International specialized medium for agricultural mechanization in developing countries

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.XIII, NO.3, SUMMER 1982

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

Contributing to the mechanized farming, Iseki works its way.

The survival of a nation depends on how well its agriculture meets the needs of its people.

Since 1926, Iseki has devoted itself to developing agricultural equipment and technology capable of insuring our well-being and survival.

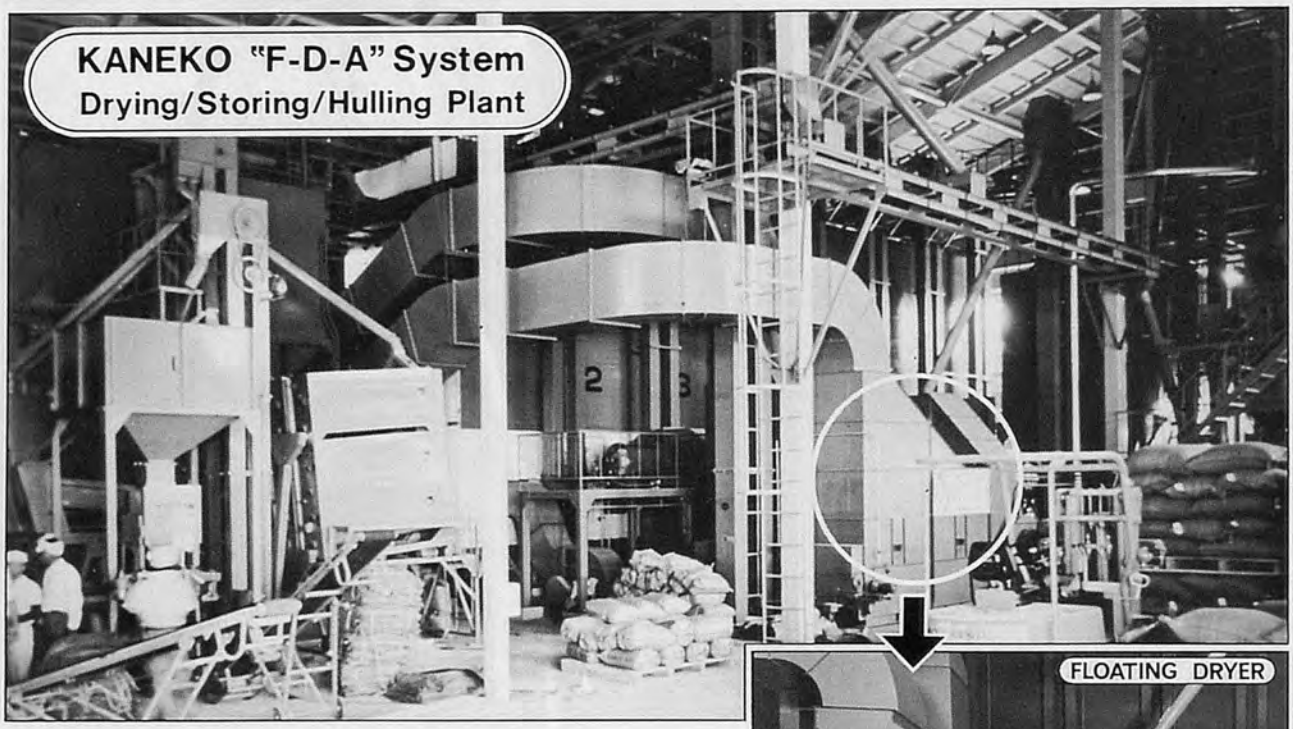
By developing unique farming technology, and striving for superior quality and improved technical services, Iseki promotes its vision of "better farming everywhere."

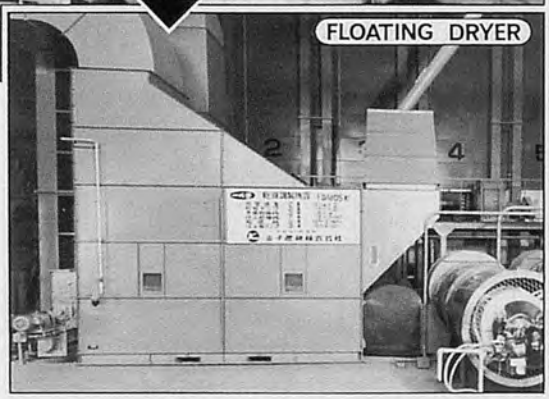
Iseki is concerned . . . and stands ready to share and communicate with all those engaged in improving the world through agriculture.

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

KANEKO SELLS THE POST HARVEST SYSTEM





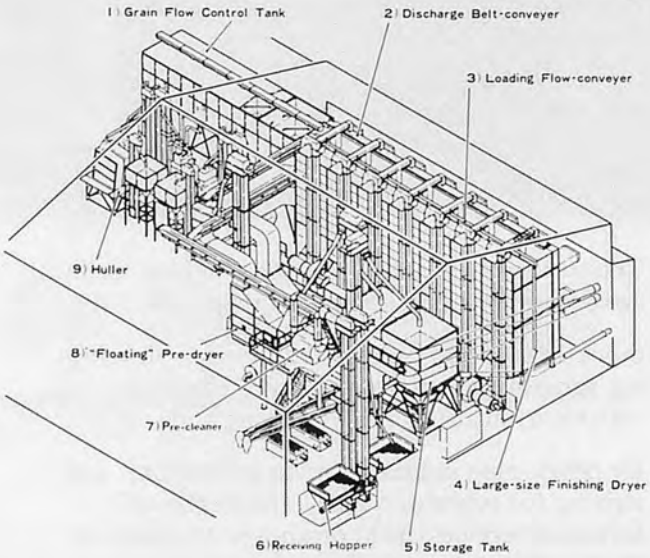
New"F-D-A"system characterized by the FLOATING Dryer, a pre-drying machine, dries paddy and corn of high moisture contents quickly, in large amount, with good quality, and, even more, at low cost.

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.

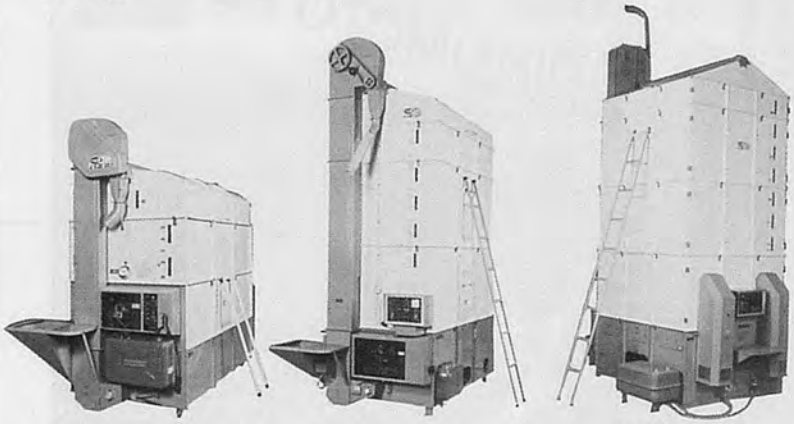
Thus, drying is completed easily and effectively in the"F-D-A" system with the KANEKO originated two-tier drying process empolyed.

*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.

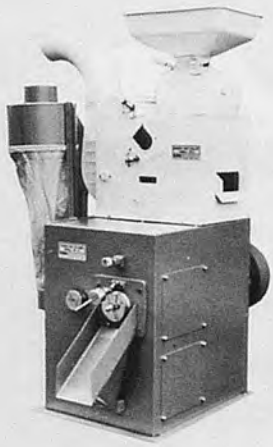


AND SERVES FULL BEFORE-AFTER CONSULTATION

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

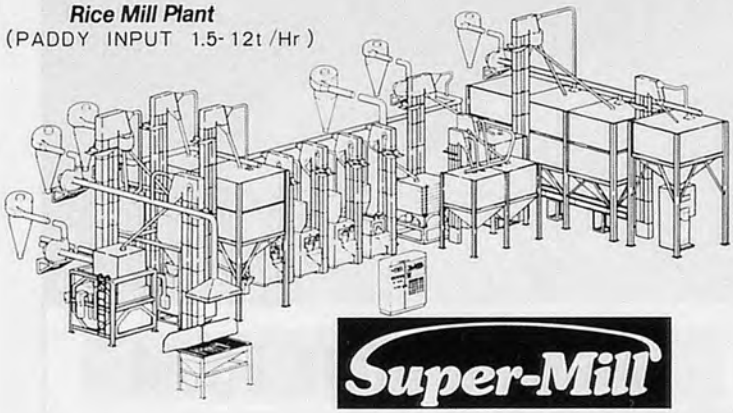


*Model SP-91A *Model SP-281C-V *Model SP-461G
Grain Holding Capacity-Paddy
0.4-0.9t. 0.8-2.8t. 1.5-4.5t.
14 Models from 0.9 to 4.5t. Grain Holding Capacity/Paddy

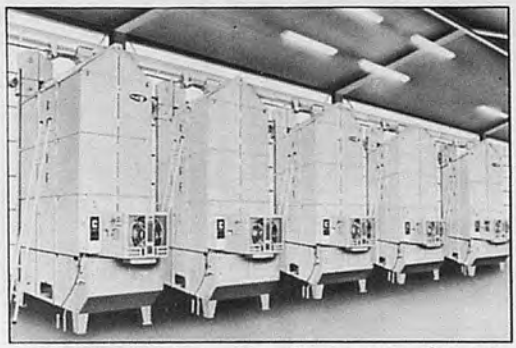


COMPACT RICE MILL UNIT
model KRM-500
capacity;
650-750kg/h

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.

E384
FRONT LOADER

41H.P.(Max.)·1994c.c.·4WD

ENGINE & BODY FROM INTEGRATED PRODUCTION

Improved functions and mechanisms have been developed based on our advanced technology. Performance factors required for tractors, such as workability, durability, comfort, safety and ease of service have all been carefully considered. Operating mechanisms are designed for fast, accurate control and handling for higher efficiency. The result is far more profitable operation and the ability to get big jobs done faster.

TOYOSHA CO.,LTD.

55, Joshoji-16, Kadoma-city, Osaka, 571 Japan
Cable: TOYOSHA NEYAGAWA
Telex: 5347763 MBTRAC J

International specialized medium for agricultural mechanization in developing countries

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.XIII, NO.3, SUMMER 1982

Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

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

Contributing Editors and Cooperators

- AFRICA -
Van Lancker, Julien G. (Brundi)
Hanna, George B. (Egypt)
Kandiah, Arumugam (Ethiopia)
Choudhury, Md. Shahansha-ud-Din (Nigeria)
Mittal, Jitendra P. (Nigeria)
Odigboh, E.U. (Nigeria)
Kuyembeh, N.G. (Sierra Leone)
Abdoun, Abdien Hassan (Sudan)
Bedri, Mohamed A. (Sudan)

- AMERICAS -
Nääs, Irenilza de Alencar (Brazil)
Phillips, Allan L. (Chile)
Valenzuela, A.A. (Chile)
Mirdha, A.H. (Mexico)
Goyal, Megh Raj (Puerto Rico)
Chancellor, William J. (U.S.A.)
Esmay, Merle L. (U.S.A.)

- ASIA and OCEANIA -
Farouk, Shah M. (Bangladesh)
Roy, Kshirode Chandra (Bangladesh)
Gurung, Manbahadur (Bhutan)
Wang, Wanjun (China)
Chandra, Satish (Fiji)
Michael, A.M. (India)
Verma, S.R. (India)
Soepardjo, Siswadhi (Indonesia)
Sakai, Jun (Japan)
Snobar, Bassan A. (Jordan)
Chung, Chang Joo (Korea)
Andreou, Paris (Lebanon)
Bardaie, Muhamad Zohadie (Malaysia)
Saxena, Naresh Chandra (Malaysia)
Shrestha, Bala Krishna (Nepal)
Chaudhry, Allah Ditta (Pakistan)
Devrajani, Bherulal T. (Pakistan)
Mughal, A.A. (Pakistan)
Lantin, Reynaldo M. (Philippines)
Lee, Chul Choo (Philippines)
Venturina, Ricardo P. (Philippines)
Aziz, M.H. Abdel (Saudi Arabia)
Illangantileke, S. (Sri Lanka)
Kathirkamathamby, Suppiah (Sri Lanka)
Peng, Tien-Song (Taiwan)
Singh, Gajendra (Thailand)

- EUROPE -
Pedersen, T. Touggaard (Denmark)
Pellizzi, Giuseppe (Italy)
Moens, Adrian (Netherlands)
Kilgour, John (U.K.)

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: 300 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 © 1982 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 36th issue since the issue, Spring of 1971.

EDITORIAL

A Question of Proper Technology

A current best-seller, Alvin Toffler's "The Third Wave", contends, among other considerations, that the advanced, industrialized countries are now on the threshold of what he describes as the second wave and that when the third wave rolls around in the not-too-distant future, the scheme of things regarding the political situation, world economy and society at large will change drastically. This contention triggered some thought-provoking and interpretative discussions in a recent meeting of Japan's International Agricultural Mechanization Society when a notable speaker, Dr. Shoichi Nakada, profounded that technical assistance efforts to developing countries must be attuned to the latters' peculiarities, real-life situations, and methodologies that would enable these countries to shift their positions from the second to the third wave without having to stick to the advanced countries that are in the second wave.

What it all boils down to is that available technical assistance to needy countries, in order to be truly effective, needs to be considered in the context of all known technologies from which a judicious selection of the proper technology should be made in order to match the tempo, phase and realities peculiar to the recipient countries.

For example, it has become abundantly clear from the many technical papers contributed to the AMA in recent issues that even the seemingly trivial research efforts in mechanical engineering common in many advanced, industrialized countries have come of age in developing countries. What this means is that technologies, common, old or new find meaning and use in various fields of endeavor in other countries – developed or developing. The use of automation technology in agricultural machinery even in developing countries is no exception in this regard. In the same vein, basic technology in both industry and agriculture equally find use in developed countries. Therefore, the search for proper or appropriate technology for a given situation in a given country is the question regardless whether it is old, common or new.

This issue is better seen in the light of the fact that historically, civilization as a whole, has not been advancing in a unified or synchronized fashion. As a rule, civilization in some countries lag behind in much the same way that within these countries, some segments of society are more advanced than others, or, conversely, in many highly civilized countries of the world today, some pockets of society progress less than others.

This historical trend, the "Third Wave" notwithstanding, is likely to go on for sometime yet to come but that the gap between the poor and the rich countries or civilization should eventually narrow down. One alternative open to mankind in hastening technology transfer is to strengthen development communications and the establishment of methodologies for strengthening it. In this respect, the AMA, its readers and contributors are being called upon to rally behind the total effort to disseminate and monitor the cause of agricultural mechanization.

Chief Editor
Yoshisuke Kishida

July, 1982
Tokyo

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. XIII, No. 3, Summer, 1982

Yoshisuke Kishida	9	Editorial
R. C. Fischer	11	A More Efficient Buffalo Plow
B. P. Varshney T. N. Mishra Akhilesh Kumar R. P. Singh	15	Performance of Harnesses Used for Draught Animals
Sheruddin B. Bukhari Jan Mohammed Baloch	20	Fuel Consumption of Tillage Implements
Riaz A. Khattak Mohammad Asrar Jehangir K. Khattak S. U. Khan	23	Economic Evaluation of Land Levelling
K. M. Hassanuzzaman S. M. Rahman M. R. Biswas	25	Contribution of Ground Water in the Evapo-Transpiration Demand of Soybean(Glycine Max. L.)
Md. Motiur Rahman Khan	29	Effect of Preplanting Irrigation on Cotton Cultivation
M. Zohadie Bardaie Wan Ishak Wan Ismail	31	Mechanization of Oil Palm Fruits Harvesting and Transportation in Malaysia
Naresh Chandra Saxena	35	Mechanization of Oil Palm Plantation Technology
E. U. Odigboh S. F. Ahmed	40	A Cassava Harvester: Design Analysis and Prototype Development
M. A. Mazed K. C. Roy	53	Design, Construction and Performance of a Jute Decorticating Machine
A. A. Mainul Hussain	56	Mechanization of Paddy Production in Malaysia
U. G. N. Anazodo	59	Mechanization of Family Farms in Nigeria: I. A Quantitative Analysis of the Problems and Prospects II. A Comparative Study of Selected Villages
R. N. Sharma	66	Standardization and Quality Control in Agricultural Machinery
M. M. Kashyap Amar Singh	69	Paddy Straw Utilization for Bags and Mats
Subhash S. Arora Kiran S. Arora	71	Calotropis procera(Ait.) R. Br. – Ak: A New and Free Source of Fibre and Renewable Hydrocarbons
News	78	
New Products	79	
Book Review	85	

★ ★ ★

Co-operating Editors 76
A Note to Contributors 87
Back Issues 88
Index to Advertizers 89

A More Efficient Buffalo Plow

by
R.C. Fischer
Associate Agricultural Engineer
International Rice Research Institute
G.P.O. Box 2453
Bangkok, Thailand

Abstract

Farmers who cannot afford engine power require means for improving their output by increasing their timeliness of field operations. A reduction of approximately one-third in the specific draft requirement was obtained in controlled tests compared to a typical manufacturer's plow for the northeastern region of Thailand. The improvement was obtained with a larger radius of curvature, a change in orientation of the plow relative to the soil, and a reduction in the point suction angle.

Introduction

There is an urgent need for increasing crop production to meet the demand for larger quantities of food, which is required by an expanding population in Thailand and Southeast Asia. Agricultural production in developed countries increased by 50% from 1957 to 1975. A higher increase of 60% was obtained in developing countries. However, because of a higher birth rate in the latter category, the agricultural production per capita was virtually constant. Some of the countries in this area are food importers. Thailand exports large quantities of rice but is running a deficit in foreign exchange. Thus, higher production is important to help pay for the high cost of petroleum imports.

The buffalo plow continues to be used extensively for paddy tillage in many areas of Thailand. Its use in regions other than the more highly mechanized central plain is extensive, particularly in the northeast, because the low farm income suppresses their ability to purchase mechanical power. The rainfed farmer typically waits for a certain amount of rain before he starts to plow because the buffalo cannot pull the plow very long if the soil is dry. When the rainy season begins several weeks later than normal, he is behind schedule and may not get all of his paddy into production. His prospect then is a more meager annual farm income than usual. There is a need for a timeliness advantage for him, even though he cannot afford mechanical power to obtain it.

The Thai-IRRI Cooperative Small Farm Machinery Project adopted the objective of reducing the draft of the buffalo plow in May, 1979. A popular plow manufactured in the northeastern province of Khon Kaen was selected as a basis for comparison. Two hypotheses were suggested:

1. A moldboard with a larger radius of curvature should require less draft
2. Rotating the plow point and moldboard assembly clockwise a suitable amount about a horizontal axis should provide a more gradual approach to the soil and further reduce the draft.

Plow Test Program, Upland Soils

Three moldboards of varying radii of curvature were fabricated from steel, along with a 3″ square wood block for mounting them with the attitude of the plow bottom rotated clockwise an arbitrary 20°, to test the assumptions. The middle radius moldboard was a copy of the manufacturer's.

The first trial was near Ayudhaya in June, 1979. Gage wheels were provided for the plow frame to control the depth at 127 mm (5″). A double acting hydraulic cylinder was inserted in the pull member, with oil in the rod end and a breather in the head port. A hose was attached to the rod end

* Condensation of paper presented at International Conference on Agricultural Engineering and Agro Industries in Asia, Asian Institute of Technology, Bangkok, Thailand, 10–13 November, 1981.

Acknowledgement: The IRRI contribution to the Thai-IRRI Cooperative Project is financed by USAID

port with a pressure gage at the opposite end. An IRRI power tiller was used for power, because the velocity would be more uniform than with an animal, which should provide more reliable data.

The gage was read at intervals of three meters, which provided a limited number of pressure readings. The needle oscillated profusely which made reading of the pressure gage difficult. Each test pass was spaced from the prior furrow so that the depth gage means was on undisturbed soil and the plow bottom was cutting at full width.

There was some power tiller wheel slippage for the 0° condition (manufacturer's orientation) of heavier draft which required a longer time interval for the run. The data was not adjusted for time variance. The limited data was not considered to be reliable; however, it appeared that the 20° plow attitude was an improvement over the manufacturer's plow.

The second test was at Phraputtabaht in sandy loam soil in October, 1979. A valve was inserted ahead of the pressure gage, which was closed when a reading was made to avoid needle oscillation. A 15 Hp Thai tractor provided ample power and avoided wheel slippage, with a ground speed of 3.9 km/h. The test plow bottoms were mounted on a horizontal shaft with provision for clockwise rotation in 5° increments from 0° to 35°. The beveled cutting edge was the lowermost line on the test plows. In contrast, the manufacturer's plow has interference below the cutting edge, which is not important in a puddled paddy field because the soil flows readily. Elimination of interference below the cutting edge of the plow is essential for upland plowing. Three randomized replications of the three radii of curvature moldboards at varying attitude angles were made. All test runs were made at the same engine speed. The time variance of passes was ±3% which was ignored in computing specific draft. The psi data was averaged for each test condition and converted to pull in kg, using the rod end cylinder area of 14.97 cm² (2.32 in²). Projected areas were determined by a planimeter from layouts of the various plow conditions. The largest radius of curvature moldboard, 356 mm (14″) produced the least specific draft at 20° rotation, 16% less than for the manufacturer's plow which had a 279 mm (11″) radius of curvature and 0° of rotation. (Radius is at middle of moldboard).

A power tiller plow moldboard with 380 mm (15″) radius of curvature was mounted on a shaft for incorporating in comparative trials with the prior three moldboards at Kamphaengsaen in November, 1979. The corn stubble field was sandy loam and the ground speed was 3.9 km/h. The plow frame required considerable reinforcing for the power tiller moldboard in upland soil. The specific draft data indicated an inverse relationship with radius of curvature (Fig. 1). The larger power tiller moldboard had the lowest specific draft of the four moldboards tested at every attitude angle in 5° increments from 0° to 30°. The lowest value of .54 kg/cm² was obtained for both 25° and 30° rotation, which was 52% less specific draft than for the manufacturer's plow. Fig. 2 shows total draft requirement.

A Dillon strain gage dynamometer and continuous recording equipment arrived for upland trials in heavy clay at the Asian Institute of Technology (A.I.T.) in July, 1980. A new moldboard with radius of curvature of 380 mm (15″) and side edges more compatible with a 20° – 25° attitude angle was substituted for the power tiller moldboard that had been used in recent tests. For this and subsequent tests, the point suction angle for fabricated test moldboards was reduced to 18°, compared to the manufacturer's 22°. The ground speed was 3.0 km/hr. This new moldboard had a specific draft of 1.17 kg/cm² at 30° attitude angle, compared to 2.28 kg/cm² for the manufacturer's plow at 0°, a reduction of 49%. The new moldboard had 50% more projected area of furrow slice, but it required less total draft than the manufacturer's plow. A steel strap extending 19 mm (3/4″) below the cutting edge was added to one side of the wood moldboard support at the rear, to resist side draft.

Plow Tests in Paddy

The wheels were replaced by skids for gaging the plow depth in paddy soils. The heavy clay at the Bangkhen Rice Station was flooded

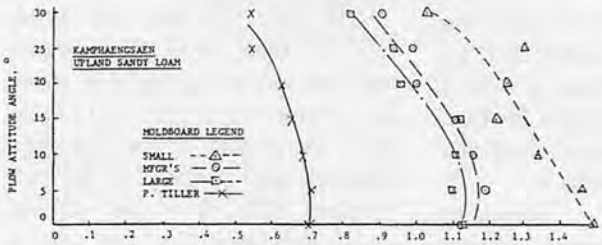


Fig. 1 Specific draft in kg/cm²

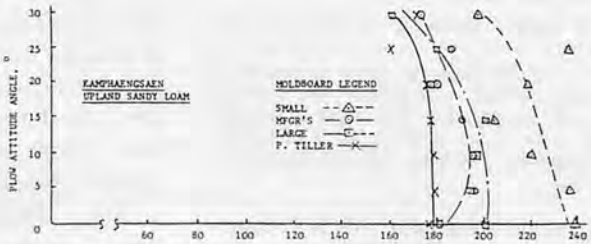


Fig. 2 Total draft in kg

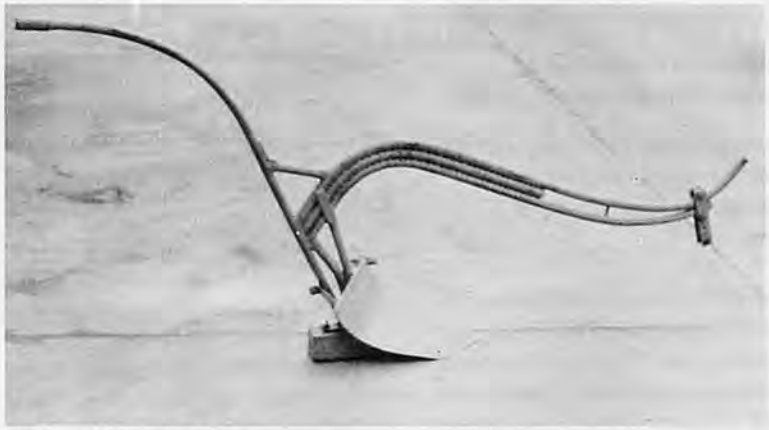


Fig. 3 Plow whole view

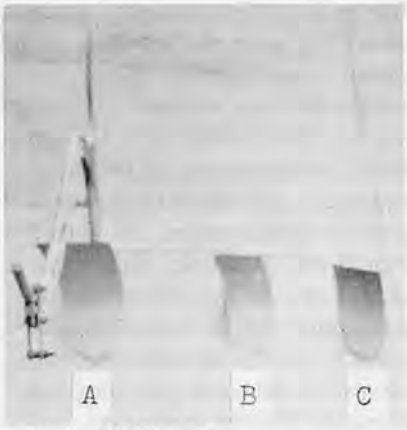


Fig. 4 Moldboards

with 2-3 cm of standing water for the February, 1980 trials. A Chinese boat tractor was effective in pulling through the deeply tilled wet soil at 3.6 km/h. The least specific draft was with the largest radius of curvature power tiller moldboard at a 30° attitude angle, which was 28.6% less than for the manufacturer's plow. Performance based on radius of curvature of the moldboard was similar to the upland test results at Kamphaengsaen.

Another test was made in August, 1980 near Bangkhen in heavy clay paddy. The new large moldboard required specific draft of .60 kg/cm^2 at 20° attitude angle which was 31% less than for the manufacturer's plow. Another evaluation in heavy clay paddy in September, 1980 at 2.5 km/h resulted in 37.5% less specific draft for the new moldboard at a 25° attitude angle, as compared to the manufacturer's plow.

A sandy loam paddy test was conducted at Khon Kaen, the location of the manufacturer who produced the plow used as a basis for comparison, with the recommended moldboards described in the summary on July 8, 1981. The least specific draft of .52 kg/cm^2 for the recommended wide plow at 20° attitude angle was 29% less than the comparable figure for the manufacturer's plow. The recommended narrow plow required a specific draft of .51 kg/cm^2 at 30° attitude angle which was a reduction of 30% compared to the commercial plow. The best results of these plows were obtained with a 10° difference in attitude angle; however the results for either plow for angles of 20° – 30° were not significant.

The two recommended plow moldboards described in the summary were tested by Department of Extension personnel in paddy at Pitsanuloke. A vertically adjustable hitch was provided to facilitate plowing at comparable depths, in lieu of depth gaging means. A buffalo was used for five hours (6:00 to 9:00 and 15:00 to 17:00) on a commercial plow used in that area. On the two following days the same buffalo pulled one of the recommended plow moldboards for the same 5 h. A depth of 12–13 cm was reported for all tests in a medium heavy soil (one plowing). The measured area covered showed results generally similar to the specific draft reduction in measured draft tests. The recommended narrow plow reflected a timeliness advantage; the buffalo ground speed apparently increased with a reduction in draft, compared with the commercial plow.

Item	Area Plowed	
	m^2	% increase
Commercial Plow	1,980	–
Recommended Narrow	2,480	25
Recommended Width	3,290	66

Summary and Conclusions

The average reductions in specific draft for three upland and four paddy tests were 39% and 32%, respectively, compared with the manufacturer's plow. The lower improvement in paddy may be due to the lubrication effect of water, which would also improve the performance of the less efficient manufacturer's plow. The improved moldboards used were not identical in all tests, but they were of similar design. The improved moldboard in the Phraputtabaht test had a 22° point suction angle compared to 18° on experimental shapes used in all other tests, which would be a factor in its relatively poor performance.

The average attitude angle that produced the best results in seven trials is 24°, compared to the manufacturer's 0°. Since many farmers typically hold the plow frame slightly to the right of vertical, the recommended attitude angle is 20°. If the frame is held 10° to the right of vertical, the plotted data suggests that the adverse effect of 6° beyond the test average of best angle should not be significant.

A wide moldboard with projected area of furrow slice of 237 cm^2 at 127 mm (5″) plowing depth, which is 47% larger than the manufacturer's plow, is recommended

for paddy. This should require about the same total draft as the present northeastern plow and reduce the time required for plowing by 32%. A similar moldboard with a projected area of 161 sq.cm equivalent to the manufacturer's plow, is recommended for upland conditions. It should reduce the total draft to two-thirds of the requirement for the manufacturer's plow. Except for size, both recommended moldboards have identical geometric features, as follows:

Point suction angle	18°
Angle relative to bottom line of moldboard, starting from lower L.H. corner, where forming stops	31°
True moldboard radius (form in sheetmetal roller)	26cm
Approximate radius along middle of moldboard	38cm
Attitude angle of moldboard, rotated clockwise relative to manufacturer's plow	20°

The principles of draft reduction of an improved buffalo plow for the northeast of Thailand have been verified in limited tests. This should benefit farmers who cannot afford mechanical power by reducing their time required for plowing even though they cannot afford engine power. The recommendations may have application in other countries where animal power is used extensively.

REFERENCES

1. Chanchai Rojanasaroj, R.C. Fischer, and Chak Chakkaphak, 1981: Buffalo Drawn Implements.
2. Chak Chakkaphak and R.C. Fischer, 1981: Rainfed Agricultural Mechanization and Transfer of Technology.
3 R.C. Fischer, 1981: Farm Machinery for Upland Rice.
4. IRRI, 1978: Economic Consequences of the New Rice Technology. ■■

Performance of Harnesses Used for Draught Animals

by
B.P. Varshney
Associate Professor
Department of Agricultural Engineering
G.B. Pant University of Agriculture and Technology
Pantnagar, Nainital, India

Akhilesh Kumar
M. Tech. Student
I.I.T., Kharagpur
India

T.N. Mishra
Associate Professor
Department of Agricultural Engineering
G.B. Pant University of Agriculture and Technology
Pantnagar, Nainital, India

R.P. Singh
Junior Engineer
CAD, Kota
Rajasthan, India

Abstract

Five animal harnesses were procured from different regions in Uttar Pradesh, India in order to evaluate their performance on the basis of four parameters: speed, rise in temperature, pulse rate and respiration rate of the animal. Four loads: 62 kg, 105 kg, 150 kg and 210 kg were used to study the above parameters. The local harness was found to be the best in terms of minimum rise in temperature and pulse rate of the drought animal. However, the minimum rise in respiration rate was observed for the hilly harness. Further, the variation in speed of travel was not significant, hence, this parameter was omitted in deciding the performance of the harnesses. It was also found that the Hill harness and that one developed at the Allahabad Agricultural Institute, Allahabad were second and third, in that order, as far as their performance is concerned.

Introduction

Various agricultural operations performed on the farm are accomplished by different sources of power, i.e. human, animal, petroleum oils, electrical and wind. The most important and common source of which (in India) is the animal. There are approximately 80 million draught animals available in the country for various farm operations. An average pair of bullock produces 1 hp or roughly equivalent to 750 watts. The total draught animal power for agricultue amounts to 30,000 MW. In other words, about 33 % of the total power available for agriculture is provided by animals against 13 % by human, 33 % by petroleum oils and 20% by electricity.

The utilization of animals for draft purposes depends mainly on how they are harnessed and guided. Different types of harnesses are used in various parts of the country and their type and design vary from region to region or even within a state. A few earlier studies have indicated that there is much scope for improving the design of the existing harnesses. It has also been reported that the power developed by a pair of draught animal may be increased by 10 to 15 %. At present, as the country is facing an energy crisis, there is acute need to improve the design of the existing harnesses.

The present study was undertaken with following major objectives:

1. To study the constructional details of different types of harnesses used in Uttar Pradesh.
2. To test and evaluate the performance of these harnesses.

Review of Literature

There are various types of harnesses which have been used and are presently in use in different countries. The double neck yoke is the most wide-spread and is used all over Africa, throughout India, Burma and the Mediterranean area. These harnesses are mostly used for bullocks in Iran, Iraq and Syria.

In 1938, a three-pad harness was developed in Germany but has since then been replaced by other types of cattle harness in most of the central European countries. It combines the advantages of the neck yoke with those of the collar harness. The three-pad harness consists of two wooden shoulder hames with a cushion padding on upper side to protect the shoulder without impeding their movements.

In 1961 at the Indian Agricultural Research Institute, New Delhi, another three-padded bullock harness with bow-shaped, two wooden frames and leather belting was developed which was reported in the Rockfeller Foundation Annual Report of 1962 that it was a development based on German design and that its performance was better than the locally-made harnesses.

A study on a single and double bullock harness was conducted at Allahabad Agricultural Institute in 1962 which was reported to give 38% more power than the Indian-made harness but cost 7-8 times more than the local wooden harness. The weight of the double harness is 16 kg compared with 7-8 kg of the local wooden harness.

Since animals are almost completely replaced by mechanical power in the developed countries, not much research is now in progress in these countries on animal harnesses, including other developing countries.

Materials and Methods

The following harnesses were used in the study: local (Tarai), hilly (Kumaon), Eastern Uttar Pradesh, Western Uttar Pradesh, and one developed at the Allahabad Agricultural Institute, Allahabad.

The local harness is simple in design which consists of two paralell wooden beams joined together by two vertical wooden rods as shown in **Fig. 1**. At the outer ends, two iron rods are provided which guide the animals during operation. On the other hand, the harness from the Hill is similar to the Tarai harness in construction but lighter by 0.5 kg. The harness from Eastern U.P. is a simple wooden beam as shown in **Fig. 2**. That from Western U.P. consists of one wooden beam provided with two vertical iron rods on both sides of the animal's neck to keep them at proper place **(Fig. 3)**. The improved Allahabad harness is made of steel which is provided with three rubber foam paddings which protect the animal's neck from injury. The dimensions and other details are shown in **Fig. 4**.

The following items were used in the whole experiment: a drum type loading device, a hydraulic dynamometer, a thermometer, stop watch, anemometer and a pair of bullocks (medium size).

The drum type loading device was used to apply variable loads during the testing **(Fig. 5)** by tightening and loosening the nuts on the pressing plates. An 80 m long wire rope was used one end of which was fixed on the drum while the other was attached to the yoke to crank the drum manually.

The total force required to rotate the drum type loading device was measured with the use of a hydraulic dynamometer which was calibrated against each load through a universal testing machine.

The thermometer was used to measure the temperature of the bullocks and atmosphere. The stop watch recorded the time of travel for a fixed distance for each load. The anemometer measured the wind velocity. An 80 m track, 4 m wide, was used for the experiment.

Testing procedure – The following parameters were selected to evaluate the performance of the harnesses: load, temperature, pulse rate/min, respiration/min and travel speed.

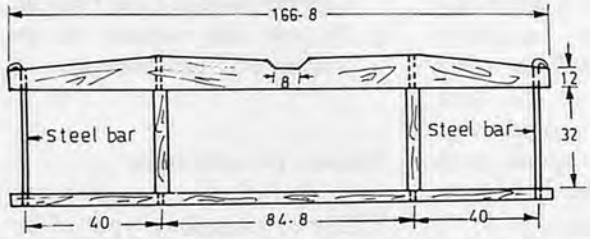


Fig. 1 Sketch of the local (Tarai) harness (weight 8.5 kg). Unit: cm

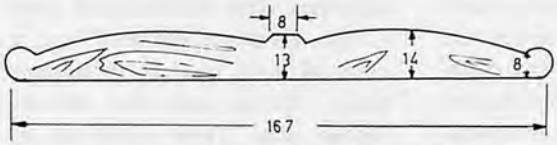


Fig. 2 Sketch of the Eastern Uttar Pradesh harness (weight 4.5 kg). Unit: cm

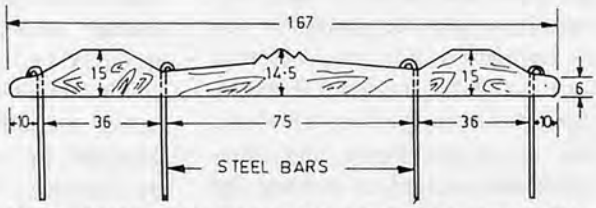


Fig. 3 Sketch of the Western Uttar Pradesh harness (weight 7.5 kg). Unit: cm

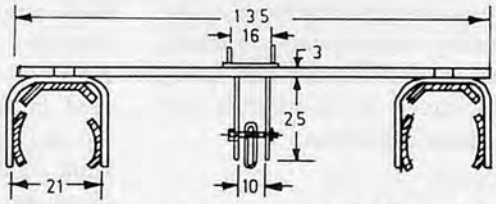


Fig. 4 Sketch of the steel harness (weight 16 kg). Unit: cm

Fig. 5 Drum type loading device

As the bullocks were to be run at various loads as follows: four loads were selected, one in light range, two in medium range and one in heavy range, i.e., 62 kg, 105 kg, 150 kg and 210 kg against the hydraulic dynamometer reading of 200 psi, 350 psi, 500 psi and 700 psi, respectively.

