International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.30, NO.1, WINTER 1999

Special Issue:

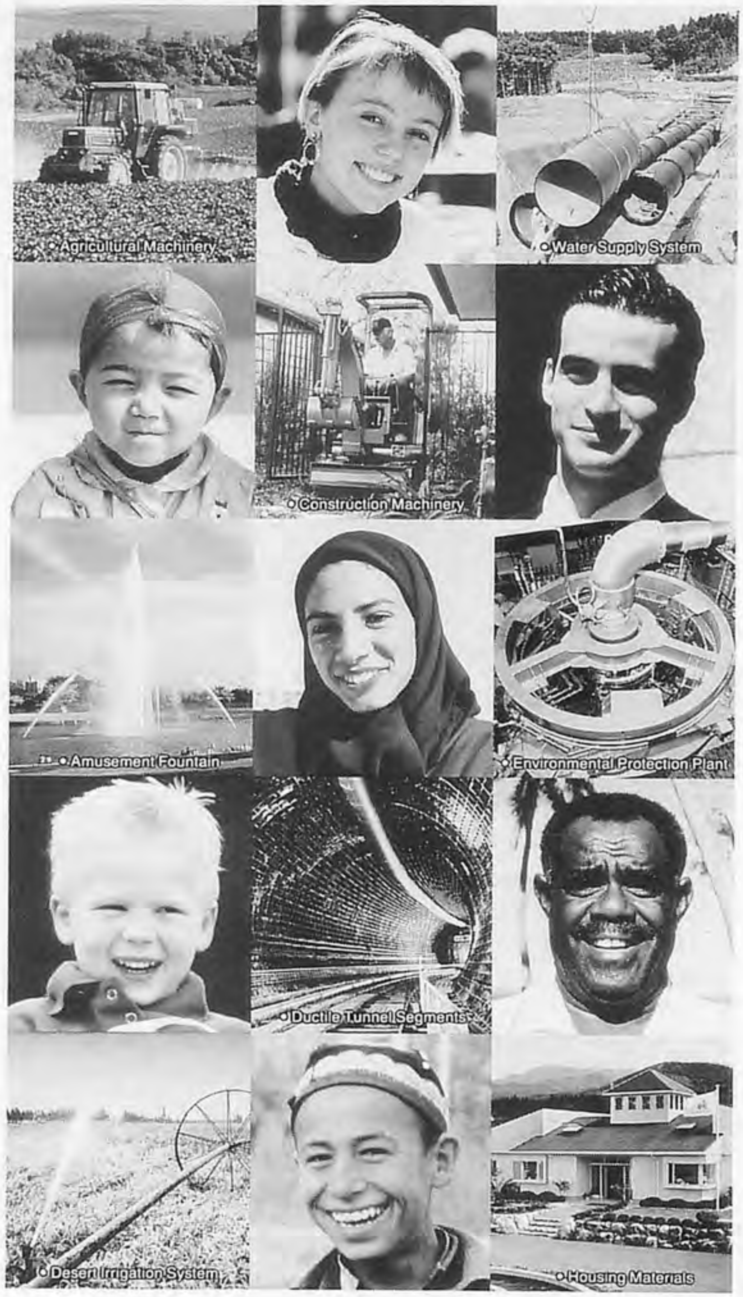
The Farm Machinery Industry in Japan and Research Activities

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

As long as people and nature coexist, Kubota's work is never done.

Reaping the fruit of the earth.
Making the best use of water.
Contributing toward the betterment of life and the perfection of infrastructure.
Building the future cities.
Improving global living environments.
Technology for the symbiosis of people and the natural environment.

Kubota's Five Key Words
The first key word is **Soil**. Kubota's tractors and agricultural machinery are helping to stablize the world's food supply. The second key word is **Water**. Kubota's ductile iron pipes, pumps, and valves are used to improve the urban water supply and sewage systems. Our water handling expertise lead to a successful irrigation project in Egypt, where more than 6,000 acres of desert was transformed into rich farmland. The third key word is **Environment**. Protecting our precious environment is a major Kubota concern. Our sewage treatment and garbage incineration facilities are making sure it remains protected. The fourth key word is **Cities**. In the cities, our ductile tunnel segments are used to strengthen subway tunnels in weak grounds, while cast steel G-columns are used to support various engineering structures and buildings. The fifth key word is **Homes**. Kubota is ready to help improve the living environment by supplying external walling material, roofing material, prefabricated bathrooms, and much more. As long as people and nature coexist, our work is never done. We believe **"Loving and Caring for Our Earth"** is KUBOTA's Task.



Kubota
KUBOTA Corporation

HEAD OFFICE: 2-47, Shikitsuhigashi 1-chome, Naniwa-ku, Osaka 556-0012, Japan Phone: (06)6648-2111 Telex: KUBOTA J65251 Facsimile: (06)6648-3862

MAMETORA DEDICATES TO AGRICULTURE ALL OVER THE WORLD

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 goods of high quality and are pleased to devote ourselves to the food industry in the world as well as that in Japan.

EXPORT SERIES

MC-8C
MINI POWER TILLER MULTING ROTOR SET (1.7ps)

MC-AII
ONE WHEEL POWER TILLER (4.0ps)

DMC-700V
POWER TILLER (7.0ps)

HMD-V-RB
POWER TILLER(8.0ps)

SRV-4V
POWER CULTIVATOR (7.0ps)

TP-3V
VEGETABLE TRANSPLANTER

MH-750
HAMMER KNIFE MOWER

SC-10
CRAWLER CART

MAMETORA AGRIC. MACHINERY CO., LTD.

HEAD OFFICE ADD: 9-37, NISHI-2 CHOME, OKEGAWA-SHI, SAITAMA-KEN, JAPAN.
TELEPHONE: 0487-71-1181 FAX: 0487-71-1529

AMA ABSTRACTS AND INDEX, 1971–1980
— A Key to Wealth of Information —

As the AMA enters its 13th year of publication this year, the Editorial Staff deems it appropriate to commemorate the event by publishing "Abstracts and Index 1971-80" in May, 1983 for only ¥2,000 a copy, including sea mail postage.

During the decade 1971-1980, more than a thousand articles were received by AMA from readers and co-editors. Over 600 of these contributions were published from which the abstracts and index in various aspects of agriculture and agricultural mechanization in developed and developing countries were arranged for use as a handy reference by students, government officials, ressearchers and academicians interested in agriculture and agricultural mechanization. For example, at a glance, the abstract and index tell about the content of the article, author and AMA issue number. The publication form is A3 size (18.5 cm x 21 cm) 82 pages.

A limited number of copies are still available for which reason they will be sold on a first-come, first-served basis. In order that interested readers get their copies of the publication, it will be very useful for them (and convenient for the AMA Staff) to fill up the order from inserted in this issue and mail it to –

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

International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.30, NO.1, WINTER 1999

Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

Editorial, Advertising and Circulation Headquarters
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan

SHIN-NORIN Building
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan
Printed in Japan

This is the 102nd issue since its maiden issue in the Spring of 1971

EDITORIAL

Some Economic Scenario

The 1988 economic crisis that swept many countries, particularly in the Southeast Asian region, still sees the world's general economy in recession. The whirlpool effect of the crisis even seems to threaten many business concerns in the United States. The anticipated flow of investment monies to the international market in hopes of liberalizing the world economy has fallen short of expectations as it seems to have generated more serious repercussions instead. This situation has hit hard the economy of many developing countries which ceased growing compared with the fast pace of growth in recent years. The agriculture sector was no exception as farmers now feel uneasy about their future.

In the face of all this economic dislocation, there is no hiding the fact that many developed countries have excess or surplus food supplies in stark contrast with the recurring food shortages in developing or underdeveloped countries. Even as a number of the latter countries have somewhat progressed mechanizing agriculture, their farm machinery industries are, however, still not competitive. What this suggests is that greater support by governments of developed countires is called for the improvement of agricultural productivity in the developing economies.

I hold the view that a free economy system is actually not the almighty one considering that a strong economy tends to keep its resources and other factors of production to itself whereas the weak economies should be helped by the former to gain strength. As a matter of fact, even the prices of farm products are controlled by the free market economy such as the Chicago Board of Trade operations. This is just unfair from the standpoint of the development of world agriculture considering the large differnces in farm scales. To be sure, some control on prices of farm commodities is necessary to enable small-scale farmers to survive and protect the environment at the same time. In this regard, the responsibility of agricultural engineers and scientists are great as we usher into the 21st Century.

International cooperation between the "haves" and the "have nots" must be promoted for we all owe our lives to the land, sea and solar energy for food supply. The former must realize that as human population increases, agricultural resources such as farm lands remain the same or less and the per capita water and energy resources decrease. This condition undoubtedly calls for agricultural science and technology transfer, particularly agricultural mechan-ization technology and sustained international cooperation.

The AMA wishes all our readers and cooperating editors a more productive New Year!

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January, 1999

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 30, No. 1, Winter 1999

Performance of Different Tillage Implements and their Influence on Soil Fertility and Paddy Yield

by
A. Kadir
M.S. Student
Dept. of Irrigation and Water Management
Bangladesh Agricultural University
Mymensingh-2202
Bangladesh

S.M. Shirazi
Scientific Officer
Farming Systems and Environmental Studies
Bangladesh Agricultural University
Mymensingh-2202
Bangladesh

M.S.U. Talukder
Professor
Dept. of Irrigation and Water Management
Bangladesh Agricultural University
Mymensingh-2202
Bangladesh

M. Ahmed
Professor
Dept. of Irrigation and Water Management
Bangladesh Agricultural University
Mymensingh-2202
Bangladesh

Abstract

A field experiment was conducted on a clay loam soil at Kazirshimla site under Trishal thana in Mymensingh district of Bangladesh to study the performance of different tillage implements and their influence on soil fertility and paddy yield (IR50). Four types of tillage implements viz. power tiller, improved plough-I, improved plough-II and country plough were used for the study. The depth of ploughing with improved plough-I (BARI plough) was significantly different compared to those of the other implements used. The physicochemical properties of the experimental soil showed that during land preparation the soil P^H was in the medium range whereas at harvest it was in the low range; sulphur was in the low range both during land preparation and at harvest; electrical conductivity, organic carbon and total nitrogen increased at harvest, and phosphorous was the same both during land preparation and at harvest. Highest grain yield (4 375 kg/ha) was obtained using improved plough-I because of higher number of panicles/hill (7.32), number of grains/panicle (46.85) and 1 000 grain weight (33.66 g). Thus, the use of improved plough-I may ensure better utilization of available draft power with good tilling performance and may save time to a large extent.

Introduction

Bangladesh is basically an agro-based country. Agriculture contributes about 35% (BBS, 1994) to gross domestic products (GDP). Soil is the most important natural resource and ingredient for cultivation. Composition and structural changes of soil are caused artificially by means of tillage tools and implements during land preparation. These changes occur because forces are imparted to the soil by tillage tools and implements which in turn affect the physical and chemical properties of soil. Tillage is the most important operation on crop production system. The process by which forces are imparted and changes in soil properties occur are known as tillage which is comprised of some technical operations such as ploughing and harrowing (Brady, 1974). The major objectives of primary tillage is to break upon the soil surface, to promote water infiltration, conserve moisture, maintain surface mulch, control weed growth, easy movement of air, incorporation of applied fertilizers, plant residues and amendments into the soil. The extent and number of tillage operations depend on soil type, water availability, crop varieties, power sources, land topography, agronomic and cultural practices. About 80% of farm families use traditional wooden plough pulled by draft animal for land preparation (Satter, et al., 1993). Draft animal contributes about 65% of the total power required in agriculture (Sarker, 1981) for ploughing and other farm activities like transportation, harvesting and threshing. Sarker (1993) carried out surveys in four areas of Bangladesh and observed that there was a shortage of draft power for land preparation in HYV boro irrigated areas. To overcome the shortage of draft power improved mouldboard ploughs (I and II) were developed by Satter et al. (1993), Bangladesh

Agricultural Research Institute (BARI), Joydebpur, Gazipur and Hussain et al. (1985), Department of Farm Power and Machinery (FPM), Bangladesh Agricultural University, Mymensingh, respectively. The main targets of these new ploughs are to save labour and time so that good tilling can be done efficiently with available draft animal. The replacement of traditional agricultural tools and implements by improved farm implements would enable a greater volume of work to be accomplished with less efforts and time. The present piece of work was, therefore, undertaken to study the performance of different tillage implements and their influence on soil fertility and yield of HYV paddy.

Fig. 1 A view of tillage operation using a power tiller.

Fig. 2 A view of tillage operation using the improved plough-I.

Fig. 3 A view of tillage operation using the improved plough-II.

Fig. 4 A view of tillage operation using a country plough.

Materials and Methods

The experiment was conducted at the Kazirshimla site using four farmers' plots during February to June, 1995 with Hijack paddy variety. Each plot was divided into four equal sub-plots following randomized block design (RBD). Four types of tillage implements were used: power tiller, improved plough-I (developed by BARI), improved plough-II (developed by FPM Department) and country plough. The operational photographs of the different types of tillage implements are shown in **Figs. 1** to **4**. The soil samples at 15 cm depth from ground surface were collected with an auger from each sub-plot during land preparation and at harvest for physico-chemical analysis. The land was prepared for transplantation following ploughing twice by the power tiller, ploughing thrice by improved ploughs (I and II) and country plough. After each tillage operation, the depth of cut and time of ploughing were recorded for all the sub-plots. Although the crop was grown under rainfed condition, supplemental irrigation water was applied on February 26, March 14 and 27, April 10 and 18 and on May 2 and 15, 1995 during the growing season.

N, P, K and S fertilizers were applied at the rates of 80, 60, 40 and 30 kg/ha in the form of urea, triple super phosphate (TSP), muriate of potash (MP) and gypsum, respectively. Simultaneously, intercultural operations were done and insecticides were also applied as and when necessary. Grain and straw yields, plant height, number of panicles/hill, length of panicle, number of grains/panicle and 1 000 grain weight were recorded at harvest and the results were analyzed.

Results and Discussion

The investigation included the performance of different tillage implements, physico-chemical properties of soil and the yield of rice crop as influenced by different tillage practices. The performance of different tillage implements are shown in **Table 1**. The depth of ploughing with improved plough-I was significantly different compared with those of the other implements used. The highest depth of ploughing (9.70 cm) was found with improved plough-I and the lowest depth (7.71 cm) was found using the country plough. The results are in conformity with the findings of Satter et al. (1993) and Hussain and Sarker (1978), respectively. The average field capacities of the power tiller, improved ploughs (I and II) and the country plough were 0.090, 0.030, 0.028 and 0.027 ha/h, respectively. The results reveal that the highest performance was found with the power tiller which is in agree-

Table 1. Performance of Different Tillage Implements Used in the Experiment

Tillage implement	Cultivated area (m^2)	Average depth of ploughing (cm)	No. of tillage operation	Time of ploughing (min.)	Field capacity (ha/h)
Power tiller	40	7.79	2	2.68	0.090
Improved plough-I	40	9.70	3	8.13	0.030
Improved plough-II	40	8.68	3	8.60	0.028
Country plough	40	7.71	3	8.74	0.027
LSD (0.05)	—	1.00	—	—	0.0037

Table 2. Physico-chemical Properties of Soil During Land Preparation and at Harvest

Tillage implement	pH	EC (μ/cm)	Org. carbon (%)	Total N (%)	Phosphorous (ppm)	Potassium (me/100g)	Sulphur (ppm)	Sand (%)	Silt (%)	Clay (%)	Textural classes
a) During Land Preparation											
Power tiller	7.24	89	0.874	0.084	10	0.20	8.36	23.04	44	32.96	Clay loam
	7.22	74	0.822	0.075	14	0.17	8.36	27.04	48	24.96	Loam
	7.20	86	0.874	0.081	12	0.18	13.94	27.04	42	30.96	Clay loam
	6.96	68	1.028	0.106	10	0.20	33.46	25.04	44	30.96	〃
Improved plough-I	7.16	95	1.079	0.109	16	0.20	11.15	25.04	44	30.96	〃
	7.25	84	1.079	0.106	18	0.24	16.73	25.04	44	30.96	〃
	7.23	79	1.079	0.112	10	0.26	11.15	23.04	44	32.96	〃
	7.14	78	0.720	0.075	12	0.24	8.36	27.04	48	24.96	Loam
Improved plough-II	7.44	58	0.720	0.070	10	0.20	11.15	21.04	48	30.96	Clay loam
	7.46	62	0.669	0.058	18	0.16	8.36	23.04	44	32.96	〃
	6.93	87	1.130	0.114	10	0.18	11.15	25.04	46	28.96	〃
	6.86	85	1.181	0.117	16	0.16	8.36	27.04	46	26.96	〃
Country-plough	7.60	59	0.771	0.078	10	0.26	19.52	13.04	46	40.96	Silty clay
	7.24	64	0.925	0.084	14	0.22	8.36	21.04	44	34.96	Clay loam
	7.18	73	0.874	0.081	10	0.29	8.36	23.04	46	30.96	〃
	7.52	62	0.822	0.075	10	0.18	8.36	27.04	42	30.96	〃
Average	7.23	75.19	0.915	0.089	12.5	0.21	12.20	—	—	—	—
b) At Harvest											
Power tiller	5.94	125	1.530	0.112	14	0.18	60.86				
	5.88	96	1.492	0.109	10	0.24	75.29				
	5.98	59	1.989	0.120	14	0.25	8.36				
	6.01	56	1.683	0.114	10	0.22	8.36				
Improved plough-I	6.00	46	1.606	0.112	12	0.20	13.94				
	6.02	108	1.339	0.109	10	0.22	55.77				
	6.06	38	1.874	0.112	12	0.24	11.15				
	5.98	52	1.950	0.117	14	0.20	13.94				
Improved plough-II	5.85	159	1.989	0.117	12	0.22	64.13				
	5.86	122	1.645	0.112	10	0.28	69.71				
	5.70	168	1.987	0.120	10	0.21	75.29				
	6.10	29	1.950	0.114	10	0.20	8.36				
Country plough	5.93	64	1.989	0.117	14	0.32	36.25				
	6.09	36	1.415	0.109	12	0.28	16.73				
	5.93	36	1.950	0.114	16	0.25	16.73				
	6.02	64	1.950	0.112	20	0.20	33.46				
Average	5.96	78	1.77	0.114	12.5	0.23	35.52				
Range:											
Low	<6.5			<0.10	<10		<80				
Medium	6.6-7.5	—	—	0.10-0.15	10-15	—	80-150				
High	>7.5			>0.15	>15		>150				

Table 3. Yield and Yield Contributing Characters of Boro Rice Using Various Tillage Implements

Tillage implement	Plant height (cm)	No. of tillers/ hill	No. of panicles/ hill	Length of panicle (cm)	No. of grains/ panicle	1 000 grain weight (g)	Yield (kg/ha)	
							grain	straw
Power tiller	78.20	8.75	7.20	19.50	44.80	33.47	4 000	12 000
Improved plough-I	78.75	9.10	7.32	20.65	46.85	33.66	4 375	13 050
Improved plough-II	78.70	8.85	6.85	20.20	43.75	33.64	4 325	13 150
Country plough	77.45	8.85	7.15	19.75	44.45	32.36	3 625	11 925
LSD (0.05)	2.26	1.67	0.60	2.01	6.42	5.65	442.7	2 315

ment with the findings of Calilung and Stickney (1989).

The physico-chemical properties of the experimental soil during land preparation and at harvest are shown in **Tables 2** (**a** and **b**). The soil was clay loam. The results indicate that during land preparation the soil P^H and phosphorous were in the medium range, and total nitrogen and sulphur were in the low range. It can also be seen that at harvest the soil P^H and sulphur were in the low range and total nitrogen and phosphorous were in the medium range. Electrical conductivity, organic carbon and total nitrogen increased at the time of harvest. Phosphorous and potassium were almost similar and sulphur was in the low range both during land preparation and at harvest.

The yield and its contributing characters of "Boro" rice under different tillage practices are shown in **Table 3**. The results indicate that the highest grain yield (4 375 kg/ha) was found with improved plough-I due to increased number of panicles/hill and 1 000 grain weight and the lowest yield (3 625 kg/ha) was found with the country plough. Similar results were also obtained by Razzaq et al. (1993). No significant differences in plant height, number of tillers/hill, number of panicles/hill, number of grains/panicle, 1 000 grain weight and straw yield were found among the different implements used. The highest plant height (78.75 cm), number of tillers/hill (9.10), length of panicle (20.65 cm), number of grains/panicle (46.85) and 1 000 grain weight (33.66 g) were obtained with the improved plough-I compared to other ploughs used, including the power tiller. Therefore, the farmers expressed their willingness to buy the improved plough-I in order to improve their yields.

Conclusions

On the basis of the results of the experiment, the following conclusions may be drawn:

1. For the production of boro rice in calcarious grey soils, the improved plough-I was advantageous in terms of depth of ploughing, yield and yield components;
2. Satisfactory land preparation for transplantation could be accomplished with the improved plough-I;
3. Time of ploughing with power tiller was almost one-third compared to those of other ploughs used; and
4. The highest grain yield was obtained with deep ploughing up to 9.70 cm using the improved plough-I.

REFERENCES

Bangladesh Bureau of Statistics (BBS). 1994. Statistical yearbook of Bangladesh, Statistics Division, Ministry of Planning. Government of the People's Republic of Bangladesh. pp. 431.

Brady, N.C. 1974. The nature and properties of soils. McMillan publications Co., New York.

Calilung, E.J. and R.E. Stickney. 1989. Comparison of tillage equipments for small rice farm. AMA. 20(1): 9-16.

Hussain, A.A.M., S.M. Farouk and N.N. Sarker. 1985. Improved animal drawn mouldboard plough utilizing available draft power. AMA. 16(2): 25-26.

Hussain, M.D. and R.I. Sarker. 1978. Performance studies of country plough in Bangladesh. AMA. 16(3): 55-60.

Razzaq, A., B.A. Sabir and A. Karim. 1993. Effect of soil inversion tillage practices on rice production. AMA. 24(2): 13-16.

Sarker, R.I. 1981. Research and development needs for improved utilization of animal draught power in Bangladesh. AMA. 12(4): 24-26.

Sarker, R.I. 1993. Draft power constraint affecting irrigated crop diversification. In. Biswas, M.R. and M.A.S. Mandal (ed.). Irrigation management for crop diversification in Bangladesh. The University Press Limited, Dhaka, Bangladesh. pp. 100-115.

Satter, M.A., Wahab, S. Borhan, F.R. Khan and M.I. Hossain. 1993. Development of an animal drawn mouldboard plough. Bangladesh J. Agric Res. 18(2): 137-144. ■■

Development and Evaluation of Multi-crop Planter for Hill Regions

by
M.L. Gupta
Agricultural Mechanization Section
Department of Plant Production
University of Queensland Gatton College
Lawes Qld. 4343, Australia

D.K. Vatsa
Department of Agricultural Engineering
Himachal Pradesh Krishi Vishvavidyalaya
Palampur
India

M.K. Verma
Department of Agricultural Engineering
Himachal Pradesh Krishi Vishvavidyalaya
Palampur
India

Abstract

A single-row, multi-crop planter was developed for use in hill areas. It can sow a number of crops such as maize and wheat. The field trials were conducted to determine the performance of the planter. The effective field capacity of the machine was 0.157 ha/h for maize and 0.064 ha/h for the wheat crop. The average field efficiency was about 76%. The machine was efficient and economical compared with traditional methods of sowing.

Introduction

Most of the farm lands in the hill regions are in small terraces. Manual or bullock power is predominantly used for farm work. Farm equipment for the hill regions must suit the terrain. Machines designed for the plains are not suitable in the hills. Topography and size of land holdings are the major constraints. The average size of land holdings in Himachal Pradesh is about 0.6 ha only, indicating that small and marginal farmers are predominant in the State (Kingra and Singh, 1986).

A single field operation that makes or mars the prospects of a crop is sowing the crop. The farmers in Himachal Pradesh still use traditional methods of sowing, i.e., broadcasting or hand-dropping of seeds behind the plough. These methods result in lower yield due to uneven distribution of seeds and fertilizer, low germination, excessive weed growth, etc. Although, a number of animal-drawn seed-cum-fertilizer drills (3 to 5 rows) have been developed in the country (Singh and Bhardwaj, 1985), these cannot be adopted by the farmers of hill areas due to their heavy weights. Maize and wheat are the major crops grown in Himachal Pradesh. Presently, there is no suitable drill/planter available in the country which can sow these crops in hill areas. Keeping these factors in view, a light weight single row multi-crop planter was developed and evaluated.

Materials and Methods

Design Considerations

The basic design considerations in developing the multi-crop planter were:

(i) It should be suitable for operation with manual as well as animal power;
(ii) It should be light in weight so that it can be transported easily from one terrace to another;
(iii) It should be able to sow the crops such as maize and wheat;
(iv) The design of planter should be simple so that it can be easily fabricated by local manufacturers; and
(v) The cost of the planter should be within the purchasing power of small and marginal farmers.

Constructional Details

The machine consists of a main frame, ground wheels, seed and fertilizer hoppers, furrow opener, covering device, power transmission system, handle and hitch (**Fig. 1**). The metering of seeds is done with the help of rotors. Different types of rotors are used to sow different crops. Fertilizer application is metered with the help of a fluted roller. The ground wheels provide drive to the metering shaft through the sprocket and chain arrangement. The depth of sowing can be adjusted by lowering or raising the furrow opener. The planter can be pulled either by employing two labourers or a pair of animals. The estimated cost of the machine is about Rs. 600. The major specifications of the planter are as follows:

Overall dimensions	
Length (mm)	: 1 570
Width (mm)	: 530
Height (mm)	: 900
Total weight (kg)	: 18
Power source	: 2 men or a pair of animals
No. of rows	: Single
Hopper capacity	
Seed (kg)	: 3.5
Fertilizer (kg)	: 4.0

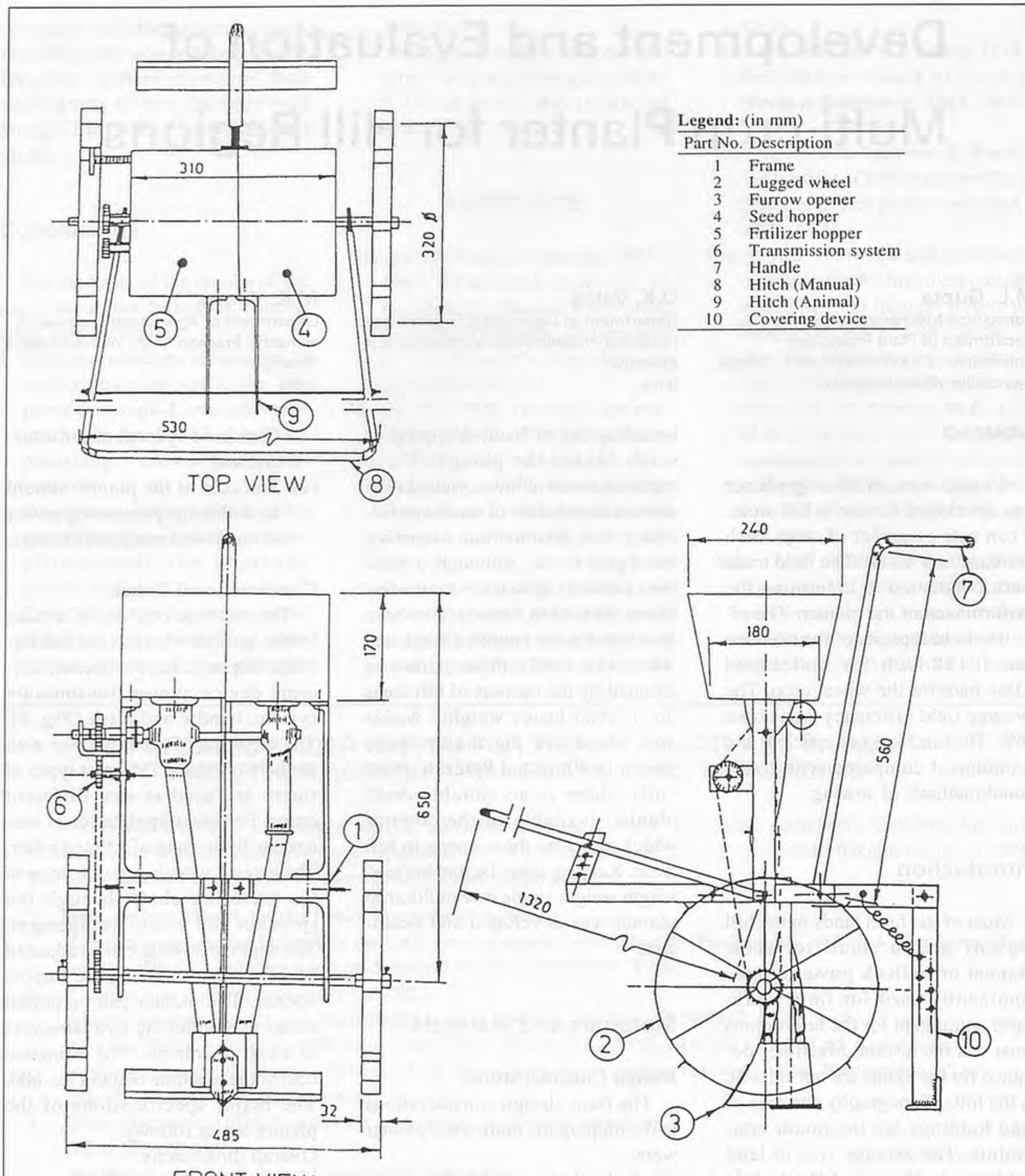


Fig. 1 Assembly sketch of multi-crop planter.

Furrow opener : Shovel type
Depth of sowing
: Adjustable up to 100 mm
Seed metering device
: Plastic rotors having different numbers and sizes of cells
Fertilizer metering device
: Fluted roller made of aluminium
Power transmission to metering devices
: From ground wheel through sprocket and chain arrangement

Field Evaluation

Field tests were conducted at the

HPKV Farm in order to evaluate the performance of the multi-crop planter and to compare it with the traditional method of sowing. The planter was tested using manual as source of power. Two persons pulled the machine while the third person controlled it. Machine performance parameters like effective field capacity, field efficiency, speed of operation, depth of sowing and labour requirement were determined. Field data were also collected to determine the labour requirement and cost of sowing operation by the traditional method.

Cost Analysis

Cost calculations were carried out based on the procedure given in the IS Code (Anon, 1979). The useful life of the planter was assumed to be 8 years and its annual use was assumed to be 100 hours.

Result and Discussion

Field performance data of multi-crop planter are shown in **Table 1**. The values given in this table are average based on three replications for each crop. Row to row spacing was 605 mm for maize and 226 mm for wheat crop. The average seed-to-seed spacing for maize was 210 mm against the designed spacing of 200 mm. The actual seed rates were 23.2 kg/ha and 126.6 kg/ha against the recommended rates of 20 kg/ha and 120 kg/ha for maize and wheat crop, respectively. The effective field capacity of the planter was 0.157 ha/h for maize and 0.064 ha/h for wheat crop.

For maize crop, the cost of sowing with the planter was Rs. 65/ha as compared to Rs. 143/ha with the traditional method, thus resulting in net savings of 55%. Labour requirement was only 19 man-h/ha as compared to 52 man-h/ha with the traditional method, thereby indicating labour savings of 63%. The cost of sowing wheat with the planter was Rs. 159/ha as compared to Rs. 385/ha with the traditional method, resulting in net savings of 59%. Labour requirement was only 47 man-h/ha as compared to 140 man-h/ha with the traditional method, thereby making labour saving of 66%.

Conclusions

The planter developed at HPKV is a suitable machine for small and medium farmers of hilly areas. It can sow the major crops like maize and wheat. It is light in weight and works well in small terraces. By using this planter, the cost of sowing can be cut down by more than 50% and labour requirements by more than 60% compared to the traditional method. The planter cost of Rs. 600 is within reach of small and medium farmers.

Table 1. Performance of Multi-crop Planter

Parameter	Maize	Wheat
Row to row spacing (mm)	605	226
Seed to seed spacing (mm)	210	—
Depth of sowing (mm)	51	55
Speed of operation (km/h)	3.5	3.7
Seed rate (kg/ha)	23.2	126.7
Fertilizer rate (kg/ha)	222.7	286.3
Effective field capacity (ha/h)	0.157	0.064
Field efficiency (%)	75.4	76.8
Labour requirement (man-h/ha)	19	47
Cost of sowing (Rs/ha)	65	159

REFERENCES

Anon. (1979). Guide for estimating cost of farm machinery operation. IS: 9164-1979, Bureau of Indian Standards, New Delhi.

Kingra, I.S. and Singh, C. (1986). Agricultural development. In: N.M. Nayar and S.C. Verma (Editors), Agricultural Research and Development in Himachal Pradesh. Govt. of Himachal Pradesh, Shimla, pp. 11-24.

Singh, G. and Bhardwaj, K.C. (1985). Directoryof agricultural machinery and manufacturers. Central Institute of Agricultural Engineering, Bhopal.

■■

A Low-cost Rice Cleaning/Destoning Machine

by
A.S. Ogunlowo
Agricultural Engineering Department
Federal University of Technology
Akure, Nigeria

A.S. Adesuyi
Agricultural Engineering Department
Federal University of Technology
Akure, Nigeria

Abstract

The purpose of this study was to develop a device to separate stones and other accompanying impurities from milled and paddy rice grains. Separation was accomplished using a combination of oscillating sieves and a variable directional air stream. Three sieve sizes with oval shapes having lengths ranging between 4.55 mm and 6.75 mm and aperture thickness between 2.25 mm and 3.35 mm were used. The reciprocating sieves performed effectively at crank speed of 160 rpm. The machine effectively removed all chaffs and other light impurities from both milled and paddy rice. The machine also performed satisfactorily in removing nearly all the stones in the rice samples. From the performance evaluation of the machine it was observed that 874 kg/h of milled rice and paddy rice could be processed. Although this work did not cover the effects of sieve size, sieve agitation on machine capacity, one could suggest that the capacity of this device could be increased with the use of proper sieve size, sieve agitation and air direction. Tray loss was 2.99% for paddy rice and 17.81% for milled rice. The average separation efficiencies of the machine for paddy and milled rice were 97% and 82%, respectively.

Introduction

The concept of separating rice into fractions has not received adequate attention in the developing countries, particularly Nigeria; thus making the consumption of our locally produced rice unacceptable. Seed cleaning consists of removing foreign materials from the crop seed. In Nigeria many methods are used. The earliest one consists of traditional methods of employing manual labor while the latest methods encouraged by technological advancement in many countries and its recent awareness in Nigeria, involve the use of different machines that separate the admixtures based on the differences in their physical as well as aerodynamic characteristics.

In Nigeria the harvesting and post harvest handling methods of rice encourage the presence of contaminants such as stones, sticks, chaffs and dust. This makes effective cleaning necessary before consumption. Ogunlowo (1983) reported that for effective removal of extraneous matter in products, it is required that the admixture be adequately dispersed and that the rate of feeding the material into the separation medium be below some threshold value. Henderson and Perry (1976) stated that mechanical methods of separating rice from extraneous matter depends on the differences in such characteristics as size, shape and specific weight. Koya and Adekoya (1994) studied some physical and aerodynamic properties relevant in destoning some grain crops. They observed that the suspension velocities of the grains are useful in determining velocities of air required for aerodynamic cleaning of the grains.

Adeyemi (1978) in his study of grain cleaning highlighted the ineffectiveness of manual grain cleaning which he claimed has an output less than 40 kg/h. Other methods that have been tried in the past consisted of throwing the grains mass into the wind. The basic principle involved in this method is the unconscious utilization of the relative suspension velocities of the grains and the accompanying foreign materials by the local farmers. When the grains are thrusted upwards in the opposite direction of the wind, the chaffs and lighter particles are blown further from the point of release while the stones and the grains are partially separated. West (1972) described this method as inefficient. Henderson and Perry (1976) in experimenting with sieve cleaners for grains highlighted the main disadvantages of such cleaners to be the tendency for sieve blockage. Several studies, Mohsenin (1978), Ogunlowo and Oladapo (1990) and Ogunlowo and Ademosun (1991) have agreed that when an air stream is used for separation of a product from its associated foreign materials, aknowledge of the component admixture terminal velocity would define the range of air velocities that will effect good separation of the desired product from the foreign (unwanted) materials. Hence, to separate grains such as rice, a series of detailed studies of their terminal velocities and physical properties relative to the accompanying debris should be known.

Experimental Apparatus and Procedure

Theory

One of the most important phenomena in the problem of separating materials of different properties in a pneumatic system is the sedimentation motion of the heavier materials while the lighter ones remain as suspended particles being carried along with the fluid medium flowing in the separator. To achieve these types of motions simultaneously requires a thoroughly dispersed admixture in the flowing fluid. When this happens the forces on the solid materials are dependent mainly on the local fluid velocity, the Reynolds Number, the material shape, and the volume of the duct. Some of the important properties considered in this study are: size, shape, density and suspension velocity.

Shape

Sphericity expresses the shape character of a solid relative to that of a sphere of the same volume. By using the isoperimetric property of a sphere, the geometric foundation of the concept of sphericity is defined as:

$$\text{Sphericity} = d_e/d_c \qquad ...(1)$$

where,

d_e = diameter of a sphere of the same volume as the object, and, d_c = diameter of the smallest circumscribing sphere or usually the longest diameter of the solid. Assuming that the volume of the solid is equal to the volume of a triaxial ellipsoid with intercepts a, b, and c and that the diameter of the circumscribed sphere is the longest intercept, a of the ellipsoid, then the sphericity is:

$$S_p = \left[\frac{abc}{a^2}\right]^{1/3} \qquad ...(2)$$

The shape factor which measures the degree of roundness of the solid is:

$$\lambda = \frac{A_p}{A_s} \qquad ...(3)$$

where,

A_p = the projected area of the solid, and,

A_s = area of the smallest circumscribed circle.

Terminal Velocity

When a particle falls through an air stream, the terminal velocity is attained when the resisting drag force balances the gravitational force corrected for buoyancy, thus the terminal velocity of a solid could be calculated from:

$$V_t = [2\theta_v V_p(\rho_p - \rho_a)g/\phi_a A_p \rho_a C_D]^{1/2} \qquad ...(4)$$

where,

ϕ_v = volume correction factor = $(d_s/d_p)^3$

V_p = volume of particle

ρ_p, ρ_a = density of particle and air, respectively

A_p = projected area of solid

ϕa = area correction factor = $(d_s/d_p)^2$

C_D = drag coefficient

d_s = diameter of smallest circumscribed sphere, and

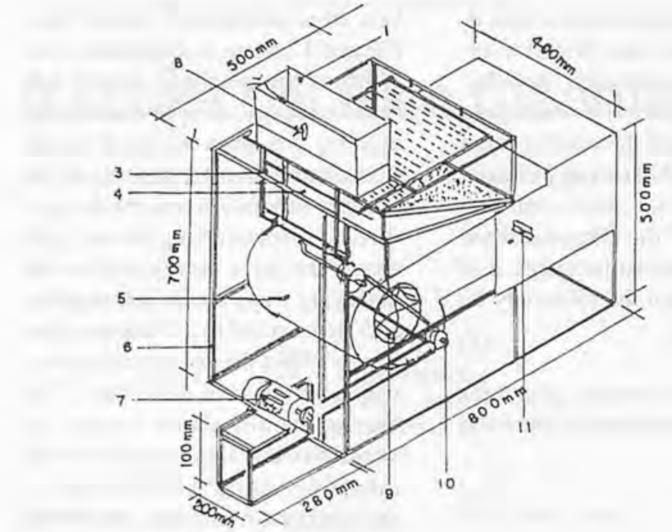
d_p = diameter of the solid particle

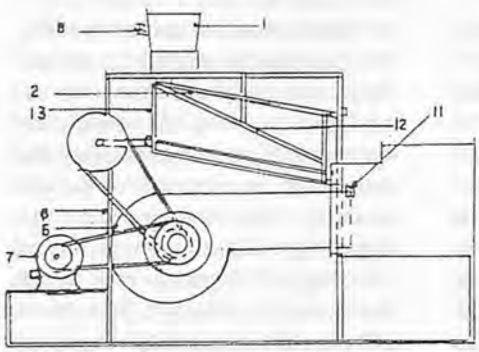
Destoner Design

The machine which utilizes both mechanically agitated sieve cleaners and an aerodynamic separation was designed and built to separate stones and other accompanying debris from milled and paddy rice. **Figure 1** shows a schematic diagram of the machine which was made compact, simple and affordable by rice growers at all levels. The arrangement consists of the primary separation unit made up of three reciprocating sieves and trays. The three sieves and the underlaying trays are bolted together and are coupled to a crank mechanism to effect the reciprocating motion of the sieve and trays. The sieves should allow larger and smaller rice grains to be collected, thus performing the first stage of the separation process. Below the sieve and the tray arrangement is the final separation unit comprising of an adjustable angled air stream. This secondary separation was intended to remove the remaining stones and light particles using the aerodynamic properties of the admixture. The machine was designed for a maximum capacity of 1000 kg/h. For paddy rice which has terminal velocity 5.36 m/sec a 279 mm diameter pulley was used for the fan which was operated by an electric motor running at a speed of 800 rpm. The other functional components of the machine are the centrifugal fan, the feeder (hopper), separator chamber and the collecting chutes for clean rice.

