International specialized medium for agricultural mechanization in developing countries
ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.25, NO.1, WINTER 1994

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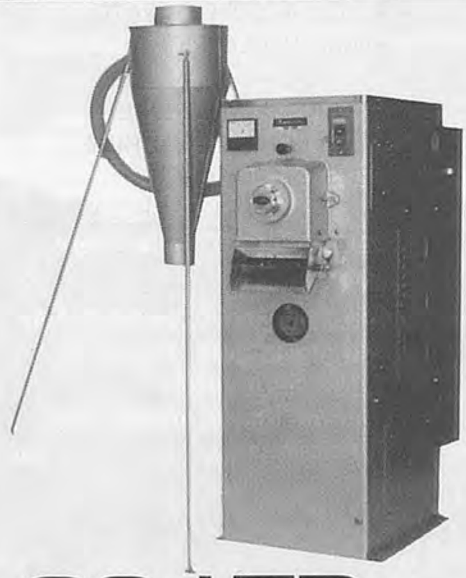

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This publication, published quarterly, has an objective to promote agricultural mechanization in developing countries. Its readers consist of so many people in various fields such as farmers, dealers, manufacturers, researchers, government officials,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

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VOL.25, NO.1, WINTER 1994

Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

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

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

This is the 82nd issue since its maiden issue in the Spring of 1971

EDITORIAL

The human population on earth has already got over 5.5 billion and it is still on the increase by more than 0.1 billion a year. Assuming that a rate of increase is 1% a year, saying the least, after 2000 A.D., the population will be over 8.5 billion in 2025. Presently the population of developed countries accounts for only 22% of total world population and 78% lives in developing countries. This percentage is to change because of the rapid population increase in developing countries. While the earth is narrowing more and more by the progress of traffic and communication means, economical gap is expanding, which causes international disputes in many places of the world. Human history tells that a small number of mighty always takes the limited resources by force. The recent Golf War is one of its examples.

Population increase is constantly putting pressure on eco-system on earth. Every year 1.7 million ha of forests are being destroyed and 6 million ha of land changes to desert. The climate condition has been affected by expansion of ozone hole, increase of acid rain, carbonic acid gas and methane. Many kinds of microorganisms that have maintained good eco-system are going to diminish. It is not known to what extent these invisual organisms and various insects have diminished and how they have changed. As we notice an important role of those microorganisms in maintaining earth eco-system, it is very unearthly. In a sense the earth is taking a decadant aspect. Besides a number of farmers is decreasing and agricultural policy on a consumers' basis is being taken in developed countries. End last year Urguai Round finally reached an agreement. We are afraid this will be resulted in large destroyment of agriculture and eco-system. We have to raise the cost of eco-system to recover its balance. Nevertheless an agreement in Urguai Round takes the direction to utilize eco-sustem at lower cost. Farmers are large majority on earth, yet the result of The Round will further profit a small number of consumers in developed countries through trade condition between industrial and agricultural products, that will be less profittable to farmers. The gap between the rich and poor is to expand more and more on the narrowing earth.

There will be more and more tensions, conflicts and confusion. Under such condition, what role can agricultural machinery, especially mechanization to raise productivity of farmers in developing countries, play? Agricultural mechanization is deeply involved in basic problems of earth.

Even the word "agricultural engineering" is going to be minority in developed countries. "Biology" is going to take place of the most important "agriculture" among researchers. However I never have the thought to change the title of AMA. Because agricultural mechanization for developing countries will surely give the largest effect on future direction of mankind.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January, 1994

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Draft Requirements of Selected Tillage Implements

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Abstract

The draft requirement of tillage implements has a great concern for designing tillage implements and deciding suitable tractor size. In this study an effort was made to determine the draft requirements of selected primary and secondary tillage implements at the field speed of 2.5 km/h in silty clay loam at 13.2% moisture content. The experimental results indicate that the draft consumed by cultivator, cheisel plow and subsoiler increased linearly with the increase in the depth of cultivation whereas disc implements demonstrated a curvilinear relationship. However, the draft needed by cultivators and disc harrows were close to each other at shallow depth. Since the disc harrow required less draft, therefore, it was recommended for seedbed preparation for shallow rooted crops. Maximum power consumed in this study was found in the case of chisel plowing which was 40% of 35.43 kW, tractor.

Introduction

The manipulation of soil by using suitable implements to secure a good environment for seed germination and plant growth is the oldest branch of arable agriculture and reached a relative high level of development centuries ago. However, it is the most costly operation in the budget of a farmer because amongst all the agricultural operations tillage machinery requires a tremendous amount of power for adequate seedbed preparation. It was estimated that tillage operations require over 60% of the power used in American farms (Jacobs et al., 1983). Presently about 269,000 tractors are in use in the agricultural sector in Pakistan (Anonymous, 1988). With an annual use of tractor for 350 in tillage with an average consumption of 4.5/ℓ of diesel fuel, priced at Rs.5/ℓ, the total cost of fuel in the country is Rs.2.12 billion. In this age of energy crises, therefore, utmost effort must be exercised in the selection and use of tillage implements with a view to minimizing foreign exchange spent on fuel.

In the last two decades the tendency of using agricultural implements with tractor has increased moderately and is still continuing (Anonymous, 1988). In order to use the tractor power efficiently and economically, all the implements manufactured by the local industries should be standardized. This will not only help reduce the cost of seedbed preparation but also increase the net economic return to the farmer.

The best design criterion is the draft requirement of tillage implements which determines the tractor size. Hence, it is important that implement manufacturers must know the draft requirement of various tillage machines for designing and developing them in accordance with the size of tractors available.

Kepner (1978) developed a technique to determine the draft for different implements according to the furrow size to be cut. Baloch (1991) and Smith (1964) carried out field experiments and concluded that draft requirement of an implement increased with the depth of penetration of implement in the soil. Sheikh (1989) reported that the draft requirement increased linearly for cultivators and curvilinearly for plows with the depth of penetration at constant travel speed.

Depth and width of cut, shape

and arrangement of tool and field speed are important factors which affect the draft requirements in different soil conditions. Realizing the fact that tremendous amount of energy is consumed in tillage operations only, this study was designed to determine the draft requirements of various tillage implements in heavy soil at suitable cultivable soil moisture content.

Materials and Methods

This study was carried out at the Faculty of Agricultural Engineering and Technology, University of Agriculture, Faisalabad, Pakistan in 1990. The parameters considered were soil moisture content, soil texture, draft, depth and width of operation. All these variables were measured and recorded according to the RNAM test codes and procedures for machinery. Tillage implements and tractors used in this study are listed in **Table 1**.

Table 1. Specifications of Tractors and Implements Used in the Study

Item	Specification
Front tractor MF-265	46.25 kW (62 H.P.)
Rear tractor MF-135	35.43 kW (47.5 H.P.)
N.T. cultivator	Mounted, 10 tines, general purpose
Chisel plow	Mounted, 3-tines
Disc harrow	Mounted offset type, 8 discs, (23 cm dia)
Sub soiler	Mounted, 1-tine
Disc plow	Mounted, 2 discs (80 cm dia each)

Draft Measurement

A dynamometer was installed between the two tractors for measuring the draft as shown in **Fig. 1**. The implement was pulled through the soil at a desired depth with a constant speed of 2.5 km/h. The depth of cultivation was varied from 5 cm to 45 cm with a successive step increase of 5 cm. All these experiements were performed in silty clay loam soil having 13.2% moisture content. This moisture content was within accepted range of cultivating land (Baloch, 1991). The actual drawbar pull of the implement was determined by subtracting the amount of pull required by the front tractor in pulling the rear tractor without engaging the implement from the total drawbar pull exerted by the front tractor when the implement was engaged. The drawbar pull required by different implements is shown in **Table 2**.

Table 2. Draft and Power Requirements of Different Tillage Implements at Various Depths of Operations

Implement	Depth of Penetration (cm)	Width of Operation (cm)	Total Draft (N)	Draft/unit Width (N/cm)	Drawbar Power (kW)
N.T. Cultivator (10-tine)	6	250	2943	11.8	2.03
	10	250	4905	19.6	3.38
	15	250	6867	27.5	4.74
	20	250	11772	47.1	8.12
Disc harrow	10	184	4710	25.6	3.25
	15	184	5101	27.7	3.52
	20	184	6965	37.9	4.81
	25	184	10791	58.7	7.45
Disc plow	15	120	4905	40.9	3.38
	20	120	6867	57.2	4.74
	25	120	9810	81.8	6.77
	30	120	14713	122.6	10.15
Sub-soiler	5	50	1892	37.8	1.31
	10	50	2158	43.2	1.49
	15	50	4022	80.4	2.78
	19	50	8142	162.8	5.62
	26	50	9908	198.6	6.84
	33	50	13488	269.7	9.31
Chisel plow	6	150	1962	13.1	1.35
	10	150	2748	18.3	1.89
	15	150	4944	32.9	3.41
	20	150	9810	65.4	6.77
	35	150	17644	117.6	12.74
	47	150	20454	136.4	14.11

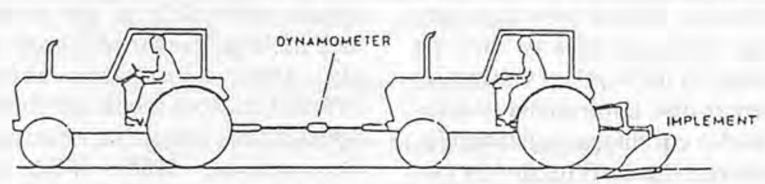

Fig. 1 Measuring of draft for a tractor-mounted implements.