Each harness was placed on the neck of the pair of bullocks. One end of the hydraulic dyrnamometer was attached to the wire rope of the loading device and the other was fixed to the harness through another rope. Prior to running the bullocks, their initial temperature, pulse rate/min and respiration rate/min were measured. Therefore, the pressing plates of loading device were adjusted by tightening or loosening the nuts to such a position until the hydraulic dynamometer indicates the required load which is to be applied to the bullocks. After applying this load the bullocks were allowed to move forward for a distance of 75 meters and the time taken to cover this distance was recorded with the use of a stop watch.

The final temperature, pulse and respiration rates were taken after one load and the same procedure was adopted for other loads for each harness. Three replications were done for each load and all observations were recorded. The average wind velocity and atmospheric temperature were also measured for each day to indicate the atmospheric conditions.

Result and Discussion

The improved harness developed at the Allahabad Agriculture Institute is made of steel and weighed 16 kg, somewhat heavier than the other harnesses, e.g. the harness from Eastern Uttar Pradesh weighed 4.5 kg, the lightest of them all. The constructional details of these harnesses are shown in **Figs. 1 to 4.**

For the improved harness the spacing between the pads cannot be changed because it was designed only for small-sized bullocks. In comparison, the other harnesses may be used satisfactorily for any size of bullock. The cost of the improved harness is about 5 to 6 times more than the available wooden harness which may be a limiting factor for its popularization. The wooden harnesses are simple in design and easy in construction. Therefore, they may be easily made by village artisans whereas improved harness can only be made at specific shops.

The relationship between load and speed is shown for the different harnesses in **Fig. 6.** As the load is increased in weight its speed is decreased for the local and western harnesses. However, for the Hill, improved and eastern U.P. harnesses there is decreasing trend in the speed from 62 kg load to 150 kg load and thereafter there is slight increase in the speed, i.e., from 3.67 to 3.71 km/h for the eastern harness and speed remains almost constant for the Hill and improved harnesses due to the fact that bullocks were not in a position to pull the heavy load without beating them to speed up.

The relationships between the loads and respiration rates are shown in **Fig. 7.** There was an increase in the rise of respiration rate as the load was increased. However, for improved harness, the rise in respiration rate remained constant between load increase from 62 kg to 105 kg. After 105 kg load, it was observed that in all the

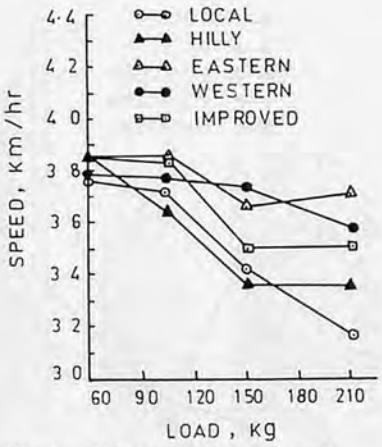


Fig. 6 Effect of load on speed of travels

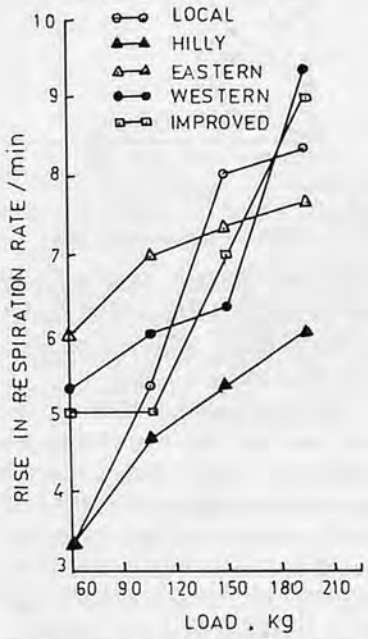


Fig. 7. Effect of load on respiration rate

cases the rise in respiration rate increased when the load is increased to 210 kg.

The relationship between the rise in pulse rate and load is shown in **Fig. 8.** As the load is increased the rise in pulse rate also increased in the case of local, eastern and improved harness. For the Hill harness, the rise in pulse rate decreased when the load was increased from 62 kg to 105 kg. Thereafter the rise in pulse rate increased. For the western harness, the rise in pulse rate increased from 62 kg to 210 kg but decreased from 7.67 to 5.67/min when load was increased from

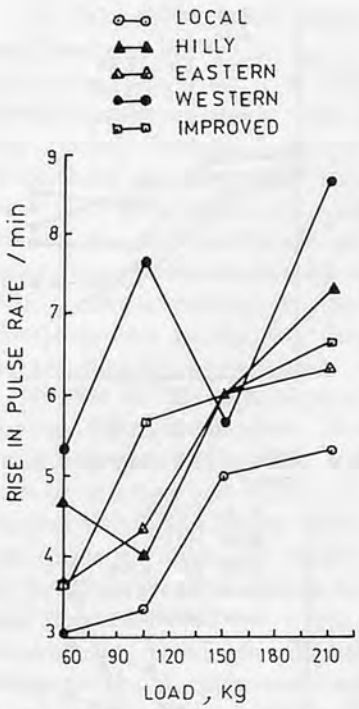


Fig. 8 Effect of load on pulse rate

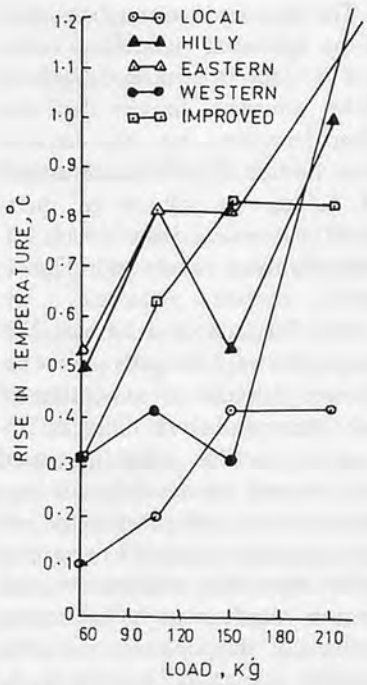


Fig. 9 Effect of load on temperature rise

105 kg to 150 kg. This decrease may be due to the hindrance caused on the bullocks when the observations were being recorded.

The relationships between the load and rise in temperature are plotted in **Fig. 9**. There was an increase in temperature as the load was increased for the local, improved and eastern harnesses. However for the Hill and western harnesses the temperature increase was on the 62 kg to 105 kg load but decreased somewhat on the 105 kg to 150 kg load and again increased after 150 kg load. The reason for this discripancy may be due to the hinderance caused by the bullocks while measuring temperature resulting in to slight decrease in the temperature of the bullocks.

The histograms for each load were prepared to compare the effects of variable load on the parameters based on the average speed, rise in temperature, rise in pulse and respiration rates **(Figs. 10 to 14)**.

Between 62 kg and 105 kg load, there was hardly any variation in the speed of the bullocks for the local and Hill harness. Even at 150 kg load, the variation in speed was only 0.31 km/h for the Hill and eastern harnesses. At 210 kg load, a variation of 0.55 km/h was observed at minimum speed of 3.16 km/h and maximum of 3.71 km/h was for the local and eastern harnesses, respectively.

The variation in temperature rise was not considerable for all loads: from 0.10°C to 0.57°C and 0.43°C to 1.33°C at 62 kg and 210 kg load, respectively. In general, there was a minimum rise in temperature for the local harness.

There was a minimum rise of 3.00 beats/min and maximum rise of 5.33 beats/min in pulse rate of the animal for the local and western harnesses, respectively at 62 kg load. At 105 kg load the minimum rise in pulse rate was 3.33 beats/min for local harness and maximum of 7.67 beats/min for western harness. The rise in pulse rate at 210 kg load varied from 5.33 to 8.67 for the local and western harnesses, respectively. For all load categories, the minimum rise in pulse rate was found for the local harness and maximum for the western harness.

The rise in respiration rate of the draught animal was minimum for the local and Hill harnesses, i.e., 8.33 and maximum for the eastern harness at 6.00 at 62 kg load. At 105 kg load, the rise in respiration rate varied from a minimum of 4.67 for the Hill harness and

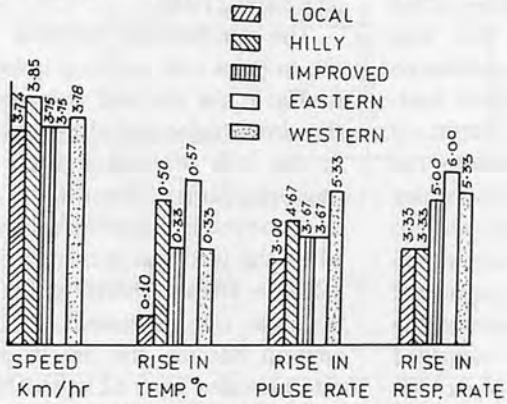


Fig. 10 Comparative performance of various harnesses at 62 kg load

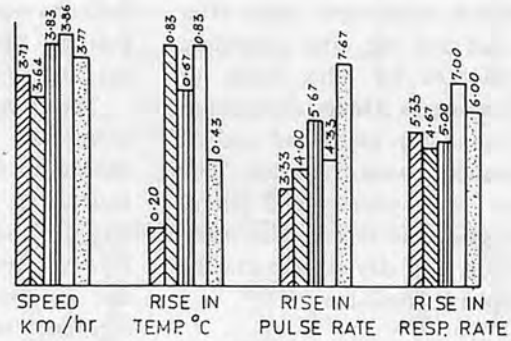


Fig. 11 Comparative performance of various harnesses at 105 kg load

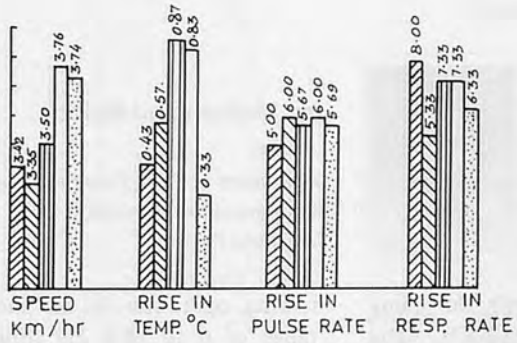


Fig. 12 Comparative performance of various harnesses at 150 kg load

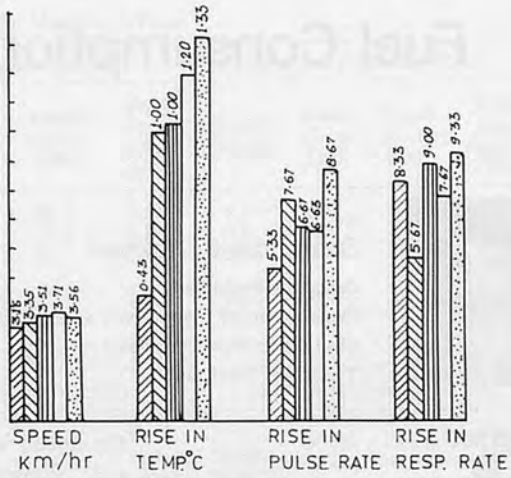


Fig. 13 Comparative performance of various harnesses at 210 kg load

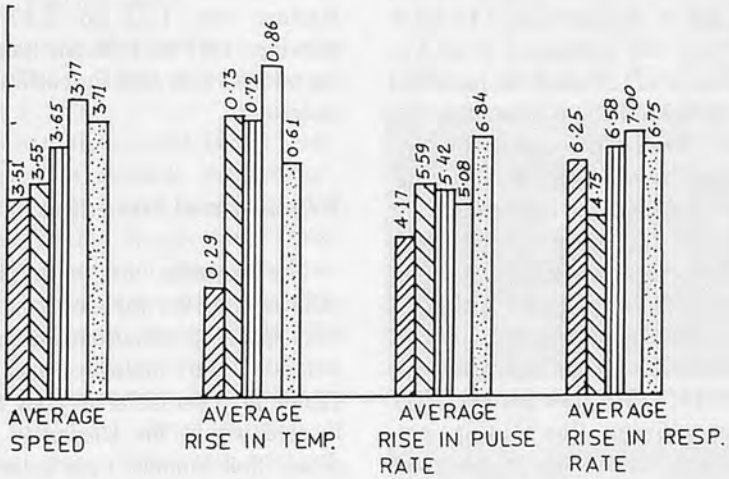


Fig. 14 Comparison of various harnesses at average load

maximum of 7.00 for the eastern harness. At 150 kg load, the minimum rise was 5.33 for the Hill harness and maximum of 8.00 for the local harness. There was no variation between the improved and eastern harnesses which was 7.33 in both the cases. At 210kg load the rise in respiration rate was minimum at 5.67 for the Hill and maximum of 9.33 for western harness. There is not much difference in rise for local and eastern harness and their respective values are 8.33 and 7.67. For the improved harness, the rise was 9.00.

Conclusion

The four histograms mentioned earlier were superimposed into one for a more comprehensive comparison of the test effects on each of the parameters (Fig. 14). As a conclusion, the three most desirable harnesses were the Hill, local and improved, in that order – from the standpoint of the draught animal.

REFERENCES

1. Giles, G. Wallace, A drawbar dynamometer. Agril. Engg. 16(6): 215, 1935
2. Ojha, T.P. Design and construction of a piston-cylinder type hydraulic drawbar dynamometer for animal drawn farm implement, M. Tech. Dissertation, I.I.T. Kharagpur(WB) 1956.
3. Pandya, A.C., Energy for Agriculture in India. Central Institute of Agril. Engg., Nabi Bagh, Bhopal 462010, INDIA 1981.
4. Patel, S.M. Report on design of hydraulic dynamometer. The Agricultural Engineer, 7:35-39, 1962.
5. Singh, R.D. Design and development of three-dimentional dynamometer for tillage studies. M. Tech. Dissertation, G.B. Pant Univ. of Agricultural & Tech., Pantnagar. 1979. ■■

Fuel Consumption of Tillage Implements

by
Sheruddin B. Bukhari
Associate Professor
Department of Farm Power and Machinery
Sind Agriculture University
Tandojam, Pakistan

Jan Mohammad Baloch
Lecturer
Department of Farm Power and Machinery
Sind Agriculture University
Tandojam, Pakistan

Abstract

Among the tractor operating costs, that of fuel is the major item and is a direct out-of-pocket expense on the part of the farmer. The factors that affect fuel consumption are speed of operation, width of cut, depth of cut, type of soil and skill of operator. The availability and cost of tractor fuels is constantly changing and has shaken the foundation of the farm economy throughout the world. In order to save on the cost of fuel, field operations have changed their route from plowing to no-till method. Also, tractor designers have turned their mind from diesel-operated tractors to alternate energy operated tractors.

Objectives of the Study

The present study aimed at determining the fuel consumption of tillage implements so that maximum farm economy could be obtained. For this purpose, three implements: a mounted moldboard plow, a mounted disk plow and a regular trailed tandem disk harrow were used on different soil conditions.

Frisby and Summers[2] carried out a study on energy related data for selected implements using a John Deere 2630 diesel tractor. They found that the three-bottom moldboard plow with 1.07m width of cut and 20.5 cm depth of cut at the speed of 5.95 km/h on loamy soil consumed 20.62 ℓ/h. The tandem disk harrow having width of cut 3.97 m and depth of cut 10.2 cm at the speed of 6.14 km/h on loamy soil consumed 23.62 ℓ/h. Sheltan *et al*[3] studied the farm fuel use in Nebraska and found that the mean diesel fuel consumed for plowing was 17.49 ℓ/ha; disking, 7.39 1/ha; and for harrowing 5.52 ℓ/ha. On the other hand, Bhattacharya[1] carried out a research study on standardizing tractor field test with matching implements, namely; two/three-bottom moldboard plow, mounted/trailed disk harrow and a 9-tine cultivator. The plowing operation was carried out in the moisture range of 10 to 15% and harrowing operation in the moisture range of 6 to 14%. He concluded that the drawbar specific fuel consumption ratio of both the tractors was 1.22 to 1.57 for plowing, 1.07 to 1.76 for harrowing and 1.31 to 2.29 for cultivation operation.

Experimental Procedure

The variables that have direct influence on the fuel consumption were speed of operation, soil manipulation and moisture available **(Table 1)**. Two different sites were located within the University premises. Soil samples were collected from both sites and the moisture

Table 1 Farm Machines Used

Name	Width (m)	Specification
MF-135 tractor	–	Massey Ferguson-135, two wheel drive tractor, 35 kW, three point hitch system.
Moldboard plow	0.9	Mounted, 3-bottom, 30 cm each, general purpose.
Disk plow	1	Mounted, 3-disk, 60 cm disk. Tilt and disk angles are adjustable, tail wheel adjustable.
Tandem disk harrow	1.32	Trailing, regular, 12-disk, plane disk 56.5 cm, notched disk 57.5 cm, 22 cm disk spacing

Table 2. Soil Moisture Content of Test Soils

Soil sample number	Soft soil			Hard soil		
	Weight of wet soil (g)	Weight of dry soil (g)	Soil moisture content (%)	Weight of wet soil (g)	Weight of dry soil (g)	Soil moisutre content (%)
1.	316	288	8.96	326	312	4.29
2.	346	319	7.08	381	366	3.93
3.	325	302	7.07	338	326	3.55
4.	331.8	303.8	8.44	427,5	412.5	3.51
5.	338	314	7.01	480	463	3.54
6.	327	300	8.25	356.73	331.73	7.00
Mean	–	–	7.9	–	–	4.3

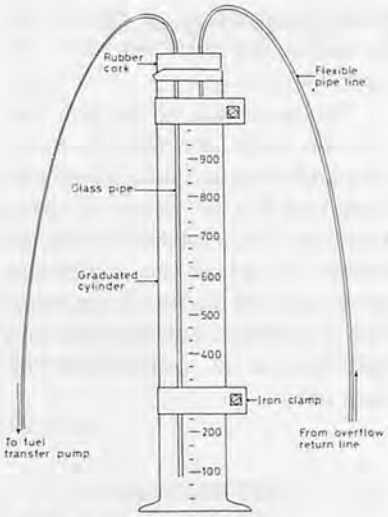


Fig. 1 Fuel flow meter

content was calculated on wet-bulb basis. The moisture data is given in **Table 2.**

A fuel flow meter **(Fig. 1)** was designed to measure the fuel accurately. It was mounted and bolted to the tractor body. Fuel supply line from the fuel flow meter was directly connected with the fuel supply pump of the MF-135 tractor. Excessive fuel returned from atomizers was sent back to the fuel flow meter through a return pipe. Three test runs of 30.5m long at approximately a constant tractor speed were carried out with each implement. Fuel consumed during each test run on soft as well as hard soil was recorded directly from fuel flow meter. The soil manipulated by each implement was also recorded for further analysis.

Discussion of Results

Table 3 shows the fuel consumption of the MF-135 diesel tractor operating the mounted three bottom moldboard plow on two soil types. In the soft soil, the moldboard plow with 102.78 cm width of cut and 19.33 cm depth of cut at a speed of 5.97 km/h consumed 5.51 ℓ/h diesel fuel. The soil tilled is shown in **Fig. 2.** In hard soil the moldboard plow with 90.78 cm width of cut and 15.2 cm depth of cut at a speed of 6.9 km/h consumed 8.83 ℓ/h diesel. In hard soil, the tractor operating the moldboard plow consumed 3.32 ℓ/h more fuel. The soil plowed is shown in **Fig. 3.**

The fuel consumption of the tractor is shown in **Table 4.** In soft soil, the disk plow with 95.22 cm width of cut and 13.78 cm depth of cut at a speed of 7.1 km/h consumed 5.44 ℓ/h. The land plowed is shown in **Fig. 4.** In hard soil, the disk plow operating at a speed of 6.59 km/h and plow operated at a depth of 18.11 cm and 108.33 cm width of cut consumed 7.4 ℓ/h. In soft soil, the tractor operating the disk plow saved 1.96 ℓ/h. The land plowed is shown in **Fig.5.**

The fuel consumed by the tractor pulling the regular tandem disk harrow is given in **Table 5.** In soft soil, the disk harrow with 103 cm

Table 3 Fuel Consumption of Moldboard Plow

Replication	Soft soil (Moisture 7.9%)				Hard soil (Moisture 4.3%)			
	Speed (km/h)	Width of cut (cm)	Depth of cut (cm)	Fuel consumed (l/h)	Speed (km/h)	Width of cut (cm)	Depth of cut (cm)	Fuel consumed (l/h)
R_1	5.54	102.7	20.7	5.54	6.13	83	13.3	8
R_2	6.1	103.7	19.3	5.84	6.1	94	15.7	9
R_3	6.27	102	18	5.14	6.46	95.3	17.3	9.53
Mean	5.97	102.78	19.33	5.51	6.23	90.78	15.2	8.83

Table 4 Fuel Consumption of Disk Plow

Replication	Soft soil (Moisture 7.9%)				Hard soil (Moisture 4.3%)			
	Speed (km/h)	Width of cut (cm)	Depth of cut (cm)	Fuel consumed (l/h)	Speed (km/h)	Width of cut (cm)	Depth of cut (cm)	Fuel consumed (l/h)
R_1	5.86	92.7	14	5.63	6.46	109.3	18.3	7.4
R_2	5.86	98.7	12.7	5.5	6.66	111	18	7.6
R_3	6.57	94.3	14.7	6.21	6.66	105	18	7.2
Mean	5.76	95.22	13.78	5.75	6.59	108.33	18.11	7.4

Fig. 2 Soil tilled by moldboard plow in soft soil

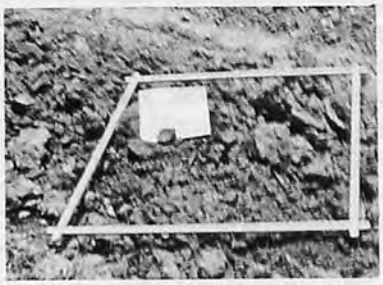


Fig. 3 Soil worked by moldboard plow in hard soil

Fig. 4 Soil plowed by disk plow in soft soil

Fig. 5 Soil plowed by disk plow in hard soil

Table 5 Fuel Consumption of Disk Harrow

Replication	Soft soil (Moisture 7.9%)				Hard soil (Moisture 4.3%)			
	Speed (km/h)	Width of cut (cm)	Depth of cut (cm)	Fuel consumed (l/h)	Speed (km/h)	Width of cut (cm)	Depth of cut (cm)	Fuel consumed (l/h)
R_1	7.84	96.3	10	5.14	7.84	121.7	8.4	5.14
R_2	7.84	109.7	11	5.14	7.32	130	9.0	6
R_3	7.32	105	10	6	7.57	135	7.9	6.17
Mean	7.63	103	10.33	5.43	7.58	129.89	8.43	5.77

Fig. 6 Soil worked by disk harrow in soft soil

Fig. 7 Soil disturbed by disk harrow in hard soil

width of cut and 10.33 cm depth of cut operating at a speed of 7.63 km/h consumed 5.43 ℓ/h. The soil harrowed is shown in Fig. 6. In hard soil, the tandem disk harrow operating at a speed of 7.58 km/h, harrowing at a depth of 8.43 cm and the width of cut 129.89 cm, consumed 5.77 ℓ/h. In soft soil, the tractor operating the regular tandem disk harrow consumed 0.34 ℓ/h more than in the hard soil. The soil harrowed is shown in Fig. 7.

Conclusions and Suggestion

The moldboard plow operating on soft soil turned up more soil and consumed less fuel as compared with the operation on hard soil at almost the same speed of operation.

The moldboard plow proved more economical than the disk plow on soft soil at almost the same speed of operation. However, the disk plow, at reasonably higher speed of operation, gave better performance on hard soil than the moldboard plow.

The work rate of the disk harrow was much faster than the moldboard plowing and disk plowing on both soils but the depth of operation was less. Hence it would be better to operate the moldboard plow and disk harrow in combination on soft soil and disk plow and disk harrow in combination on hard soils.

REFERENCES

1. Bhattacharya, T.K. 1981. Standardizing tractor field tests. AMA, Japan 12(2): 31-32.
2. Frisby, J.C. and J.D. Summers. 1979. Energy related data for selected implements. ASAE. Trans., 22(5): 1010-1011.
3. Shelton, D.P., K.V. Barger and A.S. Al-Jiburi. 1979 Nebraska on-farm fuel use survey. Agril. Enging. 60(10): 38-39. ■■

Economic Evaluation of Land Levelling

by
Riaz A. Khattak
Lecturer
Department of Soil Science
N.W.F.P. Agriculture University
Peshawar, Pakistan

Mohammad Asrar
Assistant Professor
Department of Farm Machines
N.W.F.P. Agriculture University
Peshawar, Pakistan

Jehangir K. Khattak
Associate Professor and Chairman
Department of Soil Science
N.W.F.P. Agriculture University
Peshawar, Pakistan

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

Abstract

The economic evaluation of land levelling was appraised on a farmer's field by comparing the cost of irrigation water, labour charges and yield of sugarcane crop before and after levelling. An added income of Rs. 5563 (US$ 556) per hectares was obtained on the basis of saving of 17, 39, 67 and 32% in terms of number and period of irrigation water, labour cost and increase in yield of sugarcane, respectively. Increase in cropped area, convenient application of cultural operations and facilitation of the use of agricultural machinery were the other beneficial effects.

Introduction

Uniform distribution of water is profoundly important both in irrigated and unirrigated areas. In Pakistan, the farm water whether from natural precipitation or applied irrigation is not evenly distributed due to the undulated farm surfaces. According to an estimate (4) about 90% of irrigated farms are not precisely level. On such farms the unevenness ranges from ±5 to ±25 cm, a condition which amply precludes efficient utilization of water and resulting in considerable water loss. At present the irrigation application efficiency of less than 25 % is quite common in the country. As surveyed by Ali, Clyma and Early (2), out of 52 sites, 10 % was under-irrigated, 19 % received normal irrigation whereas 71 % was over irrigated due to the uneven field level condition. Thus the practice of over-irrigation results in loss of water and contributes towards the development of waterlogging and salinity while the practice of under irrigation adversely affects the crop growth and yield.

But in the farming community, the effects of levelling have been a controversial issue. Most of the farmers are of the opinion that levelling destroys the top fertile soil and thus causes detrimental effect on soil fertility. Cox and Alam (3) tried to clarify this assumption and stated that since our soils are deep alluvial, homogenized and uniform in texture up to the root zone, levelling has no adverse effect on soil fertility and productivity. Rather it has beneficial effects by breaking the tillage pan and providing better field condition for water application and crop growth.

The present study was undertaken to clarify the effects and economics of land levelling in order to present a true and clear picture to the farmers in simple terms of cost benefit analysis on farms in Peshawar Valley. This limited economic analysis might prove an effective incentive to the farmers to adopt levelling which is an essential part of mechanized agriculture in all the developing countries like Pakistan.

Material and Methods

This comparative study of the economics of land levelling was undertaken in the irrigated area of Charsadda, central part of Peshawar Valley, taking a farmer's field at village Parong situated at the left bank of the River Gindi. The area is crossed by a network of rivers, viz, Khaili, Naguman, Gul Abad, Gindi and Sarderyab which are the ultimate tributaries of the River Indus. The soils of the areas are alluvium, homogenized and calcareous having sandy loam to silt loam texture and is best suited for the production of sugarcane, maize and sugar beet. A 1.41 ha field was selected after consultation with the farmer. Data on the first phase of study is shown in **Tables 1** and 2 prior to land levelling. The field was thoroughly surveyed as suggested by Twitty (6) in a grid system of 20 x 20 m. Elevations were recorded by a planimeter and a contour map was developed dividing the whole field into two portions with 7 cm difference in elevation. After computing the volume of cut amounting to 810 m^3 earth removal, the field was levelled and rechecked by allowing an elevation tolerance of ±2 cm. In the second phase, a sugarcane variety 48/103 was planted and the field was fertilized and manured with 85 kg P_2O_5, 170 kg N and 37 t of farm yard manure per ha. (This rate of fertilizer included an additional application of 25 %

Table 1. Land Levelling Effects

Item	Before levelling	After levelling	Percent saving
No. of irrigations required for sugarcane crop	18	15	17
Hours required for one irrigation	28	17	39
Total hours of irrigation	504	255	
No. of labour required for one irrigation	3	1	67
Total labour (h)	54	15	
Yield in "gur" (kg/ha)	3825	5582	32

Table 2 Income Changes Resulting from Land Levelling Unit: Rs.

Items	Before levelling	After levelling	Income change per ha
Total cost of irrigation(Rs.4/h)	2016	1020	
Total labour charges(Rs.10/labour)	540	150	
Irrigation charges/ha,(1+2)÷1.41	1812	829	983
Income from gur produced/ha.	15700	22328	7028
Total income due to levelling(3+4)			8011*
Expenditure Incurred due to Land Levelling:			
Cost of levelling per ha (@ Rs.3/m^3)			1723
Cost of additional F.Y.M. and organic fertilisers			725
Total			2448**
Net income due to levelling:			
Income obtained after levelling			8011*
Expenditure incurred due to levelling			2448**
Net			5563

chemical fertilizers and 50% F.Y.M). The use of insecticides and other cultural practices was maintained as before levelling. The data regarding number, time and labour required for irrigating the sugarcane crop and the "gur" (raw sugar) produced from the sugarcane was recorded. The savings obtained due to land levelling were evaluated in monetary terms. (Table 2).

Results and Discussions

There was appreciable saving both in irrigation water and labour requirement coupled with considerable increase in yield of sugarcane (Tables 1 and 2). Some 39% of the time was saved in total irrigation while the number of irrigation application was reduced by 17% and the labour requirement decreased by 67%. About 32% more "gur" was obtained from sugarcane after levelling the field. As such, the income obtained after levelling was Rs. 8011 (US$801) against an expenditure of Rs. 2448 (US$ 244) incurred on levelling and application of fertilizers and manures. Hence, a net income of Rs. 5563 (US$ 556) per ha was generated. Similar results were reported by Hanif *et al* (5) who found an increase of wheat yield by 267 kg to a total of 1958 kg/ha with precision land levelling. According to Ali, Clyma and Ashraf (1) the primary benefits of levelling in Pakistan are mainly related to saving in irrigation water and improved yeilds. Similarly, in this study the promising savings obtained in irrigation water and increase in yield were mainly due to precision levelling whereby unnecessary ridges and ditches were removed and the high and low spots were levelled off. This resulted in a smooth and plain land surface and the breaking of tillage pan. By obtaining such better conditions for proper irrigation application, efficient use of fertilizers, effective use of farm implements and machinery, a uniform stand of crop was ensured with significant increase in yield. Moreover, the flow of water to adjacent field was controlled and other field operations before and after planting were conveniently applied.

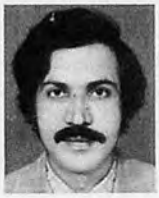
Conclusion and Recommendation

On the basis of these findings, it could be safely concluded that levelling is not any more a controversial issue in that it has no adverse effects on soil fertility and productivity. It is one of the most useful and beneficial operations if applied on deep alluvial and homogenised soils. It is recommended that extra inorganic fertilizers along with adequate organic manures must be applied to counter balance the adverse effects on the cut portions.

REFERENCES

1. 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.
2. 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: and Tech. Univ: Oct: 13-17-1975.
3. Cox, P.M. and Alam, M.M. Precision land levelling and its effects on Soil Fertility and Productivity., p.4, 1977.
4. Cox., P.M. Precision Land Levelling in Pakistan, SCS Team Lahore, PLLP Lahore P-2
5. 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, p-12, 22, 1976.
6. Twitty, K. and Kaulvik, P. Guide for Precision Land Levelling in Pakistan, USAID, Islamabad 1975. ■■

Contribution of Ground Water in the Evapo-Transpiration Demand of Soybean (Glycine Max. L.)



by
K.M. Hassanuzzaman
Lecturer, Irrigation and
Water Management Department
Bangladesh Agricultural University
Mymensingh, Bangladesh

S.M. Rahman
Senior Scientific Officer
Institute of Nuclear Agriculture
P.O. Box 4, Mymensingh, Bangladesh

M.R. Biswas
Professor, Irrigation and
Water Management Department
Bangladesh Agricultural University
Mymensingh, Bangladesh

Abstract

A drum-culture experiment was conducted in the Brahmaputra flood-plain soil of Bangladesh to estimate the contribution of groundwater in the evapo-transpiration demand of soybean crop. Soil moisture depletion studies were made in bottomed and bottomless drums which were sunk in the field at different depths. Results show that the seasonal consumptive use of water (evapo-transpiration) by soybean varied from 63 to 70 cm in the lysimeters (drums) during the growing season (February to May). The contribution of groundwater in the total consumptive use by soybean varied from 0.76 to 34.50% and decreased with an increase in distance of the lysimeters from the water table. The water-table in the experimental field fluctuated between 120 and 230 cm.

Introduction

Usually crop yields are significantly increased due to application of irrigation water in areas where there is little or no rainfall but not necessarily for soils with shallow water table depths. Habibullah *et al* (1979) reported that wheat yields in the Brahmaputra flood-plain soils were not increased by the application of irrigation water because of the existence of a shallow water-table in the area. Misra *et al* (1969), Modgal *et al* (1969), Sharma and Singh (1971) also found that crops responded little to irrigation mainly because of the shallow water-table existing in the experimental area. Crops require irrigation water only when their needs exceed the rate of replenishment of sub-soil either from precipitation or groundwater. In the case of soils with shallow water-table, plants can extract soil moisture directly from the zone of capillary fringe thus meeting their evapo-transpiration demand. Assessment of groundwater contribution in the evapo-transpiration demand of crops will thus help in making a sound irrigation planning for any locality.

In consideration of the facts stated above, the present investigation was initiated with the following objectives: (i) to assess the magnitude of groundwater contribution, if any, in meeting the water needs of soybean and (ii) to find out the variations of groundwater contribution with different depths of water-table.

Table 1 Climatological Data in the Study Area (Growing Season) 1980

Month	Pan evap.* (mm)	Precipitation* (mm)	Duration of sunshine* (h)	Air temp.** (°C) max.	min.	mean	Air Pressure** (mbs)	Relative humidity** (%)	Wind speed** (mph)
January	82.7	2.0	265.3	24.93	11.62	18.27	1 012.9	74.83	2.12
February	96.0	11.0	231.7	26.74	14.02	20.38	1 011.4	70.14	3.48
March	158.9	16.5	216.3	31.01	19.35	25.18	1 008.5	70.29	4.27
April	201.5	83.5	228.6	34.55	23.43	28.99	1 004.4	72.47	8.25
May	214.9	723.5	195.0	30.15	22.17	26.16	1 003.3	84.13	8.57
June	156.7	310.5	176.2	31.45	26.22	28.83	1 000.2	86.90	6.82

* Monthly total; ** Monthly average.

Table 2 Consumptive Use of Water (evapo-transpiration) for Different Treatments

Treatment		Irrigation applied (cm)	Effective rainfall (cm)	Stored soil moisture use (cm)	Seasonal consumptive use (evapo-transpiration) (cm)	Groundwater contribution (cm)
T_0	B*	41.79	12.95	8.68	63.42	
	BL*	27.36	12.95	1.23	41.54†	21.88(34.50)**
T_1	B	41.07	12.95	9.16	63.18	
	BL	30.55	12.95	4.78	48.28†	14.90(23.60)
T_2	B	40.28	12.95	10.58	63.81	
	BL	36.00	12.95	6.04	54.99†	8.82(13.84)
T_3	B	43.13	12.95	13.71	69.79	
	BL	49.56	12.95	6.75	69.26†	0.53(0.76)

* B = Bottomed drums, BL = Bottomless drums; ** Figures in parethesis indicate the percentage of contribution from groundwater in the seasonal consumptive use; † does not indicate the actual consumptive use as the effect of water-table is confounded.