Mixture Separation

Various admixture of contaminants and rice grains were separated in the tests. Locally processed rice variety ITA 257, average density 549.95 g/m^3 and sphericity average equal to 41 was obtained. About 25 percent, by weight, of stones was added to a specified amount of rice and thoroughly mixed before introducing the admixture into the machine. The diameters of motor fan pulleys used were 57 mm and 279 mm diameter, respectively. These were obtained from the calculation of air velocity required to suspend the grain particles. At these values the





Legend

No.	Qty.	Item
1	1	Hopper
2	1	Oblong sieve
3	4	Canvas
4	1	Round sieve
5	1	Fan housing
6	12	Frame support
7	1	Electric motor
8	1	Feed control adjuster
9	6	Fan blade
10	1	Fan shaft
11	2	Stones outlet chute
12	2	Collecting tray
13	4	Tray support

Fig. 1 Rice destoning machine (front view).

air velocity was 5.75 m/sec which is slightly higher than the terminal velocity of rice grains. At the start of each test run, the feed control adjuster was turned opened thus regulating the feed rate into the machine. As the admixture drops on the first sieve which is oval in shape, the reciprocating action of the sieve allows the rice and foreign materials having the same size or smaller than rice to pass through while the larger stones and trash are separated.

The mixture then falls on the underlaying collecting tray which disperses the admixture and transfers it to the second sieve. This sieve separates smaller stones from the mixture. The remaining rice and stone admixture then drops on the third sieve. As the admixture of rice and stones having the same size as rice drops from the third sieve, the secondary separation which is accomplished by an airblast on the admixture takes place. Here air stream at 45° to the horizontal was used. This was based on the finding of Ogunlowo and Oladapo (1990) that the efficiency of separation of foreign materials from grains was high when the directional air stream was set at angles between 30° and 60° to the horizontal. For this unit, the fan assembly was made adjustable by mounting it on the main frame through slots on the frame carrying the fan housing. The three reciprocating sieves and trays were made to incline toward the discharge point at angle 36.5° which is higher than 35°, the angle of repose of rice.

The air velocity which was preset at 5.75 m/sec was used in the performance evaluation. This was to ensure that the air velocity used was slightly higher than the terminal velocity of 5.36 m/sec as determined by Ogunlowo and Ademosun, (1991). Based on the differences in the physical and aerodynamic properties of rice and stones, the trajectories of stones are shorter than those of rice, thus effecting secondary separation in the air stream. The height of fall, 340 mm from the second to the third sieve was such that enough resident time in the air stream is achieved for rice-stone admixture interaction with the air stream. The design of the sieves for effective separation of grains was based on the shapes of the samples. By using the standard methods in Mohsenin (1978), Ogunlowo (1983), and oje (1993) for determining roundness and sphericity of particles, many samples of rice grains and stones were taken. Their dimensions in the three orthogonal planes were measured and the sizes of the sieves were based on the results of the particle size computations. The sieve arrangement in the assembly was influenced by the stages at which each size of the admixtures are to be separated.

After the operation, the rice and stones removed and discharged through the chutes were collected. The time taken to separate a measured quantity of the mixture was determined using a Cronus 3-S digital stop watch. The performance of the machine was quantified by calculating the separation efficiency and the tray loss. The impurity level was used to specify the mass of rice being contaminated by one stone piece. Thus, the impurity level before separation was computed from:

$$I_{bs} = M_{sm}/M_{m} \times 100\% \qquad ...(5)$$

and the impurity level after separation was computed from:

$$I_{as} = M_{scr}/(M_{cr} + M_{scr}) \quad ...(6)$$

where,

I_{bs} = Impurity level before separation, %

I_{as} = Impurity level after separation, %

M_{cr} = mass of clean rice, g, and

M_{sm} = mass of stones in admixture, g

M_{scr} = Mass of stone in clean rice after separation, g

Tray loss was calculated using the expression:

$$T_L = [1 - M_{cr}/M_{rm}] \times 100\% \quad ...(6)$$

where,

M_{rm} = mass of rice in admixture before separation, g

The performance efficiency of the machine was determined using the following relationship:

$$\eta_r = (M_{cr}/M_{rm}) \times 100\% \quad ...(7)$$

and,

$$\eta_s = (M_{sc}/M_{sm}) \times 100\% \quad ...(8)$$

where,

η_r = Rice separation efficiency, %

η_s = Stone separation efficiency, %

All test groups were replicated five times and the averages were recorded.

Results and Discussions

Results of the tests are shown in **Tables 1** and **2**. These tables were produced from the results of admixture of rice, stones and other impurities being separated by the machine and weighed separately. Based on the initial tests on the air velocity required to suspend rice grains, a fixed size fan pulley was used thus ensuring constant air velocity. Resulting from these initial trials, the machine was operated at 160 rpm for the performance evaluations. On the average, the machine capacity was 875 kg/h for the performance evaluation. Air velocity used was constant at 5.37 m/sec which appeared to be adequate for separating the rice grains from the stones. Observations in **Tables 1** and **2** show that an increase in admixture inflow rate into the system affected the separation efficiency. The separation efficiency of paddy rice was observed to be higher than that of milled rice be-

Table 1. Results of Destoner Performance Evaluation with Milled and Paddy Rice at Moisture Content of 13.27 Percent

Rice Type	Admixture Quantity (g)	Quantity of Rice (g)	Quantity of Stone (g)	Mass of Rice Separated (g)	Mass of Stone Separated (g)	Elapsed Time (min)
Paddy rice	501	396	105	372	70	3.27
	776	613	163	594	114	5.33
	950	751	200	734	163	6.63
	948	749	199	732	163	6.62
	856	696	180	658	137	5.93
	896	708	188	691	148	6.23
	542	428	114	405	77	3.58
	799	631	168	612	120	5.50
	959	758	201	741	167	6.70
	976	771	205	755	171	6.83
	919	726	193	709	154	6.40
	979	773	206	757	172	6.85
Milled rice	501	396	105	274	54	3.27
	776	613	163	500	88	5.33
	950	751	200	641	153	6.63
	948	749	199	640	154	6.62
	856	676	180	565	119	5.93
	896	708	188	598	134	6.23
	542	428	114	309	59	3.58
	799	631	168	518	96	5.50
	959	758	201	649	157	6.70
	976	771	205	663	164	6.83
	919	726	193	616	142	6.40
	979	773	206	664	165	6.85
Milled rice Average	841.75	664.87	176.88	553.08	123.75	5.82
Paddy rice Average	841.75	664.87	176.88	646.67	138.00	5.82

Table 2. Separation Efficiencies for Stones and Rice at Average Moisture Content, 13.27 Percent

Type of Rice	Feed Rate	Impurity Level (Before)	Impurity Level (After)	Tray Loss	Separation Efficiency	
					Rice	Stone
	(g/min)	(%)	(%)	(%)	(%)	(%)
Paddy rice	153.21	20.96	8.60	6.06	93.87	66.39
	145.59	21.01	7.62	3.10	96.85	69.86
	143.29	21.05	4.80	2.26	97.74	81.46
	143.20	20.99	4.69	2.27	97.78	81.91
	144.35	21.03	6.13	2.66	97.33	76.11
	143.82	20.98	5.47	2.40	97.54	78.78
	151.40	21.03	8.37	5.37	94.58	67.18
	145.27	21.03	7.27	3.01	96.97	71.47
	143.13	20.96	4.39	2.24	97.81	83.26
	142.90	21.00	4.31	2.08	97.90	83.42
	143.59	21.00	5.21	2.34	97.63	79.94
	142.92	21.04	4.30	2.07	97.89	83.32
Milled rice	153.21	20.96	15.69	30.81	69.20	51.12
	145.59	21.01	13.04	18.43	81.59	53.80
	143.29	21.05	6.83	14.65	85.32	76.36
	143.20	20.99	6.57	14.55	85.47	77.24
	144.35	21.03	9.74	16.42	83.60	65.96
	143.82	20.98	8.28	15.54	84.46	71.16
	151.40	21.03	15.11	27.80	72.14	51.74
	145.27	21.03	12.20	17.91	82.11	56.94
	143.13	20.96	6.35	14.38	85.58	77.93
	142.90	21.00	5.82	14.01	85.96	80.18
	143.59	21.00	7.65	15.15	84.84	73.42
	142.92	21.04	5.82	14.10	85.93	79.99
Milled rice Average	145.22	21.01	9.43	17.81	82.18	67.99
Paddy rice Average	145.22	21.01	5.93	2.99	96.99	76.93

ing an average of 97% and 82% for paddy and milled rice, respectively. This difference could be attributed to a number of factors. One very likely factor is that broken rice become lighter than whole rice and these remain as suspended particles in the air stream being carried out beyond the collection chute with the air stream. The tray loss at the operational conditions of the machine was on the average 2.99% and 17.81% for paddy and milled rice, respectively. This could be due to the fact that a greater amount of clean paddy rice is collected in the collecting chute than the milled rice which as some of the broken grains blown beyond the collecting chute by the air stream.

For the test runs, the separation efficiency for milled and paddy rice as affected by the feed rate could be obtained from the following relationships:

$$\eta_m = 318.240 - 1.625q_m \qquad ...(9)$$

where,

R^2 = 0.9999 and Covariance = 19.268

q_m = feed rate of milled rice and stone admixture, g/min

while, the separation efficiency for paddy rice is given by:

$$\eta_p = 153.706 - 0.391q_p \qquad ...(10)$$

where,

R^2 = 0.9999 and Covariance = 4.629

q_p = feed rate of paddy rice and stone admixture, g/min

Observations of **Table 2**, show that the average separation efficiencies are 82.18% and 96.99% for milled and paddy rice, respectively. This indicates that 17.82% of milled rice and 3.01% of paddy rice will be lost. The average stone separation efficiencies from milled and paddy rice are 67.99% and 76.93%, respectively. The impurity levels after separation tests indicate that on the average, 9.43% and 5.93% of stone will remain in milled and paddy rice, respectively. This makes further separation necessary to remove all stones from the rice grains.

Conclusions

The mechanical reciprocating sieves in combination with air blast could effectively separate both milled and paddy rice from stones and other impurities. With the use of different sizes of sieves, it is possible to handle different rice varieties of different sizes. The separating efficiency of the machine is a function of feed rate. The separating efficiency of the machine is a function of feed rate. The principle of operation of this machine should be useful in separating rice from foreign materials. It is suggested that with a longer trajectories by increasing the release speed from the bottom sieve into the airstream and also increasing the numbers of sieves, all the stones could be removed. This deduction was made because for all loading rates and foreign matter contents, less than 5.93% and 9.43% stones was recovered in the destoned paddy and milled rice, respectively.

REFERENCES

1. Adeyemi, S.O. 1978. Design and construction of a grain cleaner. Unpublished B.Sc. Project Report, Department of Agricultural Engineering, Obafemi Awolowo University, Ile-Ife.
2. Henderson, S.M. and R.L. Perry. 1976. Agricultural Process Engineering. 3rd Edition. The AVI Publishing Company Incorporated, Westport, Conneticut. pp. 108-109.
3. Koya, O.A. 1988. Design, construction and testing of a grain destoner. Unpublished M.Sc. Thesis. Department of Agricultural Engineering, Obafemi Awolowo University, Ile-Ife.
4. Koya, O.A. and L.O. Adekoya. 1994. Some Physical and Aerodynamic properties relevant in destoning some grain crops. Ife Journal of Technology, Vol. 4, No. 2, Pg 35.
5. Mohsenin, N.N. 1978. Physical properties of plant and animal materials. Gordon and Breach Science Publishers, London, PP 51-70, 495-664.
6. Ogunlowo, A.S. 1983. Theoretical and Experimental Investigation of bulk material flow in a pneumatic chamber for chopped sugarcane. Unpublished PhD Dissertation, Texas A&M University, College Station, Texas. 208 pages.
7. Ogunlowo, A.S. and F.O. Oladapo. 1990. Grain-Chaff separation in a crossflow airstream. Proceedings of the 15th Annual Conference and General Meeting of the Nigerian Society of Agricultural Engineers.
8. Ogunlowo, A.S. and O.C. Ademosun. 1991. Design and evaluation of a pneumatic separation for selected seeds. Nigerian Journal of Technological Reserch. In Press.
9. Ogunma, O.N., U.G. Ezenwa and D.O. Anyawu. 1992. Design, construction and testing of a destoner - Rice/Sand Separator. Nigerian Journal of Technical Education. Vol. 9, No. 2. Pg. 97.
10. Oje, Kayode. 1993. Some engineering properties of Theretia nut. Journal of Agricultural Engineering and Technology, Vol. 1 Pg. 38.
11. West, N.L. 1972. Aerodynamic force predictions. TRANSACTIONS of the American Society of Agricultural Engineers. Vol. 15 No. 2, PP. 582-587.

An Anthropometric Model of Indian Tractor Operators

by
Rajvir Yadav
Associate Professor
College of Agricultural Engineering
and Technology
Junagadh 362001
India

V.K. Tewari
Assistant Professor
Dept. of Agricultural and Food Engineering
Indian Institute of Technology
Kharagpur
India

N. Prasad
Ex. Research Scholar
Dept. of Agricultural and Food Engineering
Indian Institute of Technology
Kharagpur
India

A.H. Raval
Associate Professor
College of Agricultural Engineering
and Technology
Junagadh 362001
India

Abstract

Although Indian tractor operators are not as diverse a population as those in the United States and Great Britain, they are not a homogenous group. They are not necessarily representatives of the population as a whole. An anthropometric survey was conducted from the Eastern part of India to provide details of drivers, specially related to the design of tractor workplaces and for the development of ergonomic consciousness for the designers. Twenty-four body dimensions related to tractor design were measured for a sample of 105 tractor operators. Data has been analyzed statistically and the mean, CV and SD calculated. Comparisons were made with other populations like Americans and British. The variation was found at 5% level of significance. Dimensional models are suggested for 5th and 95th percentile drivers, which may be used as design tools. Knowledge of user dimensions can aid proper machinery design for reducing occupational injury and enhancing safety and productivity.

Acknowledgment: The authors are thankful to CSIR, New Delhi for providing financial help to carry out this work.

Introduction

Many problems in the design of vehicles are related to the size of the occupants. The Indian tractor industry has a potential home market of 1.5 million tractors. In India a wide choice of competitive tractor models, in the range of 18 to 75 pto HP, is now available to farmers but the design changes in these tractors are not adequate enough due to economical regions (Anon., 1990). Opposite to highly sophisticated designs in Europe, North America and Japan (in saturated markets), the two biggest nations of the world, China and India, could became important with their tractor productions using "medium technology" and units of low power level achieving high annual growth in domestic sales (Renius, 1994).

The tractor driver must be positioned such that he can reach all the controls, and see the road in front of him, while the safety belt must be in the optimum place to restrain him in the event of an accident. The designer, therefore, has to consider tall drivers with long and short arms, and small drivers with short legs but long arms. He can provide a relatively wide range of adjustment in the travel seat, but the position of any control relative to the seat will depend upon several interacting dimensions of the driver, each of which will have its own range of variation within the population.

Designers have had, therefore, to rely heavily on the more detailed information available for the American population. This may have advantages for the export market, but India has a large potential market for farm tractors. Proper matching of machinery requirements with the operator's capabilities are necessary to achieve better performance. Little attention has been given towards the efficiency, comfort and safety of the operators of agricultural machines and tractors.

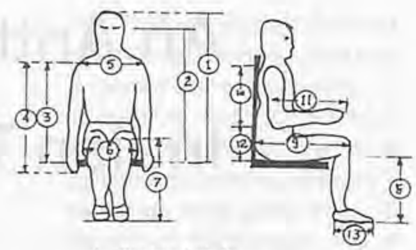
Many designers are working to current legislation, much of which is based on American anthropometric data, since this has been virtually the only source (Haslegrave, 1979). In Western countries a large amount of anthropometric data are available as a ready reference (NASA, 1978). However, it does not contain any data of Indian population. The Indian anthropometric data available for reference is not sufficient and the dimensions included are specific to the requirements. Few anthropometric survey of the Indian body dimensions brings the design of equipment utilized in the Indian agriculture into question. Equipment do not appear to have been designed for the use population because of insufficient anthropometric data, and therefore, are liable to cause operational difficulties, job-related fatigue and lower overall performance efficiency. Considerable difference has been found in anthropometric data of Indian and Western countries (Sen, 1964; Fernandez and Uppugonduri, 1992).

Anthropometric survey of agricultural workers from the Western, Northern, Central and Southern India have been reported (Sen, 1964; Gupta et al., 1983; Gite & Yadav, 1989; Fernandez and Uppugonduri, 1992). This paper reports an anthropometric data of male tractor operators in Eastern India as reference for the ergonomic design and modifications. It is, therefore, important to identify the driving population, as the design of many aspects of the tractor depends on their anthropometric characteristics.

Methodology

Anthropometric measurements were carried out on 105 subjects chosen randomly among tractor/power tiller operators and farm mechanics involved in tractor driving, working at Indian Institute of Technology, Kharagpur; Seed Farm, Midnapur; Soil Conservation Farm, Midnapur and Balrampur village, Kharagpur. Only male operators were considered because in India no female operators are employed for tractor driving task. The standard anthropometric definition of measurements were adopted from Damon et al., (1966), Pheasant (1986), Hertzberg (1968) and Reobuck et al., (1975).

The 24 body dimensions included stature, body weight, sitting height, sitting eye height, sitting shoulder height, knee height, popliteal height, buttock-popliteal length, buttock-knee length, elbow rest height, functional leg length, chest circumference, thigh clearance, hip breadth (sitting), shoulder breadth, grip diameter (inside), metacarpal III height, elbow height (standing), arm length, forward grip reach from wall, shoulder-elbow length, elbow-fingertip length, hand length and food length. The observer was given enough practice to measure all the dimensions in a correct posture and precise manner. The data recorded for a subject was the mean of three readings.



1. Sitting height
2. Sitting eye height
3. Sitting shoulder height
4. Arm length
5. Shoulder breadth
6. Hip breadth (sitting)
7. Knee height
8. Popliteal height
9. Buttock-knee length
10. Shoulder-elbow length
11. Elbow-fingertip length
12. Elbow rest height
13. Foot length

Fig. 1 Anthropometric measurements.

Results and Discussion

Anthropometric Measurements

The anthropometric data for the various body dimensions and the estimates of mean, standard deviation, coefficient of variation and percentile values (5th, 50th and 95th) are presented in **Table 1**. It may be noted that the 5th or 95th percentile operator will not have limb length and dimensions of 5th or 95th percentile values because all dimensions are not well correlated with each other.

Variability in Anthropometric Data

The measured anthropometric data were compared with American

Table 1. Anthropometric Data of Indian Tractor Drivers

Body Dimension	Mean	SD	CV	Range	Percentile		
					5th	50th	95th
Stature	162.1	5.80	3.58	147.5-183.0	152.3	161.9	172.9
Body weight, kg	53.6	6.73	12.58	36.0- 75.0	45.8	53.0	73.0
Sitting height	80.9	2.20	2.72	73.0- 87.4	73.6	80.2	85.1
Sitting eye height	71.4	2.00	2.80	61.6- 76.1	62.6	70.1	75.8
Sitting shoulder height	53.4	2.12	3.97	50.0- 56.0	50.7	53.6	55.2
Knee height	51.5	2.87	5.57	46.4- 59.8	48.0	51.7	55.7
Popliteal height	42.0	1.74	3.95	39.1- 46.0	40.0	42.6	45.2
Buttock-popliteal length	46.2	2.28	4.94	42.7- 47.9	44.1	45.8	47.2
Buttock-knee length	55.1	3.10	5.62	47.9- 64.3	51.9	55.2	58.6
Elbow rest height	17.5	1.58	9.05	14.0- 21.2	16.0	17.0	17.8
Functional leg length	97.6	4.24	4.34	89.5-111.0	91.3	95.4	108.5
Chest circumference	81.3	4.87	6.00	66.0- 92.7	77.1	83.4	91.0
High clearance	12.9	2.24	17.36	11.0- 19.1	11.6	14.0	15.8
Hip breadth (sitting)	31.7	2.30	7.49	27.0- 37.0	27.8	32.6	36.0
Shoulder breadth	36.3	2.60	6.15	32.2- 38.5	33.0	36.2	37.8
Grip diameter (inside)	4.3	0.39	7.19	3.8- 5.8	3.8	4.4	5.3
Metacarpal III height	67.8	2.70	2.92	62.0- 72.1	62.6	67.9	71.5
Elbow height (standing)	101.8	3.80	3.73	96.0-109.7	97.2	102.2	108.6
Arm length	72.6	3.90	4.72	60.7- 75.7	68.9	71.8	73.2
Forward grip reach from wall	73.7	4.46	6.05	60.6- 86.8	71.2	74.1	76.4
Shoulder-elbow length	30.2	1.80	5.96	27.6- 35.0	28.1	31.5	34.3
Elbow-fingertip length	44.6	1.96	4.39	41.5- 50.2	41.9	45.2	49.7
Hand length	17.8	1.61	9.04	16.1- 21.0	16.4	18.7	20.1
Foot length	23.9	1.24	5.19	20.3- 27.4	21.4	23.6	25.8

(Measuring unit: cm unless otherwise specified)

Table 2. Comparison Between Indian to British and US Drivers

Dimension	Mean	Percentile		
		5th	50th	95th
Stature, cm				
Indian	161.1	152.3	161.9	172.9
British	173.8	162.6	—	185.1
U.S.	173.2	161.5	—	184.9
Mass, kg				
Indian	53.6	45.8	53.0	73.0
British	74.3	58.0	—	94.1
U.S.	76.2	57.2	—	98.4

and British drivers and presented in **Table 2**. This comparison indicates that the Indians are smaller than Americans and Britishers almost in all the dimensions. Leg working envelopes were also drawn for Indians as well as for Europeans (50th percentile value) and compared **(Fig. 2)**. It shows the clear variation in both types of the envelopes. Therefore, this type of investigation is important for Indian tractor operator workplace design.

Tractors and power tillers have played an important role in Indian agriculture for various farm operations. For better operation and human comfort, a proper power tiller handle height will be between 62 to 97 cm. The placement of different controls in tractor is a complex task for the designers and requires the anthropometric characteristics of the target population. As suggested by Grandjean (1988), seats should be designed so that in both the forward and backward sitting postures they prove support to the upper edge of the pelvis. In order to accommodate tractor operators ranging from 5th to 95th percentile, it is easier to adjust seat than adjusting controls, however, there must be few compromises between hand and foot controls. The height of the seat cannot be changed greatly as for a small person, a higher seat would result in worsened foot pedal relationship. The horizontal adjustment of the seat is required to accommodate tractor operator between 5th and 95th percentile stature. It is easy to provide horizontal adjustment in seat with little design effort.

The hydraulic control and gear shift levers should be placed within the arm reach of the tractor operator with the least change in his alert driving posture. It should specially be ensured that the operator need not bend forward or side ways while operating these levers. The forward or side ways bending is likely to strain the spinal column. The efficiency and comfort of the operator can be improved with properly designed tractor workplace. The dimensions of seat, location of controls and access/exit provisions are the parameters where anthropometric data can provide help in matching the workplace layout **(Fig. 3)** according to the user's capabilities. Anthropometrically, seat height from foot rest to suit Indians 5th and 95th percentile population would be within the range of 40.0 to 45.0 cm. The weight range of corresponding percentile is 45.0 to 73.0 kg. The dimensions related to seat design and workplace such as buttock-knee length, elbow-finger tip length, shoulder-elbow length, arm length and buttock-popliteal length for 5th

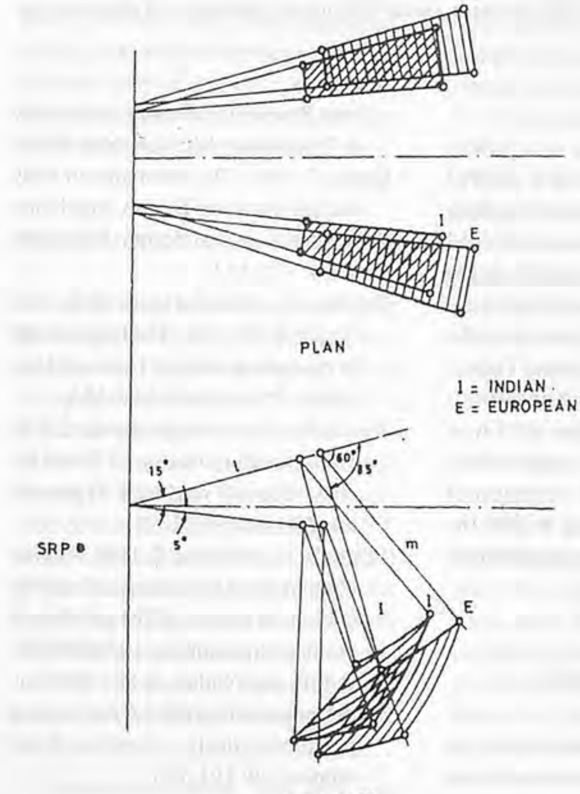


Fig. 2 Comparison of leg working envelope for 50th percentile Indian to European.

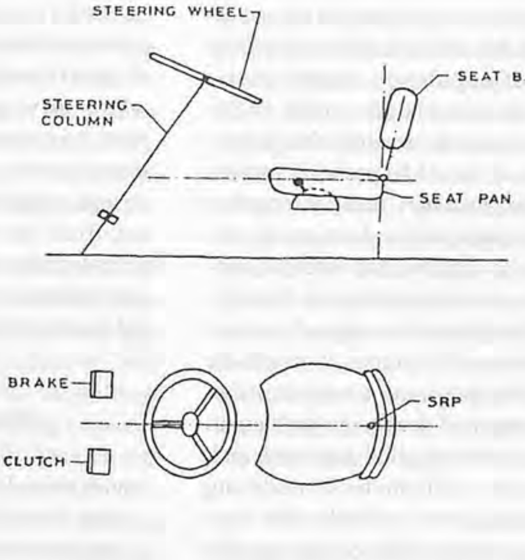


Fig. 3 Tractor operator workplace layout.

percentile Indians are 51.9, 41.9, 28.1, 68.9 and 44.1 cm, respectively. The stature and mass of the American and Britishers were compared to Indian operators and variations were found significant. Physiologically, the steering angle should be within the range of 50° to 60° with the horizontal (Lehmann, 1958). Therefore, European data related to workplace and seat design may not be suitable for Indian operators.

Models of 5th and 95th Percentile Drivers

As mentioned previously, design problems often relate the range of a particular dimension. However, when the accommodation of the population within the whole vehicle is considered, interactions occur between the dimensions. It is then convenient to treat the design in relation to the two extremes of a small (5th percentile) and tall (95th percentile). A 5th percentile man will not have limb lengths and dimensions of 5th percentile value, because dimensions are not correlated with each other. From data gathered in the survey, the dimensions for this model were all calculated. **Figure 4** shows the models of the 5th percentile and 95th percentile drivers whose dimensions are the mean values of the shortest 10% and tallest 10% of population, respectively. The dimensions are closer to the mean population values. Models of this form would be useful in assessing designs where many interacting dimensions are involved, as for, instance in determining whether controls can be reached easily the drivers throughout the range of seat adjustments. Of course, it would be possible in a more comprehensive assessment of the design problem to return to the original data bank and, with the mathematical modeling techniques now available with computers to check the design against the representative sample.

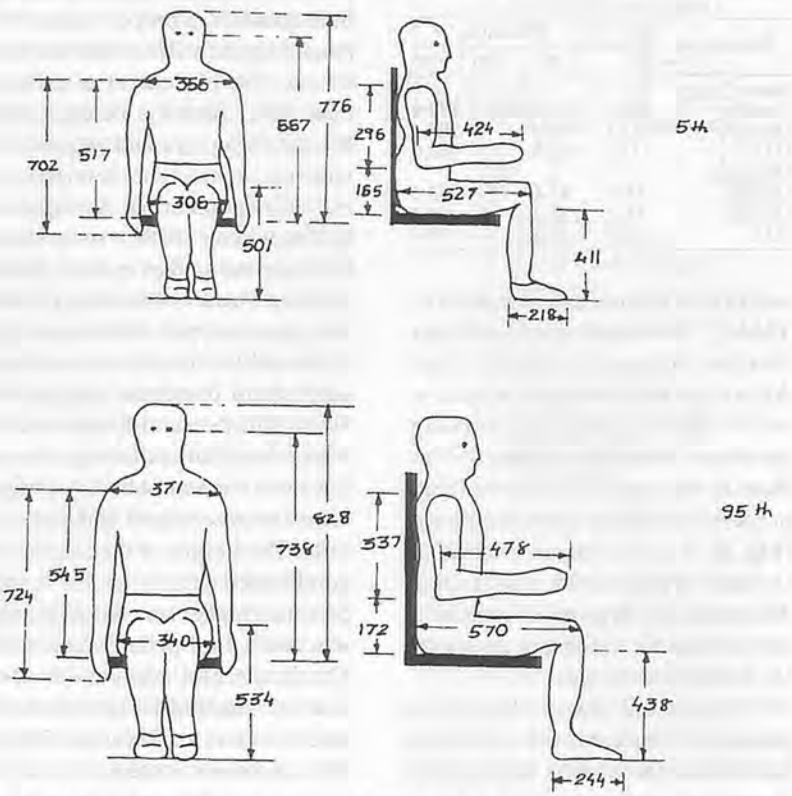


Fig. 4 Models of 5th and 95th percentile Indian male tractor operators (All dimension in mm.)

Conclusions

This survey presents a useful compilation of anthropometric data of Indian tractor operators. It would be useful to construct a mathematical model which uses anthropometric data from banks representing the whole driving population. Therefore, it is hoped that the anthropometric survey will prove useful in design assessments at various levels, from the range of variation of an individual dimension within the population, to complete mathematical model of a design.

REFERENCES

Anonymous 1990. Technology in Indian tractor industry (a status report prepared under the national register of foreign collaboration), Govt. of India, Dept. of Science and Industrial Research, Ministry of Science & Technology Bhawan, New Delhi.

Barka, D. 1961. The estimation of body measurements of British population in relation to seat design. Ergonomics, 4: 123-132.

Damon, A., MacFarland, R.A. and Stoudt, H.W. 1966. The human body in equipment design. Harward University Press, Cambridge MA.

Fernandez, J.A. and Uppugonduri, K.G. 1992. Anthropometry of South Indian industrial workmen. Ergonomics, 35(11): 1393-1398.

Floyd, W.F. and Ward, S. 1969. Anthropometric and physiological considerations in school, office and factory seating. Ergonomics, 12: 132-139.

Gite, L.P. and Yadav, B.G. 1989. Anthropometric survey for agricultural machinery design. Applied Ergonomics, 20: 191-196.

(Continued on page 32)

Problems and Prospects of Agricultural Mechanization in Lebanon

by
Moatasim M. Sidahmed
Assistant Professor of Mechanization
Faculty of Agricultural and Food Sciences
American University of Beirut
Beirut, Lebanon

Teffera Betru
Assistant Professor of Extension
Faculty of Agricultural and Food Sciences
American University of Beirut
Beirut, Lebanon

Abstract

A survey was conducted in five major agricultural regions in Lebanon to determine the status of agricultural mechanization. Relevant information was obtained by visiting and interviewing farmers using a structured questionnaire. Problems pertaining to socio-economic, technical, environmental, management, institutional (local manufacturing, extension services, and research and training) aspects of mechanization were identified. Possible solutions are proposed.

Introduction

Lebanon is located in the Middle East region bordering the Mediterranean Sea, Syria and Israel. It has a population of about 3.7 million, a third of which is involved in agriculture. The total land area of Lebanon is 10 230 km^2. Twenty-five percent of this land is arable. Also, 40% of the total cultivable land is located in the Beqaa Valley, 20-25% in the plains and hilly areas of the South and North, and the remainder is located in the terraced parts of Mount Lebanon (Arab Agriculture, 1994).

Acknowledgement: This work was supported by the American University of Beirut (University Research Board, URB) in the form of a research grant to the senior author.

Specific details on topography, soil and climate are found in Kampe (1965). Lebanon is poised to be one of the most potentially rich Arab countries in agriculture (Arab Agriculture, 1994).

According to the Hariri Foundation (1987), 15% of the population lives in rural areas while the remaining are urban dwellers. One-fourth of the farm-land is used for crop production; the remainder is mainly range lands for migrating flocks of sheep and goats.

Crop production is either rain-fed (80%) or irrigated (20%) (Betru, 1996). Rain-fed crops are grains and pulses, while vegetables and fruits are grown with supplemental irrigation. Wheat, grapes, and olives are the major crops in the North. Vegetables, wheat, grapes, tobacco, sugar beets, and pulses are widely grown in Eastern and Central Lebanon. The production of vegetables under plastic-houses is gaining importance.

There are different forms of agribusiness in the country. They include agricultural input companies, farm machinery dealers, and modern poultry farms. Sugar beet production and processing is an example of a vertically integrated agribusiness in the country.

There are a number of studies on the potentials and constraints in the development of agricultural mechanization in the Middle East (Henderson 1978; Haffar and Ahmed, 1991). While these studies provide a useful overall outlook, it is important to study the situation in some countries of the region separately. This is particularly important to Lebanon for a number of reasons. First, there are some critical differences in such major constraints as land size and tenure patterns, capital, adaptive technology, local manufacturing, and institutional setups and linkages. Second, the tragic events of the 17-year Civil War in Lebanon disrupted the operations and activities of all productive sectors, including agriculture. Third, Lebanon is undergoing a massive reconstruction process. In this regard, the Lebanese government has recently initiated a five-year development plan to improve agricultural roads and increase farmers access to formal credit, which will be provided on market-based interest through a newly established National Bank for Agricultural Development (Eco News, Dec., 16, 1996). Thus, it is high time to evaluate and understand the current state of mechanization, discover unresolved technical and management problems, and recognize and prioritize the real needs of the private sector.

Objectives and Approach

The main objective of this study

was to obtain technical and socio-economic information pertaining to the problems of agricultural mechanization in Lebanon, thereby to determine its future prospect in the agricultural development process of the country.

Farmers were visited and interviewed using a structured questionnaire to collect relevant statistical data and information on the status of farm mechanization in the country. The farm survey covered five regions, namely; North Beqaa, West Beqaa, Mount Lebanon, Batroun, and Jbeil, and involved 178 farmers (about thirty-six farmers from each region). The questions dealt with information about: 1) farmers social characteristics; 2) farm size; 3) use of tractors and implements; 4) record keeping, maintenance and repairs costs, 5) availability of spare parts; 6) soil and water conservation practices; and 7) chemical application practices.

Survey Results

While there were differences in farming systems among the different regions covered in this survey, only the summary of overall results is presented here in order to provide a clear picture of the collective trends and problems associated with mechanization in Lebanon.

Socio-economic Characteristics of Farmers

Sixty-three percent of the farmers were older than 50 years, 30% were between 30 and 50 years and only 5% were less than 30 years. Thirty-six percent of the farmers were illiterate, 49% finished elementary school, 8% went to high school, and only 7% were college or university graduates.

Farm Size and Land Tenure Patterns

Most of the farms in Lebanon are small and fragmented. In general, there were no large commercial farms in the country. Fifty-five percent of the farms were less than 2 ha each, 25% were between 2 and 10 ha, and only 20% of the farms were larger than 10 ha each. Twenty-four percent of farmers farm their own piece of land, 11% were pure renters, and 65% were mixed operators of both their own and rented piece of land. Thus, it is evident than farm size places one of the sever limitations on the level of mechanization in Lebanon (Najjar, 1980). Betru (1997) indicated that land ownership was a key factor that determines the rate of adoption of irrigation technologies in the country.

Tractors

Farming in Lebanon is almost fully mechanized. Ninety-two percent of the farmers used tractors. A small portion, (8%) of the total farmers who did not use tractors were located on Mount Lebanon (7%) where terraced farming is a common practice, and on the Jbeil region; (1%), where farmers mostly use green houses for vegetable production. However, only 32% of the farmers owned tractors. This means that 68% of all mechanized farming is based on custom hiring from neighbouring farmers on the basis of availability.

The survey result also indicated that almost all tractors were small, under-utilized and relatively old. Eighty percent were 15-25 years old and required frequent repairs. Thirteen percent were less than 26 kW, 56% were 26-41 kW, and 31% were 41-56 kW. Sixty-five percent of the tractors were used for more than 400 h/year, 28% for 100-400 h/year, and 7% were used 50-100 h/year.

Although the above statistical information indicate that there were more tractors than needed in some areas, the fact is that 68% of the farming operations were based on custom hiring of tractors, and that most farmers complained about lack of availability of tractor services on time when they needed them. This indicates that there is a poor distribution of tractors to meet the farmers' demand on critical periods. A factor contributing to this problem is the fact that most of the tractors in use were ageing and needed frequent repairs.

Equipment

While plowing and disc-harrowing on the farms were almost fully mechanized, other operations were far from being mechanized. Planting, weeding, and harvesting operations were manually done, except for potatoes, and in few cases wheat on large farms. Almost all farmers performed tillage operations with locally manufactured plows, applied fertilizers with centrifugal broadcaster, and sprayed chemical using knapsack sprayers (green houses and small farms) and boom-sprayers (field and vegetable crops in large farms).

Most farmers were not able to answer questions related to the sizes of their tractors, or to differentiate between engine and maximum PTO (power-take-off-shaft) power.

Management and Technical Problems

Ninety percent of the farmers did not practice bookkeeping. This fact made most of their answers to our technical questions to rely on memory and visual judgement. However, while only 4% of the farmers complained about lack of spare parts, almost all farmers complained about: 1) the high cost of repairs; 2) unavailability of tractors on time; and 3) lack of qualified repair technicians.

Conservation Practices

Ninety-seven percent of the farmers were not aware of any soil conservation practices. Only 13% indicated awareness about water conservation practices. Also, 92%

of the farmers were not aware of minimum tillage practices.

