 7 shows an overlapping of the one-way and two-way drying processes, or the curves in Figs. 5 and 6. Apparently, the conventional one has a wider discrepancy of mositure distribution during the drying process than the new one. Thus, it will take more time to dry the top layer when a uniform moisture distribution is desired.

By using the two-way method, however, the moisture range will be half-reduced as shown in Fig. 7. Meanwhile, the moisture of the medium layer will then become the highest during drying process. The top and bottom layers for example, show both curves in Fig. 7 step down every 2 hrs in turn, showing an opposite effect that either one is in drying, while the other will be in tempering. Concerning moisture changes of the bottom layer, it goes down following the path a–b for tempering, and again, drops from point b to c because of drying action. Here, suppose the tendency of drying is following curve A of the bottom layer as if it were drying continuously without tempering as the one-way method does, the moisture at point b should then parallel the arc ac'' and drop to point c' along the dash line 2 hrs later, or at the 6th hr as Fig. 7 shows. But actually, the moisture drops more than that amount and down to point c because the effect of tempering has resulted in this extra moisture reduction of 2%, or, segment c'c.

It is obvious that this two-way airflow method, besides the merit in obtaining a uniform moisture distribution, can be characterized by this tempering effects, which the one-way drying method fails to have.

However, the moisture content does not really keep unchanged during the tempering period, particularly when the grain has been dried up to a certain degree. Figs. 6 and 7 show that moisture changes during the tempering period tend to tilt downward or become flat when the moisture is still high enough like segments o-p and a-b, but tend to remoisten or become higher at the end of this period when the moisture is mostly removed. This rewetting phenomenon can be attributed to the condensation of vapor when the exhausted air passed through the grain layer.

Table 1 shows the presumed factors that affect the paddy drying quality. It reveals that the drying of paddy on a deeper grain bed or under a higher air temperature will generally cause a wider moisture discrepancy after drying. It is also interesting to note that operations in a 1-hr reversing period will likely cause a wide range of moisture changes. This consequence is favorable, however. For, to meet the farmer's daily work schedule, the reversing period of air direction should be long. The 2-hr period gives a good result, but it could be longer and better.

The airflow rate, however, has influence in some other respects. It is found that an increased airflow rate has little effect on the discrepancy of the final moisture content but will enhance the drying rate dramatically.

No one would dispute the importance of air temperature to grain drying. As a matter of fact, high-temperature drying not only directly enlarges the range of moisture distribution but increases the drying rate and crack ratio also. Therefore, the proper control of heated air is greatly essential if a good drying result is to be achieved.

By comparing the results of field drying tests, it is found that the standard deviation of moisture at the final stage by the two-way airflow method is less than ±0.4%, drying from 35% to 14.1% (dry

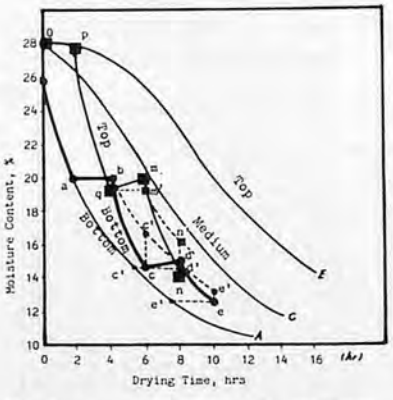


Fig. 7 A comparison of moisture changes during the drying process by overlapping Figs. 5 and 6.

Table 1. Factors that Affect Paddy Drying Quality

Item	Feature	Initial Moisture Content, % (d.b.)	C_V value* % (at final mc)	Total Drying Rate, %/hr. (d.b.)	Crack Ratio ** %
Grain depth	30 cm	24.1	3.6	1.16	6.9
	45 cm	34.5	10.1	1.33	10.0
Air temperature	40°C	29.6	5.5	1.07	7.3
	45°C	29.0	8.7	1.43	9.5
Reversing period	1 hr.	28.0	8.13	1.15	8.3
	2 hrs.	30.3	6.05	1.35	8.1
Airflow rate	Normal	35.1	8.3	1.37	7.1
	Enforced	41.6	8.3	2.01	31.9
Method of drying	One-way	38.9	18.5	1.95	45.8
	Two-way	34.5	10.6	1.33	10.0
Field test	Two-way	35.1	3.2	1.02	12.0

* Mean of fianl moisture content for all treatments: 15.07 ± 0.74% (d.b.).
** Including checks and cracks.

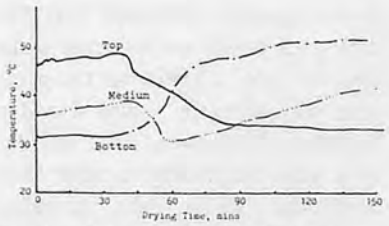


Fig. 8 The change of grain temperatures when air direction is shifted

basis) moisture, which makes the range of moisture difference across the whole grain depth less than 1%. Laboratory experiments with a grain depth of less than 30 cm and an air temperature of less than 40°C have almost the same effects on moisture as noted in field tests.

The grain layer should not be so thick as to cause an uneven moisture distribution. A depth of 40 cm appears appropriate for paddy drying if the two-way airflow method is used.

The change of grain temperatures in each layer when air direction is shifted can be observed in **Fig. 8.** It will last about ½ hr until a stable state is reached.

Table 1 also shows us how the factors affect the rice quality criterion in judging the performance of a drier. A 10% crack ratio has been set as a standard level to permit the circulating drier for sale in Taiwan for years. According to **Table 1**, nearly all of the treatments have never exceeded this limit except in the case of a high airflow rate. Obviously, airflow cannot be unlimitedly increased in practical use. Meanwhile, either the grain depth of 45 cm or the air temperature of 45°C will also cause more cracks than other treatments.

In comparing their overall effects, we found that the two-way airflow method is better than the conventional one. Most important of all, the former's crack ratio was only ¼ of the latter's.

Conclusion

It has been established that the two-way airflow method of paddy drying with stationary beds is markedly effective to improve the rice quality. By this method, the range of moisture difference across the whole grain depth is less than 1% – a standard level already set for the circulating drier for years in Taiwan. Therefore, we can conclude that the two-way process is not only better than the conventional one but also as good as the circulating drier.

We would like to recommend that farmers improve the performance of their flat-bed stationary driers by adding an air direction changing device and that manufacturers design this type of driers a new model in accordance with this two-way airflow drying principle.

REFERENCES

1. Hall, C.W. Drying Farm Crops AVI Co., 1971.
2. Brooker, D.B. Drying Cereal Grains AVI Co., 1974.
3. Calderwood, D.L. & Wasserman, Theodore. Rough Rice Drying, Rice Chemistry and Technology, Chap. 5.
4. Calderwood, D.L. & Hutchison, R.S. Drying Rice in Heated Air Dryers with Aeration as a Supplementary Treatment. USDA Marketing Research Report No. 508, 1961.
5. USDA ARS 20-7, Nov., 1958. Research on Conditioning and Storage of Rough & Milled Rice.
6. Esmay, M.L. Drying, Storing and Handling Food Grains in Developing Countries. Agricultural Mechanization in Developing Countries. Chap. 6.
7. Henderson, S.M. A Basic Concept of Equilibrium Moisture. Agricultural Engineering 33: 29-32.
8. Toshizo Ban, Rice Cracking in High Rate Drying. Japan Agricultural Research Quarterly 6:2., 1971.
9. Khan, A.U. Accelerated Drying of Rice Using Heat Conduction Media. ASAE Paper No. 73-321. 1973.
10. Kunze, O.R. Grain Fissuring Potentials in Harvesting and Drying of Rice ASAE Transactions 21:2. 1978.
11. Kunze, O.R. Fissuring of the Rice Grain After Heated Air Drying. ASAE Transactions 22:5. 1979.
12. McKenzie, B.A. Dryeration– Better Corn Quality with High Speed Drying CES, Purdue University, Paper No. AE-72. 1972.
13. Young, J.H. Evaluation of Costs for Drying Grain in Batch or Cross-Flow Systems. ASAE Paper No. 74-3016. 1974. ■■

Potential of Sugarcane as Alternative Energy Source in India



by
Subhash S. Arora
Scientist S-1
Division of Plant Studies
Central Arid Zone Research Institute
Jodhpur-342003, India



Kulbir Singh Malhotra
Scientist S-1
Division of Wind Power & Solar Energy Utilization
Central Arid Zone Research Institute
Jodhpur-342003, India

Abstract

Hexane, a volatile hydrocarbon with maximum heat value and which can be obtained from sugarcane has been suggested as a possible source of energy for India which is the second largest sugarcane producer in the world. A fraction of the total sugarcane production in the country, if converted into hexane, can meet various energy demands like oil, electricity and irrigation. For example, sugarcane required for oil, electricity and irrigation is only 3.86%, 1.10% and 1.23% of India's total production, respectively. A small Indian state, like Haryana, is also sufficient to meet India's total energy demands. It is, therefore, emphasized that research should either be directed or imported immediately to mass-produce hexane from sugarcane.

Introduction

Hexane is a very good alternate energy source for use in chemical feed stock, motor fuel and heat source because of its high heat value as compared to other fuels (**Table 1**). Malhotra (1980) listed sugarcane, sorghum, sugarbeet, wheat, corn, wood and grasses as possible sources of hexane.

The objective of this paper is to analyze the potential of sugarcane in India as a possible source of hexane and how much sugarcane can meet various energy demands when converted into hexane.

Table 1. Comparison of Heat Values of Important Fuels

Fuel	Heat value in kJ/kg
Methanol (Wood alcohol)	22,330
Wood	25,586
Ethanol (Grain alcohol)	29,773
Coal	30,238
Diesel (Hexane cane)	47,260
Gasoline (Octane)	47,894
Hexane	48,313

Results and Discussions

Although sugarcane is not indigenous to India, the country is the second largest sugarcane grower in the world. Nearly 3 million ha of land produced 160 million t of sugarcane in 1976-77 (**Table 2**). The increase in sugarcane production over the years have been substantial even as the total area planted to sugarcane did not increase considerably.

Sugarcane yield in the country has in recent years steadily increased from 40t/ha to 50t/ha. (**Fig. 1**).

Although sugarcane is produced in almost all states potential producers are Andhra Pradesh, Haryana, Maharashtra, most Tamil

Table 2. Distribution of Sugarcane Area and Production, Leading States

Year	Andhra Pradesh		Haryana		Maharashtra		Tamil Nadu		Uttar Pradesh		All India	
	A	P	A	P	A	P	A	P	A	P	A	P
1976-77	151.8	10,522.3	168.0	7,280.0	240.0	21,498.0	132.7	13,162.8	1,490.6	68,109.1	2,872.4	154,023.1
1975-76	146.6	10,332.3	157.8	6,870.0	211.8	18,869.6	128.3	11,936.0	1,440.7	58,359.3	2,762.2	140,603.5
1974-75	151.2	11,478.9	162.0	5,940.0	191.8	17,731.8	155.7	12,737.0	1,447.0	59,429.3	2,771.2	140,196.0
1973-74	143.6	10,907.1	149.7	5,930.0	164.6	12,943.0	186.2	18,297.7	1,472.7	60,772.7	2,752.1	140,804.5
1972-73	120.7	9,209.2	136.0	6,000.0	180.8	11,917.7	113.1	9,770.2	1,341.8	58,743.4	2,480.6	123,967.9
1971-72	125.5	11,205.8	114.0	5,140.0	181.8	11,494.5	120.7	9,793.1	1,274.1	49,662.7	2,418.0	115,378.2
1970-71	135.4	10,508.3	155.0	6,980.0	217.2	14,770.0	135.0	10,443.4	1,368.6	55,663.8	2,657.0	128,769.4
1969-70	158.4	11,108.1	169.0	7,920.0	222.1	14,443.7	135.0	10,215.4	1,376.6	60,678.3	2,748.0	135,024.3
1968-69	153.7	11,540.2	161.0	6,730.0	173.5	11,561.3	101.2	8,164.4	1,233.7	51,083.4	2,460.7	117,571.7
1967-68	116.8	9,566.0	122.0	4,760.0	168.4	10,672.7	95.7	7,558.9	993.3	39,998.0	2,036.9	96,884.3
1966-67	108.4	8,032.6	151.0	5,100.0	160.5	9,977.2	88.2	6,897.2	1,189.7	39,367.6	2,301.3	92,826.1

A = Area planted to sugarcane in 1,000 ha. P = Production of sugarcane in 1,000 t.

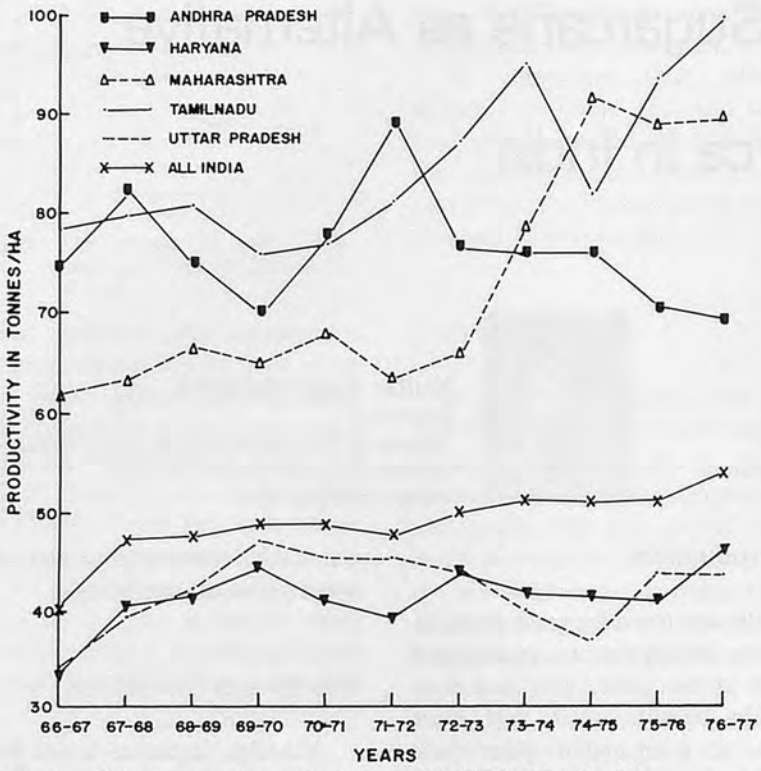


Fig. 1 All India sugarcane productivity in t/ha (1966-67 to 76-77)

Nadu and Uttar Pradesh. Andhra Pradesh, Tamil Nadu and Maharashtra have always shown higher sugarcane production levels than other major sugarcane producing states in India. (Figs. 2, 3, 4 and 5)

Sugarcane composition varies considerably according to variety and climatic conditions. The internodes have higher sucrose content than the nodes and the maximum concentration of sucrose has been reported in the central internodes of the mature canes. Under normal Indian conditions, the percentage composition of sugarcane (Chadha, 1972) is as follows: water, 70-75; fibre, 12-20; nitrogenous substances, .3-.4; fats and waxes, .15-.25; gums and proteins, .15-.25; free fatty acids, .08-.12; combined acids, .10-.12; ash, .30-.50; and sugar (sucrose, glucose and fructose), 12-15.

Hexane has distinct advantage over other physical and chemical fuels in terms of heat energy contents. **Table 1** indicates that hexane has a higher heat value than methanol, ethanol, diesel oil and gasoline. It is, therefore, highly desirable to convert sugarcane to hexane. According to Freeman (personal communication, 1979) the glucose from sugarcane can be converted into hexane as follows:

$$C_6H_{12}O_6 + 14\,H^+ \xrightarrow{\text{Acid catalyst}} C_6H_{14} + 6H_2O$$

Freeman indicated that approximately 100 litres of hexane can be produced from 1 t of sugarcane. This means that India can produce 15 million t of hexane from sugarcane on its 1976-77 production

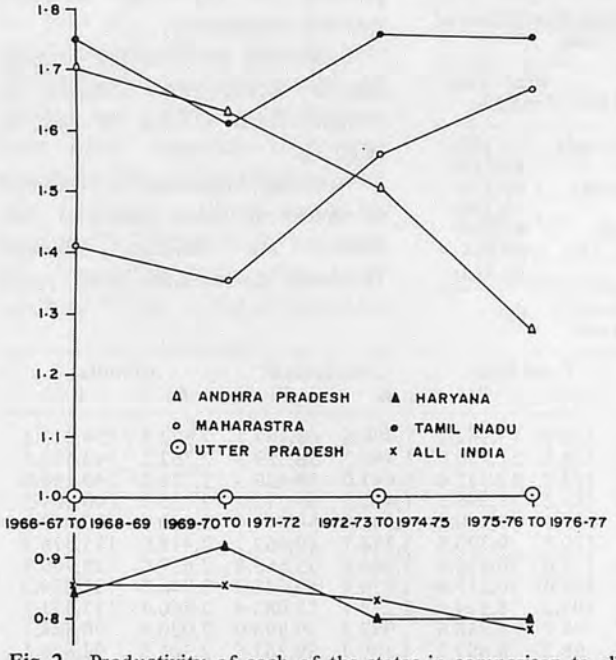


Fig. 2 Productivity of each of the states in comparison to all India production

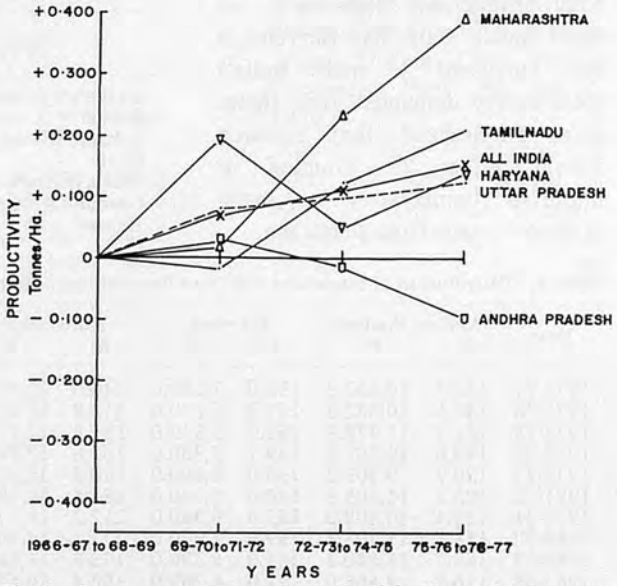


Fig. 3 Increase or decrease in productivity for each three years block (1969-70 to 1976-77) over the initial block year (1966-67 to 1968-69)