Materials and Methods

In order to determine the contribution of groundwater-table, a drum culture experiment was conducted with soybean (glycine max. L., CV-Bragg-74) crop in the Bangladesh Agricultural University Farm, Mymensingh. The flood plain sandy loam was developed from the Brahmaputra river alluvium. The pH of the soil was 6.3. The field capacity and bulk density values of the field soil at 0-15 and 15-30 cm depth were 26.5 and 35.4% by volume and 1.40 and 1.32 g/cm^{-3}, respectively. The experimental design was split-plot one with 4 main-plot treatments such as drums (0.9 m deep with diameter of 0.6 m) sunk in soil (i) up to ground level (ii) keeping 20 cm (iii) 40 cm and (iv) 60 cm above ground level and designated as T_0, T_1, T_2 and T_3 respectively. The sub-plot treatments were (i) drums with bottom and (ii) drums without bottom and designated as B and BL, respectively. The drums were sunk in a 30 m x 20 m plot and were filled with the soil earlier removed according to stratification. Sufficient time was allowed to stabilise the soil in the drums. Since it was not practically possible to vary the water-table depth under field conditions, the drums were placed at different elevations according to the treatments and the surroundings were covered with soils to maintain a natural condition. In each of the drums, an aluminium access tube was placed at the centre to monitor soil moisture content at various depths from time to time with the help of a neutron moisture meter. The bottomed drums were provided with auxiliary pipes to expel water deposited at the bottom. Here the applied water, rainfall and the stored soil moisture were the sources of water and there was no contribution from the groundwater. In bottomless drums, there was no barrier for upward movement of water from water-table to the root zone, wherefrom the plants could meet a portion of the water demand. The entire experimental area was cropped with soybean according to normal practices and was supplied with water as and when necessary. The number of plants after germination were kept at 20/drum.

In both the bottomed and bottomless drums, the plants were grown in identical conditions and it was presumed that the total evapo-transpiration in both the cases was similar. As a result, the amount of irrigation water in the bottomed drums was greater. The difference of the sum of irrigation water, effective rainfall and stored soil moisture use between the bottomed and bottomless drums represents the amount of water contributed by the water-table.

Irrigation was applied to all the drums when there was 40% of depletion from field capacity level of the upper 60 cm soil. The soil moisture content in the drums were measured from time to time with a neutron moisture meter. All climatological data were recorded (**Table 1**) and fluctuations in the water-table were recorded from observation holes. The plants were harvested at maturity and yields of grain, straw and total dry matter were recorded. Statistical analyses were done following LSD test.

Results and Discussion

The effects of different treatments on the consumptive use of water (evapo-transpiration) by soybean under bottomed and bottomless conditions is presented in **Table 2**. Plants grown in bottomed drums depleted more soil moisture in all the treatments than those grown in bottomless drums. The moisture depletion, however, gradually decreased in bottomless drums with the depth of the drums sunk in the soil. In other words, the contribution from ground water varied with the distance of the drums from the water-table, the highest being in treatment T_0 (34.5%) and the lowest being in T_3 (0.76%).

Irrigation requirement in bottomed drums was greater and almost similar in all the mainplot treatments, compared to that of the bottomless drums which were less and increased with the depth of the drums sunk in the soil. This has a direct relationship with the stored soil moisture use. More soil moisture was used from the bottomed drums, whereas the bottomless drums met its requirement from the ground water.

There was no significant difference in the grain, straw and total dry matter yields of soybean in the bottomed and bottomless drums (**Table 3**) and this is what is expected to produce identical yields under these two sets of conditions. But treatment differences were observed in respect of straw and total dry matter yields with the depth of drums. The highest quantity of dry matter was produced in treatment T_0 which was significantly different from other treatments.

Although the yields in bottomed and bottomless drums were not comparable, the measured values of consumptive use (evapo-transpiration) was significantly higher in bottomed drums than the bottomless ones thus indicating the contribution of water table in the evapo-transpiration demand of the soybean crop.

The upward movement of water through capillary fringe of the soil profile and rooting depth are the main factors in considering water-table as a source of crop water use. The seasonal consumptive use by soybean in this study ranged between 63 and 70 cm and the amount of ground water contribution decreased with the increase in the distance of water-table from the drums. The depth of water-table from soil surface in the experimental field varied from 160 cm in the mid-February, then went down to the extent of 230 cm in April and again went up to 130 cm in late May (**Fig. 1**). Monthly rainfall during February and March were also smaller (**Table 1**). Therefore, it is quite likely that the soybean roots in the bottom-

Table 3 Yields of Grain, Straw and Total Dry Matter of Soybean Crop

Treatment		Grain yield g/drum	Straw yield g/drum	Total dry matter yield g/drum
T_0	B	58.7	92.3	151.0
	BL	66.1	94.7	160.8
	Mean	62.4	93.5	155.9
T_1	B	51.3	70.3	121.5
	BL	55.76	71.2	126.9
	Mean	53.5	70.7	124.2
T_2	B	50.2	67.9	118.1
	BL	50.3	74.8	125.1
	Mean	50.3	71.4	121.6
T_3	B	48.3	68.1	116.4
	BL	51.1	67.2	118.3
	Mean	49.7	67.7	117.4
LSD .05 for main plot		NS	19.2	28.2
for sub-plot		NS	NS	NS

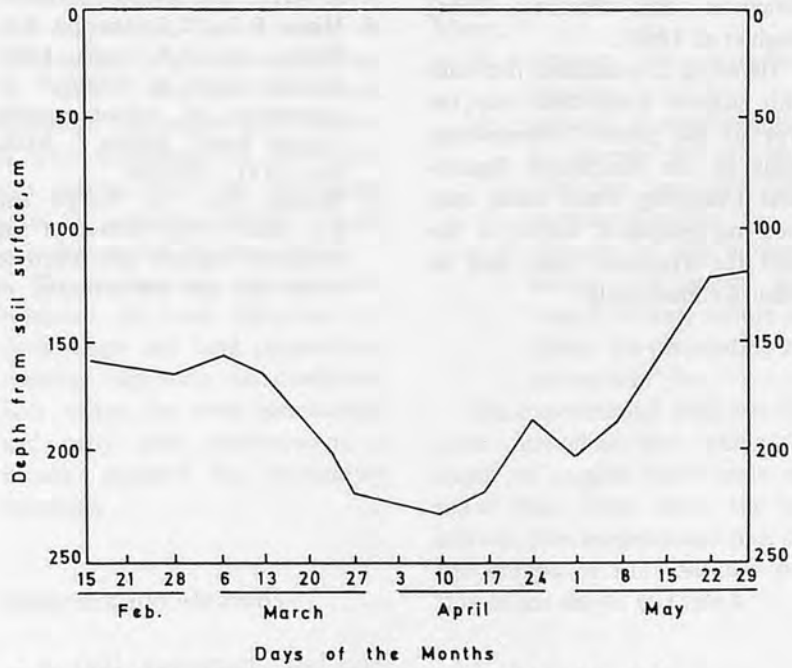


Fig. 1 Weekly fluctuation of water table during experimental period

less drums penetrated deeper in search of water and met their water requirements from the capillary fringe of the soil. This proves that the water-table holds a great promise for reducing the irrigation requirement of the crop. There are reports that 40-70% of the total water requirement were supplemented from a water-table of a depth of 100 to 300 cm (Purvis, 1964). In India also, it was observed that irrigations were of no advantage for wheat because of the presence of water-table at shallower depth (Lal and Sharma, 1974; Nalamwar and Dastane, 1968; Singh *et al.* 1969).

Hence, it is concluded that soils with shallow water-table like the type of the present experimental fields in the Bangladesh Agricultural University Farm either may need no irrigation water or the need for irrigation water may be reduced considerably.

REFERENCES

1. Habibullah, A.K.M., S.M. Rahman, M. Enayetullah, D.H. Sikdar, M.R. Biswas and M. Idris, 1979. Determination of irrigation water and fertilizer phosphorus requirements of wheat in Bangladesh using tracer techniques. Isotopes and radiation in research on soil plant relationships. IAEA-SM-235/3: 235-246.
2. Lal, Pyare and K.C. Sharma, 1974. Contribution of groundwater in the evapo-transpiration demand of wheat crop. Indian J. Agric. Sci. 44(10): 635-639.
3. Misra, R.D., K.C. Sharma, B.C. Wright and V.P. Singh, 1969. Critical stages in irrigation requirement of wheat variety 'Lerma Rojo'. Indian J. Agric. Sci. 39(9): 898-906.
4. Modgal. S.C., A. Joseph and S.S. Goel 1968. Effect of soil moisture regimes and nitrogen levels on the performance of Indian and Mexican wheats under Tarai conditions of UP. Proc. Symp. Wat. Managt., Udaipur 118: 26.
5. Nalamwar, R.V. and N.G. Dastane, 1968. Cultural practices for crop production under soil salinity-cum-high water-table conditions. Proc. Symp. Wat. Managt., Udaipur: 251-60.
6. Purvis, E.R. 1964. Crop production on high water-table soils of the New Jersey Pine barrens. Bull. 806. N.J. Agric. Exp. St. p.115.
7. Sharma, K.C. and M. Singh 1971. Optimum time of first irrigation for dwarf wheats in tarai soils with high water-table. Indian J. Agron. 16: 271-5.
8. Singh, K.N., S.S. Bains and K.N. Agarwal, 1969. Fertilizer use under saline-cum-high water-table conditions. Indian J. Agron. 14: 26-30. ■■

Effect of Preplanting Irrigation on Cotton Cultivation

by
Md. Motiur Rahman Khan
Assistant Professor
Department of Irrigation and Water Management
Bangladesh Agricultural University
Mymensingh, Bangladesh

Abstract

Adequate amount of soil moisture is one of the vital factors necessary for proper germination, growth and yield of cotton. This paper discusses the effect of preplanting irrigation on germination and yield of cotton. The field experiment results show that the preplanting irrigation two weeks after sowing cotton seeds causes a germination of 71.9% compared with no preplanting irrigation of 8.5%. The preplanting irrigation also increased the yield of cotton by 3.5% more than that of without preplanting irrigation.

Introduction

The development of the cotton plant is rapid in the early period, hence the soil should be wetted to a sufficient depth before sowing the cotton seeds either by rainfall or by preplanting irrigation. Burnett and Fisher (1954) demonstrated in Texas the importance of an adequate preplanting irrigation. Yields were in proportion to the wetted depth of soil at planting in the lower Rio Grande valley, Texas. Gerand et. al. (1964) found that satisfactory yields on Willacy loam with a preplanting irrigation were obtained about 30 days after the appearance of first bloom. However, the usefulness of this practice depends on soil conditions and climatic factors, including the amount of rainfall and frequencies. The advantage of preplanting irrigation was shown by Nable (1954) in Queensland, Australia. The preplanting irrigation is also important for favourable salt balance since the infiltration rate is generally highest during irrigation shown by Erie (1963).

The preplanting irrigation consolidated the soil disturbed by deep tillage and land preparation, thereby improving the condition. Soil water for seed germination and early plant development is usually supplied by preplanting irrigation.

Materials and Methods

A field experiment was conducted in Tashkent, USSR with Tashkent - 1 Variety of cotton during the vegetation growth period of cotton to predict the effect of preplanting irrigation. The quantity of preplanting irrigation was determined by the formula of Kostiakov (1960).

$M_p = (M-n)\ m^3/ha$

Where,

M_p = Amount of preplanting irrigation in m^3/ha

M = Amount of water required to saturate the soil layer (100 cm) upto the field capacity in m^3/ha

n = Amount of soil moisture within the active root zone (100 cm) before applying the preplanting irrigation in m^3/ha

The experimental field was clay loam non-saline soil where the depth of ground water table was more than 10 m from the soil surface. For experimental purpose, the groups of soil moisture considered are shown in **Table 1**.

Results and Discussion

The effect of preplanting irrigation was determined during two vegetative growing seasons of cotton. The value of capacity and

Table 1 Soil Moisture Levels at Different Stages of Growth of Cotton Plant

Type of Group, T	Soil moisture of field capacity		
	Pre-flowering and bloom stage	Flowering and formation of cotton boll	Post-bolling stage
Preplanting irrigation, T_1	70%	70%	60%
Without preplanting irrigation, T_2	70%	70%	60%

specific gravity of the experimental plot were determined and shown in **Table 2**.

To predict the effect of preplanting irrigation on cotton cultivation, two experimental treatments were performed, one with preplanting irrigation, T_1 and other without preplanting irrigation, T_2. All other applications such as irrigation water, fertilizer, etc were kept constant. In both years, cotton seeds were sown on 21st April. Three days before sowing the cotton seeds, preplanting irrigation was applied in the treatment plot T_1 by furrow irrigation method. The soil samples from both the treatment plots T_1 and T_2 were collected just before sowing the cotton seeds. Soil moisture contents are shown in **Table 3**.

During the vegetative growth of the plants in 1975 the amount of rainfall was 275 mm before sowing cotton seeds and after sowing cotton there was almost no (6 mm) rainfall. Observations on the cotton plant germination are shown in **Fig. 1**. After 14 days of sowing the cotton seeds showed 72% of germination in the treatment plots T_1 compared with 8.5% in the treatment plot T_2. Due to lack of sufficient soil moisture in the latter treatment there was almost no germination. To increase the soil moisture in the treatment plot T_2, necessary for germination, 1 200 m^3/ha water was applied through furrow irrigation method. After increasing the soil moisture level in treatment T_2, the germination of cotton plants started and about 50% germinated (**Fig. 1**) within 12 days after application of water. Without depending upon the natural rainfall, it is better to apply preplanting irrigation to increase the soil moisture level so that proper germination can take place.

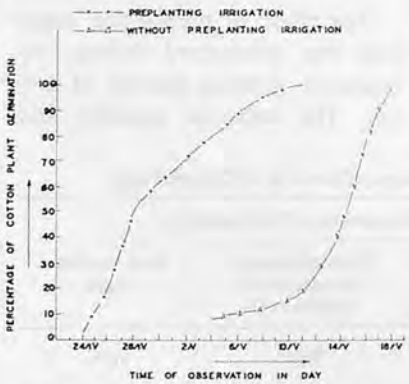


Fig. 1. Germination of cotton plants with and without preplanting irrigation

The quantity of irrigation and yield of cotton are shown in **Table 4**. The yield of cotton was almost similar for both treatments. This was possibly due to the application of irrigation water for germination in treatment T_2. But throughout the vegetative period an additional amount of 12.8% water was required for treatment T_2.

Table 2 Value of Field Capacity and Specific Gravity within the Horizontal Soil Layer

Depth of horizontal soil layer in cm	Field capcity in percentage of volume	Specific gravity in g/cm^3
0-50	21.8	1.38
0-70	21.7	1.41
0-100	21.6	1.44
0-150	20.7	1.48

Table 3 Percent Soil Moisture Content before Sowing Cotton Seeds

Horizontal layer (cm)	Preplanting irrigation	Wihtout preplanting irrigation	Preplanting irrigation	Without preplanting irrigation
	1975		1976	
0-20	19.1	17.4	19.0	17.6
20-50	20.4	18.7	20.3	20.2
50-70	19.3	18.5	19.0	19.1
70-100	19.8	18.5	19.2	20.0
0-100	19.3	18.4	19.4	19.1

Table 4 Quantity of Irrigation and Yield of Cotton

Treatment T	Quantity of preplanting irrigation water (m^3/ha)		Quantity of irrigation water (m^3/ha)		Average yield of cotton (kg/ha)	
	1975	1976	1975	1976	1975	1976
Preplanting irrigation water, T_1	1 300	1 260	7 223	6 736	4 980	4 860
Without preplanting irrigation water, T_2	–	–	8 284	6 760	4 930	4 700

Conclusions

1. For proper germination of cotton plants, preplanting irrigation is very helpful if there is insufficient moisture in the soil.
2. Preplanting irrigation reduces the total amount of irrigation water throughout the vegetative growth period.
3. Preplanting irrigation also increases the yield of cotton and reduces the vegetative growth period.

REFERENCES

1. Bunnett, E., and C.E. Fisher 1954. Correlation of soil moisture and cotton yields. Soil Sec. Amen, Proc. 18: p.216-218.
2. Erie, L.J. 1963. Irrigation Management for optimum cotton production cotton Gin and oil plill press 64: p.30-72.
3. Genard, C.J., C.A. Burleson, W.R. Cowley, L.N. Namkem, and M.E. Bloodworth. April, 1964. Cotton irrigation in the lower Rio Grande Valley. Texas Agri. Exp. Sta. Bull. B-1014. 15 p.
4. Kostiakov, A.N. Principles of Melioracia, 1960 Moscow. (in Russian Language)
5. Negel, A. 1954. Irrigation practice for cotton production in Queensland Agri. J. 79: p.198. ■■

Mechanization of Oil Palm Fruits Harvesting and Transportation in Malaysia

by
M. Zohadie Bardaie
Faculty of Agricultural Engineering
Universiti Pertanian Malaysia
Serdang, Selangor, Malaysia

Wan Ishak Wan Ismail
Faculty of Agricultural Engineering
Universiti Pertanian Malaysia
Serdang, Selangor, Malaysia

Introduction

Malaysia is the world principal producer of palm oil. In 1981, it produced 2.7 million t of palm oil, and it is estimated that the production in 1982 will increase to 2.9 million t. The total area planted to oil palm throughout the country in 1981 was about 992,000 ha (Anon, 1982).

One major problem currently faced by the palm oil industry is the unavailability of adequate labor supply for the handling of heavy and strenuous tasks such as the harvesting of fresh fruit bunches on oil palm plantations. This problem is caused mainly by the migration of labor to urban areas. This labor shortage has caused the plantation sector to lose a lot of money. According to a survey conducted by the United Planting Association of Malaysia (Upam) in 1980, the crop losses were 170,000 t. The report said that based on the December 1980 prices, the losses suffered by the plantations amounted to $54 million (Anon, 1981).

Mechanization

Much of this labor shortage can be alleviated by increasing the productivity of labor through mechanization. Mechanization can increase the productivity of labor significantly as evidenced from the experience in the Western countries. In the United States, it was estimated that the productivity of a man working in a mechanized harvest of fruits and vegetables is approximately ten times that of a man working in a hand harvest (Barnes, 1966). This increased in labor productivity will drastically reduce the labor requirement in the oil palm plantation and thus alleviate the current labor shortage. Mechanization will also improve the working conditions in the plantation by alleviating the physical burden of some of the operations.

In working towards the above mentioned situation, the Department of Power and Machinery at the Universiti Pertanian Malaysia initiated a project on the mechanization of oil palm fruits harvesting and transportation. The harvesting and transportation process was studied and a machine was devised to assist in its operation.

Harvesting and Transport of Fruits

The aims of harvesting routine can be listed as follows.

a) To obtain the maximum amount of crop available in the harvested area.
b) To avoid any wastage of fruit in cutting, collection and transportation routine.
c) To get the highest possible oil content in bunch associated with the lowest possible acidity.

Oil palms in Malaysia commence to develop fruit bunches about 30-50 months after planting. Fruit bunches are usually ripe for harvesting within a period of 5½ to 6½ months from date of pollination. Ripening takes place throughout the calendar year but the rate of cropping fluctuates, and peak months may give up to 15% of a total year's fruit harvest, while slack months may yield only 5 to 6% of a total year's fruit harvest. One of the principal features in the ripening of the fruit is the gradual change in color. In the earlier

stages of development, they have a deep purple or violet color, which verges on black. Above 50 days before attaining a stage when loose fruits begin to fall off fruit bunches, the color gradually changes to orange-red, with the apex of the fruit always retaining its dark color. When ripe, the parts of the fruits pressed close together in the bunch are of a pale yellow color than the parts exposed to the sunlight.

The real indication of commercial ripeness is when single outside fruits in the crown of the bunch loosen and fall to the ground. Thus, the theoretical ideal system of harvesting would be to collect such loose fruits daily, for at this stage the oil content is at its maximum. However, the feasibility of the theoretical ideal system is defeated by the entirely impracticable aspect of plucking individual ripe fruit from fruit bunches growing well above normal plucking level and of covering all planted area within a day.

Current Practice

The current practical method of harvesting is to cut the bunches which show some loose fruits on the ground. Cutting these bunches is done on an interval of between 5 to 15 days.

Cutting – The detachment of the ripe fruit bunch is done by means of a picking knife tied to a picking bamboo when tall palms are involved. For young palms, the cutting is done by means of a narrow-headed chisel. In the cutting process, the bunch is allowed to drop on the ground, before it is collected to be transported to a collection center. For tall palms, there will usually be a considerable scattering of loose fruits as the bunch drops on the ground.

Collection and transportation – The transportation of fruit bunches from field to factory is either by means of road or by means of light railway track. The collection of fruit bunches to the main transportation lane is carried out either manually or mechanically by means of tractor and trailer, or by means of bullock-drawn carts.

Machine for Collection

The harvesting and transportation process can be made more efficient by having a machine which can collect the bunch directly after cutting without letting it fall on the ground. This will eliminate the process of collecting the bunch and loose fruits manually. Furthermore, it will eliminate the problem of loose fruits being scattered on impact on the ground. This will result in more efficient fruit collection and also making the work less arduous to the harvesting team.

Based on this principle, a machine was developed for this purpose, which could go under the palm to collect the bunch directly. The machine was developed by modifying a dump-truck to suit the condition in the plantation as well as developing a collection unit to serve the above mentioned purpose.

Design of Machine

The dump-truck was selected for the purpose due to the following reasons:

1) A relatively low initial cost because this vehicle is produced in quantity for a wide range of industrial purposes.
2) It is highly manoeuvrable because of the rear wheel steering and short wheel base.
3) Front and side loading facilitate the picking up of bunches lying in the pathway of the vehicles.
4) Front unloading allows easy tipping from a single ramp.
5) It is extremely robust.
6) Traction is good because the driven front wheel bears the major load.
7) Powered by adequately-sized engine making for reliability and economy.
8) Good traction and moderate vehicle weight would minimise soil damage under difficult conditions.

Fig. 1 shows the initial configuration and dimensions of the dump-truck. Modifications were made on the machine to facilitate better traction and direct reception of oil-palm bunch as it falls from the tree. **Fig. 2** shows the design modification made. The design and construction was based upon utility, cost and also operator-dumper relationship. Modifications were made on three major sections of the dump-truck, namely, the hopper for collection, the operator space for safety and driving wheels for better traction.

The hopper was constructed based on the area of catch and the payload. The extensions were constructed at 30° vertically for the sides and front of the hopper. The sides extension were made of 3.2 mm mild steel whereas the front and back components were constructed using wire mesh, to provide good visibility for the operator. The dimensions for the modified dumper are given in **Fig. 2**. A channel-shaped section was cut at the top front extension of the hopper to allow the dumper to be placed as near as possible to the palm. The size cut was based on the largest diameter of the palm.

For the safety of the operator, a canopy was constructed. The roof was constructed out of hard steel whereas the front and back sections were of wire mesh. For better traction, dual tyres were fixed at the driving wheels. The

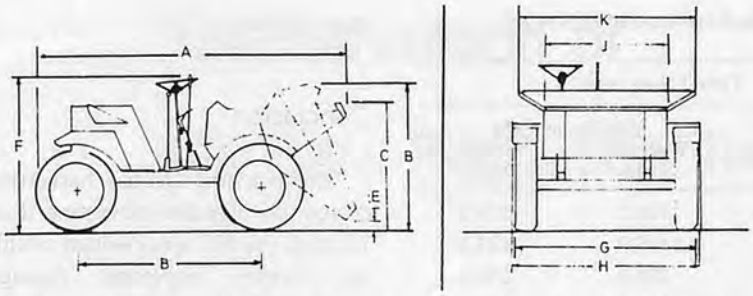


Fig. 1 Original configuration and dimensions of the dump truck (unit: mm). A – 2 740, B – 1 600, C – 1 130, D – 1 270, E – 60, F – 1 400, G – 1 460, H – 1 520, J – 1 000, K – 1 460

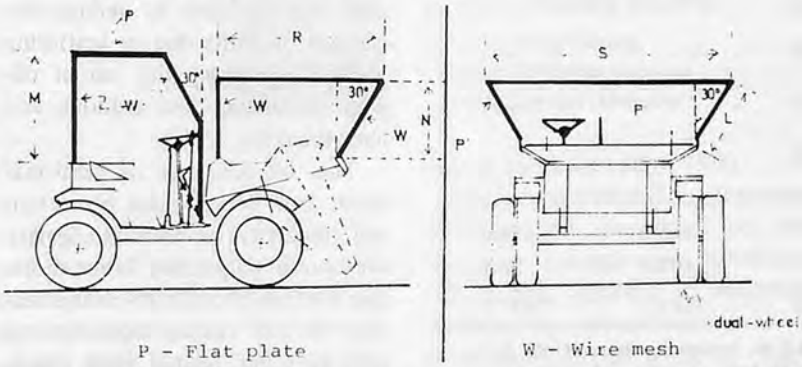


Fig. 2 Configuration and dimensions after modification (unit: mm). L – 620, M – 1 200, N – 580, R – 1 400, S – 1 950

Fig. 3. Front-view of the machine

Fig. 4 Side-view of the machine

Fig. 5 Getting the machine into position under the palm

Fig. 6 Cutting the bunch and letting it fall directly into the collector

extension for the dual tyres was locally designed. Figs. 3 and 4 show the photographs of the machine after modifications.

Performance of Machine

Tests were made to evaluate the performance of the machine (Fig. 5 and 6). Technically, the machine works very well in doing the job it was designed to do. A time and motion study was also made to compare the performance of the machine against that of manual operations. The results obtained are shown in Table 1. As can be seen from the table, the total time taken for manual harvesting was 7 641 sec (2.12 h), whereas the machine-assisted harvesting took 3 281 sec. (0.91 h). This is already a saving of 57% on the total time taken. Furthermore, for the machine-assisted case, there was an idling time of 1 750 sec. This idling time was spent waiting for the cutter to move from one palm to the next and cutting the fronds. This idling time could be reduced by having another cutter who could cut and remove the fronds in advance. This will not increase the total number of workers as compared to the manual harvesting, since the present manual harvesting team is made up of three persons, whereas the machine-assisted team is only made up of the cutter and the machine driver.

Machine manoeuvering and the time taken by the machine to move from one palm to the next constitute 22.2% of the total operation time. Couple with idling time, they constitute a major percentage of losses in time for the operation. The authors felt

Table 1 Time and Motion Study for Manual vs Machine-Assisted Harvesting of Oil Palm

Operations	Time Taken (sec)		
	Manual	Machine-assisted	
		Without chains	With chains
Cutting of fronds	529.3	529.3	529.3
Cutting of bunches	1286.0	1445.0	1445.0
Removing the fronds	230.0	230.0	230.0
Moving to the next palm	349.0	349.0	349.0
Collecting loose fruits	2150.0	–	–
Collecting cut-bunches	371.5	–	–
Moving to the next palm	160.0	–	–
Loading of bunches and loose fruits	280.0	–	–
Carrying of bunches to field collection point	1187.0	–	–
Unloading of fruits at field collection point	115.0	–	–
Moving from palm to palm empty	983.0	–	–
Machine manoeuvering		266.0	184.0
Moving to the next palm		462.0	96.4
Total	7640.8	3281.3	2827.7

Palm age, 16 years; palm height, 7.5 to 9.0 m; harvesting interval, 30 days; number of bunches harvested, 20; harvesting area, 2 rows (32 palms/row); terrain, 15% to 20% slope.

Table 2 Man-Hour Comparison between Manual and Machine-Assisted Harvesting

Item	Manual	Machine-assisted	
		Without chains	With chains
Worker for cutting	1	1	1
Worker for collection	1	–	–
Worker for infield transportation	1	–	–
Machine-operator	–	1	1
Time taken for cutting (h/ha)	1.5	1.6	1.6
Time taken for collection (h/ha)	2.0	0.5	0.2
Time taken for infield transportation (h/ha).	1.6		
Man-hour/ha for operation	15.3	4.2	3.6

that improvement on the traction device should be incorporated to the machine to reduce the time loss. Thus, traction-aid chains were installed on the dual tyres of the driving wheel. Results of the test using these chains are also shown in **Table 1**. As can be seen from the table, the total time taken by the machine with traction aid is 2 828 sec (0.79 h). This is a saving of 63.0% on the total time taken as compared with manual harvesting, and 14% improvement from the machine-assisted harvesting without the chains. These manoeuvering and idling time could be reduced further through practice and good coordination between the harvester and the machine operator.

To compare on man-hour basis between the two harvesting systems, **Table 2** shows the computation based on per unit area. The man-hour required per ha for manual harvesting was 15.3, whereas for machine-assisted harvesting it was only 3.6. This is a 76% saving on the man-hours requirement per ha.

Conclusion

The machine-assisted harvesting system of oil-palm harvesting does increase the efficiency which could be further improved through practice in the handling and coordination of the machine with the cutter. The use of the machine also will be able to reduce the wastage of fruits due to scattering as well as making the job of oil-palm harvesting less arduous and back-breaking.

The introduction of this machine into the oil-palm plantation will hopefully be able to alleviate the current impending labor shortage. Further efforts into mechanization of the cutting operation as well as other related field operations will be continued towards the objectives of mechanizing the whole field operations in oil-palm production.

REFERENCES

1. Anon (1981). "Labour shortage cost estates $54m last year," New Straits Times (Daily), Kuala Lumpur, Malaysia, June 25.
2. Anon (1982). 'Palm oil output expected to rise by 9pc: Porla,' Business Times (Daily), Kuala Lumpur, Malaysia, January 28.
3. Barnes, K.K. (1966). "A factor of ten," Implement and Tractors, November 7. ■■

Mechanization of Oil Palm Plantation Technology

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

Abstract

Two international conferences and two workshops related to the palm oil industry assessed the research work and development efforts done, particularly towards the aspect of mechanisation. The outcome is not encouraging. However, the working papers point towards the current crises of energy, environment and employment so vital to any mechanisation effort. Important inferences are highlighted and due deductions derived and described.

Introduction

The Malaysian oil palm industry is a successful story of the twentieth century. Expansion in area and production continues. The 1981 production level of 3 million t palm-oil is expected to rise to 4 million t by 1985 and 6 million t by 1990. This represents 62% of the world's palm-oil production and accounts for 80% of the total export of palm-oil, hence Malaysia is the world's largest producer and exporter of this commodity. Palm-oil contributes 10% to the country's total export earnings, concerns the livelihood of a quarter million people and involves a total cultivated land area of about 1 million ha at the end of 1980.

Many international conferences, seminars and workshops on the oil palm industry are, therefore, rightly held regularly in Malaysia. A three-day international conference on 'The Oil Palm in Agriculture in the Eighties' covering the topics from breeding to harvesting, transport to mill as well as effluent treatment, utilisation and waste recovery was held during 17 to 19 June 1981 (organised by The Palm Oil Research Institute of Malaysia and The Incorporated Society of Planters) at Kuala Lumpur. Another two-day international conference on "Palm Oil Product Technology in the Eighties" covering processing, quality-control, storage, shipping, refining, fractionation, end-uses, economics and marketing followed soon during 22 to 23 June 1981. It was organised by the same organisers at the same place. A total of 110 papers were presented and only seven were concerned in some way with the mechanization of the oil palm plantation technology.

Energy or fuel is to mechanization what foundation is to a structure. Even though the Workshop on 'Bioconversion for Fuel Production' (organised by and held at the Universiti Pertanian Malaysia, 20 to 24 Oct. 1981) was not for oil palm industry alone; only 2 out 25 papers presented converged on it.

Seventeen technical papers were presented at the 'Workshop on Oil Palm By-Products Utilisation' (organized by Palm Oil Research Institute of Malaysia - PORIM - and Malaysian Oil Palm Growers Council - MOPGC, held in Kuala Lumpur, 14-15 December 1981). Only 17 of them directly or indirectly elaborated on mechanization of palm-oil plantation technology. Land application of digested or treated palm oil mill effluent (POME), a term which is synonymous with POS (Palm Oil Sludge), of Bunch ash and mulching were the only topics for mechanized methods and their feasibility.

Mechanization

The labour shortage on plantations is acute and real. The demands due to energy, environmental requirements and the employment situation mean more mechanization. The present practices cannot cope with present and future conditions, hence increased and innovative mechanization is imperative. As a matter of fact the development and progress of mechanization cannot afford to remain static.

Saxena and Van (1981) have

suggested a simple quadrant system to locate the status of mechanization of the operations in agriculture, in general, and those of palm-oil production, in particular (Fig. 1). The first quadrant represents an operation which is partly mechanized and partly manual (for example, in-field and off the field transportation of ffb); the second quadrant is completely mechanized; the third is neither mechanized nor manual (for example, use of animals in transportation) and the fourth indicates complete manual operations without any mechanization whatsoever (for example, at present, palm fruits harvesting). In the model, harvesting and in-field or off-field transportation is not treated in isolation, but as a part of the overall system of the oil palm processing industry. The problems related to harvesting and transport of oil palm are so important that, in a way, the final quality of the product is mostly dependent on them. The harvesting problems are criterion of ripeness and mechanization of the operation. The in-field and off-field transport is a function of quickness and fastness of collection and transport with the least damage to the fruits.

The in-field and off-field transportation of fresh fruit bunch (ffb) has been tried using cableways in Costa Rica where banana farms were converted into palm-oil plantations. Geesink (1981) suggests that for flat areas, both feeder and main cableways are desirable. However, for hilly areas, only the main that runs along the contour lines is desirable. The feeder cable runs into the planted sections and hauls out the fruit. When connected to the main cableway system, unloading into hoppers is done at recollection centres. Otherwise, the ffb are transferred from feeder cables to trailers or trucks.

The cableways can also be used to transport herbicide and fertilizer into the plantation.

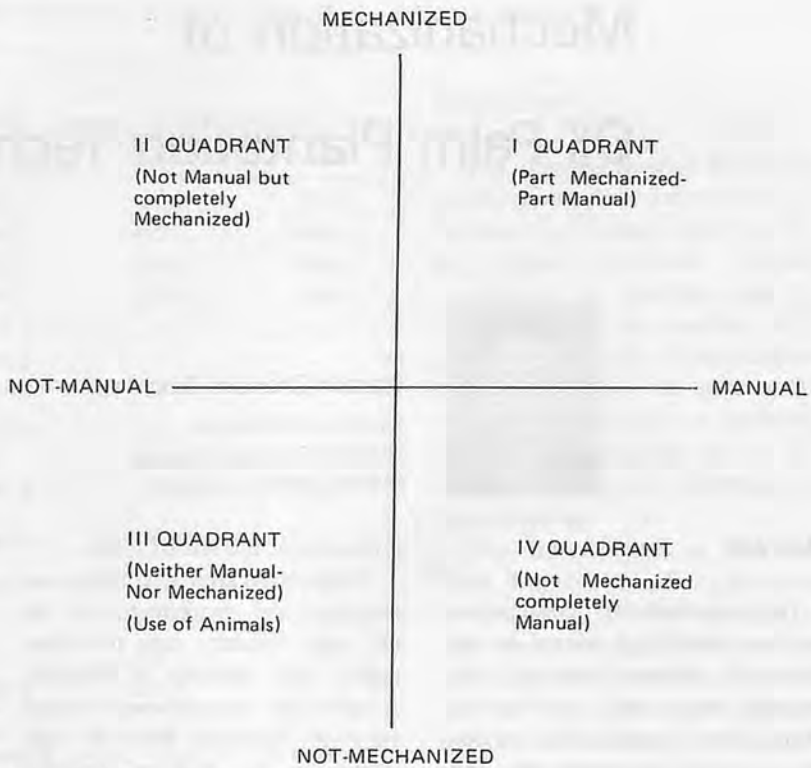


Fig. 1 Quadrant system for agricultural operations

The advantages of the cableway system are: 1) No soil compaction and hence higher production; 2) less investment in tractors, trailers and trucks; 3) less maintenance of roads and bridges; and 4) less fuel consumption. The disadvantages are: higher investment costs and higher labour cost per tonne of ffb.

Aerial applications of fertilizers or top dressing is essential and appropriate under the Federal Land Development Authority of Malaysia (FELDA) due to following conditions:

(i) Increasingly hilly terrain makes even application of fertilizer difficult.

(ii) The complete type of fertilizers are good for single round application of granulated compounds at heavy rates, ideal for aerial use.

(iii) Hilly topography implies difficult road conditions.

(iv) More efficient distribution means reduction in application rates and saving in cost.

Mechanized operation in replanting oil palm is costly and difficult. Several methods are used: (i) poisoning the old stand; (ii) felling by chain saw; (iii) digging out of old stand; and (iv) total elimination, including fragmentation of palms, burning, heaping and burning the residue. The latter method is more practical. McCulloch (1981) recommends the total elimination method requiring a sufficient number of excavators (tracked type) each fitted with bucket with cutting edge and labourers. The method is, however, labour intensive in respect of heaping and burning.

The mechanized system of bunch mulching of oil palms on commercial scale is easier on flat terrain. Singh et al (1981) report improvements in growth and ffb yield by using three systems. In the Seri Pelangi and Nova Scotia systems, a tractor-trailer combination is used to transport the empty bunches to the fields where spreading and levelling is done

manually or by using a spring tine cultivator. In the Jendarata system, especially constructed empty bunch spreaders powered from the tractor PTO are employed for transporting as well as spreading the material. The empty bunches are applied at the rate of 75 to 100 t/ha either in the inter-rows or between palm points. The efficiency depends on the number of trailers (or spreaders) and tractors available, distance of fields (2 to 3 km preferred) from the mill, the turn around time and ffb throughput per hour. The cost is approximately the same for each of the three systems, i.e., US$120.0/ha.