Chemical Application and Safety

This part of the survey dealt with farmers awareness of the hazards and added costs associated with improper chemical and pesticide application practices. While 83% of the farmers indicated awareness about chemical drift, only 65% used some kind of protective measures (mostly mask and gloves) when spraying. Only 9% of the farmers indicated past illness related to the use of pesticides. With regard to proper chemical application practices, 70% of the farmers applied chemicals without calibrating their sprayers.

Institutional Aspects of Farm Mechanization

Extension services — Another aspect revealed by this study was the lack of technical extension agents. The Extension Department in the Ministry of Agriculture did not have a farm mechanization section. Therefore, farmers rely solely on the sales persons for technical advice on selection, use, and management of tractors and machinery.

Local manufacture — There was great interest amount the farmers in locally manufactured agricultural machinery. For example, one manufacturer (Hobeika Freres Industries & Commerce, Zahle, Lebanon) makes almost all kinds of plows, levellers, cultivators, grain and potato planters, hydraulically operated dump trailers, stone collectors, stainless steel spray tanks, and fertilizer broadcasters. Another manufacturer (Joseph S. Abouzeid Factory, Zahale, Lebanon) makes, screw augers, animal feed mixers, feeders, electrical control panels, and automatic packaging systems for grains. A third manufacturer (Agrotec s.a.r.l., Lebanon) specialized in chemical application equipment.

Research and training institutions — Research in agricultural mechanization is a missing component both in the public and private research systems in Lebanon. This part is not even well considered at the only international research center for the region (International Center for Agricultural Research in the Dry Areas, ICARDA, Aleppo, Syria). There are seven technical vocational agricultural schools in Lebanon, of which only three were functional during the time of this study. These schools' management complained about shortages of publications, computerized technological services, and in-service training for the teaching staff.

Discussion

Although it is argued that there were enough tractors in service, in general, farming in Lebanon is still far from being fully mechanized. The factors which were deterrent to agricultural development two decades ago remained persistent. These factors include land ownership, subsistence farming, and illiteracy (Najjar, 1980; Andreou et al., 1979). The constraints to effective mechanization are similar to those in other Middle East countries (Henderson, 1978; Ali and Al-Khafaf, 1988; and Haffar and Ahmed, 1991) or other developing countries (Mirdha, 1993).

However, this study reveals that while most tractors were under-utilized, the majority of the farmers complained about unavailability of tractors on time. This indicates the poor distribution of tractors. This problem along with the problems related to small farm size, lack of capital (to purchase machinery) could be resolved by establishing agricultural co-operatives and similar credit institutions.

An area that needs special attention is the development of affordable specialized machinery, particularly for operations that cannot be performed with standard commercially available equipment. These operations include 1) harvesting of local varieties of lentils and other legume crops; 2) harvesting potato in stony fields; 3) working in terraced lands; and 4) orchard spraying (In most cases orchards' were not properly spaced in planting the trees to allow machine operation). Creating institutional linkages between farmers, manufacturers, research and training institutions, and extension services is a key element that needs to be given due attention.

The chaotic situation that exists due to the lack of technical extension services is much more pronounced with pesticide application equipment. Many of the equipment are sold with little or no guidelines for farmers to ensure efficient and safe application of pesticide. Thus, there is an urgent need to create new job lines for extension engineers, probably similar to the Cooperative Extension Service in the United States. This would likely reduce or eliminate most of the technical and management problems, encourage development of adaptive and appropriate technology, and improve farming and environmental safety. This would also expand the job market for mechanization students and allow mechanization to play its role in agricultural development.

The dominance of locally manufactured plows is a success story for adaptive or appropriate technology. The study of Henderson et al. (1981) showed that potato and wheat yields were improved with the use of a local plow were not significantly different from those under conventional mouldboard or deep plows. However, without encouragement and government support, local manufacturers may face financial difficulties. This can lead to a gradual erosion and loss of the industrial base, and complete dependence on foreign-made equipment which are highly specialized and expensive.

Conclusions

The results of this survey indicated the urgent need to; 1) establish a mechanization section in the Extension Department of the Ministry of Agriculture; 2) develop an extensive technical extension program to help farmers with machinery management, soil and water conservation practices, and proper techniques for applying pesticides; 3) revive the agricultural cooperatives to provide tractor and machinery services as well as spare parts at moderate prices; 4) prepare qualified technicians to maintain and repair tractors and implements; 5) encourage local manufacturing of simple but modern machines; and 6) create institutional linkages between farmers, machinery dealers, manufacturers, research and training institutions, and extension services.

REFERENCES

Ali, L.H.M., and A.M. Al-Khafaf. 1988. Status of farm mechanization in Iraq. AMA 19(2) 69-73.

Andreou, P., N.J. Daghir, N.S. Kawar, M.N. Nimah, and A. Saghir. 1979. Agricultural development in Lebanon, Publication No. 62. Faculty of Agricultural and Food Sciences, American University of Beirut, Beirut Lebanon.

Arab Agriculture. 1994. The Annual Publication of ARAB WORD AGRIBUSINESS Magazine. Fanar Publishing WLL, Manama, Bahrain.

Betru, T. and J. Long. 1996. Agricultural extension as a development strategy for war-torn countries. The case of Lebanon. Journal of International Agricultural and Extension Education 3(2): 11-15, 23.

Betru, T. 1997. The role of communication variables in the adoption of irrigation technologies in Lebanon. Proceedings of the 13th Annual Conference of the Association for International Agricultural and Extension Education, 3-4 April, Arlington, Virginia.

Eco News, 1996, Dec. 16. A weekly news paper of the Middle East, Beirut, Lebanon.

Hafffar, I. and M.H. Ahmed. 1991. Potentials of and constrains to the Adoption of agricultural mechanization technology in the Middle East region. AMA 22(2): 74-80.

Hariri Foundation. 1997. Lebanon at present and its needs for rehabilitation and development. Printing Services Company, Beirut, Lebanon.

Henderson, H.D. 1978. The role of agricultural engineering in Middle East Development. Transactions of the ASAE 21(3): 460-464.

Henderson, H.D., M. Almassi, A.A. Malik, and Z. Mojaddadi. 1981. Deep tillage in Beqa's Valley, Lebanon. 1981. Transactions of the ASAE 24(6) 1466-1470, 1983.

Kampe, R.E. 1965. The Agricultural economy of Lebanon. U.S. Department of Agriculture, Economic Research Service, Publication No. ERS-Foreign 138.

Mirdha, A.H. 1993. Prospects and problems of agricultural mechanization in Tonga. AMA 24(2): 47-50.

Najjar, F. 1979. The contributions of the private sector to development of agriculture. In *Agricultural Education for Development in the Middle East*, ed. J. Ryan and A.T. Saad, 40-47, Beirut, Lebanon: American Universityof Beirut.

World Factbook. 1995. Center for Development Information and Education, United States Agency for International Development, Arlington, Virginia, USA. ■■

(Continued from page 28)

An Anthropometric Model of Indian Tractor Operators

Grandjean, E. 1988. Fitting the Task to the Man (Taylor & Francis).

Gupta, P.K., Sharma, A.P. and Gupta, M.L. 1983. Anthropometric survey of Indian farm workers. AMA, 14: 27-30.

Haslegrave, C.M. 1979. An anthropometric survey of British drivers. Ergonomics, 22(2): 145-153.

Hertzberg, H.T.E. 1968. The conference on standardization of anthropometric techniques and technology. Journal of Physical Anthropology, 28(1): 1-16.

Hertzberg, H.T.E., Daniels, G.S. and Churchill, E. 1954. Anthropometry of flying personnel-1950. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. WADC TR 52-321.

Lehmann, G. 1958. Physiological basis of tractor design. Ergonomics, 1(3): 197-206.

NASA. 1978. Anthropometric Source Book, vol 11. National Aeronautics and Space Administration, Washington.

Pheasant, S. 1986. Bodyspace: Anthropometry, Ergonomics and Design. Taylor & Francis, London.

Reobuck, J.A., Kroemer, K.H.E. and Thomson, M.S. 1975. Engineering Anthropometry Methods. John Wiley and SOns, New York.

Renius, K. Th. 1994. Trends in tractor design with particular reference to Europe. J. Agric. Engng. Res., 57: 3-22.

Sen, R.N. 1964. Some Anthropometric Studies on Indians in Tropical Climate. Proc. Symposium on Environmental Physiology and Arid Conditions (UNESCO, Paris), 163-174. ■■

Field Power and Equipment Trends in Agricultural Production in Kenya


by
Philip M.O. Owende
Postgraduate Student
Dept. of Agricultural and Food Engineering
University College Dublin
Earlsfort Terrace, Dublin 2
Republic of Ireland


Shane M. Ward
Statutory Lecturer
Dept. of Agricultural and Food Engineering
University College Dublin
Earlsfort Terrace, Dublin 2
Republic of Ireland

Abstract

The trend in sales of agricultural tractors and auxiliary tillage equipment in Kenya is discussed to evaluate the inherent limitations to small farm mechanization. Sales statistics and corroborative information from five agricultural machinery dealers who share 95% of the market were used. From data covering the period 1983-93, it was found that the sales of tractors and tillage equipment was dominated by the demand for units in the 30-60 kW power range, while units of the less than 30 kW were insignificant. It is suggested that group ownership of farm machinery, contractual machinery services, and enhanced utilization of draught animal power should be fostered for applications in the small holdings. This may be the case in other developing countries.

Introduction

Kenya is an agricultural economy with about 90% of the population deriving livelihood from agriculture (Ngugi et al., 1992). Agriculture also serves as the source of raw material for the predominantly resource-based industrial sector, and account for 66% of export earnings and approximately 30% of the Gross Domestic Product (World Bank, 1990). Despite previous attempts to modernize the economy through encouragement of industrialization, it is projected that agriculture will continue to take a dominant position in contribution to the Gross Domestic Product, export earnings and employment (Ministry of Planning and National Development, Kenya, 1986).

The production levels of food and fibre have remained inadequate. Consequently, Kenya is a net importer of these commodities which is an indication of the low efficiency in utilization of land and labour (Ministry of Agriculture Livestock Development and Marketing, Kenya, 1992). It has been argued (Owende and Kaumbutho, 1996) that the current levels of productivity of labour may be improved upon by appropriate mechanization i.e., the application of human, animal and mechanically powered equipment in agricultural operations with consideration to the prevailing technical, socio-economic and cultural constraints.

Agricultural mechanization may be idealized to consist of three stages: the elementary stage which is wholly based on human labour; the intermediate stage where human labour is complemented by animal power, and; the advanced stage which entails the use of tractors, with increasing options in new and renewable sources of power. The advantage of mechanized tillage over hand labour has long been quantified (Segler, 1975), and when the intensity of soil manipulation and quality of the final seedbed are also considered (Perdok and Kouwenhoven, 1994), the productivity in the use of DAP and different power ranges of tractors are much higher. Positive correlation between yield and power input to crop production (Giles, 1975), indicates the inherent advantage of increasing available power, and a minimum disposable power of 0.75 kW per ha has been recommended (Davie 1973). However, systems supported by manual labour can only provide 0.02 kW per ha typically, while the use of DAP may allow up to 0.14 kW per ha. For Kenya, these studies underscore and need to complement the application of human labour with animal power and/or tractors, if the desirable increase in labour productivity is to be realized.

The tractor as a source of power may be used for tillage, planting, crop harvesting and processing, and other operations such as hay making (mowing, windrowing and

Acknowledgement: We thank CMC Holdings (K) Ltd., Sametract-Cassini and Tonolo Ltd., Farm Machinery Distributors Ltd., Lima Ltd., and Kenya Motors Ltd., who provided the data that has been used in the manuscript. Gratitude is also due to Mr. S.K. Githua for useful discussions. We acknowledge the assistance from the Kenya Motor Industry Association who allowed us to access some of its data for corroboration.

baling), water pumping, power generation and transportation. These require different ranges of power, and the optimal section of units depends on the constraining power requirement, which is typically primary tillage (Kepner et al., 1982). In Kenya, wheeled tractors account for the largest source of mechanical power in agriculture and related sectors (**Table 1**), where 75% of the total units sold are used (Kiiru, 1993). They also account for 75%, on average, of the total cost of imported agricultural machineries (**Table 2**). The use of crawler tractors is modest and mainly confined to the operation in plantations owned by multinatioal companies and parastatals in the strategic agro-industries, e.g., the sugar industry. However, they are dominant in non-agricultural applications, mainly in the construction industry.

Currently, the sales and backup service of agricultural tractors and auxiliary equipment is dominated by five dealers who market Ford tractors with Nardi ploughs and harrows, SAME tractors with FAIMA ploughs and harrows and Malleti rotorvators, Massey Ferguson tractors and plough with AMCO harrows, Case-IH tractors with Baldan ploughs and harrows, and Fiat tractors. Based on cumulative sales over a 14-year period (Githua, 1992), they hold market shares of 25%, 18%, 31%, 14% and 7%, respectively. The rest is an assortment of makes without established franchises in the country.

Due to population growth and cultural practices, farm sizes in Kenya have gradually decreased (**Table 3**). For example, farms of less than 50 ha increased from 32% of the total holdings in 1981 to 52% in 1989. Currently, 80% of farmers have plots of less than 2 ha (World Bank, 1990). With the trend in reducing farm sizes and the diversity of the probably utilization, optimal mechanization may be remote. It is, therefore logical to study the trends in sales of tractors and the auxiliary tillage equipment, as an attempt to address a fundamental mechanization problem in the dominant smallholder agricultural production in Kenya. A survey was, therefore, initiated in 1993 to acquire some necessary information and data.

Table 1. Mechanical Equipment Inventory in Agricultural Farms in Kenya, 1981-89

Equipment	Year								
	1981	1982	1983	1984	1985	1986	1987	1988	1989
Tractors:									
Wheeled	6 075	6 322	8 150	6 077	6 330	8 760	9 050	9050	8 953
Crawler	324	332	368	317	338	464	362	362	396
Combine harvesters:									
Self-propelled	155	193	238	250	347	416	522	522	486
Tractor-drawn	75	106	315	195	93	173	169	169	170

Source: Central Bureau of Statistics, Kenya (1991).

Table 2. Cost of Importing Agricultural Tractors in Relation to Total Cost of All Imported Agricultural Machinery in Kenya, 1981-1988

Year	Number of tractors	Cost in million US$			Tractors, %
		Tractors	Other machines	Total	
1981	1 242	2.56	0.83	3.39	76
1982	791	2.06	0.95	3.01	68
1983	995	1.43	0.56	1.99	72
1984	781	2.45	0.79	3.25	76
1985	1 111	3.77	0.73	4.50	84
1986	1 139	4.80	1.46	6.25	77
1987	1 173	5.31	2.68	7.99	66
1988	1 486	7.26	1.60	8.88	82

Source: Ministry of Agriculture Livestock Development and Marketing, Kenya, 1993
1 US$ = KSh 55.45 (September, 1995)

Table 3. Sizes of Farm Holdings in Kenya, 1981-1989

Farm size, ha	Number of farms								
	1981	1982	1983	1984	1985	1986	1987	1988	1989
<15	659	697	726	961	1 022	1 023	1 023	1027	1 031
15-49	526	587	729	1 043	1 063	1 062	1 063	1065	1 063
50-99	303	376	422	446	433	433	433	430	435
75-99	303	416	308	384	382	382	382	382	382
150-299	368	363	374	312	303	303	312	300	305
300-399	257	264	236	214	210	212	212	212	210
300-499	226	226	212	166	156	156	156	156	156
500-999	492	497	462	462	383	358	358	359	363
750-1 999	215	219	150	171	161	161	161	160	152
1 500-3 999	106	103	102	84	85	86	84	0	0
3 000-19 999	104	101	92	87	87	86	87	0	0
>15 000	12	10	10	10	11	87	87	0	0

Source: Central Bureau of Statistics, Kenya (1991).

Objectives of the Survey

The objective of the survey was to establish the trend in sales of agricultural tractors and auxiliary tillage equipment in Kenya to enable an evaluation of possibilities for, and limitations to the use of tractors for applications in various levels of tillage operations.

Methodology

The primary data for this study was collected in 1994 through a questionnaire which was administered to the five main farm machinery dealers in Kenya, and by personal interviews. The information sought included:

1. Imports and sales statistics (number, units cost and cost per kW) on wheeled tractors and auxiliary tillage equipment up to 1993;
2. Sales statistics in (1) above, categorized by four user groups;
3. Supply of spare parts and provision of back-up service; and
4. Financing of end-user purchases.

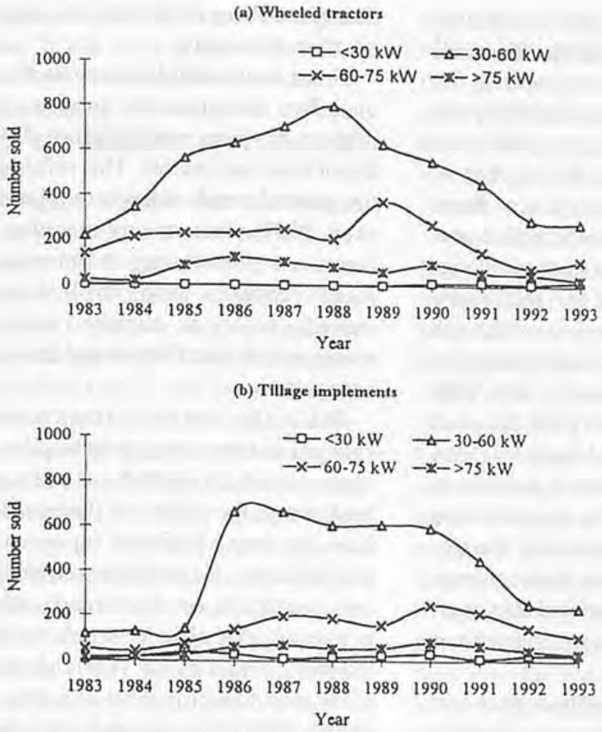


Fig. 1 Sales for wheeled tractors (a) and tillage implements (b) by power category in the period 1983-1993.

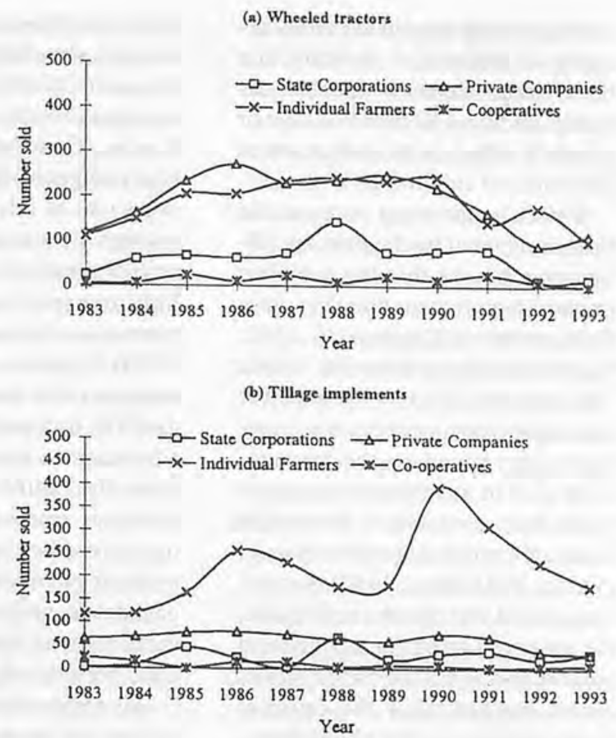


Fig. 2 Sales for wheeled tractors (a) and tillage implements (b) by user category in the period 1983-1993.

Results and Discussion

The total sales of wheeled tractors and auxiliary tillage implements by power categories between 1983 and 1993 are presented in **Fig. 1**. **Figure 2** shows the sales statistics by users under four categories, viz. state corporations, private companies, individual customers and cooperative organizations. **Figure 3** depicts the variation in cost per-unit and cost per kW of engine power, for wheeled tractors for the period 1990 to 1994.

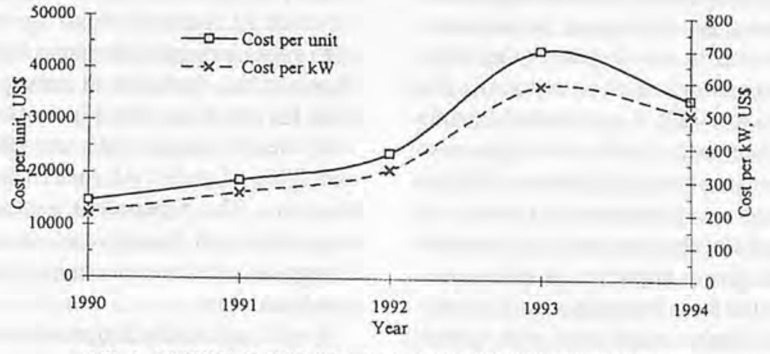


Fig. 3 Variation in cost per-unit and cost per-unit power (kW) for wheeled tractors in Kenya in the period 1990-1994.

The best selling of tractor units **(Fig. 1)** were in the 30-60 kW range, followed by the 60-75 kW range and the higher than 75 kW category. This order was consistent throughout the period analyzed. Sales in the less that 30 kW range was very low throughout the same period, while there was significant decline in number of tractors sold between 1989 and 1993. It was found that only two of the dealers marketed tractor units below 30 kW power range, and these were delivered on order, mainly for specialized applications such as lawn-mowing and light transport with trailers.

Like for tractors, implements in the 30-60 kW range had the highest demand (**Fig. 2**), followed by the 60-75 kW range, then the greater than 75 kW category. Implements in the less than 30 kW category had the least demand, and all the sales were recorded by one dealer.

In the purchase of tractors by user category (**Fig. 3**), state corporations accounted for approximately 14%, private companies 42%, individual users 41% and cooperatives 3%. For tillage equipment, state corporations accounted for 8%, private companies 15%, individual users 69% and cooperatives 3% of the recorded sales. Whereas all the dealers offered varied imported tillage implements, only one included locally produced implements in its range. One dealer recorded significant sales of implements in the less than 30 kW category, at an average of 21 units per year, with a maximum of 39 units in 1985. In the absence of corresponding sales in the same category of tractors, it is likely that these were matched with excess capacity tractors (30-60 kW range or greater), which is an indication of difficult soil conditions.

Power requirement on an arable farm is dictated by the primary tillage practice, as this has a higher traction requirement than any other field operation (Kepner et al., 1982; Perdok and Kouwenhoven, 1994). The economy of operation of power and machinery systems are, however, determined by the management skill in matching work output to the time available, at acceptable levels of fixed and operational costs (Witney and Oskoui, 1982). Assuming rational investments in this case, the observed trend for agricultural tractors and auxiliary tillage implements suggest that the optimal power requirement for tillage operations in Kenya, are in excess of up to 30 kW combinations, on average.

Small two-wheeled tractors have been tried in the past, but were unsuccessful mainly due to their limited power and short economic life (Scott, 1960). Four wheeled tractors of less than 30 kW which have also been promoted (Holtkamp, 1990) as the most appropriate technology in mechanizing the small to medium size farms. However, tests have revealed their limited power for tropical edaphic conditions, with further constraints due to the characteristic high altitude operations (Scott, 1960) and high costs of repair and maintenance. They have limited traction (Crossley and Kilgour, 1983), hence, incur high running costs when used for primary tillage. Their fuel consumption is in the range of 30-70 ℓ/ha (Crossley and Kilgour, 1978; Simalenga and Hatibu, 1988), which is high for their power output. In comparison, typical fuel consumption for agricultural tractors in the 50-80 kW range when used for conventional primary tillage operations is in the range of 25-40 ℓ/ha (Michel et al., 1985 and Bowers, 1989). The outlined disadvantages render the small tractors (<30 kW) inappropriate for operations on the small holdings in Kenya. Observations from this study suggest that the market is cognizant of this fact, hence, these tractors are currently intended and usually promoted for lawn-mowing, light transport and for stationary operations through power-take-off (PTO). However, for applications in transport and stationery jobs with the PTO, they probably lost the price advantage to second-hand tractors, since the entire tractor market in Kenya is small. The second-hand tractor market is currently the domain of government departments, parastatals, and minor private organizations that afford to replace their units periodically.

All dealers maintained spare part outlets and workshops in all major towns in the agricultural districts of Kenya. In areas with low farm machinery utilization, they ensure distribution of spares through agents with other primary business foci. Three of the dealers had arrangement for part financing of purchase, with credit ranging between 40% and 70% of the total cost of the machine. The repayment periods ranged between 1 and 3 years, on declining balance interest rates at current bank rates.

It was impossible to quantify and compare the diversity in the intended use of the tractors sold, due to unavailability of fine records. However, all the dealers considered their units as multipurpose, which may be in error. An earlier study (Gumbe et al., 1991) and corroborative information from this survey, indicates that within the range of makes on the market, there exists some relative advantages depending on application. For example, it was noted that buyers specializing in transport were biased to one specific make, which they attributed to its robust transmission system. The presence of very old tractor units that are still operational was also noted in this study.

From tractor-implement matches on offer, dealers were supplying implements from manufacturers different from the tractors. This reflects the general trends elsewhere (Hood et al., 1989) where tractor manufacturers are purchasing or entering joint ventures with implement manufacturers to supply implements to their distribution and dealer networks.

With the current structural changes in farm sizes, crop requirements and changing systems of crop husbandry, the ability of dealers to have the many different types and power ranges of equipment required is a constraint on the already depressed agricultural machinery market (Ministry of Agriculture Livestock Development and Marketing, 1992). Tractors and auxiliary equipment of greater than 30 kW power are arguably unaffordable to small holder farmers, and may also be uneconomical to operate in the typical farm sizes. This leaves a 'power gap' over small-holdings in Kenya, which are then mechanized through low capacity and highly inefficient hand labour.

Under the current conditions, individual farmers may only benefit from tractor utilization by cooperating in their purchase and use, in order to share the ownership costs and achieve economic levels of utilization. However, from **Fig. 2**, it is noted that the purchase of machinery (tractors and implements) by cooperatives is insignificant and the same may be true for current utilization. The few units acquired by cooperatives were for operations in joint ventures other than service to individual holdings of the members, including tillage.

All dealers indicated that the variability in the number of units and power ranges in their import consignments were based on demand. Due to the slow turnover, the delivery of tractors and equipment of less than 30 kW, and of higher than 75 kW were generally serviced on order. On significant occasions, annual sales superseded the imports, which reflected the presence of old stock.

Figure 3 shows the variation in cost per unit and cost per kW between 1990 and 1994. Five-year data is used due to inability of the dealers to readily supply statistics backdating to 1983, while a retrievable data-base is not yet an integral part of agricultural machinery management in Kenya (Owende and Kaumbutho, 1996). Generally, the values are increasing, against a declining or unstable pricing of agricultural products in Kenya (Ministry of Agriculture Livestock Development and Marketing, Kenya, 1993). Since land sizes are progressively declining, there is a definite need to exploit sources of power specifically aimed at the requirements of increasingly smaller holdings. Currently, available options have increased the use of tractors, and improved application of DAP. DAP has the potential to alleviate the deficiency in power input to crop production, in systems where the prevailing socio-economic conditions may allow for its adoption. Consequently, it is still a vital factor in the attempt to increase the energy input to enhance the production of Kenya's agriculture. In the high potential areas, the opportunity cost of keeping cattle for work is high, and manual labour is, therefore, preferred. However, a better alternative may be in fostering administrative and organizational measures to encourage multi-farm use of agricultural tractors and auxiliary machinery through cooperatives and contractual services, which has been effective elsewhere (Kolawole, 1974).

In view of the number of old tractors that were noted to be still in service in the course of this study, rehabilitation and/or enhanced management programmes for tractors and auxiliary equipment may also be a useful option. However, potential gain may only be evaluated after a survey to acquire basic data on the use and condition of the tractors and auxiliary equipment that are currently in use.

It is also notable that a proportion of the increase in pricing of tractors and combine harvesters has resulted from the increasing complexity of these machines, to include state-of-the-art technologies (Degnan, 1995). Therefore, in collaboration with respective manufacturers, design simplification in the optimal range of tractors may be explored as a means of reducing their production cost. When linked to local (Kenya) design and manufacture of tillage equipment, this may provide mechanical power at lower and possibly affordable capital and operational costs.

Conclusions

Currently, the Kenya market for agricultural tractors and tillage implements is dominated by the demand for units in the 30-60 kW range. There is evidence to suggest that these are inappropriate to operations in the typical farm sizes in Kenya, hence, the need to strengthen alternative sources of power such as the use of draught animals for the small farm if socio-economic circumstances permit its adoption. Where DAP is not practical, there is need to foster group ownership of tractors and auxiliary tillage equipment. With encouragement of contractual machinery services, these should service the 'power gap' between the requirements of small farms and the appropriate options in tractor mechanization.

REFERENCES

Bowners, C.G. 1989. Tillage draft and energy measurement for twelve south-eastern soil series. Transactions of the ASAE 32(5): 1492-1502.

Central Bureau of Statistics. 1991. Kenya Statistical Abstracts, 1991. Ministry of Planning and National Development. Government Printer, Nairobi Kenya.

Crossley, C.P. and J. Kilgour. 1978. Field performance of a winch-powered cultivation device for Central Africa. Journal of Agricultural Engineering Research, 23: 385-396.

Crossley, C.P. and J. Kilgour, 1983. The Development of winch based small tractor for developing countries. Journal of Agricultural Engineering Research, 28: 149-161.

Davie, J. 1973. Animal as a source of power. Paper presented at Conference on Ox-powered cultivation in Wets Africa. NIAE Silsoe, Bedford 8-9 August, 1973. 2 pp.

Degnan, J. 1995. Technology for technology's sake? Resource 2(9): 37-39.

Giles, G.W. 1975. The re-orientation of agricultural mechanization for developing countries. Part 1: Policies and attitudes for action programmes. AMA, 6(2): 15-25.

Githua, S.K. 1992. Agricultural Machinery Marketing in Kenya. Proceedings of workshop on National Agricultural Mechanization Strategy (NAMS). Unpublished report. Agricultural Engineering Division, Ministry of Agriculture and Livestock Development, Kenya. p. 30-33.

Gumbe, L.O., M.O. Odhiambo, V. Kamasara and P.M.O. Owende. 1991. Modalities for the Project Tractor Hire Unit for West Kenya Rainfed Rice Development Programme (WKRRDP). An African Development Bank (ADB) funded study for Lake Basin Development Authority (LBDA), Kenya. LBDA, P.O. Box 1516, Kisumu, Kenya.

Holtkamp, R. 1990. Small four-wheel tractors for the tropics and subtropics: Their role in agricultural and industrial development. GTZ, Weikersheim Germany.

(Continued on page 40)

Comparative the Suitability for Mechanical Harvesting of Two Olive Cultivars

by
H.F. Al-Jalil
Associate Professor
Department of Agricultural Engineering and Technology
Jordan University of Science and Technology
P.O. Box 3030, Irbid
Jordan

J. Abu-Ashour
Assistant Professor
Department of Agricultural Engineering and Technology
Jordan University of Science and Technology
P.O. Box 3030, Irbid
Jordan

K.K. Al-Omari
Engineer
Department of Agricultural Engineering and Technology
Jordan University of Science and Technology
P.O. Box 3030, Irbid
Jordan

Abstract

The detachment force required to remove fruits from branches of two olive cultivars was determined experimentally using the Instron Tensile Tester with specially-modified adapters. The effect of spraying Zibar, a by-product of the olive extraction process, on reducing detachment force was studied. The test results showed that the larger fruit size cultivar (Nabali Rosie) has lower force-weight ratio (F/W) and hence it is more suitable for mechanical harvesting by shaking. Zibar showed significant reduction on F/W of the Nabali Rosie cultivar improving the suitability for mechanical harvesting.

Introduction

The olive oil tree is one of the main crops in Jordan which covers most of its orchard area. In this country, the olive fruits are harvested by hand. The workers pick the fruits one by one, or beats the tree limbs with a pole causing the fruits to fall. Canvases or nets are placed under the tree to collect the fallen fruits.

The higher cost and slow rate of hand harvesting make mechanical harvesting desirable. Tree shakers remove fruits by vibration. Fruit detachment is a complex phenomenon where many actions (inertial and bending forces, and fatigue due to cyclic stress and cumulative damage) have an influence. According to the frequency and amplitude

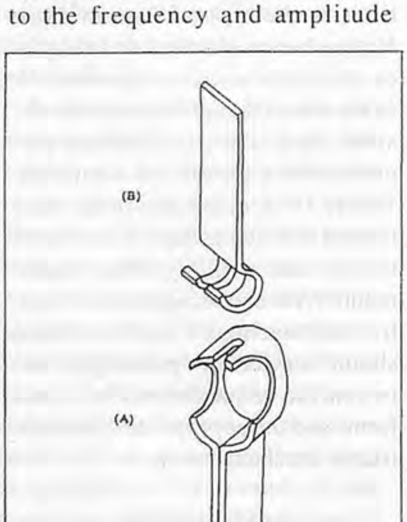


Fig. 1 Special adapters to hold olive fruit (A) and branch (B).

With the shaking action, fruit size and connection force are important and vary with cultivar and time of harvest. Fruit size affect both the inertial and detachment force. Hence the parameter detachment force/fruit weight (F/W), is used for comparing the suitability of olive cultivar for mechanical harvesting and determining the optimum time for tree shaking.

To reduce the detachment force

Fig. 2 Instron Model 1195 testing instrument.

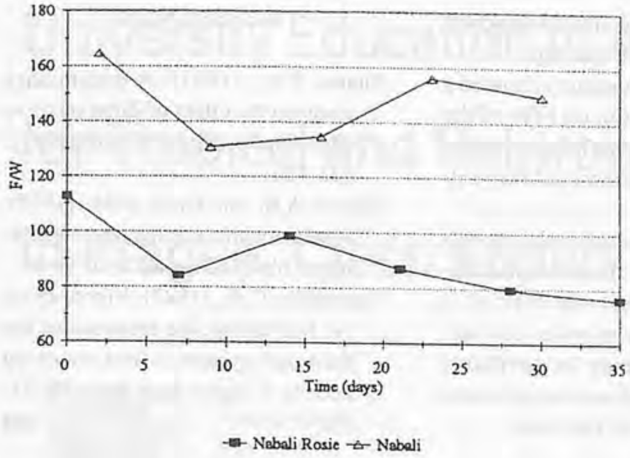


Fig. 3 Comparison of F/W for the two olive cultivars.

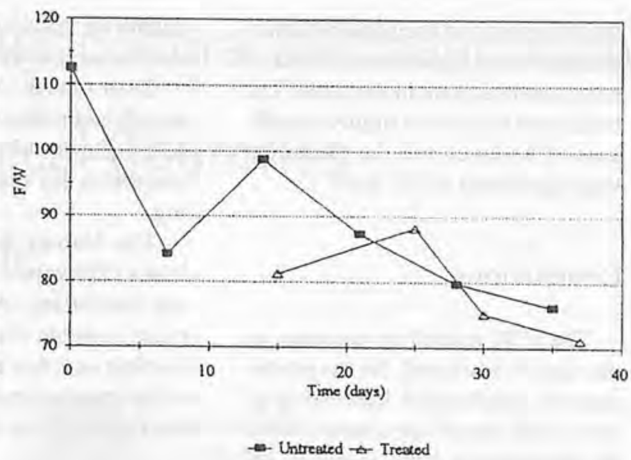


Fig. 4 Effect of Zibar Treatment on the Nabali Rosie Cultivar.

Table 1 Student's t-test Analysis Comparing Nabali and Nabali Rosie Cultivars

Mean	92.5 (for untreated Nabali Rosie) 147 (for untreated Nabali)
t	-8.3617
P(T≤t) two-tail	0.00112
t Critical two-tail	2.7764

Table 2 Analysis of Variance of Main Factors Affecting F/W for Nabali Rosie Cultivar

Source of variation	Sum of squares	d.f.	Mean square	F-ratio	Sig. Level
Main Effects					
A: Block	5 238.9	3	1 746.3	4.30	0.0063
B: Day	6 877.7	3	2 292.6	5.64	0.0012
C: Treatment	2 645.1	1	2 645.1	6.51	0.0119
Interactions					
AB	5 119.0	9	568.8	1.40	0.195
AC	1 600.8	3	533.6	1.31	0.273
BC	2 339.1	3	779.7	1.92	0.130
ABC	3 845.6	9	427.3	1.05	0.403
Residual	52 013.8	128	406.4		
Total (Corrected)	79 956.8	159	—	—	—

and facilitate harvesting operation abscission chemicals such as ALSOL, CHI, and Zibar were used by many research workers (Snobar and Faqih, 1975; Shatat, 1981).

In this work two commonly planted olive cultivars were studied. One of the cultivars has a large-sized fruit and the other has medium-sized fruit. The objective is to compare their suitability for mechanical harvesting.

Materials and Methods

The experiment was conducted during the 1995 olive harvesting season on one of the olive orchards at Jordan University of Science and Technology.

Two olive cultivars were used in the test. One of them has medium-sized fruit (Al-Nabali) and the other has a large-sized fruit (Al-Nabali Rosie). For each cultivar an area was selected randomly and was divided into four blocks. In each block the trees were selected randomly. For each tree of the Nabali Rosie cultivar one side was used as control and the other was sprayed with Zibar (a by-product of olive oil extraction process similar to vegetation water).

From each tree several sprayed and unsprayed branches were cut each week. At the laboratory, using Instron testing machine, five samples from the sprayed and unsprayed olive were selected and tested for detachment force. This force is recorded in addition to the fruit weight.

Special adapters, shown in **Fig. 1**, were designed to hold the branch from a side and the olive fruit from the other side. These special adapters were fixed on the Instron clamps (**Fig. 2**). Tensile tests were done with a slow constant cross head speed at 20 mm/min to avoid the effect of variations in the rate of loading on detachment force. The experiment started on October 9, 1995. The trees were sprayed with Zibar on October 21, 1995.

Results and Discussion

The fruit force/weight ratio (F/W) measurement showed that the ratio decreased as the season advanced (**Figs. 3** and **4**). The student's t-test analysis comparing Nabali cultivar and Nabali Rosie cultivar (**Table 1**), showed a significant difference in the means of F/W. Nabali Rosie cultivar has smaller F/W values compared with Nabali cultivar (**Fig. 3**). The Nabali Rosie treated with Zibar showed significant reduction in F/W over the untreated fruit (**Fig. 4**). Data for treated and untreated Nabali Rosie were analyzed by randomized block design to isolate and remove from the error term of variation attributable to the blocks while assuring that the treatment means will be free of block effects. **Table 2** shows the analysis of variance of the main factors affecting the F/W which are the advance of season (days), treatment (Zibar) and block. The effect of these factors and their interaction is shown by the significance level of error means square in the table. The block and days were highly significant (1%) level and the treatment was significant at 5% level.

Conclusions

The F/W tended to decrease as the season advanced. So the proper date for mechanical harvesting of olive fruit should be chosen when the detachment force is small, reducing the required effort and power and hence less tree damage.

Zibar (cheap loosener) showed a significant reduction on F/W of the Nabali Rosie cultivar improving the suitability for mechanical harvesting.

The Nabali Rosie cultivar has lower F/W values than Nabali cultivar indicating that the former is more suitable for mechanical harvesting and this may be attributed to the increase in the size and hence the inertial force of the fruit.

REFERENCES

Shatat, F.A., (1981). A preliminary study on the effect of Zibar on olive fruit removal force. Dirasat, 8(1): 123-126.

Snobar, A.B., and Faqih, A.M., (1975). A step towards mechanized harvesting of olives. Dirasat, 2(2): 39-60.