Results and Discussion

The data in **Table 2** was analyzed using computer SPSS Package and best fit curves of drawbar pull (P) per unit of cutting width. The depth of operation (D) were drawn for different implements. Equations developed along with the value of r^2 are as follows:

Item	Equation	r^2
N.T. cultivator	$P = -4.56 + 2.44\ D$	0.98
Disc harrow	$P = 13.3\ 2^{0.056D}$	0.96
Disc plow	$P = 13.45^{0.073D}$	0.99
Sub-soiler	$P = -27.53 + 8.86D$	0.98
Chisel plow	$P = -9.27 + 3.28D$	0.99

where,

P = drawbar pull per cm width of the implement, N/cm

D = depth of operation of the

implement, cm

Fig. 2 shows that the draft required by all the implements increased with the depth of operation. Similar results were reported by Smith (1964) who demonstrated that the draft of implements increases with the depth of cultivation. Nevertheless, the relationship between the draft required and the depth of operation is linear for cultivator, chisel plow and sub-soil but curvilinear for disk plow and disk harrow employed in this study. The following reasons may be advanced for the wide variation in behaviour of implements in respect of draft needed: The construction of cultivator, chisel plow and sub-soiler is simple and the forces on the implement are acting in one plane in the direction of travel. On the other hand, the construction of disk implements is complex. The implement travels at an angle behind the power source and the forces on the implement are acting in different plans. It can also be seen from **Fig. 2** that the difference in draft as shallow depths is quite insignificant. However, a sudden increase in pull occurred at greater depths of operation.

Fig. 2 also shows that the draft required per centimeter of cutting width at shallow depths is very close to each other for N.T.. cultivator and disc harrow. Since the disc harrow gives better tilth condition (Sheikh, 1984) therefore, it is economical for seedbed preparation of cereal crops. This is true because two passings of a disc harrow manipulate soil better than five passings of a N.T. cultivator (Sheikh, 1984). Disc plow, subsoiler and chisel plow are used as primary tillage implements and consume more energy. Therefore, they should be used for deep cultivation to break plow pan whenever it is developed in the soil. **Table 2** shows that the maximum total power consumed by the chisel plow was 14.11 kW. Since the rear tractor of 35.43 kW capacity was used for operating the implements, therefore, 40% of the tractor power was consumed for the chisel plow having three tines at 2.5 km/h tractor speed. For economical use, 70% of the tractor power must be utilized (Anonymous, 1989). Therefore, it is recommended that five tine chisel plow can be used very effectively at this field speed of tractor.

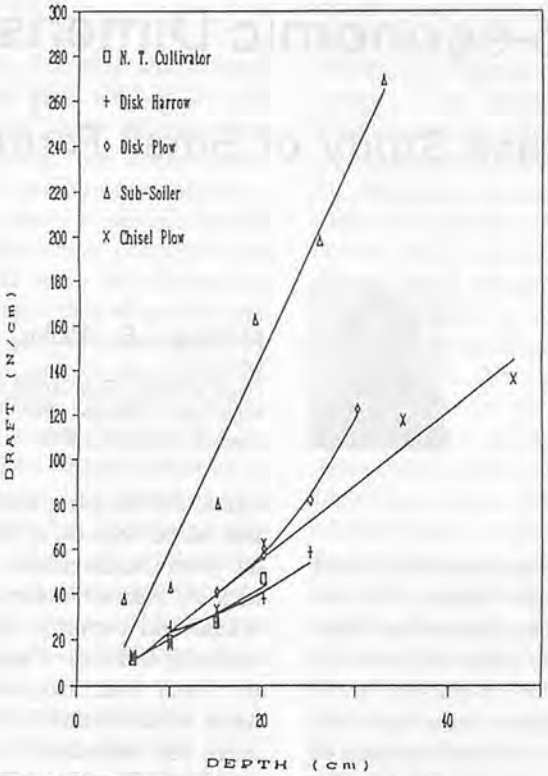

Fig. 2 Draft of implements at different depth.

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Socio-economic Dimensions of Ox-traction

— A Case Study of Small Farmers in Sierra Leone

by
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Abstract

This study undertaken in order to address the history of ox-traction in Sierra Leone and identify the social, economic, and cultural factors of ox-traction at the small farm level. Data were collected from 47 oxen owners and 41 non-oxen owners. The results show that although there were marked cultural differences between oxen owners and non-oxen owners, these are not so in socio-economic characteristics and adoption behaviour. This finding has implications for equal development policy that may bring equal benefit to all farmers in the study area. Irrespective of ethnic or cultural differences, farmers are likely to adopt whatever technology, introduced to them provided it proves to be profitable.

Introduction

The importance of ox-traction as a means of accelerating agricultural development in less developed countries is too well known to require much elaboration here. Agricultural mechanization with the engine power has always been severely criticised in developing countries. A number of attempts to motorise agriculture in these countries have failed. In Sierra Leone for instance, mechanization has failed because of factors such as poor maintenance facilities; lack of trained manpower; high initial and running cost of tractors: dependence of engine power on fossil fuel; tropical environment which is unsuitable in most areas for mechanical cultivation; inability of farmers to hire tractors and fragmented, inaccessible, and small nature of holdings which renders mechanization unsuitable. These factors indicate that the engine-powered tractor is not appropriate for present day Sierra Leone. There is, therefore, a need for an alternative technology such as ox-traction for the small farmers in the rural areas.

The use of animal traction for sustained food crop production has been thoroughly proven by farmers in the Northern area of Sierra Leone. The recent inception of the Work Oxen Project (WOP) in Sierra Leone has gradually given momentum to animal traction as a topic in development policy and technical discussions after a long time of neglect. With the present and continuous increase in the cost of conventional types of energy (petroleum) already having disastrous consequencies for Sierra Leone, it could be speculated that the use of animal traction as an alternative source of energy in the future will continue to be of enormous importance for many agricultural holdings in the country. There is, therefore, considerable scope for increasing the use of work oxen in Sierra Leone which could lead to benefit at both local and national levels. The advantage is the low cost of the technology, with the possibility of puting it at the door steps of the majority of poor farmers. In addition, foreign exchange is conserved because the animals are from local sources, while equipment and spare parts could be manufactured locally.

Despite the numerous advantages of animal traction, FAO experience has shown that the use of the technology has generally been underutilized and limited to primarily tillage and transport (Gifford, 1986). Why this under-exploitation of such a potentially very productive technology? There is obviously no single answer to this question. While cost, market, technical and field obstacles stand to justify this position, it seems that the use of animal traction has been constrained by the social, economic and cultural conditions of the farmers. Under the present plans of the Work Oxen Project, it is intended to extend animal traction activities to most parts of Sierra Leone. This study is relevant because knowledge about the social, economic and cultural features of the present owners and users of ox-traction will enhance the formulation of extension strategies that will facilitate the rapid expansion of the project's activities to other farming communities in the country.

Objectives of the Study

The objectives of the study were:

1. To obtain data on the historical development of ox-traction in Sierra Leone.
2. To identify the social and economic characteristics of oxen team owners and non-owners and how these characteristics relate to the adoption of ox-traction technology.
3. To derive implications from the above findings for ox-traction development through the Work Oxen Project.

Hypotheses

Some of the arguments developed about the socio-economic characteristics of farmers with regard to the use of ox-traction were shaped into two main hypotheses. The aim here was to assess whether owners of oxen sets differed from non-owners in socio-economic characteristics. Hence the hypotheses:

HO_1: There is no significant difference between oxen team owners and non-owners in terms of their socio-economic characteristics and adoption behaviour.

HO_2: There is no significant relationship between socio-economic characteristics and the adoption of ox-traction technology.

Methodology

The data for this study were collected in May 1983 in 26 villages. Ten of these villages were visited during the exploratory survey for preliminary information on farmers. A sample size of 95 respondents was proposed out of which 88 were interviewed in the following order: 47 ox-traction set owners and 41 non-owners of ox-traction sets. In the group of non-set owners, 20 were chosen from villages with oxen sets and 21 from villages without oxen sets. The reason for this selection was to detect whether there was any spill-over effect of ox-traction activities from oxen set owners to non-owners either residing with the former or in villages away from them.

The data were analysed using simple descriptive statistical techniques, including percentages, means and chi-squared test.

Findings

History of Ox-traction in Sierra Leone

Ploughing with oxen started in Sierra Leone around the Mabole Valley in 1928 by Madingo migrants from the neighbouring Republic of Guinea. As a means of introducing improved ploughs and promoting farming, the Department of Agriculture initiated the Mabole Ploughing Scheme in 1950. The scheme, which included the supply of ploughs and oxen on loan to some progressive farmers, resulted in increases in farm size.

Apart from the Mobale Valley Ploughing Scheme, ox-ploughing schemes were also tried in Bonthe, Rokupr and Koinadugu. Most of these were, however, not as successful as the Mabole schemes because of (a) lack of interest and general apathy on the part of farmers and (b) mounting arrears of loans to the District Council which the farmers could not repay. The Mabole Valley Scheme, on the other hand, succeeded because of (a) the ability of the Madingo farmers, who are a cattle rearing tribe, to take proper care of their oxen and (b) migration of most inhabitants on the Mabole Valley to mining areas, thus shifting attention from farming activities. This caused more labour shortages on the farms as more youths migrated to mining areas. Norwithstanding the above factors of success, the oxen owners of the Mabole Valley faced practical problem, including (a) lack of suitable animals for draft purposes; (b) lack of knowledge among non-cattle farmers to take proper care of their oxen; (c) lack of ploughs that combined suitability and durability; (d) lack of training facilities for oxen farmers; and (e) attack on animals by diseases. These factors are possible indicators to explain why many farmers, until recently, neglected animal traction as an alternative means of food production.