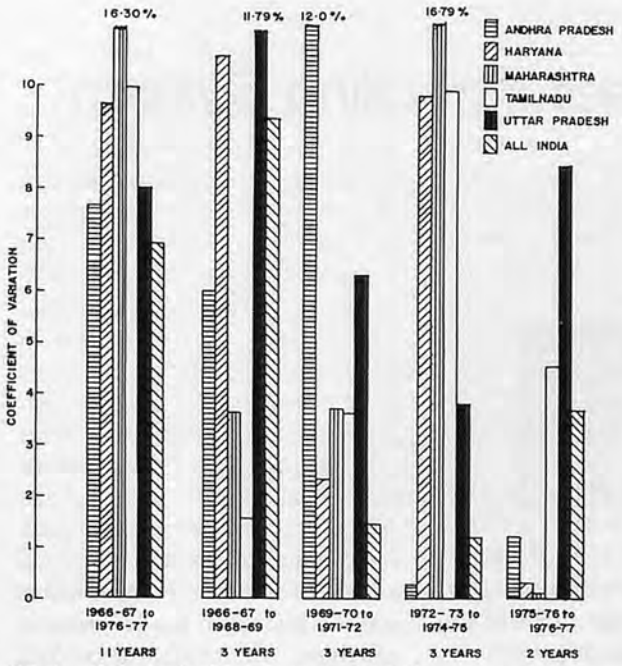


Fig. 4 C.V. graph of sugarcane productivity

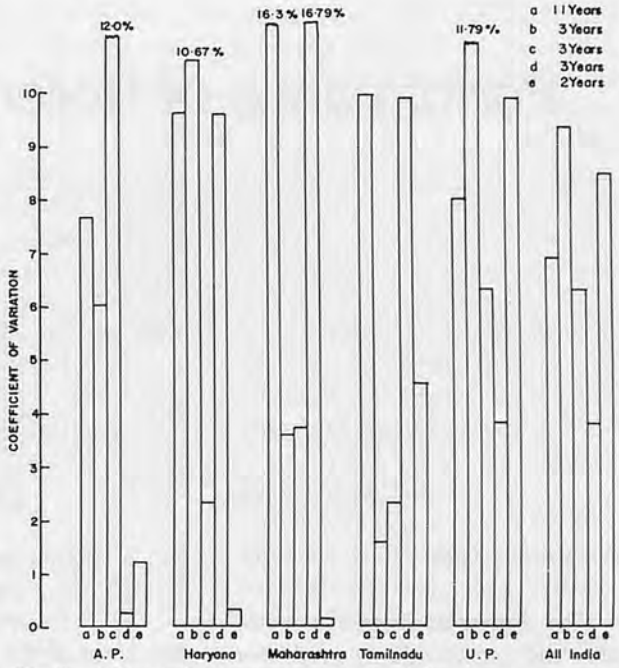


Fig. 5 C.V. graph of surgarcane productivity

level. World annual energy demand at present is 45×10^{12} kwh. The equivalent hexane for this purpose is about 1.5×10^{9} kl for which about 8,000 million t of sugarcane is sufficient. This means that India can meet 1.95% of the world energy demand if it converts total sugarcane into hexane.

Indian electricity demand at the present time is 9.8×10^{3} million kwh for which 31.5 kl of hexane is required. That much hexane can be produced from 1.7 million t of sugarcane which is only 1.10% of India's total sugarcane production and 2.50% and 23.35% of the sugarcane production of Uttar Pradesh and Haryana, respectively. Another very important demand throughout the world is oil. India requires 3.4×10^{4} million kwh of oil energy for practically all purposes for which 1.10×10^{2} kl of hexane is required. For this, only 3.86% of India's total sugarcane production is required to be converted into hexane. Uttar Pradesh and Haryana can easily meet this demand as only 8.74% and 81.73% of their sugarcane production respectively is sufficient. Further, for agricultural operation like lift irrigation, energy required is 10.9×10^{3} million kwh annually (Michael, 1975) for which only 1.23% of India's total production (1976-77) level is sufficient to meet the demand. Uttar Pradesh and Haryana need to contribute only 2.77% and 25.96% of their sugarcane production, respectively towards this venture. Haryana can safely meet at least the lift irrigation and oil demands of India if all sugarcane produced in this state is converted into hexane.

Constraints in Hexane Production

In spite of the fact that India can be self sufficient for almost all energy demands without adversely affecting the domestic sugar production, no efforts have gone into the exploitation of this possible fuel source. It is, therefore, urgent that research be directed toward this end: know the ways and means of manufacturing hexane cheeply and abundantly. In fact, we can transfer technology from U.S.A. which already has sufficient know-how to convert sugarcane into hexane and that would perhaps not be costly in the long run specially in the light of the fact that there is a lot of potential in India to double, if not more, the sugarcane productivity, as discussed earlier, in the near future.

According to Freeman, the conversion cost per litre of hexane from sugarcane is only $0.03 to 0.12.

REFERENCES

1. Chadha, Y.R. 1972: The Wealth of India, CSIR, New Delhi.
2. Freeman, J.F., 1979, Sucron Inc., California; Personal Communications.
3. Malhotra, K.S. 1980: Hexane, A Cheap Alternative Energy Source from Sugarcane, Urja, 6(5), 183-185.
4. Michael, A.M. 1975: Water Problems in Agriculture with Special References to Power Utilization, Special Report. ■■

Performance of Boilerless Parboiling System

by
S. Tiwary
Rice Process Engineering Centre
I.I.T., Kharagpur, India



T.P. Ojha
Rice Process Engineering Centre
I.I.T., Kharagpur, India

Parboiling Test

The system is designed to hot soak and parboil 680 kg paddy per day of 18 hours in 4 batches on per unit basis. Two parboiling methods namely: RPEC method and hot soaking followed by open steaming method were selected for conducting parboiling tests with the Jaya variety of paddy. In the RPEC method the paddy was soaked between 75°C and 80°C for 4 to 5 hours for starch gelatinization while in the second method, the hot soaking temperature ranged between 65° and 70 °C for 3.5 to 4 hours followed by steaming at the atmospheric pressure for 20-30 minutes. Based on the findings of the experiments conducted under controlled laboratory conditions by the authors on different parboiling methods, two best treatments for different varieties were selected for both the methods. The treatments are:

RPEC method

Hot soaking at 75°C for 4 hours, and hot soaking at 75°C for 4.5 hours

Open pan steaming method

Hot soaking at 70°C for 3.5 hours followed by steaming for 30 min, and hot soaking at 65°C for 4 hours followed by steaming for 30 min.

To start with, the tank was filled with water up to the soaking level mark (paddy water ratio 1:1.25). The oil-soaked cotton waste was used to ingite the husk on the fire grate before commencing the feeding of husk at the full rate. The feed roller was rotated very slowly until the flame became prominent and the smoke emerged from the chimney. The damper was also used to control the chimney draught. The husk feed rate was increased slowly as the fire spread over the grate bars. After about 10 minutes the furnace stabilized and the feed rate was increased further. The temperature of the tank water was checked from time to time and as soon as it attained the temperature of about 2°C above the soaking temperature, paddy was poured and spread evenly over the perforated sheet. The tank was covered with steel sheet and the rate of husk feeding was decreased considerably to maintain soaking temperature. The temperature of the tank was checked at 5-6 points to ensure uniformity. The variation in temperature was observed to be in the range of ±2°C between 65° and 75°C. At the end of the soaking period, the outlet valve connected at the perforated sheet level was opened to drain the soak water and the feed rate of husk was increased to almost maximum for steam

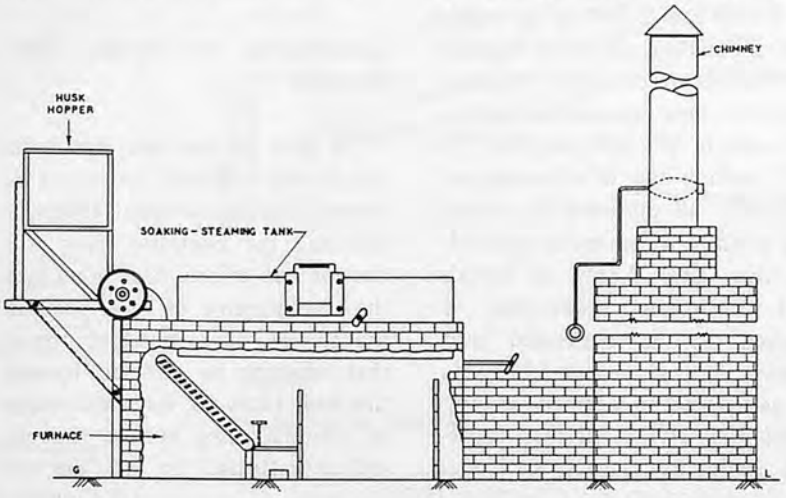


Fig. 1 Boilerless parboiling system

Note: This paper refers to and is part of an article entitled as "Efficient Use of Agricultural Wastes for Energy Production" which appeared in the preceding issue of AMA.

generation. The soaked paddy was then covered with gunny bags. The temperature at the level of the perforated sheet increased to about 98°C within 15 minutes of firing. The high temperature zone started moving upward at a slow rate to start with and then at a very fast rate after the lapse of about 7 minutes. Steam started coming out at few places from the bulk after about 25 minutes. The feed rate was reduced to minimum at this stage. Within the next 3-5 minutes, steam rushed through the entire paddy mass. At that stage the discharge gate was lifted for unloading steamed paddy to be removed for drying. The perforated sheet was cleaned and the sliding gate was put back in position. Thereafter, tap water was added in the tank to bring back the water level to the original mark. The parboiling tank was then ready for receiving the second batch of paddy. In the RPEC method no steaming was done and the paddy was unloaded after the hot soaking was over. About 1 kg paddy sample was collected and dried in the shade from each lot for milling experiments. The results are tabulated in **Table 1**.

Overall Heat Utilization Efficiency

The treatment selected for overall heat utilization efficiency was hot soaking at 70°C for 3.5 hours followed by open steaming for 30 minutes.

The time devoted for various operations were recorded. On the average, furnace required 2 hours for heating water from 28°C to 70°C in the initial stage. The time required for firing and stabilization of the furnace is included in the above duration. The breakdown of time required for different operations is –

Loading of paddy	5 min
Hot soaking of paddy	3 hr 30 min
Steaming of paddy	30 min
Unloading of paddy and topping of water	15 min
Total	4 hr 20 min

Husk consumed in various operations were recorded for each batch.

Unit: kg

Items	First batch	Second batch
Furnace firing and stabilization	6.0	0.0
Water heating	30.0	0.0
Hot soaking	18.0	18.0
Steaming	24.0	24.0
Total	78.0	42.0

After unloading the first batch of paddy, the tap water was added in the tank to bring back the water level to original mark. The temperature of hot water (left over from previous batch) and tap water mixture was observed to vary from 71° to 73°C. Therefore, the second batch of paddy was dumped in the tank as soon as the steamed paddy was transferred. Hence, the husk requirement for heating water before soaking remained zero for the second and subsequent batches.

The other parameters are:

Water for steaming (w_1). . 275.0 lit
Water for soaking and reserve water in tank (w_2)..... 455.0 lit
Total capacity of tank (w) ..... 570.0 lit
Weight of paddy per batch (m)..... 167.0kg
Initial temp. of water (t_1) 25.0°C
Soaking temp. (t_2) ..... 70.0°C
Temp. of boiling water (t_3) ..... 99.8°C
Temp. of steamed paddy (t_4) ..... 98.5°C

The overall heat utilization efficiency (O.H.U.E.) may be defined as the heat utilized in soaking as well as parboiling over the heat put in through the fuel. For this system, the efficiency may be calculated for three different conditions i.e., (I) if only one batch of paddy is parboiled per day; (II) if the unit is run for producing more than one batch per day; and (III) if the unit is run continuously without rest.

Case-1: One batch of paddy per day

1) Quantity of husk used–

Table 1. Milling Characteristics of Rice

	Treatment No. and details	Replication	Moisture content %(w.b.)	Sample size (g)	Brown rice (g)	Husk (g)	Milled sample (g)	Bran (g)	Head Rice (g)	Broken (g)	Total yield (%)	Head yield (%)	White belly (%)
T_1 –	RPEC method, 75°C soaking for 4 hours	1	14.5	250.0	200.0	50.0	190.0	10.0	187.0	7.0	76.0	73.2	
		2	14.5	250.0	201.0	49.0	192.0	9.0	184.0	8.0	76.8	73.6	34-35
		3	14.5	250.0	200.0	50.0	191.0	9.0	185.0	6.0	76.4	74.0	
T_2 –	RPEC method, 75°C soaking for 4.5 hours	1	14.2	250.0	198.0	52.0	188.0	10.0	176.0	12.0	75.2	70.4	
		2	14.2	250.0	200.0	50.0	190.0	10.0	178.0	13.0	76.0	71.2	12-13
		3	14.2	250.0	200.0	50.0	190.0	10.0	177.0	13.0	76.0	70.8	
T_3 –	Open pan steaming, 70°C soaking for 3.5 hours followed by 30 min steaming	1	14.5	250.0	201.0	49.0	191.0	10.0	188.0	3.0	76.4	75.2	
		2	14.5	250.0	202.0	48.0	193.0	9.0	186.0	7.0	77.2	74.4	10-15
		3	14.5	250.0	200.0	50.0	192.0	8.0	188.0	4.0	76.8	75.2	
T_4 –	Open pan steaming, 65°C soaking for 4 hours followed by 30 min steaming	1	14.4	250.0	201.0	49.0	191.0	10.0	187.0	4.0	76.4	74.8	
		2	14.4	250.0	202.0	48.0	193.0	9.0	189.0	4.0	77.2	75.6	39-40
		3	14.4	250.0	201.0	49.0	191.0	10.0	187.0	4.0	76.4	74.8	

78 kg

2) Heat value of fuel at the rate of 3,000 kcal/kg
= 234,000 kcal

3) Heat utilized in

a. Water heating
$= W_2(t_2 - t_1)$
= 455 (70–25)
= 20,475 kcal

b. Soaking – No heat energy required, only losses.

c. Steaming
$= w_1 (t_3 - t_2) + ms (t_4 - t_2)$ + heating soaked water
(s = specific heat of paddy, 0.5 kcal/kg°C)
= 275(100–70) + 167 (98.5–70) x 0.5 + 30 (98.5–70)
= 11,530 kcal

Therefore, heat utilized
= (a) + (b) + (c)
= 20475.0 + 0.0 + 11530.0
= 32,005 kcal

Hence, O.H.U.E.
= (32,005/234,000) x 100
= 13.7%

Case-2: Four batches of paddy per day

1) Quantity of husk used
= 204 kg

2) Heat value of fuel at the rate of 3,000 kcal/kg
= 612,000 kcal

3) Heat utilized in 4 batches
= 32,005 x 4
= 128,020 kcal

In calculating the heat utilized in each batch, the value has been taken from Case-1 and the husk saved in heating water for second and subsequent batches has been taken as additional gain for the system.

Therefore, O.H.U.E.
= (128,020/612,000) x 100
= 20.9%

Case-3: Continuous operation

1) Quantity of husk used per batch
= 42kg

2) Heat value of fuel at the rate of 3,000 kcal/kg
= 42 x 3,000
= 126,000 kcal

3) Heat utilized
= 32,005 kcal
(value taken from Case- 1)

Therefore, O.H.U.W.
= (32,005/126,000) x 100
= 25.4%

Discussion

The milling results are summarized in **Table 1**. The paddy variety selected for testing the system was Jaya which is high-yielding and very popular in West Bengal region. It is fragile in nature and the raw milling yield does not exceed 55 to 60%. In addition, it has very high percentage of chalky grains (more than 80%), hence desirable for parboiling. In all treatments the head yield exceeded 70%. The open pan steaming method appears to be superior to the RPEC method as the former gave consistently high yield in all replications. The white belly percentage was also minimum in open pan steaming method in which paddy was soaked at 70°C for 3.5 hours followed by RPEC method (soaking at 75°C for 4.5 hours). For the other treatments (No.1 and 4), the white belly percentage exceeded the acceptable level. Milled rice grains obtained from the open pan steamed samples were brighter in appearance compared to those obtained from the RPEC method.

The time taken in various operations was less than 4.5 hours. Only the first batch took additional 2 hours for the initial heating of water and the furnace stabilization. Therefore, if the system is to run at the rated capacity, it should be able to produce 680 kg of parboiled paddy in 4 batches for 18 hours a day. The total cost of the unit including fabrication and installation costs at the present market rates would be about Rs. 2,500. Other systems in use cost much more. Because overall heat utilization efficiency increased from less than 12% to over 20% over the existing units the improvement should bring about considerable saving of husk which could be diverted for other uses.

Considering the different O.H.U.E. of the system, an increase of about 35% is achieved from 1 to 4 batches per day of 18 hours. As expected, the highest O.H.U.E. (25.4%) was achieved on continuous use basis. Therefore, the proposed system appears to be technically feasible, economically viable and suitable for use at the village level.

Summary and Conclusions

Both the traditional and modern methods of paddy parboiling systems suffer from poor yield quality of rice and high investment resulting in high parboiling charges. The boilerless process offers potential for improving the small-scale operations. The system, in conjunction with the husk-fired furnace, can produce 680 kg of parboiled rice in four consecutive batches within 18 hours and by increasing the capacity of the unit, the total output can double.