Energy

The current world-wide energy crisis is responsible for developing and utilizing the renewable resources as fuels rather than continued dependence on non-renewable and conventional ones. Vegetable oils have already been under tests for fuels and recent researches have shown that engines can run either on such oils alone or on a predetermined mixture with diesel only or diesel and ethanol or both. Saxena (1981) discusses palm oil as one of the important and competitive possibilities and other elements of oil palm (**Table 1**) like wood, fronds, empty bunches, fibre and shell, and sludge/effluent which are also presently and potentially useful as fuels. Due to increased replanting frequency more firewood would be available earlier and could be completely converted into solid, liquid or gaseous fuel. A large quantity of fronds (approximately 0.75 t/year/ha) exists on plantation sites. They are, at present, agricultural wastes but which can also be converted into useful fuel by gasification. Empty bunches are burnt as such as fuel in the incinerator to produce bunch ash which is very useful as fertilizer. Environmental problems would restrict incineration, the alternative is uneconomical and a costly process of mulching. Fibre and shell are the most established fuels and a palm-oil mill is self-sufficient in fuel and power generation due to them. Palm-oil sludge is bio-degradable anaerobically and produces methane. Palm-oil itself is a potential fuel with or without conversion, mixing or refining.

Table 1 Fuel from Oil Palm

Material	Energy Yield
Wood	not estimated
Fronds @ 5%	= 0.75 ton per year per hectare
One metric ton of ffb gives the following:	
Empty bunches @ 25%	= 250 kg (calorific value 1 600 Btu/lb)
Clarified palmoil @ 21%	= 210 kg
Fibre @ 6%	= 60 kg (calorific value 8 090 Btu/lb)
Shell @ 16%	= 160 kg (calorific value 8 450 Btu/lb)
Kernel @ 4%	= 40 kg
Sludge @ 60% (representative percentage)	= 600 kg
Bunch ash @ 0.5%	= 5 kg (potash content 43%)

Assumption: Approximate average yield of 15 metric tons of ffb per year, per hectare of oil palm plantation

Kam (1981) concentrates on the properties, processing, economics and utilization of oil palm empty fruit bunches (efb) in heating and power generation, which, otherwise are a neglected energy source. The potential energy from empty fruit bunches (@ 0.96 x 10^9 ton/year) in Malaysia is 13.6 x 10^9 MJ per year, equal to 4% of the country's total energy consumption per year. Compared to wood, the efb has lower fixed carbon, higher oxygen and ash. It has 60% moisture content when emerging from the factory. Its wet calorific value is 1 600 Btu/lb (672 k.j/kg) but when bone dry, it is 6 200 Btu/lb. Its very low bulk density (dry) of only 3 lb/cu ft makes transport over reasonable distances uneconomic. The processes to turn efb into viable fuel are, comminution, dehydration (reducing moisture to 10%), densification (compression), transport and pyrolysis/gasification to handle low bulk density cellulosic matter featuring separate chambers for pyrolysis and gasification, compactors and stirrers. Internal gas flows minimize tars and oils in the product gas.

Felling Criterion

The felling of oil palm trees after a predetermined period depends on low or uneconomical yield, age, plantation policies and height of the tree which many times determines that harvesting is difficult or impossible. The tall trees, even if their yield is substantial, and have a life span of up to 60 years, are felled much earlier. A new criterion, based on damage-mechanics, to determine the optimum height of felling, is derived from the data and discussions of Saxena and Ong (1981) and Saxena and Van (1981). It is assumed that the bio-yield point (internal failure in cellular structure) determines the damage limit beyond which enzymatic activity would render the development of ffa (free fatty acids) to be unacceptable by the industry. Taking data from these studies for the seven-year old Tenera variety, average weight of fruitlet, 18.25 g, the bio-yield point is 41.5 kg at the strain rate of 100 mm/min. The energy required

to reach the bio-yield point is measured as the area under the force-deformation curve which is multiplied by a reduction factor of 3 assumed to be due to (i) the bunch falls and the fruitlets are integral part of it, (ii) quasi-static and not impact tests and (iii) variation of surface of impact.

The potential energy and the above measured energy are equated to give $18.25 \times h = (34 \times 10^4 \div 3)$ g-mm or height $h = 6.21$ m.

The oil palm trees, therefore, based on this criterion of damage-mechanics, should be felled when they reach the height of 6.21 m.

It is important to note that these calculations are intended to be the first approximation based on several assumptions.

The severe shortage of labour is also responsible for early replanting because of the difficulties associated with harvesting tall palms. The Dunlop Estates of Malaysia (Annual report for 1980, May 1981), for example, could not adhere to a usual rigid programme of cutting out all oil palms in their 20th year of age and replanting. They would be forced to do it earlier, that is, 18th year or less due to the continued problem of availability of labour in the longer term but subject to the tolerable financial burden of early and frequent replanting. It means more wood would be obtained early when replanting frequency is increased.

Saxena and Ong (1981) determined the quasistatic force-deformation characteristics of oil palm fruitlets under parallel plate compression tests on the Instron machine. The typical curve containing linear limit, rotation points, bio-yield point, rupture point, initial nut loading and nut cracking point together with the density and the derived properties like modulus of elasticity and natural frequency constitute the essential engineering data for design and analysis of the process and the machines. The damage mechanics of the fruits which is an important consideration in mechanisation and quality control, can be explained and understood with such experimental results and discussions.

Effluent Treatment

Palm oil mill effluent (POME) must be treated on a commercial scale so that environmental standards can be met satisfactorily. There should be considerable reduction in BOD, COD, solids, oil and grease and total nitrogen. Ngan et al (1981) surveyed several systems, including ponding, extended aeration after anaerobic digestion, decanter, and a combination of mechanical, chemical and biological systems. The ponding system seems to be the most preferred, economical and practical when suitable land is available.

Tam *et al* (1981) studied several techniques of raw and treated effluent applications on land. They were tractor/tanker application of raw effluent via gravity flow within the field, tractor/tanker application of treated effluent via pump discharge within the field, lorry/tanker application of treated effluent via pump discharge into adjacent areas along the main/field roads, and rail/tanker application of treated effluent via pump discharge into adjacent areas along the railway line. The application rate for treated effluent was calculated at 546 ℓ/palm/year. They had also experimented with bunch ash (utilized as potassic fertilizer and as a soil ameliorant) which had been effectively broadcast in the field using a Vicon Vari-spreader. A Vicon/MF 165 tractor combination could cover between 32.5 to 40.5 ha/10 h day at a cost of US$0.9/ha. Application rates ranged from 600 to 900 kg bunch ash per ha-year.

Chan (1981) reported on the disposal of sludge on land from the anaerobic Mostyn effluent pond. He designed a mobile sprayer because fixed installations lacked flexibility and could encourage the application of high rates too frequently to the limited land area. Mobile spraying from the main road directly on to cut frond heaps would not disrupt field work nor cause nuisance.

Koh and Png (1981) used two types of sprinkler systems, fixed and movable sprayline, for land application of POME. They found the movable one to have less cost, lower rate of application, less pollution and savings in fertilizer cost.

Wood et al (1981) emphasized the use of digested rather than raw POME and recommended the sprinkler-system with movable heads and lateral pipes for low capital cost. This system is well adapted to flat land and the problems include blockages of sprinklers and pipe bursts. Monitoring of streams and ground waters, to ensure that contamination does not occur, was considered an essential part of the system.

Conclusions

The two international conferences and two workshops give the impression that, the mechanization of plantation technology seems to be lagging behind in research and development, as compared to other aspects of oil palm industry. While in some areas mechanization itself is badly needed, for example, highly labour-dependent harvesting, there is yet lot of improvement and further development required, like in the in-field and off-field transportation of ffb.

REFERENCES

1. CHAN, J.S. (1981). 'Mostyn Land Disposal of Anaerobic Sludge by Mobile Sprayer'. Workshop on Oil Palm By-Products Utilization, held 14-15 December 1981, Kuala Lumpur, Malaysia.
2. GEESINK, H.C.O.W. (1981). 'Cableway Transportation in Oil Palm'. International Conference on the Oil Palm in Agriculture in the Eighties, held 17-20 June 1981, at Kuala Lumpur, Malaysia.
3. KAM, E.K. (1981). 'Palm-oil Empty Fruit Bunches: A neglected Energy Source.' Workshop on Bioconversion for fuel production, held 20 to 24 October 1981, at Universiti Pertanian Malaysia.
4. KOH, S.H. and PNG, T.C. (1981). 'Land Application of Digested Palm Oil Mill Effluent by The Sprinkler System'. Workshop on Oil Palm By-Products Utilization, held 14-15 December 1981, Kuala Lumpur, Malaysia.
5. LAMIN, J. (1981). 'Techno-Economic Aspects of Large Scale Oil Palm Planting'. International Conference on the Oil Palm in Agriculture in the Eighties, held 17-20 June 1981, at Kuala Lumpur, Malaysia.
6. McCULLOCH, G.C. (1981). 'A Method of Clearing Old Oil Palms for Replanting.' International Conference on the Oil Palm in Agriculture in the Eighties, held 17-20 June 1981, at Kuala Lumpur, Malaysia.
7. NGAN, M.A.; CHOW, C.S.; JOHN, C.K.; IBRAHIM, A. and ISA, Z. (1981). 'Disposal of Palm Oil Mill Effluent in Malaysia - A Survey'. International Conference on the Oil Palm in Agriculture in the Eighties, held 17-20 June 1981, at Kuala Lumpur, Malaysia.
8. SAXENA, N.C. (1981). 'Fuel from Oil Palm'. Workshop on Bioconversion for Fuel Production, held 20 to 24 October 1981, at University Pertanian Malaysia.
9. SAXENA, N.C. and ONG, K. (1981). 'Quasi-static Force-Deformation Characteristics of Oil Palm Fruitlets'. International Conference on Palm Oil Product Technology in the Eighties, held 22-24 June 1981 at Kuala Lumpur, Malaysia.
10. SAXENA, N.C. and VAN, V.T. (1981). 'Problems Related to Harvesting and Transport of Oil Palm'. International Conference on the Oil Palm in Agriculture in the Eighties, held 17-20 June 1981, at Kuala Lumpur, Malaysia.
11. SINGH, G.; TAN, Y.P. and HO, C.Y. (1981). 'Mechanical System of Bunch Mulching Oil Palms in the Lower Perak District.' Workshop on Oil Palm By-Products Utilization, held 14-15 December 1981, Kuala Lumpur, Malaysia.
12. Tam, T.K.; TAJUDIN, M.H. and YEOW, K.H. (1981). 'Land Application Techniques for oil mill by-products – Effluent and Bunch Ash'. Workshop on Oil Palm By-Products Utilization, held 14-15 December 1981, Kuala Lumpur, Malaysia.
13. WOOD, B.J.; LAI, A.L ; LIM, P. and KANAGARATNAM, J. (1981). 'Application Methods of Digested Palm Oil Mill Effluent in relation to Land Characteristics and Oil Palm Crops'. Workshop on Oil Palm By-Products Utilization, held 14-15 December 1981, Kuala Lumpur, Malaysia. ■■

A Cassava Harvester: Design Analysis and Prototype Development

by
E.U. Odigboh
Professor
Agricultural Engineering Department
Faculty of Engineering, University of Nigeria
Nsukka, Anambra State, Nigeria

S.F. Ahmed
Senior Lecturer
Agricultural Engineering Department
Faculty of Engineering, University of Nigeria
Nsukka, Anambra State, Nigeria

Abstract

The prototype cassava harvester discussed in this paper has a separately powered rotary knife mounted in front of the tractor and designed to cut the cassava stems and clear the above ground vegetation to facilitate the root lifting operation. Behind the tractor is mounted the cassava root lifter which is a reciprocating hoe designed to move under the cassava roots to dig and lift them onto a belt which conveys the roots to a collection box at the rear of the machine. The harvested roots are dumped in heaps at intervals along the row for subsequent collection. Although a single row harvester field tests on the prototype give a net work rate of better than 0.15 ha/h at a speed of 2.5 km/h which is more than 20 men can achieve by hand. The percentages of broken, cut and skinned roots vary somewhat with soil conditions but were less than possible in manual harvesting.

Acknowledgement: Funds for the work described in this paper were provided by the National Committee of Operation Feed the Nation (OFN) which is hereby gratefully acknowledged. The authors also wish to acknowledge the U.N.N Agricultural Engineering Departmental Wrokshop technologists and technicians who fabricated the prototype harvester under the authors' supervision.

Introduction

Need for mechanical cassava harvester

Harvesting cassava by hand is very laborious, tedious and slow. An investigation by the authors shows that, with a combination of such traditional tools as a digger (mbazu in Igbo), a hand hoe and a matchet, a man can harvest cassava at an average rate of 1/100 ha/h. It is not, therefore, surprising that labour costs for harvesting cassava accounted for well over 40% of the total cost of production (Philips, 1970). Yet, harvesting by hand leads to a substantial damage in the form of cuts, bruises or complete breakage of the roots.

There now exist integrated garri processing systems such as the PRODA plant, the Newell Dunford plant and the Fabrico plant which can handle 50-100 t of cassava roots daily. This quantity of roots would be harvested from 7-14 ha at the currently reported Nigerian average yields of 7.5 t/ha. To supply such plants with cassava roots harvested manually would require an army of workers and would represent a major cost factor especially nowadays that agricultural labour is very scarce and very expensive. To complicate the situation further, the large cassava processing plants cannot resort to long-term storage since cassava roots do not store well and must be processed 2-4 days or sooner after harvest or deterioration sets in. Therefore, commercial scale processing of cassava requires mechanized harvesting to supply the roots.

Earlier attempts at mechanized cassava harvesting

Naturally, various attempts have been made, in and outside of Nigeria, to mechanize cassava harvesting. Krochmal (1966) discussed an attempt to use the mould-board plough. Earlier, Bates had proposed the adaptation of the potato digger/lifter and the sugar beet harvester for cassava harvesting (Bates, 1963). Makanjuola et al (1973) had experimented with a mould board ridger and a mould board plough with and without

the board. All these attempts were not quite successful. Wijewarden (1978) is currently trying out various approaches at the International Institute for Tropical Agriculture in Ibadan.

The problems involved in the mechanization of cassava harvesting are many and varied (Odigboh, 1976). Apart from the serious difficulties arising from the random growth patterns of the roots and the equally random branching of the stems, cassava has no specific harvesting season. Therefore, the harvester must be able to work in the parched hard soils of the dry season and the drenched muddy soils of the rainy season as well as in soils of consistency varying between the two extremes. While handling about 0.25 m^3 of soil per metre length of ridge to dig and lift the roots, the harvester must also cut and carefully windrow or otherwise handle the stems which are planting materials for the next crop.

In this paper, the details of the design and development of a single-row cassava harvester are presented.

Design Concept

In current Nigerian cultural practice, especially in commercial-scale plantations, cassava is planted on ridges with both between-row and within-row plant spacings of 0.8-1.0 m. In this case, the cassava is usually harvested at 12-15 months of age when the ridge is 150-200 mm high and about 500 mm wide. At this time, depending on cassava variety, the above-ground stems, branches and leaves are 1.0-1.75 m high and have a mass that may vary from 1 to 6 kg per stand. The roots of mass 0.5-6 kg per plant have a depth of penetration of 150-450 mm, number of roots of 3-8 and radius of root spread of 100-250 mm. It should be noted that with improved/modern technology for cassava culture, it appears that optimum yields are possible at a root/shoot ratio of 3:2 and that lower proportions of shoots adversely affect yields (Cock et al., 1978). Fig. 1 shows a cassava field ready for harvest.

Fig. 1A A cassava plot above ground vegetation intact

Fig. 1B A cassava plot weedy with leaves partially sheded

As may be evident from the introduction, adaptation of existing root/tuber harvesters will not suffice for cassava harvesting. A special harvester must be designed to take into consideration the unique characteristics of the crop. To remove the stems and clear the above-ground vegetation to facilitate the root lifting operation, it is designed to have a separately powered circular knife mounted in front of the tractor to cut the stems while an endless reeling guide is provided to direct and move the cut stems clear of the ridge and the tractor wheels. Behind the tractor is mounted a reciprocating hoe designed to move under the cassava roots to dig and lift them. The reciprocating action of the hoe is intended to make it possible to work under different soil types and conditions, to shake the roots free of soil and to move the roots backwards for collection. Just behind the hoe, a conveyor is installed to take the roots to a pellet box which empties its contents at a predetermined weight of roots so that the harvested roots are dumped in heaps at intervals all along the row for easy collection subsequently.

Design Considerations

Design of cutting angle (α)

The weight of soil and cassava roots handled by the hoe averages 150 to 200 kg/m length of ridge. The hoe has been designed to let through the soil but retain the roots which are moved backwards as the implement moves forward.

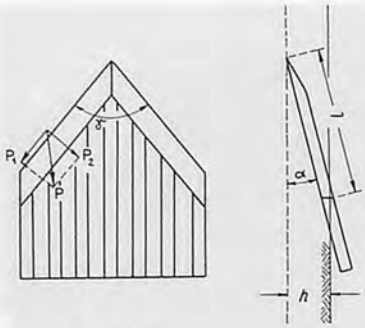


Fig. 2 Hoe shape

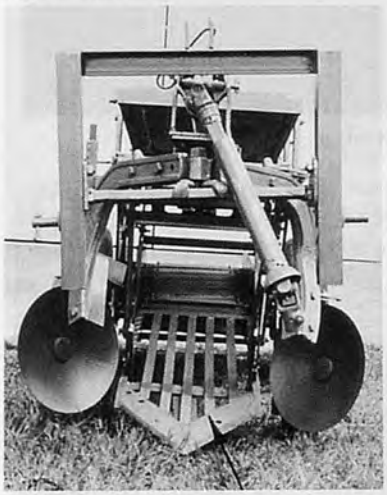


Fig. 3 Reciprocating hoe mounted on the lifter prototype

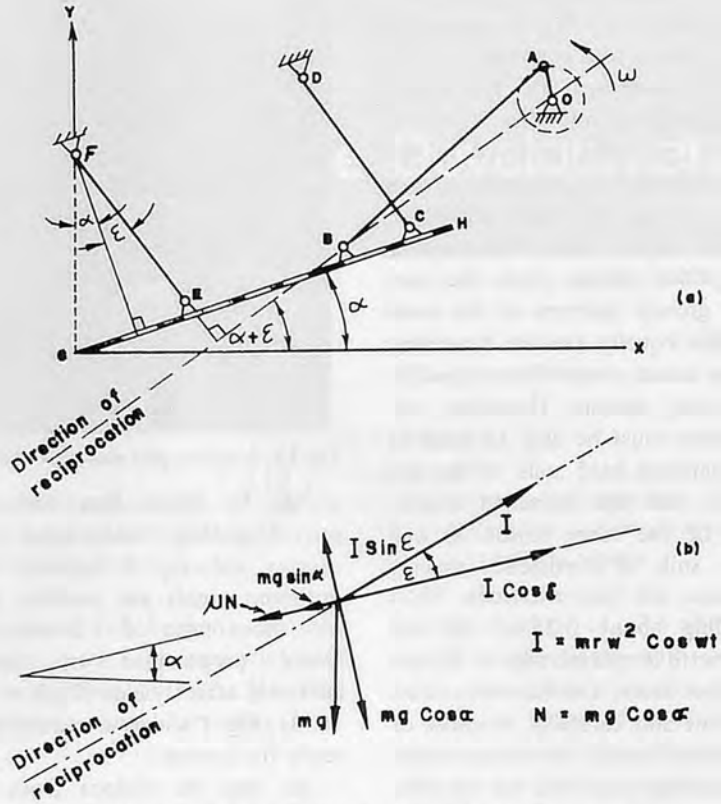


Fig. 4 (a) Mounting arrangement of reciprocating hoe;
(b) Forces acting on a particle in contact with the hoe surface

The shape of the hoe is sketched in Fig. 2. The hoe consists of a V-shaped cutting edge and a body composed of bars as shown in Fig. 3.

Referring to Fig. 2, the depth of cut, h and the length of cut, ℓ co-determine the magnitude of the cutting angle, α thus,

$$\alpha = \sin^{-1} (h/\ell) \quad (1)$$

Angle α should be made small enough to minimize soil resistance and draft. On the other hand, it is known that the higher the value of α the greater the scouring ability of the hoe. In practice, the values of α range from 15 to 25°. In this design, α is taken as 25° in order to achieve the desired scouring and penetration.

Selection of knife angle of hoe (γ)

As shown in Fig. 2, the force P acting on the cutting edge of the hoe may be resolved into two components, namely P_1 tangential and P_2 normal to the cutting edge, such that

$$P_1 = P \cos (\gamma/2) \quad (2a)$$

$$\text{and } P_2 = P \sin (\gamma/2) \quad (2b)$$

For the soil and trash to slide along the knife edge during cutting, P_1 must be greater than the frictional force, or

$$P \cos (\gamma/2) > P \sin (\gamma/2)$$

or in terms of tangent of angle of friction between soil and steel,

$$P \cos (\gamma/2) > P \tan \phi \sin (\gamma/2) \quad (3)$$

$$\text{i.e. } \cot (\gamma/2) > \tan \phi$$

$$\text{or } \gamma/2 < k/2 - \phi \quad (4)$$

Although dependent on soil moisture content, values of tan ϕ range from 0.25 for very light soils to 0.9 for heavey soil (Klenin and Popov, 1970) corresponding to values of ϕ of 14° to 42°. From relation (4) and taking a ϕ value of 40°,

$$\gamma < 100° \quad (5)$$

It is recommended that γ should not be more than 90°. But for a given width of cut, the smaller the value of γ, the longer the length of cut and therefore the greater the frictional resistance (and draft). In this design, γ was chosen at 80° to give the desired width of cut without unduly long cutting edges of the hoe.

Design of reciprocating mechanism

The forces acting on a non-reciprocating soil-cutting tool may be given as

$$\bar{P} = \bar{P}_c + \bar{P}_s \quad (6)$$

Where P_c is the force to overcome soil resistance to cutting, and P_s is force to overcome frictional resistance due to soil sliding on the share or tool surface. For a reciprocating tool, an additional force, P_k may be introduced during the cutting action such that,

$$\bar{P} = \bar{P}_c + \bar{P}_s + \bar{P}_k \quad (7)$$

where P_k is impact resistance due to soil or other materials reposing on tool surface or body during the cutting action.

To reduce draft the value of P should be minimized. Nothing can be done about the contribution to draft from P_c which depends on the soil. But, if there is no soil or other materials on the hoe during the cutting stroke, P_s becomes practically zero which also eliminates P_k so that

$$\bar{P} = \bar{P}_c \qquad (8)$$

The design of the reciprocating mechanism is aimed principally at determining the hoe mounting arrangement and the number of reciprocations per minute to achieve the condition under which materials are thrown off the hoe surface during its soil cutting stroke and thereby achieve the condition expressed in (8) above.

Based on the analysis of the mechanics and motion of shakers, sieves and soil engaging vibratory tools by Klenin and Popov (1970) – ref. Appendix 1 – the mounting arrangement of the reciprocating hoe, sketched in **Fig. 4**, was adopted. The essential features of the arrangement include the following:

i) The hoe, GH is suspended by four equal links represented by EF and CD at angle α of 25° to the horizontal.

ii) The ratio of the crank radius, represented by OA, to the length of the forcing links or pitman AB is 0.026.

iii) The direction of reciprocation, denoted by OB, makes an angle ϵ of 15° with the plane of the hoe.

iv) The ratio of the length of the suspension links, EF or CD to the crank radius is 0.032.

v) The links, EF and CD are at right angles with the direction of reciprocation, OB.

The specifications given in (ii) to (v) above comply with the analysis of Klenin and Popov earlier referred to. The set-up of **Fig. 4** was built and tested, without a translational motion, at different rpm of the crank. For a range of crank rpm of 450 to 560, the following observations were made:

a) During some fraction of the period of the reciprocation cycle when the hoe was moving backwards, soil materials on the hoe surface remained on the hoe.

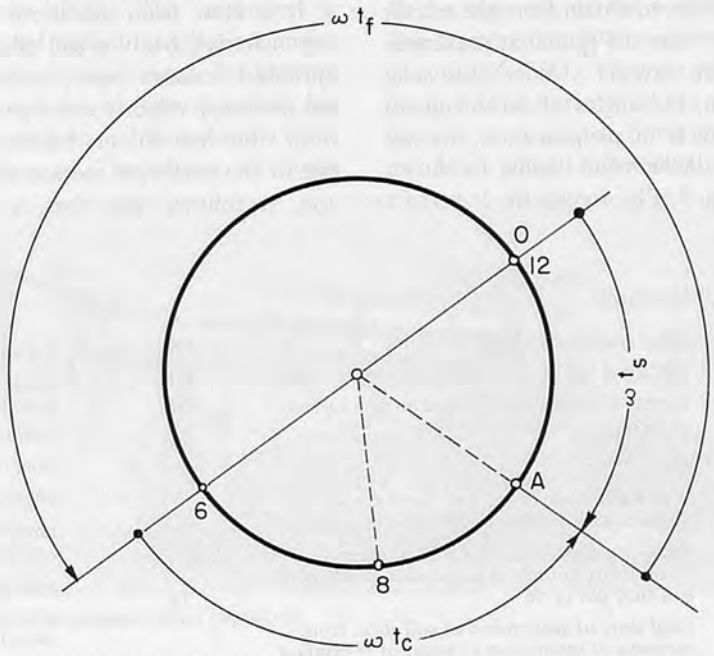


Fig. 5 Angles of salient phases per cycle

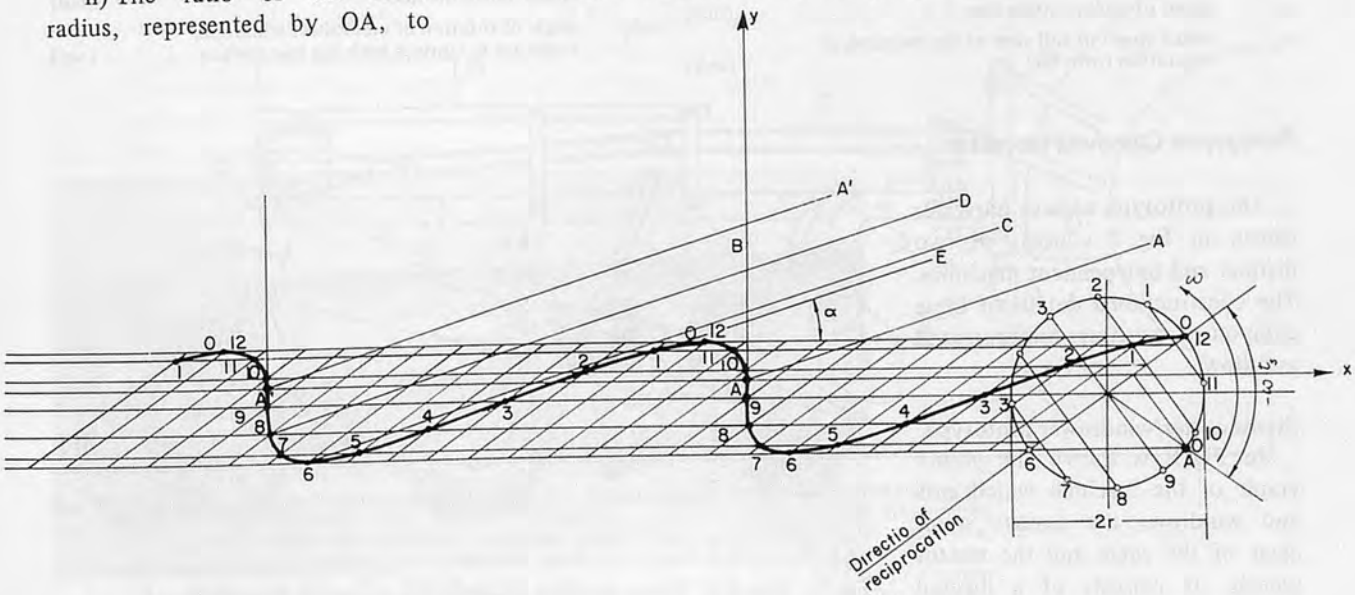


Fig. 6 Locus of a point on cutting edge of hoe

b) At the commencement of the forward motion, corresponding to the cutting stroke of the hoe, the materials on the hoe were thrown off and remain suspended during the forward stroke.

It was thus established that for crank rpm in the range of 450 to 560, the hoe mounting arrangement of **Fig. 4** yielded the desired condition (8). (It should be noted that this particular range of rpm was chosen for the test because it is easy to obtain from the tractor power take-off (p.t.o) at maximum tractor power). Under this condition, the angles of salient phases per cycle of reciprocation, according to Klenin and Popov, are shown in **Fig. 5**. **Fig. 6** gives the locus of a point on the reciprocating hoe during the cycles of reciprocation with the following significant positions:

A-A: material on hoe commences to separate from it.

6-C: material begins to resettle on hoe

8-D: material fully bears on hoe.

8-D to A-A: material acquires separation velocity.

A-A to 6-C: material suspended above the hoe.

It is clear from the above that any material, be it a soil slice or uprooted cassava root, acquires the necessary velocity and separates from the hoe at or before the end of the backward motion of the hoe. It follows then that, as the cutting stroke begins, this material is moving backwards at a horizontal velocity of $\nu_o \cos\alpha$ while the point of separation moves forward at the combined speeds of the implement ν_m and the hoe, $\nu\cos\alpha$ i.e. at $\nu_m + \nu\cos\alpha$. If the material re-contacts the hoe, it will be at a point behind the separation point whose distance may be given as,

$$\delta = (\nu_o \cos\alpha + \nu_m + \nu\cos\alpha)t_f \quad (9)$$

This means that the resultant direction of a soil slice for uprooted cassava roots) will always be backwards and opposite to the direction of forward travel of the implement.

List of Symbols

P_c	shear resistance of soil to cutting	(N)
P_s	frictional forces due to soil on hoe surface	(N)
P_k	impact resistance due to soil on hoe surface	(N)
r	crank radius	(m)
t	time	(s,h)
t_c	time during which soil and roots are in contact with surface of the hoe per cycle	(s)
t_s	time measured from moment of separation to moment of highest suspension position of soil slice per cycle	(s)
t_f	total time of suspension of soil slice, from moment of separation to point of re-contact with hoe per cycle	(s)
ν	speed of reciprocating hoe	(m/s)
ν_o	initial speed of soil slice at the moment of separation from hoe	(m/s)
ν_m	forward speed of implement	(m/s)
α	angle of cut or inclination of hoe to the horizontal	(deg)
γ	knife angle of hoe	(deg)
μ	coef. of friction of soil + crop on steel = tan ϕ	
ϕ	angle of friction of soil on steel	(deg)
ϵ	angle between the direction of reciprocation and the plane of the hoe	(deg)
ω	angular velocity of crankshaft	(rad/s)
$-\omega t_s$	angle of rotation of crankshaft during the ascent of soil slice above the hoe	(rad)
ωt_f	angle of rotation of crankshaft while soil slice floats above the hoe	(rad)
ωt_c	angle of rotation of crankshaft while soil/roots are in contact with the hoe surface	(rad)

Prototype Cassava Harvester

The prototype cassava harvester shown in **Fig. 7** consists of two distinct and independent machines. The constructional details of these component machines are presented as follows:

Stems cutter/windrower prototype

In **Fig. 8** is shown the photograph of the machine which cuts and windrows the cassava stems clear of the ridge and the tractor wheels. It consists of a disused renovated and modified mower as

Fig. 7 Prototype cassava harvester mounted on a tractor; A – cassava stems cutter/windrower, B – cassava root lifter

shown in the illustration to power a 0.5 m diameter disc saw mounted in place of the mower blades. Mounted above the saw is a reeling guide consisting of two chains, 0.5 m apart on two vertical shafts, and 100 mm-wide plywood blades attached at 0.75 m intervals on both chains. The reeling guide which stretches across the swath defined by the tractor front tyres is belt-driven from an extension of the mower engine shaft at a linear speed of 1.5 m/s. To reduce the effort needed to start the engine, the belt drive is designed such that the reeling guide is engaged only after the mower engine has been started, using the belt tensioning arrangement visible in **Fig. 8**. The cassava stems cutting/windrowing machine is mounted in front of the tractor with the disc saw cutter directly in line with the row of cassava plants at a height adjustable between 0 and 15 cm above the ridge. Thus, the cassava stems are cut at the base and just above the ridge. The cut stems are collected by the plywood blades and moved clear of the ridge and tractor tyres to the previously harvested portion of the field. The machine is provided with three wheels to make it easy to manoeuvre for moving into and out of store as well as for mounting on and dismounting from the tractor. The wheels are made detachable and are removed before the machine is put into use in the field.

Root lifter prototype

The side view of the cassava root lifter prototype is given in **Figs. 9 and 10** where the major parts are identified by numbers. The reciprocating hoe (1) constructed strictly as designed is suspended by four links (2) from a heavy main frame (3) which provides the support for all the elements of the root lifter. The frame is mounted on two rear wheels with 750 x 15 tyres (4) and hitched to the tractor at the drawbar (5) of a special hitch attachment (6) which is described more

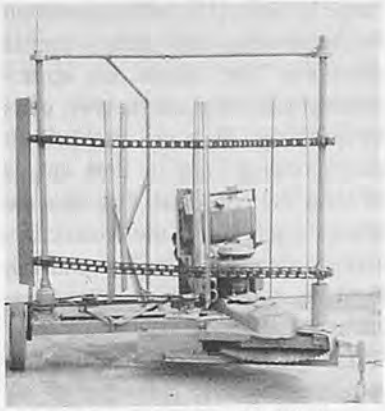


Fig. 8. Cassava stems cutter/windrower prototype

Fig. 9 Cassava root lifter prototype

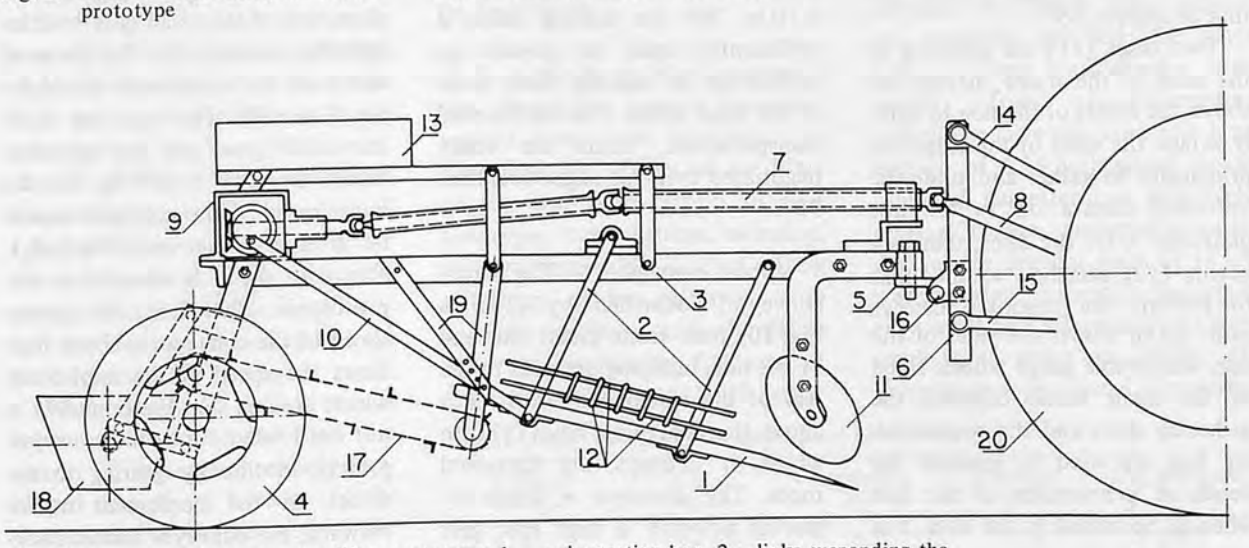


Fig. 10 Side view of cassava root lifter prototype: 1 – reciprocating hoe, 2 – links suspending the hoe, 3 – main frame, 4 – rear wheels, 5 – drawbar on (6), 6 – special hitch attachment, 7 – systemof universal joints, 8 – universal joint from tractor P.T.O., 9 – gear-box, 10 – reciprocation pitman, 11 – gathering discs, 12 – gaurd frame work, 13 – weight box, 14 – tractor top link, 15 – tractor lower links, 16 – horizontal boom on (6), 17 – apron conveyor, 18 – collection box, 19 – links supporting (17) from main frame, 20 – tractor rear wheels.

fully later. Mounted on the frame is a system of universal joints (7) connected to the tractor pto through another universal joint (8). At the rear end of the system of universal joints is a bevel gear which drives another bevel gear in a 90° gear box (9). The shaft carrying the second bevel gear extends left and right out of the gear box. At each end of the extension is mounted an eccentric with an effective throw of 26 mm. One end of a pitman (10) is connected to each eccentric while the other end is attached to the corresponding side of the hoe, towards the rear as shown. Thus, the tractor pto, through the system of universal joints and the bevel gears, drives the two eccentrics which relay their motion to the ends of the two pitmans to produce the reciprocating motion of the hoe. The number of teeth on the bevel gears is equal. The measured revolutions of the eccentrics are an average of 500 rpm at 540 rpm of the pto at maximum tractor power. The lengths and the attachments of the pitmans and the links to the frame and the hoe are such as to ensure that the value of angle α is 25° and that of angle ϵ, 15°.