Socio-economic Characteristics of Farmers

Table 1 presents a summary of the social and economic characteristics of farmers. As shown in the table, the majority of farmers (72.7%) were in their productive age group of between 40 and 59 years, with an average age of 48 years. A high percentage (96.6%) of the respondents never went to school. About 43% of the respondents were full time farmers, while 36.4% reported to be part-time and were engaged in non-farm occupations like carpentry, tailoring and blacksmithery. Some 20.4% of them were not active farmers because of old age and sickness. Majority of respondents (68.1%) had between 13 and 24 family members with an average

Table 1. Social and Economic Characteristics of Farmers

Characteristics	Farmers with oxen sets		Farmers without oxen sets		Total	
	No	%	No	%	No	%
Age group						
20-29	3	6.4	2	4.9	5	5.7
30-39	6	12.7	3	7.3	9	10.2
40-49	20	42.6	14	34.1	34	38.6
50-59	12	25.5	18	43.9	30	34.1
60-69	6	12.7	4	9.8	10	11.4
Schooling						
Went to school	2	4.3	1	2.4	3	3.4
Never went to school	45	95.7	40	97.6	85	96.6
Dependence on farming						
Full time	21	44.7	17	41.5	38	43.2
Part time	19	40.4	13	31.7	32	36.4
Not working	7	14.9	11	26.8	18	20.4
Family size						
1-6 members	2	4.3	9	22.0	11	12.5
7-12 members	4	8.5	13	31.7	17	19.3
13-18 members	12	25.5	14	34.1	26	29.5
19-24 members	29	61.7	5	12.2	34	38.6
Family size (Ha)						
0.82-2.86	32	68.1	5	12.2	37	42.0
2.87-4.91	11	23.4	32	78.0	43	48.9
4.92-6.96	4	8.5	4	9.8	8	9.1
Membership in social groups						
None	3	6.4	9	22.0	12	13.6
1-4	11	23.4	21	51.2	32	36.4
5-8	33	70.2	11	26.8	44	50.0
Land tenure						
Personal land	17	36.2	13	31.7	30	34.1
Family land	30	63.8	28	68.3	58	65.9
Farm labour						
Family labour	36	76.6	32	78.0	68	77.3
Hired labour	11	23.4	9	22.0	20	22.7
Income (US $)*						
251-500	2	4.3	8	19.5	10	11.4
501-750	5	10.6	14	34.1	19	21.6
751-1000	14	29.8	15	36.6	29	32.9
1001-1250	26	55.3	4	9.8	30	34.1

* U.S. $1 = 8 Leones (local Currency).

family size of 15 people. Fifty percent of the respondents reported membership to between 5 and 8 rural organizations with as may as 36.4% claiming membership to between 1 and 4 organizations. Average membership to social organiztions was 4.8.

The average earning power of farmers was U.S.$850 with majority of them (67%) earning between $751 and $1250 per annum. The income of farmers, to a large extent, came from the sale of crop and animal products. For the oxen owners, hiring fees for oxen teams was reported as an important source of income. Hiring cost, however, varied greatly depending on the relationship between the oxen owner and farmer hiring. The average acreage was at 3.2 ha with most of the farmers (90.9%) cultivating between 0.82 and 4.91 ha of farm land. Farmers reported using both family and hired labour but with the majority (72.3%) using the former as the main means of cultivation. Labour was reported to be scarce and costly. On the contrary, land was not a production constraint. Majority of the respondents (65.9%) used family land as compared to 34.1% who cultivated personally owned lands.

Customs and material products such as animals and tools had significant implications for ox-traction. To own cattle in rural communities of the study area, like in most other African communities, was reported as a sign of wealth. There were marked differences in the ownership of cattle between oxen owners and non-owners. As high as 62% of the 982 cattle head in the villages at the time of this study were owned by owners of oxen sets. Apart from material wealth, social status was also a relevant component of possessing oxen teams. In most of the villages studied, the village headman, the Imam (Muslim leader) and other recognized personalities in the community were owners of oxen teams. Women never owned oxen sets personally and did not operate oxen teams on the farms. However, they showed great interest in using ox-traction. All the wives of oxen owners studied were using oxen teams on their personal plots. The services on such plots were not on hired basis. Rather, the women of such personal plots only provided food, cigarettes, kolanuts and, in rare cases, cash tokens to oxen team operators who were, in most cases, children of these women. It was also shown that wives of non-oxen owners hired oxen teams for their personal farm plots in a similar way their husbands did for the general farm plots. The blacksmith was reported as the main source of agricultural tools, including the repair of major damages done to ox-ploughs. Because of the indispensable services of the blacksmith, all operations on the blacksmith's farm were done by the farmers within reach of his services. In addition to the agricultural labour offered, farmers also paid minimal charges for the repair of old tools and the manufacture of new ones. Such charges were, however, negotiable.

Adoption of Agricultural Innovations

As shown in **Table 2,** there was a relatively high adoption of ox-traction technology among both oxen and non-oxen owners. As many as 58.5% of the non-oxen owners adopted ox-traction for operations on their farm plots.

Table 2. Distribution of Farmers by Adoption of Innovations

Innovation	Farmers with oxen sets		Farmers without oxen sets		Total	
	No	%	No	%	No	%
Use fertilizer						
Yes	18	38.3	17	41.5	35	39.8
No	29	61.7	24	58.5	53	60.2
Use improved varieties						
Yes	9	19.1	8	19.5	17	19.3
No	38	80.9	33	80.5	71	80.7
Swamp development						
Yes	10	21.3	12	29.3	22	25.0
No	37	78.7	29	70.7	66	75.0
Keepimg farm records						
Yes	4	8.5	2	4.9	6	6.8
No	43	91.5	39	95.1	82	93.2
Use animal traction						
Yes	47	100.0	24	58.5	71	80.7
No	—	—	17	41.5	17	19.3

On the contrary, few of the respondents adopted other agricultural innovations addressed in this study. The use of fertilizers was relatively higher than the use of improved rice varieties, swamp development and record keeping. Since most respondents (96.6%) never went to school, only the few (6.8%) who were literate in English and Arabic said they kept farm records. The 25% who had developed their swamps were participants of the Northern Integrated Agricultural Project. There was no prospect for irrigation because water is normally hard to come by in the dry season in this part of the country.

Test of Hypotheses

The hypotheses started earlier were tested using the chi-square test. The first hypothesis that "there is no significant difference between oxen team owners and non-owners in terms of their socio-economic characteristics and adoption behaviour" was split into two. The analysis on socio-economic characteristics and adoption behaviour are presented in **Tables 3** and **4**, respectively.

As shown in **Table 3**, there was no significant difference between oxen team owners and non-owners with respect to their age, schooling, dependence on farming, family size, membership in rural organizations, land ownership, sources of farm labour and income. There was, however, a significant difference between the two categories of respondents with regard to the size of farms they operated, i.e., owners of oxen teams operated bigger farms than the non-owners of oxen teams.

The second part of hypothesis 1 is closely tied with the first part. It was assumed that if the two categories of farmers could differ in socio-economic characteristics, then the difference might, in turn, contribute to their differential proneness to accepting innovations. This assumption was then hypothesized and tested. It was, however, found that there was no significant difference between the oxen team owners and non-owners in terms of innovation adoption as shown in **Table 4**.

The analysis on the second hypothesis which states that "there is no significant relationship between socio-economic characteristics and the adoption of ox-traction technology" is presented in **Table 5**.

As shown in this table, schooling, family size, farm size, land holding right and income were significantly related to the adoption of ox-traction technology. This implies that farmers with larger family sizes, high net incomes, some educational back-ground, claiming personal right over land and cultivating bigger farms adopt ox-traction more than those farmers without these favourable characteristics. On the other hand, age, dependence on farming, membership in rural organizations and type of farm labour employed by the farmer, were not significantly related to ox-traction adoption.

Conclusions and Recommendations

The basic aim of the analysis reported here was to determine whether farm families having oxen teams have different characteristics from those not possessing ox teams. This aim is of considerable practical importance. There are many farmers in Sierra Leone who do not presently use ox-traction probably because of non-exposure to the innovation, lack of purchasing power, cultural biases and the nature of their physical environment, to name but a few problems. If such families have distinctive social, economic and cultural characteristics, then the Work Oxen Project can utilize such information in the design and selection of strategies that will facilitate the participation of these farm families into ox-traction programmes.

The findings of this study showed marked cultural differences between the Madingo oxen owners and the Limba non-oxen owners. They were not however, very different in socio-economic characteristics and adoption behaviour. Cultural values, for instance, inhibited the use of ox-traction among farmers of the Limba tribe most of whom envisaged ox-traction as punishment or undue wickedness to cattle. The difference in food habits imposed by religious beliefs of the Madingo tribesmen, who were mostly Muslims further aggravated the situation. This could be a possible explanation as to why the Limba non-oxen owners viewed ox-traction with suspicion and indifference. A

Table 3. Chi-square (X^2) Value of Significant Difference Between Oxen Set Owners and Non-owners in Terms of Socio-economic Characteristics

Socio-economic characteristics	X^2 cal	X^2 tab (0.05)	Remarks
Age	0.48	11.07	NS
Schooling	0.01	3.84	NS
Dependence on farming	0.25	5.99	NS
Family size	3.70	9.49	NS
Farm size	6.66	5.99	S
Membership in rural organizations	2.74	5.99	NS
Land ownership	0.05	3.84	NS
Farm labour	0.004	3.84	NS
Income	3.16	9.49	NS

S = Significant. NS = Not Significant.

Table 4. Chi-square (X^2) Value for Differences in Adoption Between Oxen Owners and Non-owners

Innovation	X^2 cal	X^2 tab (0.05)	Remarks
Fertilizer application	0.03	0.84	NS
Improved rice varieties	0.0004	3.84	NS
Swamp development	0.14	3.84	NS
Farm records	0.03	3.84	NS
Animal traction	3.76	3.84	NS
Recommended cultural practices	3.44	3.84	NS

NS = Not significant.

Table 5. Chi-squared (X^2) Value for Significant Relationship between Socio-economic Characteristics and Adoption of Ox-traction

Socio-economic characteristics	X^2 cal	X^2 tab (0.05)	Remarks
Age	3.00	5.99	NS
Schooling	26.27	5.99	S*
Dependence on farming	2.68	5.99	NS
Family size	10.50	5.99	S*
Farm size	6.59	5.99	S
Membership in rural organizations	4.10	5.99	NS
Land tenure	9.55	5.99	S*
Type of farm labour	0.05	5.99	NS
Income	10.02	5.99	S*

NS = Not significant. S = Significant at 0.05 only.
S* = Significant at both 0.05 and 0.05 levels.

stragegy designed to bridge the existing cultural gap will enhance even development. The Work Oxen Project may be tempted to discriminate against farmers because of lack of interest and enthusiasm on the part of the latter. Such a venture will be a mistake that could prevent even development and the rapid spread of ox-traction technology. The fact that this study found oxen and non-oxen owners to have similar socio-economic characteristics suggests far reaching implications for equal development policy that may bring about equal benefits to all farmers in the study area and beyond. Irrrespective of ethnic or cultural differences, farmers are likely to adopt any technology introduced to them as long as it proves profitable.