REFERENCES

1. Maheshwari, R.C. and Ojha, T.P. (1974), Fuel characteristics of Rice Husk (Proceedings). International Conference on By-product Utilization of Rice, pp. 67-76, Valencia, Spain.
2. Jaiswal, D.K. (1978): Development and Testing of Husk-fired Parboiling System. M. Tech. thesis (Unpublished), Rice Process Engineering Centre, IIT Kharagpur. ■■

Food Processing and Preservation for Rural Women in Bangladesh



by
Jinnat Ara Begum
Associate Professor & Head
Department of Food Technology and Rural Industries
Bangladesh Agricultural University
Mymensingh, Bangladesh

Introduction

Bangladesh is an agricultural country and more than ninety per cent of her population, of which nearly fifty per cent is women, live in the rural areas. The lives of rural people move around the various agricultural courses of ploughing, sowing, weeding, harvesting, threshing, processing, drying and storage of crops all throughout the year. Of all such tasks the rural women take care of the processing and storage part of the crops, whereas men do most of the work in the field. Traditionally, the women in Bangladesh do not work in the field. The domestic tasks of the rual women include the processing and storage of paddy, pulses and spices, cooking for their families, rearing poultry and growing fruits and vegetables in the kitchen garden. Rural women also process fruits and vegetables for future use. They make country pickle (Achar) and sauce (chutney) from green and ripe mangoes. Vinegar is prepared by rural women from molasses, date juice and black berries. In the rural areas women also dry small fish and preserve hilsha fish in brine. A large number of home-made confections and sweets like pithas (country cakes), murabba (preserve) and sweets made of milk are made by rural women. Most of the traditional methods of food processing and preservation practiced by rural women are crude and the products are made in an unhygienic condition. Improvements in the processing techniques and development of simple machines or devices and maintenance of hygienic conditions are necessary to improve the present status of food processing and preservation in the rural areas of Bangladesh.

Table 1. Population of Bangladesh by sex, urban and rural 1974*

(Unit: million)

Sex	Urban	Rural
Male	3,541	33,532
Female	2,733	31,673
Total	6,274	65,205

* 1974 census unadjusted data and 1979 statistical yearbook of Bangladesh.

Traditional Methods of Food Processing and Preservation

A brief outline of some of the important traditional methods of food processing and preservation is given below.

Threshing

Though the actual threshing is carried out by men, the threshing floors are prepared by women. The rural women also help men during the separation of straw and grain.

Drying of paddy

The paddy is spread on the threshing floor from sunrise to sunset and women turn it over with their feet several times a day. If the amount is large it takes several days to complete the process.

Winnowing

Winnowing is as important as threshing and this process is entirely carried out by the women. About 15-20% of the paddy grown

is usually empty and this has to be separated from the rest of the paddy. There are several different ways of doing this but the method the rural women usually practice is a time consuming one and it is repeated after husking and milling also. The women use sieves after winnowing to clean the paddy still further.

Storage

The methods of storage of paddy are different for different areas. In case of the small subsistence farmers the paddy is stored in a bamboo busket "dole" in a corner of the house on a bamboo platform. The basket is sealed with one or two layers of mud and mixed with cowdung and rice husks, which is then allowed to dry hard. A bamboo stick is used to ram the paddy down into the busket (dole) so that there is no air pocket and a mat is placed on the top.

Parboiling

Parboiling of rice is not practiced nation-wide and not all varieties of rice are parboiled. The process of parboiling varies with different types of rice and in different areas. Rural women first make a stove (Chula) and steam the paddy in a big metal pot by burning twigs, leaves and rice straw in the stove. They know from experience, the amount of water to use and how long to steam the paddy. The parboiled paddy is then laid on a coarse bamboo mat and later spread out on the threshing floor to dry in the sun. During drying it is turned frequently. The whole process is sometimes repeated and usually takes two to three days to complete. After drying the paddy is stored in a bamboo basket as mentioned earlier. Only the rural women take part in this process and men know very little about it.

Husking

Husking paddy is done mainly by women. Two methods of husking are used. In the first method, women pound the paddy in a specially designed wooden mortar (Ghail) with a heavy wooden pestle (Sia) which they hold vertically and drop down into the paddy rhythmically. Usually two women take part in this job by pounding in turn. In the second method they employ a "dheki" which is made of wood. It is rather costly to buy but it speeds up the process and is easier to handle. Three women operate a dheki and can husk five maunds (a maund equals to 88 lbs) of paddy in three days. Engine-operated rice mills are now doing the husking on a large scale. But the process is wasteful since it normally produces only 20-22 seers of rice from a maund of paddy, whereas the women get as many as 30 seers (40 seers equal to a maund) by their method. The rice mills also polish the rice and in so doing remove much of its nutrients. The total capacity of medium rice mills is 2.3 million m.t. which mill about 18 percent of the country's total rice production of 12.8 million m.t.

Home-made mollasses

Mollasses or "gur" are prepared in homes in Bangladesh. Two types of "gur" are available; cane gur and date Palm gur. Gur technology has remained unchanged for many years. The rural housewives take active part in the preparation of gur as cottage industries. Of the country's total sugarcane production of 6.4 million m.t., 0.14 m.t. is sugar and 0.15 m.t. is "gur."

Fruits and vegetable processing

In the rural areas women make pickle (achar) and sauce (chutney) and preserves (murabba) from fruits like mango, olive, lemon and lime. Sometime they cut green mangoes in thin slices and mixing with a little turmeric dry these in the sun. After drying, these are stored in an air tight container or earthen pot. The ripe mango pulp is cooked and spread on bamboo trays in layers to make a dry product known as "Amsatta". In 1976/77 and 1977/78, the total fruits and vegetable production in the country were estimated at 1.36 million m.t. and 1.59 million m.t., respectively.

Women in the rural areas take pride in growing vegetables in their kitchen garden. They usually store different varieties of ripe pumpkin, bean seeds, potatoes, sweet potatoes, onions, garlic, ginger, turmeric, chillies etc. on bamboo mat, in earthen pot in a cool place of the house. Sometime they store these in "sikas", hanging from the ceiling. Women also store pulses, and lentils and after drying and husking in bamboo busket or in earthen pots.

Meat and fish processing

Rural women dry the surplus meat (usually beef after the Eid-ul-Azha festival) in the sun with a little salt and turmeric. They also dry small fish in the sun and preserve "hilsa" fish in brine. After drying they store the fish in air tight container or in earthen pot. In 1976/77, Bangladesh's fish production was estimated at 826,000 m.t. of which 136,000 m.t. was inland and 90,000 m.t. was marine product.

Milk products

Indigenous milk products are

prepared by rural women. These includes ghee, dahi, country cheese, khoa, kheer, chana etc.

Scope for Improvement of Traditional Methods

Due to the climatic condition of Bangladesh food perishes quickly and is spoiled by insects, rodents and microorganisms if adequate precautions are not taken. The methods used by rural women for the processing, preservation and storage of foods are primitive and outmoded. The unsatisfactory practices cause immeasurable losses of food. The tasks of processing paddy are monotonous, time consuming and arduous. By applying of simple techniques rural women could be helped to make their present tasks of processing paddy much easier. Improvement in the processing methods includes development of suitable threshing machine, winnowing devices, development of new techniques for parboiling, drying and storage of paddy. In introducing new techniques care should be taken so that these do not come in conflict with their local customs. Sun drying of fruits and vegetables, traditional methods of making achar, and vinegar and storage practices could also be improved to extend the shelf life of the products.

Responsibilities of Food Technologists

The food technologists working in the universities, research institutions and home science colleges could take up projects to train rural women in suitable food processing and preservation. This type of training could be given through the local women's organization and the women's community centre. It is also the responsibilities of the food technologists and food scientists to evaluate the traditional methods of food processing and preservation and storage practices and this will help them to modernize the traditional practices of processing and storage of paddy and rice, fruits and vegetables, meat, fish and dairy products.

REFERENCES

1. Peterson, M.S. and Tressler, D.K. 1965. Food Technology the World Over. Avi Publishing Co. Westport. Conn.
2. Proceedings of the Workshop on Appropriate Agricultural Technology 1975. Bangladesh Agricultural Research Council, Dacca, Bangladesh.
3. A Feasibility Survey of Productive/income Generating Activities for Women in Bangladesh, 1977. Women's Development Programme, UNICEF.
4. 1979 Statistical Yearbook of Bangladesh, Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Govt. of the People's Republic of Bangladesh, Dacca. ■■

Paddy Post Harvest Technology in Bangladesh

(Continued from page 42)

REFERENCES

1. Bala, B.K., 1978. Post-harvest losses of paddy in Bangladesh. A.M.A., Japan, Volume IX. No. 4.
2. Monthly Statistical Bulletin of Bangladesh, 1977. Volume IV. No. 1. Bangadesh Bureau of Statistics, Ministry of Planning, Dacca.
3. Monthly Statistical Bulletin of Bangladesh. 1977. Volume IV. No. 9. Bangladesh Bureau of Statistics, Ministry of Planning, Dacca.
4. Andersen, Palle C. and Hobarg, J., 1974. Pilot project on mechanized paddy drying (preliminary report), Comilla, Bangladesh.
5. Islam, M.N., 1977. Harvesting, conservation and storage of paddy rice at farm level with special reference to Bangladesh. Institute of Agricultural Engineering, Royal Veterinary and Agricultural University, Denmark.
6. Statistical Pocket Book of Bangladesh, 1978. Bangladesh Bureau of Statistics, Ministry of Planning, Dacca.
7. Ali, N. and Ojha, T.P., 1976. Parboiling in rice post-harvest technology. Edited by E.V. Araullo, D.B. de Padua and Michael Graham. IDRC-o53E. Ottawa, Canada.
8. Campbell, J.K., 1976. Development and manufacture of a thresher for developing countries in South-East Asia. A.M.A., Japan, Summer.
9. Brooker, D.B., Bakker-Arkema, F.W. and Hall, C.W., 1974. Drying cereal grains. First edition. The AVT publishing company. Inc. West Port, Connecticut. ■■

Performance of

Low-Cost Sail-Wing Windmill

by

S.C. Chowdhry
Junior Research Engineer
Division of Wind Power & Solar Energy Utilization
Central Arid Zone Research Institute
Jodhpur, India

B.V. Ramana Rao
Senior Scientist and Head
Division of Wind Power & Solar Energy Utilization
Central Arid Zone Research Institute
Jodhpur, India

P. Sharma
Foreman
Division of Wind Power & Solar Energy Utilization
Central Arid Zone Research Institute
Jodhpur, India

Abstract

The water discharge in litres per hour and efficiency at different wind velocities in respect of the low-cost sail-wing windmill developed at Central Arid Zone Research Institute (CAZRI), Jodhpur were given on the basis of performance studies conducted for a period of two years. This windmill was found to work with greater efficiency compared to other types of windmills recently developed in India. The efficiency of the windmill is maximum (23%) at wind speed of 9 km/hr and found to decrease with an increase in wind speed beyond 9 km/hr. The volume of water that can be pumped from the water table at varying depths at wind velocities ranging from 8 to 30 km/hr was also determined.

Introduction

In view of the increasing prices of fossil fuels and frequent power failures, attention is being drawn to utilizing renewable sources of energy like wind power for pumping water for irrigation. Wind power can be conveniently used economically (Michael and Ojha, 1965) for lifting water for irrigation in regions where the mean monthly wind speed exceeds 8km/hr for considerably more than 8 to 9 months provided the water table is shallow and not below a depth of 10 m. Ramana Rao *et al*, (1980) have shown that the command area of a windmill is about 3-4 ha in the "kharif" season and about 1 ha during "rabi" season in some of the arid regions of India considering a constant water table of 10 m depth. Recently several windmills were designed in India by Chowdhary and Krishnan (1978), Govinda Raju and Narasimha (1979) and Tewari *et al* (1979). Of these windmills, the sail-wing windmill developed by Chowdhary and Krishan (1978) is the least expensive: US$375 per unit.

The details of design and fabrication of the low-cost sail-wing windmill (**Plate 1**) developed at CAZRI are given by Chowdhry and Krishnan (1978) and subsequent improvement of the design by Chowdhry and Sharma (1980). The present paper deals with (1) the performance of the low-cost sail-wing windmill on the basis of field tests conducted for a period of two years (1978-1979) and (2) the estimates of water that can be pumped from wells of different depths at different wind speeds so that the suitability of the windmill for pumping water in any region can be easily determined.

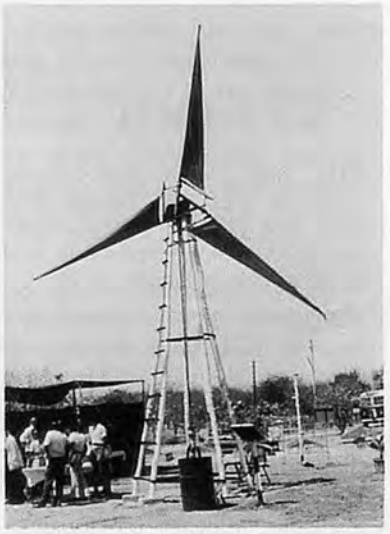


Plate 1 Details design of the wind mill

Acknowledgements: The authors are thankful to Dr. H.S. Mann, Director, Central Arid Zone Research Institute, Jodhpur for his valuable encouragement in conducting the above study.

Material and Methods

According to Lahiri (1975), the ground water table occurs at a depth of 40-60 m while the perched water occurs at a depth of 7-20 m in the Jodhpur region. Therefore, for studying the performance of the windmill, a tank was kept in the soil and the water level was maintained at a depth of 3.5 m below the ground. Observations on discharge of water were taken every hour periodically in 1978 and 1979. The average wind speeds were simultaneously measured using a cup anemometer installed in the meteorological observatory very close to the site of the windmill. The number of revolution of the rotor was measured with the help of a revolution counter.

The average discharge of water in litres per hour at different wind speeds were estimated by graphical interpolation after analysing the data. The efficiency of the windmill at different wind velocities was calculated by using the formula

$$\eta = \frac{2\,\nu\,h\,d\,g}{\rho\,A\,V^3}$$

where

ν = volume of water pumped in l/sec
h = depth of the water column in m
d = density of water in kg/cm^3
g = acceleration due to gravity in m/sec^2
ρ = density of air in kg/m^3
A = area of cross-section of the rotor
V = wind velocity in m/sec.

After finding the efficiency of the windmill at different wind velocities, the water that can be pumped by the windmill from wells of different depths at different wind velocities were calculated.

Results and Discussion

The average discharge of water in l/hr and the efficiency of the windmill at different wind speeds are shown in **Fig. 1**. It can be seen that the windmill works with a maximum efficiency of 23% at wind speed of 9 km/hr. The efficiency of the windmill at operating wind speed of 8 km/hr is 17%. The windmill registered an efficiency of more than 10% up to wind speeds of 13 km/hr. The efficiency decreased with an increase in wind velocity beyond 9 km/hr almost at an exponential rate. Tewari *et al* (1979) have shown that the maximum efficiency of the windmill was 11% at wind velocity of 10 km/hr and decreased with increase in wind velocity beyond 10 km/hr in respect of a horizontal axis sail windmill. Govinda Raju and Narasimha (1979) found that the efficiency of water pumping windmill using Savonius rotor developed by them was maximum of 12% at a wind speed of 10 km/hr and there was rapid fall in efficiency with increasing wind speeds 10 km/hr. Therefore, it is obvious that the low-cost sail-wing windmill developed at CAZRI has comparatively greater efficiency, hence more suitable in regions with wind speeds of 10-15 km/hr on the average. The decrease in efficiency with an increase in wind speed may be due to (1) vibrations produced on the sails by the pulsating and strong winds and (2) variation of overall efficiency with the rpm of the rotor as reported in respect of a typical centrifugal pump by Lazarkiewicz and Troskolanski (1965).

Fig. 2 shows the discharge of water and efficiency for different rpm of the rotor. As expected, the water discharge proportionally increases with increase in rpm. But the efficiency of the windmill was found to increase with rotor rpm up to 17 rpm and then onwards decreases exponentially as pointed out by Lazarkiewicz and Troskolanski (1965) in respect of a typical centrifugal pump. This is one of the limiting factors in achieving greater efficiency of the windmills.

The estimated discharge of water that can be pumped by the sail-wing windmill in l/hr at wind speeds from 8 to 30 km/hr from water table of depths 1, 3, 5, 7 and 9 m are shown in **Fig. 3**. Using this figure, one can readily find the

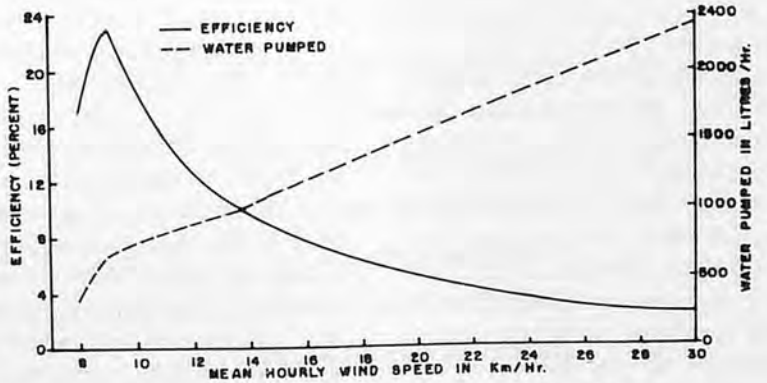


Fig. 1 Discharge of water and efficiency for different wind speeds

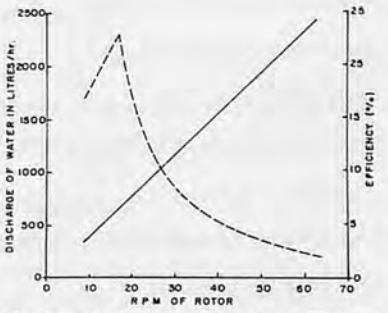


Fig. 2 Discharge of water, efficiency for different rotors

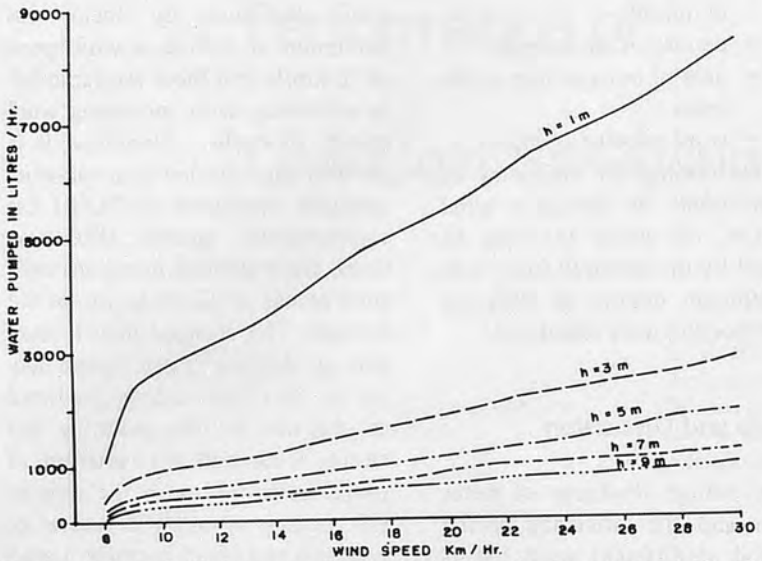


Fig. 3 Estimated discharge at different wind speeds from water table of different depths

water output in l/hr from a well of depth up to 9 m for any wind speed ranging from 8 to 30 km/hr. Depending upon the depth of the water table and the wind regime of the given region, the suitability of using the windmill for irrigation can be ascertained.