Two discs (11) are attached to the sides of the frame, astride and above the shares of the hoe to lightly scrape the sides of the ridge but principally to gather and guide the uprooted cassava on to the hoe platform. After the discs, there are guards (12) attached to the links to prevent the uprooted cassava from falling down the sides of the hoe. Adjustable gauge wheels fixed to the main frame between the gathering discs and the reciprocating hoe are used to regulate the depth of penetration of the hoe when in operation in the field. The gauge wheels also serve as a stand for the implement when in the implement garage. They are raised off the ground during road transportation. A weight box (13) fixed on the frame is provided to hold weights which may be added to prevent the wheels from skidding.

Special hitch attachment – The cassava root lifter prototype is semi-mounted using the special hitch attachment sketched in **Fig. 11**. When attached to the upper link (14) and lower links (15) of the tractor three-point linkage, the special hitch attachment becomes integral with the tractor as shown in **Fig. 10**. The draw-bar is free to rotate in a heavy sleeve which is rigidly welded to a horizontal beam (16) which is also free to rotate relative to the special hitch attachment. Thus, when hitched to the draw-bar and while the wheels always rest on the ground, the lifter may be lifted to raise the hoe above ground level for transportation or lowered to make the hoe penetrate to the required working depth, just like any mounted implement. At the same time, the machine may be pulled or manoeuvred, in raised or lowered position, with the same facility as for any trailed implement. The length of the machine, from the hitch point to the wheels, is 2.10 m. Yet the turning radius is sufficiently small to present no difficulties in making sharp turns if the need arises. For on-the-road transportation, turns are easily negotiated even for angles less than 90°.

Apron conveyor – The apron conveyor, identified by (17) in **Fig. 10**, runs from under the end of the hoe, inclining upwards to the rear of the machine where it ends above the collection box (18) into which it conveys the harvested roots. The conveyor is driven by gearing whereby a large spur gear which is concentrically bolted to the hub of the wheel meshes with a smaller gear keyed to the conveyor drive shaft. Two 12-tooth 15 cm diameter sprockets are also keyed on

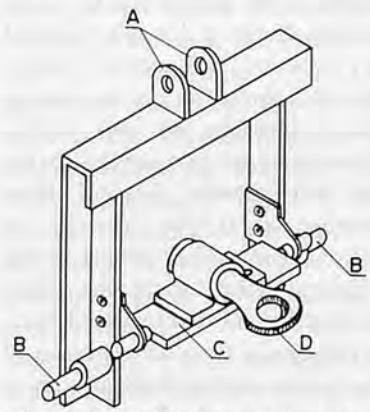


Fig. 11 Special hitch attachment: A – top link hitch; B – lower link hitch; C – horizontal boom; D – draw-bar

the drive shaft. The drive shaft of the conveyor, attached to the main frame by links (19) with a provision for tensioning, also carries similar sprockets. Two chains are appropriately tensioned on the two pairs of sprockets. Slats are attached on corresponding links of both chains to form the conveyor. The slats are spaced such that the soil clods carried over from the hoe can fall through while the cassava roots cannot.

Let D and N be the diameter and rpm, respectively, of the drive wheel and let d_g and d_s be the diameters of the small gear and the sprocket, respectively. The forward speed of the implement would be equal to πDN. The rpm, say n, of the small gear and the sprocket would be equal to DN/d_g. So, the linear speed of the conveyor would be given by $\pi d_s n$ or $\pi DN(d_s/d_g)$. The ratio d_s/d_g is about 4 in the prototype. Therefore, the linear speed of the conveyor is about four times the speed of the implement which ensures that the conveyor is not overloaded. Since the conveyor gets its motion by gearing to the wheel, as the implement moves forward, the conveyor moves backwards to carry the harvested roots to the collection box.

The tipping collection box – The collection box identified by

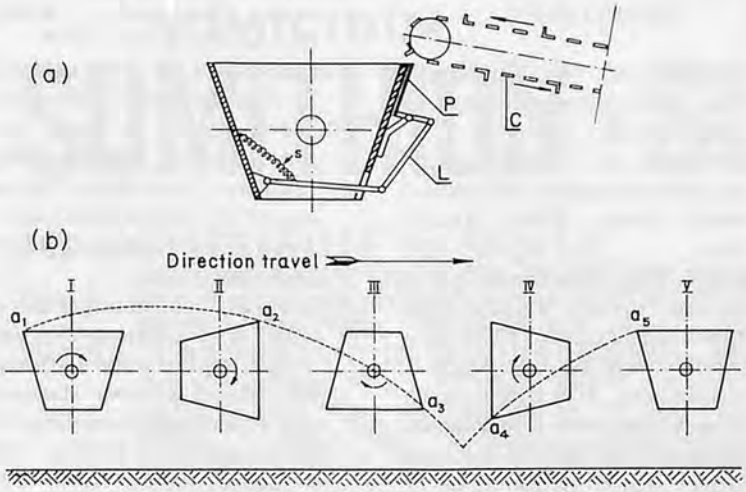


Fig. 12. Collection box for harvested cassava root:
(a) Construction/mounting details; L–pull link; P–push link; C–return conveyor; S–tension spring
(b) Tipping/emptying mechanism

(18) in **Fig. 10** is sketched in **Fig. 12** to show construction details and the tipping/emptying mechanism. The box has the shape shown and is held in position by mounting it on short shafts at the end faces such that the axes of the shafts go through the centre of gravity of the box. The box is fixed such that it is free to rotate around the shafts. The bottom of the box is hinged along the outer side so that it can swing down. Two short rods are attached at two symmetrical positions on the un-hinged edge of the bottom. These rods slide fit in two grooves cut in the other side of the box. The bottom of the box is held up in position by connecting the rods to a system of a linkages secured to the side of the box as illustrated. A pair of tension springs attached to the hinged side and the bottom also acts to hold the bottom of the box up.

When about 75 kg of cassava roots are fed into the box the weight of the roots pushes the unhinged side of the bottom slightly down relative to the rest of the box. The bottom pulls with it the link marked L in **Fig. 12(a)**. Simultaneously the link, P pushes up into the path of the returning apron conveyor which pulls it along slightly to set the box into the motion illustrated in **Fig. 12(b)**. Thus, the box automatically tips over at a designed weight of cassava roots, empties its contents and resumes its position, ready to receive more cassava roots. Therefore, the harvested cassava roots are collected and dumped in heaps along the row.

Evaluation of Prototype Performance

To evaluate the performance of the prototype cassava harvester, various tests were scheduled to determine the effects of the lifter on the crop with respect to root breakages, cuts, bruises, skinning, etc., to determine its root lifting efficiency under different crop densities on ridges or on the flat in terms of leavings or fractions of roots not dug up or sufficiently exposed for picking; to measure the field efficiency and practical field capacity; to measure the draught-force requirements and power demand; to measure the stresses in various members of the planter; to assess the general operating characteristics of the harvester on the basis of traditional manual harvesting methods. The front-mounted machine for cutting and windrowing the tops (leaves and stems) was evaluated as regards the optimum height of cut, cleanliness of cutting and effectiveness of windrowing. The details of the performance tests and evaluations form the subject of a separate report. Here, only the summary of the main results of some of the performance evaluations are presented as shown in **Table 1**.

As an overall evaluation, the prototype harvester works effectively under different soil conditions, crop densities, cassava varieties and cultural methods due largely to the reciprocating action of the hoe. The percentages of broken, cut and skinned roots varied appreciably with soil conditions. However, in all cases, provided the depth gauge wheels are properly adjusted, the lifter gave a better performance than results from hand-harvesting techniques. The net work rate is an average of 0.16 ha/h which means that the harvester can effectively replace 20 men harvesting by hand. An average draught force of 18 kN was recorded. Percentage leavings is very small and affect only the very small roots which are usually left behind even in manual harvesting.

Table 1 Field Test Data for Cassava Root Lifter Prototype

Cultural method	No. of plants/ha	Breakage[1] (%)	Leavings[2] (%)	Avg. Work rate ha/h
Ridge	~ 10 000	2.7	2.5	0.17
	~ 12 000	1.5	1.8	0.18
Flat	~ 10 000	10.3	15.1	0.15
	~ 14 000	9.7	16.6	0.16

1: Percentage of total number of roots in a random sample.
2: Percentage of total number of roots in ridge length of 50 m.

The accuracy of the topper depends on the skill of the operator, the straightness of the crop rows and the degree of branching of the above ground vegetation.

Conclusion

As stated above, full evaluation of this prototype cassava harvester when completed will form the subject of a separate report. However, the low draught and the overall good performance in the field of the present design, when commercialized, will represent a practical solution to the mechanization of cassava harvesting.

REFERENCES

1. Phillips, T.A.: 'An Agricultural Note Book', Longmans Nigeria Ltd., 1970.
2. Krochmal, A.: 'Labour Input and Mechanization of Cassava', World Crops, 1966, Vol.19, No.4.
3. Bates, W.N.: 'Mechanization of Tropical Crops', Temple Press Books Ltd., London, 1963.
4. Makanjuola, G.A.; Onochie, B.E. and Schulte, E.E.: 'Preliminary Studies on the Mechanical Harvesting of Cassava Roots in Nigeria', Paper presented at the Third International Symposium on Tropical Root Crops, Ibadan, Nigeria, 1973.
5. Wijewardene, R.: 'Notes on Tools for Productivity', National Committee of OFN Sponsored Seminar on Mechanization of Crop Production, Kaduna, Nigeria, 30, 31 Oct., 1978.
6. Odigboh, E.U.: 'Mechanization of Nigerian Cassava Production and Processing: Research Needs and Interests', The Agricultural Engineer – Journal and Proceedings of the British Institution of Agricultural Engineers (IAgrE), 1976, Vol.31, No.1.
7. Cock, J.H.; Abelardo, C.M. and Julio, C.T.: 'Agronomic Implications of Mechanical (Cassava) Harvesting', Cassava Harvesting and Processing-Proceedings of a Workshop at CIAT, Cali, Colombia, 24-28 April, 1978, (IDRC-114e).
8. Klenin, N.E. and Popov, E.F.: 'Selskokhozaistvenneye Machini', Kolos Publishers, Moscow, 1970. in Russian. (Transl.: Farm Machinery). ■■

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.

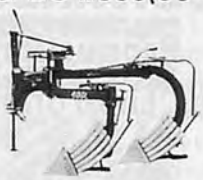
15, 5-chome, Kitahama, Higashi-ku, Osaka, Japan.
Cable Address: CHEMISUMIT OSAKA

Niplo AGRICULTURAL MACHINERY

Rotary Tiller : DC-2000
The side drive system increases durability and makes complete tilling a certainty.
With the perfectly waterproof mechanism, it can be used in paddy fields.

Model DC-2000(60~100ps)

Reversible Plow : TR-255F
Reversing and width control of bottom can be easily operated by a single shifting of the handle.
Unique share shape reduces draft force and makes a small tractor as efficient as a big one.
Because of the differencial effect of moldboard fingers, soil is ideally inverted.



Model TR-255F(20~28ps)

Digger : D-653S
Highly elfective in digging root crops such as potatoes, onions and bulbs.
Specially designed share effectively scoops soil and crops.
Soil and crops are completely separated while they are conveyed backward by the swinging conveyer.

Model D-653S(25~35ps)

MATSUYAMA PLOW MFG. CO.,LTD.

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

TOKAI, ALL-ROUND MAKER OF PREVENTIVE AND EXTERMINATING MACHINES

Power Sprayer Model TS-25

Knapsack Man-power Sprayer Model H-1

With 35 years' history of manufacturing and credit of users, Tokai is a most outstanding company in Japan which has specialized all along in the manufacture of preventive and exterminating machines. We produce hand-operating sprayers of some 20 kinds ranging from pack to shouldering models. In the area of power sprayers we turn out some 12 kinds ranging from the super light-weight and mini-size to all of the standard size as well as large-size power sprayers Tokai has put on the market lately some 10 kinds of speed sprayer - the Apolo series speciaily designed for use for orchards.

TOKAI SPRAY MACHINE CO.,LTD.

Head Office and Factory: 32, Midorien, Ogaki City, Gifu-pret., 503 Japan.
phone: 0584-78-6131(R)
telex: 0-4793-678 TOKAIS J
cable adress: "TOKAISPRAY" OGAKI JAPAN

CONTRIBUTORS WANTED

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

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

EIMA BOLOGNA

BOLOGNA
10-14 NOVEMBRE 1982

Admission by invitation:
10-11-12 November

Admission to public:
13-14 November

international exhibition of agricultural machinery manufacturers

exhibition of gardening machinery

Organized by **PROMOZIONI UNACOMA S. p. A.**
with the collaboration of the ENTE AUTONOMO FIERE DI BOLOGNA

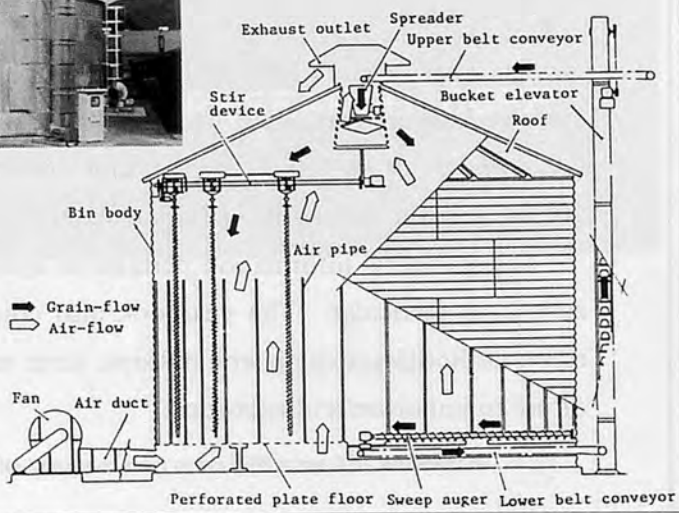
for further details :

eima 00161 ROMA-VIA L. SPALLANZANI 22/A
TEL. (06) 855787 TELEX 614126 -TELEGRAMMI (UNACOMA-ROMA)

YAMAMOTO STIR DEPOT

Features
- Drying while stiring eliminates rotation
- process.
- Stiring operation limits air resistance and
- saves energy through less horsepower.
- Drying process is performed under conditions of 18 to 20 percent moisture up to complete dryness in the normal temperature airing operation. This process saves energy and secures natural storage conditions.
- A blower and a stiring equipment are installed in each bin, permitting independent disposal work in each bin.
- This outdoor type can be attached to existing facilities.

SBD-6M · 8M · 10M



Specifications

Model			SBD-6M	SBD-8M	SBD-10M
Bin diameter		m (ft²)	5.57(18.3)	7.96(24.9)	10.35(34.0)
Overall height		m (ft)	7.80(25.6)	8.40(27.6)	9.80(32.2)
Max. loading level		m (ft)	3.5(11.5)		
Floor area		m²(ft²)	24.4(262.6)	49.8(536.1)	84.1(905.3)
Max. volume		m³(ft³)	83.3(2943.5)	166.7(5890.5)	277.8(9816.3)
Max. holding capacity	Paddy	t	50	100	180
	Wheat	t	60	120	200
Fan	Type		L L F.4½ ≡	L L F.5½ ≡	L L F.7 ≡
	Power req.	KW(HP)	5.5(7.4)	11(14.8)	15(20.1)
Drying rate per hour		%	0.015 (at normal temperature)		
Fuel consumption		ℓ /h(gal/h)	2 – 3.5(0.5 – 0.9)	3 – 7(0.8 – 1.8)	5 – 12(1.3 – 3.2)
Max. loading capacity		t/h	20		
Max. unloading capacity		t/h	10		
Total power required		KW(HP)	14.23(19.1)	19.73(26.5)	24.73(33.2)

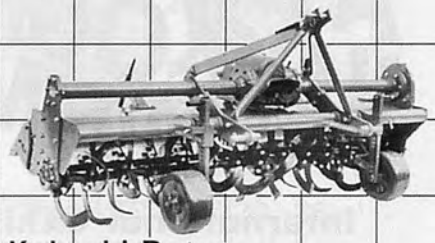
Working with farmers effectively and scientifically

YAMAMOTO MFG. CO.,LTD.

Tendo-shi, Yamagata-ken, 994, Japan. Telex: 8722-66

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

1982 EDITION

FARM MACHINERY YEARBOOK

The 1982 edition now available has 227 pages of the latest comments, statistics and useful addresses pertaining to agricultural mechanization in Japan. The commentaries focus on trends in Japan's agricultural development and agricultural machinery industry and production and results of farm machinery research efforts.

The statistical information pertains to agriculture, in general, and agricultural mechanization, in particular. The yearbook also contains addresses and references of administrative authorities, experiment stations, farm machinery manufacturers and foreign address of use to importers and exporters.

It measures 18.0 cm x 26.5 cm in hard cover and sells for ¥9,300 (sea mail) and ¥11,000 (air mail).

SHIN-NORINSHA Co., Ltd.
7, 2-chome, Kanda Nishikicho, Chiyodaku, Tokyo 101 Japan

INQUIRY and REQUEST to AMA

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

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

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

ADVERTISED PRODUCTS INQUIRY

Product	Advertiser	Vol., No., Page

EDITORIAL REQUEST TO AMA

Your Name :

Address :

Occupation :

SUBSCRIPTION/ORDER FORM

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

Issued Quarterly

Subscription Rate (includes surface mail postage)

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

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

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

(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

Design, Construction and Performance of a Jute Decorticating Machine

by
M.A. Mazed
Head
Agricultural Engineering Division
Bangladesh Agricultural Research Institute
Joydebpur, Dacca, Bangladesh

K.C. Roy
Senior Scientific Officer
Agricultural Engineering Division
Bangladesh Agricultural Research Institute
Joydebpur, Dacca, Bangladesh

Abstract

Jute decortication is the operation of separating the green jute fibre from the jute plants either manually or by a mechanical device. No research work has yet been done to develop a machine that separates the green fibre from the jute plant without wasting the inner stick which is very much needed in many households. The present study deals with the design, development and test of such a jute decorticating machine operated manually.

Introduction

Jute is the most important cash crop in Bangladesh. Bangladesh tops the list of the jute growing countries that contributes 70–85% of the country's foreign exchange earnings. The role of jute in the national economy can be discerned from **Table 1**.

The jute industry is the most important sector of the agro-industry in Bangladesh which provides employment to millions of people. Jute harvesting, retting, stripping, etc. are highly seasonal and take place at a time when there is peak labour demand for other agricultural activities. The total time for harvesting jute and other crops is very limited as flood waters usually damage the crop. Jute bundling, hauling and retting are labour-intensive operations. The introduction of a jute decorticating machine should reduce labour cost and lighten the burden on the part of the workers.

During the retting process, the jute plants are submerged in water for about three weeks. If the water is stagnant, the retting process becomes a nuisance and provides breeding places for mosquitoes, insects and other organisms that result in environment pollution. But when retting can be done after mechanical decortication, only a small quantity of water and an equally small retting pond will be sufficient as long as the decorticated green fibres can be preserved with enough moisture content. The quality of the jute fibre can also be improved by this method.

The development of an appropriate decorticating machine should mechanize the jute industry that should enable the jute growers to sell the green jute to the processing plants instead.

Objectives

The main objectives of the study are:

a) To design and develop a jute decorticating machine which can separate ribbons from the jute plants without damaging the jute sticks.

b) To test the performance of the machine.

c) To modify it, if necessary, and introduce the machine to farmers.

Review of Literature

Kirby (1963) studied the possi-

Table 1 Role of Jute in National Economy

Year	Jute Export Earning Tk. (million)	Total Export Earning Tk. (million)	Percent of Jute in Total Export
1973-74	2529.8	2983.3	84.80
1974-75	2617.0	3135.9	83.25
1975-76	4414.6	5551.7	79.55
1976-77	4615.4	6670.1	69.19
1977-78	5172.9	7178.2	72.06
1978-79	6575.3	9631.8	68.27

Source: Statistical Pocket Book of Bangladesh, 1978 & 1979.

Acknowledgements: Authors are grateful to Bangladesh Agricultural Research Council for financing the research Project.

bility of jute decortication in British Guiana early in the 1950s, but since British Guiana is not a major producer of jute, the idea was soon abandoned. The Colonial Office in London set up the Mechanized Production of Jute Committee and arranged for work to be carried out in harvesting of the stems using machines to separate the ribbons. The first trials were carried out with Kenaf in Nigeria. The work was reasonably successful for some varieties. Bradely and Kirby (1953–54) investigated the mechanized production of jute and jute substitute fibres and recommended the development of a jute decorticating machine. The experiment of French Muller (1960) on cultivation, harvesting and retting of jute in British Guiana provides useful lessons. The International Kenaf Corporation, U.S.A. designed and manufactured a machine consisting of three metallic slotted rollers that separate the fibre but do not spare the jute sticks. The process also led to a considerable fibre loss. The Directorate of Agricultural Engineering and University of Agriculture, Faisalabad, Pakistan developed a power-operated two-roller and three-roller decorticator but likewise damaged the pith core when extracting the fibre by hand.

Technical Design

The design of a jute decorticating machine should consider such factors as the anatomy of the jute plant, socio-economic conditions, availability of energy, etc. The price of the machine should be within easy reach of the farmers and should be light in weight so that it can be carried easily from one place to another. Kirby (1963) estimated that 88 man-days/ha are required from harvesting to storing of jute that is stripped manually compared with only 38 man-days when mechanical decortication is used at the rate of 10 stems/min.

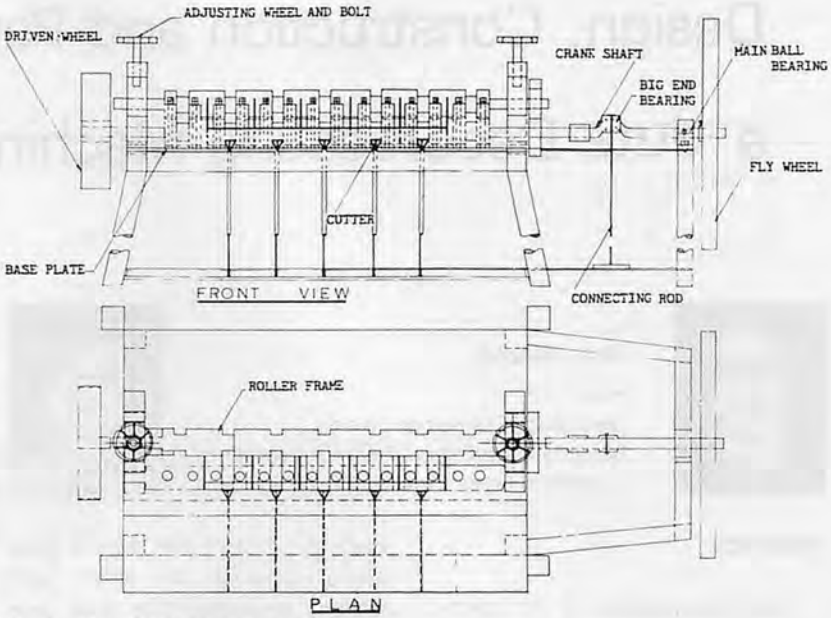


Fig. 1 Jute decorticating machine

A manually-operated system should be designed for the machine. As jute harvesting is seasonal (about 4 to 6 weeks per year) the machine should be developed for multi-purpose use. The design should enable the machine to decorticate jute plants that have branches. More importantly, the machine should spare the sticks.

Methodology

The principle adopted in the design of the machine is the separation of the green ribbon from the inner stick by pulling it in one same direction and separating the ribbon from the butt-end with the help of knife and roller system **(Fig. 1)**. This system satisfies the following conditions:

a) The green ribbon should be separated such that the fibre splits into each of the two rollers.

b) The ribbon should be pushed in between the two horizontal main rollers such that the stems are pulled equally from both sides.

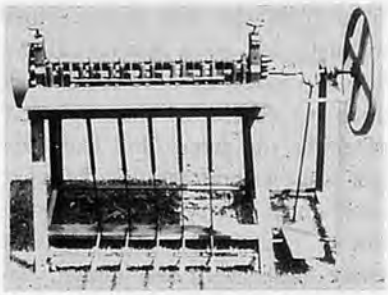


Fig. 2 General view

The main frame of the machine is simple and made of steel angle. The frames are assembled with nut bolts. The height of the frame is 84 cm which is suitable for use by an average-height worker. The power is applied by manual labour through a crank connecting rod pedal system. By playing the pedal with one leg the power is transmitted through the crank to the main rollers. To maintain the working torque, a 58 cm diameter flywheel is assembled with the main roller. The initial torque is high but once the machine is started, the torque is low enough for operation by one person. There are two main rollers each of which is made of a 6.5 cm steel rod. It is so designed that seven sets of rollers and groove system are provided in the main rollers. In order to adjust the distance between the main

rollers, there are two adjusting wheel and bolt systems at both ends of the main rollers. When the bolts are too tight, more power will be required to run the machine and the bolts may be slackened to reduce the gap between the main rollers and power requirement will be less. A photograph of the machine is shown in **Fig. 2**.

Experimental Procedure

Random samples of green jute plants were collected from the farmers' field whose diameters varied between 1.5 cm and 3.5 cm and length between 2.5 m to 3 m. After harvesting the jute plants, the green leaves were stripped off by hands and then fed to the machine for testing. One man operated the pedal and another man fed the green jute stems. Three replications were made by each of three pairs of middle-aged healthy workers or a total of 9 replications. The results are shown in **Table 2**.

Discussion and Conclusion

The average number of stems decorticated was 6 against a required minimum of 10 per minute. This happened because of the new operator did not have skill to operate the machine. Although the initial torque of the machine was high it was possible for an operator to run the machine continuously. The number of stems fed per minute could be increased after developing the experience on the part of the operator. The machine was easily transportable to any place of operation by 2–3 persons as the total weight was approximately 160 kg. The total cost was Tk. 3 000 which was reasonably within the reach of the jute growers. The repair and maintenance was very simple as only greasing was required in the bearing and other frictional parts from time to time. During the test of the machine, the jute sticks were intact. But the separation of the fibre from the butt-end of the plants needs to be improved in order to ease the operation.

Recommendations

The set-back found in the performance test of the machine was in respect of capacity of separating the stems per minute. Also, the jute sticks could not be moved in forward direction as their ends were touching the ground. Therefore, the future line of work should be:

a) To improve the design so that the green fibres from the butt-end of the jute plant can be easily separated and fed automatically in the machine, hence increase its capacity.

b) On the opposite side of the operator a bed made of horizontal rollers should be constructed so that the sticks after separation can move forward over the revolving horizontal roller and be at some distance from the machine.

REFERENCES

1. Baten, A.(1975). Factors affecting the quality and price of jute in certain selected areas of Bangladesh.
2. Bradly, J. & Kirby, R.H. (1953–54). Report on investigations into the mechanized productions of jute and jute substitute fibres clon pl. Animal production 3, pp 135–164.
3. Chaudhury, A.D. et al (1980). Design and development of jute decorticator, Agricultural Mechanization in Asia. Vol XI No. 1 pp 81–94
4. Chaudhury, S.D. & Ali, M.A. (1958–59). Report on survey of cost of production of jute in East Pakistan, Pakistan Central jute Committee.
5. French-Mullen, M.D. (1960). Experiments in the cultivation, harvesting and retting of jute in British Guiana, Tropical Science 1 pp 231-285.
6. Govt. of Pakistan, September, 1970. Central Statistics Office, Pakistan Key Economic Indicators; Volume No. 4.91, p-16
7. Kirby, R.H. (1963). Vegetable fibres, Lenard Hill Books Ltd. London.
8. Mazed, M.A. (1975) Design of a device for decortication of Urna Lobota Fibre Report submitted to the Tropical Product Institute (Unpublished).
9. Ranjan, T.C. (1973) Handbook of Jute, Vol 1, Oxford and TBH Publishing Co. Calcutta.
10. Statistical Pocketbook of Bangladesh (1978 & 79). Statistics Division, Ministry of Planning, Govt. of Bangladesh.

Table 2 Results of Experimental Tests

Operator	1st Replication (stems/min)	2nd Replication (stems/min)	3rd Replication (stems/min)	Average (stems/min)
No. 1	6	6	6.5	6
No. 2	7	6	6	6
No. 3	5	5.5	5	5

Mechanization of Paddy Production in Malaysia

by
A.A. Mainul Hussain
Department of Power and Machinery
Faculty of Agricultural Engineering
University Pertanian Malaysia
Serdang, Selangor, Malaysia

Introduction

Peninsular Malaysia consists of about 50,700 square miles of land area of which about 22% is presently arable. The total area under cultivation is 7.06 million acres of which rubber production covers 4.46 million acres or 63% of the total. This is followed by rice with 1.03 million acres or about 14% of the cultivated area. Therefore, rice is a very important crop of Peninsular Malaysia the production of which was 1.32 million t in 1979 and is expected to go up to 1.36 million t in 1981. This total production represents about 86% of the total rice availability, hence domestic production of paddy is estimated to fall short by about 15% of domestic requirement. Therefore, attempts should be undertaken to reduce this shortfall.

Under the Fourth Malaysia Plan, 13 paddy growing areas/schemes were identified for further development. It is expected that the irrigation facilities provided by the Government would extend to over 1.0 million acres of rice land by the end of 1981. The Muda area covering 0.26 million acres produced about 3.5 t per acre as compared to 2.35 t per acre in other areas.

The rice industry now sustains a loss of about 10% of the total output due to waste and loss during harvesting and handling activities. This means that about 0.11 million t valued at M$100 million are lost annually because of poor post harvest facilities, inadequate transportation, milling, drying and storage system. Another problem facing the paddy production is the shortage of labour caused by the rural-urban migration from paddy growing areas during planting and harvesting seasons. This has resulted in the abandonment of paddy land estimated at 0.12 million acres throughout Peninsular Malaysia. Heavier industrialization in the coming years will further bring about labour shortfall in the agriculture sector.

Why Mechanization is Necessary in Paddy Production

In most of the paddy growing areas the farms are fragmented and small in size. Land preparation activities are mostly done by 4-wheel tractors or 2-wheel pedestrian tractors and much of the harvesting and threshing operations are done by combine harvesters. Other operations such as transplanting, seeding, and weeding are done manually.

In areas outside the scheme, except for land preparation, all other operations are done manually and therefore requires a higher proportion of labour force. Table 1 indicates the distribution of family and hired labour for different operations in the paddy production. The high proportion

Table 1 Percentage Distribution of Hired and Family Labour in Paddy Production

Operation	Labour force hired (%)	Family labour force required (%)
Land preparation (excluding tractor ploughing)	19.6	80.4
Transplanting	92.3	7.7
Weeding	19.9	80.1
Pest control	5.1	94.9
Harvesting and threshing	89.8	10.2

of hired labour needed for transplanting, harvesting and threshing, like the high proportion of family labour in land preparation, weeding and pest control can be reduced substantially by the adoption of machinery. In this way, it will save the farmers of the scarce and costly hired labour and at the same time relieve the family labour to enable them to engage in other income-generating activities. In so doing, the types of machinery to be adopted must be suitable for local conditions.

Research Areas and Methodology

Land Preparation – This is one of the most important operations in the entire paddy production. If the land is not prepared properly the rice plant will not grow adequately and the yield will be low. It has become a standard practice to use 4-wheel custom hired tractor or 2-wheel pedestrian tractor for land preparation in the country. In most cases rotary blades or cultivators are used. Some research work should be carried out into the appropriate shape and size of rotary blades for best soil pulverisation and puddling action.

Transplanting or Seeding – This is another labour intensive operation in paddy production. Transplanting is more labour intensive than direct seeding operation. In the case of transplanting it is necessary to grow seedlings in a special nursery for 20 to 25 days. Automatic transplanting machines have not been very successful in Malaysia due to the fact that rice seedlings have to be grown in special boxes. The field requires precise water control and land preparation. Investigation should be made into the design of the machinery to eliminate these problems so that they can operate smoothly. The other most commonly used device is the multi-hopper direct seeding machine. For seeding operation it is necessary that the seeds are released at equal intervals at definite rate and that the pregerminated seeds are not damaged before seeding.

This type of machine used elsewhere in Malaysia is also not very effective. Therefore, investigation should be carried out to make necessary modifications and testing so as to fit the machine in local soil conditions and cultural practices.

Weeding – Proper weed control is very important to achieve expected yields. Even as standing water in the field may destroy a substantial amount of weeds, the remaining weeds have to be removed with the use of some hand tools. Various types of push-type weeders are developed and are available in the market. Further research on rendering the weeders more efficient and easy to operate is necessary. The design of the weeders should be such that they can be manufactured and maintained locally for better farmer acceptability.

Post-Harvest Operations – It has been reported that in most of the South East Asian countries between 13 and 34% of the crop during harvest and post harvest operation is lost or wasted. Other important losses are grain quality deterioration and under-utilization of by-products. Research work should be intensified in the above mentioned areas in order to reduce these losses.

Harvesting and Threshing – The major consideration in harvesting rice pertains to the degree of maturity of the grain. Under tropical conditions this point is generally reached 28 to 32 days after flowering when the moisture content of the grain is between 21 to 24% WB. If the crop is allowed to stand in the field after it reaches maturity, large losses occur during harvesting.

Rice fields less than 1.5 acres are not suitable for the use of mechanical harvesters – both in efficiency and cost, particularly in small fragmented land holdings. In this type of situation the small multi-row grain harvester may be a practical solution even as the initial cost of this machine is perhaps beyond the capacity of small farmers. Therefore, manual harvesting will continue to be popular for small farm holdings.

Mechanical threshers remove the drudgery from the process and save time. Although they require some capital investment, the cost of operation is low. Small threshers, either operated by man or engine, may be used effectively for this purpose. There are quite a number of designs of engine driven threshers available. Some improvements and modifications can be made on these threshers in order to make them more efficient and suitable for small farm use. In re-designing this type of thresher it must be borne in mind that the cost of the threshers should be such that it is within the economic capability of the farmers, can be made locally from available resources, and easy to maintain.

Cleaning and Drying – Hand-sieving and winnowing are still the traditional farm methods for cleaning the paddy grains after threshing. However, winnowing and cleaning machines are available in different sizes for various farm sizes for this purpose. It consists of vibrating screens of different mesh sizes for removing particles larger and smaller than the grains.

Paddy drying traditionally uses the heat of the sun which is dependent on nature and is slow process. On the other hand, the most commonly used fuel for mechanical driers are the fossil fuel the price of which has gone up in recent years. Alternative sources of fuel such as rice husk and rice straw are now being

tried as substitute for fossil fuels for this purpose. Rice husk has a calorific value of about 6 000 Btu/lb and can be used as an alternative source of energy for this purpose. A comparison of costs of different types of fuel is given below.

Fuel source	Energy value	Cost Kcal/M$
Fuel oil	10 240 Kcal/ℓ	24 000
Coal	5 560 Kcal/kg	140 000
Electricity	860 Kcal/kWh	17 200
Rice hull	3 300 Kcal/kg	920 000

Rice husk is 5 times cheaper than many other fossil fuel sources. Therefore, an efficient utilization of rice husk for the rice drier should result in a large saving in fuel cost. The most important factors to be considered in the design of a rice husk furnace for this purpose are: (i) efficient burning of the fuel; (ii) removal of the burned ash; (iii) loading of the furnace; and (iv) circulation of hot air through the grain at a suitable rate. Of course, the drying temperature of air will depend on the burning rate of rice hull and air flow rate.

Therefore, investigations into the design of the furnace for proper rate and efficient burning characteristics of rice husk are very important, including the construction of the plenum chamber at the bottom of the grain bin for efficient distribution of the hot air throughout the grain bed.

Summary

The research works mentioned above should be undertaken in order to mechanize the paddy production system in the small farm holdings. New or renovated farm machines should be within reach of the small farmers. In developing the machines for small farm holdings the following factors should be carefully considered:

1. The size of machine developed should suit the average size of the plots in the small farm holdings in Malaysia.
2. Utilize local raw materials available to the maximum.
3. Design characteristics should be simple so as to be within the technical know-how of the rural people.
4. The machines should be easy to operate and maintain.
5. The cost of the machine should be within the economic reach of the farmers.
6. The cost-benefit ratio should be low.
7. The machine should have a low operating cost.
8. The machine should have efficient labour utilization.
9. The machine should be acceptable to farmers.
10. Use of the machines should redound to increasing the farmers net earnings.
11. The design of the machines must take into account the climatic and operating conditions in the country.

REFERENCES

1. Chandler, Robert F. (1979). Rice in the Tropics, International Agricultural Development Service, New York, USA.
2. Muda Agricultural Development Authority, (1970). Farm Mechanization in Muda Scheme, General Manager's Office, Muda Agricultural Development Authority, Telok Chengai, Alor Star, Kedah, Malaysia.
3. The Association of Japanese Agricultural Scientific Societies (1975). Rice in Asia, University of Tokyo Press, Tokyo, Japan.

Mechanization of Family Farms in Nigeria:

by
U.G.N. Anazodo
Senior Lecturer
Agricultural Engineering Department
University of Nigeria, Nsukka
Anambra State, Nigeria

I: A Quantitative Analysis of the Problems and Prospects

Abstract

A quantitative approach for the evaluation of the problems and prospects of mechanizing family farms in any developing country was developed and applied in conducting three field surveys of farmers in two eastern states of Nigeria. The factors identified as limiting agricultural mechanization were low awareness index and low good management index, despite a high willingness index. The study reveals that little progress has been made towards improving the conditions that favour the mechanization of family farms in the project area.