Tsatsarelis, C.A., (1987). Vibratory olive harvesting: the response of the fruit stem system to fruit removing actions. J. Agric. Eng. Res., 38: 77-90. ■■

(Continued from page 37)

Field Power and Equipment Trends in Agricultural Production in Kenya

Hood, C.E., R.E. Williamson and G.J. Wells. 1989. Field power trends in production agriculture. ASAE/CSAE Paper No. 89-1021. 15 pp.

Kepner, R.A., R. Bainer and E.L. Barger. 1982. Principles of farm machinery. AVI, Westport Connecticut.

Kiiru, W.K., D.W. Ngii and S.K. Ngugi. 1993. Tractor distribution and importation of agricultural tools and implements. In: Industrial survey of local supply of machinery, implements and tools. Agricultural Engineering Division, Ministry of Agriculture and Livestock Development, Kenya. pp. 85-101.

Kolawole, M.I. 1974. Economic aspects of private tractor operations in the Savanna Zone of Western Nigeria. Journal of Agricultural Engineering Research, 19: 401-410.

Michel, J.A., K.J. Fornstrom and J. Borrelli. 1985. Energy requirements of two tillage systems for irrigated sugarbeet, dry beans and corn. Transactions of the ASE 28(6): 1731-1735.

Ministry of Agriculture Livestock Development and Marketing (MALDM), Kenya, 1992. Agricultural mechanization strategy with special reference to crop production. Agricultural Engineering Division, MALDM, Unpublished. 28 pp.

Ministry of Planning and National Development, Kenya. 1986. Agriculture and Food Security. In: Sessional Paper No. 1 of 1986 on Economic Management for Renewed Growth, pp. 62-89. Government Printer, Nairobi.

Ngugi, S.K., S.S. Weru and J.T. Makanga. 1992. The Role of small tractor in Kenyan agriculture. Proceedings of workshop on National Agricultural Mechanization Strategy (NAMS). Unpublished report. Agricultural Engineering Division, Ministry of Agriculture and Livestock Development, Kenya. p. 34-39.

Owende, P.M.O. and P.G. Kaumbutho. The role, shortcomings and future prospects of agricultural machinery testing in Kenya. AMA, 27(3): 27-36.

Perdok, U.D. and J.K. Kouwenhoven. 1994. Soil-tool interactions and field performance of implements. Soil and Tillage Research, 30: 283-326.

Scott, P.F.C. 1960. Engineering problems in overseas agriculture. Journal of Agricultural Engineering Research, 5: 123-127.

Segler, G. 1975. Agricultural technique in India as example of development. AMA, 6(2): 76-82.

Simalenga, T.E. and N. Hatibu. 1988. General performance of small tractors for small holder peasant farming: A case study of the Tinkabi tractor under conditions in Morogoro, Tanzania. Unpublished report, 9 pp. Department of Agricultural Engineering and Land Planning, Sokoine University of Agriculture.

Witney, B.D. and K.E. Oskoui. 1982. The bsis of tractor power selection on arable farms. Journal of Agricultural Engineering Research, 27: 513-527.

World Bank. 1990. Staff Appraisal Report: Kenya, Second National Agricultural Extension Project. World Bank Report No. 9051-KE. ■■

University Education in Agricultural Mechanization for Tropical and Subtropical Countries in Prague, Czech Republic


by
Pavel Kic
Vice-dean
Technical Faculty
Czech University of Agriculture, Prague
165 21 Prague 6 - Suchdol
Czech Republic


Karel Otto
Director
Institute of Tropical and Subtropical Agriculture
Czech University of Agriculture, Prague
165 21 Prague 6 - Suchdol
Czech Republic

Abstract

The Czech University of Agriculture in Prague (CUA) consists of four faculties: Agronomy, Forestry, Agricultural Economics and Management and Technical Faculty, which is focusing at the education of mechanical engineers prepared for operational and designing work in firms involved not only in production but also in the processing of farm products as well as in food production. The Institute of Tropical and Subtropical Agriculture is a specialized part of the CUA which prepares the specialists for tropical and subtropical agriculture. The special study programmes and combination of different study courses give very good opportunity also to the students from Asia, Latin America and Africa to study for bachelor's degree (B.Sc.), or postgraduate level degrees (Ph.D.) and master (M.Sc.).

Introduction

The Czech University of Agriculture in Prague has provided university education to thousands of students over the period of more than 90 years of its existence. The CUA can show outstanding results in educational activities, research work, advisory and expert service. All faculties of the University provide complete university education (5 895 students in 1997-98), 435 graduate, graduate students also in 1997-98 and various types of lifelong education.

Czech University of Agriculture Prague

First, we recall some of the important years in CUA history. The Czech University of Agriculture commemorated in 1996 its 90th anniversary of its foundation. At the same time, it is necessary to note the tradition of 200 years of higher learning in agriculture in Bohemia in which Czech University of Agriculture, Prague, the oldest agricultural university in this country, has its important position. A temporary Chair of Agriculture existed in the years 1776-1781 at the Prague University. Several years later, in 1788 a chair of Agriculture was founded at the Faculty of Philosophy which was then amalgamated with the Czech Estates Technical College in 1812. The CUA history proper begins with the establishment of an Agriculture Department at the Czech Technical University by the Decree of the Emperor Franz Joseph I of 26th October 1906.

The First World War interrupted the successful development of agricultural education in Bohemia, but the post-war reforms which were concerned also with education, resulted in the transformation of Czech Technical University and then the Agriculture Department was transformed in 1920 into the School of Agriculture and Forestry of the Czech Technical University.

The years of Nazi occupation and the year 1948 brought a number of events which had a negative influence upon agricultural education. On 8th July 1952 an independent University of Agriculture was founded by a government decree on the basis of the School of Agriculture and Forestry of the Czech Technical University.

The Agriculture University was transformed according to Act No. 192/1994 of 1st January 1995. Following the changes in 1989, the Czech University of Agriculture, Prague has tried honestly to cope with the problems of the past as well as with the new tasks. In agreement with the government education policy and with the development plan of 1992, the Czech University of Agriculture, Prague has been reorganizing its study programmes, courses, research programmes and entire organization and personnel structure.

Organization of the Czech University of Agriculture, Prague

The structure of the university does not differ from any similar universities world-wide. It consists of four faculties and one institute: Faculty of Agronomy, Faculty of Forestry, Technical Faculty, Faculty of Agricultural Economics and Management and Institute of Tropical and Subtropical Agriculture (ITSA). Under the University roof belong as well centrally administrated units: the Teacher Training Department, Department of Physical Education, the CUA Farm at Lany and CUA Forest Establishment at Kostelec and Cernymi lesy.

Further, the CUA has independent departments and institutes which serve the needs of all the faculties. The Study and Information Centre provides a variety of services to students, academic staff as well as researchers. The Centre includes a library with 120 000 volumes and 395 periodicals. The Centre also provides the most recent information from the world databases on CD-ROM and three series of digitalized Current Contents. The study hall, the reading room and the copy centre are in the focus of considerable interest. The university's computer network contains a catalogue of new library accessions since 1990. The Audio-Visual Centre produces the university's own video programmes and provides photo services in connection with links to the national and international computer networks and cooperates in the introduction and operation of the CUA's integrated information system.

Admission Policy

Secondary school graduates can apply for admission at the University following their successful school-leaving examination. They must sit for entrance examination. These examinations are based on the secondary-school curricula and they take place in the middle of June in the following subjects:

- The Technical Faculty: Mathematics, Physics
- ITSA: Biology, Mathematics, Foreign Language
- The Faculty of Agronomy: Biology, Chemistry
- The Faculty of Agricultural Economics and Management: Mathematics, Biology or a Foreign Language
- The Faculty of Forestry: Mathematics, Biology or a Foreign Language

The System of Studies

All faculties and the Institute of Tropical and Subtropical provide their students with knowledge and experience in various branches in agriculture, forestry and related subjects. Both theoretical and practical approaches are equally emphasized. Besides the bachelor degree programs (B.Sc. = Bc. in Czech), complete university degree programs (M.Sc. = Ing. in Czech), and postgraduate studies (Ph.D. = Dr. in Czech), both internal and distance-type, the university offers various other types of training and workshops, including in-service training for teachers of secondary (agricultural) schools. Anyone can choose his/her course at the faculties which provide education in their specific areas. At the same time, it is possible to organize studies in overlapping areas between the faculties and even in cooperation with other universities.

The Faculty of Agronomy has a long tradition. There are 17 departments at this faculty. This Faculty has in its study programme both the preparatory disciplines (such as botany, physiology, biochemistry, microbiology, etc.) and the agricultural subjects of general type (e.g. plant and animal nutrition, farming techniques, genetics and improvement, etc.) along with the specific subjects (crop production, animal breeding, etc.).

The extensive scope of problems has called for subject specialization which resulted in six study programmes: General Farming; Crop Production; Animal Production; Phytopathology and Protection; Horticulture; and Agriculture Production Quality and Processing.

Forestry studies at university level in Prague had their own course immediately after the foundation of independent Czechoslovakia in 1919. Following a forced break in its activities in the 1960s, the faculty resumed its work in 1990 and its courses were reorganized in line with the new political, economic as well as ecological situation in the country.

The Faculty of Forestry offers three study programms: Forestry Engineering; Land and Water Engineering and specialization in Applied Ecology; and Timber Management.

The Faculty of Agricultural Economics and Management educates economists, managers, specialists for finance, banking, insurance, informatics, trade, state administration and other services. Lectures are provided by eleven departments. The five-year complete university programs are organized in two basic areas: Economics and Management and Informatics.

Technical Education at CUA

The Technical Faculty (formerly Faculty of Mechanization) was established as part of the University of Agriculture in 1952. Originally, the faculty's objective was to educate engineers for mechanization in agriculture as well as for machinery and tractor stations and for heavy machinery centres.

Currently the faculty is focusing at the education of mechanical engineers who are preparing for operational and designing work in firms involved not only in production but also in the processing of farm products as well as in food production. The graduates of the Technical Faculty also receive professional training in the application of computer technology and informatics. The teaching is also based on the basic knowledge of agricultural materials and products, of their manufacturing, properties and technological processes. The students are first thoroughly familiarized with the basic principles of design and the technology of machine manufacturing.

Students attend lectures with problems, ways and methods of reconstruction and the technology updating and its rational and efficient renewal. The students acquire the necessary knowledge of electronics, electrotechnics and automation. They become familiar with regulation and control systems of manufacturing installations, with the ways and method of measuring the quality parameters of machines, and with material and energy management in manufacturing. They are taught to respect into account environmental aspects of machine functioning, as well as all the basic principles of efficient manufacturing.

The faculty has the main aim of preparing its graduates for a career in any of the following activities:

- Designing and control of the operation of machines;
- Assuring reliability and renewal of technology in food processing and food industry;
- Technological development of enterprises of various types;
- Development of new machines for agriculture and their testing;
- Teaching in secondary and technical apprentice schools; and
- Consultation and training centres.

The newly conceived study programme at the faculty foresees a three-year study and five-year study. The curricula are divided into two parts. The first part, covering three years, is made up of general study. Students obtain basic knowledge in engineering and general knowledge about the substance of their future activity in the running of enterprises. Most of the subjects are compulsory. The students may only choose from a limited group of optional subjects, of which a set number is compulsory. The basic part takes three years and can be completed with a first state examination (B.Sc.).

In the second part of the curricula (fourth and fifth years) students have the opportunity to choose their study programme in keeping with legal rules and regulations set by the faculty. The students are not limited to subjects of their specialization. They may choose subjects such as control and operation of combine-harvesters, teaching training, and others. The study programme at the faculty is completed by the state final examination that includes a defence of MSc. thesis.

The faculty offers five study programmes in:

- Agricultural Engineering;
- Road and City Transport;
- Technological Equipment of Buildings;
- Technology and Technique for Waste Processing; and
- Trade with Technology.

The study programme in Agricultural Engineering includes three optional specializations: machinery operation projecting and management, maintenance and renovation of machinery and production equipment, and automation and management technology. This course provides education in technology operation in agriculture, forestry, civil engineering, in ecological and communal operations, service and maintenance stations, in supply organizations, in technical development, testing stations, etc. The course also provides basic knowledge in machine construction and production technology.

The study programme in Road and City Transport educates graduates for operation, technology and economics management in road and city transport with the exception of rail. In principle, the course deals with all automobile transport of piece, bulk and liquid character as well as with the transport of passengers.

Graduates in Technological Equipment of Buildings study programme are qualified according to Act No. 360/92 of 7th May 1992 for work in construction development in agriculture, forestry, food industry, transport and storage management.

The study programme in Technology and Technique for Waste Processing educates specialists for operations and design activities with technologies in firm dealing with waste recycling as secondary sources of raw material or energy.

The study programme in Trade with Technology educates university graduates for independent work as salesmen with agricultural machinery and processing industry equipment, including advisory services in machinery and equipment purchase.

In accordance with the new law of higher education, the graduates of faculty, after being awarded the academic grade of engineer (or graduates of other faculties) can continue in postgraduate courses targeted on upper education (Ph.D.). The Ph.D. study can be in the field of:

- Agricultural Technology and Machinery;
- Technology of Manufacturing Processes;
- Quality and Reliability of Machines and Devices;
- Automation and Robotization;
- Properties and Manufacturing of Agricultural Materials and Prod-

ucts; and

- Power Supply.

All study programmes are supported by the faculty departments and specialized workshops:

1. Department of Mathematics
2. Department of Physics
3. Department of Mechanics and Mechanical Engineering
4. Department of Electrical Engineering and Automation
5. Department of Materials and Engineering Technology
6. Department of Automobiles and Tractors
7. Department of Farm Machinery
8. Department of Technological Equipment of Buildings
9. Department of Machinery Application
10. Department of Machine Quality and Reliability.

The Technical Faculty graduates find job in agricultural, forestry and construction primary production, ecological and communal enterprises, service and maintenance/repair stations, supply and sales organizations, management of operational, technical and economic activities in road and town transport and in environment protection institutions.

The faculty is involved in Scientific and Research Projects funded by Grant Agencies in many branches of science. The principal fields of research work are:

- Ventilation and air-conditioning of agricultural buildings (Development of models for design of ventilation systems in animal houses; Use of secondary and renewable sources of energy; Tests of natural and forces ventilation systems of animal houses; Control of microclimate in animal houses);
- Crop production technology problems (Technology of cultivation and harvest of sugar-beet and potatoes; The influence of technology on quality and properties of grains during harvest);
- Transport properties of vehicles and machines in agriculture and relation to the damage to soil; Ecological effects of combustion engines; Construction of transmissions mechanisms and chassis;
- Technology of conservation, storage and processing of agricultural materials; Physical models of determining properties of biological materials; Application of mathematics in technical fields;
- Quality and reliability of machines (Operational reliability; Technical diagnostic; Machine quality care control; Optimization of services and operational activities)

Any prototypes developed in the last 5 years:

- Threshing mechanism with rotation of rolls of threshing drum;
- Prototype of combined straw shaker in combine-harvester;
- Ventilation unit for adiabatic cooling and humidifying of air with special construction of nozzles;
- Set for psychrometrical measurement of relative humidity of air;
- Measuring instrument for diagnostic control of specific fuel consumption of internal combustion engines;
- Special mirror for manual welding of thermoplasts;
- Fixture for tests of steel hardenability with cooling of the sample.

The Technical Faculty has currently collaboration with many Departments of Agricultural Engineering, research and scientific institutions in the field of mechanization of agriculture, agricultural engineering and similar branches in the Central Europe and the EU countries. Many foreign students from all over the world (e.g., Poland, Slovakia, Russia, Greek, Cuba, Germany, Vietnam, Laos, Sri Lanka, Mongolia, Jordan, Ethiopia, Iran, Iraq, Senegal, Syria, and some others) have graduated at the Technical Faculty.

The knowledge of teaching and scientific staff, capacity of departments and laboratories are used also for teaching and technical preparation of students from other CUA faculties, including the students from ITSA.

The Institute of Tropical and Subtropical Agriculture

The Institute of Tropical and Subtropical Agriculture (ITSA) was established in 1961 as an educational and research institute of the CUA in Prague. Its role is to educate specialists in tropical and subtropical agriculture which is the basic study programme for complete university and postgraduate studies for Czech as well as foreign students. ITSA graduates can then work in agricultural primary production as well as in research, in schools, in processing industry, in trade with tropical and subtropical farm commodities and their quality control, in international organizations and as experts in developing countries. The total number of graduates from ITSA has now reached 1000 candidates from 72 countries.

In the five-year study programme in Tropical and Subtropical Agriculture the students can specialize in crop production, animal husbandry, economics and management and in agricultural engineering. The first three years are devoted to the subjects of the common core as well as to technological subjects. The students can graduate with B.Sc. degree after three years of study. The following two years' study programme includes subjects according to the students' field of specialization. The Institute also offers extraordinary types of study in various courses and specialized courses mainly for foreign students. The courses, both graduate and postgraduate, are given in Czech or in English. Specialized courses for foreign students are given in English.

In the postgraduate studies in Tropical and Subtropical Agriculture it is possible to register for the same type of specializations as in the graduate study programme: crop production, animal husbandry, economics and management and in agricultural engineering. The topics of dissertations in above mentioned fields are derived from the research projects of ITSA and can be adopted according to the interests and requirements of applicants in Czech or English languages. Conditions of admission: Foreign Languages (English, French, Spanish), orientation in the selected field of study, scholarship or contract of self-payment.

Graduates in the five-year course receive a diploma of an Ing. (equivalent to M.Sc.) following a successful final state examination and a defence of a thesis. The diploma is both in Czech and in English. Ph.D. course students sit for rigorous examinations and defend a dissertation after which they are bestowed upon the doctoral degree (Dr.).

Departments of the ITSA

1. The Department of Tropical and Subtropical Crops

Crop production subjects in TSA. Tropical and subtropical greenhouses are available for practical training, together with a laboratory and an experimental plot at the university site and in Lednice (Moravia).

2. The Department of Animal Husbandry in the Tropics and Subtropics

Animal husbandry subjects in TSA. A poultry house is available.

3. The Department of Technical and Economic Development in the Tropics and Subtropics

Economics and technology subjects in TSA.

Scientific and research activities are part of the work of all departments which are currently involved in two grant projects funded by the Czech Grant Agency and a third grant has also been made available recently, as well as several other international grants and a research project. Research activities of ITSA combine both the basic and applied research in the field of tropical and subtropical agriculture.

The foregoing extensive projects benefiting from long-term and permanent operations in humid tropics had been aimed at the winged bean, citrus, nodule bacteria, poultry, mould and feed mycotoxins, have been restricted recently to nutrition of tropical feeds and their hygienic quality, research on aromatizing, medicinal and tonizing plants and air loading by the exhaust gasses, ecological and economical utilization of agricultural machines, renovation and maintenance of machines and, unconventional sources of energy.

ITSA has carried out extensive services for foreign trade companies and has participated on projects in the developing countries. It takes also an active part in the Committee for FAO in the Czech Ministry of Agriculture.

Studies, Examinations and Graduation

There are two ways of admission to study at the ITSA. The first way requires the full coverage of all study, accommodation and insurance costs by the applicant. The second way is to win a sponsorship from an independent organization or subject which will offer a scholarship for the applicant.

The second way of admission may be accepted only after successful completing a one-year long preparatory and language courses instructed in Czech. The preparatory courses is run by the Charles University, Prague, and is held at the university's College for Language and Science Preparation in a small town called Dobruska located some 140 km east of Prague. It includes Czech, mathematics, physics, biology, and chemistry. Even though the teaching language is Czech teachers are able to communicate with students either in English, French or Spanish.

Closing date for presenting applications to attend the preparatory course is April 30. Admitted students should arrive between 1 and 10 September. The course starts on 14 September. Participants must present a proof of payment of all fees for the whole course or an officially acknowledged certificate confirming a scholarship award. All admissions to the ITSA are administered by the ITSA. The necessary prerequisite for this is a successful completion of Secondary School Education, certified with a Secondary School Leaving Examination Certificate which has to be equivalent to the Secondary School Leaving Examination Certificate issued in the Czech Republic. In English speaking countries this can be the General Certificate of Education – Advanced Level, provided that the Advanced Level includes the required subjects for admission to the CUA Prague (Chemistry, Biology). In French speaking countries, a similar equivalent is the Baccalaireat, and in Spanish speaking countries the Bachileratocurso scientifico.

Applicants for 2-year graduate courses must submit an examination certificate and a B.Sc. degree in Agriculture or Biological Sciences from a recognized University.

Applicants for 3-year postgraduate courses must submit an examination certificate and a M.Sc. degree or it's equivalent. Language preparatory course last 6 months only, or the applicants can study in English.

All application forms to study at Czech University of Agriculture Prague must also include a declaration that all study, accommodation, and health expenses are to be covered by the applicant or his sponsor who is willing to pay for the scholarship. An official verification of all proclamations will be carried out prior to any admission. ITSA has no possibilities of awarding scholarships.

One school year is divided into two semesters; winter and summer. A semester lasts 14 weeks in winter and 14 weeks in summer, and students attend lectures, take part in seminars, laboratory and workshop activities. The maximum number of students in a group taking part in laboratory and seminars is 15. This makes teaching and instruction more efficient and practical. Students' participation and activities are evaluated regularly by the lecturer, who according to study results of each student issues credits. Fulfilment of credits entitles a student to sit for an examination in the respective subject. Examination rating has four grades; Excellent, Very good, Good, and Failed. Students who fail in an examination may sit for two more correction terms. A third term can be allowed only after presenting a written request to the Director of the ITSA.

Examination period is 5 weeks long, and commences right after the end of the respective term. Examination and credits dates are fixed by students together with the examiner in a written form. Examination and credits of the winter semester should be done before March 30. For the summer semester the last day is September 30. Admission to the new school year is certified into each student's record book (index) by the Study Dept. of the ITSA after successful examination and credit results, and the presentation of other necessary documents such as participation in summer field practices, etc.

During the summer vacations preceding the last year of study students have to go through a two month long comprehensive pre-graduation practice at the University Farm or other private, cooperative or public agricultural farms in the Czech Republic or abroad.

Graduation ceremony takes place in the presence of the Rector, the Deans and all other dignitaries of the Czech University of Agriculture, Prague, at the Congregation Hall of the University.

Career Opportunities of Graduates

The courses in tropical and subtropical agriculture at the ITSA have been designed in consideration of the needs and priorities of the developing countries from where the majority of the students come. Students at the ITSA receive in-depth instructions on the basic biological subjects, supplemented with studies in chemistry, physics, mathematics, economics and other subjects. In the higher years these basic theoretical and practical studies are followed by specialized courses. Courses introduce to the students the specific features and problems of tropical and subtropical agriculture, and the methods and techniques of modern farming in Czech Republic and other developed countries.

In the course of five-year university study, the students of ITSA, have an excellent opportunity to understand properly the major role, and problems of development in agriculture. They master the basic aspects of effective crop and animal production, agricultural mechanization, farm management and economics, as well as the status of agriculture in the national economy of nations. The knowledge and experiences they acquire make them fully qualified to take up various responsibilities in agricultural executives in their home countries. The wisdom of ITSA shows that graduates have been almost invariably successful in their profession and career jobs. The ever present scarcity of erudite and skilled specialists, especially in agriculture, in the developing world makes graduates of ITSA attractive candidates for posts at ministries of agriculture, research centres, agricultural projects, food processing industries, and international organizations dealing with agricultural development and research.

Short-term Agricultural Training Courses

Courses are organized in the following subjects:

Agricultural management and cooperatives:
- Large-scale farm management
- Agricultural cooperatives

Plant production
- Study and usage of genetics resources of tropical and subtropical productive plants
- Growing of medicinal and aromatic plants and their exploitation in phytotherapy and industry
- Propagation of tropical and subtropical cultural plants using plant explantates

Animal husbandry
- Dairy cattle feeding in tropical and subtropical conditions
- Selection and crossbreeding in cattle, sheep, and goat populations
- Embryotransfer techniques in domestic ruminants with regard to tropical and subtropical conditions
- Dairy farm management and production
- Practical training in AI for poultry
- Biological evaluation of the nutritional values of feeds for non-ruminants

Agricultural engineering
- Farm machinery machines; equipment, operation and maintenance
- Milking machines; equipment, operation and maintenance
- Non-conventional sources of energy and their utilization in agriculture
- Using computers and data processing in farm power and the exploitation of agric. machines
- Grain harvesting machines

(Continued on page 50)

Thin-layer Drying of Khalas Date Variety

by
K.N. Abdalla
Department of Agricultural Engineering
King Faisal University
P.O. Box 420
Al-Ahsa 31982
Saudi Arabia

A. M. S. Al-Amri
Department of Agricultural Engineering
King Faisal University
P.O. Box 420
Al-Ahsa 31982
Saudi Arabia

Abstract

A review of the literature on drying of agricultural products revealed that no efforts have been made to measure the drying rates of dates under heated air conditions. In the present work on thin-layer drying, studies were conducted in a laboratory dryer. Drying curves for one date variety were obtained for three dry bulb temperatures (37, 49 and 61°C). A thin-layer drying equation has been proposed and was found to describe the drying characteristics of the date variety under consideration reasonably well.

Introduction

Saudi Arabia is considered to be one of the leading date producing countries in the world with its annual production exceeding 500 000 metric tons (Ministry of Agriculture, 1995). Thus dates play an important economic role for many farmers in the region. However, less than 10% of the dates produced are processed and considered for export and as a result substantial amounts are lost annually.

Dates harvested in the Eastern region are characterized by having a high initial moisture content which is undesirable as it contributes to the high spoilage rate experienced in this region. Farmers used to dry dates traditionally by spreading them on mats and leave them to dry naturally. Such practices are poor as contamination by dust, dirt and insects is unavoidable. It is, therefore, envisaged that the design of a simple artificial solar dryer could contribute greatly in solving this problem. Nevertheless, before embarking on such a task, basic data on the drying curves of dates are required. The objective of the present study is to develop a thin-layer drying model for one variety of Saudi dates cultivated in this region.

Literature Review

Efforts to measure drying rates of any date variety have not been reported in the literature. On the other hand, a remarkable amount of work on thin-layer drying of many agricultural products are being conducted. As a result, numerous mathematical models have been proposed by many researchers. Most of these studies have been carried out on thin-layer drying of grains, peanuts, seeds and some vegetables but very little information is available on the drying of dates. These models include those of Lewis (1921), Page (1949), Whitaker and Young (1972), Syarief (1984), Hummeida and El-sheikh (1989) and Hansen et al. (1993).

Thin-layer drying models are formulated essentially to be used in the development of bulk drying simulation studies. A comprehensive review of such models has been given by Parry (1985). Thin-layer drying equations are divided into three groups, namely; empirical equations, semi-empirical equations and theoretical equations (Parti, 1993). Empirical equations are not entertained because they neglect the internal resistance to mass transfer. On the other hand, theoretical equations were found to give inexact results in the first and last stages of drying because they tend to ignore the temperature change and moisture content dependance of the diffusion coefficient. However, the semi-empirical equations have been successfully applied by many researchers to describe drying rates for various crops.

The Lewis (1921) equation is considered one of the best semi-empirical drying equations and is expressed as:

$$MR = \frac{M - Me}{Mo - Me} = e^{-Kt} \quad ...(1)$$

A modified version of the above equation based on heat and mass transfer was proposed by Hansen et al. (1993) and was expressed as:

$$MR = \sum_{i=1}^{j} A_i e^{-K_i t} \quad ...(2)$$

Where j takes values between 1 and ∞.

For the case of j = 1, K is known as the drying constant and is evaluated from thin-layer drying curves by plotting on semilog paper. Most K values are reported as a function of temperature only (Syarief et al. (1948), Huizhen et al. (1984).

Experimental Set-up

The thin-layer drying apparatus and instrumentation used in this study are shown schematically in **Fig. 1**. The apparatus consisted of an air conditioning laboratory unit (P.A. Hilton model A 573) which delivered controlled dry-bulb temperature and relative humidity air. The centrifugal fan of the unit is driven by a variable speed electric motor. Series of heating coils were fixed around the inner walls of the heating chamber just prior to the test chamber. Each heater was controlled by a separate switch.

The instruments used included wet-and dry-bulb thermometers to measure the relative humidity of the air. Other thermometers were used to sense the temperature of the entry and exit air. The air flow was measured with a differential head meter which consisted of an orifice plate and an inclined manometer.

The test chamber was an insulated metallic box of 40 cm x 40 cm cross section, 40 cm high with a 15 cm diameter horizontal opening which connected it to the plenum chamber. The chamber was insulated on all sides to reduce temperature variations from outside. A circular opening of 27 cm diameter with a perforated lid was provided at the top of the test chamber which allowed insertion and removal of the sample. The tray carrying the sample was held inside the test chamber on a 4-leg 3 mm diameter copper rod frame where each leg was allowed to pass through a small hole drilled at the bottom of the chamber to allow them to rest on a digital balance placed underneath.

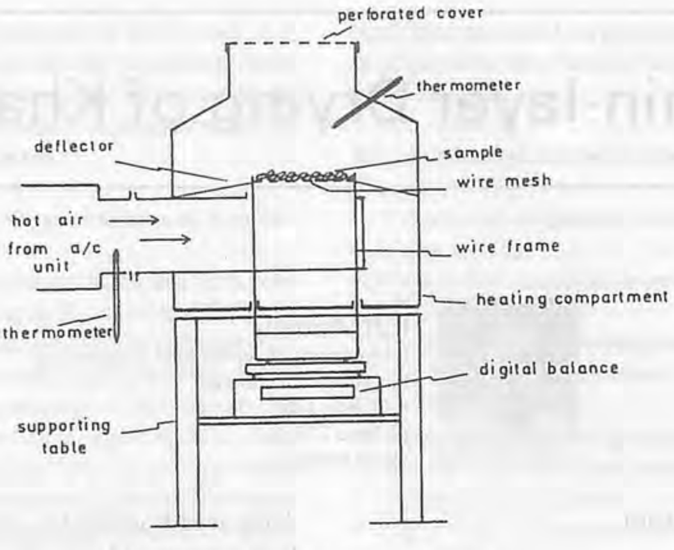


Fig. 1 Dates drying experimental set-up.

The sample tray was 18 cm x 22 cm and was framed from a 3 mm diameter copper rod with its sides and bottom wrapped with a 5 mm wire mesh.

Test Procedure

One date variety (Khalas) considered for the thin-layer drying tests was obtained from a farm in Al-Hassa in the Eastern region of Saudi Arabia. The dates were handpicked during harvest season (1995) and were put in plastic containers each weighing approximately 200 g and were stored in the laboratory.

Before each test run the drying system was allowed to stabilize at the desired air condition prior to the start of the test. With the fan off the 200 g sample was placed in the drying tray to determine its initial weight. Then the fan was turned on to start the test. At the same time a sample of the lot of dates (about 50 g) was set aside to determine its moisture content by placing it in an oven set at 103°C for 24 h.

Drying continued for same time until no change in weight of samples was observed where at this stage the sample was assumed to be in equilibrium with the drying environment. Three test runs at three dry bulb temperatures (37, 49, 61°C) were carried out to obtain drying profiles of dates. The dry bulb temperature and relative humidity inside the drying chamber were frequently monitored with a digital hygrometer. Each test condition was replicated two times.

The start of each drying test was recorded using a digital watch. The ambient temperature and relative humidity were also noted. Each sample was dried for a certain period of time during which periodic weighings every 20 min were made. To avoid the effect of the air lift on the drying tray weighing of the sample was conducted while the fan was switched off. This procedure did not take more than 10 sec. When a constant weight was obtained for three consecutive readings, it was concluded that the sample has reached equilibrium conditions and the test was terminated.

Results and Discussion

The collected data was analyzed to study the drying of dates under heated air conditions. In order to compare thin-layer drying rates for the three drying temperatures under consideration, moisture ratios as a function of time in hours are plotted

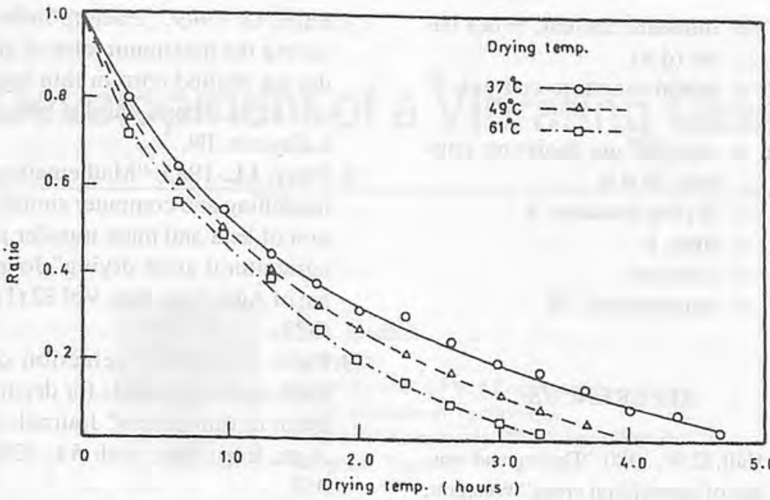


Fig. 2 Drying curves for Khalas dates vs. drying temperature.

in **Fig. 2**. The results show that drying time decreased as drying temperature increased.

The model used to fit the experimental data is of the following form:

$$MR = \frac{M - Me}{Mo - Me} = A\exp(-Kt) \quad ...(3)$$

A procedure described by Hall (1980) for determining the drying constant K is used in this analysis. A semilogarithmic plot of moisture ratio (MR) versus time (t) is shown In **Fig. 3** for the same results shown in **Fig. 2**, except that the curves are truncated for MR < 0.1. The data show almost straight line relationships. **Table 1** shows the results of a regression analysis where parameters of equation 3 are tabulated for each of the drying temperatures tested.

Several equations were tested in the regression procedure to express A. The equation that provided the best results is of the form:

$$A = -42.5654 + 26.6578 \times 10^{-2}T - 40.55 \times 10^{-5}T^2 \quad ...(4)$$

with a coefficient of determination (R^2) of 0.99.

A regression analysis of the drying constant K vs. drying temperature in °K gave:

Table 1. Evaluation of Thin-layer Drying Constants for Khalas Dates ($MR = Ae^{-kt}$)

Dry bulb temp. °C	Relative humidity	No. of observations	A	K h^{-1}	R^2 value
37	23.0	15	1.088	0.665	0.960
49	20.5	13	1.222	0.907	0.927
61	16.5	11	1.223	1.063	0.948

$$K = -33.41 + 0.197T - 2.8 \times 10^{-4}T^2 \quad ...(5)$$

with a coefficient of determination (R^2) of 0.998.

The proposed model for predicting thin-layer drying rates of dates is based on equation (3) with the constant A predicted by equation (4) and the drying constant K predicted using equation (5). The model was checked by plotting the predicted moisture ratio against the observed moisture ratio for all test conditions as shown in **Fig. 4**. This figure shows close agreement between the predicted and observed moisture ratios as most of the points are shown to fall very close to the line Y = X. These results indicate that the proposed model is suitable for predicting most moisture ratios within reasonable range throughout

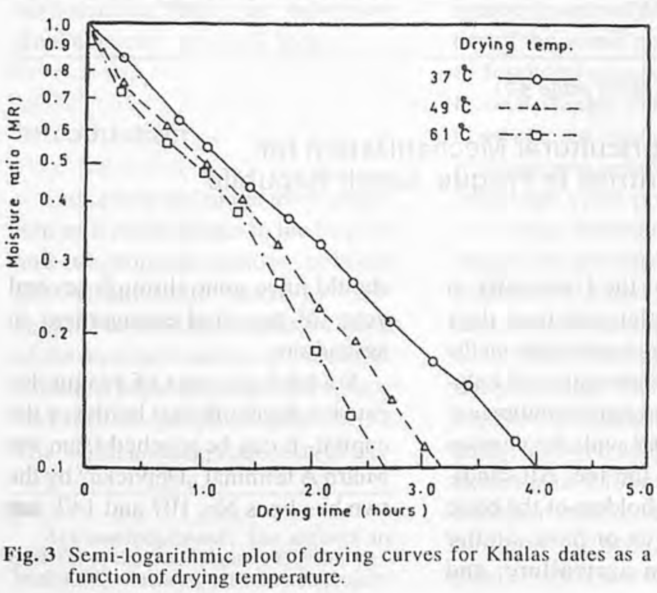


Fig. 3 Semi-logarithmic plot of drying curves for Khalas dates as a function of drying temperature.

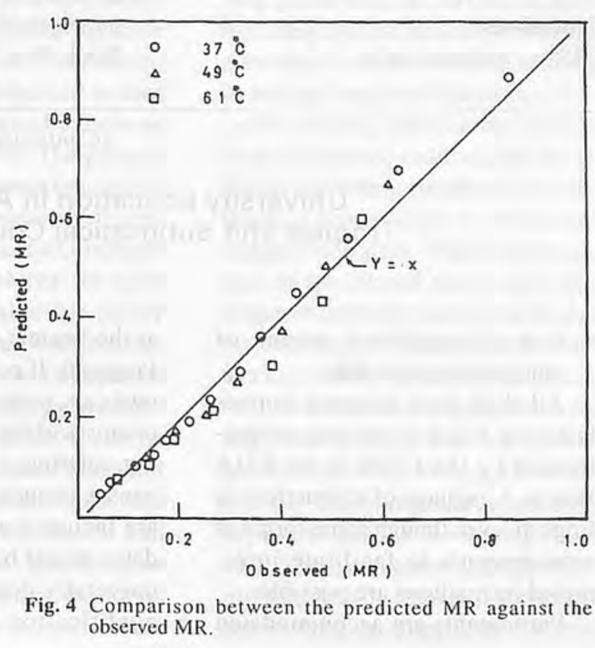


Fig. 4 Comparison between the predicted MR against the observed MR.

the entire period of each test condition.

Conclusion

A comprehensive literature review on drying of agricultural products revealed that information on dates drying is scarce. In the present work, thin-layer drying data have been collected for one date variety (Khalas) grown in the Eastern region of Saudi Arabia. Experiments were conducted in a laboratory dryer at three dry bulb temperatures (37, 49 and 61°C). Moisture ratios were calculated for each test condition and drying curves were obtained. Using these information, a thin-layer drying model has been proposed.

Moisture ratios predicted with the proposed model were shown to be within reasonable agreement when compared to observed moisture ratios obtained from three actual test runs at different drying air temperatures. It is recommended that further studies be conducted on other date varieties at wider experimental test conditions in order to arrive at a more generalized and comprehensive model.

Notations

MR = moisture ratio
M = moisture content, % dry basis (d.b)
Mo = initial moisture content, % d.b.
Me = equilibrium moisture content, % d.b.
K = drying constant, h^{-1}
t = time, h
A = constant
T = temperature, °K

REFERENCES

1. Hall, C.W. 1980. "Drying and storage of agricultural crops" Westport, Conn. AVI Publishing Co., Inc.
2. Hansen, R.C.; H.M. Keener and H.N.El-Sohly, 1993. "thin-layer drying of cultivated Taxus Clippings" Trans. of the ASAE, Vol. 36 (6): 1873-1877.
3. Huizhen, L. and R.V. Morey, 1984. "Thin-Layer drying of yellow dent corn" Trans. of the ASAE Vol. 27 (2).
4. Hummeida, M. and A.E. Sheikh 1989. "Determination of drying curves for two varieties of peanuts" AMA Journal, Vol.20, No.4; 47-51.
5. Lewis, W.K., 1921, "The rate of drying of solid materials" Journal of Industrial Eng., vol. 13 (5), pp 427-432.
6. Ministry of Agriculture and Water. Agricultural Statistical Year Book, Vol. 10.
7. Page, G. 1949. "Factors influencing the maximum rates of air drying shelled corn in thin layers" M.Sc. Thesis, Purdue Univ., Lafayette, IN.
8. Parry, J.L. 1985. "Mathematical modelling and computer simulation of heat and mass transfer in agricultural grain drying" Journal of Agri. Eng. Res. Vol 32 (1): 1-29.
9. Parti, M. 1993. "selection of mathematical models for drying grain in thin layers" Journal of Agri. Eng. Res., vol. 54: 339-352.
10. Syarief, A.M.; R.V. Morey and R.J. Gustafsen, 1984. "Thin-layer drying rates of sunflower seeds" Trans. of the ASAE, Vol. 27 (1):195-200
11. Whitaker, T.B. and J.H. Young. 1972. "Application of the vapor-diffusion equation for concentric spheres in describing moisture movement in peanut pods" Trans. of the ASAE, Vol. 15 (1):167-171.
12. White, G.M; I.J. Ross and P.W. Westerman, 1973. "Drying rate and quality of white shelled corn as influenced by dew-point temp." Trans. of the ASAE Vol. 16(1): 118-120., May 7, 1996.