REFERENCES

1. Chowdhry, S.C. and Krishnan, A. (1978). A Low-cost Sail-wing Windmill. Research and Industry, 23 : 81-84.
2. Chowdhry, S.C. and Sharma, P. (1980). Windmill for Villagers. URJA (in press).
3. Govinda Raju, S.P. and Narasimha, R. (1979). A Low Cost Water Pumping Windmill Using a Sail-type Savonius Rotor. Proc. Indian Academy of Sciences, C2(1) : 67-82.
4. Lahiri, A.N. (1975). Water Use by Desertic Vegetation and its Hydrological Implications. Annals of Arid Zone 14(2) : 135-148.
5. Michael, A.M. and Ojha, T.P. (1966). Principles of Agricultural Engineering, Volume 1 (Bhopal : Jain Brothers).
6. Ramana Rao, B.V., Rama Krishna, Y.S. and Chowdhry, S.C. (1980). Wind Power Potential for Irrigation in the Arid Regions of India (Communicated).
7. Tewari, S.K., Ningaiah, Subrahmanyam, D.V.V. and Samraj, A.C. (1979). A Horizontal Axis Sail Windmill for Use in Irrigation. Proc. Indian Academy of of Sciences, C2(1) : 107-116. ■■

INDEX TO ADVERTISERS

Arimitsu Industry Co., Ltd. 46
Hashimoto Seisakusho, Ltd. 88
Hōden Mfg. Co., Ltd. 89
Honda Seisakusho Co., Ltd. 89
Iseki & Co., Ltd. 2
Kaneko Agricultural Machinery Co., Ltd. 86
Kett Electric Laboratory 43
Kobashi Kogyo Co., Ltd. 89
Mametora Agric. Machinery Co., Ltd. 92
Marumasu Machinery Co., Ltd. 46
Matsuyama Plow Mfg. Co., Ltd. 43
Nissan Kizai Co., Ltd. 88
Ochiai Cutlery Mfg. Co., Ltd. 91
Satake Engineering Co., Ltd. 44
Sumitomo Chemical Co., Ltd. 6
Yanmar Diesel Engine Co., Ltd. 4

Population Growth and Food Supply in Bangladesh



by
Md. Daulat Hussain
Assistant Professor
Department of Farm Power & Machinery
Bangladesh Agricultural University
Mymensingh, Bangladesh



Md. Faroque Ahmed
Assistant Professor
Department of Agricultural Statistics
Bangladesh Agricultural University
Mymensingh, Bangladesh

Introduction

Bangladesh is the most densely settled rural nation in the world. It provides an acute illustration of the recent concern over the precarious global balance between food supply and rapid population growth. The economy of Bangladesh is dominated by agriculture. Despite the predominance of agriculture, the country has consistently imported a significant fraction of food grains and the fraction has increased in recent years. This is so because production in the country was seriously affected due to war in 1971 and other natural catastrophes in subsequent years. Moreover, the population is growing at an alarming rate and as a result the balance between population growth and food supply has been precarious. The food situation in the country is likely to be worse in future because of rapid population growth, resulting mainly from the effective fall in the mortality rate.

The expansion of the cultivated area in Bangladesh is almost impossible and the country also lacks other resources, such as exploitable minerals which could be used to finance food imports. Moreover, according to demographic projections, the population of Bangladesh would double before the end of this century even if optimistic reduction of fertility is possible (16). Now the question arises whether Bangladesh with its existing resources is able to feed its growing population in the future. Because of this state of affairs, the need arises for a reassessment of the food and population situation in Bangladesh for development policy implications.

Table 1. Population Growth and Agricultural Land of Bangladesh, 1964–77 (in '000' ha)

Year	Population (million)	Net Cropped Area (ha)	Net Cropped Area per Capita (ha)	Total Cropped Area (ha)	Total Cropped Area per Capita
1964–65	59.9	8,543	0.142	11,553	0.192
65–66	61.7	8,745	0.141	11,959	0.193
66–67	63.5	8,547	0.134	11,756	0.185
67–68	65.3	8,805	0.135	12,728	0.194
68–69	67.2	8,755	0.129	12,604	0.187
69–70	69.3	8,811	0.127	13,295	0.191
70–71	71.0	8,648	0.121	12,297	0.172
71–72	72.6	8,247	0.113	11,404	0.157
72–73	74.3	8,437	0.113	11,756	0.158
73–74	76.4	8,492	0.111	11,912	0.156
74–75	78.0	8,328	0.106	11,593	0.149
75–76	79.9	8,489	0.106	12,018	0.150
76–77	81.8	8,277	0.101	11,732	0.143

Source: Statistical year book, 1979, Govt. of Bangladesh

This study is an analysis of the relationship between agricultural area and population over the period 1964–1977. Table 1 shows the increasing discrepancy between rapid population growth, on the one hand, and the slow increase in the total cropped area, on the other. There is unfavourable relationship between agricultural area and population and the imbalance between the agricultural land and population. In 1964–65, there was a net cropped area of 8.5 million ha and total cropped area of 11.6 million ha. The corresponding figures in 1976–77 were 8.3 and 11.7 million ha respectively. Net cropped area decreased by 3% and total cropped area increased by 1.55%. During the study period, per capita net and total cropped area decreased from 0.142 to 0.101 and 0.192 to 0.143 ha respectively.

Some Aspects of Bangladesh Agriculture

Bangladesh has a backward agrarian structure, a long history of colonial exploitation and has borne the major share of responsibility for prolonged stagnation and persistent poverty. Agrarian means

Table 2. Land Utilization Pattern in Bangladesh (1973–74)

Type of land	Area (million ha)	Percent
Total area	14.3	100.00
Permanent medows and pastures	00.6	4.20
Forest and wood lands	02.2	15.50
Other lands, houses and rivers	02.4	16.60
Total land not available for cultivation	05.2	35.30
Land available for cultivation	09.1	64.74
More than once cropped area	04.5	–
Cropping intensity	–	150.00

Source: FAO (1973). Production Year Book, FAO, Rome, Mettrick, H (1976). Socio Economic Aspects of Agricultural Mechanization in Bangladesh, Dept. of Agricultural Economics and Management, University of Reading, March, 1976.

high man-land ratio, tremendous fragmentation of land, peasant economy predominantly subsistence-oriented and primitive technology.

The country lies on the combined delta of three great rivers. The climate is tropical and crops can be grown throughout the year. Of a total surface area, 64.70% is utilized for agriculture (**Table 2**). In 1976–77, the net cropping area (land cropped once or more) was 8.3 million ha and constituted 58% of the total area and more than 90% of the arable land. The cropping intensity is approximately 150%. This means that only about half of the cultivated land was cropped more than once a year. The cropping intensity in Bengal in 1928–29 according to Banking Inquiry Committee Report was about 120%. The present level of cropping intensity appears good.

Table 3 shows the cropping pattern in Bangladesh. Most of the agricultural land is planted to principal crops such as paddy, jute, sugarcane, etc. during the rainy months from May to October. From December to March, land is mostly utilized for vegetables and winter crops (4). Six important cropping patterns are:

1) High and medium lands: single Aman.
2) Medium lands: Aus-or-Jute and transplanted Aman.
3) High and medium lands: Aus-or-Jute and rabi (winter) crops.
4) Low lands: broadcast Aman-or-Jute and rabi crops.
5) Medium and high lands: sugarcane.
6) Very low lands: Boro crop.

Due to peculiar climatic and physical condition, it is not very easy to develop new cropping pattern during the kharif season (summer season) which constitutes 80% of total cropped area. The winter crops locally known as rabi crops which accounts for only 18% of the total cropped area have vast potentiality (13). Several kinds of vegetables such as brinjal, bottle gourd, radish, cabbage, tomato, lettuce etc are grown in winter season. Due to lack of sufficient vacant lands and drainage problem, cultivation of summer vegetables is less extensive than the winter vegetables. Area under winter crops is also tremendously decreasing probably due to increasing cultivation of potato, wheat and other rabi cereal crops. However, if irrigation facilities can be provided, it will be possible to grow more winter vegetables and crops. In fact, irrigation can tremendously increase cropping intensity and develop new cropping pattern for increased production.

Table 3. Area of Principal Crops for the Year 1976–77

Crops	Area (ha)	Percent of Total Cropped Area
Cereals	9,882,294.4	84.3
Wheat	160,050.8	1.4
Pulses	333,011.4	2.8
Edible oil seeds	264,609.5	2.3
Jute	648,908.1	5.5
Sugarcane	144,593.2	1.2

Source: Bangladesh Bureau of Statistics 1979

Table 4 shows a picture about the size structures of farms in Bangladesh. There are three groups in size structures of farms in Bangladesh such as small farms, medium farms and large farms. Among these groups, only large farms can produce surplus which is sufficient enough for accumulation and reinvestment. A comparison of the structure of ownership right in agriculture between 1960 and 1974 shows that during this period the social inequalities in agriculture became more pro-

Table 4. Percentage of Farm and Farm Area (Operational)

Size (ha)	Farms (%)			Area (%)		
	1960	1968	1974	1960	1968	1974
Less than 0.202	13	12	32	1	1	2
0.202–0.405	11	13	9	2	3	3
0.405–1.012	27	32	25	13	17	19
Less than 1.012	51	57	66	16	21	24
1.012–2.024	26	26	28	28	30	34
2.024–3.036	12	9	7	19	18	19
3.036–5.060	7	5	3	19	15	13
5.060–above	4	3	1	20	16	11
2.024–above	23	17	11	58	49	43

Source: Alamgir Mohiuddin, Some Aspects of Bangladesh Agriculture: Review of performance and evaluation of policies, The Bangladesh Development Studies, V, III, July, 1975.

nounced. The interesting finding of **Table 4** is that due to constant pressure of rapid population growth and law of inheritance, the large farms have broken down into medium and medium into small farms. The small farmers have mostly turned into agricultural labourers. It is also clear from the table that sufficient land accumulation has taken place in large farm size and also in medium farm size.

Population Growth, Food Supply Margin and Measures to Increase Agricultural Productivity

Since population is growing at the rate of approximately 3% per annum, the gap between food production and population growth has continued to increase.

Measures for Improvement:

Measure 1. Increasing the intensity of land use—This can be achieved in several ways: e.g., by utilizing available land resources more effectively, by employing modern technology in land use and also by effective farm management. During the past 46 years (1928–74) a considerable increase in agricultural output has been achieved by this method alone. As discussed earlier in this paper, the cropping intensity has increased form 120 to 150% during the period. The present level is also very low in comparison with 184.30% cropping intensity in Taiwan and approximately 238% in West Malaysia (11). So Bangladesh is the most appropriate area for multiple cropping which will result in an increase in the cropping intensity from the present level.

Progress has already been achieved in the field of agricultural research: Improved varieties are available for almost all crops. Future research will be directed to cover the major areas such as crop improvements, fertilizer application rate, soil and water management and water conservation practices, multiple cropping etc.

Cooperative movement was started long ago, but it made very little progress over the years and little impact on the agricultural development.

To allow the system of land tenure of the country to suit the needs of development planning, the act in 1950 also provided for the growth of cooperative farming and voluntary consideration of fragmentation holdings.

Measure 2. Land reforms and cooperatives—After partition in 1947, old Zamindari system was abolished by the East Bengal State Acquisition and Tenacy Act, 1950 (12) for the economic emancipation of the tillers of the soil and the development of agricultural economy.

The main objectives of the new system were to abolish all rent receiving interests between the government and the actual cultivator to give permanent, heritable and transferable rights to raiyats (later called malik) and fix the ceiling on land ownership at 13.48 ha per family. In order that this new system did not affect the development of agricultural economy, some exceptions to this rule were provided for; for instance, the ceiling is relaxable in the case of large scale farming by power driven mechanical appliances, large scale dairy farming, cultivation and manufacture of tea or coffee, cultivation of rubber and the cultivation of sugarcane by a company for the manufacture of sugar. Another aspect of the new land reform was the redistribution of land among the landless agricultural labourers. Since the ceiling fixed in the new system was too high relative to the average size of holdings, the land available for redistribution was insignificant (2). It is clear from the discussion that the landless families were not given top priority in the previous act. The landless should be identified as a priority group in the land redistribution programme as because the number of landless farmer is increasing. According to the 1960 census of agriculture, 17.52% of the total civilian labour force were landless agricultural labourers and the 1968 Master Survey of Agriculture reported 20% as landless labourers (15). In the new arrangement under presidential order 96 and 98 (6) a family holding 25 bighas (about 3.34 ha) or less is exempted from payment of land revenue and (ii) a family would not be able to hold more than 100 bighas (4 x 3.34 ha). Further as a result of provisions of this act, 31,045 ha of excess land were available for redistribution. From this figure it is evident that the distribution impact of this measure was also very insignificant. In view of the above circumstances, it is frequently suggested that in Bangladesh a drastic land reform and changing in the law of inheritance would ensure increased productivity and equity.

Cooperative system is one of the several rural institutions. Government, however, are aware of the importance of the cooperatives in nation building and have recently adopted some suitable steps to revitalize the movement. These steps include execution of two tier cooperative frame work through IRDP evolved in Comilla to organize farmers, and to provide them training, credit, modern inputs and services. It has been envisaged in the two year plan (1978–80) that IRDP will be extended to 250 thanas, 25,000 primary cooperative societies will be organized, number of cooperative members will exceed 0.6 million and approximately taka 50

million will be saving from the cooperators.

Further, it was envisaged in the first five year plan of Bangladesh (1973–78) to expand physical facilities of Bangladesh Academy for Rural Development (BARD), Cooperative College at Comilla, eight Zonal Institutes and establish two regional academies etc. The programme therefore has not achieved any significant success.

Measure 3. Development of new agricultural areas–the most spectacular method to increase the food supply is dependent on the expansion and improvement of the irrigation systems, giving a resultant gain in the amount of agricultural land. To what extent new land has been gained by irrigation, and how the ratio of agricultural land to population is steadily deteriorated is shown in **Table 5.**

Comparision of 1949–50 and 1976–77 shows that despite the increase of total cropped areas by about 13%, per capita total cropped area has decreased from 0.235 to 0.143 ha. The situation is likely to be even worse if the population control measures are not encouraged seriously to check the population growth.

The area irrigated by different methods in 1969–70 was about 1 million ha which constitutes 7.96% of the total cropped area. The area irrigated by different methods in 1973–74 was 1.3 million ha which constitutes 10.88% of the total cropped area. Since irrigation water constitutes one of the important inputs for stepping up agricultural production, it was envisaged in the two year plan that 2.0 million ha of land will be brought under irrigation by different methods by the end of the plan period. Fertilizer programme will be intensified during the period.

Since the abolition of Zamindari system in 1950, land development and reclamation were being neglected. So government established WAPDA in 1956 to undertake all these works on a large scale basis in order to effect real improvement in the land and thus agricultural production. WAPDA, by the year 1964, with the help of foreign assistance drew up a master plan for various projects to construct embankments by the side of the main rivers, diversion of flood escapes and channel improvement (17). The Projects were designed to provide flood protection and to facilitate better drainage and irrigation practices so that cropping intensity may be increased and high-grain yielding crops cultivated. The total number of river embankments to be constructed are 31 and the biggest embankment is on the west bank of the river Jamuna covering 250 km which has been more or less completed. The other embankments are in the rivers Khowai, Manue, Haldu, Feni, Gumati, Muhuri etc. In order to avoid consequences of a drop in production and productivity due to the silt deposit affected by the protection measures, farmers have changed the old system of broadcasting to transplantation, adjusting the methods of their crop cultivation and cropping pattern. As a result of the change in the system, a good crop is being harvested at least in some areas, though silt deposit has been affected due to the embankments (4).

The construction of big irrigation project such as G.K. Project, D.N.D. Project. Chandpur Project and Barisal Project were of decisive importance for the development of new agricultural land in Bangladesh because these multipurpose projects are designed to provide flood protection and improve drainage and irrigation system. The aim of the G.K. Project is to irrigate 121,410 ha but it is now hardly irrigating 28,329 ha because of insufficient water in the river. The aim of the D.N.D. Project is to provide irrigation for about 5,261 ha and its work has successfully been completed. The construction works of Chandpur and Barisal Irrigation Projects which will cover 52,825 and 56,658 ha respectively, are in progress. Besides, WAPDA undertook the construction of 4,038 km coastal embankment along with the construction of sluice gates in order to wash out the accumulated salinity and prevent entry of salt water from the sea, affecting raise crops in the coastal area. The project is expected to be completed by 1979–80 (8). As a result of the scheme, loss of huge human and animal life will be reduced and salinity will go down which will result in growing more than one crop in a year.

Besides, WAPDA has undertaken deep and shallow tube well and low-lift irrigation programmes in large areas of Bangladesh. Moreover, cross dykes were constructed in the coastal areas of the Noakhali district and huge area were recovered for cultivation.