Adoption of ox-traction as observed in this study represents an important capital investment mainly due to the present high cost of bulls and plough which averaged U.S.$1,500 for the set (2 bulls and a plough) at the time of this study. Considering the average annual income of farmers which was U.S.$850, one could easily infer that ox-traction technology was already beyond the reach of poor farmers. In fact with the escalating cost of commodities emanating from economic mismanagement and the devaluation of the local currency one wonders whether farmers can currently afford to buy an oxen set. For those farmers who had some heads of cattle, capital for using ox-traction was already available. Effort is, however, needed on the part of government through the Work Oxen Project to bring about an even spread of ox-traction in the study area where it has great potential and to other parts of the country where it has also been found to be adaptable. This could be achieved through the provision of essential services such as adequate and timely provision of credit and loans to farmers; giving incentives in the form of subsidy to encourage farmers to adopt ox-traction technologies; and the construction of seasonal roads in rural communities which will enhance the use of ox-carts and hence contribute to efficient marketing and distribution networks. Some socio-economic characteristics such as income, farm size, family size, land holding right and schooling were found to be significantly related to the adoption of ox-traction. The Work Oxen Project can use these characteristics as criteria for the selection of farmers who can serve as innovators for the diffusion and issemination of ox-traction technology.

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Development and Testing of a Power Tiller-operated Pre-germinated Cuban Paddy Seeder

by

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Abstract

A six-row power tiller operated pre-germinated paddy seeder was developed at O.U.A.T., Bhubaneswar. The effective field capacity of this seeder was 0.168 and 0.114 ha/h for 9.9 and 25.3 cm hardpan depth, respectively. The row-to-row spacing was 20 cm and hill-to-hill spacing was 9.95 cm with 3-5 seeds per hill. The estimated cost of the seeder was Rs.2286 with an operating cost of Rs.173/ha. A net saving of Rs327 and Rs.452/ha can be obtained by using the power tiller operated paddy seeder in lieu of the manual-hill dropping and transplanting methods.

Introduction

In Orissa, paddy is grown on 47% of the gross cropped area under both dry and wet land conditions (Anon, 1990). Paddy seedlings are transplanted preferably in medium and low lands. Manual transplanting is a labour-consuming operation which requires approximately 25% of the total labour requirement of the crop. The human stress and drudgery involved in transplanting operation is also very high. Rapid industrialisation has caused substantial shift of agricultural labour resulting in acute shortage of labour during peak cropping season of transplanting. Direct seeding offers a great promise over manual transplanting as a labour saving and cost reducing system and comparable yield can be obtained with good management practices (Anon, 1978). To overcome the constraints of manual- and bullock-drawn paddy seeders, a six-row power tiller operated, pre-germinated paddy seeder was developed to meet the requirement of farmers.

Materials and Methods

The hopper and pick up chamber were made up of G.I. sheet of 28 gauge thickness. The frame was made from M.S. angles and M.S. flats and on the frame G.I. sheet was placed with the help of 3 mm dia nuts and bolts to get the desired size. The volumetric capacity was 0.085 m in which an average of 40 kg of sprouted seeds can be accomodated. The bottom of the hopper was provided with 50 degree slope to ensure free flow of sprouted seeds from hopper to pick up chamber. The pick up chamber is semi circular so as to facilitate picking up the seeds from the bottom of the chamber. The details of the pre-germinated paddy seeder are shown in **Figs. 1** and **2**.

Seed metering is done by means of six cupdiscs, mounted on central cast iron hollow shaft. The seeder is provided with two-step metering mechanism. To control seed rate, six openings of 45 mm × 50 mm size fitted with sliding plates were provided at the bottom

Acknowledgements: The authors are grateful to the Indian Council of Agricultural Research for providing financial assistance to fabricate and test this seeder. The comments and sugestions of Mr. F.C. Das, Head, Division of Agril. Engg. C.R.R.I., Cuttack are also gratefully acknowledged.

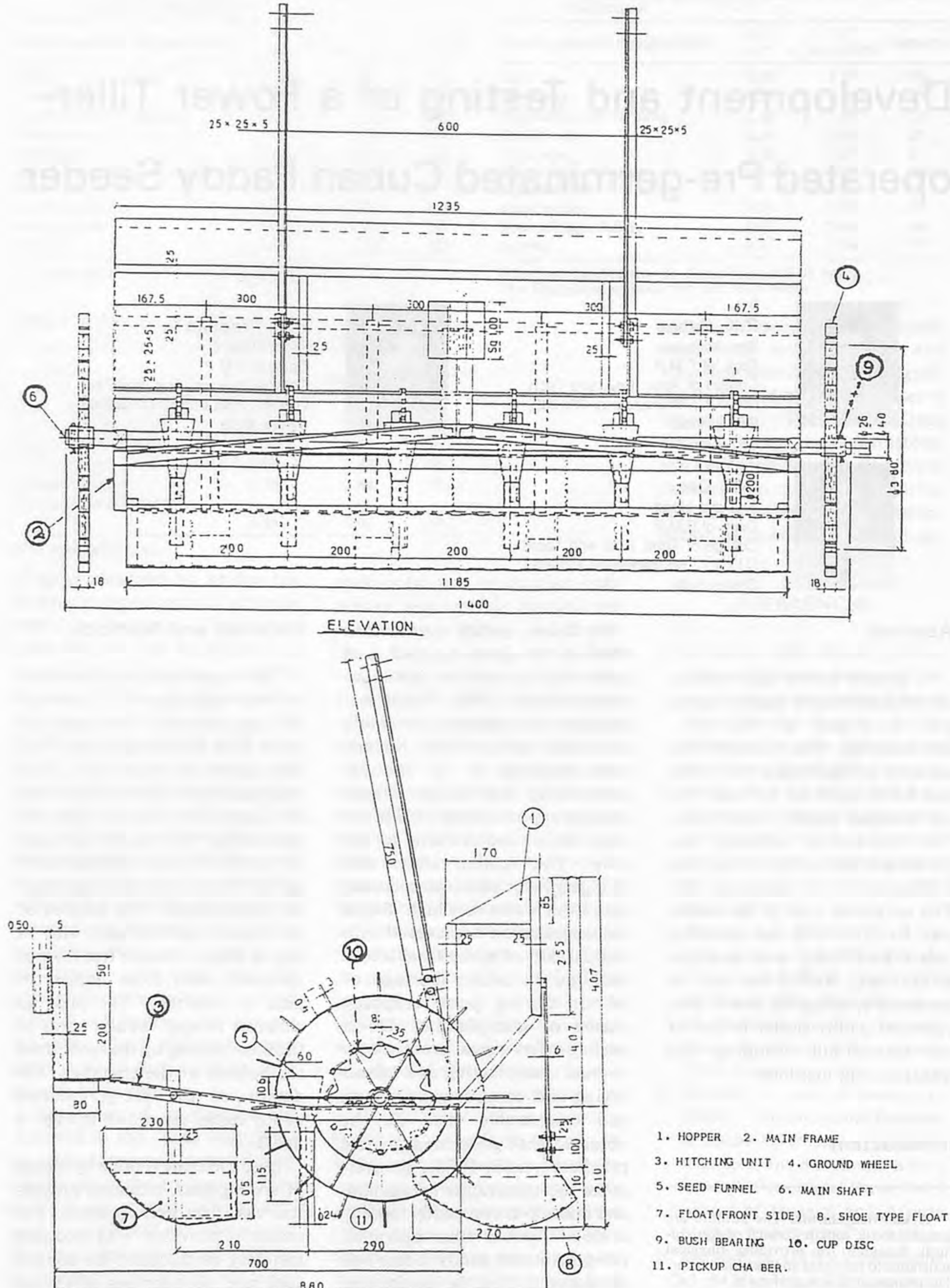

Fig. 1 Power tiller-operated pre-germinated paddy seeder.

Fig. 2 Power tiller-operated pre-germinated paddy seeder.

of the separator through which the sprouted seeds pass to the pick-up chamber by gravity. The cups measured 8 mm dia and 6 mm depth so as to pick only 3-5 seeds in each cup. The design was made so as to achieve 9.95 cm hill spacing and 20 cm row spacing. The float of volumetric capacity 0.038 m^3 with an upward thrust of 0.025 kg/cm^2 was provided to counter act the maximum force exerted by the operator and to prevent sinkage in puddled condition. The seeder was so designed such that the ground wheel lugs would enter into the puddled soil only.

The performance of the seeder was evaluated in the laboratory for superfine, fine and coarse varieties of paddy. The required germination was achieved by soaking the paddy seeds in water for 24 h and then incubating in between two gunny bags for another 24 h. Laboratory test included actual seed rate, percentage variation in seed discharge among the rows and mechanical damage.

The experiments were conducted in sandy loam soil having sand, silt and clay in the ratio of 82.44, 6.00 and 11.56%, respectively. The experimental field was prepared by twice rotapuddling by power tiller and than levelled. After levelling the land was kept undisturbed for 24 h to allow the slurry to settle. The standing water was drained completely before sowing. The test was repeated thrice with two different hardpan depths in a plot size of 30 × 12 m^2.

The field evaluation included seed rate, seed distribution efficiency, field capacity, labour requirement and cost.

Results and Discussion

From the laboratory calibration the maximum percentage variation among the rows was 4.34% as shown in **Table 1**. The deviation in between the actual and desired seed rate was within 5%. No mechanical damage was found while calibrating the seeder.

Before the field trials of the paddy seeder were done, the hardpan depths and puddling indices of the testing plots were determined as shown in **Table 2**.

In the field 3.70% higher seed rate was recorded in the case of 9.9 cm average hardpan depth whereas for 25.3 cm average hardpan depth the actual seed rate was reduced by 13.77% than the desired seed rate (**Table 3**).

The seed distribution efficiency was 87.87% for 9.9 cm hardpan depth and for 25.3 cm hardpan depth the seed distribution efficiency was found to be 69.53% only (**Table 4**).

The effective field capacity of 0.169 ha/h, having field efficiency of 0.169 ha/h, with field efficiency of 77.18% was recorded for the 9.9 cm hardpan depth (**Table 5**).