■■

(Continued from page 46)

University Education in Agricultural Mechanization for Tropical and Subtropical Countries in Prague, Czech Republic

- Non-conventional means of transporting materials

All short-term training courses last from 3 to 4 weeks and are performed by the ITSA at the CUA Prague. Language of instructions is English, even though some forms of arrangements to facilitate interpreted instructions are possible.

Participants are accommodated at the hostels of the University in Prague 6. If participants have their own cars, parking is available on the premises of the University. All lodging, catering, and transportation expenses connected with the courses are included in the fee. All candidates should be holders of the basic university degree or have similar qualification in agriculture, and should have gone through several years of practical engagement in agriculture.

Suchdol is a part of Prague located at the Northwest border of the capital. It can be reached from the Metro A terminal „Dejvicka" by the two bus lines No. 107 and 147. ■■

Development of a Vibrating Cassava Root Harvester

by

C.P. Gupta
Professor
Agricultural and Food Engineering
Asian Institute of Technology
PO Box 4, Kongluang 12120, Pathumthani
Bangkok, Thailand

W.F. Stevens
Professor
Bioprocess Technology
Asian Institute of Technology
PO Box 4, Kongluang 12120, Pathumthani
Bangkok, Thailand

S.C. Paul
Research Engineer
Agricultural and Food Engineering
Asian Institute of Technology
PO Box 4, Kongluang 12120, Pathumthani
Bangkok, Thailand

Abstract

The cassava root harvester is a wedge-shaped vibrating plow consisting of a triangular share and a slat type plane bottom inclined at 25-30° rake angle. It is attached to the main frame by two leaf-spring beams. The harvester is rear-mounted and can harvest 100% roots. It required 16 kW draft power at speed of 6.1 km/h at 37 cm depth in sandy loam soil at 18.6% moisture content (db). The maximum field capacity was 0.64 ha/h.

Introduction

Cassava is one of the most important root crops grown in the tropical and sub-tropical countries between the latitudes 30° north and 30° south. The area encompasses some of the poorest countries of the world. Cassava provides food for nearly 500 million people (Cock, 1985). The world annual production of cassava roots in 1990 was estimated at 158 million tonnes (FAO, 1991). About 46% of that quantity was produced in Africa, 33% in Asia and 21% in Latin America. The major producing countries are Nigeria, Brazil, Zaire, Thailand and Indonesia, which together produce over two-thirds of world production. About 20% of Asian production (mainly from Thailand) is exported primarily to Western Europe, where it is used as a chief carbohydrate source in animal feed. The remainder of the world production is used as food and to a limited extent, as feed (Bokanga, 1996). The plant is of paramount importance because of it's comparatively high starch content, high yield potential, drought resistance and suitability for soils which are not suitable for paddy cultivation. Cassava produces acceptable yields on poor or depleted soils, where other crops yield essentially nothing. Therefore, it can be used to take advantage of marginal lands. It is well adapted to areas that experience a long dry season and uncertain rainfall, thus qualifying as the crop for drought-prone areas (Cock, 1985). For these reasons cassava is particularly suitable for farming systems with a deteriorating resource base under an increasing unpredictable climate.

In contrast to the industrialized processing of the cassava roots, the harvesting operation is not fully mechanized. In the absence of a suitable machine, the crop is usually harvested by pulling the roots from the ground. The roots of cassava may go as deep as 50 cm. In pulling, the roots are broken or bruised. Any injury to cassava roots is likely to initiate bacterial infection.

Harvesting cassava by hand is very laborious, tedious and slow. When harvesting conditions are difficult, a crude lever is sometimes lashed to the stem. With a combination of traditional tools such as a digger, a hand hoe and a machete, a man can harvest cassava at an average rate of 0.01 ha/h. The labor cost for harvesting cassava accounts for well over 40% of the total cost of production. Moreover, agricultural labor is becoming scarce and very expensive even in developing countries. The commercial scale processing of cassava requires mechanized harvesting to supply the roots/

Acknowledgement: The authors are grateful to the Thai Tapioca Development Institute for financing the research project.

tubers.

At present, there is a marked lack of any suitable low-cost tractor-driven cassava root harvester. The known machines are still in the pilot stage or are being employed in very small numbers under easier harvesting conditions. The machines suffer from the lack of sturdiness when working in comparatively heavier soils. The losses and damages due to the pressure exerted by the tool occur. Losses arise when roots get broken or remain in the soil. These machine need a comparatively high power input in heavy soil.

A vibratory digging tool has the following advantages over passive digging tool:

1. Reduced draft and, therefore, reduced soil compaction as a direct result of decreased traction requirement and reduced wheel loading.
2. Opportunity to accomplish deep digging with a medium horsepower tractor available with LDC farmers.
3. Improved soil break-up which helps in loosening the soil around the roots of cassava plants.
4. The operator can control clod size by controlling amplitude and forward speed.
5. The use of slat bottom plow allows smaller soil clods to pass through which leads to higher exposure of root cluster at the ground surface.

Literature Review

Van der Sar (1979) at the Agricultural University, Wageningen, Netherlands developed two types of hand-operated cassava harvesters. In these two types of manual harvester, after cutting off the stem, the plant is gripped by a self-clinching pair of tongs. The difference between the two types is that the first design requires two persons and the second design can be operated by one man.

Diaz-duran (1979) at CIAT developed two types of harvesting aid for cassava: one to harvest individual rows and the other to harvest two rows at a time. Basically, the implements consists of a horizontal blade or share with two end supports that couple into a tool bar. On the top of the blade, one or two platforms are placed in the form of inclined planes at an angle of 17 degrees. The blade and inclined planes act as a wedge when they penetrate the soil, the desired depth is maintained by the action of the tractor hydraulic system. The harvested roots amounted to 0.23 t/ha, broken roots, to 3.3% and cut roots to 0.1%.

Results of the study conducted by Sharma (1979) established that a tractor of medium horsepower and above range attached to a single bottom moldboard plow can harvest 0.4 ha (1 acre) of crop in 6 hours with minimum acceptable (1.44%) tuber damage. Two men were required for efficient digging of cassava. Before the use of the equipment, the cassava stems are cut 10 to 15 cm above the ground level so as to avoid any damage caused by tractor to the stems which are used as planting materials. The portion of the cassava stems left above the ground enable easier hand picking after the tubers have been exposed to ground surface. The permissible speed of the tractor for better efficiency has to be not more than 3 km/h. A speed higher than this will cause damage to the tubers. The output of work is only 1 acre in 6 hours which is too low.

Odigboh and Ahmed (1982) at the University of Niger, Nsukka, developed a prototype cassava harvester. It has a separately-powered rotary knife mounted in front of the tractor and designed to cut 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. No test data is reported and, therefore, performance of the machine can not be judged.

Odigboh (1991) developed a single row model II cassava harvester which is a development of the semi-mounted model-I cassava harvester. The novel arrangement and design of the digger ensure an efficient and lean harvesting operation which leaves uprooted bunches of cassava tubers shaken free of soil with minimum damage to the tubers. Depending on conditions, it operates well at forward speeds of 2.5-4 km/h.

Giametta and Mazzanti (1992) developed a prototype cassava harvester with the aim of reducing harvesting losses caused by mechanical damage and thereby increasing the yield. Further tests could improve performance of the machine.

Peipp and Maehnert (1992) proposed a method in which harvesting of the roots with machine is preceded by cutting of stalks at a height of about 30 cm above the soil and by the removal of the trash. The machine cuts the soil beneath the cluster, loosens it and at the same time lifts it by 20 cm. This is immediately followed by the pulling process caused by grasping the stalks between belts with an incline of 20 to 30 degrees with the latter lifting the roots from the soil and depositing them on the surface of the field. The machine leaves the field smooth and soil loosened. The dead weight of the machine can increase the available traction of the tractor. It can be adapted to different row distances. The convex moldboard attached to the share breaks up the soil as to loosen it evenly, preventing damage and losses. The hydraulic drive of the pulling unit allows for an easy adoption to the driving speed of the machine. The soil resistance for digging and pulling was reported to be 15 kN at working depth of 40 cm and working width of 100 cm. They used tractor of draw bar pull of 20 kN. The draft requirement of the machine is too high.

A prototype 1.4 m wide cassava harvester suitable for use in Cuba was developed and tested in different soil types. The prototype was drawn by LT-323 and DT-75 tractors and tested in cassava fields typical of Cuba. The presented result shows that the developed harvester performed satisfactorily with tuber damage of <4% (Martinez et al., 1990).

Objectives

The project aims at developing a cassava harvester for harvesting cassava roots tubers with a view to:

1. Reducing human drudgery and labor requirement;
2. Minimizing loss and damage to roots;
3. Reducing harvesting costs and time; and
4. Maintaining a steady supply of roots for the buyers.

Materials and Methods

Design Consideration

The following were the main considerations in the design of the cassava digger:

1. The design should lead to the development of a digger with minimum root damage, low cost as well as low power requirement. The total power requirement of the machine should not exceed the power available from a medium horse power, four-wheel farm tractor;
2. The machine should improve the efficiency of working with adequate safety and reduce drudgery in harvesting;
3. The machine should be able to work in sandy loam to loam soil, normally used for cassava growing;
4. The cassava digger should be able to operate down to a depth of 50 cm;
5. The digger should be able to dig out clean and uninjured roots, tubers across a width of 90 cm which was observed to be the maximum width of root cluster; and
6. In order to harvest clean root, the digger plow should be able to vibrate close to natural frequency of soil as it's share digs out the soil underneath the root tuber cluster.

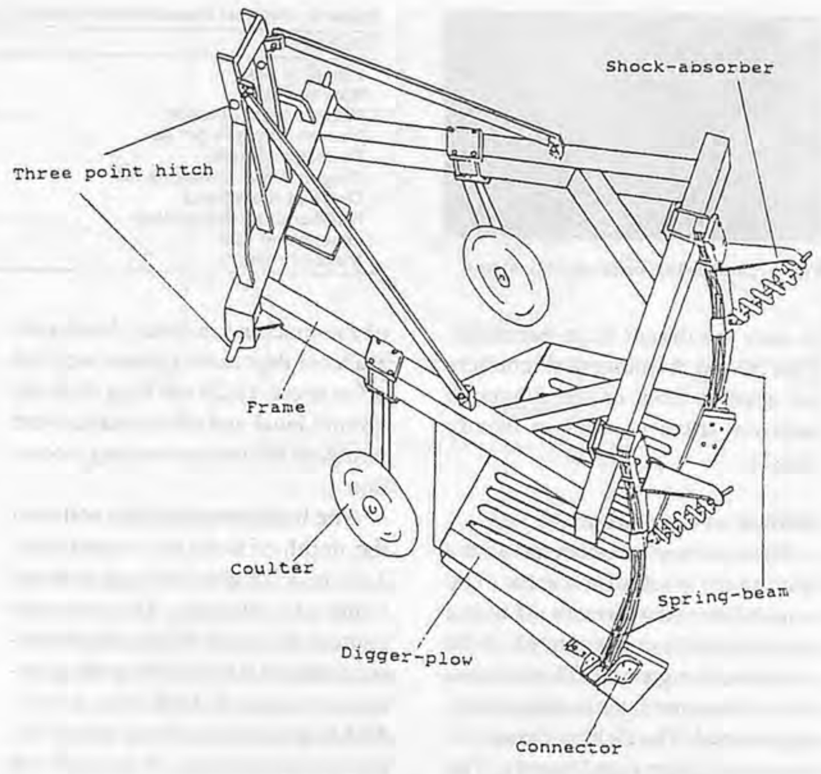


Fig. 1 Cassava digger sketch.


Fig. 2 Cassava harvester mounted on the tractor.

Description of Machine

The schematic diagram of the newly developed cassava harvester is shown in **Fig. 1** and its photograph is shown in **Fig. 2**. The machine is essentially a vibrating plow which consists of a triangular share, made of high carbon steel and a trapezoidal shaped slat type plane bottom made of medium high carbon steel. The plane of share and the bottom make a rake angle of 25-30° with the horizontal. The edge of the share is 10 mm thick and 90 mm wide and sharpened to 30° angle for clean cutting of the soil. The 800 mm wide triangular share with 125° apex angle is provided with a chisel shaped point for easy penetration in hard soil. The frame of the harvester has a hollow rectangular cross-section (100 mm x 100 mm). The plow is attached to the frame by two leaf spring breams, at both sides of the frame. Two shock load absorbers (springs) connect the main frame with leaf springs and resist any sudden shock load, which may be created by hidden stone or root of a tree,

Fig. 3 Cassava harvester under field test.

Table 1. Physical Parameters of Cassava During Harvest (1-year old crop)

Parameter	Average	Maximum	Minimum
Height of plant	1.8 m	2.5 m	1.0 m
Row spacing	1.2 m	1.3 m	1.0 m
Plant-to-plant distance	1.0 m	1.2 m	0.8 m
Number of plants per ha	8 333	—	—
Diameter of stalks	38 mm	60 mm	20 mm
Height of first branching off	270 mm	500 mm	50 mm
Depth of root cluster	343 mm	450 mm	250 mm
Number of roots per plant	11	15	5
Diameter of root	92 mm	120 mm	60 mm
Yield of roots	65 t/ha	—	—

to save the digger from breakage. Two 50-cm diameter disk coulters are used in front of the digger to improve trash control in weedy plots.

Method of Operation

The machine is connected with a three-point hitch of a tractor. The stems of the plants are cut off with a chopping knife at a height of 15-20 cm above the ground. These stems of the plants are later used as planting material. The field is cleared of the cut-off stems and weeds. The share of the digger is lowered so that it penetrates the soil beneath the roots. The depth of penetration of the share should be such that the blade barely touches the root clusters in order not to damage them. As the tractor advances forward, the inclined plane of the share and trapezoidal bottoms acts as a wedge due to angle formed by the blade. A vertical force is created and the root cluster is pushed upwards. The soil in the vicinity of the roots is loosened due to vibrations created by the leaf spring as a result of fluctuations in soil resistance in process of soil cutting by the blade. The leaf spring is subjected to preliminary deformation opposite to that caused by the soil forces acting upon it during the operation of the plow in the field.

Field Test

The vibrating cassava harvester was tested in the cassava field at Korat, Thailand (**Fig. 3**). A one ha (133 m x 75 m) field, having one year old cassava plantation (Kasetsart-50 variety) was selected for evaluation of field performance of the machine in sandy loam soil. Stalks of the cassava plants were cut off at about 15-20 cm high from the ground level and all cut stalks were removed before harvesting operation.

The bulk density of the soil over the depth of 0-40 cm varied from 1.42 to 1.77 g/cc with an average value of 1.60 g/cc. The moisture content of soil (0-40 cm depth) varied from 15.0 to 21.5% with an average value of 18% (dry basis). **Table 1** presents data about the physical parameters of one-year old cassava (Kesetsart-50) grown in Korat, Thailand. The experiments were conducted at six different forward speeds of the tractor varying from 0.33 to 2.44 m/s. A three-point linkage dynamometer was used to measure the draft and vertical component of soil resistance. The dynamometer comprised of left and right lower link transducers and a top link transducer. Each lower link transducer had two bridge circuits to detect the horizontal force (draft) and vertical force. The top link transducer was used to detect the compression force.

The strain gauges were energized by the dynamic strain amplifier. In addition, the dynamic strain amplifier was equipped with a built-in active low pass filter and used to amplify the output signals from these force transducers. The output of all the transducers were fed to the data tape recorder. Before the actual test runs in the field, all the force transducers were calibrated at static load condition in the laboratory. A good linearity was observed between observed load and output voltage during calibration. All the experimental data recorded during field testing wre transferred to the 16 channel data logger from the data tape recorder sequentially. These analog signals were converted into digital form by the data logger and a microcomputer.

Results and Conclusion

The prototype of the newly developed vibrating cassava harvester showed excellent performance by harvesting 100% roots by digging to a depth of 400 mm in one-year old cassava plantation (Kasetsart-50 variety). However, about 2.3% of the roots were broken due to their impact on the ground after harvest. **Figure 4** shows the variation of draft with forward speed of the tractor. As expected, the draft increased with an increase in forward speed. The draft has maximum value of 9.48 kN at 1.69 m/s at 370 mm depth of digging. In other wards, it required a draft power of 16 kW (21.5 hp) at forward speed of 6.1 km/h for digging cassava root clusters in sandy loam soil with moisture content of 18.6% (dry basis).

Figure 5 shows the variation in vertical force (force of penetration) with forward speed of the machine. It may be noted that vertical force increases with increase in forward speed of the machine. For example, it increased from 4.97 kN at speed of 0.33 m/s to 8.01 kN at 1.69 m/s. In other words, the vertical force increased 1.61 times while the speed increased about 5.12 times.

The field capacity of the machine

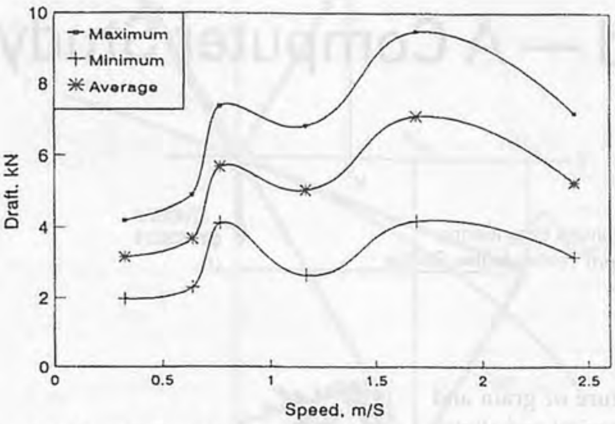


Fig. 4 Draft force for cassava harvester.

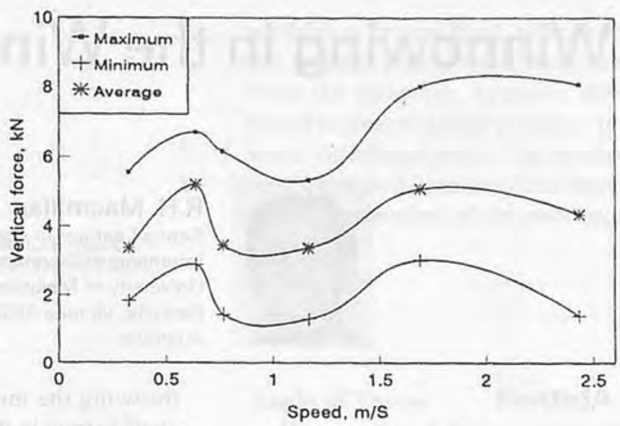


Fig. 5 Vertical force for cassava harvester.

varied from 0.636 ha/h at speed of 2.44 m/s to 0.124 ha/h at speed of 0.33 m/s.

Recommendations

Although the performance of the vibratory cassava harvester was observed to be excellent for harvesting cassava grown in loam soil, the machine should be vigorously tested for it's performance, structural strength and wear for different varieties of cassava under various soil and climatic conditions. The surface of the plow bottom may be coated with enamel to achieve better scouring in sticky soils and reduce soil-metal friction. The clearance between the upper portion of the frame and digger blade should be increased for free flow of dug soil and harvested cassava roots.

REFERENCES

1. Bokanga, M.1996. Biotechnology and cassava processing in Africa. IITA Research 12: 14-18.
2. Cock, J.H.1985. Cassava: New potential for a neglected crop. Westview press, Boulder, CO, USA.
3. Diaz-Duran, Alfonso. 1979. A cassava harvesting aid. Series 05EEn-3, Cassava information center, CIAT Apartado Aereo 67-13, Cali, Colombia, S.A.
4. FAO (Food and Agricultural Organization of the United Nations). 1991. Food Outlook, May 1991, p.15.
5. Giametta, G. and R. Mazzanti. 1992. Cassava harvesting by means of a prototype lifting machine. Proc. International Agricultural Engineering Conference, Bangkok, Thailand. December 7-10, p.43-52.
6. Martinez, J.A.: L. Romero; M. Fernadez and Y.R. Urquijo. 1991. Cassava drawer for row planting to 1.40 m. Ciencias del Suelo, Riego Y Mecanizacion 1(1): 73-82.
7. Odigboh, E.U. and S.F. Ahmed. 1982. Cassava harvester: design, analysis and prototype development. Agricultural Mechanization in Asia, Africa and Latin America (AMA) 12(3): 40-48.
8. Odigboh, E.U. 1991 Single row model II Cassava Harvester. Agricultural Mechanization in Asia, Africa and Latin America (AMA) 22(2): 63-66.
9. Sharma, A.P. 1979. Studies on the mechanized harvesting of cassava in Fiji. Agricultural Mechanization in Asia, Africa and Latin America (AMA) 10(2): 39-41.
10. Van der Sar, T. 1979. Hand operated cassava harvester. Agricultural Mechanization in Asia, Africa and Latin America (AMA) 10(1): 64-68.

■■

Winnowing in the Wind — A Computer Study

by
R.H. Macmillan
Senior Lecturer in Agricultural Engineering
International Development Technologies Centre
University of Melbourne
Parkville, Victoria 3052
Australia

Abstract

A general computer program written to solve fluid-particle mechanics problems was used to analyze the particle separation that occurs when grain and chaff are winnowed by being thrown through, or dropped in the wind.

The results suggest that throwing the mixture against the wind at an angle of about 140° to the horizontal gives maximum separation. Increasing the air velocity, the throw velocity and the height of release give a near linear increase in separation.

Introduction

Winnowing in the wind is the process of separating chaff from grain by dropping or throwing it in a natural air stream. While the origins of this process are lost in the mists of history it is clear from **Fig. 1** showing winnowing in China during the Sung dynasty in the 12th Century (Needham 1984) and **Fig. 2** in India in the 20th Century that little has changed in 800 years. The process is still commonly used in the Third World today but, as a problem in fluid-particle mechanics, it appears to have received little or no attention.

The process involves tipping or throwing the mixture of grain and chaff / straw in the wind and allowing the latter, lighter fractions to be blown further than the grain. If the fractions are not completely separated then further winnowing is necessary to achieve total separation and a clean sample of grain. The failure to achieve this in one operation is presumably due to the variation in the properties of the particles and the presence of many particles in the mixture stream which cause turbulence in the air stream and hence a reduction in the fluid drag on the individual particles.

The following variables may be used to define the system appropriate to the two alternative winnowing methods mentioned above:

*Tipping the mixture
 *height of fall
 *wind velocity (magnitude)
*Throwing the mixture
 *height of release
 *velocity of throw (magnitude)
 *direction of throw in the vertical plane
 *velocity of wind (magnitude)

It is assumed that the angle of throw in the horizontal plane, relative to the direction of wind, is not an important variable.

The present paper reports on the results of a study using a general computer program that was developed for the solution of such fluid – particle problems. The program can be used to plot the trajectory of single spherical particles dropped or projected at any angle into a fluid stream moving at any angle.

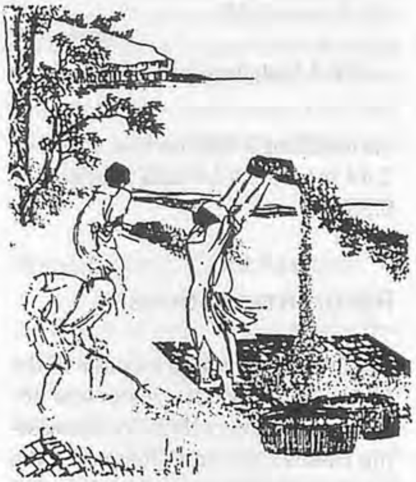


Fig. 1 Winnowing in China in 12th Century (Needham 1984).

Fig. 2 Winnowing in India in 20th Century (Patrick Mulvaney ITDG).

Computer Program

The program is based on the numerical integrationof the equations of motion where the drag force, D, is given by the standard fluid mechanics analysis and is assumed to act in a direction opposite to the velocity of the particle relative to the air.

Acknowledgment: The assistance of computer science students at the University of Melbourne, in the development of the computer program, is gratefully acknowledged.

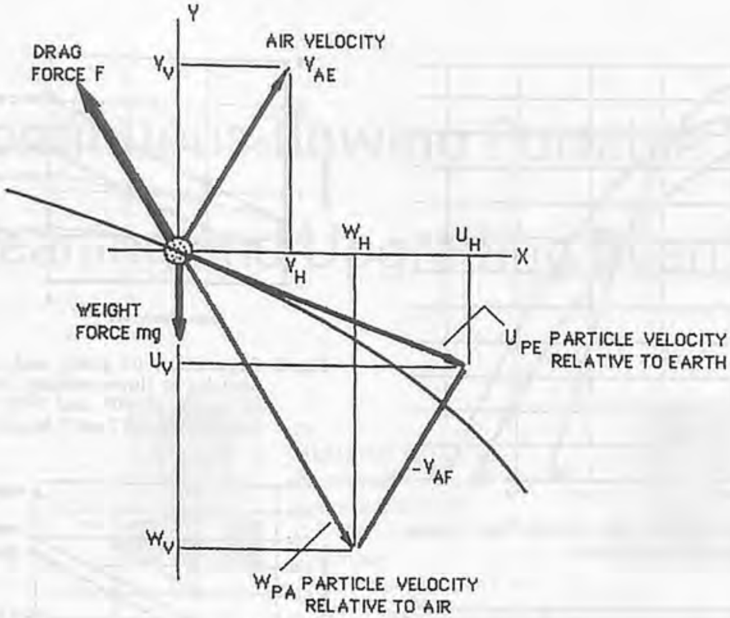


Fig. 3 Velocity and force diagram.

$$D = \frac{1}{2} CA\rho V_{PA}^{2}$$

Where

A = projected area of the equivalent sphere

ρ = density of the fluid

V_{PA} = velocity of particle relative to the air

C = drag coefficient for spherical particles = function (Reynold's Number)

The velocityof the particle relative to the air V_{PA} is given by the solution of the velocity diagram shown in **Fig. 3**.

The program requires the specification of the following:

*particle parameters

*diameter or equivalent diameter

*mass

*magnitude and direction of the initial particle velocity (relative to the earth), U_{PE}

*fluid (air) parameters

*density

*viscosity

*magnitude and direction of the air velocity (relative to the earth), V_{PE}

The program provides plots of x (horizontal position) vs. y (vertical position) also each vs. time (t). It also provides x, y, t, together with the magnitude and direction of the particle velocity, all at a user defined end line.

The general accuracy of the program was confirmed by the re-calculation of published trajectory data from various sources that had been calculated on the basis of similar assumptions to those used in this program.

Method

In the following study the grain and chaff were assumed to be spherical with the following parameters as measured by Farran and Macmillan (1979) for wheat.

Table 1. Properties of Grain and Chaff

Parameter	Grain	Chaff
Mass, g	0.04	0.0035
Equivalent diameter, mm	4.0	5.5

The program was used to plot the trajectory of grain and chaff particles for the following conditions:

*wind velocity, ms^{-1}:

1 2

*mixture throw velocity, ms–1

0 1 2

*release height, m:

1 2 3

*throw angle(range):

0° horizontally 'down wind.'

90° vertically upwards

180° horizontlly 'against the wind.'

The horizontal position of the particles at ground level, relative to the release point, were obtained from the program; negative distances represent a final position 'up wind' of release point. The results were expressed in terms of the (horizontal) separation of the two fractions.

Results

Angle of Throw

Figures 4 and **5** show a typical set of trajectories for grain and chaff, respectively, for air velocity 2 ms^{-1}, throw velocity 1 ms^{-1}, release height of 1 m and for various angles of throw in the vertical plane aligned in the direction of the wind. **Figure 6** shows a plot of the positions of the particles at ground level and of their separation.

Figure 7 shows the separation for the four combinations of air and throw velocity at various angles of throw. From this it is clear that:

1. For a given throw velocity, increasing the air velocity increases the separation for angles of throw.
2. For a given air velocity, increasing the throw velocity increases the separation for angles greater than about 70°
3. For all combinations of air and throw velocity the maximum separation is achieved at an angle of throw of about 140°.

Throw Velocity

Figure 8 shows the separation vs. throw velocity for both air velocities at angles of throw of 90° (vertically upwards) and 140° (the optimum angle). At 90° throw, the separation varied from 40 to 80% of the maximum.

Release Height

Figure 9 shows the separation vs. height of release for angles of throw of 90° and 140°; air and throw velocities were 2 ms^{-1}. Separation for a particle dropped in the air

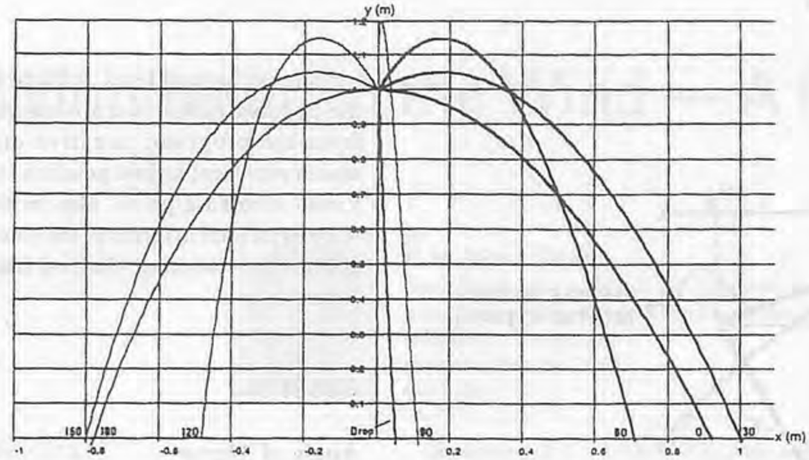


Fig. 4 Trajectories of grain particles for angles of throw shown. Air velocity, 2 ms^{-1}; throw velocity 2 ms^{-1}; height 1 m. Also trajectory for particle dropped.

Fig. 5 Trajectories of chaff particles for angles of throw shown. Air velocity 2 ms^{-1}; throw velocity 2 ms^{-1}; height 1 m. Also trajectory for particle dropped.

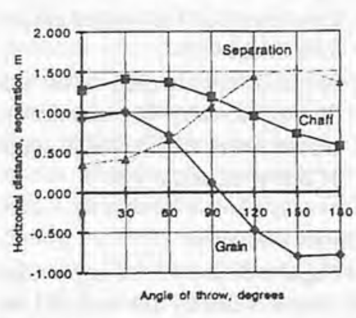


Fig. 6 Horizontal position and separation of grain and chaff particles vs. angles of throw shown. Air velocity, 2 ms^{-1}; throw velocity 2 ms^{-1}; height 1 m.

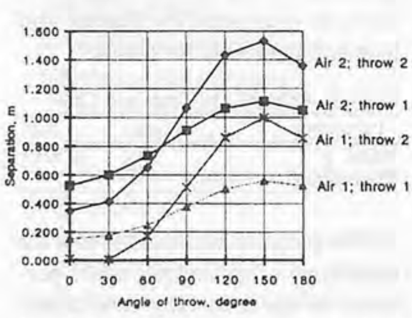


Fig. 7 Separation of grain and chaff particles vs. angles of throw shown. Air velocities 1 and 2 ms^{-1}; throw velocities 1 and 2 ms^{-1}; height 1 m.

stream is also shown for comparative purposes.

Conclusions

The following conclusions, although based on the properties of wheat, are likely to apply generally to similar grain components.

At 90° the grain movement is near zero and the separation occurs mainly due to the movement of the chaff. However, increasing the

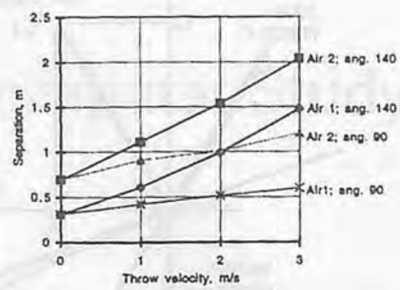


Fig. 8 Separation of grain and chaff particles vs. throw velocity. Angles of throw of 90° and 140°; Air velocities 1 and 2 ms^{-1}; height 1 m.

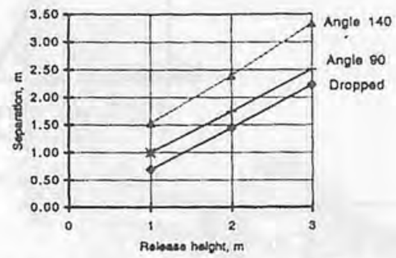


Fig. 9 Separation of grain and chaff particles vs. release height. Angles of throw of 90° and 140°; air velocity 2 ms^{-1}; throw velocity 2 ms^{-1}.

angle of throw increases the separation, mainly due to the extra movement of the grain against the wind.

Throwing the mixture may be a convenient way of handling it but there is little advantage over dropping it from the maximum height reached during throwing unless it is thrown against the wind.

Increasing the height and the air velocity have a near linear effect on the separation; increasing the throw velocity has a slightly curvilinear effect.

REFERENCES

1. Needham, J. (1984) Science and Civilization in China. Volume 6: Biology and Biological Technology, Part II: Agriculture by F. Bray. Cambridge University Press, Cambridge; Figure 164, page 348.
2. Farran I.G. and Macmillan R.H. (1979) Grain-Chaff Separation in a Vertical Air Stream J. Agric. Eng. Res. 24, 115-129.

Continuous-flowing Portable Separator for Cleaning and Upgrading Bean Seeds and Grains

by
Roberto Aguirre
Associate Professor
National University
A.A. 237, Palmira
Colombia

Adriel E. Garay
Seed Consultant
6835 SW Raleighwood Way
Portland, OR 97225
USA

Abstract

A continuous-flowing portable separator for cleaning and upgrading seeds and grains lots was designed, built and evaluated. The machine is made of PVC (rigid vinyl polychloride) accessories and sanitary piping 160 mm in diameter. The separator was evaluated by cleaning threshed samples of bean (*Phaseolus vulgaris* L.) cultivar PVA773. On average, the separator increased the physical purity of the samples from 87.6% to 97.9%, working at an average capacity of 932 kg h^{-1}. The separator removed an average of more than 85.4% of inert matter contained in the samples, with an average recovery of pure grain of 97.2% and of "select grain" of 99.4%. To clean the bean samples, the machine requires a fan with an air flow of 0.3 m^3s^{-1} to produce an air current with an average velocity of 14.6 m s^{-1}. The machine is easy to transport, very light (less than 20 kg) and can be operated by one person. The separator can be operated in the field with a portable air source. The machine costs less than 300 US$ and the operating cost is less than 1.2 US$ t^{-1} of grain.

Introduction

The removal of contaminants from seed and grain lots after threshing is an essential practice in farming. There are innumerable techniques and equipment for carrying out this task, all of them based on one or more differences between the physical characteristics of contaminating particles and the grain that is to be cleaned. Among these techniques, using an air current to do the cleaning has shown to be very effective for separating contaminants from grain (Nicholls and Burrows, 1985; Henderson and Perry, 1979).

One of the traditional methods used by small farmers for cleaning grain and removing the lightest contaminants is the winnowing with natural air. This is the case with most bean producers in tropical Africa and America, where more than 6.2 million tons of beans were produced in 1986 (CIAT, 1988; Camargo, Bragantini, Aguirre, Garay and Fernández, 1988; Brandenburg, 1977). The main disadvantages of natural winnowing are due to the unpredictable direction, velocity and continuity of natural wind.

It has been found that inert matter and pure grain from bean seed lots threshed with different methods (motorized rotary thresher, beating on the floor and beating on a suspended wire screen) have such differences in terminal velocity distribution, that an air current is all it takes for cleaning and upgrading them (Aguirre and Garay, 1996).

Based on these results, the present research was aimed at designing a simple, effective and efficient continuous flowing separator for cleaning and upgrading bean seeds and grain lots.

Materials and Methods

Preparation of Samples

Bean plants (cultivar PVA773) were harvested with high humidity and were dried until the moisture content of grain was 15% (wet basis). Then the plants were threshed using the three most common methods in the region:

a) Stationary rotary thresher powered by a gasoline motor;
b) Beating the plants with clubs on the floor; and
c) Beating the plants with clubs on a suspended wire screen (Camargo et al., 1988).

These methods were selected because they leave several contaminants with distinctive physical characteristics, so their cleaning requirements would also be different.

Once threshed, the three samples were dried to 13% moisture content; afterward they were scalpered with a wire screen with 11 mm square holes. The precleaning, which is also a common practice among farmers, is done to remove the largest contaminants. Care was taken to keep the sample in conditions as real as possible.

Design and Description of the Portable Separator

The separator was designed taking into account the application of technical principles to the specific requirements of non-conventional seed and grain producers. Generally, in the development of farm equipment, design simplicity should be the goal; the fewer parts there are, the less opportunity there is for errors, failures and maintenance requirements. When possible, easily obtained uniform parts should be used. Special parts should not be used unless they are absolutely necessary. Whether it is simple or complex, the equipment should be reliable, durable, and safe (Gorial and O'Callaghan, 1991; Campbell, 1986). From previous work it was established that the required air velocity would be at least 16 m s^{-1} (Aguirre and Garay, 1996; ISTA, 1988; Kashayap and Pandya, 1965).

The final design of the machine was reached after several preliminary tests during which several configurations were tried. **Figure 1** shows a sketch of the portable separator.

The materials used (PVC accessories and sanitary piping) were selected because of their wide availability, durability light weight, low cost, impermeability and ease of use and assembly without significant modifications.

The feeding height had to be suitable for manual and continuous feeding and the clean grain exit should be high enough to pick it up comfortably without needing bucket-type elevators. To allow the use of different air sources, the separator does not include a fan.