In order to increase agricultural productivity significantly, mechanization of agriculture is essential in Bangladesh. However, Bangladesh has recently made a humble venture for agricultural mechanization by employing considerable amount of machinery such as

Table 5. Distribution of Population and Agricultural Used Land

Year	Population in million	Net Cropped Area (ha)	Net Cropped Area/Capita (ha)	Total Cropped Area (ha)	Total Cropped Area/ Capita (ha)
1949–50	44.00	8,132,851.2	0.185	1,038,460.2	0.235
1952–53	46.62	8,461,467.5	0.181	1,112,196.5	0.238
1976–77	81.80	8,274,091.5	0.101	1,172,801.0	0.143

Source: Bangladesh Bureau of Statistics, Statistical Year Book, 1979.

imported tractors, power tillers, irrigation pumps and tube wells, locally made push type weeders etc. But impact of this scheme is very much insignificant because major part of this programme was initiated in some selected areas of Bangladesh and infrastructure necessary for its success does not exist (3). Though mechanization of agriculture is highly controversial in Bangladesh, use of machinery in agriculture have an important role in the effort to increase food production and improve nutritional standards, to improve agricultural incomes and foreign exchange earnings, to improve efficiency of farming and to enable a group of rural people to raise better cattle for increased production of milk and beef.

The magnitude of the influence of the various irrigation and flood control projects, use of improved seeds, introduction of HYV etc. on the agricultural sector is shown by the rise in the cultivation of rice (Table 6). During the period from 1950–51 to 1977–78, total rice area have increased from 8.1 million ha to 10.03 million ha and yield per ha has increased from 922 kg to 1,295 kg. Despite the progress in rice cultivation, country has consistently imported rice to feed its growing population. A comparison of average yields for selected crops are shown in Table 8.

Table 6. Development of Rice Cultivation in Bangladesh

Year	Area Cultivated (000 ha)	Production (000 tons)	Yield/ ha (kg)
1950–51	8,100	7,343	922
53–54	8,101	8,245	941
56–57	8,119	8,185	1,025
59–60	8,563	8,482	1,008
62–63	8,697	8,730	1,021
65–66	9,364	10,380	1,123
68–69	9,746	11,165	1,166
71–72	9,301	9,774	1,069
74–75	9,795	11,108	1,154
77–78	10,031	12,764	1,295

Table 7. Land Utilization in Bangladesh (000 ha)

	1947–48	1960–61	1976–77
Not available for cultivation	2,165	2,272	2,681
Forest	1,206	2,211	2,205
Culturable Waster	1,735	768	267
Current fallows	1,053	328	849
Net cropped areas	7,862	8,442	8,274
Total cropped areas	10,236	11,166	11,727

Source: Bangladesh Bureau of Statistics

Table 8. Comparison of Average Yields for Selected Crops (1970–1978)

Crop	Unit of Measurement	1970–71	73–74	77–78
Maize	Kg	944.00	719.00	839.00
Potato	Tons	9.78	8.96	9.53
Sweet potato	Tons	11.24	10.32	10.67
Pulses	Kg	810.00	747.00	716.00
Jute	Kg	1,360.90	1,226.36	1,333.18
Tea	Kg	704.00	611.00	870.00
Oilseeds	Kg	834.00	781.00	820.00
Sugarcane	Tons	46.90	42.00	42.00
Tobacco	Kg	891.00	895.00	899.00
Cotton	Bales	0.96	0.79	0.93
Betelnut	Tons	0.56	0.60	0.66

Source: Bangladesh Bureau of Statistics, 1979

Measure 4. Intensification of livestock. Livestock plays a vital role in Bangladesh agriculture. Farm animals are almost the only source of traction power for agricultural activities in Bangladesh. Besides, livestock supplies meat, milk, eggs, hides and skins, manure and a number of other products. Bangladesh has a good number of animals and birds though poor in quality. The livestock population in 1976– 77 has been estimated at 29.5 million animals and 86.4 million poultry birds (8). Animals and birds are reared and maintained on small farms by way of mixed farming and commercial livestock industry has not yet developed. Productivity of local animals and birds are very low.

It is estimated that a buffalo yields between 1,700 and 1,840 kg of milk & a cow about 1,200 kg per year.

However, government has been endeavouring to improve their production capacity through breeding, adopting artificial insemination, supply of selected bulls and improved cocktails. Livestock is a very important source of protein and essential amino acids. The minimum requirement of animal protein has been estimated to be 25 gm per capita per day. But the present availability of protein from livestock is about 3.0 gm only. Lack of sufficient feed and fodder both in quantity and quality, is probably the most important factor responsible for this poor condition of livestock in the country.

Development Trends

A comparision of past and present land use patterns (Table 7) clearly shows that the expansion of agricultural land in Bangladesh is almost impossible. The table shows that customable waste and current fallows have decreased from 1.74 million ha to 0.28 million ha and 1.05 million ha to 0.84 million ha during the period from 1947–48 and 1976–77 respectively. But it has been mentioned earlier in this paper that there is scope for multiple cropping. In order to raise agricultural capacity and total economic capacity the following measures should be undertaken on a priority basis.

1) To impure over all mechanization programme of Bangladesh agriculture.
2) To develop other branches of industry.

3) To accelerate rural development activities.

Employing a strategy aimed at increasing yields, the First Five Year Plan (1973–78) established a food grain production target of 15.0 million tons by the end of the plan period (9).

This target indicates average annual increase of about 4%, nearly double the trend of the 1960's. The World Bank estimated that food grain production could increase upto 33 million tons by the end of this century (3.5% per year) (10). The present level of production is clearly only fraction of potential levels obtainable with existing technology. Over the short run, however, even the most optimistic supply projections suggest that the deficit of food grains will continue. However, under these circumstances, it is clear that a balance of food supply and demand can not be achieved without substantial and sustained reduction of rapid population growth. For future it is evident that both agricultural and demographic breakthrough will be required to feed the growing population of Bangladesh adequately. While modern agricultural technology has expended agricultural potential, major structural and social change in rural Bangladesh will probably be necessary if the agricultural potential is to be realized. In Bangladesh and elsewhere it is generally accepted that antiquated land tenure system, lack of rural institutions, and inequitable social relations act as constraints to higher production. Further, extension improvements in agriculture are not possible without a considerable increase in the supply and the production of fertilizers and cement for dams, canals, roads and other items of infrastructure. The same is true for the food and textile industries, which can be built up on the basis of the improved agricultural production. Small and cottage industries should be considered of crucial importance in the present economic and social conditions of Bangladesh because it may create an opportunity for providing means of livelihood to the unemployed people and for both domestic and export market. The existing reserve of natural gas ensures fuel supply for electricity generation, provides further potential for industrialization. Moreover, there is a large human potential albeit untrained can be given proper training for improvement of the skills and utilized for as vital inputs for industrial progress. Under these circumstances it seems reasonable to suggest to develop branches of industry which are not related to the agricultural sector in order to reduce the discrepancy between population growth and food production.

REFERENCES

1. A.R. Khan (1972); The Economy of Bangladesh, London: MacMillan St. Martin Press, 1972. Bangladesh Development in a Rural Economy: Volume 1. The Main Report, Washington D.C. IBRD, PP. 47-140.
2. Abu Abdullah (1976): Land Reform and Agrarian Change in Bangladesh–The Bangladesh Development Studies, Volume IV, January, 1976, No. 1.
3. A.A. Mainul Hussain (1977): Present Agricultural Situation in Bangladesh and Future Strategies; Agricultural Mechanization in Asia, Vol. VIII. No. 1, Winter 1977.
4. Alim (1979): Land Reform in Bangladesh, 1976.
5. Bangladesh (1972): Government of the People's Republic of Bangladesh: Master Survey of Agriculture in Bangladesh. Bangladesh Bureau of Statistics, 1972.
6. Bangladesh (1972): P.O. 96–The State Acquisition and Tenancy Act, Third Amendment Order 1972 and P.O. 98–The Bangladesh Land Holdings (Limitation) Order 1972, Bangladesh Gazette, Extraordinary, Part -III A, August 15, 1972.
7. Bangladesh (1972): Bangladesh Agriculture in Statistics, Agro-Economic Research Section, Ministry of Agriculture, (1973) P. 29.
8. Bangladesh (1978): The Two-Year Plan, Planning Commission, Govt. of the People's Republic of Bangladesh, September, 1978.
9. Bangladesh (1973): First Five Year Plan (1973–78); Planning Commission, Government of the People's Republic of Bangladesh, Nov. 1973, PP. 83-194.
10. Bangladesh: Development in a Rural Economy, Vol. 1, PP. 92-98.
11. Dalrymple (1973): Agricultural Mechanization in Asia.
12. East Pakistan, 1965, Government of East Pakistan: The East Bengal State Acquisition and Tenance Act 1950 (as modified upto 31 May 1961), East Pakistan Government Press, 1965.
13. Kalim Uddin (1965): Agriculture in East Pakistan.
14. Mia, Md. Shaheed (78-89): Farm Size and Productivity, Krishi Aurthoniti Samoyiki 1978-79.
15. Pakistan (1962): Pakistan Census of Agriculture 1960, Karachi, Ministry of Agriculture, 1962.
16. Roger Revelle, et al (1972): Population Projections for Bangladesh, 1973-2003 Cambridge, Harvard Centre for Population Studies, 1972, Mineo.
17. Reports: Krug Mission Report 1956. General Hardins Report, 1963, and Professor Thijsse's Study in 1964. ■■

Huhn & Schwein '81
International Exhibition
for Pig and Poultry Production
June 24-27, 1981
Hannover/West Germany

New marks will be set during the DLG-Exhibition "Pig & Poultry 81" in Hanover for professionals of poultry and pork production. For all those who intend to show both new and proven developments, or who want to get acquainted with them, participation at this international exhibition is a "must", either as exhibitors or as visitors. Here new trends and developments are set for the next decade.

- in the exploration of new markets
- in the application of new production tools and methods
- in the competitive situation of the farming enterprises
- in the exchange of opinions and experiences.

In 1979, 520 exhibitors and 209 firms represented, from 16 countries demonstrated the progress on both the biological and technical sectors.

41554 specialists from more than 47 countries of the world took advantage of this exhibition to gain comprehensive information and to prepare for their investment decisions.

The sponsors, the German Agricultural Society and the Central Association of the German Poultry Producers, will again present this exhibition on the fair grounds of the world-renowned Hanover Fair, which will cater to all demands of exhibitors and visitors as well.

Exhibition Program

Means of production and essential goods for the poultry and pork industry – including marketing: enterprises for breeding and improvement for live-stock, capital goods, feed, veterinary goods, products for cleaning and disinfecting, tinctures, pesi controls, etc.; stables, equipment, accessories; equipment for live-stock shelters; (for example, waste disposal), feed storage and feed preparation, automation and control engineering; marketing facilities (means of transportation, packaging containers and packaging machines); information and advice.

International Conference on
Agricultural Engineering and
Agro-Industries in Asia
November 10-13, 1981, Bangkok/
Thailand

Purpose and Scope

Increasing the application of engineering to agriculture and associated industries in Asia is a means of achieving high and economic levels of food production. A direct link between agricultural engineering and agro-industries requires special considerations with regard to the engineering applications of food and energy production, land use criteria, and their influence on people and the environment. It is important that the engineering input to the agricultural industry be appropriately recognized.

The problems concerning the development of agricultural engineering and agro-industries are both regional and international in scope. This conference aims at bringing together agricultural engineers and other professionals in related fields from the Asia-Pacific region in particular, but also from other parts of the world, to discuss the state-of-the-art, to define research needs, and to exchange ideas and experiences on the contribution of agricultural engineering to the development of agriculture and associated industries. This first International Conference in the Asian region is a significant step towards achieving these goals. The main objectives of this Conference are:

1. to identify areas requiring research and development work to help agricultural industries to increase food supplies,
2. to stimulate basic and applied research in the fields of agricultural engineering and agro-industries; and
3. to promote the exchange of ideas and experiences pertaining to present and future developments in agricultural engineering and agro-industries.

Participants

The Conference is for the benefit of engineers, scientists and other professionals actively engaged in or associated with the fields of agricultural engineering and agro-industries.

Call for Papers

Participation in the Conference is open to all interested persons. Papers are invited on all aspects of agricultural and agro-industrial engineering and management. Areas recommended, but not limited to, are:

Soil and Water Engineering & Management
Agricultural Machinery & Management
Food Process Engineering
Energy Utilization in Agriculture and Agro-Industries
Agricultural Equipment Manufacturing
Food and Feed Processing Indus-

tries
Interaction between Industry and Research

Correspondence:
All correspondence be addressed to:
Dr. V.K. Jindal, Secretary
International Conference on Agricultural Engineering and Agro-Industries in Asia
Division of Agricultural & Food Engineering
Asian Institute of Technology
P.O.Box 2754 Bangkok, Thailand

17th Annual Convention of Indian Society of Agricultural Engineers
Feb. 6-8, 1980, New Delhi/India

The Seventeenth Annual Convention of Indian Society of Agricultural Engineers concluded in Delhi. Over 400 agricultural engineers from all over India, also from Pakistan, Bangla Desh, U S A, and U S S R participated in various technical sessions.

Energy

Energy was the theme of the Presidential address by Dr. B.S. Pathak. Consumption of energy in the agricultural sector from commercial resources is increasing at the rate of 16 per cent per year. Although, less than 4 per cent of total commercial energy is consumed in agriculture, at the present growth rate, commercial energy requirements in agriculture 25 years hence will exceed the total commercial energy consumption for all purposes in 1980. Use of improved bullock drawn implements, pumping sets, threshers and recommended amounts of fertilizers and chemicals results in consumption of over 1,500KWH of energy per hectare of rice and 1,600KWH for wheat. About one third of a tonne of petroleum fuel or its equivalent is needed per year for one hectare of traditionally cultivated land under scientific dry farming, using animal draught power for tillage and transport. Requirement is doubled with lift irrigation.

Alternative energy sources include wind, solar and bio-gas. Present cost benefit analysis is more favourable for bio-gas. Bio-gas plants call for an improved design for more efficient performance. There is lack of R & D efforts in the private sector. An exception is Escorts Scientific Research Centre – who are now looking into this area. Let us hope some well known names in Indian Industry will also get involved.

Agro-Services

Dr. M.S. Swaminathan focussed attention on the Agro Service Centres to serve small farmers. Experience on over 3000 centres so far established by independent entrepreneurs has been mixed. The programme to organize more centres is at present at a standstill. Performance of these centres calls for an in-depth study to identify reasons for success and failures. Running such an enterprise calls for skill, experience, maturity and business acumen. The industry and trade should be motivated to organize such an activity. Incentives can include the benefit of rural development allowance under section 35cc of the Income Tax Act.

Integrated Agro-Services Complex need be organized in each agriculturally important region so that on one campus, a farmer can walk in for most of his requirements, as also for sale of his produce.

Training of entrepreneurs and blue collar farm workers is imperative and the convention strongly recommended setting up of a National Institute for Training in Agro-Industrial Services (N I T A).
The Central Institute of Agricultural Engineering, established by the Indian Council of Agricultural Research, has now become operative with its thrust areas of R & D on farm machines, post-harvest technology, renewable sources of energy and industrial extension.

A paper which attracted popular attention was presented by N C A E R on its recent study on the impact of tractorization on employment, productivity and income. The survey covered 21,162 farm holdings in seven States representing different agro-climatic conditions. Findings show increased yields, higher cropping intensity, increased hired labour and higher income on tractorized farms. Mechanized and non-mechanized farms showed interesting changes in income and expenditure patterns. There was no evidence of any significant displacement of labour on mechanized farms. Some data has been summarized in

Table 1

Items	Unit	Tractor owner	Bullock farm
Net income	Rs/ha	1743	682
Mandays per ha		110.5	104.9
Cropping intensity	index	112	100
Average yield	index	107 to 172	100
Value of output	index	163	100

Note: This article was sent from Mr.B.K.S. Jain, Bombay who received the ISAE Gold Medal at the convention for outstanding efforts for promoting the cause of agricultural engineering.

Other Disciplines

Soil and Water Engineering group stressed the importance of better water-shed management. End use of irrigation water must receive higher priority. Mass scale training of farmers and farm workers in more efficient irrigation practices is called for. Sprinkler and drip irrigation could be promoted for popular use in 'problem' belts. We must develop remote sensing techniques for agricultural applications. Agricultural information system can be revolutionised by use of remote sensing satellites and aerial biosensing.

The group on processing called for greater efforts to reduce post-harvest losses, estimated at more than 10 per cent. Harvesting, handling, storage, processing, packaging and marketing have to be integrated into one comprehensive approach for best returns to the farmer and service to the consumer through better quality products at attractive prices.

During display and demonstration of equipment and services, items which attracted attention included solar water pumps, cost estimated at over Rs.40,000, at present commercially not so viable; small 10-15 H.P. Rustom tractor, assembled by a small scale entrepreneur of Haryana, sold for about Rs.25,000 (as against Rs.55,000 being the price of a 35 H.P. tractor); instant moisture reading meters and a panel on professional and technical consultancy services offered to the agro sector by an enterprising agricultural engineer.

FAO Panel of Experts on Agricultural Mechanization
Sept. 8-11, 1980, Hannover/W. Germany

The third session of this panel was held at Hannover on 8-11 September 1980.

One of the main recommendations at the end of a very successful meeting was that FAO should prepare a position paper for submission to governments and for use by all agencies and institutions interested in 'Multifarm Use of Agricultural Machinery'.

A draft has been prepared and has been sent to a small group of Panel Members for their comments and criticism.

The multifarm use had been proposed by the Panel's hosts, DLG, and it was an appropriate one. Multifarm use, in the sense of sharing equipment and labour for certain farm work, was as old as agriculture itself. It had developed on different lines in different countries and different agricultures and in some countries, of which the Federal Republic was one, it had reached sophisticated levels. For the developing countries the scope for multifarm use was considerable. It offered a realistic way of bringing mechanical power technology to small farms; and, in turn, of contributing to increased food and agricultural production. Successful multifarm use schemes had to be appropriate to the local needs, the locally available skills and to local customs.