By operating the seedeer in higher hardpan depth of 25.3 cm, operational difficulties were experienced due to clogging and

Table 1. Laboratory Calibration of Pre-germinated Paddy Seeder for Different Paddy Varieties

Paddy variety	Rate setting	No. of obs.	Weight of seeds from seed funnels 25 revolution							Percent variation
			No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	Avg.	
Superfine (IR-31)	75 kg	1	47	48	44	46	45	46	46	2.80
		2	48	48	46	47	46	47	47	1.74
		3	46	46	41	42	44	45	44	4.34
		4	48	47	45	45	46	45	46	2.00
		5	46	47	43	45	44	45	45	2.87
Fine (Lalat)	80 kg	1	50	50	48	47	46	47	48	3.19
		2	50	51	50	48	47	48	49	2.88
		3	51	50	50	49	47	47	49	2.12
		4	48	49	47	45	46	47	47	2.74
		5	48	48	46	47	46	47	47	1.74
Coarse (Pathara)	85 kg	1	52	57	49	49	50	49	50	2.30
		2	54	55	52	51	52	54	53	2.66
		3	51	50	47	48	49	49	49	2.63
		4	43	53	51	50	52	53	52	2.21
		5	51	49	47	47	50	50	49	3.12

Table 2. Puddling Index and Hardpan Depth

Block	Plot No.	Mean hadpan depth, cm	Mean puddling index, %
I	1	9.8	72.98
	2	10.2	73.56
	3	9.7	73.30
	Average	9.9	73.28
II	1	24.5	86.44
	2	26.3	84.72
	3	25.1	83.10
	Average	25.3	82.75

Table 3. Actual Seed Rate in Field Condition

Average hardpan depth, cm	Rate setting	Plot No.	Seed rate kg/ha	Percentage deviation from the rate setting
9.9	80 kg	1	83.472	4.34
		2	82.222	2.78
		3	83.194	3.99
		Average	82.963	3.70
25.3	80 kg	1	65.278	18.90
		2	74.444	6.95
		3	67.222	15.97
		average	68.981	13.77

Table 4. Seed Distribution Efficiency

Average hardpan depth, cm	Plot No.	Seed distribution efficiency, %	Average
	1	87.99	
9.9	2	87.91	87.87
	3	87.72	
	1	70.47	
25.3	2	67.42	69.53
	3	70.69	

Table 5. Theoretical Field Capacity, Field Efficiency and Labour Requirement

Average hardpan depth, cm	Plot No.	Theoretical field capacity, ha/h	Effective field capacity ha/h	Field efficiency, %	Labour requirement man h/ha
	1	0.222	0.162	73.42	6.91
9.9	2	0.212	0.160	75.42	7.00
	3	0.219	0.181	82.65	6.19
	Average	0.217	0.168	77.18	6.70
	1	0.180	0.118	65.56	9.49
25.3	2	0.178	0.109	61.23	10.28
	3	0.184	0.115	62.50	9.74
	Average	0.180	0.114	63.10	9.84

slippage of ground wheels. Hence the effective field capacity of 0.114 ha/h with a low field efficiency of 63.10% only was observed. The operation of the power tiller operated pre-germinated paddy seeder is shown in **Fig. 3**. On the average, 6.70 man-h were required to sow one hectare of land for 9.9 cm hardpan depth. For higher hardpan depth of 25.3 cm, the average labour requirement was 9.84 man-h/ha. The manual hill dropping and transplanting in line are shown in **Figs. 4** and **5**, respectively.

The estimated cost of the seeder is about Rs.2286. The operational cost of the seeder was Rs.173/ha. A net saving of Rs.327.00 and Rs.452/ha can be obtained by using the power tiller operated paddy seeder in lieu of the manual hill dropping and transplanting methods.

Fig. 3 Operation of the pre-germinated paddy seeder.

Fig. 4 Manual hill-dropping in line.

Fig. 5 Manual transplanting in line.

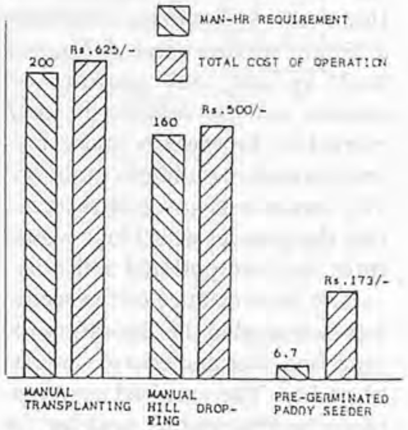

Fig. 6 Man-hour requirement and operating cost of different methods.

Conclusions

On the basis of results obtained from the laboratory calibration and field trials of the pre-germinated paddy seeder the following conclusions can be drawn:

1. From the laboratory calibration, the percentage variations among the rows were well within the permissible range of 5% without any mechanical damage. Hence the seeder can be used for superfine, fine and coarse varieties of paddy.
2. The effective field capacity of the seeder was 0.168 ha/h with a field efficiency 77.18% under 9.9 cm hardpan depth. On the other hand, the effective field capacity of 0.114 ha/h and field efficiency of 63.10% was recorded at 25.3 cm hardpan depth. The seeder was very much suitable under shallow hardpan depth only.
3. The estimated cost of the seeder was Rs. 2286 with an operating cost of Rs.173.00/ha. A net savings of Rs.327 and Rs.452 in the cost of the seeder and operating cost, respectively, can be obtained by using the seeder over the manual hill dropping and transplanting methods.

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■■

Development of Two-wheel Tractor-operated Seed-cum-Fertilizer Drill

by
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Abstract

A 7-row seed-cum-fertilizer drill with working width of 1.75 m to match a two-wheel tractor was developed from the 8-row AIT direct paddy seeder which had some operational and mechanical problems. The improvement was done in many components of the original machine. A fertilizer applicator which can place fertilizer in the soil was added to this machine to increase its capability.

For each row of seed, there is a speed hopper, a 6-fluted seed metering roller, a double disc furrow opener and for each row of fertilizer there is a fertilizer hopper, a fertilizer agitator and hoe type fertilizer furrow opener. The fertilizer furrow opener frame is fixed to the seed furrow opener frame to place fertilizer 2 cm below seed level and 5 cm beside the seed.

Two lugged driving wheels rotate the metering rollers and fertilizer agitators mounted over a common shaft. Each flute in a metering roller can pick-up 3 to 6 seeds with a seed rate of 25.8 kg/ha for paddy and adjustable for soybean and place them at desired depth 3 to 7 cm. Fertilizer discharge can be adjusted from 5 kg/ha to 130 kg/ha. The machine is provided with a foot-operated clutch to disengage the seed metering mechanism and fertilizer agitator and a sun-shade to protect the operator from direct sunlight.

The capacity of the machine is about 0.3 ha/h at forward speed 0.7 m/sec and field efficiency of 72.2%. Damage due to metering mechanism is nil for dry paddy and about 0.6% for soaked paddy and soybean. The ratio of established plants to seeds sown was about 86% for soaked paddy seeds and 79% for dry paddy seeds. The production cost of the prototype is about Baht 13,300 and it will meet breakeven point at about 4.2 ha/year compared to broadcasting and 1.8 ha/year compared to hand transplanting.

Introduction

Direct seeding and transplanting are two general methods for planting rice. The primary difference between the two methods is that in the transplanting method, seedlings are first raised in a seedbed before they are planted whereas in direct seeding, the seeds are sown directly in wet or dry field. Slow planting operation was identified as one of the major constraints to upland crop production in the Philippines (Villaruel and Duff, 1977).

Drill seeding in dry soil makes the use of a mechanical seed drill feasible. It improves soil structure since pudding is minimized. The method eliminates seedbed preparation in a nursery, care of seedlings in the seedbed, pulling seedling and hauling and transplanting operation. Direct seeded rice may mature 7 to 10 days earlier than transplanted rice (Ganjoo, 1985).

Fertilizer use efficiency on upland rice was 50% to 60% and on flooded wet land rice 30% to 50% (Prasad and De Datta, 1979). Deep placement of fertilizer can increase fertilizer use efficiency (Khan, 1983). Deep placement of fertilizer increases grain yield of maize significantly. (Syarifudin et al., 1981). The saving of labor and seeds and increasing fertilizer use efficiency may substantially reduce production cost.

Weeding is a problem if broadcast seeding is used. The weeding problem is less in row seeding because it allows the use of mechanical weeders. This is true especially in countries where chemical weed control is not yet widely practiced due perhaps to the fact that herbicides are too expensive for the ordinary farmer.

The IRRI and UPCA researcher are of the opinion that there are no significant differences in the yeild of transplanted or direct seeded rice if good management practices are used with each method. The problem in direct seeding and fertilizer application is to devise suitable methods which would reduce labor cost further, increase fertilizer use efficiency and minimize rat and bird infestation on germinating seeds.

Previous Works

A 3-row manually-operated seed drill was designed and constructed for jute (Husain et al., 1979). The problem of this machine was the inaccuracy of the metering device. Jadav (1977) tested a seed drill with fluted roll metering device, hoe type furrow opener and V-shaped solid iron press wheel. Post sowing packing resulted in better germination, seedling emergence and higher yield.

Choudhary (1988) developed a 2-row multi-crop inverted T seeder for upland crop establishment. The seeder used an inverted T groove opener. The plant establishment was maximum at 77% for corn, 46% for soybean and 65% for mungbean.

The IRRI has designed a multi-crop upland seeder. This is power tiller- or animal-drawn, 5-row seed cum-fertilizer drill for seeding into conventionally tilled soil. This seeder was more economical to use than the traditional method (Singh et al., 1988). However, the machine was heavy and expensive and the seed metering mechanism needed improvement.

The IRRI designed also an inclined plate planter for conventional and reduced tillage planting. The furrow opener is a special narrow coulter that opens a slit in the soil for seed placement. However, the seeder is limited for sowing into well prepared soil and seed metering ability was limited to few seed sizes or species (Chaudhary, 1988).