A dust collector was added for the purpose of picking up debris, filtering the air and when necessary, enabling the machine for use in closed spaces. The separator is made of the following parts:

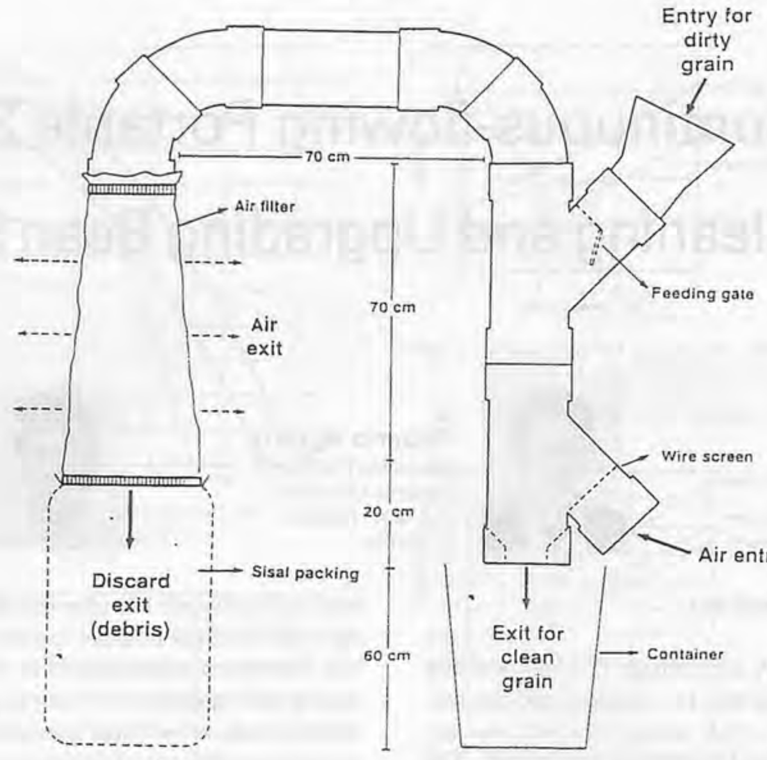


Fig. 1 Sketch of the portable separator (without tripod).

a) Entry for dirty grain, formed by a bottomless plastic bucket screwed to one of the upper ends of the separator's body. It has a gate to regulate the flow of dirty grain that enters the machine, which opens and closes with a counterweight, allowing the passage of dirty grain and impeding the escape of air;
b) Exit for clean grain, located on the lower part of the separator, where there is a PVC reduction 160 x 80 mm. This reduction diminishes the fall velocity and physical damage on the grain and reduces air escape.
c) Discard for light debris, located on the upper part of the separator's body, where it is connected to the dust collector, made of PVC 45° elbows (160 mm in diameter) and thin cloth or linen. The lifted air and debris, are separated along the dust collector: the air passes through the cloth, which acts as a filter, and the debris goes out through the lower part of the collector, where there is a metal ring that allows hanging a sisal or burlap bag to collect the debris. When working in an open field, the collector can be dispensed with.
d) Air inlet: this includes a wire screen that acts as filter, avoiding the passage of material. The gate for regulating the air flow is located at the exit of the fan (not shown in the figure).
e) A tripod (not shown) that supports the separator's body is made of metal tubing, with telescoping legs that allow levelling the machine on inclined surfaces. The tripod can be easily dismantled to facilitate transporting the separator.
f) The separator body, formed by two PVC Yees, 160 mm in diameter, joined at one of their ends. This is the part of the separator where air and sample interact.

Dirty grain goes into the separator in the upper part and enters in contact with the air current which is flowing in the opposite direction. The heaviest particles (grain) fall into the exit at the bottom of the machine and the lightest ones are lifted by the air current and carried to the discard and the dust collector. At this point air and debris are separated, the former passes through the filter and the latter goes out to the filter exit where it is collected in a sisal bag.

The PVC pieces are joined together with PVC pipe sections and screwed so the machine can be taken apart if necessary. Since the separator does not have movable parts and is made out of resistant materials, wear on the machine and maintenance required are minimal and its useful life is expected to be long. Neither qualified labour nor special tools are required for its construction.

The air source can be provided by:

a) a fan powered by an electric motor;
b) a back sprayer powered by a gasoline motor; and
c) a fan activated manually or by pedal.

The last two options allow using the separator in areas where there is no electricity or to take the machine into the field to clean the grain at the same site where threshing is done. The separator can be operated by only one person, but for the evaluation tests, work was done with two people in order to guarantee that feeding of the dirty grain would be uniform and continuous.

Methodology for Evaluation of the Portable Separator

In order to evaluate the separator, the air current was generated by a straight blades-centrifugal fan powered by a 535W (0.5 hp) electric motor. The air velocity was regulated by a gate located at the fan's outlet. In order to determine the appropriate air velocity, the test began with minimum air speed and was increased slowly until the lightest grains began to be lifted and go out with the debris. In this way, the grain loss was minimal and the removal of light contaminants was maximum. Once a suitable velocity was found, its value was measured by taking four readings with a Davis anemometer, 100 mm in diameter.

The dirty grain, previously homogenized, was weighed before being used to evaluate the separator. Several preliminary tests were made with each one of the three bean samples described earlier in order to determine the appropriate feeding rate of dirty grain and air velocity. Three evaluations were made with high and low capacity for each one of the samples. The time was recorded at the beginning and end of each evaluation to determine the machine's capacity.

At the end of each test, the exit and discard materials were weighed, sampled (three sub-samples of each) and separated into two components: pure grain (PG) and inert matter (IM), according to the international methodology (ISTA, 1985). This work was done at the Seed Unit's Quality Control Laboratory of the International Center for Tropical Agriculture (CIAT).

Results and Discussion

Table 1 shows the experimental data obtained. In order to evaluate the performance of the separator, the following variables were considered: air velocity (m s^{-1}); machine capacity (kg h^{-1}); lot yield (%); physical purity (%) of dirty and clean grain; effectiveness (% of IM removed); efficiency (% of PG recovered) and select grain recovery (%).

Table 2 presents a list of the main components of the machine and its initial cost (US$) and **Table 3** shows its operating cost (US$ t^{-1}).

The average air velocity (14.6 m s^{-1}) used in the tests is within the range of terminal velocity reported for bean seed (Aguirre and Garay, 1996; ISTA, 1988). This velocity requires an air flow of 0.3 m^3 s^{-1} for the separator which has a diameter of 160 mm.

The average capacity (kg h^{-1} of material that enters the separator) is shown along with the quantity of clean grain that leaves it. The difference between these two values corresponds to the amount of material discarded through the exit. The ratio between them represents the lot yield, with an average value of 86.9%.

The average capacity (932 kg h^{-1}) of the separator is high considering its simplicity, size and quantity (weight and volume) of IM that it removes.

With grain lots that have a large amount of thick chaff (large fragments such as stems and roots), feeding the machine becomes difficult and its capacity is reduced. In these cases, it is recommended that the lot be scalped before passing it through the separator.

The physical purity of dirty grain that enters the separator and of clean grain that leaves it was determined and is shown in **Table 1**. The average initial physical purity of the six lots was 87.6% and the final average was 97.9%, which represents an increase of 10.3 percentage points.

Table 1. Experimental Data Obtained When Cleaning on the Separator Bean Samples Threshed with Three Different Methods

Separator capacity	Threshing method						
	Rotary thresher		On the floor		On a screen		
	Low	High	Low	High	Low	High	Average
Air velocity (m s^{-1})	15.4	15.0	13.2	14.4	14.9	14.6	14.6
Capacity - dirty grain (kg h^{-1})	678	834	868	1 344	748	1 117	931.5
Capacity - clean grain (kg h^{-1})	579	728	754	1 125	660	1 006	808.7
Lot yield (%)	85.4	87.3	86.9	83.7	88.2	90.1	86.9
Entry physical purity (%)	91.1	90.8	84.0	83.4	87.6	88.6	87.6
Exit physical purity (%)	98.7	98.5	96.2	97.7	98.6	97.6	97.9
Efficacy - IM removal (%)	87.9	85.8	79.5	88.2	89.9	81.4	85.5
Efficiency - PG recovery (%)	92.5	94.7	99.5	98.1	99.2	99.3	97.2
Select grain recovery (%)	98.0	98.8	100.0	99.9	99.8	99.8	99.4

Table 2. Main Components of the Separator and Their Cost

Parts and materials	Quantity	Cost (US$)
PVC 45° elbow - 160 mm	4 u	28.0
PVC Yee - 160 mm	2 u	18.0
PVC reduction - 160 x 80 mm	1 u	4.0
PVC - sanitary pipe - 160 mm	0.8 m	10.0
Galvanized pipe - 19 mm	2.7 m	8.0
Galvanized pipe - 12 mm	3.6 m	8.0
Plastic bucket - 15 liters	1 u	2.0
Cloth for air filter	2.3 m^2	2.0
Labour	8 h	8.0
Other parts (screws, wire screen, clasp, pressed wood, etc.)	—	2.0
Electric centrifugal fan	1 u	200.0
Total cost of separator	—	290.0

Table 3. Operating Costs for Separator and Winnowing Methods

Item	Separator			Winnowing		
Work hours per year	2 000			2 000		
Equipment useful life	10 000 hours			0.0		
Electricity use	0.536 kW			0.0		
Electricity cost	0.05 US$ kW h^{-1}			0.0		
Equipment initial cost	290 US$			0.0		
Capacity (t h^{-1})	0.932			0.050		
Operating Costs	US$ h^{-1}	US$ t^{-1}	%	US$ h^{-1}	US$ t^{-1}	%
Depreciation	0.029	0.031	2.6	0.0	0.0	0.0
Maintenance	0.004	0.004	0.3	0.0	0.0	0.0
Electricity	0.030	0.032	2.6	0.0	0.0	0.0
Labour	1.000	1.070	94.5	1.0	20.0	100
Total operating cost	1.06	1.14	100	1.0	20.0	100

The final physical purity in all cases was high, above all if it is considered that the original samples had a high content of impurities. It can also be observed that there are no large differences in the values of end physical purity for the different evaluations, which indicates that the separator does good cleaning when it works at low or high capacity, and with samples threshed under different methods.

Another variable considered in the evaluation of the separator was the quantity of IM removed. **Table 1** presents the inert matter content remaining in the clean grain, considering the total IM contained in the dirty grain that enters the separator equal to 100%. It can be seen that the separator removed an average of 85.5% of the total IM contained in the samples of dirty grain. The IM particles that are not lifted by the air current are mainly heavy contaminants (rocks, dirt clumps, unthreshed pods, and large fragments of stems and roots), which are not separable pneumatically and which require other methods for their removal.

In order to avoid these materials from contaminating the lot, preventive measures should be taken during harvest. For example, if plants are cut instead of being pulled out, dirt, dirt clumps, and rocks are eliminated. This practice is particularly useful when harvest period coincides with the rainy period and it is not easy to shake mud from the roots. The method of threshing on a suspended wire screen has the additional advantage that its wire mesh precleans the lot, removing the largest chaff and even the smallest debris. Thus, the resulting product will have lighter contaminants, facilitating their removal by the separator. In this way, the efficiency of the separator is increased, along with the final physical purity of the grain lot.

However, there are light particles that should have been removed by the separator, but because of the high and continuous feeding of dirty grain, they do not have an opportunity to interact with the air current and be lifted.

This light debris that still remains in the clean grain sample could be removed by passing again the sample through the separator or by lowering the machine feeding rate. In this way, more opportunity is given to the light particles to come in contact with the air current and to be lifted in accordance with their terminal velocity. If these conditions are met, the separator could remove all the impurities from the bean lots without needing additional equipment.

In order to evaluate the separator's performance, the recovery of PG (efficiency) was also considered. **Table 1** shows the fraction of PG that goes out with the clean grain, considering the total PG contained in the sample that enters the separator as equal to 100%. Clean grain at the exit of the separator contains 97.2% (on average) of the weight of PG present in the dirty grain samples, that is, when passing the samples through the separator, only 2.8% of the grain is lost, on average. This loss is considered low, given the large quantity of IM that is being removed from the lot.

Upon observing the appearance of the discarded grain, although some of them meet the definition of "pure grain" in the norms of the International Seed Testing Association (ISTA), they would not be acceptable for commerce as grain or seed because they are poorly formed, immature, damaged, shrivelled, or rotten. For this reason, it was decided to classify as "select grain" (SG) with good enough appearance to be commercially used as grain or seed and the other grain, though pure grain, are considered undesirable on the lot that should be discarded.

With this classification it was determined that the separator recovered, on the average, 99.4% of the "select grain" present on the samples. This means that in cleaning the samples with the separator, only 0.6% of the weight of the "select grain" that enters the equipment is lost. These results, linked with those of physical purity and inert matter removed, demonstrate the separator's good performance.

Seed lots can be passed through the separator a second time, increasing slightly the air velocity, to remove the lightest seeds, which are usually immature, diseased, and poorly formed, thus improving and upgrading the quality of the seed lot.

Costs of Building and Operating the Portable Separator

Within the scope of this study, it was determined that the separator would be easy to build and it would be made of easily obtained, low-cost materials. Therefore, the materials used were selected taking these criteria into account. **Table 2** presents the list of materials (and their cost) used for building the separator.

The separator's total cost is 290 US$, including the fan. This value equals the cost on the market of 193 kg of beans (1.5 US$ kg^{-1}) or 290 hours of labour considering an opportunity cost for labour of 1 US$ h^{-1} (data for Colombia, September 1996).

Table 3 presents the information on the operating cost for the separator and traditional winnowing. For the separator, the operating cost was 1.14 US$ t^{-1}, with labour costs representing 94.5% of this value. If the blower used is a back sprayer, the cost would be lower because this equipment can be used also for other purposes.

Considering that one person can clean 50 kg h^{-1} of grain with the traditional winnowing method, at a cost of 20 US$ t^{-1} vs. 1.14 US $ t^{-1} with the separator, that represents labour savings of 94.3% or 18.86 US$ t^{-1}.

That means that the total cost of the separator (290 US$) is paid with the savings in labour resulting from cleaning 15.4 t of grain. With the separator's capacity (0.93 t h^{-1}) the separator pays for itself in the first 17 hours of work. In other words, the separator's initial and operating costs are so low that using it would make big savings in the producer's labour costs.

Results demonstrate the separator's good performance working at two capacities (high and low) cleaning bean samples threshed through three different methods. The final physical purity is high, considering the high initial content of contaminants in the samples. The amount of inert matter removed is high and it could be increased even more by passing the samples through the separator again. Recovering of pure grain and "select grain" is high for the two cases. The separator's initial cost is low considering the quantity and quality of work done and its operating cost is lower than the cost of traditional methods used by small producers.

These data indicate that the separator will allow producers to clean their bean lots better, easier and at a lower cost. The good performance, high capacity and light weight of the separator would make it possible to offer cleaning services to other farmers.

Conclusions and Recommendations

1. The continuous-flowing portable separator designed, built, and evaluated showed good performance in cleaning and upgrading bean samples threshed through three different methods.

2. The separator is simple, portable, light (weighing only 20 kg) and inexpensive (290 US$). It was built with parts and materials easily obtained on the market.

3. The separator has a high capacity (932 kg h^{-1}). To clean beans, it works with air at an average velocity of 14.6 ms^{-1} and an air flow equal to $0.3m^3s^{-1}$. The operating cost is less than 1.2 US$ t^{-1}.

4. On average, the separator increased the physical purity of bean samples used in the evaluation from 87.6% to 97.9%, removing an average of more than 87.1% of the inert matter present in the samples, with losses of pure grain that were, on the average, less than 2.8% and losses of "select grain" of less than 0.6%.

5. Because of the good performance of the separator, cleaning and upgrading bean grain lots, it is recommended that it be tried out with seeds and grains of other species.

BIBLIOGRAPHY

Aguirre R. and A.E. Garay. 1996. Differences in terminal velocity distribution: Good enough for cleaning bean (*Phaseolus vulgaris* L.) seeds and grains. In process of publication.

Brandenburg, N.R. 1977. The principles and practice of seed cleaning; separation with equipment that senses dimensions, shape, density and terminal velocity of seeds. *Seed Science & Technology* 5, 173-186.

CIAT. 1988. Trends in CIAT commodities. CIAT. Cali, Colombia. 110 p.

Camargo C., Bragantini C., Aguirre R., Garay A.E. and Fernández J. 1988. Seeds for small farmers – Support infrastructure. Seed Unit, CIAT. Cali, Colombia. 39 p.

Campbell, J.K. 1986. Design and development of small farm equipment to simplify fabrication, operation and maintenance in developing countries. International Rice Research Institute (IRRI), Los Baños, Philippines. 629 p.

Gorial B.Y. and J.R. O'Callaghan. 1991. Separation of grain from straw in a vertical air stream. *Journal of Agricultural Engineering Reserach* 48, 11-122.

Henderson, S.M. and R.L. Perry. 1979. *Agricultural process engineering*. AVI Publishing Company, Westport, Connecticut, USA. 442 p.

ISTA. 1985. International rules for seed testing. *Seed Science & Technology* 13. 315-319.

_____. 1988. Handbook for cleaning of agricultural and horticultural seeds on small scale machines. Part II. International Seed Testing Association, Zurich, Switzerland. 117 p.

Kashayap M.M. and A.C. Pandya. 1966. Air velocity requirement for winnowing operations. *Journal of Agricultural Engineering Reserach* 11, 24-32.

Nicholls, C.F. and V.D. Burrows. 1985. Air suction of chaff and debris from grain conditioning machinery. *Journal of Agricultural Engineering Research* 31, 377-378.

The Present State of Farm Machinery Industry

by
Shin-Norinsha Co., Ltd.
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan

Outlook of Agriculture

Trend of Agriculture

In 1995 agricultural total products was ¥6 799 billion, it occupied 1.4% of GNP. The imports agricultural products are on the increase. In 1996 the imports reached $40.4 billion (an increase of 2.5% of the preceding year). The exports agricultural products are $1.5 billion (a decrease of 9.2% of the preceding year). In Japan, feed cereals, soybean, wheat and so on depend on the imports from foreign countries. Self-sufficiency ratio of agricultural product for food by calorie base in 1996 is 42%, cereals is 29%.

Population mainly engaged in farming has been decreasing yet, in 1996 it was 3 210 000 persons. It was 4.9% of total working population. Farm house has decreased, in 1997 are 3 340 000 farm houses. And, commercial household was 77%. Arable land was 4 950 000 ha in 1997. Arable land per one farm family was about 1.5 ha very small.

In Japan, food life has varied since 1970's. While, rice, oranges, milk, eggs and so on have been over-produced. In such surroundings, the GATT settlement require Japan to have more competitive power. In Japanese agriculture, it is requested to reduce production cost, increase people destined to bear agricultural production, produce various products satisfying consumers' need, and to realize agriculture keeping the earth favorable.

Trend of Farm Mechanization

Agricultural mechanization in Japan has remarkably progressed in the field of low land rice, chief crop, in a short period since 1955. Rice production at present almost planting and harvesting have been mechanized. In 1997 as to rice, working hours per 10 a decrease to 36.8 hours, they were 117.8 hours in 1970.

In recent years farm machinery for rice crop is developed to be larger-sized, higher-efficiency and more commonly used. In addition, farm machinery for field crops and live stock farming is being developed and improved, which had been lagged behind so far.

From 1993 Japanese government started the program developing the new high-tech machine to make farm working efficient and to reduce farm burden. By 1997 those developing have finished such as big size multipurpose combine and vegetable grafting robot so on 36 types. And we decided eight types of unification for growing vegetables. Local governments have been developing the machine to vitalize special local products. Moreover, in 1998 new program developing 27 types machine have started.

In 1995 Ministry of Agriculture, Forestry and Fisheries made a committee which studied method to reduce cost of farm product materials like farm machines. Those farm product materials are major parts of farming cost. In 1996 concrete movement started in the field of production and distribution.

Following are the numbers of popularization of farm machinery as of Feb. 1, 1995: riding tractor reached 2 309 000 units; walking tractor 1 714 000; rice transplanter 1 865 000; and head feed combine 1 202 000 (**Table 1**).

Shipments of major farm machinery in the domestic market in

Table 1. Major Farm Machinery on Farm Unit: Thousand

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1990	2,185	2,142	1,983	1,871		1,298	1,215	1,282
1991	1,765	1,966	1,904	—	—	—	1,169	—
1992	1,786	2,003	1,881	—	—	—	1,158	—
1993	1,743	2,041	1,866	—	—	—	1,158	—
1994	1,669	2,060	1,835	—	—	—	1,149	—
1995	1,718	2,313	1,869	1,921		1,022	1,203	1,121

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

Table 2. Shipment of Major Farm Machinery

Unit: Number

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1990	205,944	95,691	89,139	183,820	107,227	37,117	65,247	51,954
1992	199,141	88,754	80,105	184,016	105,028	20,888	60,941	52,275
1994	172,471	88,501	82,210	162,422	98,266	22,589	60,741	57,070
1995	163,323	90,623	81,729	162,352	96,499	23,293	64,572	60,564
1996	173,894	93,660	73,204	165,467	99,342	18,476	60,198	59,546
1997	174,004	87,416	64,859	177,064	90,133	16,770	53,095	52,389

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

1997 are as follows: riding tractor reached 87 000 units (those under 20PS were 29 000; those 20-30PS 380 000; 30-50PS 14 000; over 50PS were 6 300); walking tractor 174 000; rice transplanter 65 000; power reaper 17 000; combine 53 000 (standard types were 493); grain dryer 52 000; and huller 36 000. A safety cabin and a safety frame for tractor which are devoted to guarding operator increased sharply. This shipment was 82 000 units (**Table 2**).

Recently more and more used farm machines are distributed. The rate of used farm machinery in 1996 in the total sales amount is as follows: riding tractors forms 38%; rice transplanter 28%; and combine 33%.

Movement of Farm Machinery Industry

Japan is facing to great change also in agricultural field. Ministry of Agriculture, Forestry and Fisheries (MAFF) is preparing New Agricultural Basic Law which will replace Agricultural Basic Law. This law was, as it were, the Constitution of Japanese agriculture. That law will change in order to adapt new agricultural condition.

It will influence Japanese agriculture very much, also agricultural machinery manufacturers.

A production of farm machinery in Japan was over 600 billion yen in 1995, 1996, 1997. But in 1998, it is hard to be more than 500 billion yen. Farmer say we are very severe condition. Because of rice price decreasing. Especially, rice production machines are decreasing. It shows rice farmer's investment for machines getting are weak.

Farm households are dividing to two sides. One is large households, the other is small household. Farm machinery manufacturers should take care of this tendency. After New Agricultural Basic Law, this movement will be accelerating.

In Japanese agriculture women power gets stronger and stronger. There are many women operate farm machines as well as men operators. They needs machine which is easy to operate for women's body shorter than men.

Environment problems gets severe. Agriculture must solve this problem. Agricultural machine had great role in making farm products. Now, agricultural machinery manufacturers are trying to solve environment problem through machines.

Trend of Farm Machinery Production

Farm machine production of 1997 amount to ¥616.0 billion (3.3% a decrease of over the preceding year).

Production of the major farm machinery is as follows: Riding tractor 160 518 units increased by 4.9% under the preceding year. Seeing by h.p., those under 20PS amounts to 60 619 units, 20-30PS 60 604 units, over 30PS 39 295 units. Every class increasing preceding year.

The production of walking tractor amounted to 225 229 units, which showed an increase of 4.9% over the preceding year. Under 5PS was 132 034 units, over 5PS was 93 195 units.

The production of combine, which is next to the riding tractor is 56 709 units (a decrease of 10.5% over the preceding year). Main type is its harvesting wide is about 1 meter head feed type.

Following are the production of other types of farm machinery: rice transplanter amounted to 63 367 units (a decrease of 10.3% over the preceding year); binder (walking type harvesting machine for rice and wheat, barley, etc.) 15 027 units (a decrease of 30.2%); thresher 9 041 units (a decrease of 22.0%), grain dryer 56 647 units (a decrease of 12.8%); huller 56 887 units (a decrease of 5.2%) bush cleaner 948 178 units (a decrease of 22.3%); and power pest controller 218 535 units (a decrease of 24.4%) so on (**Table 3**).

Trend of Farm Machinery Market

In Japan distribution systems for farm machinery is roughly divided into two major channels: the traders concerned and Agricultural Cooperatives Association. As of June 1997, the retail shops were recorded to about 8 800, the employees amounted to 45 000 persons, and the annual sales amounted to ¥1 265.9 billion (**Table 4**).

According to the governmental survey by Ministry of Agriculture, Forestry and Fisheries, the total sales of farm machinery by Agricultural Cooperative Association reached ¥415.7 billion in 1996 (¥413.5 billion in 1995) (**Table 5**). In 1996 numbers of Agricultural Cooperative was about 2 330, amount of dealing machines per Cooperatives was about ¥180 million.

About half of traders are small

Table 3. Yearly Production of Farm Machinery

Unit: Number, Million Yen

Year	Farm machinery total		Riding type tractor		Walking type tractor		Rice transplanter		Power sprayer		Power duster		Blower sprayer	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1990	—	585,561	115,939	198,557	269,027	38,248	91,141	52,462	220,528	12,339	149,789	5,575	9,565	9,514
1991	—	615,131	148,437	203,260	270,714	40,102	87,019	54,265	198,887	10,607	163,306	6,155	9,318	12,766
1992	—	575,986	145,948	195,189	245,675	35,917	80,540	50,760	181,475	7,826	162,040	6,548	9,923	14,884
1993	—	588,627	146,115	186,983	225,564	33,738	84,980	58,344	165,909	6,899	134,901	5,985	8,559	12,155
1994	—	606,279	156,039	198,278	212,539	30,921	85,837	66,726	141,556	6,569	123,268	5,670	6,260	8,261
1995	—	649,874	153,890	205,489	205,758	28,271	86,713	69,218	161,360	7,370	129,995	6,293	7,018	11,622
1996	—	637,209	152,956	201,357	214,702	31,400	70,614	57,581	154,260	6,752	126,594	6,121	8,280	12,843
1997	—	615,974	160,518	219,446	225,229	31,803	63,367	53,236	172,034	7,776	110,736	5,278	7,799	10,223
(1998)	—	498,150	143,700	194,810	213,700	29,450	56,000	49,300	170,300	7,720	87,000	4,100	7,900	9,150
Year	Grain reaper		Brush cutter		Power thresher		Grain combine		Rice husker		Dryer		Grain polisher	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1990	42,502	11,110	1,601,652	25,798	22,634	9,118	68,993	138,396	60,006	18,332	59,269	39,990	58,500	4,871
1991	37,782	9,542	1,657,897	27,117	20,337	7,898	72,913	152,827	60,690	19,124	57,747	43,250	57,625	5,243
1992	30,511	7,753	1,890,427	28,994	12,656	4,838	65,673	143,335	50,208	15,292	51,821	38,236	45,182	4,274
1993	27,286	7,173	1,588,837	27,399	11,663	4,562	65,192	149,867	41,664	14,129	56,079	44,224	40,368	3,844
1994	21,033	5,379	1,554,478	28,726	11,422	4,439	61,242	148,537	42,115	14,680	62,044	49,846	53,514	5,493
1995	27,562	7,484	1,471,192	27,731	12,422	4,751	66,767	162,329	56,792	21,178	67,700	56,215	56,590	6,755
1996	21,541	6,364	1,220,005	24,291	11,593	4,568	63,371	168,391	60,021	22,639	64,969	53,483	44,451	6,096
1997	15,027	4,283	948,178	21,071	9,042	3,542	56,709	152,627	56,887	21,434	56,647	46,529	42,391	5,148
(1998)	9,000	2,410	959,800	21,150	6,000	2,340	42,400	108,900	38,700	14,870	38,600	31,620	40,300	3,920

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

Note: Data for 1998 are forecast by Farm Machinery Industrial Research Corp.

Table 4. Farm Equipment Distributor and Sales Value

Unit: Million yen

Year	Number of retailers (1)	Employes	Annual sales vaue (2)	Inventory	Square meters of shop m²	Annual sales value (2)/(1)
1979.6	9,257	48,548	1,007,298	159,772	898,854	108.8
1982.6	10,084	49,081	1,018,983	164,269	1,005,546	101.0
1985.6	9,142	43,921	946,507	144,837	985,453	103.5
1988.6	9,444	45,952	1,015,304	159,798	923,726	107.5
1991.6	9,480	45,705	1,158,924	170,104	984,700	122.2
1994.6	8,838	43,112	1,128,087	166,298	978,788	127.6

Source: Ministry of International Trade and Industry

Table 5. Handling of Farm Equipment by Agricultural Cooperative Association (1996 Business Year)

Unit: Million yen

Business year	Total number of coops. surveyed	Purchase in this term	Of which purchased through affiliated organs	Amount of supply and handling
1990	3,591	349,521	268,763	375,660
1992	3,204	354,728	268,393	388,031
1994	2,669	378,660	281,625	417,474
1995	2,457	374,952	283,193	413,664
1996	2,331	374,334	279,070	415,691

Source: "Statistics on Agricultural Cooperatives—1995 business

firm which employees are under 5. In a long time, it is important problem to improve management structure.

Export and Import of Farm Machinery

Export

In 1997 the exports of farm machinery amounted to ¥130.4 billion, which showed an increase of 14.8% over the preceding year. The ratio of exports to the total production amounts to ¥616.0 billion ended 21.2%.

Seeing by the shipments, ¥62.1 billion for North America (an increase of 19.6%), ¥31.6 billion for Asia (an increase of 13.9%), ¥24.5 billion for Europe (an increase of 7.8%). For North America, ¥58.6 billion was U.S.A., tractor 56 588 units, ¥48.3 billion, which is a major part.

As for the types of farm machinery, tractor was chiefly exported: 91 851 units were exported in 1997 (the total production was 160 518 units). It amounts to ¥68.5 billion. Seeing by horse power, those under 30PS amounted to 69 015 units, those from 30 to 50PS 18 394 units, those over 50PS 3 443 units.

Major farm machinery, next to tractor, is bush cleaner. The total exports were 936 849 units, ¥23.0 billion. The exports of other farm machinery are as follows: walking tractor 50 148 units; lawn mower 40 254 units; grass mower 46 879 units; and chain saw 162 150 units, etc. (**Table 6**).

Import

In 1997 the imports of farm machinery amounted to ¥33.1 billion, which means a decrease of 1.4% over the preceding year.

Followings are the major imported farm machinery: tractors 3 392 units (those more than 70PS were 2 276 units of all the tractors); chain saw 60 833 units, lawn mower 58 913 units; mower 4 443 units; and fertilizer distributor 1 631 units. Tractors 1 206 units were imported from U.K. and 834 units from Italy (**Table 7**).

Trend of Research and Experiment

The surroundings of Japanese agriculture are very hard, because of claims for opening the market for agricultural products by U.R. settle-

Table 6. Export of Farm Equipment 1997

Unit: FOB Million yen

Year	Unit	Value	Ratio	Major destinations
1990		132,757		
1991		129,943		
1992		143,891		
1993		124,505		
1994		120,079		
1995		104,597		
1996		113,586		
1997		130,351	100.0	U.S.A., Taiwan, Korea, France
Power tiller	50,148	3,595	2.8	France, Spain, Germany
Wheel tractor	91,851	68,468	52.5	U.S.A.
Seeder, Planter	3,330	1,925	1.5	Taiwan
Power sprayer	49,250	1,704	1.3	Taiwan, Korea
Duster	17,406	571	0.4	Korea, Taiwan, Mexico
Lawn mower	40,254	3,461	2.7	U.S.A., France
Brush cutter	936,849	23,013	17.7	France, U.S.A., Korea
Mower	46,879	1,271	1.0	Korea, Malaysia, U.S.A., Taiwan
Combine	3,060	8,597	6.6	Taiwan, China
Chain saw	162,150	3,691	2.8	U.S.A., France, Italy
Other	—	14,075	10.7	

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

Table 7. Import of Farm Equipment 1997

Unit: CIF Million yen

Year	Unit	Value	Ratio	Exporters
1990		33,205		
1991		26,598		
1992		25,778		
1993		25,578		
1994		27,779		
1995		27,015		
1996		33,542		
1997		33,069	100.0	U.K., U.S.A., Germany
Wheel tractor	3,392	13,521	40.9	U.K., France, Italy China, U.S.A.,
Pest control machine	2,779,796	1,919	5.8	Israel
Lawn mower	58,913	2,381	7.2	U.S.A., Sweden, Germany
Mower	1,458	986	3.0	France, Netherlands, Denmark
Hay making machine	1,666	1,038	3.1	France, Germany
Bayler	788	1,381	4.2	U.S.A., France, Denmark
Combine	68	1,137	3.4	Belgium, Germany, Australia
Chain saw	60,833	1,762	5.3	Germany, Sweden, U.S.A.
Other	—	8,944	27.1	

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

ment, consumer's various favor, the increase of the aged and the females as farmers, being called for the contribution to solve the environmental problems. That's why the structural and technical reforms in Japanese agriculture are requested urgently.

Researchers are chiefly made for high performance, automatic and popularized farm machinery in order to reduce cost in the production of agricultural products. Electronics and mechatronics are positively adopted for their technology. In 1993, the law promoting agriculture mechanization was revised. "Urgent Development program" which is promoting the machine has a weak demand, but has a strong needs, is going ahead. As a result, one of them like vegetables grafting machine is on market. And in 1998, new "Urgent Development Program" including 27 types study has started.

In 1997, in the field of farm machinery, there were movement as follows;

Tractor has developed auto-running systems, and that study has been continuing.

In rice production, direct sowing methods are vigorous. A lot of kind method are studying. Studies have been developing, and which are management of irrigation water in the paddy field.

In machine weeding which maintain environment, a study of auto small weeding robot controlling early growth of paddy field grass has started. A study of implement type burner weeding machine has started.

In vegetable production, many planters and harvesting machines has been developing. A technology of image handling and harvest hand in order to robotize working has been developing.

In fruits production, machines working in slope, fertilizer distributor, pest control machine and carrier studies have been developing. And non-destructive evaluation for fruits machines studies are developing.

In stock rising, seed-cube press machine and distributing machine and system supporting design for animal house have been developing. Management of each livestock, slurry disposal technology for environmental problem have been developing. ■■

Activities of the Tohoku National Agricultural Experiment Station

by
Yukio Yaji
Team Leader, Research Project Team 1
Department of Integrated Research for Agriculture
Tohoku National Agricultural Experiment Station
Akahira 4, Morioka, Iwate 020-0123, Japan

A Shot of History

The Tohoku National Agricultural Experiment Station (TNAES) was established in 1950 at the present address, Akahira, Shimokuriyagawa, Morioka, Iwate as one of the regional agricultural experiment stations that belong to the Ministry of Agriculture, Forestry and Fisheries (MAFF). The station incorporated the Tohoku Branch of Sericultural Experiment Station in 1983 and was reorganized in 1988. The station comprises the Department of Research Planning and Coordination, Department of General Administration and seven Research Departments with 36 laboratories, including 5 Research Project Teams.

Background and Research Activities

The Tohoku district is located in the North-eastern part of Japan, showing a rectangular shape, some 200 km from East to West and 500 km from North to South. It consists of 6 prefectures; Aomori, Iwate, Akita, Miyagi, Yamagata and Fukushima (**Fig. 1**). By mountain ranges lying from North to South in the middle of the district, it is mostly divided into two characteristic regions. One is the Eastern region which is sometimes attacked by cool and humid North-eastern wind named "YAMASE" in early summer and causes cold damage of summer crops: rice, soybean and vegetables. The other is the Western region which has deep snow pile brought by North-western wind in winter, is famous for good production of tasty rice varieties depend on high temperature and plentiful flow of irrigation water in summer. These characteristics affect the development of its agriculture.

The Tohoku district belongs to the high yielding area of the major crops: rice, soybean, wheat and corn from global standards. Also in Japan, the Tohoku district is considered as the main granary of food supply. But the agriculture of this district is confronted with several problems, reduced numbers of farmers, rapid aging of farmers and the introduction of price competition of farm products by opening the market to foreign countries.

Based on the character of the Tohoku region representing North-eastern Japan and the changes in the agricultural situation, TNAES conducts research projects as follows:

1) Establishment of improved and stable farming systems in rice, upland crops and animal husbandry;
2) Mechanized rice production system in large-scale paddy fields;
3) Production of high quality upland crops which utilizes the climate properties of cool temperature area, and marketing;
4) Cattle production based on effective utilization of forage grass resources in hilly and mountainous cool area; and
5) Improvement of crop adaptabil-

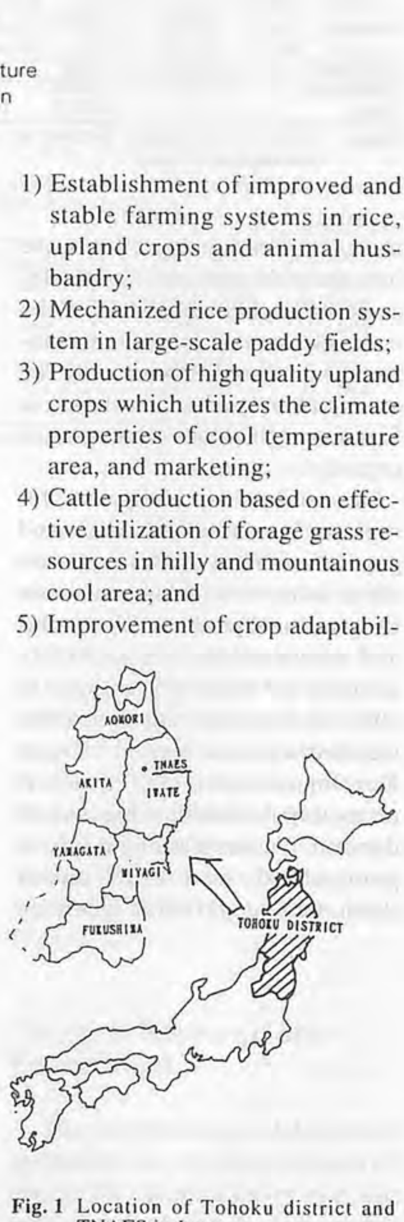


Fig. 1 Location of Tohoku district and TNAES in Japan.

ity under fluctuating climate and control of agricultural environment.

The Department of Integrated Research for Agriculture is carrying out collaborative researches concerning the establishment of integrated agricultural technology for progressive farming and active rural community in the Tohoku district. Five research project teams comprising natural and social scientists are presently responsible for developing: 1) large-scale production system by direct sowing of rice; 2) low-cost beaf cattle grazing system at grassland; 3) environmentally friendly technology for upland farming; 4) dynamic weather forecasting system for protecting crops from cool summer damage; 5) marketing system for vegetable produced in the hilly remote areas.

The Department of Biology and Environmental Sciences conducts interdisciplinary research activities to: 1) evaluate the Yamase phenomenon and the ecophysiological responses of crops and pests to cool and fluctuating weather; 2) minimize unfavorable climatic influences on crop production; and 3) utilize natural resources such as cool weather and snow in order to improve crop qualities and production.

The Department of Crop Breeding conducts research activities to develop varieties and germplasm lines of wheat, barley, soybean, rape and job's tear, with suitable processing traits, resistance to disease and insect pests and other environmental stresses. Improvement of breeding methods for upland crops by using plant biotechnology such as tissue and cell culture are conducted. Researches on quality and processing adaptability of crops are also in progress.

The Department of Lowland Farming conducts research activities to increase yield, improve quality and establish low cost paddy production systems. To achieve these objectives, research programs

Fig. 2 Super wide spreader for rice direct sowing of rice.

concerning rice breeding, physiological analysis of crop growth, amendment of soil fertility, cultural practices for weeds, diseases and pest control, mechanization, and labor-saving farming system are being carried out.

The Department of Upland Farming intends to establish new upland farming systems through synthesized research on cultivating and processing regional upland crops and vegetables with high quality and safe for human-beings and the environment.

The Department of Animal Production aims to establish highly efficient cattle production systems based on wide land for pasture and forage crops in the Tohoku district. The Department places particular emphasis on breeding and reproduction of beef cattle, ruminant nutrition and metabolism, and management of cattle pests.

The Department of Grassland is carrying out researches concerning the production and utilization of forage crops for cattle feeding. The main research programs are as follows: 1) breeding of new cultivars of forage; 2) establishment, management and utilization of grassland; 3) production of high yielding and high quality forages; and 4) processing, storage and evaluation of roughage.

The Department of Research Planning and Coordinations is responsible for research planning, coordination with prefectural institutes, collection and analysis of research information, publication and dissemination of research results, management of experimental fields and livestock to support research

Fig. 3 Precise land leveler using laser beam.

activities.

Current Research and Development Programs

Rice Direct Sowing Mechanization

In order to reduce the production cost of rice and eliminate troublesome handling work of nursery mats, a super wide spreader for rice direct sowing in wet land was developed. The spreader consists of a blower, a tank, a rotary valve and a swinging nozzle installed on a turntable. The spreader has a performance of spreading rice seeds into 50 m width. It can complete the sowing operation within 20 minutes for 2 ha. The mechanism of the spreader gives lower damage to the Karper (oxigen supplying powder) coated rice seeds, and it can also handle granular chemicals, herbicides, fertilizer, pesticides and insecticides (**Fig. 2**).