Highlights and Recommendations

The Panel was unanimous in its conclusion that in the context of widespread and increasing food shortages in most, if not all, developing countries the need for additional technology to overcome this shortage was essential. Within that technology the role of mechanization was important and it was the Panel's view that multifarm use, under organizational arrangements suitable to local conditions, provides the most practical and economical way of making equipment and services more readily available to small farmers. The Panel also emphasized that the problems associated with fossil energy for agriculture and the urgent question of prevention of food losses to which FAO had rightly directed its attention are both relevant to multifarm use of machinery.

In assessing the various organizational forms of multifarm use in different countries the Panel concluded that performance had been variable. On balance, however, multifarm use schemes based on relatively small numbers of farms under private sector operation showed a higher success rate than other organizational forms.

The Panel's primary recommendation was that Governments and FAO should, in conjunction with other agencies and organizations, promote and encourage the development of multifarm use schemes that are suitable to the economic, technical and social conditions in the countries concerned. The Panel also made specific recommendations that FAO should initiate projects, such as the current project in Egypt; undertake studies of multifarm use schemes and establish methods of evaluating and monitoring them; prepare a Position Paper for use by Governments and agencies and update the existing FAO publication on multifarm use.

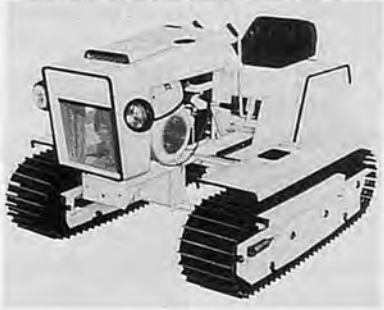
In all these activities the Panel offered its individual and collective expertise to assist FAO achieve its overall objectives in this field.

Arrangements for Future Meetings

The Panel agreed that one meeting should be held in 1981 and discussions are taking place on timing and subject matter. ■■

NEW PRODUCTS

Struck Magnatrac II Crawler Tractor



The new MAG II tractor with all gear drive can be purchased in knocked down kit form ready to assemble with simple hand tools. The kit is easily assembled by the average mechanically inclined owner with only basic experience in handling tools. All parts are precisely fabricated to fit together quickly.

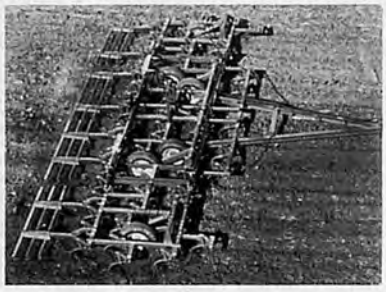
The MAG II features a completely redesigned track system for better track stability and traction. The track system has double chains and sprockets with heavy 7 guage track shoes which are 241 mm wide. This new, wider, heavier track system gives the MAG II additional side hill stability along with 50% better flotation than previous models. The redesigned track sprockets give additional mud relief when operating in soft ground. The track sprockets and axles are heat treated for wear resistance.

The 16 HP four stroke, single cylinder, air cooled gasoline engine with electric start has a balanced design for quiet operation with less vibration. The transmission is driven from the engine by a heavy-duty steel cable core drive belt. The transmission with 4 speeds forward and 1 reverse drives the track system through heavy-duty no. 50 steel chains.

The crawler can be used with a full range of agricultural implements such as plows, harrows, planters and cultivators. The rugged design of the MAG II also permits mounting a front loader, dozer blade and rear backhoe for light industrial work such as excavating, trenching, landscaping and material handling.

(C.F. Struck Corp.: c/o Dummann world Trade Co. Inc., P.O. Box 18665, Milwaukee, Wisconsin 53218 U.S.A.)

John Deere 1010 Field Cultivator



John Deere has introduced a new line of field cultivators, the 1010 Series, with additional frame strength to improve stress distribution, and horizontal fold for convenient transport and storage.

The line includes both integral and drawn models, flexible and rigid, in 9½- to 42½-foot widths, providing models to match varied working conditions and any 50- to 225-hp tractor. All sizes are equipped with Real Action™ shanks that work and stir soil aggressively yet flex back and up as much as 11 inches when they meet rocks or other field obstructions.

New drawn John Deere 1010 Field Cultivators include rigid non-folding models in 12½- to 17½-foot widths and horizontal-fold, 18½- to 23½-foot models that lock rigid for field work. This horizontal fold is also optional on the 15½- to 17½-foot sizes. Flexible, horizontal-fold sizes are available in 22½- to 30½-foot widths, and flexible, vertical folding models come 31½ to 42½ feet wide.

Integral 1010 Field Cultivators are available in 9½- to 17½-foot widths with rigid, non-folding configuration and 15½- to 24½-foot widths that lock rigid for work but fold vertically for transport.

Frame bars of 3 x 3-inch tubular steel provide rigidity and durability for ideal seedbed preparation or summerfallow work. Drawn models are further strengthened by two 1½ x 3-inch steel bars that connect front and rear frame bars to distribute pulling forces throughout the entire unit.

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

Robin Power Rotor PR06



Light in weight, compact in size and excellent in maneuverability. Well in balance due to a low center of gravity and stable in working performance, most suitable for the works in small fields and sloping ground, not only in a family garden, and delightful in use by the whole family members from adults to children.

[Specifications]

Dimension: 1,330 x 615 x 925 mm (L x W x H), Dry weight: 28 kg, Engine: Robin air-cooled 2-cycle gasoline engine, Displacement 60.8 cc · Max. output 2.5 PS/500 rpm, Attachment: Rotors 1 & 2 · Plow and Ridger.

(Fuji Robin Industries Ltd:

Shinjuku Bldg. 1-8-1, Nishi-Shinjuku, Shinjuku-ku, Tokyo Japan)

Ochiai Engine-Powered Digger M-3



This equipment is developed as a good substitute for mulching tillers/cultivators and features in:

1. Light in weight and easy operation, 2. Anti-vibration handle, 3. Simple construction.

Applications:

1. Transplanting trees, 2. Soil preparation for planting, 3. Deep cultivation, 4. Breaking frozen surface, 5. Fertilizing down to the tree root, 6. Drilling, 7. Trenching, 8. Breaking asphalt.

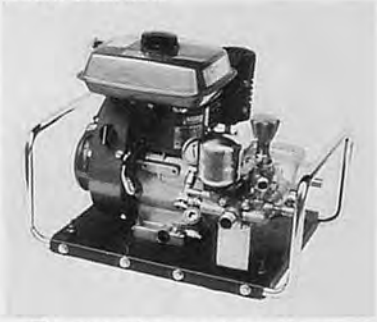
[Specifications]

Body: Dry weight 16kg, Working depth approx. 30 cm, Handle Anti-vibration and adjustable in height. Standard tool: 3-prong digging fork, Option spade, shovel and drilling bit.

Engine: 2-cycle forced air-cooling gasoline engine, Displacement 22.6 cc, Output 0.73/6,000–1.0 HP/7,000 rpm (max.)

(Ochiai Cutlery Mfg. Co., Ltd: Kikugawa-cho, Ogasa-gun Shizuoka-ken, Japan)

Arimitsu Portable Power Sprayer Model CSE-20K



Features in energy saving, compact design and easy maintenance.

The pump is directly coupled wiht the engine. This helps eliminate power loss by transmission.

Total weight and volume of the machine are cut back by 20 % and 40 % respectively compared with conventional models, so that quite easy to carry.

For the maintenance four nuts should be loosened to dismantle cylinder and stuffing box.

Only three pieces of patented combination valve work efficiently, resulting in higher output, fewer number of parts and smaller size.

The engine is equipped with capacity discharge ignition system for easy start and is quite maintenance free.

[Specification]

Dimension: 505 x 356 x 408 mm (L x W x H), Weight (main body): 26 kg, Pump: Model SE-20, Horizontal triplex plunger type, Pressure; 35 kg/cm^2, Crankshaft rev.: 1,800 rpm, Suction capacity: 20.5 l/min, Engine: KAWASAKI KF 34GX Model Air-cooled 4-cycle gasoline engine, Displacement: 132 cc, Output: 2.3-3.4PS, with Recoil starter

(Arimitsu Industry Co., Ltd: 3-21, Fukaekita 2 chome, Higashinari-ku, Osaka 537, Japan)

Sasaki Diesel Sprayer SS-500DA



* 6-wheel drive with powerful diesel engine
* Easy operation
* Dynamic blower
* Anti-corrosive FRP tank
* Good climing capability (30°)
* Buzzer gives alarm when tank became empty
* Back buzzer for human safety

[Specifications]

Dimensions (L x W x H): 3,170 x 1,395 x 1,250 mm, Weight: 975 kg Tank capacity: 500 l, Axial-flow Blower: 850 m^3/min 670 mm diam., Plunger pump: 15 kg/cm^2 74 l/min, Nozzle: Disk type 1.0-2.0 mm x 22 pcs 651 l/min, Turnin radius: 1.6 m Clutch brake steering, Tyres: 20 x 10.00-10 4PR, Speeds: forward x 6 reverse x 2, Engine: Isuzu 2AB1 water-cooled 2-cylinder diesel engine · Displacement 1,184 cc, Rated output: 25.5 PS/2,800 rpm, Efficiency: 6-8 ha/day, Effective spray distance: 10-12 m

(Sasaki Noki Co, Ltd: 1-259, Satonosawa, Towada-shi, Aomori-ken, Japan)

Shikutani Speed Sprayer SG-65R



* Applicable to both trellis and ordinary-shaped trees.
* Two gasoline engines are mounted: 10 PS for travelling and 20 PS for sprayer.
* Compact design and 6-wheel drive ensures good maneuver-

ability in the narrow space.

[Specifications]

Dimensions: 3,010 x 1,290 x 1,210 mm (L x W x H), Weight: 730 kg, Tank capacity: 500 l, Sprayer output: 72 l/min (at 25 kg/cm^2)

(Shikutani Co., Ltd.: 470 Renshoji, Odawara-shi, Kanagawa-ken, Japan)

Marumasu Air Conveyor "Quper" Model 20



* No damage to the materials to be carried (because materials do not go through the blower).
* Low capital cost per horse-power.
* Comapct design, small floor space and low building cost.
* Simple operation. Suction hose is simply put into the material to be carried. Material is carried up to 100 meter distance.
* Applicable to any kind of pulverized material.
* Also applicable to powdered material by the help of rotary feeder attachment.

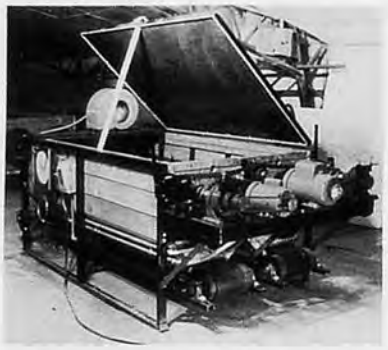
[Specifications]

Floor space: 755 x 1,580 x 1,030 mm (W x L x H), Weight: 640 kg, Power requirement: 20 PS

For example Model 20 can deliver clean paddy or rice to 50 m and 100 m distance on the same level at a rate of 12 t/hr and 7.3 t/hr respectively.

(Marumasu Kikai Co., Ltd.: Kamiichi-cho, Nakaniikawa-gun, Toyama-ken, Japan)

The Brill Digester



Without artificial heat, it consumes tons of animal or bird waste (or human), including fresh manure, offal, pauch, casualties, vermin and useless agricultural by-products. Within 72 hours it changes the input into an output of dry, fluffy, almost odorless, protein-rich animal or poultry feed supplement. It does in hours what Nature takes months to do.

A Brill Digester can be made in any size, but the standard unit is 9 m long by 2 m wide by 1.4 m high, with a weekly capacity of 70 tons input. It has an air-control lid, two end-to-end rotating paddles and an unloader conveyor belt on its bottom. The input animal wastes, plus any carbonaceous waste matter (such as grain husks, straw, wastepaper, sawdust, chopped corn cobs, grape pumice or rice hulls) are loaded into it and the cover closed. It is not necessary to pre-mix the input, nor are any additives needed.

Immediately, natural aerobic bacterial action commences, but on a vastly accelerated pace because of the confinement, the controlled oxygen intake and the slow churning action of the paddles.

Enormous, naturally generated heat-eventually as high as 70°C-aids in the rapid composting and, in the end, kills the bacteria when they have finished their work. The process takes from 36-48 hours, depending to a large degree on the moisture content of the in-out mix. This is ideally 60%, but can run as high as 70%. At this point the composted material is removed by the conveyor belt into the drier, where fans and agitation complete the process in another 6-12 hours. The product is now ready to be bagged, mixed with feed or loaded into spreader or truck.

(Gentrex, Inc.: 22725 Greater Mack Avenue, St. Clair Shores, Michigan 48080 U.S.A.)

Honda Milker K Type



K type has been developed on the basis of well-accepted A type for easier handling with powerful vacuum pump. K type causes no udder inflammation, more lactation, results in quality milk.

[Specifications]

* Milking bucket unit

Milking system: front and back alternatively, No. of pulsation: 38-42/min, Pulsation ratio: 5:5, Normal vacuum: 36 cm Hg, Measurement: 540 x 310 mm (H x Diam.), Material: SUS 303, Weight: 6 kg

* Vacuum pumps

Five types are available according to number of cows.

(Honda Seisakusho Co., Ltd.: 338 Kami-cho Moroe-cho, Kanazawa-shi, Japan) ■■

A NOTE TO AMA CONTRIBUTORS

The Editorial Staff of the AMA requests contributors of articles for publication to observe the following editorial policy and guidelines in order to improve communication and to facilitate the editorial process :

Criteria for Article Selection

Priority in the selection of articles for publication is given to those that —

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

Rejected/Accepted Articles

a. As a rule, articles that are not chosen for AMA publication are not returned unless the writer(s) asks for their return and are covered with adequate postage stamps. At the earliest time possible, the writer(s) is advised whether the article is rejected or accepted.
b. When an article is accepted but requires revision/modification, the details will be indicated in the return reply from the AMA Chief Editor in which case such revision/modification must be completed and returned to AMA within three months from the date of receipt from the Editorial Staff.
c. The AMA does not pay for articles published. However, the writer(s) is given 10 free copies of the AMA issue wherein the article appears, including 50 off-prints of the article so published.

Procedure

a. Articles for publication (original and one copy) must be sent to AMA through the Cooperating Editor in the country where the article originates. (Please refer to the names and addresses of Co-operating Editors in any issue of the AMA). However, in the absence of any Co-operating Editor, the article may be sent directly to the AMA Chief Editor in Tokyo.
b. Contributors of articles for the AMA for the first time are required to attach a passport-size ID photograph (black and white print preferred) to the article. The same applies to those who have contributed articles three years earlier. In either case, ID photographs taken within the last 6 months are preferred.
c. The article must bear the writer(s) name, title/designation, office/organzation, nationality and complete mailing address.

Format/Style Guidance

a. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
   i) a brief and appropriate title ;
   ii) the writer(s) name, designation/title, office/organization ; and mailing address ;
   iii) an abstract following ii) above ;
   iv) body proper (text/discussion) ;
   v) conclusion/recommendation ; and a
   vi) bibliography
b. The pages must be numbered (Arabic numeral) successively at the top center. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e. g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top, center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e. g., "Figure 1. View of the Farm Buildings".
c. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
d. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
e. Express measurements in the metric system and crop yields in metric tons per hectare (mt/ha) and smaller units in kilogram or gram (kg/plot or g/row).
f. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
g. Convert national currencies in US dollars and use the later consistently.
h. Round off numbers, if possible, to one or two decimal units, e. g., 45.5kg/ha instead of 45.4762kg/ha.
i. When numbers must start a sentence, such numbers must be written in words, e. g., Forty-five workers . . . , or Five tractors . . ." instead of 45 workers . . , or, 5 tractors.

Co-operating Editors


B. K. Bala


M.A. Mazed


M. Gurung


T. T. Pedersen


G. B. Hanna


Satish Chandra


A. M. Michael


Siswadhi Soepardjo


G. Pellizzi


Jun Sakai


Bassan A. Snobar


Chang Joo Chung


Paris Andreou


M. Z. Bardaie


N. C. Saxena


B. K. Shrestha

Bilash Kanti Bala
Head, Dept. of Farm Power & Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh

M.A. Mazed
Head, Agricultural Engineering Division, Bangladesh Agricultural Research Institute, Sher-E-Bangla Nagar, Dacca-7, Bangladesh (Until Dec., 1983: C/o Agric. Engineering Dept., Oklahoma State Univ., Stillwater, OK-74074, U.S.A.)

Manbahadur Gurung
Horticulture Extention Officer, Ministry of Development Dept. of Agriculture, HA Bhutan P.O.HAA, Bhutan

T. Touggaard Pedersen
Professor, Agricultural Engineering at the Royal Velerinary–and Agricultural University, Copenhagen, Denmark

George B. Hanna
Chairman, Agricultural Engineering Dept., College of Agriculture, Cairo University, Giza, Cairo, Egypt.