A rolling injection planter was designed for reduced and zero tillage. It has performed well on untilled light textured soil and on tilled, dry soil. However, in relatively wet soil the soil sticks between the injectors stopping the seeds from falling into the seed holes. In relatively dry heavy soil, inadequate penetration of the injector causes shallow seed placement and low percentage germination (Chaudhury, 1985).

Totok and Gupta (1990) developed an 8-row direct paddy seeder for dry land. This paper describes the conversion of this machine into seed-cum-fertilizer drill.

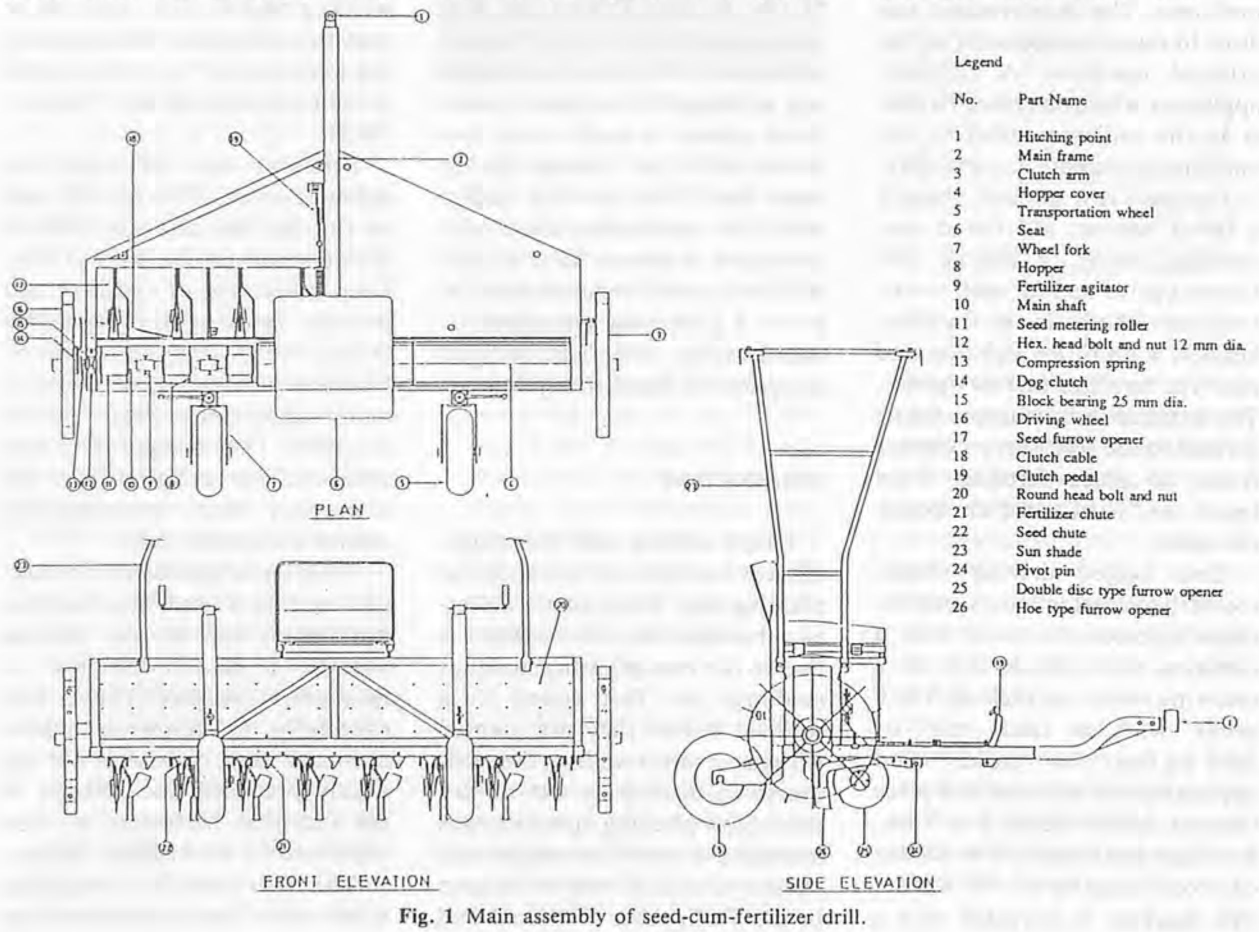

Fig. 1 Main assembly of seed-cum-fertilizer drill.

Material and Methods

The main assembly of seed-cum-feertilizer drill is shown in **Fig. 1**. The following are the main components of the machine: frame, hitching point, ground wheel and lifting mechanism, seed hopper, fertilizer hopper, fertilizer agitator, seed and fertilizer guide, driving wheel, metering roller shaft, seed metering roller, seed furrow opener, fertilizer furrow opener, marker, operator seat and sun shade.

Laboratory Tests

The laboratory tests included: test of metering mechanism, germination and breakage of seeds, and seed and fertilizer distribution test.

Test of Metering Mechanism

In the case of the seed metering mechanism, three tests with two kinds of seeds filled to full, one-half and one-eighth of hopper capacity with 6 replications were carried out.

For the fertilizer drill, five tests at different shutter openings with 6 replications were carried out. This test was also done by running the seed-cum-fertilizer drill with full outfit over a greased plastic sheet at the same speed as in the field. The seeds and fertilizer were trapped in the greased sheet at the point where they fell.

Germination Test

Germination tests were conducted for dry seeds and soaked seeds before and after passing through the metering roller. In the case of soaked seeds, they were soaked in water for 24 h. After soaking the seeds were cleaned and put in the plastic net for 6 h to allow the moisture on the surface of seeds to evaporate.

Field Performance Test

Field performance tests were carried out to obtain actual data, overall machine performance, operating accuracy and work capacity. During the tests, soil moisture content, bulk density, clod size distribution and cone index were measured. Field performance tests were conducted with two replications, and two treatments. The treatments were planting with dry seeds and soaked seeds.

Performance and accuracy test consisted of delivery rate, row spacing, population of seeds planted in unit area, population of established plants in unit area, ratio of established plants to seeds planted, skid and ease of handling and operating.

Work Rate and Labor Requirement

The parameters measured and observed were average traveling speed, operating hours, time for turning at head land, time for supply of seeds and fertilizer, time spent for adjustment of machine, time spent for machine troubleshooting, working capacity (ha/h), draft, fuel consumption, required number of workers and man-hours.

Measurement of Draft

A load cell was attached to the front of the two-wheel tractor on which seed-cum-fertilizer drill was trailed. A 4-wheel tractor was used to pull the seed-cum-fertilizer drill and 2-wheel tractor through load cell.

A strain amplifier was used to amplify voltage signal generated by the load cell. The amplified signals were recorded in a portable tape recorder in cassette. The recorded signals in the cassette were transferred to digital and stored in diskette through data logger and micro-computer.

The parameters measured were: rolling resistance of seed-cum-fertilizer drill and two wheel-tractor, draft of seed-cum-fertilizer drill with seed and fertilizer furrow opener and two-wheel tracotor, draft of seed-cum-fertilizer drill with only seed furrow opener and two-wheel tractor, draft of machine to rotate metering mechanism and two-wheel tractor, and rolling resistance of 2-wheel tractor only. The traveling speed and power requirement were also calculated.

Results and Conclusions

The machine was pulled by a Japanese type two-wheel tractor. The movement of the machine rotated the driving wheels which, in turn, rotated the seed metering roller and fertilizer agitator at the same time. Slots in the metering roller picked up seeds in the hopper and dropped them to furrow through the seed tube. The agitator agitated the fertilizer in the fertilizer hopper to avoid bridging. The fertilizer flowed down to the furrow through a shutter opening and chute. The fertilizer furrow opener was set 5 cm beside the seeds and 2 cm below the level of seed furrow opener. It cuts the soil surface and inverted the soil to cover seeds in the furrow. As the angle of inclination of the side walls of the furrow opened by the fertilizer furrow opener is higher than the angle of repose of soil aggregates, the fertilizer furrow gets closed automatically. **Fig. 2** shows the side view of the machine.

The overall dimension of the machine are: length, 1.96 m; width, 2.19 m; height, 2.08 m and weight, 217 kg. Adjustable spring loaded double disc type furrow openers can place seed at the

Fig. 2 Side view of seed-cum-fertilizer drill.

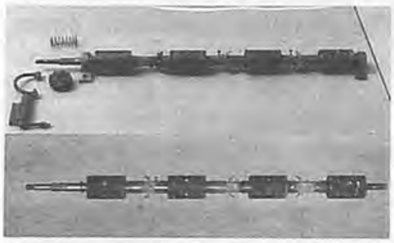

Fig. 3 Seed metering roller and fertilizer agitator assembly for paddy seed (top) and for soybean and maize (bottom).

Fig. 4 Fertilizer shutter opening adjustment.

desired depth 2-5 cm following the ground contour.

The hoe type furrow opener, fixed on the disc furrow opener frame, can place fertilizer 5 cm beside the seed row and 2 cm under the seed level. This furrow opener can cover the seed furrow

Fig. 5 Paddy plants 7 days after sowing using seed-cum-fertilizer drill.

Fig. 6 Paddy plants 15 days after sowing using seed-cum-fertilizer drill.

Fig. 7 Paddy plants 45 days after sowing using seed-cum-fertilizer drill.

with soil completely.

The delivery rate of paddy seed was about 15.8 kg/ha with inter-row spacing of 25 cm. For soybean, it was about 41.7 kg/ha with 50 cm inter-row spacing.

Damage to dry seeds due to metering mechanism was nil but damage on soaked paddy seeds and soybean seeds was about 0.6% each.

The delivery rate of ammonium phosphate fertilizer (16-20-0) can be varied from 5 kg/ha to 130 kg by adjusting the shutter opening.

The two driving wheels with 16 lugs on each wheel rotated the metering mechanism and fertilizer agitator mounted on the same shaft with skid of about 11%. The fixed flute of the metering roller can pick up 2-7 paddy seeds in each flute and with adjustable slot, it can pick up 2 to 4 soybean seeds in each slot.