Introduction

Nigeria has a total of 98.3 million ha of land with 72 % of it considered as potentially cultivatable and 35 % under actual cultivation by 1975. Despite this abundant land resources, in addition to her huge oil wealth and generally favourable weather, there has been a nineteen-fold increase in food importation into Nigeria since the country gained her independence from Britain in 1960 (Anazodo, 1981).

The major factor limiting agricultural production in Nigeria is the failure to achieve an effective mechanization of the traditional farming systems in the country. Progress in the successful introduction of mechanized methods in agriculture in Nigeria has remained elusive because of the failure to identify and eliminate the bottlenecks imposed by the socio-economic and agro-technological environment of the small family farms which dominate the Nigerian agricultural sector.

To identify the critical factors limiting agricultural mechanization in Nigeria, or in any other developing country, there is need to undertake systematic field investigations and analyses of the complex social, economic, political, technical and environmental conditions and attributes of the farming populations (Anazodo, 1975). The benefits of agricultural mechanization as a dynamic factor in increasing food production, achieving economic stability and enhancing social justice cannot be over-emphasized (Anazodo, 1980a).

Objective of this Study

The main objective of this article is to present a quantitative approach for the evaluation of the problems and prospects of mechanizing family farms in any developing country. Discussion of the socio-economic conditions that limit agricultural mechanization in any country in qualitative terms alone has tended to reinforce the misconceptions and doubts which are generally associated with the issue of mechanizing traditional farms. Quantitative evaluation of the attributes of a given population of farm families will reveal the correct magnitude of each favourable or unfavourable factor and thus assist in a mathematical simulation of the population for the purpose of determining the approximate level of agricultural mechanization for the area. It will also afford an unbiased method for comparing different farming populations for the purpose of choosing which ones are likely to benefit more from the introduc-

tion of mechanized methods. It also gives a systematic basis for a continuous assessment of the problems, prospects and status of agricultural mechanization in the area of interest.

Description of the Project Area

The field investigation and analysis were limited to farmers in two eastern states of Nigeria (Anambra and Imo States). The two states were one state when the study began in 1975 and the country had a total of twelve states. Now, Nigeria has a total of nineteen states. Topographically, the study area is made up of fairly level to moderately rolling plains, under 200 m above sea level, with scattered groups of hills (Ofomata, 1975). The dominant vegetation is the tropical rain forest. The soils of the two states are mainly sandy soils derived from sedimentary rocks. The soils range from low to medium productivity and fertility potential. The climate is characterized by uniformly high temperatures and seasonal distribution of rainfall. Mean annual range of temperature is 21 to 32°C. Annual rainfall is as high as 354 mm in most part of Imo State and as low as 276 mm in most part of Anambra State. The relative humidity could be as high as 95% for the greater part of the year and as low as 40%. The population density is well over 250 persons per square km. Population growth rate is about 5.3% per year for the two states.

Method of Study

A questionnaire containing 90 questions was designed by the author and applied in three field surveys of farmers in Anambra and Imo States of Nigeria.

In the first survey conducted between July and September 1975, farmers were selected with the help of the extension staff from the government ministry of agriculture in each of the two states. A second survey was conducted in December 1975 to obtain a more random sampling of the farming population. In this case the interviewers did not go through any extension staff to reach the farmers. Farmers were randomly selected and interviewed in the villages which were also randomly selected. A total of 274 farm families in 32 villages in ten divisions of the two states were interviewed in their respective farms during the first and second surveys. The results of these two surveys were analyzed and reported by the author in an unpublished research report (Anazodo, 1976).

A third survey was conducted in July to September 1981 in three villages in three divisions of Anambra State. The aim was to estimate what progress has been made in improving the conditions for the successful mechanization of family farms in the state of interest. Twenty-seven farm families were interviewed in each of the three villages.

The same questionnaire was used in all the three surveys. The interviewers in all cases were agricultural engineering undergraduate students under the supervision of the author.

Results and Discussions

Analysis of the information and data from completed questionnaires were made by the author. Each Yes answer to each question (except otherwise stated) was counted as a

Table 1 Awareness Index

Question	% Positive Score		
	First survey 1975	Second survey 1975	Third survey 1981
Are you aware of the existence of a Tractor Hire Service	31	18	52
Have you ever witnessed a demonstration of tractorized agricultural machinery?	44	37	73
Have you ever seen any tractorized agricultural machinery under operation?	45	39	77
Do you know how much a tractor costs?	6	2	11
Are you aware of the existence of the Nigerian Agricultural and Cooperative Bank (NACB)?	38	29	51
Do you know how to obtain loan or credit from NACB?	7	4	46
Average percent Positive Score on Awareness, or Awareness Index	29	22	52

Table 2 Good Management Index

Question	% Positive Score		
	First survey 1975	Second survey 1975	Third survey 1981
Do you practise continuous cultivation?	21	7	22
Do you grow only one crop in your largest land unit?	73	44	4
Do you practise any crop rotation?	68	36	73
Do you plant your main crop on the flat areas?	19	50	27
Do you apply fertilizers?	38	15	47
Do you apply farm yard manure?	40	15	71
Do you keep any records of your farm business?	20	18	25
Average percent Positive Score on Good Management or Good Cultural Practice, or Good Management Index	40	26	38

Table 3 Willingness Index

Question	% Positive Score		
	First survey 1975	Second survey 1975	Third survey 1981
Are you willing to join a farmers' co-operative society?	83	65	97
Are you willing to adopt monocropping in your largest land unit?	70	49	84
Are you willing to buy better varieties of seeds or seedling?	100	97	95
Are you willing to benefit from a Tractor Hire Service?	84	75	100
Are you willing to use a tractorized equipment for one or more of your crop production operations?	100	78	100
Will you be willing to buy a tractor if you are given adequate loan or credit facility?	98	74	100
Will you be willing to own a tractor jointly with your neighbouring farmers?	83	69	99
Are you going to apply for loan or credit from the Nigerian Agricultural and Co-operative Bank?	59	46	63
Average Percent Positive Score on Willingness, or Willingness Index	85	69	92

Table 4 Agricultural Mechanization Status

Question	% Positive Score		
	First survey 1975	Second survey 1975	Third survey 1981
Do you apply irrigation water?	17	14	23
Do you apply a suitable erosion control measure?	10	–	16
Do you apply a suitable drainage system?	4	–	11
Do you use tractorized equipment for your land clearing or preparation?	4	–	17
Do you use tractorized equipment for your crop management or harvesting?	0	0	0
Have you a diesel/petrol engine or an electric motor for crop processing?	0	0	0
Do you use any modern storage method?	0	0	0
Do you benefit from a Tractor Hire Service?	9	0	34*
Have you the capital to buy a tractor?	0	4	0*
Average Percent Positive Score, or Agricultural Mechanization Status**	5	4	10

* These two rows were not included in the calculation of the average percent positive score.

** In this respect, Agricultural Mechanization Status is defined as the percentage of farmers interviewed in an area who on the average use a tractor, a diesel/petrol engine or an electric motor to operate crop production or processing equipment; or use a modern storage method; or use, where necessary, suitable irrigation, erosion control and drainage methods on their farms.

positive score, and considered a favourable answer from point of view of agricultural mechanization. Hence the percent positive score for each question was obtained by dividing the number of farmers who answered favourably to that question with the total number of farmers who responded to the same question, and the result expressed in percent. Some of the results are presented under four sub-headings as given in **Tables 1** to **4**.

The first index, **Table 1**, indicates the degree of awareness of farmers on the possibilities and institutional facilities that exist for mechanizing their farms. The second index, **Table 2**, expresses the suitability of the farmers' present management and cultural practices to the effective introduction of mechanized methods. The third index (**Table 3**) gives a quantitative evaluation of how willing the farmers are to accept and adopt better management techniques, technological innovations and credit facilities. The results obtained show that both the awareness index and the good management index of the farmers interviewed were low while their willingness index was high. While the awareness index and the willingness index of the farmers appeared to have considerably increased from 1975 to 1981, their good management index remained low over the same period. This fact is a reflection of the kind of efforts pursued by governments at both federal and state levels over the last decade. Agricultural development strategies in Nigeria have been characterized by ad-hoc slogans, such as "Operation Feed the Nation" and "Green Revolution" (Anazodo, 1980b; 1981). In these and similar government strategies, farmers as well as the generality of the public, are made aware of the government expenditures in importing and distributing expensive agricultural inputs with little emphasis in research and development of agro-technological techniques and systems which will improve farm practice.

The results of the fourth evaluation made are shown in **Table 4**. It is evident from this table that the status of agricultural mechanization as it concerns family farmers has been and still remains very poor in the study area, and in Nigeria at large.

Table 5 gives more of the quantified attributes of the family farmers determined from this study. Apart from the poor yields and poor rates of work which are typical of handpowered traditional agriculture in developing tropical countries, a close examination of the results will show that the problem of small size and

Table 5 Other Quantified Attributes

Attributes	Average Values		
	First survey 1975	Second survey 1975	Third survey 1981
Size of the largest farm land unit owned by a farmer, ha	7.4	2.2	1.2
Number of farm land units owned by a farm family, n	5	8	10
Degree of fragmentation = 100(n−1)/n, %	80	88	90
Prospects for land pooling (4 = Very high; 3 = High; 2 = medium; 1 = low and 0 = very low)	2	2	3
Number of resident dependants per farm family	14	14	7
Number of resident dependents engaged in active farm work	5	7	2
Number of farm labourers hired per farm family	8	7	4
Estimated crop yield, tons/ha			
Yam	3.5	1.7	3.1
Rice (Upland)	5.0	2.4	3.9
Rates of work using hand tools, ha/day			
Land clearing	0.02	0.03	0.03
Mound making	0.01	0.02	0.02
Ridge making	0.03	0.02	0.03
Planting yam	0.05	0.07	0.05
Planting rice	0.03	0.03	0.03
Weeding	0.02	0.03	0.03
Harvesting yam	0.02	0.05	0.04
Harvesting rice	0.02	0.01	0.02

Table 6 Estimating the Progressiveness of a selected village[1)]

Attributes	Measured average values		Change over 5 yrs	Remarks[2)]
	1975 (a)	1981 (b)	100(b−a) %	
Degree of literacy, %	38	52	37	P
Awareness Index, %	38	55	45	P
Good Management Index, %	29	27	−7	R
Willingness Index, %	75	93	24	P
Size of the largest land unit owned per farm family, ha	1.7	1.3	−24	R
Number of farm units owned per farm faily, n	6	11	83	R
Degree of fragmentation, 100 (n−1)/n, %	83	91	10	R
Number of resident dependants per farm family	6	6	0	–
Number of resident dependants engaged in active farm work per farm family	1	2	100	R
Number of paid farm labourers engaged at peak season by a farm family	7	4	−43	P

1) Ikem village in Isi-Uzo Local Government Area. The number of farm families interviewed in the village in 1975 and 1981 were 19 and 27, respectively.

2) P stands for Progressiveness while R stands for Retrogressiveness.

fragmentation of farm land is getting worse despite government efforts in land reform (see Igbozurike, 1980, for analysis of the Nigerian Land Use Decree). Indeed, **Table 6**, in which the progressiveness of a selected village was estimated reveals that little progress has been made towards improving the conditions that will favour the mechanization of family farms in the two eastern states of Nigeria.

The values computed from data obtained during the first survey were consistently higher than those for the second survey. A major reason for this is that the more productive areas of the two states were visited during the first survey. The selection of the divisions and farmers visited during the second survey was random and hence a mixture of relatively good and relatively poor areas and farmers was sampled.

Conclusions

The socio-ecological factors which may limit agricultural mechanization in Anambra and Imo States of Nigeria include high population density, soils of low to medium productivity and fertility potential and rainforest vegetation.

A quantitative analysis of the data obtained from the first two surveys showed that the farmers had low awareness index and low good management index, but they had a high willingness index. The most recent survey conducted showed that both the awareness and willingness indices have increased considerably while the good management index has remained low. Thus the so-called conservatism of traditional farmers is no longer a tenable argument against the mechanization of their farms. What is now needed is emphasis on research and development aimed at evolving appropriate agro-technological techniques and systems which the farmers can easily adopt in order to improve their farms and farm practice.

The farm size is much less than 5 ha on the average and there is a very high degree of farm land fragmentation. This situation appears to get more problematic with time, in the absence of an effective land reform.

The status of mechanization of family farms has been and still remains very poor in the states of

interest. Use of tractors, electric motors, pumps, modern machinery and structures for agricultural production, processing and storage is still limited to government farms and agro-industrial projects. Only very few private farmers use tractorized equipment for land preparation. For effective mechanization of the Nigerian agriculture, new and bold initiatives are now urgently needed to encourage and sustain research and development efforts towards the indigenous design and manufacture of agricultural machinery appropriate to the socio-economic conditions of the family farmers who are, by far, the major producers of food and raw materials in Nigeria.

REFERENCES

1. Anazodo, U.G.N. 1975. Systems Approach to Farm Mechanization in Nigeria. NIJOTECH, 1(1) 7-11. Nigerian Journal of Technology.
2. Anazodo, U.G.N. 1976. A Field Study and Analysis of Problems and Prospects of Family Farms in Nigeria: Anambra and Imo States. Unpublished Research Report. Department of Agricultural Engineering, University of Nigeria, Nsukka, Nigeria. 101 pages.
3. Anazodo, U.G.N. 1980a. Agricultural Mechanization as a Catalyst for Rural Development. Paper presented at the National Seminar on Achieving Even Development in Nigeria. Economic Development Institute, University of Nigeria, Enugu Campus, Nigeria.
4. Anazodo, U.G.N. 1980b. Strategy For Nigerian Agriculture. West Africa. 10 March 1980, page 446.
5. Anazodo, U.G.N. 1981. Selective Agricultural Mechanization or Massive Food Importation: The Choice Facing Post-Independent Oil-Rich Nigeria. Paper presented at the National Conference in Agriculture, Rivers State University of Science and Technology, Port-Harcourt, Nigeria.
6. Igbozurike, M.U. 1980. Nigerian Land Policy: An Analysis of the Land Use Decree. Department of Geography, University of Nigeria, Nsukka, Nigeria. 87 pages.
7. Ofomata, G.E.K. 1975. Nigeria in Maps: Eastern States. Ethiope Publishing House. Benin City, Nigeria. 146 pages. ■■

II: A Comparative Study of Selected Villages

Abstract

Mechanization survey data collected in 1975 from 11 village in two eastern states of Nigeria were statistically compared. The result showed considerable degree of variations in the socio-economic, agronomic and technological resources of farm families among the villages in the same ecological, cultural and linguistic zones of Nigeria. The variations within a given village were also high. Such differences justify the adoption of the concept of selective mechanization of family farms in developing countries.

Similar data collected in 1981 were examined to quantify the differences in the attributes of literate and illiterate farmers.

Introduction

The process of agricultural modernization involves progressive transformations in agricultural technology. The effectiveness of an agricultural modernization or development strategy depends to a large extent on the degree of integration of the modern concepts and techniques being proposed with the prevailing socio-economic factors in the area of interest. Hence, a sound knowledge and appreciation of the socio-economic resource base of an area is a fundamental requirement for a successful application of new technological inputs into the agricultural production function.

Many factors combine in a complex but fascinating and dynamic manner to define the socio-economic resource base or constraints of an area. Attitude to work, cultural practice, traditionalism, land tenure, size of farm land, fragmentation of farm land, labour, capital and rural infrastructural facilities are some of the more general factors limiting progress in agricultural development (Schultz, 1964; Carpenter and Ahmed, 1970; Fisher, 1972; Innes et. al., 1972; Cleave, 1974; Fabiyi, 1975; Hopper, 1976).

Equally complex is the process involved in accepting a new technology. This process, which consists of a sequence of thoughts and actions, may be divided into five stages, namely; awareness, interest, evaluation, trial and adoption (Iowa State University, 1962).

In the first part of this study, the author presented a quantitative approach for characterizing the attributes of farmers as regards the mechanization of their farms (Anazodo, 1982). Three indices were introduced to quantify the awareness, good management or cultural practice and willingness of the farm families in two eastern states of Nigeria, Anambra and Imo.

The main objective of this second part of the study was to determine what variations exist in the measured attributes of farmers from different villages. Variations among farmers in the same village were also detemined.

Since education and training play an important role in the process of accepting technological innovations, a secondary objective of this article was to compare the attributes of literate and illiterate farmers in selected villages.

Field Investigation and Data Analysis

Three surveys were conducted in 1975 and 1981 to collect data on the problems and prospects of mechanizing family farms in Anambra and Imo States of Nigeria. Details of the field investigation and of the method of analysis used in interpretting the data collected were explained in the first part of this publication (Anazodo, 1982). The results were then presented as averages for each of the three surveys conducted. In the present article, 11 villages were selected from the 32 villages visited during the first and second surveys. The average values of the attributes quantified were calculated for each of the selected villages. The means, standard deviations and coefficients of variation were then calculated.

To determine variations among farmers in a village, two villages were selected from the 11 villages previously selected.

Analysis of the 1981 data was limited to an examination of the differences in the attributes of literate and illiterate farmers. This was done for each of the three villages surveyed in 1981.

Results and Discussions

The results obtained, **Table 1**, showed that considerable degree of variations exist in the values computed for the awareness index, good management index, willingness index, farm size and degree of farm fragmentation of the farm families interviewed in the 11 villages selected for this comparative study.

Table 2 also shows the highly significant variations in the values of the farm size and the number of land units owned by individual farmers in each of the two villages selected for this analysis. In Amike village, for instance, the size of the largest land unit owned by an individual farm family ranged from 1.2 to 25.8 hectares. In the same village, the number of land units owned by a farm family ranged from 3 to 25.

These findings will support the adoption of the selective agricultural mechanization approach in developing countries. Selective agricultural mechanization (SAM) is the concept of choosing areas for mechanization where the ingredients for success exist or can be more easily developed. It also implies selecting farmers who are most likely to maximize the benefits derivable from the use of mechanization inputs in agriculture. Furthermore, the substantial variations in the computed values found among and within the villages would discourage over-generalization of the ecological, social, economic and technical factors which are said to impede the mechanization of agriculture in developing countries. Rather, ef-

Table 1 Comparison of Attributes in Selected Villages

Name of Village	Number of Respondents	Awareness Index (%)	Good Management Index (%)	Willingness Index (%)	Farm size (ha)	Degree of Fragmentation (%)
Aba-Ukwu[1]	17	15	16	87	1.1	67
Amavo[1]	10	25	15	73	–	–
Amibo[1]	20	3	11	13	0.3	91
Amike	14	45	34	71	11.3	83
Iboko	10	7	13	73	–	–
Izogo	19	11	29	34	7.8	94
Ikem	19	38	29	75	1.7	83
Obazu[1]	17	21	7	92	0.9	67
Ohafia-Abam[1]	20	28	38	71	1.4	80
Otuocha	12	37	50	74	3.4	75
Umuogwu[1]	20	35	41	66	2.2	93
Average	16	24	26	66	3.4	81
Mean Deviation	4	12	12	16	2.8	8
Standard Deviation	7	14	14	23	3.7	10
Coefficient of Variation(%)	44	58	55	35	111	13

[1]: Villages in Imo State while the other five villages are in Anambra State, all surveyed during the first and second surveys conducted in 1975.

Table 2 Variations within two Selected Villages

Farm Family No.	Amike Village		Obazu Village	
	Size of farm (ha)	Number of farms	Size of farm (ha)	Number of farms
1	18.5	4	0.8	3
2	12.3	3	0.8	2
3	12.3	3	1.2	2
4	2.5	3	0.6	3
5	25.8	3	0.6	3
6	8.2	3	0.6	2
7	16.4	5	1.0	3
8	2.5	4	1.2	4
9	4.9	14	1.0	2
10	2.1	4	0.8	3
11	24.6	25	1.2	3
12	6.2	5	1.0	4
13	20.5	3	1.0	2
14	1.2	8	1.6	4
15	–	–	0.6	2
16	–	–	0.6	2
17	–	–	0.8	3
Average	11.3	6	0.9	3
Mean Deviation	7.4	4	0.2	1
Standard deviation	8.7	6	0.3	1
Coeff. of variation (%)	77	100	31	33

Table 3 Comparison of Attributes of Literate and Illiterate Farmers

Attribute	Ikem Village		Aku Village		Nneyi Village		Average	
	Literate	Illiterate	L.	I.	L.	I.	L.	I.
Awareness index (%)	82	23	80	11	83	38	82	24
Good management index (%)	37	20	44	28	42	23	44	24
Willingness index (%)	99	87	98	90	96	85	98	87
Ratio of farmers who engaged in other business (%)	79	62	60	31	86	77	75	57
Number of resident dependants per farm family	6	6	8	8	6	6	7	7
Number of resident dependants engaged in active farming	1	2	1	2	1	2	1	2
Number of labourers hired per farm family	5	3	7	4	5	3	6	3
Number of farm units owned by a farm family	11	11	10	7	12	9	11	9
Size of largest farm units (ha)	1.4	1.2	1.3	1.2	1.3	0.9	1.3	1.1

Based on 1981 Field Survey. The villages are Isi-Uzo, Igbo-Etiti and Anambra Local Government Areas.

forts should be made to identify areas and farmers with attributes relatively more favourable to agricultural mechanization.

Table 3 gives a comparison of the values determined for literate and illiterate farmers. Literate farmers have higher awareness, good management and willingness indices than illiterate farmers. This result therefore re-emphasizes the importance of education as an essential instrument in modernizing and mechanizing traditional family farms. However, literate farmers engage a larger number of hired labourers than illiterate farmers. This tendency may be due to the following reasons: (1) literate farmers engage more in other business activities, e.g., teaching; (2) literate farmers have slightly greater number of farm holdings; and (3) literate farmers have slightly larger farm sizes.

Conclusions

Generalization of the socio-economic, ecological and agro-technical factors which impede the mechanization of agriculture in developing countries is misleading. This is because, as found in this study, a great deal of substantial variations in such factors can exist within a country, within a state of the country, within a division of the state, and even within any given village in a division of a state. This fact makes the concept of selective agricultural mechanization very crucial in any programme of farm mechanization in developing countries. The author has developed a master plan which underlines this important approach (Anazodo, 1976).

Literate farmers have higher awareness, good management and willingness indices than illiterate farmers. This finding highlights the important role of education and training in efforts to mechanize family farms in developing countries.

REFERENCES

1. Anazodo, U.G.N. 1976. A Programme for Selective Mechanization of Agriculture in the Nigerian Rain Forest Zone. In Appropriate Approaches for Accelerated Food Production in the Rain Forest Zones of Nigeria. Symposium Proceedings edited by U.G.N. Anazodo and E.U. Odigboh, University of Nigeria, Nsukka, pp 140 to 147.
2. Anazodo, U.G.N. 1982. Mechanication of Family Farms in Nigeria: A Quantitative Analysis of the Problems and Prospects. Submitted to AMA.
3. Carpenter, N.R. and Ahmed, M.M.A. 1969. Socio-Economic Problems Encountered in Dryland Farming Development. Proceedings of an International Conference on Mechanized Dryland Farming. FAO, pp 202-219.
4. Cleave, J.H. 1974. African Farmers: Labour Use in the Development of Smallholder Agriculture. Praeger, New York.
5. Fabiyi, Y.L. 1975. Structural Transformations of the Agricultural Production System in Western Nigeria: Land Reform, Land Settlement and Co-operatives. FAO, pp 25-33.
6. Fishes, L.A. 1972. Structure of Agriculture in Relation to Land, Labour and Capital. Proceedings of a Seminar on Resource Development in the Caribbean. McGill University, Montreal, Canada, pp 165-180.
7. Hopper, W.D. 1976. The Development of Agriculture in Developing Countries. Scientific American. September 1976. pp 197-205.
8. Innes, F.C.; Iton, S.; Hills, T.L. 1972. Socio-Economic Institutions: Plantations and Small Scale Agriculture. Proceedings of a Seminar on Resource Development in the Caribbean. McGill University, Montreal Canada, pp 133-155.
9. Iowa State University, 1962. How Farm People Accept New Ideas. Special Report No. 15. Cooperative Extension Service, Iowa State University, Ames, Iowa.
10. Schultz, T.W. 1964. Transforming Traditional Agriculture. New Haven. Yale University Press. Chapters 4 and 8.

Standardization and Quality Control in Agricultural Machinery

by
R.N. Sharma
Deputy Director (Agriculture and Food)
Indian Standards Institution
New Delhi, India

Introduction

Immense progress has been made in farm mechanization in India over a relatively short period. During the first two plan periods the emphasis was on improved tools and implements only. The programme of indigenous production of tractors and other sophisticated equipment made a modest beginning hardly two decades ago. Requirements of most of the power-operated equipment and tractors were, till then met out of imports. Now the position is different. Not only the entire requirements of some of the equipment are being met out of indigenous production, but there is an exportable surplus. The welcome feature auguring this momentous change in India is well-knitted planned programming of farm mechanization activity coupled with delineations and identification of the areas of immediate importance based on agricultural pattern and changing socio-economic structure of the country.

The Government is now paying special attention to the agriculture and rural development and about 40% of the budget allocation is being made for this purpose. Various policies and programmes are being re-oriented to accelerate agricultural production. Efforts are being made to substantially widen the production bases to raise the yield per hectare. The industrial sector is hoped to play a vital role in enhancing the productivity of the soil.

In the industrial policy, announced by the Union Government, a number of items have been reserved for the small industries which, inter alia, include most of the farm equipment. The policy also emphasises that the production in this sector should be economical and of acceptable quality. This now places a greater responsibility on the part of the manufacturers to pay more attention to the aspects of quality control and, as it is well known, standard is an effective tool in the process of a quality control. Moreover, in a developing economy like India's, industrial development in general and agro-industrial in particular, make it imperative to make an efficient use of all natural, organizational, technical and economic means. For this purpose, a coordinated, integrated, rational and efficient management for resource mobilization is of utmost importance. Experience has shown that standardization serves as an effective instrument in achieving this objective.

Standardization has been defined by the International Organisation for Standardization (ISO), as "an activity giving solution for repetitive application to problems essentially in the sphere of science, technology and economics, aimed at the achievement of the maximum degree of the order in a given context. Generally the activity consists of the process of formulating, issuing and implementing standards." An important benefit of standardization to the suitability of goods and services for their intended purpose on economical level. It helps all the concerned interests, namely; consumer, producer and technologists and leads to an overall economy. Therefore, to reap the benefits of standardization, the activity was extended to the field of agricultural machinery.

Standardization of Agricultural Machinery

The work on standardization of some of the hand tools used on plantation farms was started in the early fifties under the Estates Implements Subcommittee of Engineering Division Council of the ISI. Dr. M.S. Randhawa (the then Chairman of Agricultural and Food Products Division, Council of the ISI) made a suggestion for setting up of a separate committee to deal with the standardization of

all types of farm machinery. The conference on Production, Distribution and Popularization of Farm Implements organized by the Indian Council of Agricultural Research (ICAR) gave a fillip to the idea and at the instance of the Ministry of Agriculture, ISI set up a Farm Implements and Machinery Sectional Committee in 1959 under its newly created Agricultural and Food Products Department. Initially, hand tools and animal-operated equipment were taken up for the preparation of standards. Keeping in view the enhanced manufacture and use of the equipment for mechanizing agricultural operations, the need was felt for vigorous standardization programme and the activity was geared to cope with the demand. The work which was limited only to hand tools for plantation and estates in early fifties now encompasses the areas relating to almost all types of farm machinery such as tractors and power tillers. So far over 150 Indian Standards (list of which can be procured from the ISI on request) have been published on these equipment.

During the early years of standardization, emphasis was laid on the preparation of standards mainly based on specifying material for different components and giving general guidelines for manufacturing of components based on the design and drawings supplied by the Ministry of Agriculture. However, with the technological development, it was felt that the concept of strict material and design specification is neither necessary nor possible for national standards on farm machinery. Hence, the committee thought in terms of preparation of performance-oriented specifications for whole equipment and also diversified its activities on standards for interchangeable components, test procedures, operational practices, etc.

Standardization has practically no limitations as illustrated with a circle (Fig. 1). This we can divide into a number of sectors to illustrate the major functions for standardization in relation to agricultural machinery.

Standards on Terminology on crop protection equipment, combines, dryers, farm implements and machines, in general, have been published and the work on other areas are in progress. In all fields of technology fundamental rules should be observed. Basic rules are not designed for a specific field but are generally applicable. In almost all these basic areas standards have been formulated. A thorough knowledge of these basic rules would not only be helpful to the engineers in standardization but in all walks of industrial activity. Standardization of *dimensions* is the very important task in this process. By defining dimensions we can achieve interchangeability for various components. *Variety reduction* is another area of importance. To give one example in earlier specifications on discs three different radius of curvatures have been stipulated for different sizes. This meant that 3 jigs were required for giving concavity leading to higher cost.

Standardization covers much more now than in earlier days when dimensional problems were the predominant ones. Dimensional interchangeability is not enough. *Functional interchangeability* is equally important. This has been done by specifying the strength of material, hardness and a minimum number of good operations in various equipment standards.

A standard is a most active document that is used by designers, planners, purchasers. The standards are based on data. However, stipulation of various properties and characteristics without having *test methods* for any requirement is unthinkable. Therefore, test

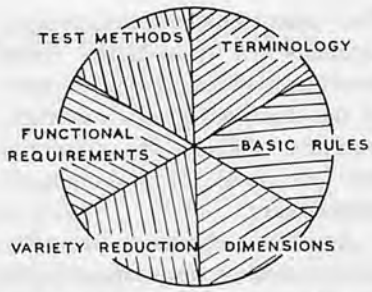


Fig. 1 Major functions for standardization in relation to agricultural machinery

methods represent an important aspect of standardization.

Quality Control

Farmer's acceptance of an equipment depends on the quality of the product. "Quality is never an accident, it is the result of intelligent effort, there must be the will to produce a superior thing" said John Ruskin as far back as in 19th century.

The term 'quality' does not convey the popular meaning of the 'best' in absolute sense but it is only the best under certain consumers' condition which includes the functional requirements and cost considerations. Preferably it refers to the composite characteristics of the product which determine the degree to which it will meet its actual end use at the most economic level. The term control means to make something behave the way we want it to be properly integrated with the standardization effort to achieve overall economies and get the maximum results. If the inter-relationship between quality control and specifications is analysed more closely, it would be clear as to how the two are complimentary to each other. A specification has to be drawn up after careful consideration of the various factors like functional requirement, consumer demand, cost consideration and process capabilities of the firms.

The assessment of the process capability in quantitative terms becomes very important in view of the variations in raw materials, machines, skills of the personnel and the level of technological advancement.

Another advantage of the quality control programmes is to fix the responsibility for the product quality at all stages of manufacture. This results in smoother relationship between various departments and the various personnel in the factory. It also creates quality consciousness in the mind of all the employees in the factory thereby resulting in improvement in the quality of the finished product. The quality control programme not only suggests the points where the inspection should be carried out but also suggests the points of inspection.

Implementation of the Standards

It is a well known fact that scientific insights remain inert knowledge unless they become the content of people's education. This is equally true for the standards. Since the formulation of standards is time – consuming and costly affair if they are not utilized by those to whom they are meant in their profession/business, the effort would go waste and knowledge contained in the standard would remain inert. It is, therefore, necessary that the standards are implemented or used by the manufacturers/technologists, purchasing agencies, testing authorities, exporters, etc.

Certification

Every consumer purchasing goods in the market has a right to get his money's worth. But in a free industrial economy, assurance of quality and suitability of article is a big problem. Deceptive finish, attractive packaging and sweet salesmanship confuses the consumer who neither has the technical know-how nor the necessary where-withal to judge the quality of products required by him. In western countries consumers are not only themselves wide awake about standardization and quality control but also have formed effective associations to look after their interest. These associations carry out comprehensive evaluation of industrial products and publish the results in their journal for the guidance of consumers.

To make quality goods available to the consumer, the ISI operates Certification Marks Scheme under which licences are issued to manufacturers for affixing the ISI mark on their products if they conform to the relevant Indian standard. For this purpose, the ISI initially inspects the applicant's factory with a view to ascertaining the capability of the manufacturer to produce quality goods on the basis of his production process, facilities for testing, availability of competent technical personal for manufacturing, inspection, etc. After testing a few of his products initially for the various quality requirements, the ISI draws up an elaborate scheme of testing and inspection in consultation with the manufacturer for his day-to-day use. After the grant of the licence, the ISI also exercises supervisory control on the manufacturing process in the following manner:

a) Regular inspection of records/charts maintained by the manufacturer in accordance with the scheme of testing and inspection.

b) Periodic drawing of sample from the licencees's factory for testing them independently.

c) Testing of the samples drawn from the licensee's factory in ISI or independent laboratories (in case the facilities for conducting the test in ISI lab is not available or the work load is more. ISI has a provision for approving the laboratories for conducting the tests of the products).

d) Surprise inspection of the licensee's factory.

e) Purchase of market samples and getting them tested at the ISI or approved laboratories.

Conclusions

The agricultural machinery industry has been continuously growing and has contributed significantly in increasing agricultural production. With more and more emphasis on increasing the productivity of the soil and post harvest operations, the industry would continue to expand. Standardization to these equipment, which was started about two decades ago, has contributed to a great extent in the growth of the industry. Adoption of these standards at all level, active participation in the process of formulation of standards and demanding equipment bearing ISI mark would not only improve the quality of the equipment but would also ultimately help in increasing the agricultural production and enhancing the programme of rural development. ■■

Paddy Straw Utilization for Bags and Mats

by
M.M. Kashyap
Head, Department of Processing and Agricultural Structures
College of Agricultural Engineering
Punjab Agricultural University
Ludhiana 141004, Punjab, India

Amar Singh
Assistant Research Engineer, Department of Processing and Agricultural Structures
College of Agricultural Engineering
Punjab Agricultural University
Ludhiana 141004, Punjab, India

Abstract

Paddy straw bags were fabricated and tested to find their suitability for handling and transportation of potato. The wrap, weft and seam strengths of these bags were compared with those of jute bags. Straw bags containing potato were also subjected to drop transportation and storage tests. During these tests the damage of potato in straw bags was less as compared to that in jute bags.

Introduction

Paddy straw is available in bulk almost at no cost in Punjab. It is estimated that the total production of paddy straw was 6 million tons during 1979/80. Generally, the straw is burnt in the field due to high storage and transportation cost. But paddy straw can be effectively and economically utilized as raw material for paper, feed and cottage industries and thus can provide a large number of rural people with employment in their spare time.

Generally, jute bags are used for handling and storage of potato and other perishable vegetables. These bags are costly and do not absorb shocks during handling or transport. Thus, the potatoes are exposed to direct impact which can cause damage to the extent of 30 %. The bags which can be made of paddy straw cheaply can be put into use for safe transportation and storage of potato with less damage as they act as shock absorber. This study was undertaken to investigate the feasibility of converting paddy straw into bags and to test the utility of these bags for handling and storage of potato and other vegetables.

Material and Methods

Jute yarn and straw of the Jaya variety of paddy were used for making the bags the capacity of which ranges from 25 to 50 kg of potato. It required about 50 g of jute yarn and 800 g of straw at 14% moisture content (w.b.) to make a bag of 50 kg capacity. The bags (Figs. 1 and 2) were fabricated mechanically by a power mat loom developed in collaboration with the Luxhmi Industries and the Department of Processing and Agricultural Structures, Punjab Agricultural University, Ludhiana.

Paddy straw and jute yarn were used in wefting and wrapping in the mat making process. The bags were fabricated from these mats.

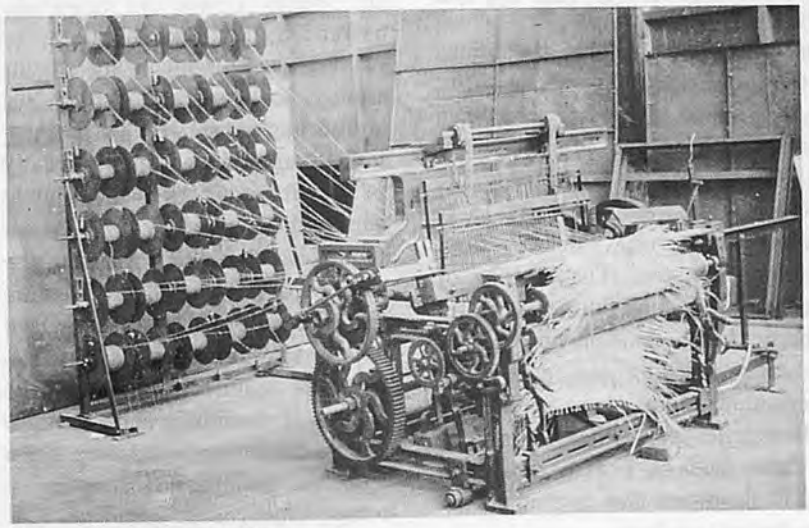


Fig. 1 Paddy straw mat loom

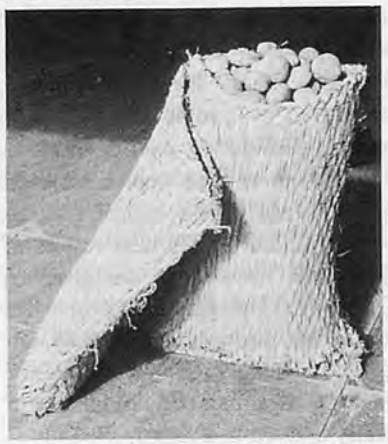


Fig. 2 Paddy straw bag filled with potatoes

The various engineering properties such as wrap, weft and seam strength of the straw bags were studied in accordance with Indian Standard (15: 2566-1966) and were compared with those of standard jute bags.