Satish Chandra
Assistant Director of Agriculture, Koronivia Research Station, Ministry of Agriculture and Fisheries, P. O. Box 77, Narsori, Fiji

A. M. Michael
Professor, Water Technology Center, Indian Agricultural Research Institute, New Delhi 110012, India

Siswadhi Soepardjo
Chairman, Agricultural Engineering Dept., Bogor Agricultural University, Jalan Gunung Gede, Bogor, Indonesia

Giuseppe Pellizzi
Professor, Institute of Agricultural Machinery, University of Milano, Via G. Celoria 2–20133 Milano, Italy

Jun Sakai
Professor, Dept. of Agricultural Engineering, Faculty of Agriculture, Kyushu University 46-05, Hakozaki, Higashi-ku, Fukuoka 812, Japan

Bassan A. Snobar
Associate Professor, Faculty of Agriculture, University of Jordan, Amman, Jordan

Chang Joo Chung
Associate Professor, Dept. of Agricultural Engineering, College of Agriculture, Seoul National University, Suweon, Korea

Paris Andreou
Associate Professor and Chairman, Department of Agricultural Economics and Business, American University of Beirut, Beirut, Lebanon

Muhamad Zohadie Bardaie
Head, Dept. of Field Engineering, Power and Machinery, Faculty of Agricultural Engineering, University of Agriculture Malaysia, Serdang, Selangor, Malaysia

Naresh Chandra Saxena
Contract Officer, Faculty of Engineering, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia

Bala Krishna Shrestha
Assistant Agricultural Engineer, 4/141, Pulchowk Behind the Fire Brigade Latipur, Nepal

Adrian Moens
Head Professor, Dept. of Agricultural Engineering, Agricultural University, Dr. S.L. Mansholtlaan 12, Wageningen, Netherlands

Md. Shahansha-ud-Din Choudhury
Principal Research Fellow, Dept of Agricultural Engineering, Institute for Agricultural Research, Ahmadu Bello University, P.M.B. 1044, Zaria, Nigeria

Jitendra P. Mittal
Lecturer Grade 1, Dept. of Agricultural Engineering, Ahmadu Bello University, Samaru, Zaria, Nigeria

E.U. Odigboh
Professor & Head of Agricultural Engineering Department, University of Nigeria, Nsukka, Nigeria

Bherulal T. Devrajani
Principal Investigator, Sind Agricul-


Adrian Moens


M. S. Choudhury


J. P. Mittal


E.U. Odigboh


B. T. Devrajani


Mohammad Ilyas


A. A. Mughal


R. M. Lantin


Chul Choo Lee


R. P. Venturina


A. Kandiah


A. H. Abdoun


M. A. Bedri


Tien- song Peng


Gajendra Singh


John Kilgour


W. J. Chancellor


M. L. Esmay

ture University, Tandojam, Pakistan

Mohammad Ilyas
Agricultural Engineer, International Rice Research Institute (Pakistan), P. O. Box 1237, Islamabad, Pakistan (on leave to Philippines : 10&78, Agricultural Engineering Dept., IRRI, P. O. Box 933, Manila)

A. A. Mughal
Assistant Professor, Agricultural Engineering in the Faculty of Agricultural Engineering, Sind Agriculture College, Tandojam, Sind, Pakistan

Reynaldo M. Lantin
Dean, Institute of Agricultural Engineering and Technology, University of the Philippines at Los Baños, College, Laguna 3720, Philippines

Chul Choo Lee
Project Engineer, Projects Deaprtment, Asian Development Bank, P. O. Box 789, Manila, Philippines

Ricardo P. Venturina
Assistant Scientist for Agricultural Research, National Science Development Board, P. O. Box 3596, Rizal, Manila, Philippines

Arumugam Kandiah
Head, Dept. of Agricultural Engineering, Faculty of Agriculture, University of Sri Lanka, Paradeniya, Sri Lanka

Abdien Hassan Abdoun
Director General Administration for Engineering, Ministry of Agric., F & NR., Khartoum, Sudan

Mohamed A. Bedri
General Manager, Democratic Republic of the Sudan Ministry of Industry Project for Manufacture & Assembly of Trucks & Tractors, P. O. Box 1855 Khartoum, Sudan

Tien- Song Peng
Specialist, Plant Industry Div. Joint Commission on Rural Reconstruction 37, Nanhai Road, Taipei, Taiwan

Gajendra Singh
Associate Professor of Agricultural Engineering, Asian Institute of Technology, Bangkok, Thailand

John Kilgour
Lecturer in Engineering Drawing and Design, National College of Agricultural Engineering, Silsoe, Bedford. MK45 4DT, U.K.

William J. Chancellor
Professor, Agricultural Engineering, University of California, Davis, California 95616, U.S.A.

Merle L. Esmay
Professor, Agricultural Engineering, Michigan State University, East Lansing, Michigan 48823, U.S.A.

BACK ISSUES

(Vol. 11 No. 1, 1980~)

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 11 No. 1, Winter, 1980)
Editorial (Yoshisuke Kishida) 9
The Challenge of Asian Farming to the Engineer (Charles J. Moss). . . . 11
Acceleration of Farm Mechanization through More Adequate Financing Taiwan (Tien-song Peng) 17
Research and Development Process of Designing Agricultural Machinery – Tractor as Example . . . . . (Jun Sakai). 19
SI Units in Agricultural Engineering (R. N. Sharma) 26
Power Tillers in Indian Agriculture, Their Place and Problems (B. K. S. Jain) 33
Tubewell Irrigation System – Installation, Operation and Cost of Water (S. Attaullah Shah Bukhari, I. D. M. Koondhar, Bherular T. Devrajani). 37
Development of Diaphragm Pump for Low Lift Irrigation (Mohammad abdul Baqui). 43
Modelling of Farm Irrigation and Drainage Structures (Ghulam Sarwar Sheikh, Khalid Pervez) 51
Design and Construction of Manually Operated Seed Cleaning and Grading Machine (Md. Nurul Islam, Kamal Uddin Ahmed, A. K. M. Moniruzzaman) 56
Design, Development and Evaluation of Tractor-Drawn "Dalo" Planter in Fiji (A. P. Sharma) 59
A Manual Seeder for Soybean (Gajendra Singh, Niyom Thunyaprasart, P. A. Cowell, J. K. Agarwalla) 62
Threshing Studies on Soybean and Cowpea (K. D. Sharma, R. S. Devnani) 65
Paddy and Rice Storage in Bangladesh with Emphasis on Insect Infestation (Jatindra Nath Samajpati, Md. Sawkat Ali Sheikh) 69
Development of Soil-Moisture Model to Predict Soil Moisture and Tractability for Harvesting (Surya Nath, William H. Johnson) 73
Design and Development of Hand-Operated Grain Harvester (Siddiqur Rahman, Jatindra Nath Sanajpati, Md. Abdur Rashid) 79
Design and Development of Jute Decorticator (A. D. Chaudhry, A. H. Hanif, M. A. Rajput, A. G. Ansari, Mohammad Yasin) 81
Design and Development of Neckharness for Cattle in Bangladesh (A. A. Mainul Hussain, Md. Daulat Hussain, Md. Mosharaf Hossain). . . 85
News 90
New Products 92
New Publications 98

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol.11, No.2, Spring, 1980)
Editorial (Yoshisuke Kishida) 9
Evaluation of Selected Upland Crops Establishment Techniques (Jai Singh, J.A. McMennamy, Gajendra Singh) 11
Tillage and Energy J Demand: Irrigated Crop Production in Semi-Arid and Arid Regions (Rüdiger Krause). 17
Farm Mechanization Facilities in Hyderabad, Sind Province, Pakistan (Kausar Ali Jafri, Sheruddin Bukhari, Bherulal T. Devrajani) 23
Hand Tractors Manufactured in the Philippines (Roberto C. Bautista, Eugenio C. Castro, Jr.) 29
Orchard Machinery in Japan (Kozo Hirata) 39
Energy-Conserving Farming Systems for the Humid Tropics (Ray Wijewardene) 47
Systems Approach in SchedullingHarvest and Post-Harvest Operations (S. Swain, T.P. Ojha) 54
Time and Costs of Loans for Pumping Sets/Tubewells for Small-Holders (A. C. Sharma, P. P. Setia) 57
Effect of Parameters of Heat Balance Method Upon Irrigation Water Requirement of Cotton Plants (Md. Motiur Rahman Khan) 62
Estimation of Ground Recharge in a Basin Water Balance Study (L. R. Khan, Tawatchai Tingsanchali, Anat Arbhabirama) 65
Effects of Moisture Content Quantitative and Qualitative Losses in Wheat (Bilash Kanti Bala, Md. Daulat Hussain, S.M. Hossain Saif, Md. Iqbal Hussain) : 69
Development and Evaluation of a Simple Tractor-Mounted Digger for Sugar Beet (Tara Chandra Thakur, Raj Deo Singh, Bachchan Singh) . . 72
Traction Potential of Pneumatic Tire for Tractors (M. A. Khan, Irshad Ari) 77
University & Institute Activity News . 83
New Products 85
Book Review 88

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 11 No.3, Summer, 1980)
Editorial (Yoshisuke Kishida) 9
An Economic Evaluation of Bangla desh's Bamail Cooperative Farming Project (Paris Andreou, Aziz Akramul). 11
Role of Standardization in the Power Tiller Industry Development (R. N. Sharma) 14
Production Technology of Japanese Rotary Blades for Rotary Tillage (Jun Sakai, Lam Van Hai) 17
The Palm Oil Industry in Malaysia and Its Need for Agricultural Engineers (Naresh Chandra Saxena) . . . 24
Effects of Different Mechanization Levels in Spanish Dryland Farms (J. Oritz-Cañavate, I. Salvador) . . . 31
Agricultural Mechanization in Tonga (A. P. Sharma). 37
Appropriate Agricultural Engineering Technology for Bangladesh (A. K. M. Moniruzzaman) 39
Human and Animal Energy and Farm Power Needs in Developing Countries: the Case of India (B. G. Yadav) 47
Benefits from Dug Well Irrigation – A Case Study in Some Districts of Orissa (India) (P. C. Senapati, G. K. Das). 51
Irrigation and Agricultural Development in Bangladesh (Sadiqul I. Bhuiyan) 55
Irrigation Potential in Orissa – A Need for Better Planning and Utilization (Sivala Kumar, P. C. Senapati) 63
Harvesting and Threshing Losses of Wheat with Mechanical and Conventional Methods (Muhammad Iqbal, Ghulam Sarwar Sheikh, Jehangir Khan Sial) 66
Effect of Improved Sickle on Field Capacity and Wheat Harvesting Drudgery (S. D. Kulkarni, B. S. Sirohi) 71
Conventional Rural Storage Structures: Bangladesh Experience (J. N. Samajpati, Md. S. A. Sheikh) 75
University & Institute Activity News . 83
News 85
New Products 90
Book Review 92

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA (Vol. 11 No. 4, Autumn, 1980)
Editorial (Yoshisuke Kishida) 9
Bin Drying of Grain and Grass with Solar Heated Air (W. Wieneke) . . . 11
Utilizing Solar Energy for Agriculture and Development in India: Problems and Prospects (H. S. Mann, R. P. Singh, P.C. Pande) 15
Availability of Solar Energy in Thailand (Md. Manimul Huq) 20
Some Practical Applications of Alternative Energy Sources in Guyana (Biswa Nath Ghosh) 23
Efficient Use of Agricultural Wastes for Energy Production (Rajvir Singh, R.C. Maheshwari, T. P. Ojha) 31
Performance Evaluation of Modern and Traditional Ploughs in Bangladesh (M. A. Mazed, K. C. Roy, M. A. Satter) 38
Disk Harrow – An Appropriate Tillage Implement (Ghulam S. Sheikh, Jehangir Sial, M. Afzal) 41
Economic Farm Size for Rice Combine Harvester in Malaysia (M. Zohadie Bardaie) 49
Development of Pantnagar-IRRI Multi-crop Thresher (Hem Chandra Joshi, Kailash Narain Singh) 53
Small-Scale Rice Bran Oil Extraction System Using an Expeller (Yasumasa Koga) 65
On-Farm Grain Storage in Nepal (R. B. Manandhar, Adrianus G. Rijk) 69
Development of the Indian Tractor Industry (Manfred Sievers) 75
News 85
New Products 87
Book Review 89

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (Vol.12 No.1, Winter, 1981)
Editorial (Yoshisuke Kishida) 9
Effect of Land Levelling and Irrigation on Wheat Yield (Jehangir K. Khattak, Abdur Rashid, S.U. Khan, Kermit E. Larsen, Riaz A. Khattak) 11
Influence of Farm Machines on Crop Production Efficiency (Bherulal T. Devrajani) 15
Experiments on Cassava Production Technologies in Fiji (S. Chandra, A.P. Sharma) 19
Design, Development and Testing of an Animal-Drawn Harvester (Madhu S. Singh) 22
Farm Mechanization Research Evaluation in Pakistan (Sheruddin Bukhari, Bherulal T. Devrajani) . . . 25
Post Rice Production Field Losses (Sarath Ilangantileke, Allan Phillips, Merle Esmay) 29
Paddy Post Harvest Technology in Bangladesh (Jatindra Nath Samajpati, Md. Shawkat Ali Sheikh, Md. Siddiqur Rahman) 39
Development of Greenhouse Solar Drying for Farm Crops and Processed Products (B.K. Huang, M.N. Özisik, M. Toksoy) 47
Stationary Flat-Bed Rice Drier and Two-Way Airflow Drying Method (Din-sue Fon) 53
Potential of Sugarcane as Alternative Energy Source in India (Subhash S. Arora, Kulbir Singh Malhotra) . . 57
Performance of Boilerless Parboiling System (S. Tiwary, T.P. Ojha) . . . 60
Food Processing and Preservation for Rural Women in Bangladesh (Jinnat Ara Begum) 63
Performance of Low-Cost Sail-Wing Windmill (S.C. Chowdhry, B.V. Ramana Rao, P. Sharma) 66
Population Growth and Food Supply in Bangladesh (Md. Daulat Hussain, Md. Faroque Ahmed) 69
News 75
New Products 78

Agricultural Mechanization in Developing Countries

Edited by Merle L. Esmay, Carl W. Hall
Publised by Shin-Norinsha Co., Ltd.

〔Contents〕 Chapterl. Principles of Agricultural Mechanization. Chapter 2. Agricultural Mechanization in Equatorial Africa. Chapter 3. Agricultural Mechanization in Asia. Chapter 4. Agricultural Mechanization in Latin America. Chapter 5. Ownership patterns for Tractor and Machinery. Chapter 6. Drying, Storing and Handling Food Grains in Developing Countries. Chapter 7. Irrigation in Developing Countries. Chapter 8. Education and Training for Agricuitural Mechanization in Developing Countries.

Size: 21cm×15cm, Page: 234, Price: $9.00 (hard-cover) or 5$ (Soft-cover)...excl. postage

SHIN-NORINSHA CO., LTD.
7, 2-Chome, Kanda Nishikicho Chiyoda-ku Tokyo, 101 Japan

Is your Agricultural Machinery Industry faced with problems of development and growth?

We can provide you with know-how to help your company and industry develop and grow.

Specific Information Service.

Statistics, Product Information, Patents, Test & Research Data, References and Directory.

Survey & Research.

Marketing Research, Forecasting on Economic, Technical, Supply, Demand, etc. and Dealer Search.

System Development.

Design of Developing System on New Products: from Ideas to Marketing.

Consultation.

Policy Making, Management Improvement, New Development of Organizations, Motivation.

Seminars & Meeting.

New Project & Up-to-date Subjects.

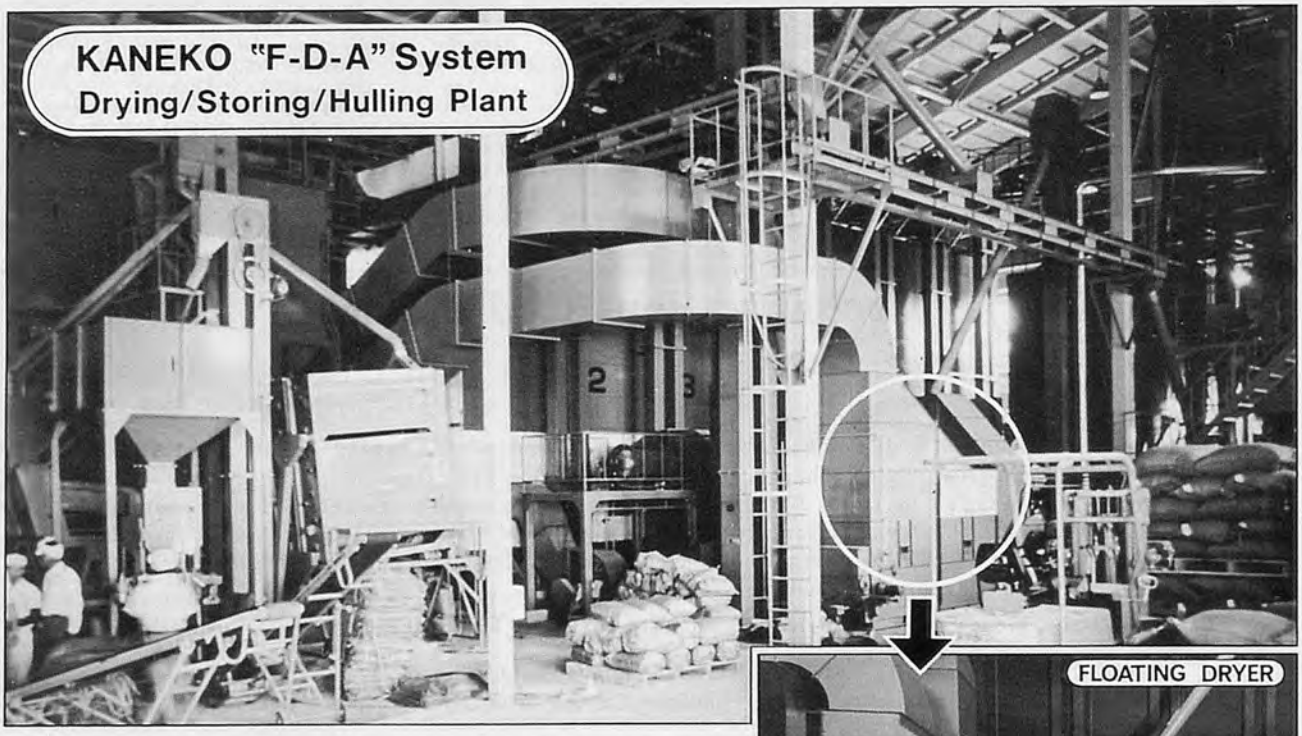
Publication Activities.