Precise Field Levelling Technique

For better germination of direct sowed rice seed and effective weed control by herbicides, precise field leveling technique was developed. A tractor-pulled laser leveling device can work efficiently for leveling operation at larger scaled paddy fields. This system consists of a transmitter, a receiver mast, a control box and some grading implements. The transmitter emits a thin 360 degree rotating laser beam of a constant height over the job site. The grader refers to the laser plane with the receiver mast and control the blade to keep constant level (**Fig. 3**).

Fig. 4 High-clearance seeder for Intercropping.

Fig. 5 Computer-controlled vehicle working between crop rows.

Wheat-Soybean Inter Cropping Mechanization

In order to materialize the soybean-wheat-soybean inter-cropping system, or 3 crops cultivation in 2 years in the northern Tohoku area, a high-clearance seeder for inter-cropping was developed. The seeder consists of high-clearance rotary cultivator, fertilizer and seeder. The seeder is mounted to a high-clearance tractor which provides dividers in front of the front tires. The slit cultivation makes germination of soybean and wheat more stable. The seeding efficiency is 20 a/h at 0.5 m/s forward speed (**Fig. 4**).

Micro-computer Controlled Vehicle Working Between Crop Rows

A small automatic running vehicle with laser-beam sensors, ultrasonic sensors, a terrestrial magnetism sensor and a micro-computer was developed. The skid steering system with 6 wheels driven by 2 DC motors was utilized. The vehicle travels along crop rows by sensing crop stems and turns automatically at the end of rows using sensors and a control system. Furthermore, a top-dressing unit and a head-topping unit were developed for sweet sorghum (**Fig. 5**).

Fig. 6 Automatic handling machine for heavy farm products.

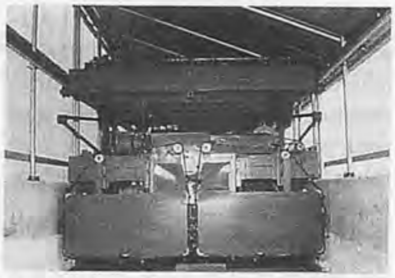


Fig. 7 Silage loading and unloading machine for bunker silos.

Automatic Handling Machine for Heavy Farm Products and Materials

Farmers often handle heavy fertilizer and products, for example Japanese radish and cabbage. A newly developed handling machine consists of a crawler tractor, a motor driven jointed arm with a gripper, a loading platform and a micro-computer which finds and grasps a container automatically using 2 CCD cameras. The machine collects a container filled with Japanese radishes in 47 seconds (**Fig. 6**).

Silage Loading and Unloading Machine for Bunker Silos

In order to establish precise and labor saving work system to handle ensilage, a prototype loading and unloading device for a small test bunker-silo was developed and its performance was investigated. The traveling device running on rails which are installed on the walls of a bunker-silo and the working device consisting of a vacket, compressing roller and a cutting device, that is suspended from the traveling device performed well. Using sensing parts, limit switches, a rotary endorder, motor inverters and developing a system control program, the loading and unloading device is controlled by a micro-computer. In the case of automatic working, the loading efficiency was 600 kg/h and the unloading efficiency was 440 kg/h (**Fig. 7**).

Fig. 8 Ejector-type spreading machine for inclined pasture.

Ejector-type Spreading Machine for Inclined Pasture

To establish a safety and labor-saving work system with spread macro-seed-pellets, an ejector-type wide area spreading machine with compression air was developed. The good point about this spreading machine is that the engine-compressor can be used as the supply source of compressed air. Moreover, it is a separately operating engine-compressor attached to the body of the spreading machine. This spreading machine can blow away macro-seed-pellets on a plot of land 40 m from the operation at an efficiency of 8.5 kg/m. Even as pellets are spread by this machine, macro-seed-pellets will not be destroyed, and few problems with seed germination will occur (**Fig. 8**).

International Collaboration in Farm Mechanization

The TNAES has carries out collaboration research works by accepting foreign trainees and sending researchers to developing countries through the Japan International Cooperation Agency (JICA) and Japan International Research Center for Agricultural Sciences (JIRCAS).■■

Japan's Technical Cooperation Focusing on Agriculture to Developing Countries

by
Haruhiko Murase
Professor
Lab. of Phytotronics and Sensibility Engineering
College of Agriculture, Osaka Prefecture University
1-1, Gakuen, Sakai 599-8531
Japan

Introduction

The world's population has swelled from 3.7 billion in 1970 to 5.8 billion in 1997. It has been projected that the world's population will reach 8 billion by the year 2025 according to the United Nation. The majority of this population increase will take place in developing countries. In these countries every effort must be made to better organize agricultural practices and increase the production of food. This must involve better methods for bringing water to the fields, improving crop breeds, and better cultivation methods. For many developing countries, agriculture is the basis of the national economy, and they must develop agriculture as well as the farming village communities that depend on the industry, to ensure their economies to grow and to achieve social stability as nations.

In 1996 Japan's ODA (Official Development Assistance) spending reached US$9.44 billion (excluding aid to Eastern Europe) even though it receded 34.9% from the year before. It was still kept at the highest level among major DAC (Development Assistance Committee) countries. The Japan's bilateral ODA total was about US$8 356 million in 1996. From that about US$3 180 million was allocated to technical cooperation. Some 12% of the total funding for the technical cooperation went to agricultural, forestry and fishery sectors.

Japan's cooperation in the area of agriculture was focused for some time on rice cultivation, drawing water on Japan's rice-growing-experience and technology, and has been directed at countries of East Asia with which Japan has had close ties. In recent years, however, the geographical scope of Japan's cooperation has widened, and at the same time, its content has changed its focus to sustainable agricultural development tailored to regional climates or agricultural development suitable for the stage of development in a region. The new types of aid introduced are increasingly diverse and advanced: 1) reducing food losses by improving post-harvest storage, processing, and distribution; 2) transferring advanced technology related to quarantine and disease prevention method in the import and export of agricultural products; 3) transferring technology for increasing added value in agricultural distribution and processing in certain developing countries that have reached relatively advanced stages of development; and 4) raising living standards in rural communities by increasing job opportunities and raising incomes, improving rural infrastructure (roads, electricity, water supplies, etc.), and providing better social infrastructure and services (sanitation, medical care, education, etc.).

JICA

JICA (Japan International Cooperation Agency) is a government organization responsible for providing technical cooperation to developing countries under Japan's Official Development Assistance (ODA). JICA conducts technical cooperation programs that include training in Japan, dispatch of experts, provision of equipment and

Acknowledgment: The author woud like to express his gratitude to Mr. Kenji Takamiya, Training Officer, Program Division, Osaka International Center, JICA for providing the author with JICA training program information.

material, project-type technical cooperation, and development study. Also it runs JOCV programs (Japanese Overseas Cooperation Volunteers). JOCV is a group of Japanese volunteers working with people in recipient countries to help improve the socio-economic situation in those countries. Other important activities of JICA are training and recruitment of qualified personnel for technical cooperation, survey and administration of grant aid programs, development cooperation, support for Japanese emigrants, and disaster relief.

JICA's technical cooperation in agriculture is striving to meet a wide range of requests from developing countries to promote agricultural production for providing a steady supply of food. JICA's technical cooperation covers a wide range from research and instruction on crop cultivation, to mechanization, biotechnologies, agricultural statistics, irrigation development, and integrated agricultural rural development.

Technical Cooperation

Technical cooperation is aid of which aim is to develop the human resources that lay the foundations of developing countries' efforts to build their nations. The objective is, by transferring Japan's technology and knowledge to counterparts to spread that technology widely in those developing countries and contribute to their economic and social development. Japan's technical cooperation through JICA extends over a side variety of fields, from BHN (Basic Human Needs), such as providing access to medical care and drinking water to high level cooperation in transferring computer technology and in drafting legislation and establishing state institutions. Some of important types of technical cooperation carried out by JICA are introduced in the following section.

Programs for Accepting Trainees

Accepting trainees from developing countries is one of the most basic types of technical cooperation. This training gives them specialized knowledge and technology in a wide variety of fields, ranging from public administration to agriculture, mining, manufacturing, energy, health, medical care, transportation, and telecommunication.

Expert Dispatch

Japan's program for sending individuals with expertise to developing countries where they carry out technical cooperation in a variety of fields, mainly as technical advisers in government organizations, is another type of the most basic types of technical cooperation, together with the trainee acceptance program.

Independent Equipment Supply Project

The independent equipment supply project is implemented with in the framework of technical cooperation. Through it, Japan supplies equipment needed by Japanese experts, JOCV team members, and Senior Overseas Volunteers in the process of technology transfer in their country of assignment or equipment needed by non Japanese trainees to disseminate the technology they acquired during their training in Japan following their return to their own country. Its purpose is to heighten the effect of technical cooperation through the communication of people and material.

JOCV

Japanese volunteers ranging in ages from 20 to 39 and having efficient command of language and expertise in technology are dispatched to the recipient country for usually a period of two years. They live with local people and transfer their technology through aid at the grassroots level. In agriculture, forestry and fisheries development cooperation, those JOCV volunteers help in a wide range of activities such as crop production, livestock rearing, organizing agricultural and fishing cooperatives, and promoting community development.

Project Type Technical Cooperation

Technical cooperation that is implemented on a planned basis over a period of several years (usually five years) and as a combination in one project of the three basic types of technical cooperation, namely accepting trainees, dispatch of experts, and provision of equipment and machinery, is called project-type technical cooperation. In recent years, there have been many cases of linkage of this type with grant aid, in which Japanese grant aid is used to fund the construction of facilities that are then used as the base for carrying out project-type technical cooperation. Project-type technical cooperation is presently being carried out in cooperation projects directed at not only agriculture but also social development, health and medical care, population control and family planning, and industrial development.

Focusing on Agricultural Mechanization in Developing Countries

The growth of agricultural productivity in developing countries must be a key item in improving world food situation. Agricultural mechanization is a vital step in raising productivity as well as releasing farmers from hard labor. There are many Japan's ODA programs which have been directed at agricultural mechanization in developing countries. In this section, some of ongoing training programs designed for providing trainees with knowledge and skills useful for agricultural mechanization and horticultural engineering are introduced.

Farm Machinery Design

The purpose of the course is to introduce scientific knowledge and techniques on designing, trial making and performance test of farm machinery, mainly for crop production, which is adoptable to the trainees' country conditions. In the training course, the emphasis is put on the actual designing and trail making of farm machinery and performance test of trial-made machinery. The main themes are: (1) mechanism and performance of farm machinery and farm energy such as windmill and solar-dryer; (2) designing methodology, trial-making process and testing methodology of trial-made farm machinery; (3) accurate and safety utilization method of measuring instruments, tools and applicable utilization of personal-computer; (4) analyzing and processing methodology of metallic and other materials concerned of manufacturing farm machinery; (5) report making and presentation for symposium; (6) study tour to university research institutes and farm machinery manufacturing companies; and (7) Japanese farm house and manufacturing factory practice.

Agricultural Machinery Management

This training course is designed for leading agricultural engineers in the field of agricultural machinery management, as an opportunity to acquire the following knowledge and skill: (1) better understanding of agricultural machinery performance; (2) selection of agricultural machinery appropriate to the operation area, soil quality and variety of crops; (3) improvement of managerial ability, i.e., cost analysis, etc; (4) practical knowledge on agricultural machinery maintenance and repair; and (5) ability to instruct others in workshop management (Notice: the agricultural machinery in this course is especially for rice cultivation). In this course, the emphasis is put on the workshop practice and lectures at agricultural machinery companies. The main themes are: (1) principal agricultural machinery (a) fundamentals of mechanical engineering (b) principles and structure of agricultural components (c) disassembling, reassembling and maintenance (d) field operation; and (2) agricultural machinery management (a) farm mechanization planning, machine selection, cost analysis, mechanized farming system, working management, etc.

Farm Machinery Testing

The purpose of this course is to systematically introduce the knowledge and techniques required for the testing and evaluation of agricultural machinery. In this course, the emphasis is placed on the actual testing and evaluating methodology of agricultural machinery. The actual testing practices are conducted under the authorized testing code. The main theses are: (1) testing and evaluation of agricultural machines to determine the performance characteristics, rate of work, durability, safety, ease of operation; (2) testing and evaluation method in laboratory and field; (3) accurate utilization of testing and measuring instruments; (4) data acquisition, data processing and data analyzing by micro-computer; (5) agricultural machinery testing system and administration; (6) agricultural mechanization features; and (7) study tour to university, research institutes and farm machinery manufacturing companies.

Through the training program, participants are expected: (1) to acquire an understanding of the mechanics and theory of agricultural machinery and to learn to; (2) maintain agricultural machinery; (3) develop comprehensive management and control schemes, including selection of appropriate machinery and cost analysis; (4) utilize micro-computers for management and control of machinery; and (5) mange workshop.

Post-harvest Rice Production

The purpose of the course is to contribute to the planning, guidance and extension of technical improvement in this field in the government and public organizations of each country. It also aims to contribute to the improvement in effective processing technology and to prevent quantitative and qualitative losses by giving participants the knowledge and information on post-harvest rice processing in Japan, namely harvesting, drying, husking, grading, inspection, storage, milling, utilization of by-products, etc. The following major subjects are covered in the course: (1) rice production and marketing; (2) characteristics of rice (indica and japonica subspecies); (3) harvesting, threshing and drying-machinery operation; (4) storage-facility control and management; (5) milling-machinery/equipment operation; (6) quality control and inspection-system and testing equipment; and (7) utilization of by-products (husks, bran and brokens).

Automation of Agricultural Machinery

The purpose of the course is to provide agricultural engineers with an understanding of the principles and mechanism of farm machinery to be able to develop, improve and repair farm machinery in their respective countries. Moreover, participants will acquire knowledge of fundamental technology for the agri-mation of farm machinery, which will aid computer assisted research and development of agricultural machinery. This course mainly covers the following themes: (1) farm machinery theory and practice; (2) training in agri-mation based on an understanding of the improvements necessary in farming; (3) computer programming (C-language); and (4) training in relay control, programmable control, microcomputer (Z80) use, sensor use, pneumatic control, etc.

Horticulture in Protected Environment

This course provides knowledge and information on plant production in protected environments, such as computer controlled greenhouses, in order to increase the production of specific cash crops in participating countries. The course introduces simple facilities and proper techniques which now draw much attention. This course is designed to aid in integrated technology transfer to create a foundation for planning the introduction of and evaluation the suitability and cost performance of new technologies for adjustment and control of plant environments in developing countries. The purpose of the course is to impart to participants an understanding of how plant productivity is altered by adjusting and controlling the production environment and to provide them with the basic environmental adjustment and control technologies which allow plant production to be matched to varying conditions such as resources, climate, crop types and production scales. Attention will also be given to acquisition of analytical, planning, management, and guidance capabilities for the introduction of these new technologies.

Through the training program, participants are expected to learn: (1) Effect of adjustment and control of the plant production environment; (2) Basic technology required for cultivation in plastic houses and mulches; (3) diversified assessment and planning capability for the introduction of new technologies; (4) technical knowledge of solar power generation as a simple source of energy; (5) use of computers for planning and environmental measurement/control; and (6) environmental factor measurement.

Fig. 1 Trainees are enjoying constructing a plastic house. It is one of important practice program in this training course conducted at Osaka Prefecture University.

Training institutions for this course are Osaka International Center JICA and Department of Regional Environmental Science jointly with Department of Applied Plant Science, College of Agriculture, Osaka Prefecture University. The training program has been mainly implemented by BICS Engineering Laboratory headed by Prof. Nobuo Honami since 1995.

Strengthening Technical Cooperation for Future

To assist developing countries in carrying out their own self-help efforts and to carefully tailor aid to their needs through adequate alignment of Japan's views with those of the developing countries, technical cooperation by the Japanese play a major role as a form of contribution with a human face. It is important to strengthen technical cooperation in Japanese aid. This is because, as Japanese aid comes to shift its center of gravity increasingly toward social development and environmental protection in developing countries, with its basic thrust focused on people-centered development, cooperation in less tangible and less easily measurable areas relying on technical cooperation, such as institution building and human resource development, will become increasingly important.

REFERENCES

1. Anonymous; 1998. Japan's Official Development Assistance Annual Report 1997, Ed. by Ministry of Foreign Affairs, Assoc. Promotion of It. Cooperation (ASPIC), Tokyo, Japan, pp. 416.
2. Anonymous; 1997. Agriculture, Forestry and Fisheries Development Cooperation, JICA, Tokyo, Japan, pp. 18.
3. Anonymous; 1998. Information on Specially Offered Training Course, Horticulture in Protected Environment JFY 1998, OSIC, JICA, pp.6.

■■

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 101-0054, Japan

ADVERTISED PRODUCTS INQUIRY

Product	Advertiser	Vol., No., Page

EDITORIAL REQUEST TO AMA

Your Name :

Address :

Occupation :

SUBSCRIPTION/ORDER FORM

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

Issued Quarterly

Subscription Rate (includes surface mail postage)

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

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

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

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

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

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

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

(check one)

□ Please invoice me/us

□ I/We enclose remittance for ¥ ________

****

Name: ________________________

Firm: ________________________

Position: ________________________

Address: ________________________

(block letters)

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7, 2-chome, Kanda Nishikicho, Chiyoda-ku,

Tokyo 101-0054, Japan

Tel. (03)−3291−3671~4, 5718

STAMP

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

TOKYO 101-0054, JAPAN

1st FOLD HERE

2nd FOLD HERE

Introduction to the Laboratory of the Agricultural and Forestry Systems Engineering, Shimane University

by
Staff of the Agricultural and
Forestry Systems Engineering
Department of Regional Development
Faculty of Life and Environmental Science
Shimane University
Matsue City, Shimane Prefecture, 690-8504
Japan

The Shimane University at Glance

The Shimane University is located in Matsue City, Shimane Prefecture. Matsue City, with a population of more than 145 000, lies some 800 km to the west of Tokyo, from where it can be reached in one and a half hours by plane. It is a beautiful city, well known from ancient times as the "town of water," with the large lakes of "Nakaumi" and "Shinjiko", respectively, on the eastern and the western borders of the city. This region, which is traditionally called the "Province of Izumo," was one of the most prosperous cultural centers in ancient Japan with its local government having been established in Matsue as far back as the sixth century.

The Shimane University was founded in 1949 as a national university with two faculties: the Faculty of Literature and Science which was made up of Matsue Higher School (originally founded in 1920), and the Faculty of Education which was made up of Shimane General School (originally founded in 1875), Shimane General School for Youth (originally founded in 1933).

Currently, it consists of four faculties (Law and Literature, Education, Interdisciplinary Faculty of Science and Engineering, Life and Environmental Science), one doctorate graduate school, four graduate schools (Law, Education, Science, and Agriculture), postgraduate courses in Literature and several other research centers and facilities. The main campus of Shimane University covers an area of some 200 000 m^2 and has about 660 faculty members and staff, and some 5 000 students.

The education at undergraduate level is given in two major disciplines: liberal education and professional education; and the graduate education is given at the Graduate School of Law, Science, Agriculture and Education. The university confers the following degrees:

Faculty of Law and Literature
- Department of Law — LL. B
- Department of Social Systems — B. Soc. Sc.
- Department of Language and Culture — B.A.

Faculty of Education — B. Ed.
Interdisciplinary Faculty of Science and Engineering — B. Sc. Engg.
Faculty of Life and Environmental Science — B. Life Env. Sc.
Graduate School of Law — LL. M.
Graduate School of Education — M. Ed.
Graduate School of Science — M. Sc.
Graduate School of Agriculture — M. Agr.
United Graduate School of Agricultural Science, Tottori Univ. — D. Agr.

The Faculty of Life and Environmental Science

The Faculty of Life and Environmental Science was established in October 1995 comprising the Department of Agro-forest Biology (Agronomy and Horticulture, Forestry and Environment, Environmental Biology), Regional Development (Rural Management, Agricultural and Forestry Systems Design, Rural Engineering), and Natural Resource Science (Bioresource Chemistry Science, Applied Biological Science) in the Faculty of Agriculture and the Department of Biology in the Faculty of Science.

The Faculty started with five Departments (**Fig. 1**): Biological

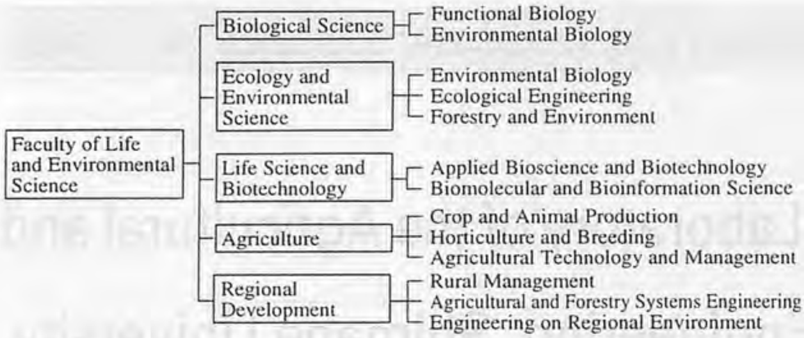


Fig. 1 Department and laboratories in the Faculty of Life and Environmental Science.

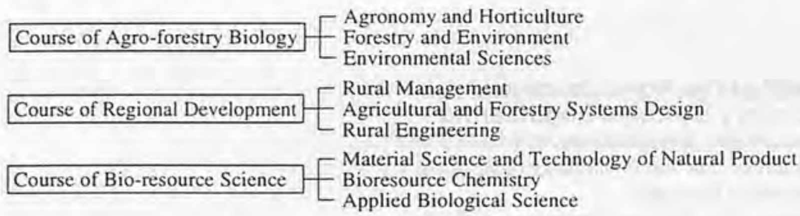


Fig. 2 Courses at the Graduate School of Agriculture.

Science, Ecology and Environmental Science, Life Science, Agriculture and Regional Development, and three Institutes attached to the Faculty (Marine Biological Station, University Farms, and University Forests).

The Graduate School of Agriculture

In 1971 Shimane University founded the Graduate School of Agriculture consisting of the following six courses: Agriculture, Forestry, Agricultural and Forest Economics, Agricultural Chemistry, Agricultural Engineering and Environmental Sciences. Upon the reorganization of the Faculty of Agriculture from six Departments to three Departments, the Graduate School of Agriculture was reorganized into three courses of Agro-Forest Biology, Regional Development and Bioresource Science in 1993. These graduate courses have the same academic calendars and systems as the counterpart of undergraduate departments.

Upon entrance, graduate students choose a seminar and carry on their individual studies under the professor in charge of the seminar of their choice.

With two years of residence at the Graduate School of Agriculture, the required units taken, an approved dissertation, and an examination passed, the graduate students are awarded a Master's degree. The courses of the Graduate School of Agriculture are shown in **Fig. 2**.

The United Graduate School of Agricultural Sciences

The United Graduate School of Agricultural Sciences is managed in cooperation the Tottori University, Shimane University and Yamaguchi University. The aim of the United Graduate School is to train researchers with advanced technical ability and to give a deep knowledge of biological production and environment, or development and conservation of natural resources and bioscience in order to contribute to development of these fields of science and related industry. The United Graduate School accepts many foreign students from many nations, especially from the developing countries.

The United Graduate School aims to let students acquire a profound knowledge of their speciality during a three-year doctoral course and aims at producing not only university instructors but also researchers who can contribute to the development of sciences in agriculture, biological resources and environmental conservation in public and private research institutions or enterprises.

The following qualifications are required for the application to the United Graduate School.

(1) Those who holds a Master's Degree;
(2) Those who have been awarded a Master's Degree from a foreign university; and
(3) Those who can show that their scholastic ability is equal to or higher than those who have a Master's Degree.

Laboratory of Agricultural and Forestry Systems Engineering

The Department of Regional Development consists of three laboratories; Rural Management, Agricultural and Forestry Systems Engineering and Engineering on Regional Development.

Education and research on agricultural machinery are performed by the Laboratory of Agricultural and Forestry Systems Engineering. This laboratory was established in 1995 by the restructure of the faculty. Before that, the section of agricultural machinery belonged to the Laboratory of Agricultural and Forestry Systems Design. The undergraduate program has already been reformed to adapt to the new system. The graduate program (Master course) will also be reformed in 2000. However, it now performs under the old organization of the Laboratory to which the staff of agricultural machinery partially belongs. The doctoral students study under the organization of the United Graduate School of Agricultural Sciences of the Tottori University.

This Laboratory of Agricultural and Forestry Systems Engineering fuses the agricultural machinery with information on science in order to solve many problems in agriculture and forestry by applying high technologies. It pursues the study of the theory and technology of agricultural machinery and cultivation control system computer. The present research program has two main aspects: (1) development and automation of agricultural machinery; and (2) systematic control of heat, water air, light, etc., in plant environment. The studies are published in the Journal of the Japanese Society of Agricultural Machinery, Kansai Branch Report of the Japanese Society of Agricultural Machinery, Journal of the Japanese Society of Agricultural Technology Management and the Journal of the Drainage and Reclamation Engineering.

The undergraduate programs of this laboratory offer students broad education on agricultural machinery and information science (**Table 1**).

The graduate program, leading to the degree of Master of Agriculture, offers advanced courses in both engineering and socio-economics fields of agricultural and forestry systems design and seminar on current topics in each field. The program is done in cooperation with the staff of the Laboratory of Rural Management. To complete a research thesis for the degree, the student may use many new facilities that include the image processor, robot, oscillograph, gas analyzer, spectroscopic analyzer and specialized apparatus in engineering field, and lively discussions with his/her professor on his/her research theme. **Table 2** shows the graduate program related to agricultural engineering.

The doctoral students of the engineering field belong to the United Laboratory of Production Environment Engineering of Tottori University. This laboratory is organized by the researchers of agricultural engineering in three universities; Tottori, Shimane and Yamaguchi Universities. It consists of two fields, agricultural engineering technique and agricultural machinery technique. The former focuses on water utilization planning, irrigation, design and construction of drainage facili-

Table 1. Undergraduate Subjects

Course	Brief Description
Farm Machinery I, II	Theory and utilization of farm machinery
Design of Machine	Design of machine elements; bolt, spring, shaft, gear, etc., and design of machine system
Control Engineering	Principles of mechanical and electrical control engineering
Computer Aided Machine Design	Principle of graphic design of machine
Laboratory Works in Agricultural Systems Control	Introduction to experimental methods in post-harvest
Laboratory Works in Farm Machinery	Experiment on mechanical dynamics, electronic circuit and computer-controlled system for robotics
Mechanical Dynamics	Theories of mechanical dynamics for robotics and biomechanics
Measuring Systems Engineering I, II	Theories, devices and systems for measurement concerning to the experiment and robotics
Electrical Engineering	Principles of electrical engineering
Electronic Engineering	Principles of electronic engineering
Strength of Materials	Mechanical properties of industrial materials
Products Quality Control Engineering	Engineering principles of agricultural products quality
Fluid Dynamics	Fundamental characteristics of perfect and viscous fluids
Information Engineering	Fundamental theory of data processing and exercise of computer programming

Table 2. Graduate Program (Engineering Field)

Master Course: Graduate School of Agriculture, Shimane University
Laboratory of Agricultural and Forestry Systems Design
Duration .... 2 years
Degree Title .... Master of Agriculture
Necessity for the degree .... 30 credits + Master thesis.
Subjects (credit)
- Advanced Measurement and Control Systems Engineering I (2)
- Advanced Measurement and Control Systems Engineering II (2)
- Advanced Farm Machinery I (2)
- Advanced Farm Machinery II (2)
- Advanced Agromaterial Systems Engineering I (2)
- Advanced Agromaterial Systems Engineering II (2)
- Advanced Cultivation Systems Engineering I (2)
- Advanced Cultivation Systems Engineering II (2)
- Advanced Water Management Systems Engineering I (2)
- Advanced Water Management Systems Engineering II (2)
- Advanced Water Use Environment Systems Engineering I (2)
- Advanced Water Use Environment Systems Engineering II (2)
- Seminar in Agricultural Information Processing (2)
- Seminar in Application of Information Processing (2)
- Special Lecture on Agricultural and Forestry Systems Engineering B (2)
- Laboratory Course in Agricultural and Forestry Systems Design I (7)
- Laboratory Course in Agricultural and Forestry Systems Design II (7)

Ph.D. Course: The United Graduate School of Agriculture and Tottori University
United Laboratory of Production Environment Engineering
Duration .... 3 years
Degree Title .... Doctor of Agriculture
Requirement for the degree ... Attendance to joint seminar + Doctor thesis
Joint Seminar (Tottori, Shimane and Yamaguchi Universities) is held at the Daisen Public Boarding House. Attendance of least 60 hours is required.

Table 3. Distribution of Foreign Students in Our Laboratory (Present and past years)

Degree program	Number of students
Current students	
Doctor 3 (grade)	1
Doctor 2	2
Doctor 1	1
Master 2	0
Master 1	1
Past years' students	
1993 (year of finish)	1
1994	1
1995	1
1996	0
1997	2
1998	2

ties, and the arrangement of farmland. The latter focuses on development and utilization of agricultural power, agricultural machinery, agricultural process machinery as well as control engineering of the production environment. Advanced theory and techniques for the qualitative improvement of life, working and living environments are taught through engineering and mechanical techniques.

Since the United Graduate School of Agriculture was established, seven foreign students have finished the doctoral course program in the laboratory (Shimane University) and received their Ph. D. degrees. At the present time, five foreign students are studying under the graduate programs of the masteral and doctoral programs. **Table 3** shows the distribution of foreign students. Strong will and much efforts are required to perform the doctoral research and to obtain the Ph.D. degree.

Research Staff and Activities

The research staff and their field of specialization and publications (Laboratory of Agricultural and Forestry Systems Engineering) are as follows:

Farm Machinery Systems Engineering

Professor Seiji Nakao, D.Agr.

a) Side slip of agricultural tire
b) Farm implements in natural farming method
c) Farm working device of RC-helicopter

Publications

1. Fundamental Research on the Development of Four-Rotor Type RC-Helicopter. — Trial Production of Electrical Type and its Performance — Yao, J., S. Nakao, and M. Dohi, J of the Japanese Society of Agricultural Technology Management, 4(2): 41-46, 1997.
2. Fundamental Studies on Solid Manure Injector (III), — Injection Control System by Photoelectric Sensor — Nakao, S., T. Fujiura, Bulletin of the Faculty of Agriculture, Shimane University, No. 25: 67-70, 1991.
3. Fundamental Study on the Side Force of Agricultural Pneumatic Tire, Report of the Agricultural Engineering, Faculty of Agriculture, Shimane University, p.1-197, 1981.

Measurement and Control Systems Engineering

Professor Tateshi Fujiura, D.Agr.

a) 3-D vision sensor for agricultural robot
b) Cherry tomato harvesting robot
c) Selective harvesting robot for crisp head vegetables
d) Recognition of cucumber by 3-D image

Publications

1. Robotics for Bioproduction Systems. Fujiura, T., N. Kondo, M. Monta, H. Murase, T. Okamoto, F. Sevila, Y. Shirai and K.C. Ting, (Kondo, N., K.C. Ting eds.) ASAE, 1-325, 1998.
2. Manipulation of Agricultural Crop, Fujiura, T., J. of the Robotics Society of Japan, 16(2): 168-171, 1998.
3. 3-D Vision Sensor for Cherry Tomato Harvesting Robot. Subrata, I.D.M., T. Fujiura, S. Nakao, H. Yamada, M. Hida, T. Yukawa, Japan Agricultural Research Quarterly, 31(4): 257-264, 1997.

Water Management Systems Engineering

Professor Koichi Takeyama, D.Agr.

a) System analysis and management of wide scale water use
b) Rainwater utilization with solar energy for the sustainable environment
c) Establishment and management of network system on information of environment

Publications:

1. Studies on the Sustainable Rainwater Utilization Systems in Japan with Frontier Technologies, Takeyama K., M. Ide, I. Kita, T. Yoshida, A. Higuchi, G. Im, Proc. of International Symposium and 1st Chinese National Conference on Rainwater Utilization, p.168-173, Ranzhou, China, Sept. 1996.
2. The Sustainable System in Japan with Rainwater and Solar Energy, Takeyama K., M. Ide, I. Kita, T. Yoshida, A. Higuchi, Y. Fujimoto, Proc. of International symposium and 2nd Chinese National Conference on Rainwater Utilization, p. 298-303, Sept. Xuzhou, China, 1998.

Water Use Environment Systems Engineering

Associate Professor Ichiro Kita, D.Agr.

a) Water use planning for irrigation system
b) Analysis of complex water resource system
c) Effective method for direct utilization of rainwater
d) Analysis of water quality for utilization of rainwater as water resource

Publications:

1. Rainwater Utilization in Kien Giang Province in the Mekong Delta. Kita, I., I. Minami, K. Kunihiko, V.B. Tuyet, J. of International Rainwater Catchment Systems 2(1): p.4-12, 1997.
2. Study on Reservoirs Storage Regulation for Effective Water Utilization Using DDDP, Kita, I., Proceedings of the 8th International Conference on R.C.S. Vol. 1: p.366-373, 1998.
3. The Effect of Storage on Rainwater Quality. Proceedings of the 8th International Conference on R.C.S., Kitamura, K., I. Kita, I. Minami, Vol. 1: p.590-595, 1998.

Cultivation Systems Engineering

Associate Professor Makoto Dohi, D.Agr.

a) Automation system which uses the function of living things
b) Six-legged walking robot for agriculture
c) Genetic algorithm for selective transplanting robot
d) Complex system in agricultural production

Publications

1. Selection Transplanting Robot for Flower Seedling. Dohi, M., T. Fujiura, Proceedings of the 16th Annual Conference of the Robotics Society of Japan, Vol. 2: 743-744, 1998.
2. Recognition of Lettuce 3-D Image Using Genetic Algorithm. Dohi, M., T. Fujiura, H. Nishio, S. Chung, Proceedings of the 75th JSME Spring Annual Meeting, Vol. 4: 45-46, 1998.
3. Development of Six-Legged Walking Robot for Agriculture at Bumpy Land. Dohi, M., K. Kobayashi, T. Fujiura, Proceedings of ROBOMEC 98 of JSME, 1AV1-3, 1998.

Agromaterial Systems Engineering

Associate Professor Yutaka Kitamura, D.Agr.

a) Biogasification of food and agricultural byproduct
b) Development of high performance methane fermentors
c) Quality evaluation of food using Spectroscopy
d) UV sterilization systems for liquid food

Publications:

1. Liquefaction for Anaerobic Treatment of Soybean Meal, Kitamura, Y., A. Tagawa, S. Nakao, and C.L. Hansen, J. of the Society of Agricultural Structures, Japan, 29(2): 69-74, 1998.
2. Treatment of Strong Organic, Nitrogenous Wastewater by an Anaerobic Contact Process Incorporating Ultrafiltration, Kitamura, Y., T. Maekawa, A. Tagawa, H. Hayashi and K.L. Farrell-Poe, Applied Engineering in Agriculture, 12(6): 709-714, 1996.
3. Anaerobic Contact Treatment of Dairy Processing Wastewater with Low Organic Matter, Kitamura, Y., K. Suzuki, A. Tagawa and H. Hayashi, J. of Agricultural Science, Tokyo Nogyo Daigaku, 41(2): 103-107, 1996. ■■

Introduction to the Department of Bioenvironmental and Agricultural Engineering, Nihon University

by
Hiroshi Morishima
Professor
Department of Bioenvironmental and Agricultural Engineering
College of Bioresource Sciences,
Nihon University
1866 Kameino, Fujisawa, Kanagawa 252-8510, Japan

General Information of Nihon University

Nihon University has its beginnings in the Nihon Law School, founded at Iidamachi, Tokyo, on October 4, 1889, by the then Minister of Justice, Akiyoshi Yamada. Underlying the school's founding was the desire to introduce Western culture in a manner compatible with the traditional spirit of Japan, in order to achieve cultural development and national prosperity. In 1903 its name was changed to Nihon University, marking the beginning of a period of steady growth.

Nihon University is the largest private university in Japan, with 15 graduate schools, 11 colleges, 3 schools and junior college. It owns approximately 30.76 million square meters of land, and its buildings have a total floor space of about 1.27 million square meters. More than 87 000 students are enrolled in its Graduate schools, Colleges and Junior college and the Corresponding division. It offers courses in all areas of the humanities, social sciences and natural sciences. The teaching and administrative staff members around 8 300. Its about 800 000 graduates play pivotal roles in their respective fields.

The special feature of Nihon University is that each of its colleges has its own campus, fully equipped with a library and all other requisite research and athletic facilities. Each college has its own faculty which provides students with meticulous instruction. Thus, all 14 colleges are fully able to function as independent colleges. Yet, at the same time, close cooperation between its colleges helps Nihon University to develop as a large university. One way of ensuring that this integrated system functions effectively is by vigorously promoting interdisciplinary research activities that transcend the confines of a particular college. For example, the "President's Grant for Specified Interdisciplinary Research" — research studies on themes chosen by the president of the university — are designed to break down the barriers between colleges and to conduct scholarly research that could only be carried on in a large university. Joint research for these projects is done primarily at the University Research Center.

In its efforts to open its doors to the world, Nihon University has signed academic exchange agreements with 38 universities and institutions in 14 nations and one area. The university has actively responded to many request — not only from these universities but also from government agencies and research institutions — to conduct joint research projects or provide technical cooperation, and the scope of its activities is steadily widening.

General Information of the College of Bioresource Sciences

The college was founded as the College of Agriculture in 1943 and was renamed the College of Agriculture and Veterinary Medicine in 1952, and was renamed College of Bioresource Sciences in 1996. Now the college has 11 departments related to agriculture, and its academic structure consists of three pillars; Life Sciences, Resource Production Science and Environmental Science. In addition, engineering and social sciences play an important role in applying the research and technology in these fields for enterprises.

College of Bioresource Sciences consists of the following eleven departments; Plant Science and Resources, Agricultural and Biological Chemistry, Veterinary Medicine, Animal Science and Resources, Food Economics, Forest Science and Resources, Marine Science and Resources, Bioenvironmental and Agricultural Engineering, Food Science and Technology, International Development Studies and Applied Biological Science. Number of students enrolled in the college is 7 134.

The College has two campuses: one in Setagaya Ward in Tokyo; the other at Fujisawa City in Kanagawa Prefecture. Four departments — Agricultural and Biological Chemistry, Food Economics, Food Science and Technology and International Development Studies — are located on the Tokyo campus, and seven departments — Plant Science and Resources, Animal Science and Resources, Marine Science and Resources, Forest Science and Resources, Bioenvironmental and Agricultural Engineering, Applied Biological Science, Veterinary Medicine — are located at Fujisawa on the vast site of the Shonan Campus. In 1999, a new building for laboratories will be constructed, and until 2001, a new main building with 16 floors will be constructed. At that time, all departments will move to Shonan Campus, to meet with development for the 21st century.

Department of Bioenvironmental and Agricultural Engineering

The Department has founded as the Department of Agricultural Engineering in 1962, and was renamed the Department of Bioenvironmental and Agricultural Engineering in 1992.

In a farm area there normally is widespread farmland such as paddy fields and upland fields for food production, as well as mountains and villages as places for living. Farm land can be upgraded to have improved productivity and partitioned to work agricultural machinery effectively. Roads and canals run through the sides of partitions. Some districts have their own cattle hours, vinyle houses, storages, packing-houses and country elevators. A rural community needs modern facilities similar to those of the city. Agricultural engineering has to deal with both life planning and production planning for an entire rural community at once. For example, emphasis may be put on improving fields for high productivity and work efficiency, making better use of agricultural machinery, and improving the use of water. Other subjects covered in the course are: treatment and processing of products to increase their value, maintenance of the rural community and its agricultural facilities, and preservation of the environment of the district. Six hundred and twenty two undergraduate students enrolled in the Department of Bioenvironmental and Agricultural Engineering. Masters and Doctorate programs are offered for students who wish to further investigate and contribute to the field of Agricultural Engineering.