The power required to operate the seed-cum-fertilizer drill at 0.65 m/sec operation speed was about 0.75 kW which consisted of 0.25 kW to overcome rolling resistance, 0.32 kW to pull disc furrow opener, 0.16 kW for pulling fertilizer furrow opener and 0.02 kW to rotate the metering mechanism and agitator. The power available at the Kubota two-wheel tractor with 8 hp (5.9 kW) engine is adequate to operate this machine.

The field capacity of seed-cum-fertilizer drill is about 0.3 ha/h at 0.7 m/sec operating speed with circuitous rounded corner operation pattern.

The average number of paddy seeds per meter length of row was about 19, that of the established plants per meter length of row was about 16 for soaked paddy seeds and 15 for dry paddy seeds. The number of established plants per sq. meter was 61 for soaked paddy seeds and 57 for dry paddy seeds.

The ratio of established plants to seeds sown in a unit area was about 86% for soaked paddy seeds and 79% for dry paddy seeds. Soaked paddy seeds grew faster than dry paddy seeds.

The machine has the capability to make sharp turns and cross small bunds and ditches and is easy to operate.

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(Continued on page 32)

Adoption Behavior of Farmers on Tractor-operated Reaper in Punjab

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Abstract

A study was conducted on the adoption behaviour of farmers towards the tractor front-mounted vertical conveying reaper of selected manufacturers in the state of Punjab (India) for harvesting wheat crop. Purposive sampling was followed for the selection of two districts whereas the reaper owners were selected on random basis. Data was collected through personal interviews of the farmers—the actual users. A sudden declining trend in the purchase of such reapers was evidently observed after a couple of years of their good initial sale. Various reasons contributing to this declining trend have been identified in this paper along with reactions of the farmers regarding the functional performance of the machine and other related problems.

Introduction

Mechanized harvesting, particularly in the labour-deficit areas like in Punjab, is very important in minimizing avoidable losses as well as for timely harvesting of wheat crop. About 4,000 combine harvesters are being used in Punjab for harvesting wheat and paddy but the farmers have not fully adopted this machine due to high initial cost, loss of wheat straw and extra tillage operations required for preparing land for the next crop. A front-mounted and pto-operated reaper-windrower was developed in 1983 by the Punjab Agricultural University which evoked much response from the farming community of Punjab. Consequently, about 3,000 machines were manufactured by as many as 50 manufacturers of Punjab. Initially, the sale of the machine showed a rapid rising trend but it started declining considerably after 1985. There were conflicting reports about the performance of this machine. The designers, Garg and Sharma (1984), claimed that farmers did not face any major problem while operating this machine and could harvest 0.4 ha in 1 hour. It was also reported that a farmer could save about 60% of harvesting cost of wheat through the use of the reaper. However, Bhatia and Dhaliwal (1987) revealed through a field survey of reaper owners that the farmers were not satisfied with the performance of the machine as there were functional problems like choking of star-wheels, blunting of knives, slippage of belt and collecting and tying of harvested crop.

In veiw of the conflicting reports about the functional performance of the reaper, it was planned to study the adoption behaviour of farmers on this machine. The components of adoption behaviour which were included reactions of farmers about the performance of the machine, their purchase behaviour and problems faced during its operation. In addition, the reasons for the decline in the use of the reapers were also identified.

Methodology

A purposive sampling plan was followed for the selection of the study area and simple random sampling for the selection of the

27 reaper-owning farmers in the districts of Ludhiana and Sangrur. Ludhiana was selected as a highly mechanized district and Sangrur as a district with low level of farm mechanization. A list of reaper-buyers in the study area was collected from the 12 leading manufacturers of tractors in Punjab.

An interview schedule was developed and pretested before administration. Data and relevant information were collected through personal interviews of the farmers. The reapers owned by the farmers were physically checked to ensure that the design of the machine was based on the prototype model developed by the Punjab Agricultural University. Important specifications of the prototype machine (**Fig. 1**) are presented in **Table 1**.

The data was analyzed in terms of frequencies and percentages of various parameters of the study.

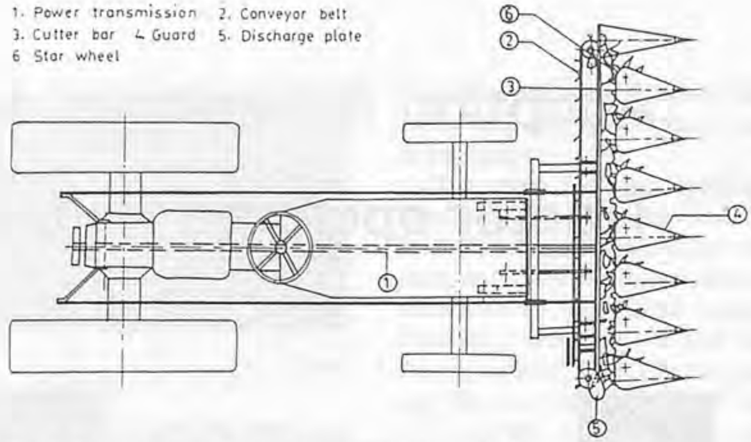

Fig. 1 Tractor-mounted vertical conveyor reaper-windrower (top view).

Table 1. Important Specifications of the Prototype Reaper Developed by the Punjab Agricultural University, Ludhiana

Particulars	Specifications
Cutting width of machine	2.14m
Length of machine	0.76m
Height of machine	0.78m
No. of row dividers	7.00m
Starwheel diameter	0.28m
Cutter bar stroke	0.76m
Lug spacing	125mm
Diameter of conveyor pulley	152mm

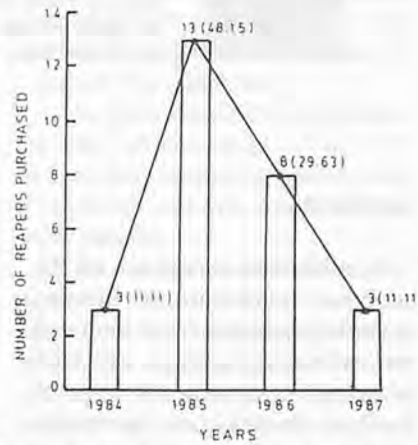

Fig. 2 Purchase behavior of farmers about reaper in the study area.

Results and Discussion

As already pointed out, the adoption behaviour of reaper-owning farmers was determined through their purchase behaviour, reactions about the performance of the machine, breakdowns during operation and reasons for the declining trend in the use of the machine. Therefore, the findings of this study, presented under these headings, are discussed below.

Purchase Behaviour

As shown in **Fig. 2**, the purchase of reapers increased until 1985 and started decreasing thereafter. This decline in the purchase of the machine may be attributed to the operational problems observed in the machine which are identified in later sections. The phenomenon of sharp increase in the purchase behaviour may be attributed to the publicity of the innovation through mass media and the extension agency whereas the linear decline may be explained by the process of diffusion effect. As the early adopters faced problems with the performance of the machine, this feedback was spread in the rural community through words-of-mouth. The impact of the diffusion was so high that the innovation lost its credibility.

Farmers' Reactions about Suitability of the Reaper

The suitability of the reaper was ascertained through farmers' views on labour saving, height of cut, after-sale service of reaper, types of breakdowns and their causes. These are stated below briefly.

Labour saving—It has been observed that farmers, in general, realised that the reaper had advantages in harvesting the crop faster because of the higher field capacity, provided there was no field problem encountered during the operation of the machine. However, the harvested crop cannot be handled with the same pace and the purpose of saving labour and time was forfeited.

Height of cut—Most of the farmers were not satisfied with this machine because of its higher height of cut, that is, 10 to 20 cm. It caused a loss of straw and difficulty in seedbed preparation for subsequent crops.

After-sale service—It was revealed by all of farmers that none of the manufacturers was providing adequate after-sale service. It was also reported by the farmers that as a result of frequent breakdowns of the reaper, they had to face many problems in repair as the spare parts were not easily available.

As indicated in **Table 2**, none of the farmes was satisfied with the after-sale service provided by the manufacturers. Only a few were partially satisfied whereas more than 60% were not satisfied at all with the after-sale service.

It was pointed out by the reaper-owning farmers that the interest of the manufacturers was to sell more machine and had no concern for caring about those reapers already sold.

Breakdowns in Reaper

The reaper-owning farmers, at the time of interview, were asked to identify the name of the components of the machine which broke down during operation. On the basis of their responses, as many as 12 components of the reaper were found to have broken down with different magnitude. Their frequencies and percentages were analyzed and for the sake of systematic description these are presented below in three categories.

1. The components with breakdown of more than 20%, in the order of their magnitude, of breakdown were blades (37%), guards (33%) and weldings (22%).
2. Components with breakdown of 7 to 11% were star wheels (11%), belt, bearings and nuts and bolts (all 7%) and other components with breakdowns of 3 to 4%.

The components indicated were lugs, gear box, pitman shaft, chain and shaft of lift. The frequencies and percentages of all these components are shown in **Table 3**. It can be inferred from the description that the most troublesome parts, as far as their breakdown is concerned, were guards and blades.

Causes of Breakdowns

The reasons for the frequent breakdowns in the operation of reaper, based on the response of the reaper-owning farmers are shown in **Table 4**. It was observed that the maximum breakdown in blades, guards, and welding failure, etc., was due to height of bunds present in the fields. Moreover, poor materials played a major role in breakdowns, as it could not withstand high thrust and vibrations.

Reasons for Declining Use of Reapers

As already observed, the sale of the reaper showed a declining trend despite the claim of the designers that the machine was appropriate. Therefore, the farmers were asked to pinpoint the reasons for this decline. On the basis of responses of the farmers, the magnitude of reasons were analyzed. The reasons thus identified appear in **Table 5** and are described in the following section.

Non-availability of spare parts—As most of the machines were being manufactured by small scale manufacturers, the interchangeability of parts in them was not easily possible. This was due to the fact that jigs and fixtures were seldom used for fabrication of various components. No spare parts were available in the nearby market. For this reason, the farmers had to go to the same manufacturers from whom they purchased the machine irrespective of their precision and possible interchangeability.

Lodged crop—It was reported by about 74% of the farmers that the machine did not work well if the crop was lodged. In the preceding two or three seasons the crop had been mostly lodged due to bad weather conditions, hence the reapers were not used for harvesting wheat.