The bags were also tested for their utility and durability during manual handling, transportation and storage. Drop test was conducted to determine the extent of damage to the potato caused by impact on cemented and kuchha floors. In these tests, external damage such as bruising, cracking, sprouting and weight loss of potato was noted.

Results and Discussion

The wrap strength of paddy straw bags was 50 kg which is nearly one third of that of jute bags. But paddy straw bags containing potato seemed to have sufficient strength as no failure was observed during handling and transportation. However, the wrap strength can be increased by using more jute yarns or by using other yarns with greater tensile strength.

The weft strength of straw bags was 350 kg while that of jute bags was 160 kg as specified by Indian Standard Institution. Though the straw bags were sufficiently strong to handle and transport 50 kg of potato the seam strength was very poor in comparison to that of jute bags. But this can be improved by double stitching with cotton yarn and by overloading.

The above tests were conducted at the Jute Technological Laboratories, Calcutta. The test results of jute and straw bags are given in **Table 1**. The physical properties of paddy straw and jute bags are given in **Table 2**. The economics of making bags manually and mechanically is given in **Table 3**.

Transportation and drop tests were performed at the Punjab Agricultural University Research Farm, Ludhiana. During transportation, it was observed that external damage of potato was 12 % in straw bags and 22 % in jute bags which may be due to the cushioning effect provided by straw bags. The damage to potato contained in straw bags and jute bags was 6.56 and 12.5 %, respectively, on cement floor; and 7.61 and 15 %, respectively, on kuchha floor during drop test. The bruising of potato on kuchha floor was greater than that on cemented floor whereas cracking was greater on cemented floor due to surface characteristics of the floors. The weight loss of potato stored in straw bags was less in comparison to that of jute bags.

Table 1 Comparative performance of straw and jute bags

Type of Bags	Total weight (g)	Length (cm)	Width (cm)	Breaking load (kg)		
				Warp	Weft	Side seam
Paddy straw	900	100	60.0	50	350	13
B-Twill jute	1 020	112	67.0	160	170	64
A-Twill jute	1 190	112	67.5	204	180	67
Heavy Cee jute	1 020	104	71.0	160	180	61

Table 2 Physical properties of paddy straw and jute gunny bags

Type of Bag	Approx. dimensions (cm)	Thickness of 20 bags stacked vertically (cm)	Bulk Wt. of 20 empty bags (kg)	Estimated volume required to transport empty bags, m^3	
				For 100 bags	For bags required to pack 10t of potates
Jute gunny bag (100 kg capacity)	107 x 65	15	19.5	0.52	0.52
Paddy straw bag (25 kg capacity)	75 x 50	40	17	0.75	3.00
Paddy straw bag (50 kg capacity)	100 x 60	40	22	1.2	2.40

Table 3 Economics of paddy straw bags manufacture

Item	Cost
Estimated market price of power loom	Rs 12 000
Power requirement	1 hp electric motor
Operator-cum-weaver requirement	1 person
Output of mechanical set-up	10 bags per day (50 kg capacity)
Output of a single craftsman without power loom	1 bag per day (50 kg capacity)
Estimated unit cost of bag, 50 kg capacity (with power loom)	Rs 3.50
Estimated unit cost of bag, 50 kg capacity (without power loom)	Rs 11.00
Present cost of jute gunny bag (estimated)	Rs 7.50

Conclusion

Paddy straw can be used for making bags which are strong enough for handling, transporting and storing potato with less mechanical damage. The optimum capacity of these bags is 50 kg. They should be handled carefully and hooks should not be used for lifting the bags full of potatoes. These bags are also suitable for storing seed potato. However, further investigations are required to improve the quality of these bags and to reduce the production cost. ■■

Calotropis procera (Ait.) R. Br. — Ak: A New and Free Source of Fibre and Renewable Hydrocarbons

by
Subhash S. Arora
Scientist S-1
Division of Plant Studies
Central Arid Zone Research Institute
Jodhpur-342 003, India

Kiran S. Arora
Scientist S-1
Division of Plant Studies
Central Arid Zone Research Institute
Jodhpur-342 003, India

Introduction

Due to the fast depleting resources, and increasing cost of fossil fuel developed or developing countries are forced to look to their own domestic new and renewable energy resources in order to be self-reliant and to save valuable foreign exchange. A step towards this direction was put forth by the first UN energy conference on new and renewable energy resources concluded in August, 1981 in Nairobi. In the conference, the Indian Prime Minister Mrs. Indira Gandhi, in her keynote address stressed the exploitation of, among others, the energy plantations – the green plants which use solar energy to produce various products usable directly or indirectly as hydrocarbons. These products include tall oil and its derivatives (fatty acids, rosin acids), waxes, tannins (phenolic compounds), and natural rubber.

Calvin(1974) suggests that hydrocarbon-producing plants be studied and developed as future oil and chemical resources. Since then there had been increasing interest in growing green plants for direct use as fuel. "Even more serious consideration is being given to green plants as sources of biomass for conversion to synthetic fuels and chemical feedstocks. Such energy farming concepts may soon become practical . . . The above considerations and our national goal of future self-sufficiency in energy and basic raw materials requires that new crop sources of hydrocarbons be developed. If the whole plant is harvested and utilized (a practical requirement for Guayule and other rubber-bearing species), agricultural hydrocarbon production can be compatible with increasing food and fibre production. Crops can be developed that will not only provide hydrocarbon but also fibre and producing carbohydrate. Furthermore, plant species are available which produce hydrocarbons on land unsuited for conventional crops. An extensive research and development programme is needed to select preferred plant species, to improve them genetically, to develop their agronomy, and to provide for their practical utilization" (Buchanan et al., 1978).

One such plant known since long as a multipurpose, non-competitive, versatile and now reported to yield hydrocarbons is Calotropis procera (Ait.) R. Br. (Eradman and Eradman, 1981), more popularly known as Ak (Sheriff, 1869) which grows abundantly in the arid and semi-arid zones of India but has a world wide distribution.

Distribution

Ak is a woody, broad-leaf, evergreen shrub (2 m tall) or a small tree (5 m tall) (Uphof, 1959 & 1968) widely distributed in the arid and semi-arid zones of the world like the Caribbean, Central America, South America (Little et al., 1974), Africa (Uphof, 1959; Mahmoud et al., 1979), India (Uphof, 1959; Raheja, 1966; Saxena and Singh, 1976) and Israel (Karschon, 1970).

Of the six species of the genus Calotropis, only three are common in India but the C. procera and C. gigantea are economically important and resemble each other in many morphological and economic atrributes (Shastri, 1950). Only the former, locally known as Ak, Madar or Akdo (Bhandari, 1978) is, however, common in the arid and semiarid regions of Rajasthan, particularly forming the dominant element of rural vegetation. It is so common in the area to the extent that it has been termed

as a weed (Sen, 1979). Ak behaves in Rajasthan as a psammophyte and is an anthropophilous plant (Meher Homji, 1977). It is a member of Prosopis cineraria – Capparis decidua type vegetation (rainfall 150 – 400 mm with 9 to 11 months dry and grows on old alluvial sandy soils). Its growth has also been related to calcium deposits of the soil (Meher Homji, 1977) and reported to exist on saline soils containing less then 0.16% soluble salts up to a depth of about 2 m with no "kankar pan", even though they have a pH value about 9.0 in lower horizons (Raheja, 1966). Kaul (1963) attributes its distribution to the mixed xeromorphic woodland or wooded desert (the formation dominated by aeolian deposits or stabilized sand dunes where the soils are deep greyish brown, fine loamy sand, weakly to highly calcareous).

Uses

Ak is widely used as a fibre source (Chevalier, 1946; Uphof, 1959), ruminant feedstuff (Canell et al., 1966; Mahmoud et al., 1979; Arora and Arora, 1979), medicinal drug preparation (Chopra et al., 1958; Uphof, 1959; Kirtikar and Basu, 1975; Garg, 1979), microbial inhibitor (Shukla et al., 1961; Khurana and Singh, 1972; Ahmed and Agnihotri, 1977), infanticide (Uphof, 1959) and poison (Sharma, 1934; Watt and Breyer-Brandwijk, 1962; Biedner et al., 1977; Lewis and Elvin-Lewis, 1977; Garg, 1979), green manure (Maheshwari and Singh, 1965; Aggarwal and Sharma, personal communication), a source of rubber-like product and chrcoal used for gun-powder (Uphof, 1959), soil binder (Saxena, 1977) and as a plant that can help improve soil water conditions (Lahiri, 1977). Inspite of the fact that Ak is widely distributed and used, its sustained commercial exploitation has, however, been thus far unsuccessful (Erdman and Erdman, 1981), much on the lines of limited economic development in the common milkweed of northeastern America (Asclepias syriaca) (Gaertner, 1979).

Even as the Ak could not be exploited commercially thus far in the arid and semi-arid zones of India, it is nonetheless most popular and a free source of white, silky, strong, cylindrical, flexible and durable stem fibre used for various purposes, viz., for making ropes to form cheap cots, gunny bags, fishing nets, ropes, and in the manufacture of paper, pulp and duplicating stencils (Arora and Arora, 1979). Also, the floss fibre which is about 2 – 3.5 cm long, white silky and strong is used in stuffing mattresses and pillows because it can not be spun alone being short-stapled. The reports on Ak's medicinal uses known since ancient times (Chopra et al., 1958) and its special place in leprosy cure in India (Uphof, 1959; Lewis and Elevin-Lewis, 1977) still hold true. The fibre yielding capability of the plant can indeed be exploited commercially provided a regular supply of it could be assured through standardization of vegetative propagation and multiplication of the elite plants, by developing agronomic, genetic and breeding means as there is no doubt that Ak can compete well with the most popular jute fibre, at least for making ropes and allied uses.

More recently, however, a special interest has been generated in the Ak as a possible source of hydrocarbons after the report by Erdman and Erdman, (1981). Their hexane extraction of Ak yielded a high-density fluid, rich in hydrocarbons. The ratio of carbon and hydrogen in hexane extract (HE) was similar to crude oil, fuel oil, gasoline, and the oxygen level was, however, 7–9 times greater than the crude oil. The gross heat value content of HE from various plant segements (stems, leaves, pods and flowers) ranged from 9 769 – 10 070.7 cal/g and was greater than coal and comparable to crude oil and fuel oil. The heat value content of methanol extact (ME) was generally comparable to lignite coal and less than wood (**Table 1**). Further, the hydrocarbon yield and heat value content of Ak were comparable to those of the much more popular energy farming plant, Euphorbia lathyris (Nemethy et al., 1979) but the HE yields from pods of the former was twice that of the latter. "Although C. procera annual yields/ha are unknown, they probably will exceed Euphorbia species (E. lathyris and E. tirucall because of the former's comparatively fast growth rates . . . In summary, the

Table 1 Characteristics of Extractables from Calotropis procera (Ait.) R. Br.

Item	Density[a] g/cm³	Total ash %	Gross heat value cal/g	Carbon %	Hydrogen %	Oxygen %
Whole plant-HE[b]	0.9299	0.71±0.05[c]	9,973.4±19.2	78.03	11.22	10.71
Stems-HE	0.9153	0.80±0.06	9,769.6±79.9	78.70	11.36	10.11
Leaves-HE	0.8817	0.78±0.01	10,003.3±66.7	80.09	11.10	8.59
Pods-HE	0.9367	0.27±0.02	10,070.7±19.1	79.00	10.93	10.03
Whole plant-ME[b]	1.2267	12.05±0.07	4,647.4±00.1	40.88	6.86	30.05
Stem-ME	1.2960	9.82±0.04	4,238.0±47.5	35.33	6.49	40.00
Leaves-ME	1.2469	14.27±0.21	4,648.5±43.6	41.90	6.56	29.99
Pods-ME	1.2228	12.23±0.12	4,625.7±40.1	41.27	6.97	39.65
Anthracite coal	–	9.6	7,155.6	97.7	2.90	6.10
Lignite coal	–	5.9	3,888.9	40.6	6.90	45.10
Crude oil	–	–	10,505.6	84.0	12.70	1.20
Fuel oil	–	–	10,764.4	85.62	11.98	0.60
Gasoline	–	–	11,527.8	84.90	14.76	–

a, 23.0°C. b. HE and ME defined as hexane extract and methanol extract, respectively. c. Mean ± standard error; N = 30 observations per mean.

data demonstrated that C. procera can be used as a renewable source of hydrocarbons and intermediate energy resources. The growth characteristics and nutritional requirements of the plant support this type of economic development. Additional work must now be undertaken to determine potential crop yields, harvest capabilities and chemical composition of the extractables from C. procera" (Erdman and Erdman, 1981). It is, therefore, obvious that the vast untapped potential of Ak has to be exploited more as a hydrocarbon source apart from being a versatile and multipurpose plant, having industrial or domestic importance.

Research Accomplishments

Enumerated below are CAZRI research efforts in the direction of exploitation of the Ak as a fibre and hydrocarbon source along with a few suggestions for the future line of work which could possibly be taken up for further yield improvement.

A research project on this plant was undertaken at the CAZRI in 1977 considering the plant's weedy growth. There may be 5 000 to 10 000 plants/ha growing naturally in the arid and semi-arid areas of the Western Rajasthan (Saxena, personal communication), but, unfortunately, not being put to any commercial use though the local people, as reported above, use it extensively as a good and free source of fibre and medicine. The objective of the project was to see the regeneration and growth capacity of the crop, in other words, to know how many times the plant could be cut per year and in its life cycle, till it keeps yielding stem fibre, floss fibre, latex or hydrocarbons. An attempt for the genetic and breeding improvement in the economic yields was also envisaged and tried so that appropriate Ak based industries could be developed in the arid areas to uplift the economic condition of the poor masses.

Ak Coppicing Ability

The objective of this study is to compare the performance and regeneration capacity in Ak after the plants are cut for the stem fibre or for the hydrocarbon yield, for which genetic improvement in yield is ultimately sought.

Material and Method

Twenty-six plant progenies collected from various parts of the arid and semi-arid regions of Rajasthan were raised through seeds at Jodhpur. Of these, five plant progenies were randomly selected for analysis of plant height, number of tillers per plant, internodal length, stem diameter, number of branches per plant, and fresh and dry weights per plant. Data were recorded on five randomly chosen plants in each progeny row and the mean was calculated (Table 2). The progeny rows chosen were Nos. 9, 10, 12, 16 and 21. The plants were then first cut in April to provide data for fibre yield and allowed to regenerate for the ensuing six months when the plants were again cut for the same purpose. After both cuttings the defoliated plants were completely soaked in water to ret for 3–5 days, completely air dried and then repeatedly thrashed to yield stem fibre.

Results and Discussion

Regeneration of the Ak plants were 90% after the cut. There was an overall excellent growth in the plant progenies after the first cut; 71% increase in the plant height; 114% increase in the number of tillers per plant; 21% increase in stem diameter; 34% increase in number of branches per plant; 49% increase in fresh or green weight per plant; and 73% increase in dry weight per plant in the population regenerated after the cut over the population raised through seeds. The increase was significant for plant height, number of tillers, stem diameter and dry weight but not on the increase in number of branches and fresh weight. It was also observed that the leaves in the regenerated population were broader and greener compared to the earlier population. These observations support the findings of Karschon (1970) that the plant is resistant to fire and coppices profusely.

Significant increase in characters like plant height, number of tillers,

Table 2 Comparative Performance of Five Calotropis procera (Ait.) R. Br. Single Plant Progenies

Row No.	Height (cm)		No. of tillers		Diameter of main stem (cm)		No. of branches		Fresh weight per plant(kg)		Dry weight per plant	
	a	b	a	b	a	b	a	b	a	b	a	b
9	200.80	106.60	8.50	4.00	1.43	1.19	5.00	3.00	3.19	2.39	0.93	0.74
10	179.00	107.50	14.66	7.00	1.38	1.14	8.00	4.00	3.56	0.85	0.96	0.27
12	157.50	111.80	9.50	5.00	1.42	1.19	6.50	4.00	2.30	2.27	0.57	0.67
16	195.60	105.80	10.00	4.00	1.58	1.17	5.20	6.00	2.27	1.61	0.73	0.47
21	177.80	102.20	8.80	4.00	1.27	1.18	4.86	5.00	1.28	1.39	1.28	0.46
Total	910.70	532.90	51.45	24.00	7.08	5.87	29.56	22.00	12.60	8.51	3.79	2.61
Mean	182.14	106.58	10.29	4.80	1.42	1.17	5.91	4.40	2.52	1.70	0.76	0.52
±S Em	±7.63	±1.54	±1.12	±.58	±.04	±.01	±.59	±.51	±.39	±.28	±.08	±.08
Percent increase of a over b	70.89		114.37		21.36		34.31		48.73		73.07	
't' value	8.83##		9.03##		4.77##		1.72NS		1.62NS		2.26##	

a = plants cut for the second time. b = plants raised through seed and cut first time.
= significant at 1% level of probability. NS = Non-significant

stem diameter and dry weight tend to contribute more towards fibre and hydrocarbon yield and should, therefore, be considered in genetic research for increasing the economic yields.

Vegetative Propagation in Ak

Since the Ak is a highly cross pollinated taxon through insects, the progeny is genetically both divergent and different than its parents. A need, therefore, was felt to device a vegetative propagation method to screen and multiply plants with superior genotype in histochemical attributes like stem and floss fibre, latex or hydrocarbon yield.

Table 3 shows the percent range success/failure achieved in vegetative propagation through root cuttings (5–10 cm long); stem cuttings (at least with two nodes or 8–10 cm long), stumps (at least 10 cm long–a part of root and a part of stem), and half-stumps (at least 10 cm long; stumps cut longitudinally into . . . almost two equal parts) without any hormonal or any other such treatment.

Significant success was achieved in the case of stumps and half-stumps but not for the root and stem cuttings.

Vegetative propagation through half-stumps assumes a special importance as compared to the entire stumps for the simple reason that propagation through half-stumps helps in faster multiplication of the parent genotypes with plus characters as each plant gives rise to two half-stumps. Stumps also help in propagating only one plant.

Table 3 Vegetative Propagation through Four Cuttings in Calotropis Procera (Ait.) R. Br.

Treatment	Sprouting (%)
Stumps	97.50 a
Half stmps	35.00 a
Root cuttings	0.00
Shoot cuttings	0.00
SEm ±	3.14
C.D. at 5%	14.16
C.D. at 1%	25.98

a: Significant at 1% level

Vegetative propagation through stem and root cuttings is also important, as is very well known, because these help in large scale multiplication of the superior genotypes provided it is a success. No success, however, could be achieved thus far in untreated stem and root cuttings in Ak and, therefore, further work is underway to propagate Ak with stem and root cuttings treated with varying concentrations of giberallic acid and auxins.

Future Line of Work

It is rather unfortunate that such a valuable and abundantly growing plant which has been termed as 'weed' of agricultural land has gone unnoticed in so far as exploitation of genetic variability for economic characters like fibre yield and hydrocarbon yield.

Some important problems in the exploitation of this plant must be mentioned.

1. Nothing is known about the agronomic requirements of the plant such as water needs, intra- and inter-row spacing, fertilizer and cutting management requirements, etc.
2. Suitable physical method(s) for the extraction of fibre and hydrocarbon are not yet known precisely.
3. The length of floss fibre is too short to be spun alone.
4. Because of its windespread medicinal uses, there is need to increase the latex yield so that it could be industrially exploited. At present a plant yields about 50 ml of latex (Arora, 1980) when extracted manually by a crude method.
5. The vegetative propagation of the elite plants through stem and root cuttings, which have failed far, should be tried as it holds a great potential for faster multiplication.
6. Genetic sutdies are lacking about the plant's important characters such as hydrocarbon and fibre yields, and their relation to a single or many genes.
7. The Ak flower structure is a very complex one and, therefore, requires suitable in vitro or in vivo methods of hybridization.

REFERENCES

1. Ahmed, S.R. and J.P. Agnihotri 1977. Antifungal activity of some plant extracts. Indian J. Mycol. Plant Pathol., 7: pp. 180-181.
2. Anonymous 1980. In Annual Progress Report of the Central Arid Zone Research Institute, Jodhpur.
3. Arora, Subhash S. 1980. Study of comparative performance and regeneration capacity in Aakra, Calotropis procera (Ait.) R. Br. Annals of Arid Zone (Submitted).
4. Arora, Subhash S. and Kiran S. Arora 1979. Aakra – A valuable weed of desert. Sci. Pen. 18: pp 630-631.
5. Bhandari, M.M. 1978. Flora of the Indian Desert. Scientific Publishers, Jodhpur.
6. Biedner, B., L. Rothkoff and A. Witztum 1977. Calotropis procera (sodom apple) latex kerato-conjunctivitis. Israel J. Med. Sci., 13: pp 914-916.
7. Buchanan, R.A., I.M. Cull, F. M. Otey and C.R. Russell 1978. Hydrocarbon and rubber-producing crops: Evaluation of U.S. plant species. Econ. Bot., 32; pp 131-145.
8. Calvin, M. 1974. Solar energy by photosynthesis. Science, 184: pp 375-381.
9. Canell, C.F.C., C.H. Tokarnia and J. Dobereiner 1966. Experimentos com plantas tidas como toxicas realizados em bovinos no nordeste do Brasil,

com resultados negativos. Pesq. Agropec. Bras, 1: pp 345-352.
10. Chevalier, A. 1946. Les arbres a kapok at les autres producteurs de soies vegetales. Rev. Int. Bot Appl. Agric. Trop., 26: pp 517-524.
11. Chopra, R.N., I.C. Chopra, H.C. Handa, L.D. Kapur 1958. Indigenous drugs of India. U.N. Dhuv and Sons. Private Limited, Calcutta.
12. Erdman, M.D. and B.A. Erdman 1981. Calotropis procera as a source of plant hydrocarbons. Econ. Bot., 35: pp 467-472.
13. Gaertner, E.E. 1979. The history and use of milkweed (Asclepias syriaca L.). Econ. Bot., 33: pp 119-123.
14. Garg, A. 1979. Effect of Ak, Calotropis procera (Ait.) R. Br., flower extract on testicular function of the Indian desert male gerbil Meriones hurrianae Jerdon: Indian J. Exp. Biol., 17: pp 859-862.
15. Karschon, R. 1970. Contribution to the arboreal flora of Israel: Calotropis procera (Willd.) R. Br. La-Yaaran, 20: pp 41-48.
16. Kaul, R.N. 1963. In Annual Progress Report of the Central Arid Zone Research Institute, Jodhpur.
17. Khurana, S.M.P. and S. Singh 1972. Studies on Calotropis procera latex as inhibitor of tabacco mosaic virus. Phytopathol. Z., 73: pp 341-346.
18. Kirtikar, K.R. and B.D. Basu 1975. Indian Medicinal Plants (2nd. Ed.). M/S Bishen Singh Mahendra Pal Singh, Dehra Dun.
19. Lahiri, A.N. 1977. Plants in relation to soil moisture conditions of the arid areas. Mann, H.S. (Ed.) Desertification and its Control, ICAR, New Delhi.
20. Lewis, W.H. and Memory P.F. Elvin-Lewis 1977. Medical Botany – Plants Effecting Man's Health. John Wiley, New York.
21. Little, E.L., R.O. Woodbury and F.H. Wadsworth 1974. Trees of Puerto Rico and the Virgin Islands. Agriculture Handbook 2, USDA, Washington, DC.
22. Maheshwari, P. and Umrao Singh 1965. Dictionary of Economic Plants in India. ICAR, New Delhi.
23. Mahmoud, O.M., S.E.I. Adam and G. Tartour 1979. The effects of Calotropis procera on small ruminants. I Effect of feeding sheep with the plant. J. Comp. Pathol., 89: pp 241-250.
24. Meher Homji, V.M. 1977. The arid zones of India. In Mann, H.S. (Ed.) Desertification and its Control, ICAR, New Delhi.
25. Nemethy, E.K., J.W. Otvos and M. Calvin 1979. Analysis of extractables from one Euphorbia. J. Amer. Oil Chem. Soc., 56: pp 957-960.
26. Raheja, P.C. 1966. Aridity and salinity (A survey of soils and land use). In Salinity and Aridity – New Approaches to Old Problems. Dr. W. Junk N.V. Publishers, The Hague.
27. Saxena, S.K. 1977. Vegetation and its succession in the Indian desert. In Mann, H.S. (Ed.) Desertification and its Control, ICAR, New Delhi.
28. Saxena, S.K. and S. Singh 1976. Some observations on the sand dunes and vegetation of Bikaner District in western Rajasthan. Annals of Arid Zone, 15: pp 313-322.
29. Sen, D.N. 1979. Weeds. Sci. Today, 13: pp 50-54.
30. Sharma, G.K. 1934. Calotropis procera and Calotropis gigantea. Indian J. Veterin. Sci. Anim. Husb., 4: pp 63-74.
31. Shastri, B.N. 1950. The Wealth of India – Raw Materials. 2: CSIR, New Delhi.
32. Sheriff, M. 1869 (Reprinted 1976). A Catalogue of Indian Synomyms of the Medical Plants, Products, Inorganic Substances, & C., Proposed to be Included in the Pharmacopoeia of India. Periodical Exports Book Agency, Delhi.
33. Shukla, O.P. and C.R. Murti 1961. Bacteriolytic activity of Ak plant latices. J. Sci. Industr. Res., 20: pp 225-226.
34. Uphof, J.C.T. 1959. Dictionary of Economic Plants. H.R. Englmann (J. Cramer), New York.
35. Uphof, J.C.T. 1968. Dictionary of Economic Plants. Verlag Von J. Cramer, The Hague.
36. Watt, J.M. and N.G. Breyer-Bandwijk 1962. Medicinal and poisonous plants of Southern and Eastern Africa (2nd Ed.). Livingstone, Edinburgh. ■■

Co-operating Editors

Van Lancker G B Hanna A Kandiah M S Choudhury J P Mittal E U Odigboh N G Kuyembeh A H Abdoun M A Bedri I de A Nääs

A L Phillips A A Valenzuela A H Mirdha M R Goyal W J Chancellor M L Esmay S M Farouk K C Roy M Gurung Wang Wanjun

AFRICA

Julien G. Van Lancker
Professor Visitor (Agricultural Engineering), University of Brundi, Brundi

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

Arumugam Kandiah
Institute of Agricultural Research, P.O. Box 2003, Addis Ababa, Ethiopia

Mr. 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

N.G. Kuyembeh
Dean, Faculty of Agriculture and Head, Dept. of Agric. Engineering, Njara University College, University of Sierra Leone, Sierra Leone

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

Mohamed A. Bedri
Senior Agricultural Engineer, Consultant, Mechanized Farming Corporation (Mail Address: P.O.Box 407 Khartoum, (Sudan)

AMERICAS

Irenilza de Alencar Nääs
Assistant Professor, Agricultural Engineering Dept., State University of Campinas, SP, Brazil

Allan L. Phillips
Project Manager — FAO-UNDP Project CHI/77/002 Technical Assistance to the Agric. Engineering Institute at the University of Conception, Chillan, Chile

A.A. Valenzuela
Head, Agricultural Engineering Department, University of Conception, Chillan, Chile

A.H. Mirdha
Visiting Professor, Dept. of Agricultural Engineering, Faculty of Superior Studies-Cuautitlan of the National Autonomous University of Mexico, Apdo. Postal-128, Cuautitlan de R.R., 54800 Edo. de Mexico

Megh Raj Goyal
Assistant Researcher, Agricultural Experimental Station, University of Puerto Rico, Subestación de Frutales S.R. No.2 Buzón 101, Juana Diaz, Puerto Rico

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.

ASIA and OCEANIA

Shah M. Farouk
Head, Dept. of Farm Power & Machinary, Bangladesh Agricultural University, Mymensingh, Bangladesh

Kshirode Chandra Roy
Senior Scientific Officer, Bangladesh Agricultural Research Institute, Joyedebpur, Dacca, Bangladesh

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

Wang Wanjun
Chief Engineer and Vice Director of the Chinese Academy of Agricultural Mechanization Sciences, No. 1 Beishatan, Deshengmen Wai, Beijing, China

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

S.R. Verma
Dean, College of Agricultural Engineering, Punjab Agric. University, Ludhiana 141004, India

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

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
Professor, Dept. of Agricultural Engineering, College of Agriculture, Seoul National University, Suwen, 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

Allah Ditta Chaudhry
Associate Professor and Chairman of the Department of Farm Machinery and Power, University of Agriculture, Faisalabad, Pakistan (on leave to New Zealand: Agronomy Dept., Massey University, Palmerston)

Bherulal T. Devrajani
Principal Investigator, Sind Agriculture University, Tandojam, Pakistan

A.A. Mughal
Assistant Professor, 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, Phillipines

S Chandra A M Michael S R Verma S Soepardjo J Sakai B A Snobar C J Chung P Andreou M Z Bardaie N C Saxena

B K Shrestha A D Chaudhry B T Devrajani A A Mughal R M Lantin C C Lee R P Venturina M H A Aziz S Illangantileke S K Kamathamby

T Peng G Singh T T Pedersen G Pellizzi A Moens J Kilgour

Chul Choo Lee
Project Engineer, Projects Department, 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

M.H. Abdel Aziz
Professor of Irrigation Engineering and Head, Agricultural Engineering Dept., Riyadh Univ., Saudi Arabia

S. Illangantileke
Head, Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Sri Lanka

Suppiah Kathirkamathamby
Head, Agricultural Engineering Research and Development Division, Dept. of Agriculture, Peradeniya, Sri Lanka

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

EUROPE

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

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

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

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

New Co-operating Editors

David Boakye Ampratwum

Date of Birth: Jan. 6, 1936
Nationality: Ghana
Qualification:
M. Sc. Agric. Engineering, Univ. of Alberta, 1969
Ph. D. in Agric. Engineering, Iowa State Univ., Ames, U.S.A., 1975
Experience:
1966-79 Lecturer and Head, Agic. Engineering, Univ. of Ghana, Legon, Ghana
1977-79 Part-Time Lecturer, Agic. Engineering, Univ. of Cape Coast, Ghana
1979 Senior Lecturer & Head, Agic. Engineering, Univ. of Ghana, Legon, Ghana
1980 General Manager, Palm Oil Mills of Agric. Development Bank, Ghana
Present Position:
Part-Time Lecturer, Agic. and Food Engineering, Univ. of Ghana, Legon, Ghana

Amir Bakheit Saeed

Date of Birth: January, 1943
Nationality: Sudan
Qualifications:
B. Sc. (Hons) Agric. Eng. First Class, University of Khartoum, Sudan, 1968
M. Sc. Agric. Eng., University of Newcastle-upon-Tyne, U.K., 1972
Ph. D. Agric. Eng. (Soil and Water Engineering) National College of Agric. Eng. – Silsoe, University of Reading, U.K., 1976
Experience:
1968-1976 Assistant Research Officer, Dept. of Agric. Eng., Agric. Res. Corp., Sudan
1976-1978 Research Officer in Agric. Eng., ditto
1978 to date: Lecturer, Dept. of Agric. Eng., Faculty of Agriculture, University of Khartoum, Sudan

NEWS

The 1982 Kishida International Award Recipient

ASAE Fellow Merle L. Esmay, PE (center in the photo), is a professor in the Agricultural Engineering Dept. at Michigan State University. He joined the MSU faculty in 1955 after four years each with the Iowa State University Agricultural Engineering Dept. and the University of Missouri Agricultural Engineering Dept.. His BS is from South Dakota State University and his MS and PhD from Iowa State University.

In addition to his teaching, research and extension work at MSU the honoree has received considerable acclaim as a consultant with national and international organizations. These include USDA Commodity Stabilization Service, Aluminum Co. of America, Big Dutchman Equipment, US/AID, both the Ford and Rockefeller Foundations, the Asia Foundation, World Health Organization, International Rice Research Institute, International Crops Research Institute for the Semi-Arid Tropics, Food and Agriculture Organization, United Nations Industrial Development Organization. He also was a member of the board for Section II, International Commission of Agricultural Engineering (CIGR).

Esmay was selected for this honor because of his effective role in education and appropriate technological transfer with developing countries. He has written three books and many technical articles on Agricultural Mechanization in Developing Countries, Post Rice Production Technology in the Topics and Environmental Control. He has carried out 20 short-term and one long-term overseas consultancies, participated in 26 international conferences, and served as advisor for 19 international graduate students. As the first director of the ASAE International Dept., he has increased ASAE participation and technical exchange with Peoples Republic of China and other nations and increased services to overseas members.

World Bank and IDA to Support First Irrigation Project in India Using Underground Plastic Pipes

Small landholders in the Kallada River area of Kerala State, southwest India, will be helped in their efforts to increase agricultural productivity through a combined loan and credit from the World Bank and the International Development Association (IDA) totaling $80.3 million.

The Government of Kerala is providing half of the total costs of a $160.3 million project for year-round irrigation and more intensive cultivation of tree crops, primarily coconuts, on hillside lands and paddy crops in valley bottoms, in an area covering 37 600 hectares.

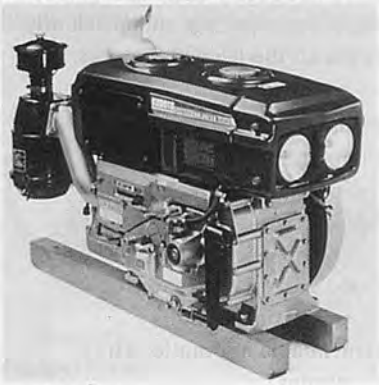
The funds will go towards completion, by 1984, of the partially completed Kallada dam and the construction of two main canals and associated minor water conveyance systems, and the provision of appropriate support services.

This will be the first major gravity irrigation project to be carried out in India using low-pressure underground plastic pipes to irrigate garden lands, where the topography does not permit the use of conventional open channel methods. The Kerala Department of Agriculture has established a special section to ensure that adequate support services are provided to farmers.

As a result of increased yields from tree crops and paddy, incomes of small landholders are expected to increase. The number of households below the poverty line is expected to be reduced by one-third within the project area. Civil works construction will generate about 22 000 jobs for five years.