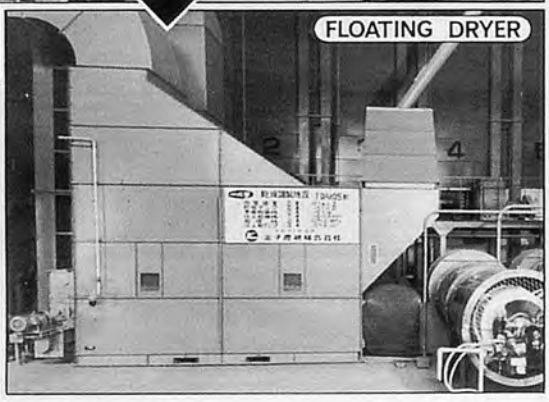
Basic, Production and Sales Statistics for Agricultural Machinery, etc.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

KANEKO SELLS THE POST HARVEST SYSTEM





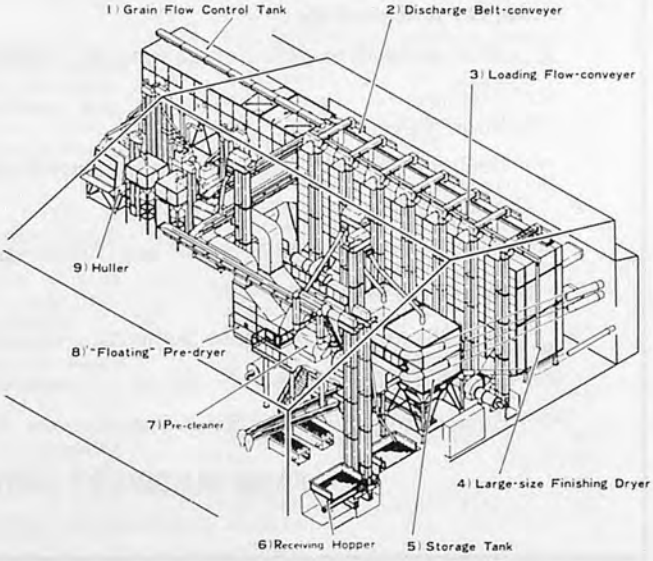
New"F-D-A"system characterized by the FLOATING Dryer, a pre-drying machine, dries paddy and corn of high moisture contents quickly, in large amount, with good quality, and, even more, at low cost.

Firstly, large amount of raw paddy and corn is rapidly pre-dryed in succession by means of the FLOATING Dryer.

Secondly, large amount of paddy and corn pre-dryed by the FLOATING Dryer is given the last finish drying in the large-scale finishing dryer.

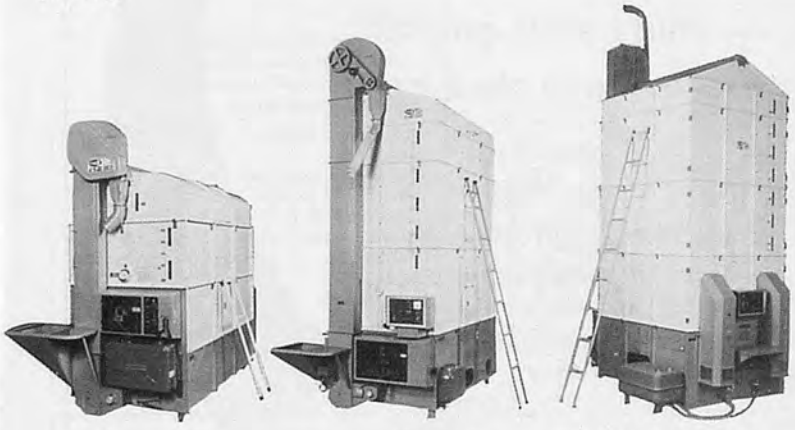
Thus, drying is completed easily and effectively in the"F-D-A" system with the KANEKO originated two-tier drying process empolyed.

*The FLOATING Dryer, both stationary and movable models available now, works efficiently by itself to dry paddy and corn. Movable one can do work at many places on purpose.



AND SERVES FULL BEFORE-AFTER CONSULTATION

"Supering" Circulating Suction Type Grain Dryer
The circulating type dryer capable of drying raw paddy.

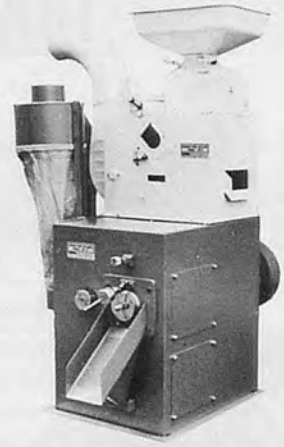


* Model SP-91A　　* Model SP-281C-V　　* Model SP-461G

Grain Holding Capacity-Paddy

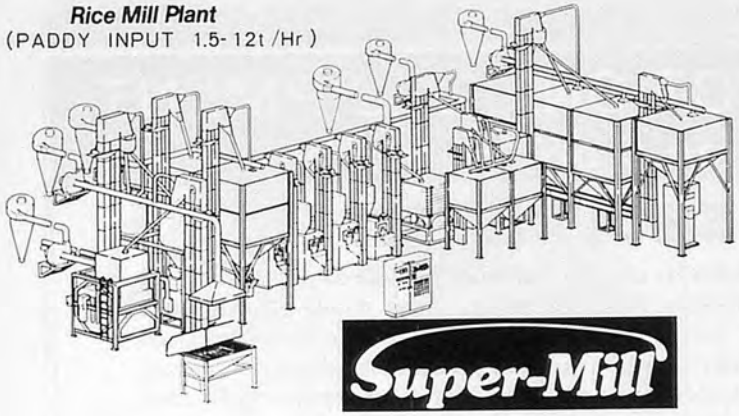
0.4-0.9t.	0.8-2.8t.	1.5-4.5t.

14 Models from 0.9 to 4.5t. Grain Holding Capacity/Paddy



COMPACT RICE MILL UNIT
model KRM-500
capacity;
650-750kg/h

Rice Mill Plant
(PADDY INPUT 1.5-12t/Hr)



Super-Mill



RICECON System—Rice Conditioning System
is small-size grain drying and conditioning facilities marked by the separate operation of each dryer and a variety of application.

KANEKO, with sixty years of experience to its credit, is a leading manufacturer of a wide variety of drying machines and related equipment and facilities.

Whether the climate is hot or cold, arid or with plenty of rain, whether the land is at high or low attitude, KANEKO farm products, with their applications of new scientific theories, guarantee the optimum in efficiency and work rationalization wherever used.

KANEKO AGRICULTURAL MACHINERY CO., LTD.

Overseas Division
26-11, Higashinihonbashi 2-chome, Chuo-ku, Tokyo 103 Japan
Phone: (03)862-2459 Cable: AGRIKANEKO Tokyo
Telex: 0265-7165

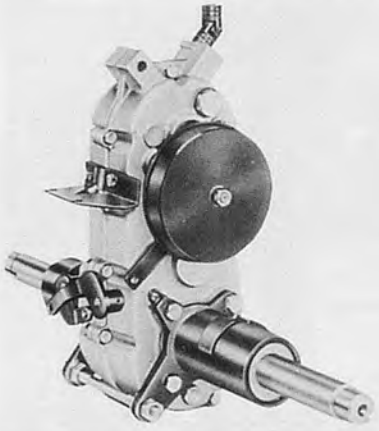
Headquarters
21-10, Nishi 2-chome, Hanyu, Saitama 348 Japan
Phone: (0485)61-2111 Telex: 2942-462

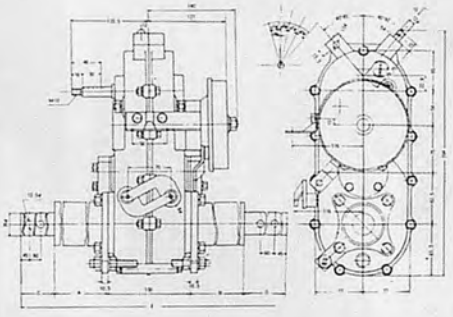
Catalogue available upon request.

HASHIMOTO

NEW PRODUCT!!

TRANS-MISSION F60 (STANDARD)





Application:
3-, 4-wheel and crawler-type carriers; Harvesters; Self-propelled mowers (reciprocating and rotary type); Mini potato planters; Transplanters (for cabbage); etc.

Speed range: Forward, 2 steps; Reverse, 1 step.
Standard reduction ratio: Top, 0.043, Second, 0.071, Reverse, 0.038
Primary shaft diam., 15-17 mm (Standard 17 mm)
Wheel shaft diam., 30-35 mm (Standard 35 mm)
Weight, 23-28 kg (Standard 23 kg)
Engine, 3.5-5.0 PS
Load capacity, 350-500 kg

Dimensions of A,B,C,D and E shown in the drawing are adjustable according to order.

Other items we manufacture to order: Worm/worm wheel reduction gear; worm/worm-wheel and spur wheel change gear

HASHIMOTO SEISAKUSHO, LTD.
〒590 1-29 SHINONOME-NISHI-MACHI 2-CHO, SAKAI, JAPAN.
TELEPONES. SAKAI (0722) 33-7301～3

NISSAN CONSTRUCTION EQUIPMENT

.... offers you high profit potential!!

DIG IT OR SHOVE(L) IT!

Or level it or back-fill it, or side-trench it or side-excavate it .... The Nissan mini-Giant N-45 Excavator does it all! Climbs 60% grades easily, and rotates 360°! Lifts itself onto its trailer! Compact yet powerful with a quiet 4-cylinder Isuzu diesel, the Nissan mini-Giant gets into tight areas that other crawler-types can't; and the enclosed dust-free cab provides low noise levels for greater operator concentration! The Nissan mini-Giant N-45 Excavator .... Dig It!



NISSAN mini-GIANT MODEL N-45



CRAWLER-CARRIER MODEL NC-3000

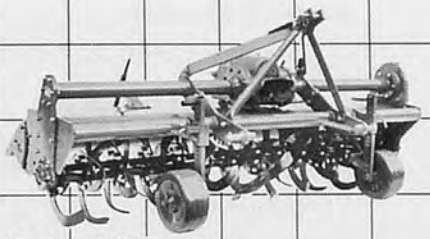
NISSAN KIZAI CO., LTD.

No.1478-1, Kamitomi, Miyoshi-cho, Iruma-gun, Saitama Pref., 354 Japan, Phone: 0492 (58) 1811 Telex: 02952-848
Cable Address: NIKKIY KAWAGOE

KOBASHI



Our high level of technique has been attained through a long time study on soils everywhere



Kobashi Tillage Blade
The supreme quality and the maximum output based on traditions and new techniques

Kobashi Rotor
A new series for 20 ps to 100 ps tractors incorporated with improved techniques

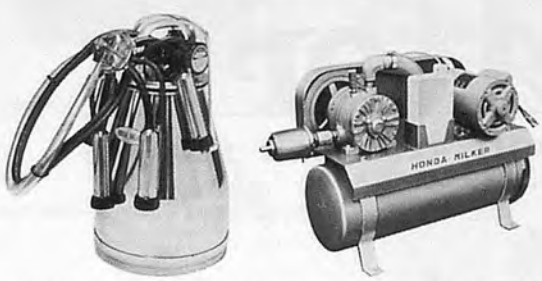
KOBASHI KOGYO CO,LTD.

Export Department :
2-1491, Yoshino-cho, Omiya City 330,
Saitama, Japan
Phone: Omiya-64-1545
Cable Address: "KOBASHIROTOR„ Omiya
Telex: 2922-139

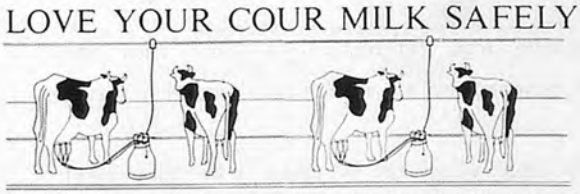
Head Office & Factory
684 Nakaune, Okayama City
701-02 Japan

KOBASHI

HONDA MILKER



LOVE YOUR COUR MILK SAFELY



Honda Milker "K" Type has been developed with a powerful new vacuum pump and a set of other easy handling instruments based on Honda Milker "A" Type which is considered a masterpiece among the dairy farming equipment industry. Honda Milker "K" Type will surely satisfy all kinds of conditions which dairymen seek for the Milker, for instance, no udder inflammation, no trouble, easy use.

· Pipe milker · Barn cleaner · Bulk cooler · Water cooler · Etc

HONDA SEISAKUSHO CO., LTD.
388, Kami-cho, Moroe-cho, Kanazawa,
Ishikawa-pref. 920 Japan
Phone: 0762 (23) 1411

ホーデン

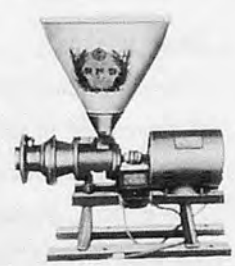
"HŌDEN" PRODUCTS ARE MOST USEFUL FROM HOUSEHOLD TO BUSINESS.

PADDY RICE POLISHING MACHINE

MODEL	INPUT CAPACITY (kg/H)	REQUIRED POWER (W)
F	30 ~ 45	250 . 300 . 400
G	45 ~ 90	300 . 400 . 450 . 750
GAT	180	2200
M	15	200~250



PADDY RICE POLISHING MACHINE



MILLING MACHINE & CRUSHER

MILLING MACHINE & CRUSHER

MODEL	REQUIRED POWER (W)	MILLING	CRUSHING
DM	250	10 (kg/h)	90 (kg/h)
	400	30 (〃)	300 (〃)
	750	50 (〃)	500 (〃)
	3700	100 (〃)	1000 (〃)

HŌDEN MFG., CO., LTD.
7Minameshozakai-Cho, Nishikyoguku, Ukyo-ku, Kyoto, Japan
Tel. Kyoto 075-313-6060

Is your Agricultural Machinery Industry faced with problems of development and growth?

We can provide you with know-how to help your company and industry develop and grow.

Specific Information Service.

Statistics, Product Information, Patents, Test & Research Data, References and Directory.

Survey & Research.

Marketing Research, Forecasting on Economic, Technical, Supply, Demand, etc. and Dealer Search.

System Development.

Design of Developing System on New Products: from Ideas to Marketing.

Consultation.

Policy Making, Management Improvement, New Development of Organizations, Motivation.

Seminars & Meeting.

New Project & Up-to-date Subjects.

Publication Activities.

Basic, Production and Sales Statistics for Agricultural Machinery, etc.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

NewsLetter

INTERNATIONAL FARM MECHANIZATION RESEARCH SERVICE

c/o SHINNORIN-SHA 2－7 KANDA NISHIKI-CHO CHIYODA-KU,
TOKYO, JAPAN., TEL. 03－291－5718, 3674

Dear friends

International Farm Mechanization Research Service was established in 1968 with the pourpose of promoting efective communications and researches on agricultural mechanization especially in developing countries.

We will gladly welcome everybody to join us who want to promote free and vital communications on agricultural mechanization over many barriers like sectionalism.

Our body is really independent one supported by every member's free and active mind to make better world.

Whenever you need more informations, please write me!

Yours Sincerely
Yoshikuni Kishida
Head of Directors



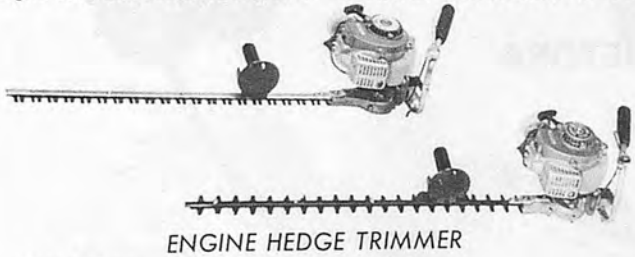
OCHIAI'S
TEA-LEAF PICKERS
TWIG CUTTER & SHEARS



Light, safe, and efficient. EOPA-8



BARIKAN TEA PICKER AM-53



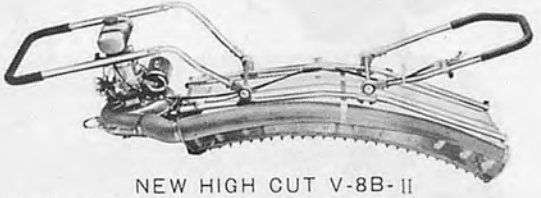
ENGINE HEDGE TRIMMER

●Features

1) Light Weight(only 5 kgs)
2) Compact Design
3) Simple Construction
4) Amazing Sharp-Cut Blades



MOTOR HEDGE TRIMMER



NEW HIGH CUT V-8B-II

Light and efficient, making little noise while in operation. In Japan, it is capable of picking tea leaves on 60 to 80 ares of tea plantation in a single day.

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 CUTLERY MANUFACTURING CO, LTD.

Head Office: 38, Chokaiji, Kikugawa-cho, Ogasa-gun, Shizuoka-ken, Japan
Tel. Kikugawa (05373) 6-2161~5 Telex 03965824 STPA J ATTN OCHIAI

MAMETORA DEDICATES TO AGRI

It is the motto of MAMETORA that we manufacture goods in order to meet customer's benefits with originality' trusty and hearty. In addition to the head office in Okegawa' Kisakata Factory has been established. Now that we have formed the much steadier basis as a comprehensive manufacturer. We are always making efforts to manufacture goobs of high quality and are pleased to devote ourselves to the food industry in the world as well as that in Japan.



MAMETORA AGRIC. MACHINERY CO., LTD.

HEAD OFFICE ADD:9-37, NISHI-2 CHOME, OKEGAWA-SHI, SAITAMA-KEN, JAPAN.
TELEPHONE:0487-71-1181 TELEX:2922561 MAMETO-J

CULTURE ALL OVER THE WORLD

○ Preeminent above the rest for economical efficiency. Rational design. Nothing but small-sized agricultural machinery displays opration efficiency like this.



This is the first Full Automatic Transplanter TPA-1 that Engineering Division of Mametora Noki Co., Ltd. has developed for the first time in the world.
This is cassette type transplanter only to put in seedling boxes. Suitable for Chinese cabbage, lettcue, cabbage and cauliflower.



Tobacco transplanter that is mostly used for trans planting tobacco in Japan.



Plowing operation by Mametora Tiller.



Oil pressure is largely introduced to this planter, and so this Mametora Planter is easy to use. This can be used for planting all Kinds of seedlings from small to large.



Operation in a greenhouse by Return Cultivator SR Type. This has wide application for seedbed, ridge and cultivation in orchards.