Laboratories composing the Department of Bioenvironmental and Agricultural Engineering

There are nine laboratories in the Department of Bioenvironmental and Agricultural Engineering. Four of them, laboratory of Farm Buildings, of Bio-Production System, of Agricultural Process Engineering and Postharvest Technology and of Bio-Environment System Engineering, are laboratories closely related to agricultural machineries and mechanization.

Students can choose two courses, one Bio-Environmental Planning, and another Bio-Production. Those who choose Bio-Environmental Planning course have to select several lectures, drawings, practices and experiments, related to surveying to get a quarification of the Registered Surveyor/ or that of the Assistant Registered Surveyor. Students who wish to get a qualification of candidacy for examination of KENCHIKUSHI, a general concept in which a person plays the real roll of an registered architect and a building engineer in Japan, have to take appointed 49 credits related to architecture including lectures, drawings, experiments. In the Department, any students can choose Bio-Environmental course and also can take appointed credits related to architecture notwithstanding his or her belonging laboratories. Our's is the only one agricultural engineering related department, from which graduated students will be given the qualification of candidacy for examination of KENCHIKUSHI, especially for the first class examination according to his or her practical experience after graduation.

The followings are the brief introduction of nine laboratories[5], including the names of staffs, and current research subjects.

1. Laboratory of Farm Environment and Consolidation Engineering

Professor (of General Research Institute): Masami SHIRAIWA

Research subject: Comparative study on rainfall patterns in California and in Japan

Assistant Professor: Kozo SAITO

Research subject: Environment survey by remote sensing

2. Laboratory of Water Resource Utilization Engineering

Professor: Toshisuke MARUYAMA D. Agr.

Research subject: Environment prevention of farmland

Associate Professor: Shigeo ISHIKAWA Ph.D.

Research subject: Water quality Environment

3. Laboratory of Agricultural Structures Engineering for Environment

Professor: Takayasu YAMANO D.Agr.
Research subject: Deformation of earth structures such as dam and road
Associate Professor: Atsushi TSUJI
Research subject: Engineering properties of liquified soil stabilization
Assistant Professor: Masao AOKI MS
Research subject: Agricultural and engineering research on acid soil

4. Laboratory of Regional Environment Conservation

Professor: Hideo KONO D.Agr.
Research subject: Preservation of marshland

5. Laboratory of Farm Buildings

Professor (of General Research Institute): Morimasa NAGASHIMA
Research subject: Odors of animal husbandry
Associate Professor: Hirofumi KAWANISHI Ph.D
Research subject: Mass transfer coefficient on the body surface of livestock

6. Laboratory of Bioregional and Archtectural Planning

Professor: Masami OKAMOTO D.Agr.
Research subject: Regional water usage system
Associate Professor: Kouji ITONAGA D.Eng.
Research subject: Pharmaculture and ecological planning of rural community

7. Laboratory of Bio-Production System Engineering

Professor: Yoshihiro SERATA Ph.D. (Agr.)
Research subject: Hybrid type wind turbine
Assistant Professor: Yoshio MIYAMOTO D.Agr.
Research subject: Transferred characteristics of fruit for shock and random vibration
Research Associate: Manzo UCHIGASAKI MS
Research subject: Automatic vegetable transplanting system

8. Laboratory of Agricultural Process Engineering and Postharvest Technology

Professor: Hiroshi MORISHIMA D.Agr.
Research subject: Mechanism causing damaged grain during storage
Assistant Professor: Setuo TODA
Research subject: Characteristics of biomass fuel under an electric field

9. Laboratory of Bio-Environmental System Engineering

Professor: Osamu KITANI D.Agr., Ph.D. The President of CIGR (1997-1998)
Research subject: Agricultural machinery engineering especially in relation to energy and environment

Graduate School

There are two Graduate Schools, Graduate School of Agriculture and Graduate School of Veterinary Medicine.

Graduate School of Agriculture

The Graduate School offers both master's and doctoral courses in nine fields; Agriculture, Agricultural Chemistry, Animal Science, Agricultural Economics, Fisheries, Agricultural Engineering, Food Technology, Forest Science and Applied Biological Science. Number of students enrolled is 133 in Master's courses, and 24 in doctoral courses.

Graduate School of Veterinary Medicine

The Graduate School offers a doctoral course, Veterinary Medicine. Number of students enrolled is 7.

Those two Graduate Schools, including the Graduate course of Agricultural Engineering, are now preparing the reconstruction based on the three pillars shown in the general concept of the College of Bioresource Sciences, in order to promote the academic activity for new era, the 21st century.

Graduate Program in Agricultural Engineering

Master's course in Agricultural Engineering opened in 1975, and Doctoral course in Agricultural Engineering in 1992. Number of students enrolled in Master's course is 9, and Doctoral course 6. Number of foreign students in Master's course is one, and Doctoral course two.

In order to preserve and improve productive and living environments, and to facilitate the securement and use of biotic resources, the graduate program in Agricultural Engineering conducts education and research in the following four sections for the time being:

1. Rural planning: developing the multifaceted uses of rural communities, including environmental, productive, and community functions, and establishing comprehensive rural community planning methods ranging from master planning to detailed, end-use planning.
2. Regional consolidation engineering: viewing farmland and surrounding areas as places that support agricultural production and human life, and investigating, on an engineering and technical basis, ways of enhancing their productive functions, as well as preserving and nurturing the natural environment.
3. Irrigation and drainage engineering: promoting efficient water use by designing comprehensive irrigation and drainage systems extending from water sources to end-use drainage canal, and investigating method to accommodate diversifying requirements for water as a resource, including securement and conservation of high-quality water in adequate amounts, and maintenance of water amenity.

4. Pre-harvest and post-harvest technology: improving production technology used on the open field in agricultural facilities and in distribution systems; developing energy-saving and efficient technical systems for all aspects of production, improving products with greater added values, as well.

The Regional Research Institute of Agriculture in the Pacific Basin (RRIAP)

The Regional Research Institute of Agriculture in the Pacific Basin (RRIAP) is an Research Institute belongs to the College of Bioresource Sciences, with the objectives of promoting the collaboration in agricultural sciences as well as close communication with researchers in Asian countries. As one of its activities, RRIAP has Researcher Exchange Program. In 1997, RRIAP accepted 5 researchers from Asian countries, and sent 3 researchers to those countries under the program.

For further Information

Home Page Address of the College of Bioresource Sciences: http://www.brs.nihon-u.ac.jp
FAX Service: +81-466-81-2450, Phone: +81-466-84-3800, Entrance Examination Office: +81-466-84-3812

REFERENCES

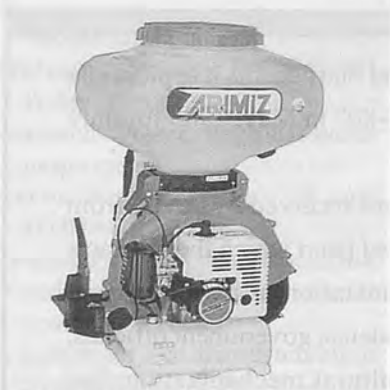
1. Nihon University Bulletin (1998)
2. Manual of the College of Bioresource Sciences (in Japanese) (1998)
3. Manual of the Graduate School of Agriculture and of the Graduate School of Veterinary Medicine (in Japanese) (1998)
4. Nihon University College of Bioresource Sciences 1999 Guidebook (in Japanese) (1998)
5. Self Evaluation Report 1997 (in Japanese)
Nihon University College of Bioresource Sciences, Graduate School of Agriculture, Graduate School of Veterinary Medicine, and Junior College at Shonan Campus (1998)
6. Annual Report of RRIAP 1997 College of Bioresource Sciences Nihon University (1998)

Main Products of Agricultural Machinery Manufacturers in Japan

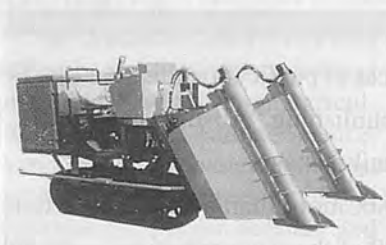
by
Shin-Norinsha Co., Ltd.
No. 7, 2-chome, Kanda Nishikicho
Chiyoda-ku, Tokyo 101-0054, Japan

Introduced here are the main products of agricultural machinery manufacturers in Japan with a number of photographs.

The products are developed and improved for both foreign and domestic markets. For further information please refer to the manufacturers contained in the directory.

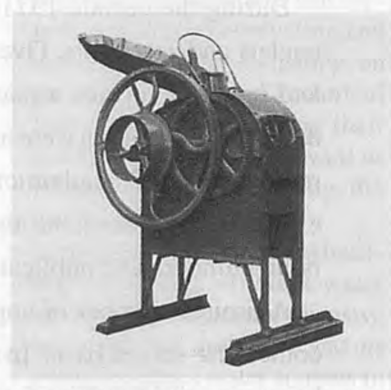


ARIMITSU Knapsack Power Duster Model SG-7030. Lightweight, compact design, but ensuring to produce bigger air volume due to high performance turbo fan to be driven by the powerful 60CC gasoline engine. Chemical tank can be quickly mounted or detached by means of the lock or release lever. Size (L x W x H): 360 x 520 x 740 mm, Weight: 10.5kg, Max. output: 3.7ps/7 500 rpm, Chemical tank capacity: 28ℓ, Air volume: 14.9 m^3/min, Max. static pressure: 900 mm AQ.



BUNMEI Sugarcane Harvester Riding Type TK-5. Crop deviders equipped both sides raise fallen cane and give sure harvesting.

DAISHIN Portable Generator SGB4000HX. Brushless generator; Non-fuse breaker; Quiet operation; AC Voltage: (50Hz); (60Hz) Max. Output: (50Hz) 3.6 kVA (60Hz) 4.5 kVA. Engine: Air-cooled, 4-cycle, gasoline 5.2 HP, 6.2 HP; Dry weight 65 kg.



CHIKUMA Corn Sheller Type 3. Removes kernels from corn-cobs by a short time. Capacity: 750-1, 125kg/h, Power r'd: 1-2 PS, R.P.M.: 300-500, Size in mm: 1,015H x 575W x 1,010L, Weight: Net 90kg Gross 130kg, Shipping meas.: 18 cft.

ISEKI TF325 Tractor. Mounted with powerful and economical 25PS water cooled diesel engine. The tractor offers wide range of travelling speeds from approximately 2 km/h to 22 km/h, which offers broad operating application and safe road travelling.

ISEKI SF300 Mower. The 28 hp diesel engine gives you the power you need to deal with all your mowing tasks quickly, while its efficient use of fuel makes it economical as well. Cutting width: 1524/1830 mm, Cutting height: 30-120mm.

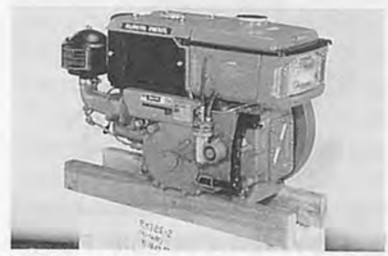
ISEKI Multi-purpose Tiller KV700D. Four-cycle/direct injection/ 6PS engine allows heavy-duty operation at low speeds with ample power in reserve. Light, Compact, Easy to use and high performance.

★ ★ ★

KIORITZ Battery-powered U.L.V. Sprayer (Shoulder type) ESD-5. A compact and lightweight battery-powered U.L.V. Sprayer providing easy portability combined with high performance. It is designed for use in environmental hygiene control such as malaria prevention, etc. in addition to general-purpose applications. Operates on six 1.5V batteries. A rechargeable battery pack can also be used.

KUBOTA Grand L Series Tractors. Built to handle a variety of agricultural applications, including field operations, heavy-duty front loader work. E-TVCS (Three Vortex Combustion System) Diesel Engine delivers more power and a high torque with cleaner emissions. In the GST (Glide Shift Transmission) models, the New GST features clutchless operation "shift-on-the-go" with faster response time and less power loss.

KUBOTA Combine Harvester SKY ROAD PRO 481. Easy-to operate, micro-computerized 4-line combine harvester that cuts down on time as well as crop. Equipped with many helpful mechanisms and a reliable water-cooled diesel engine. Max. output: 48PS/2700 rpm.



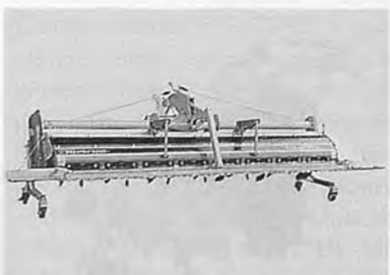
KUBOTA Diesel Engine RK 125. Based on Kubota's advanced engine technology, the horizontal, water-cooled and 4-cycle diesel engine can provide full-bore power with less fuel consumption, higher output, and quick and smooth starting. For power tillers, tractors, pumps, generators, welders and other farm and industrial used. Max. output: 12.5 HP/2400 rpm.

MAMETORA Vegetable Transplanter TP-4. This machine is available in both pot and soil block in seedling transplanting. Application: all vegetable nursery.

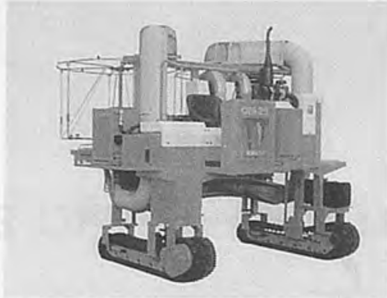
MAMETORA Power Cultivator SRV4F. Wide range use: cultivation to riding, Mounted with 7 PS engine.

MARUYAMA Portable Power Sprayers MSO55D. Engine: Air-cooled, 2-cycle, output 22.6cc, Pump: Suction capacity 5.1ℓ/mm, max pressure 25 kg/cm^2, Weight: 8.5 kg.

MINORU 4-Row Onion Transplanter OP-41. Used for potted mature seedling. Seedling box can be directly put on the transplanter. Saving the labor and total cost. Measurement (mm): L-2720, W-1095, H-1150. Weight: 355 kg (body only). Engine output (PS/rpm): 2.7/3,600; max. 3.5/ 4,000. Wheels: drum type x 2.



NIPLO Drive Harrow HR-2408B-3S for paddy field. Working width: 244 cm; Required tractor horsepower: 24~40 HP.

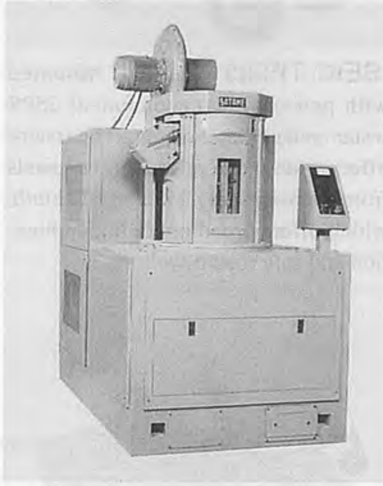


OCHIAI Riding Type Tea Picking Machine OM-25. Full working width cuter bar. Stepless speed control. Water-cooled Diesel engine 28.5PS.

OREC Power Cultivator AR700. Wide range use: Cultivation to riding. Mounted with 7 PS ~ 7.5 PS engine.

ROBIN Brush Cutter Model NBT415. 2 cylinder engine makes the operation easy and comfortable (low noise and vibration). Rotational speed of blade 4000-6000rpm.

SASAKI Fertilizer Spreader BF-300. The lever type action controls the amount of application with high accuracy. Application width: 10-12m. Hopper capacity: 300ℓ. Required tractor horsepower: 20-50PS.

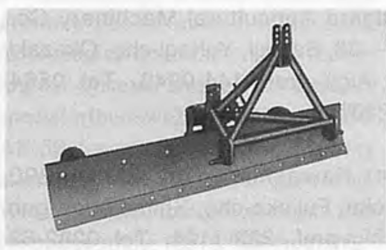


SATAKE New Rice Whiteness, Abrasive and Friction types, have high recovery, uniform & gentle milling, less installation space and high capacity. Model: VRM8A (Abrasive type) & VMA8A (Friction type) Capacity: 8 to 10 mt/h brown rice.

SATAKE Color Sorters with their quality optics and high-grade electronics allow the operator to make efficient separator on the basis of color. Model: GS40AG/AK/AP, GS60AG/AK/AP, GS80AG/AK/AP and CS500B. Major Application: Rice, wheat, coffee, corn, sunflower, beans, spices, etc.

SHIZUOKA's Single Kernel Moisture Tester CTR-800E for rough rice, brown rice, wheat and barley.

STAR Mini-Roll Baler MRB 0840. Automatic pick-up, rolling and ejection. One bale every 30 seconds. Handy bale size (50cm in diameter and 70cm long). Required tractor horsepower: 18-30 HP.



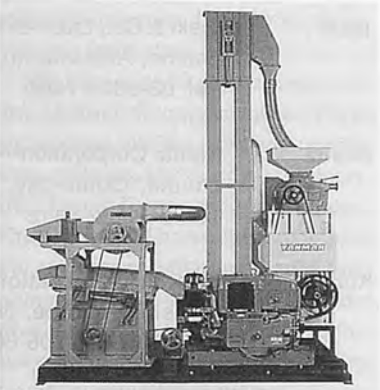
SUKIGARA Land Leveller Model TL-MB. A tractor is operated most effectively when the field has been uniformly levelled.

SUKIGARA Double Row Cultivator Model TBC. The row width can be controlled easily and quickly by adjusting each bolt at the left and right of tool bar.

TIGER KAWASHIMA Rice Combi and Grader. Rice grading machine and automatic weighting and packaging.

YAMAMOTO Rice Whitener Ricepal Series Model VP31T. High recovery rate. Immatured rice can be milled. No remaining rice in the machine. Easy-to-change milling screen. Durable construction. Milling system: vertical type single pass, Size (H x W x L): 850 x 330 x 450mm, Weight: 24kg, Power required: 0.3kW, Electric mains: single phase 100V (50/60Hz), Capacity: 30kg/h, Rpm: 1440/1730, Hopper holding capacity: 15kg, Safety device: Circuit protection.

YANMAR Diesel Tractor F-ex Series. 5 models: 21ps, 28ps, 32ps, 37ps, 42ps. Compact, quiet and vibration-reduced diesel engines are mounted at the heart of these F-ex series tractors. Engine: vertical, 4-cycle, water-cooled. Transmission: gear shifting. F8 x R8 or F9 x R9 Drive system. 4-wheel drive.



YANMAR New Mill Mate YMS-650U. Cleaner/destoner + Huller & Polisher + Engine. Input cap: 800kg/h, Engine 23ps. This machine is a complete direct-through rice mill consisting of a hulling section, winnower and polishing section. ■■

Arimitsu	Arimitsu Industrial Co., Ltd.—3-7, Fukae-kita 1-chome, Higashinari-ku, Osaka, 537-0001. Tel. 06-6973-2010
Bunmei	Bunmei Noki Co., Ltd.—11-4, 1-chome, Korimoto-cho, Kagoshima-city, 890-0065. Tel. 0992-54-5121
Chikuma	Chikumasuki Co., Ltd.—356 Koya, Yoshikawa, Matsumoto-city, Nagano-pref., 399-0031. Tel. 0263-58-2055
Daishin	Daishin Industries, Ltd.—23-1, 3-chome Yoyasu-cho, Ogaki-city, 503-0858. Tel. 0584-75-5011
Iseki	Iseki & Co., Ltd.—3-14, Nishi-Nippori, 5-chome, Arakawa-ku, Tokyo, 116-0013. Tel. 03-5604-7600
Kioritz	Kioritz Corporation—7-2, Suehirocho 1-chome, Oume-city, Tokyo, 198-0025. Tel. 0428-32-6118
Kubota	Kubota Corporation—2-47, Shikitsu-higashi 1-chome, Naniwa-ku, Osaka, 556-0012. Tel. 06-6648-2111
Mametora	Mametora Agric. Machinery Co., Ltd.—9-37, 2-chome, Nishi, Okegawa-city, Saitama-pref., 363-0017. Tel. 048-771-1181
Maruyama	Maruyama Mfg. Co., Inc.—4-15, 3-chome, Uchi-kanda, Chiyoda-ku, Tokyo, 101-0047. Tel. 03-3252-2271
Minoru	Minoru Industrial Co., Ltd.—447, Shimoichi, Sanyo-cho, Akaiwa-gun, Okayama-pref., 709-0816. Tel. 08695-5-1122
Niplo	Matsuyama Plow Mfg. Co., Ltd.—5155, Shiokawa, Maruko-machi, Chiisagata-gun, Nagano-pref., 386-0401. Tel. 0268-42-7500
Ochiai	Ochiai-Shoji Co., Ltd.—58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-pref., 439-0037. Tel. 0537-36-2161
OREC	Orec Co., Ltd.—548-22, Hiyoshi, Hirokawa-machi, Yame-gun, Fukuoka-pref., 834-0111. Tel. 0943-32-5002
Robin	Fuji Robin Industries Ltd.—35, Ohoka, Numazu-city, Shizuoka-pref., 410-0022. Tel. 0559-63-1111
Sasaki	Sasaki Corp. Ltd.—1-259, Satonosawa, Towada-city, Aomori-pref., 034-0000. Tel. 0176-22-3111
Satake	Satake Corp.—7-2, Soto-kanda 4-chome, Chiyoda-ku, Tokyo, 101-0021. Tel. 3253-3111
Shizuoka	Shizuoka Seiki Co., Ltd.—4-1, Yamana-cho, Fukuroi-city, Shizuoka-pref., 437-0042. Tel. 0538-42-3111
Star	Star Farm Machinery Mfg. Co., Ltd.—1061-2, Kamiosatsu, Chitose-city, Hokkaido, 066-0077. Tel. 0123-26-1122
Sukigara	Sukigara Agricultural Machinery Co., Ltd.—38, Sairinji, Yahagi-cho, Okazaki-city, Aichi-pref., 444-0943. Tel. 0564-31-2107
Tiger	Tiger Kawashima Co., Ltd.—4290, Fujioka, Fujioka-cho, Shimotsuga-gun, Tochigi-pref., 323-1104. Tel. 0282-62-3001
Yamamoto	Yamamoto Co., Ltd.—404, Oinomori, Tendo-city, Yamagata-pref., 994-0013. Tel. 0236-53-3411
Yanmar	Yanmar Agricultural Equipment Co., Ltd.—1-32, Chaya-machi, Kita-ku, Osaka-city, 530-0013. Tel. 06-6376-6336 ■■

1999 Agricultural Equipment Technology Conference — AETC '99

February 7-10, 1999
Louisville, Kentucky, U.S.A.

This Fourth Agricultural Equipment Technology Conference (AETC '99) is again being sponsored by the Power and Machinery Division of ASAE. AETC '99 will bring together engineers, managers, researchers, manufacturers and other professionals in the agricultural equipment industry to exchange information, discuss opportunities and address challenges facing our industry in the coming century.

AETC '99 will focus on machinery and machinery systems for agricultural production. Invited speakers will address issues such as precision farming, new equipment, benchmaking, manufacturing and international business growth.

Each year ASAE through the AE50 Award program, selects and honors companies that have developed new products for advancing engineering technologies in agricultural, food, biological systems and related areas. A special tribute will be paid to the 1998 AE-50 Award recipients on Tuesday afternoon with a reception following. We are pleased and proud to add this ceremony to the AETC '99 program.

The exhibit portion of the conference has moved to the Hyatt Hotel to insure high traffic and, in addition, has been extended to two days. All coffee breaks and the Tuesday evening AE-50 reception will be held on the exhibit floor. The poster session will also be in this general area. This will ensure that attendees have sufficient time to visit the exhibits and meet with company representatives. We feel confident that these logistical changes will assure a positive experience for all attendees.

For AETC '99 information contact:
Jim Hitch, Conference Chair
Case Corporation
545 35th Ave.
East Moline, IL 61244-3431, U.S.A.
Phone: 309-752-3949
Fax: 309-752-3814
E-mail: <jhitch@casecorp.com>
ASAE Meetings & Conferences
2950 Niles Road
St. Joseph, MI 49085-9659, U.S.A.
Phone: 616-429-0300
Fax: 616-429-3852
E-mail: <hq@hq@asae.org>

7th International Congress on Agricultural Mechanization and Energy — ICAME '99

May 26-27, 1999
Kurova University, Adana, Turkiye

The aims of the congress are to present the latest developments and future directions in agricultural mechanization and energy and to put all colleques together. In addition, you will have chance to see one of the important agricultural regions of Turkiye. Furthermore, in addition to going for technical excursions you will also have a chance to see the biggest agricultural project area you have ever seen in the world (namely Southerneast Anatolian Project), interesting touristic place of Cappadocia and Antakya.

Main Subjects of Congress
Power and Machinery
Farm Buildings
Soil and Water Use
Energy and Environment
Information and Electrical Technologies
Management and Ergonomic
Food and Process Engineering

Congress Secretariat:
Assoc. Prof. Vahit Kirisci
Phone: (90) (322) 338 65 17
Fax: (90) (322) 338 64 08
E-mail: vahitkr@cu.edu.tr

International Forestry Engineering Conference

June 28-30, 1999
Edinburgh, Scotland, U.K.

Forestry Engineering for Tomorrow - Forestry Engineering Group's (FEG) 1st International Conference - will focus on developments in engineering which represent the future of the forest industry.

We invite you to join us on June 28-30 1999 at Edinburgh University, Scotland where you can expand your personal horizons and learn from the innovators themselves.

We have over 60 papers from more than 15 major forestry countries. These are grouped into the main engineering areas of Roads, Harvesting, Machinery, GIS, Forest Engineering and Timber. The diversity of harvesting techniques and engineering will be celebrated from countries old and new. We will explore what the next century will bring as forestry is one of the fastest developing sectors of engineering today.

This will be your opportunity to meet a large and diverse group of professionals with a common interest in Forest Engineering. Meeting face to face and having the opportunity to discuss research programmes, trials, techniques and papers which will enhance the effectiveness of our entire industry and benefit the exchange of ideas.

Posters, demonstrating various techniques and innovative new ideas, will be on show on days 1 and 2.

Contact:
Geoff Freedman, Conference Convener
Forest Engineering for Tomorrow
Institution of Agricultural Engineers
West End Road, Silso, Bedford
MK45 4DU, United Kingdom.

☆ ★ ☆

International Workshop — Agricultural Transport

October 4-6, 1999
Giessen, Germany

A CIGR - EurAgEng workshop will be held in Giessen, Germany on 4-6 October 1999 to discuss relevant topics and recent developments in agricultural transport and provide a forum for the exchange of ideas and experiences between farmers, manufacturers and researchers.

In the same week following the date of this workshop. The International Cogress on Agricultural Engineering organized by VDI will be held in Braunschweig, Germany (7-8 October 1999). So participants intending to attend this conference have a good opportunity to fill up the week stopping in Giessen on their way to Braunschweig.

Topics of the Workshop

1. Technical developments and problems in handling and transport of agricultural goods
2. Agricultural transport management, electronics and GPS
3. Practical transport organization of farmers and agricultural enterprises
4. Legislation governing rural transport
5. Infrastructure

Secretariat

Dr. Guenther Weise
CIGR Workshop Agricultural Transport
Institut fuer Landtechnik, Justus Liebig Universitaet Giessen, Braugasse 7, D-35390 Giessen, Germany
Tel.: +49-641-99-37211
Fax: +49-641-99-37209
e-mail: cigr.workshop@agrar.uni-giessen.de

☆ ★ ☆

AIT 40th Year Anniversary Civil Environmental and Rural Engineering Conference — New Frontiers and Challenges

November 8-12, 1999
Bangkok, Thailand

The 40th Year Anniversary Event in 1999, in a sense, looks ahead for New Frontiers and Challenges. This is envisaged in the form of a truly international worldwide gathering of some of the finest academicians and practitioners in the area of Civil, Natural Resources and Environmental Engineering to convene at AIT and take part in an International Conference which consists of Keynote Addresses, Special Lectures and Original Research Presentations.

The major themes of the Conference are in the areas of Agricultural Aspects of Rural Engineering and Development; Water Engineering and Management; Environmental Technology and Engineering; Structural Engineering and Construction including Built Environment; Transportation Engineering and Infrastructure Management and Planning; Geotechnical and Geo-environmental Engineering. Aspects of Urban and Rural Environments with respect to Natural Resources Development and Natural Hazards and Disaster Preventions and Management are also considered as interdisciplinary fields.

Conference Themes and Topics

The main themes of the conference are:

1. Water Engineering and Management
2. Agricultural Aspects of Rural Engineering and Development
3. Environmental Technology and Engineering
4. Geotechnical and Geo-environmental Engineering
5. Structural Engineering and Construction
6. Transportation Engineering

AMA was selected as one of the world's most valuable journals to be included in TEEAL

The Essential Electronic Agricultural Library (TEEAL) is a stand-alone compact disk library which uses a standard microcomputer, compact disk reader, and laser printer. The software is easy to use.

The 130 journals were selected by citation analysis and are core literature for students, researchers, and educators in agriculture and related sciences. They are made available ONLY to developing countries through the generosity of publishers. Institutions in developing countries can now have the advantages of universities with large libraries. TEEAL is a major advance in access to agricultural literature. It is underwritten by the Rockefeller Foundation of the United States, which makes it possible to offer TEEAL for U.S. $10 000. This is 2.7 percent of the actual cost of subscription to the 130 journals for the four years (1993-96). An annual update will be available after the publication of the final issue of each calendar year. This will total 160 000 pages a year at a cost of U.S. $5 000. It will also provide a new index database covering all years. Publishers have generously waived copyright royalties to assist in advancing agricultural self-sufficiency in developing countries. TEEAL is not available to developed countries.

For further details:
TEEAL Project
Albert R. Mann Library
Cornell University
Ithaca, NY 14853-4301
U.S.A.

BOOK REVIEW

La motorisation dans les cultures tropicales

(France)

This manual is a guide for development agents, students, teachers and researchers in the field of tropical agriculture, and for all those who must advise users, lead meetings and make decisions on the choice and use of mechanization. It discusses the specific dimension of mechanisation used in tropical farming. It briefly goes over the technical characteristics of the equipment and emphasises the range of possible choices in terms of crop techniques and the interaction between mechanization and crop practices. Such choices depend on pedoclimatic and socio-economic conditions, on machine capacity, on the availability of techniques and on the sought after results. The main tropical crops are analyzed, with emphasis on teh restrictions involved in mechanization in each case.

351 pages, 6 x 9 inches, softbound.

Published by Centre de Coopération Internationale en Recherche Agronomique pour le Developpment Département Territoires, environnement et acteurs Cirad-tera.

BP5035, 73, rue J.-F. Breton, 34032 Montpellier, Cedex 1, France télé-phone: 04 67 61 57 50, télécopie: 04 67 61 12 23.

Les publications du Cirad—Catalogue général 1998-1999

(France)

128 pages, 6 x 8.4 inches, softbound.

Published by Centre de coopération internationale en recherche agronomique pour le développment Avenue Agropolis BP 5035, 34032 Montpellier, Cedex 1, France Tel: 33 (0) 4 67 61 65 53, Fax: 33 (0) 4 67 61 55 47.

Rice Inspection Technology Manual

(Japan)

This "Rice Inspection Technology Manual" is one of the products of the Food Agency's ODA Program "Promotion of Cooperation in Grain Inspection Technology".

In an international workshop on "Rice Post-Harvest Technology" that was held under a previous program, and in a smaller survey program on the effectiveness of "Rice Inspection Technology", a prototype version of this book, there were requests for a manual that would include many photographs of rats, insects and damaged rice grains, and specifically describe methods of measuring moisture content and of judging rice quality, so as to be useful in on-site inspections.

The Japan Food Agency has standards for the methods that must be used in determining rice quality. Every year new standard samples are prepared for use in rice quality inspections so that the inspections will be fair and objective, but many developing countries have not yet reached this stage. This manual has been prepared to assist government administrators and on-site inspectors who are working hard day and night to inspect rice and improve rice quality in developing countries, as well as the technicians in rice milling plants.

Main contents:

A. Measurement Methods — I. General rules, II. Basic operations, III. Measurement methods, IV. Observation and classification of rice grains, V. Sensory palatability test.

B. Stored Rice and Stored Product Insects.

C. Damage Caused by Rodents and Control of Them.

80 pages, 21 x 30 cm, softbound.

Project initiated and funded by Food Agency, Ministry of Agriculture, Forestry and Fisheries.

Project implemented by Japan Grain Inspection Association, 15-6 Nihombashi-Kabutocho, Chuo-ku, Tokyo 103-0026, Japan. Telephone: 03-3668-0911, Facsimile: 03-3668-0058. ■■

ABSTRACTS

The ABSTRACT pages is to introduce the abstracts of the article which cannot be published in whole contents owing to the limited publication space and so many contributions to AMA. The readers who wish to know the contents of the article more in detail are kindly requested to contact the authors.

659

Desorption Isotherms for Popcorn (Iopop-12): Iqbal, M., Asstt. Professor; M. Younis, Lecturer, Dept. Farm Machinery and Power, respectively, University of Agriculture, Faisalabad - 38040, Pakistan and C.J. Bern, Professor; K. Rosentrater, Graduate Student, respectively, Dept. Agric. and Biosystems Engineering, Iowa State University, Ames, Iowa 50011, U.S.A.

Equilibrium moisture contents (EMC) for popcorn variety Iopop-12 were determined at 21, 30 and 40°C, and relative humidities of 11.2, 33 and 75.5 percent. A dynamic method to reach equilibrium was used by suspending 15 g samples in a wide mouth glass jar, with 250 ml of three different saturated salt solutions. Triplicated samples were used for all trials. The data obtained were plotted on the isotherms of popcorn varieties (Purdue-410 and yellow dent). Equilibrium moisture contents were found to be different due to differences in physical and biological properties of the crops and their varieties. These differences were comparatively more pronounced at higher relative humidities than those at lower relative humidities. No problems of mold growth were observed while desorption took place at high relative humidity since a relatively short time was required to reach equilibrium.

821

Performance Evaluation of Selected Deep Tubewells in the Barind Tract of Bangladesh: Rahman, Md. Shafiqur, Former Graduate Student, AIT 6/1 Kalabagan, Lakecircus, 4th floor Dhaka, Bangladesh; V.M. Salokhe, Professor, AFE Program; and A.D. Gupta, Professor, IWM, respectively, Asian Institute of Technology, P.O. Box 4, Klongluang, Pathumthani 12120, Thailand.

In the 'Barind Tract' of Bangladesh a good number of tubewells have been sunk for pumping groundwater for irrigation. However, so far no post study has been conducted to verify the suitability of the aquifer for exploiting water for irrigation purpose. This study was conducted in order understand the present situation of the selected deep tubewells and to provide some important parameters for the planners for better decision and maintenance of the existing wells. The study revealed that the aquifer in the study area was suitable for irrigation purposes. Some tubewells seem to be deteriorating with time while others are improving. Recommendations have been given the management to take necessary action for smooth running of the tubewells in the study area.

829

On-farm Reliability of Vertical-conveyor-reaper: Tuteja, Pawan Kr., Dept. of Farm Power and Machinery; S.C.L. Premi, Dept. of Farm Power and Machinery; S. Arya, Hon'ble Vice Chancellor; K.L. Gulati, Dept. of Physics, respectively, CCS Haryana Agricultural University, Hisar-125004, India.

The studies were conducted in Hisar and Sirsa districts of Haryana (India) to collect information about specifications and failures of tractor-drawn vertical-conveyor-reapers, through field interviews using a sample size of 51 machines spread over 37 villages.

It was observed that the age of the machine have an adverse effect on the use, down-time and availability. Constants for three parameters of Weibull failure probability density function were determined for the crop-cutting-system, rest-of-machine and machine-as-a-whole. Meantime-between-failure for crop-cutting-system, rest-of-machine, and machine-as-a-whole were 33.05, 38.00 and 32.33 hrs, respectively. The reliability for crop-cutting-system, rest-of-machine, and machine-as-a-whole was 0.436, 0.346 and 0.405, respectively. Hourly failure rates at MTBF for crop-cutting-system, rest-of-machine, and machine-as-a-whole were 0.046, 0.026, and 0.036, respectively. ■■

Co-operating Editors


A K Mahapatra


F M Fonteh


E A Baryeh


A A K El Behery


A M El Hossay


B S Pathak


D B Ampratwum


R J Bani


I K Djokoto


D K Some


J C Igbeka


E U-Odigboh


K C Oni


U B Bindir


N G Kuyembeh


A H Abdoun


A B Saeed


Surya Nath


A I Khatibu


S Tembo


H A Centrángolo


I de A Nääs


A E Ghaly


E J Hetz


A A Valenzuela


R Aguirre


O Ulloa-Torres


H O Laurel


S G C Magana


W J Chancellor

M R Goyal | A L Philips | G R Quick | S M Farouk | M A Mazed | M Gurung | Wang Wanjun | A M Michael | T P Ojha | S R Verma

Soedjatmiko | M Behroozi-Lar | J Sakai | B A Snobar | C J Chung | C C Lee | I Haffar | M Z Bardaie | M P Pariyar | E S Eldin

A D Chaudhry | A Q Mughal | R ur Rehman | R M Lantin | R P Venturina | S A Al-suhaibani | S Illangantileke | S F Chang | T S Peng | S Phongsupasamit


C Rojanasaroj


V M Salokhe


G Singh


Y Pinar


P V Lang


A P Kaloyanov


P Kic


H Have


G Pellizzi


A A Wanders


J Kigour


M Martinov

Pavel Kic
Associate Professor, University of Agriculture Prague, Faculty of Agric. Engineering, 165 21 Praha 6-, Suchdol, Czechoslovakia

Henrik Have
Prof. of Agric. Machinery and Mechanization at Institute of Agric. Engineering, Royal Veterinary- and Agricultural University, Agrovej 10 DK2630 Tastrup, Denmark

Giuseppe Pellizzi
Director of the Institute of Agric. Engineering of the University of Milano and Professor of Agric. Machinery and Mechanization, Via G. Celoria, 2-20133 Milano, Italy

Aalbert Anne Wanders
Staff Member, Dept. of Development Cooperation, Netherlands Agricultural Engineering Research Institute (IMAG), Wageningen, Netherlands

John Kilgour
Senior Lecturer in Farm Machinery Design at Silsoe College, Silsoe Campus, Silsoe, Bedford, MK45 4DT, UK

Milan Martinov
Associate Professor of Agricultural Engineering, University of Novi Sad, Faculty of Engineering Sciences, Institute of Mechanization, Novi Sad, Yugoslavia

BACK ISSUES

(Vol. 29 No. 1, Winter 1998 ~)

◇ ◇ ◇

INSTRUCTIONS 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 printed, double-spaced, under 3,000 words (approximately equivalent to 6 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.
h. written on floppy disc.

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)"
d. Complimentary copies: Following the publishing, three successive issue are sent to the author(s).

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. Article must be sent on 3.5 inch floppy disk with MS DOS format (e.g. Word Perfect, Word for DOS, Word for Windows.....) along with one printed copy.
b. The data for graphs and the black & white photographs must be enclosed with the article.
c. 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
d. The printed copy must be numbered (Arabic numeral) successively at the top center whereas the disc copy pages should not be number. 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".
e. The data for the graph must also be included.
f. 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.
g. 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.
h. 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).
i. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
j. Convert national currencies in US dollars and use the later consistently.
k. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
l. 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.