The World Bank loan of $20.3 million will have a repayment period of 20 years, including five years of grace, at 11.6% interest per annum, and a standard front-end free of 1.5%. The IDA credit of SDR 52.3 million ($60 million) is for 50 years, including 10 years of grace; it carries no interest, but bears a small annual service charge of 0.5% on the undisbursed balances of the credit, and 0.75% on the disbursed balances. IDA is the World Bank's affiliate for concessionary lending. ■■

Kubota Diesel Engine ER2200



Features:
Economical operation.
Improved durability.
Large output, torque and displacement.
Easy starting.
Low vibration.
Easy maintenance.
[Specifications]
Type – Horizontal, water-cooled 4-cycle diesel engine
Number of cylinder – 1
Bore x Stroke – 116 x 105 mm
Displacement – 1.109 ℓ
Continuous rated output – 17/2 200 (HP/rpm)
Max. output – 22/2 200 (HP/rpm)
Max. torque – 8.3/1 200 (kg-m/rpm)
Cooling system – Radiator
Combustion system – Direct injection chamber
Fuel – Light diesel oil (SAE No. 2-D)
Lubricating oil – API service CB, CC-class (SAE #30, 20 10W-30)
Lubricating system – Forced lubrication with trochoid pump
Starting system – Speed doubling handle by hand
Cooling water capacity – 4.7 ℓ
Fuel tank capacity – 16 ℓ
Lamps – 12 V, 2 x 25 W (extra 25 W available)
Dimensions (L x W x H) – 1 024 x 453 x 667 mm
Dry weight – 192 kg
(Kubota, Ltd: 2-47, Shikitsu Higashi 1-chome, Naniwa-ku, Osaka 556, Japan)

Hinomoto Tractor Model E382 (2-WD)/E384 (4-WD)

Features:
Reliable, high performance 3-cylinder engine for quiet, many hours operation.
Hydraulic control mechanisms.
Full synchromesh mechanism for improved efficiency.
Mixed (position-draft) control.
12-forward and 4-reverse speeds for higher efficiency.
Easy-to-read instrumentation.
Independent PTO for a wider range of working.
Integral type power steering for high maneuverability.
Wet type disc brakes for superior braking, extended durability and improved safety.
Front wheel steering system allows sharp turns with a light touch (E384).
[Specifications]
Engine:
Model – Toyosha (Hinomoto) 3S20
Type – Indirect injection, water-cooled diesel
Bore x stroke – 92 x 100 mm
Capacity – 1 994 cc
Engine and PTO performance (DIN):
Max. power – 38 PS/2 500 rpm
Max. torque – 12.5 kg-m/1 700 rpm
Max. PTO power – 35 PS/2 500 rpm
Speeds – 12-Forward, 4-Reverse/24-Forward, 4-Reverse with L-H ranges and reduction range
Dimensions (L x W x H) and Weight:
Model E382 – 3 115 x 1 505 x 1 530 mm, 1 585 kg
Model E384 – 3 240 x 1 505 x 1 600 mm, 1 650 kg
(Toyosha Co., Ltd: 55, Joshoji-16, Kadoma-shi, Osaka 571, Japan)

Hinomoto Tractor C172/C174

Features:
Full synchromesh mechanism for improved efficiency.
Quiet, rugged, 3-cylinder high performance engine.
Hydraulic control mechanism.
Mixed (position-draft) control.
Lowering speed control.
Easy-to-read instrumentation.
Front wheel steering section allows sharp turns with a light touch.
9-forward and 3-reverse speeds with carefully selected gear ratios.
New differential lock functions positively when needed.
Small turning radious for improved maneuverability and working efficiency.
[Specifications]
Engine:
Make and Model – Toyosha (HINOMOTO) CS100
Type – Indirect injection, water-cooled diesel
Bore x stroke – 73 x 80 mm

Capacity – 1 004 cc
Engine and PTO performance (DIN):
Max. power – 18 PS/2 500 rpm
Max. torque – 5.6 kg-m/1 800 rpm
Max. PTO power – 15 PS/2 500 rpm
Speeds – 9-Forward, 3-Reverse
Dimensions (L x W x H) and Weight:
Model C172 – 2 100 x 1 035 x 1 200 mm, 580 kg
Model C174 – 2 100 x 1 035 x 1 200 mm, 658 kg
(Toyosha Co., Ltd: 55, Joshoji-16, Kadoma-shi, Osaka 571, Japan)

Iseki Tractors
Models TE4270 (2-WD and 4-WD)

Features:
Swirl-chamber type combustion system diesel engine for high fuel efficiency. Full synchromesh transmission. 18-forwar and 6-rev. speeds plus a creeping speed. Independent PTO clutch. Integral power steering system. Draft control device ensures optimum efficiency. Safety devices are equipped.
[Specifications]
Dimensions (L x W x H):
2 940 x 1 320 x 2 030 mm
Weight:
2-WD 1 020 kg; 4-WD 1 110 kg
Engine (Model E3AE1):
Type – Water-cooled, 4-cycle
No. of cylinder – 3
Displacement – 1 296 cc
(Iseki & Co., Ltd. 3-6, Kioi-cho, Chiyoda-ku, Tokyo 102, Japan)

Iseki Tractor
Model T9000 (2-Wheel Drive)

Features:
Low-speed, high torque engine. Wet-type air cleaner. Independent PTO clutch. Hydraulic system for accurate field controls. Integral power-assisted steering system. Wet-type multi-disc brake. Forward full synchromesh mechanism.
[Specifications]
Dimensions (L x W x H):
3 895 x 1 940 x 2 590 mm
Weight: 2 740 kg
Engine (Model 6BB1):
Type – Water-cooled, 4-cycle, diesel
Output – 90PS/2 200 rpm (DIN)
Displacement – 5 393 cc
Traveling speeds: 16-Forward, 4-Rev.
(Iseki & Co., Ltd., 3-6, Kioi-cho, Chiyoda-ku, Tokyo 102, Japan)

Kubota Diesel B6100DR Tractor

Kubota B6100DR is a 3 cylinder, 14HP diesel tractor with 4-wheel drive and rotary tiller that gets the work done quickly and efficiently. It has all the needed features.
Features:
Front and rear PTO shafts.
Comfortable operation from 3-stage adjustable bucket seat.
6 forward, 2 reverse speeds to match speed to work.
Good ground clearance for cultivating.
Dependable hydraulic lifting system.
Independent rear brakes.
Small turning radius for outstanding maneuverability.
Easy-to-use hitch.
Takes a wide range of implements.
[Specifications]
Dimensions (without rotary tiller) (L x W x H):
1 945 x 1 055 x 1 125 mm
Wheel base: 1 250 mm
Wheel tread:
Front – 725 mm.
Rear – 650, 750, 850 mm
Weight: 480 kg
Ground clearance (minimum): 230 mm
Engine:
Vertical, water-cooled, 4-cycle, 3-cylinder diesel engine
Max. bare horsepower – 14HP at 2 800 rpm
Piston displacement – 675 cc
Tavel speeds:
Forward – First 1.00 km/h, Sixth 13.31 km/h
Reverse – First 1.46 km/h, Second 6.69 km/h
Optional equipment:
Flashers, Front wheel weight, bumper weights.
Rear wheel weight, Front
(Kubota, Ltd: 2-47, Shikitsu Higashi 1-chome, Naniwa-ku, Osaka 556, Japan)

Kubota Diesel M7500DT Tractor

Features:
4-wheel drive.
Versatil 16-speed transmission.
540rpm "independent" and ground drive PTO.
Powerful hydraulic system.
Smooth, strong 4 cylinder engine.
Fast acting wet disk brake.

[Specifications]
Dimensions (L x W x H):
147-7/8 in. x 72 in. x 89-1/8 in.
Shipping weight: 5 666 lbs.
Wheel tread:
Front – 57-5/8 in.
Rear – 55-1/8–74-3/4 in.
Wheel base: 85-5/8 in.
Ground clearance (Minimum): 13-3/8 in.
Engine: (V4000-A 4-cylinder diesel engine)
Max. bare engine horsepower – 81HP/2 400 rpm
Max. PTO horsepower – 72HP/2 400 rpm
Piston displacement – 243 cu. in.
Hydraulics:
Capacity – Linkage pump 8.1 gpm at 2 500 psi
Implement control – Draft control/Position control/Mixed control
(Kubota, Ltd: 2-47, Shikitsu Higashi 1-chome, Naniwa-ku, Osaka 556, Japan)

Shibaura Stiger SD2843T Tractor

Features:
Exhaust gas drives turbo-charger which realizes economy in fuel consumption, higher output and clean exhaust gas. Synchromesh quick-shift transmission. IC-controlled hydraulic system.

[Specifications]
Dimensions (L x W x H):
2 865 x 1 322 x 1 823 mm
Weight: 1 100 kg
Engine (Water-cooled, 4-cycle):
Model – H843T
Output –28PS
Displacement – 1 396 cc
No. of cylinder – 3
Speeds: 24-Forward 8-Rev.
(Ishikawajima-Shibaura Machinery Co., Ltd.: 6-8, 1-chome, Nishishinjuku, Shinjuku-ku, Tokyo, Japan)

Yanmar Diesel Tractor YM (T) Series

Features:
Bigger radiator. Efficient air cleaning. Quick-cleaning radiator protection. Long-life filtration. Quick-read meters Handy levers Wide-use PTO. Fat-action 3-point hitch. Tough, all-terrain axle. All-go 4-wheel drive. Balance ballast.

[Specifications]

Dimensions:	YM 155DT	YM 241DT	YM 330DT
L (mm)	2 070	2 745	3 103
W (mm)	956	1 116	1 470
H (mm)	1 645	1 850	1 960
Weight (kg)	516	925	1 310
Engine (water-cooled, 4-cycle):			
Model	2TR 13Y	2TR 20A-Y	3T 84Y
Max. output (Hp/rpm)	15/ 2 700	24/ 2 400	33/ 2 600
Displace't,cc	662	1 145	1 496
No. of cyl.	2	2	3
Speeds:			
Forward	6	8	8
Reverse	2	2	2

(Yanmar Diesel Engine Co., Ltd.: 1-1, 2-chome, Yaesu, Chuo-ku, Tokyo 104, Japan)

Kubota Power Tiller Diesel K75 Series

[Specifications]
Dimensions (L x W x H):
2 050 x 710 x 1 235 mm
Weight (without engine) – 179 kg (with rotary)
Tilling width and No. of blades –
Standard 480 mm 14 blades
Max. 600 mm 16 blades (optical attachment)
Speeds:

Forward – 6 speeds, Reverse – 2 speeds
Tilling – 4 speeds (2 speeds by changing auxiliary sprockets)
Standard tires: 5 – 12
Brake: Inner expansion type
Main clutch: Dry multi-plate type
Wheel tread: 390 – 780 mm
Mounted engine:
Type – 4 cycle diesel engine
Rated output – 6.0 ~ 7.0 HP/2 200 rpm
Max. output – 7.0 ~ 8.0 HP/2 200 rpm
Fuel – Light diesel oil
Starting system– Double speed handle, manual
Cooling system – Radiator cooling
Weight – 83 kg ~ 86 kg
(Kubota, Ltd: 2-47, Shikitsu Higashi 1-chome, Naniwa-ku, Osaka 556, Japan)

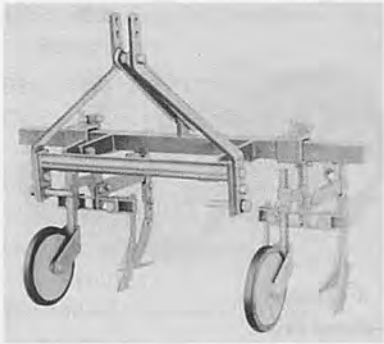
Shibaura Tiller KS340

Features:
Applicable to narrow rows (Rubber tires: 278 mm, Iron wheel: 136 mm) Light and compact. Easy-start and durable engine. Safety device for backward operation. Adjustable-length handle. Handle and gear shift lever are reversible.
[Specifications]
Dimensions (L x W x H): 1 390 x 610 x 850 mm
Weight: 45 kg
Engine (4-cycle, air-cooled):
Model – GEF13RE
Max. output – 3.4PS
Displacement – 135 cc
Speeds: 2-Forward, 1-Rev.
(Ishikawajima-Shibaura Machinery Co., Ltd.: 6-8, 1-chome, Nishishinjuku, Shinjuku-ku, Tokyo, Japan)

Otake Mini-Cultivator

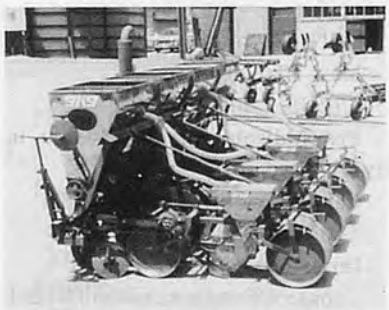
Handy and powerful tool for tillage, cultivating, weeding, hilling, ridge making in home garden, vegetable field, green house, orchard, etc.
Features:
Choice of 2 engines – R7 type (3.3HP) or M24 type (2.4HP).
Adjustable handle – Facilitates easy operation.
Small size and light weight.
High efficiency tine bites the soil quite well.
Versatile range of attachments.
[Specifications]
Dimensions (L x W x H): 1 035 x 665 x 925 mm
Weight: 27 kg (2.4HP), 31.8 kg (3.3HP)
Rotor diameter: 300 mm
Operating width: 665 mm
Engine: 2 cycle air-cooled (Meiki 2.4HP or Robin 3.3HP)
(Otake Agricultural Machinery Co., Ltd: 265, Nakajima, Oharu-cho, Amagun, Aichi, Japan)

Sukigara Double Row Cultivator Model TBC



Features:
Quickly adjustable to row-width
Tines are heat-treated, ensures sharp cutting, have long life.
Tool bar is adaptable to digging accessories or ridgers for versatile jobs.
[Specifications]
Dimensions (L x W x H): 765 x 1 100 x 865 mm
Weight: 62 kg
Power required: 11-20HP
Working speed: 3-5 km/h
(Sukigara Agricultural Machinery Co., Ltd: Yahagi-cho, Okazaki, Aichi 444, Japan)

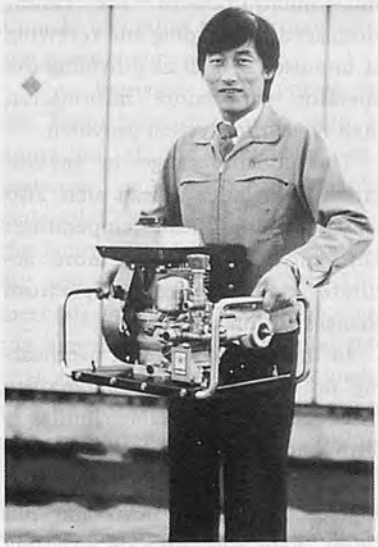
"Tabata" Planter Model TV-4WR



Features:
Seeds are vacuum-sucked and drilled with accuracy. The so-called "W"-mechanism allows application of two kinds of fertilizer without mixing them. Stainless steel construction ensures long-life an light weight. Can handle irregular shaped seeds.
[Specifications]
Dimensions (L x W x H):

1 870 x 2 750 x 1 200 mm
Weight: 520 kg
No. of rows: 3
Seeding interval: 50–400 mm
Hopper capacity:
Fertilizer – 50 kg x 4
Seed – 70 kg x 4
Row width: 60–75 cm
Efficiency: 0.1 ha/h
Tractor required: over 35PS
(Tabata Noki Seisakusho: Higashi 2-7, Inada-cho, Obihiro-shi 080, Japan)

Arimitsu Portable Power Sprayers Model CSE-320 Series



Features:
Direct coupling of pump and engine eliminates power transmission loss.
Smaller by 40% and lighter by 20% than conventional models.
By removing four nuts only, the cylinder and stuffing box are disassembled – which assures easy maintenance.
Only three pieces of patented combination valve work efficiently for higher output, fewer number of parts and compact size.
Engine is equipped with electronically controlled capacity discharge ignition system for easy start and is maintenance free.

[Specifications]
Dimensions (L x W x H) and weight of main body:
Model 320K –
515 x 400 x 403 mm, 26 kg
Model 320H –
515 x 405 x 413 mm, 27 kg
Model 320D –
515 x 326 x 381 mm, 26 kg
Model 320GS –
515 x 398 x 407 mm, 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. Gasoline engine; Air-rooled 4-cycle. Output; 2.3-3.5PS.
(Arimitsu Industry Co., Ltd: 3-21, Fukaekita 2-chome, Higashinariku, Osaka 537, Japan)

Shikutani Knapsack Type Power Sprayer Model DMG-102

Features:
Electronically-controlled engine.
Powerful fan has high efficiency.
Variety of attachments allows handling of dust, granule, fertilizer, etc.

[Specifications]
Dimensions (L x W x L):
360 x 510 x 760 mm
Weight: 23 kg
Tank volume: 23 ℓ
Discharge rate:
Dust – 6 kg/min
Granule – 10 kg/min
Mist – 4 ℓ/min
Engine:
"Kawasaki" TA51-MX, 51 cc
(Shikutani Co., Ltd.: 470, Renshoji, Odawara-shi, Kanagawa-ken, Japan)

Yamamoto Stir Depot Model SSD-10M

Features:
Stirring device helps accelerate drying process, ventilation and saves energy. Drying process is performed under conditions of 18–20% moisture up to complete dryness in the normal temperature airing conditions.

[Specifications]
Bin diameter/height:
10.47 m/9.10 m
Floor space/Volume:
86 m^2/400 m^3
Grain depth and weight:
Paddy – 4.6 m, 250 t
Wheat – 3.7 m, 250 t
Drying rate: 0.015%/h
Loading/Unloading capacity:
20 t/h
Fan (9.8 m^3/sec):
Paddy-22 kW, Wheat-30 kW
Additional power: 8 kW
(Yamamoto Mfg. Co., Ltd.: Tendo-shi, Yamagata-ken 994, Japan)

New John Deere 8450 and 8650 4-wheel-drive Tractors

The new line, powered by John Deere-manufactured turbocharged and intercooled engines, includes:

The 8650, with a 6-cylinder in-line 619-cubic-inch-displacement engine generating 290 engine hp and 235 PTO hp.

The 8450, with a 6-cylinder in-line 466-cubic-inch-displacement engine generating 225 engine hp and 185 PTO hp.

Productivity. New selective control valves with ISO couplers are used on both models. The new valves have larger openings for increased hydraulic flow; this means more power for such operations as orbital motors and hydraulic pumps. The increased flow also permits implements to be raised and lowered quickly for faster turnaround in short headlands.

Fuel economy. Both the 8 450 and 8 650 are equipped with mixed-flow fans, which move cooling air in both radial and axial directions. These fans take less power, with no loss in cooling capacity. In some test conditions, this design has saved as much as 5.4 hp. This is power that is then available for productive work at no additional cost in fuel.

Reliability. Because the engines perform so well at lower engine speeds, 2 100 rpm as opposed to the 2 600 to 2 700 rpm range on some 4-wheel-drive tractors, less stress is imposed on engine components and longer engine life is achieved.

Dual charge-pump systems separate lubrication flow from hydraulic functions, assuring constant flow of hydraulic fluid to the main pump and providing full-time lubrication of transmission components.

Engine oil filtration systems have been so improved that oil change intervals have been doubled to 200 hours from the 100 hours of operation on earlier models.

Operator convenience. Doubling of the oil change interval is but one of the improvements designed to make life easier and more productive for the operator. Additionally, when periodic service is required, he will find such primary service points as grease fittings relocated so that the 10-hour service check can be accomplished in less than 10 minutes. A tilt-up hood makes the engine more accessible. The ISO hydraulic couplings allow remote cylinders to be coupled or uncoupled with the engine running and the hydraulic system under full pressure.

Fuel tank capacities allow a full day's operation without the need to stop to refuel.

Inside the Sound-Gard body, standard equipment on both tractors, there are more ventilation ducts for more efficient air conditioning and heating. A double-wall floor, heavier sheet metal, and more insulation all contribute to reducing noise levels to below 80 decibels.

Intake and exhaust stacks have been relocated to the right side of the tractor and aligned with Sound-Gard body structural members to improve visibility. For after-dark work, exterior lighting systems include banks of four front lights. Rear lighting for both models consists of two conventional lights atop the Sound-Gard body and four halogen lights on the fenders.

Investigator II. This includes a new microprocessor for faster, more accurate sending and receiving of impulses as well as providing the operator with more information than the earlier system provided.

The coolant gauge in Investigator II includes a lead that also senses cylinder head temperature. This provides quicker, more accurate evaluation of temperature changes within the engine.

In the event of coolant overheating or cylinder head temperature rising above acceptable limits, a horn and a red light tell the operator to immediately stop the engine. This same horn and red "stop" light will come on any time the engine should be shut down.

In the event of high clutch temperature or hydraulic oil temperature, or obstructions in the air filter or transmission oil filter, a yellow light on the left side of the instrument panel turns on, identifying the problem area. Additionally, a yellow warning light on the right side of the instrument panel turns on, telling the operator to look to the left side panel to the lights indicating the specific problem.

(Deere & Company: John Deere Road, Moline, Illinois 61265, U.S.A.)

Design Considerations for Harnesses and Yokes for Draught Animals

(India)

This bulletin is a review of research work on the design considerations of harnesses and yokes for draught animals which is conducted in India and abroad. It is further to identify the gaps in the knowledge. Animal power is very well established in the Indian agriculture and will continue in the future also. The Indian farmer is well aware about the handling of animals including their proper care and maintenance.

The harnesses and yokes in use have been developed with a limitation of the knowledge, experience and local available materials. The review indicates that the factors responsible for developing animal power are known. The methods in the past for improving the harnesses were based upon the trial and error. The advances made in the field of instrumentation and ergonomics can help to improve the experimental techniques and for optimising work situations which may result in the development of better harnesses. The most difficult task will be about the determination of long duration loading effect on the state of health and the neck muscles of animals.

This bulletin will be most useful for engineers and scientists who are planning to work on the improvement of the harnesses on the scientific basis. Extentive use of literature published has been used in the preparation of this bulletin.

Size: 24.5 cm x 18.5 cm, 69pp

Soft cover, Price U.S.$10.00

Published by Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road, Bhopal-462010, India

Research Report on Agricultural Machinery No. 11, 1981

(Japan)

This report contains following papers:

An Active Seat Suspension for Farm Vehicles (Part 1). Automatic Control of Rotary Tilling Tractor (Part 3). Microcomputor Control of Field and Orchard Sprayers. Studies on Deeper Rotary Tillage (Part 2). Separating Characteristics of Paddy-Brown Rice by Indent Separator. Utilization of Electrostatic Separator for Stalk Separation in Tea Refining Process. On the System Evaluating the Shape of Farm Products via Image Processing Technique (Part 2). Energy Saving of Grain Dryer – A Thermodynamic Evaluation (Part 1). Design and Usage of Paddy Drying and Storage Facilities (Part 3).

The publishers would like to exchange the publication with other Institutes and Universities in the same research fields.

Size: 25.5 x 18 cm, 122pp

Published by the Laboratories of Agricultural Machinery and Farm Processing Machinery of Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto-shi 606, Japan

Postharvesting

(Japan)

by Ritsuya Yamashita

This booklet deals with post-harvesting processes of paddy. The captions are as follows:

Part I Grain drying: Necessity of drying. Factors influenced on drying. Theory of drying. Dryer. Problems of dryer. Problems of air blowing and heating. Grain drying, processing and storage facility.

Part II Paddy husker and rice whitening machine: Introduction. Grain sorting machine. Paddy husker. Whitening machine.

Size: 25.5 x 18 cm, 43pp

Paper cover

Published by Laboratory of Farm Processing Machinery, Faculty of Agriculture, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto-shi 606, Japan

Equipment for vegetable production

(The Netherlands)

by Institute for Agricultural Engineering, Wageningen

This technical publication aims to be a useful source, designed to assist agriculturists, agricultural instructors, extension officers and technicians in the selection, use, care and maintenance of equipment for vegetable production. After dealing with some cultivation aspects with relation to the mechanization of vegetable growing, the authors described a number of machines and implements and outlined their posibilities.

Special attention has been paid to the mechanisation on small-holdings. "Equipment for vegetable production" was made in close co-operation with the Agricultural Engineering Service of the Food and Agricultural Organization in Rome and with the ample collaboration of the Central School for Horticutural Engineering at Ede.

This manual will help the user to make a right selection of technical aids for the crops growing under their specific local conditions.

Size: 24 x 16cm, 185pp.
Soft cover, Price US$8.00/Dfl. 20,00
Published by IMAG, P.O. Box 43, 6700 AA Wageningen, the Netherlands

---

Soil Degradation
Proceedings of the Land Use Seminar on Soil Degradation/ Wageningen/13-15 October 1980
(The Netherlands)

The seminar was organized in Wageningen, Netherlands, by the Institute for Land and Water Management Research and the International Agricultural Centre, in collaboration with a number of other institutes in the Netherlands. Coverage was divided into two major topics – physical soil degradation, and losses and accumualtion of organic matter in the soil.

Problems of physical soil degradation and the concomitant decrease in production potential of soils basically revolve around the use of modern, highly mechanized agricultural systems using farm equipment with typically high wheel and axel loads. Problems of organic soil degradation can often be traced to the preference for monocultures in modern farming systems.

These two topics are covered in depth by experts from throughout the European Community. A third section outlines the conclusions and recommendations growing out of the seminar. In its entirety, the present volume offers a complete overview of European research into techniques for coping with problems of soil degradation.

Size: 25cm x 17cm, 280pp.
Hardcover, Price: US$30.00
Published by A.A.Balkema, P.O. Box 1675, Rotterdam, Netherlands.

Annual Report of the Swedish Institute of Agricultural Engineering, 1980/81
(Sweden)

This is a translation of pp. 5-78 in the Swedish edition of Bulletin No. 390. The research project section consists of a review of the research work and gives some of the results. The names of the sectors are as follows:

Soil management. Handling of fertilizers. Handling of manure and sewage sludge. Hay making. Silage-making and silage handling. Harvest, conservation and storage of cereals. The handling of straw. Handling of concentrates. Handling of potatoes. The use of electricity. Energy. Ergonomics and safety. Cooperation with SLA.

Size: 21 x 15cm, 70pp.
Paper cover
Published by Swedish Institute of Agricultural Engineering
Ultuna, S-75007 Uppsala, Sweden

IFDC/UNIDO
Fertilizer Manual
(U.S.A.)

This Fertilizer Manual was prepared by the International Fertilizer Development Center (IFDC) as a joint project with the United Nations Industrial Development Organization (UNIDO). It is designed to replace the UN Fertilizer Manual published in 1967 and intended to be a reference source on fertilizer production technology and economics and fertilizer industry planning for developing countries. The aim of the new manual is to describe in clear, simple language all major fertilizer processes, their requirements, advantages and disadvantages and to show illustrative examples of economic evaluations.

The manual is organized in five parts. Part I deals with the history of fertilizers, world outlook, the role of fertilizer in agriculture, and raw materials and includes a glossary of fertilizer-related terms. Part II covers the production and transportation of ammonia and all important nitrogen fertilizers – liquids and solids. Part III deals with the characteristics of phosphate rock, production of sulfuric and phosphoric acid, and all important phosphate fertilizers, including nitrophosphates and ammonium phosphates. Part IV deals with potash fertilizers – ore mining and refining and chemical manufacture; compound fertilizers; secondary and micronutrients; controlled-release fertilizers; and physical properties of fertilizers. PART V includes chapters on planning a fertilizer industry, pollution control, the economics of production of major fertilizer products and intermediates, and problems facing the world fertilizer industry.

Size: 29.5 x 21cm, 353pp.
Soft cover, Price US$15.00
Published by International Fertilizer Development Center. P.O. Box 2040, Muscle Shoals, Alabama, U.S.A. 35660 ■■

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 writers are given collectively 5 free copies (one copy air-mailed and 4 copies sent by surface/sea mail) of the AMA issue wherein their articles are published. In addition, a single writer is given 25 off-prints of the article and plural writers are given 35 off-prints (also sent by surface/sea mail)"

Procedure

a. Articles for publication (original and one-copy) must be sent to AMA through the Co-operating 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/organization, 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 (t/ha) and smaller units in kilogram or gram (kg/plot or g/row).
f. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
g. Convert national currencies in US dollars and use the later consistently.
h. Round off numbers, if possible, to one or two decimal units, e.g., 45.5kg/ha instead of 45.4762kg/ha.
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.

BACK ISSUES

(Vol. 12 No. 1, Winter 1981 ~)

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 ASIA, AFRICA AND LATIN AMERICA (Vol. 12 No. 2, Spring, 1981)

Editorial (Yoshisuke Kishida) 9
Farm Mechanization Program for a River Irrigation Project (Gajendra Singh, Orlando M. Cablayan) 11
Tillage and Mechanization in Leziria Grande de Villa Franca de Xira, Portugal (J. K. Kouwenhoven) . . . 17
Field Performance and Evaluation of a Paddy Transplanter (Abtar Singh, David Gee-Clough, Gajendra Singh) 23
Standardizing Tractor Field Test (T. K. Bhattacharya) 31
Improved Animal-Drawn Implements for Farming in the Semi-Arid Tropics (R. K. Bansal, K. L. Srivastava) 33
Development and Comparative Performance of a Cultivator with Sweep Shovels (Jehangir Khan Sial, Ghulam Sarwar Sheikh, M. Afzal) 39
Performance of an Intermediate-Technology Fertilizer Dispenser (J. C. Igbeka) 47
Traditional Practices and Economics of Production of Puffed Rice in Rural India (Surya Nath, T. P. Ojha, S. L. Shrivastava) 51
Development of Improved CIAE Sickle for Harvesting Cereals (M. M. Pandey, R. S. Devnani) 54
Development of a Low-Cost Hand Sprayer (A. A. Mainul Hussain, Nripendra Nath Sarker) 59
Design and Selection of Thresher Parameters and Components (Hem Chandra Joshi) 61
News 69
New Products 71
Book Review 79

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (Vol. 12 No. 3, Summer, 1981)

Editorial (Yoshisuke Kishida) 9
The Australian Sugarcane Cultural System: A Fully Mechanized, HighYield, High-Efficiency Way to Produce Sugar (Edilberto A. Uichanco) 11
Thailand-Made Power Tiller Transmission System (Gajendra Singh, A.H.M. Sakhawat Hossain, David Gee-Clough) 17
Fabrication and Testing of Strain Gauge-Mounted Proving Ring Dynamometer for Tillage (Raj Deo Singh, Bhagwan Singh, S.K. Rautaray) 22
Soil Separation by and Power Requirement of a Potato Elevator Digger (Pratap Singh, K.P. Pandey) 27
Energy Input-Output Relationship in Traditional and Mechanized Rice Cultivation in Bangladesh (R.I. Sarker, A.T.M. Ziauddin, Mosharaf Hossain) 30
Performance of Tillage Implement Combinations (Sheruddin B. Bukhari, Soos Pal, Lehoczky Laszlo, Bherural T. Devrajani) 33
Simulation of Paddy Drying under Tropical Conditions (M.N. Islam, V.K. Jindal) 37
Aspects of Cardamom Drying in Nepal (A.G. Rijk, D.G. Donovan) 47
Thermal Disinfestation of Wheat with Solid Heat Transfer Medium (G.S. Mittal, L.B. Smith, H.M. Lapp) . . . 53
Production and Analysis of White Ash (Rajvir Singh, B.K. Dhindaw, R.C. Maheshwari) 57
Comparative Performance of Different Types of Manual Pumps (Md. Shirazul Islam, M.A. Mazed, Kshirode Chandra Roy) 65
Socio-Economic Issues Pertaining to Agricultutural Mechanization in Malaysia (M. Zohadie Bardaie) . . . 69
Performance of the Japanese Impeller-Type Rice-Husker (Masanori Tsuchiya) 73
News 77
Book Review 79

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (Vol. 12 No.4, Autumn, 1981)

Editorial (Yoshisuke Kishida) 9
International Trade on Tractors (Manfred Sievers, Arno Schäfe r) . . 11
Field Evaluation of "Annapurna Transplanter" (S. Swain, S.P. Maity) 16
A Width-of -Cut Analysis of a Vertical Conveyor Cereal Reaper for Indian Farms (D.F. Howson, R.S. Devnani) 19
Research and Development Needs for Improved Utilization of Animal Draft Power in Bangladesh (R.I. Sarker) 24
Cage Wheels for Tractors in Paddy Fields (1) (Jun Sakai, Yasuo Shibata, Tran Tan Nguyen) 27
Effects of Different Irrigation Regimes on Maize Production in Acid-Sulphate Soil (Mesbauddin Ahmed, Apichart Anukularmphai) 32
Pesticide Spray Volume Determination (S.L. Patel) 35
Effects of Harvesting on Field and Milling Yields of Paddy (Surya Nath, T.P. Ojha) 41
Use of Desiccants for Drying Maize (A.C. Srivastava, W.K. Bilanski) . . . 49
Replacement Criteria for Agricultural Machines (S.Y. Wagami, J.P. Mittal) 55
Agricultural Mechanization in China (Gu Lu-ping). 58
An Economical Method of Transmitting Energy (M.N. Rifai, H. Henderson) 59
Feasibility of Improving Project Implementation and Minimizing the Need for Machinery and Labor through Tenancy System (Paris Andreou, Fawzi Al Haj, Ismail Mohammed Hamad) 63
Problems and Prospects of Agricultural Mechanization in Pakistan (Khwaja Altaf Hussain, A.D. Chaudhry) 69
Malaysia's Agricultural Situation and Future Development (A.A. Mainul Hussain, N.C. Saxena) 74
So You're Considering a Knapsack Sprayer (A.E. Deutsch). 77
News 82
Book Review 83

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (Vol. 13 No. 1, Winter, 1982)
Editorial (Yoshisuke Kishida) 9
Agricultural Engineering Technology for Developing Country Students (Merle L. Esmay) 11
Status of Agricultural Mechanization in Mexico (Ahmed Hossain Mirdha) 15
Influence of Soil-Tool Parameters on Unit Draft (S. Swain) 19
Economic Efficiency of Tractors on Punjab Farms (Parkash Mehta) . . . 22
Effect of Lug Angle of Cage Wheels on Tractive Performance of Dual Wheels under Submerged Soil Conditions (S.K. Rautaray, K.N. Singh) 27
Determination of Optimum Drying Conditions and Development of Drying Equations for Thin-Layer Drying of Parboiled Wheat (A. Chakraverty, R.T. Kausal) . . . 33
Mechanization for Modern and Traditional Agriculture in Sudan (E.S. Mahmoud) 37
Evaluation of Farmer's Competence to Maintain Farm Tractors (Sheruddin B. Bukhari) 45
Measurement of Hydraulic Properties of a Brown Flood-Plain Soil of Bangladesh (S.M. Rahman, B.C. Basak, A.K.M. Habibullah) 48
Alternative Gas-Fuel Producer for Driving Gasoline Engine (Part 1) — Charcoal Gas Producer (Jun Sakai, Yasuo Shibata) 51
Soil Crusts vs Seedling Emergence: Review (Megh R. Goyal) 62
Food Production and Rural Development in Commonwealth Countries (Nurul Islam) 79
News 81
Book Review 84

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (Vol. 13 No. 2, Spring, 1982)
Editorial (Yoshisuke Kishida) 9
Performance of a Tractor-Mounted Oscillating Soil Working Tool (P.V. Narayanarao, S.R. Verma) 11
Human Energy Expenditure in Manually-Operated Rice Transplanter (Md. Abdul Baqui, Reynaldo M. Lantin) 14
Sprinkler System Evaluation: A Case Report (Mahmoud H. Abdel Aziz, Mohammed Saeed Hadrat) 17
Application of Sprinkler Irrigation in the Sudan (Khamies Kajo Konda, Tawfig Fahmi Demian) 23
Influence of Selected Seedling Mat Parameters and Planting Speed on Performance of Rice Transplanter (I.K. Garg, C.P. Singh, V.K. Sharma) 27
Performance of a Simple Tractor-Mounted Deep-Hole Digger (R.D. Singh, Bhagwan Singh, K.N. Singh) 34
Development and Testing of a Manually-Operated Dung Cleaner (H.C. Joshi, D.N. Jana, D. Chaudhri) 39
A Comparative Study of Conventional and Mechanized Farming Relative to Energy Use and Cost (A.C. Srivastava) 42
Tillage Machines Combined with Moldboard Plow (Sheruddin Bukhari, Jori Istavan, Lehoczky Laszlo, Banhazi Janos) 51
Performance and Potential of Rubber Rolls in Husking Paddy (U.N. Singh) 56
Elastic and Visco-elastic Properties of Agricultural Products in Relation to Harvesting and Post-Harvest Processes (U.G.N. Anazodo) 59
Performance Evaluation of a Modified Fertilizer Applicator (K.C. Oni) 67
Status and Problems of Mechanization in Sierra Leone (N.G. Kuyembeh) . . . . . .
Forced Aeration: A Technique to Handle High Moisture Paddy under Humid Condition (Surya Nath, A.K. Ganguly) 77
News 79
New Products 81
Book Review 86

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (Vol.13, No.3, Summer, 1982)
Editorial (Yoshisuke Kishida) 9
A More Efficient Buffalo Plow (R.C. Fischer) 11
Performance of Harnesses Used for Draught Animals (B.P. Varshney, T.N. Mishra, Akhilesh Kumar, R.P. Singh) 15
Fuel Consumption of Tillage Implements (Sheruddin B. Bukhari, Jan Mohammad Baloch) 20
Economic Evaluation of Land Levelling (Riaz A. Khattak Mohammad Asrar, Jehangir K. Khattak, S.U. Khan) 23
Contribution of Ground Water in the Evapo-Transpiration Demand of Soybean (Glycine Max. L.) (K.M. Hassanuzzaman, S.M. Rahman, M.R. Biswas) 25
Effect of Preplanting Irrigation on Cotton Cultivation (Md. Motiur Rahman Khan) 29
Mechanization of Oil Palm Fruits Harvesting and Transportation in Malaysia (M. Zohadie Bardaie, Wan Ishak Wan Ismail) 31
Mechanization of Oil Palm Plantation Technology (Naresh Chandra Saxena) 35
A Cassava Harvester: Design Analysis and Prototype Development (E.U. Odigboh, S.F. Ahmed) 40
Design, Construction and Performance of a Jute Decorticating Machine (M.A. Mazed, K.C. Roy) . . . 53
Mechanization of Paddy Production in Malaysia (A.A. Mainul Hussain) 56
Mechanization of Family Farms in Nigeria (U.G.N. Anazodo) 59
Standardization and Quality Control in Agricultural Machinery (R.N. Sharma) 66
Paddy Straw Utilization for Bags and Mats (M.M. Kashyap, Amar Singh) 69
Calotropis procera (Ait.) R. Br. — Ak:A New and Free Source of Fibre and Renewable Hydrocarbons (Subhash S. Arora, Kiran S. Arora) 71
News 78
New Products 79
Book Review 85

INDEX TO ADVERTISERS

EIMA 51
Iseki & Co., Ltd. 2
Kaneko Agricultural Machinery Co., Ltd. 4
Kobashi Kogyo Co., Ltd. 52
Mametora Agric. Machinery Co., Ltd. 90
Matsuyama Plow Mfg. Co., Ltd. 50
Sumitomo Chemical Co., Ltd. 49
Tokai Industry Co., Ltd. 50
Toyosha Co., Ltd. 6
Yamamoto Mfg. Co., Ltd. 51

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.