Labour problem—About 41% of the farmers reported that more labour was not easily available at the peak harvesting season for collecting the crop (two persons are required for reaping and 5-7 persons for collecting the crop). In Punjab, harvesting is mostly done on contract basis. The sharp, taper cutting of the crop caused injury to the finger tips and legs of workers while collecting the crop. Thus, farm laboures was not will-

Table 2. Level of Satisfaction of Reaper-owning Farmers about After-sale Service

Level of satisfaction	Frequency	Percentage
Fully satisfied	0	0
Partially satisfied	10	38.50
Not satisfied	16	61.50
Total	26	100

Table 3. Breakdowns of Various Components of Reapers Reported by Farmers

Components broken	No. of farmers reporting	Percentage of total breakdowns
Blades	10	37.03
Guard	9	33.33
Welding failure	6	22.22
Star wheel	3	11.11
Nuts and bolts	2	7.41
Belt	2	7.41
Bearings	2	7.41
Lugs	1	3.70
Gear box	1	3.70
Pitman shaft	1	3.70
Chain failure	1	3.70
Shaft of lift	1	3.70

Table 4. Causes of Breakdowns in Reaper

Causes of breakdown	Percentage (%)
Bund problem	26
Poor material	25
Lodged crop	11
Obstacles through trash	10
Excessive vibrations	7
High speed	6
Loose bearings	6
Operaters laziness	3
Chocking of crop	3
Lack of lubrication	3

Table 5. Reasons for Declining Use and Sale

Reason	Frequency	Percentage
Non-availability of spare parts	27	100.00
Lodged crop	20	74.07
Labour problem	11	40.74
Loss of straw	5	18.52
Weed problem	4	14.81
Frequent breakdowns	3	11.11
Others	4	14.81

ing to collect the crop harvested by the reaper.

Loss of straw—The Punjab agriculture, generally, is tubewell irrigated and, therefore, there are greater numbers of bunds in the fields. The operator has to lift up and down the machine frequently which is not easy to do. The average bund height observed was 10-20 cm. The operator, therefore, kept the machine 10-20 cm above the ground surface. It was reported by 19% for the farmers that as the high-yielding varieties grown are generally of short stature and thus was substantial loss of straw. Even the straw obtained was not of good quality as it contained sufficient awns (*kasirs*), which are not good for animal consumption. So the main advantage of harvesting the crop was eliminated and the farmers had to go for combine instead of manual harvesting by sickle.

Weed problem—It was reported by about 15% of the farmers that the machine did not give good performance if weeds were present in the field.

Frequent breakdowns—About 11% of the farmers observed that there were many breakdowns in the machine, in the present form. The breakdowns of guards, blades and welding failure due to excesive vibrations, were quite frequent. Moreover, the farmer had to go to the same manufacturer for the replacement and repair of the components.

Conclusions

The following conclusions can be drawn from the field study:

1. None of the farmers was satisfied with the after-sale service provided by manufacturers.
2. The users, by and large, were not satisfied with the functional performance of the reaper due to frequent breakdowns and failures.
3. The maximum breakdowns and failures observed in reapers included breakage of blades, guards, and welding. These breakdowns were due to bund problems, poor material of reaper components and lodged crop.

Therefore, the main emphasis should be given to the mechanical improvements of the reaper. The farmers should also be given proper training for operating the machine in the field. A reaper-binder machine should also be introduced for ease of harvesting operation, including proper tying and collection of crop.

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(Continued from page 28)

Development of Two-wheel Tractor-operated Seed-cum-Fertilizer Drill

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Groundnut Harvesting Machine for Northern Nigeria

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Abstract

Groundnut is a major export crop in Nigeria. A large-scale production rehabilitation of the crop is being carried out and a harvesting machine that could be locally manufactured would be an asset. A machine is proposed which consists of a digging share followed by a flexible disc lifter consisting of two reinforced plastic discs which grip the loosened plant just above the soil surface. As the discs rotate at approximately ground speed, they lift the plant and present the roots and pods to a rotor to which is fitted in a series of fingers made of steel spring wire. A series of laboratory and rig tests were undertaken using local varieties of groundnut on the lifting discs and pod stripper. The results show that a machine suitable for local manufacture and capable of carrying out all the harvesting operations at one time in the sandy, dry soil condition prevailing with approximately 10kW power input at 1 km/h with little pod loss is feasible. A possible design of a full scale machine is suggested.

Introduction

Up to the mid-70s, Nigeria was a major producer and exporter of groundnut. The effects of petroleum discovery at the time, and the 1975 groundnut rosette epidemic were some of the main factors that resulted in a reduced production of the crop and, consequently, a complete halt in its export (**Table 1**).

One of the main problems faced by an oilseed programme to rehabilitate groundnut production in large scale to satisfy the local needs and to re-stimulate export is the heavy losses due to late harvesting caused by the general lack of manual labour during the critical harvesting period. This makes it desirable that new methods and machinery are introduced. After carefully studying the farming system, the local manufacturing factors and the harvesting operations involved, three basic needs became apparent:

1. Manual labour requirement had to be reduced;
2. Weather risk at harvest had to be reduced by introducing higher harvesting rates; and
3. The harvesting system had to be suitable for local manufacture and maintenance.

Groundnut Harvesting Operations and Methods

Groundnut harvesting operations are summarised in **Fig. 1**. In Nigeria, manual harvesting is customary; animal power is rarely used for digging. In highly mechanised methods (typically in the U.S.A.), tractor-powered digger-shaker windrowers and combines are used. In the Nigerian context, constraints on production due to manual labour shortage (mainly due to overlap of harvesting period with other staple food crops) exist in all the crop producing areas. On the other hand, existing harvesting machines are mainly unsuitable because they are expensive (requiring foreign exchange to acquire and maintain), are economically unsuitable to small/medium farm holding sizes and require highly skilled operators as they are designed for a different market.

Table 1. Contribution of Groundnut to Nigerian Foreign Trade, 1961-1978

Year	Total value of exports Nm*	Value of groundnut production exported (Nm)	Percentage groundnut of total
1961	348	74.4	21.0
1962	337.2	77.4	22.0
1963	379.2	56.4	22.8
1964	429.2	94.0	21.9
1965	536.8	106.0	19.8
1966	568.2	110.3	19.4
1967	483.6	93.6	21.6
1968	422.6	104.6	24.8
1969	636.3	103.4	16.3
1970	885.4	77.8	8.8
1971	1293.3	38.8	3.0
1972	1434.2	35.9	2.5
1973	2278.4	86.8	3.8
1974	5794.8	22.2	0.4
1975	4929.3	0.8	0.01
1976	6751.1	3.6	0.05
1977	8673.5	1.9	0.02
1978	6064.5	—	0.00

* Nm = Million Naira.

The Machine Design

The following main machine

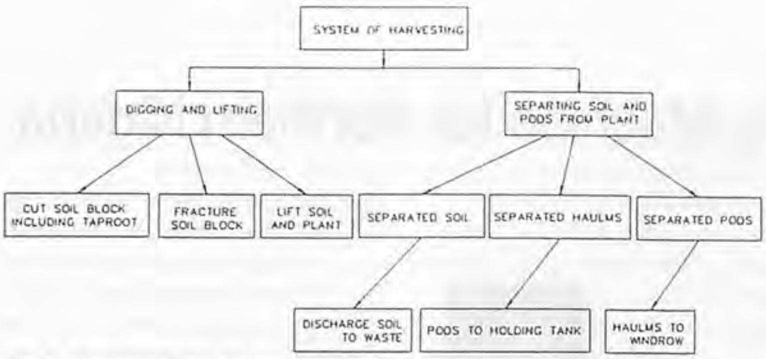

Fig. 1 Function chart for groundnut harvesting.

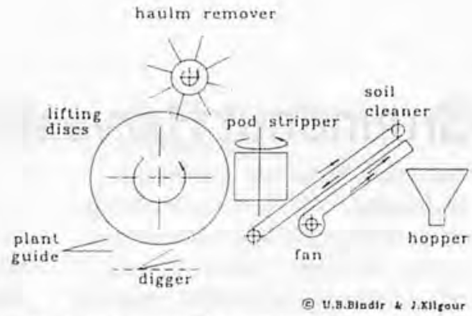

Fig. 2 The proposed groundnut harvesting machine.

specifications were listed as a design guide:

The machine should

1) Harvest crop at a higher rate than the manual method (approximately 0.1 ha/man/day for digging);
2) Carry out as many harvesting operations as possible in one pass;
3) Use fewer people;
4) Be able to leave haulms in good condition for hay making (the hay has a reasonable haulm as animal feed);
5) Be compatible to local manufacture and maintenance;
6) Be "simple" and safe to use; and
7) Have a power requirement compatible with existing tractors.

Existing techniques and machine methods were investigated to determine if the systems could be adapted for Nigerian conditions. Attributes of the once-over harvesting method was favoured over the single operation methods because of short time available. Existing once-over harvesting techniques generally would be too complicated for the Nigerian manufacturer, being too large in size and high in cost. Thus a harvesting machine consisting of four major units was proposed (**Fig. 2**). It is relatively simple, could be locally manufactured, has few moving parts (therefore will have low maintenance cost), can carry out all the harvesting operations in one pass and will leave the haulms in good condition for hay making.

Machine Description

The principal parts of the machine consist of the lifting and stripping units. These were constructed and tested in the laboratory. The lifter consisted of two fibre-reinforced plastic flexible discs of one meter diameter each, 100 mm centre to centre apart, open at the front but closed at the back, and the stripper consisted of a vertical rotating drum of diameter 300 mm on which are mounted pod stripping metal fingers 165 mm long each. The lifter was tested on a setup consisting of a field simulator on which were mounted simulated groundnut plants in Silsoe, U.K. This arrangement allowed the relative speeds of the lifter and the machine forward speed to be varied. The lifter/stripper test-rig arrangement (**Fig. 3a** and **b**) was then installed in Maiduguri, Nigeria, where it was tested on fresh groundnut plants. It was fitted with an electric motor/v-belt transmission arrangement to give a range of speed settings.

Pod Stripping Tests

The experiment involved freshly harvested plants being fed to the lifter at a pre-set machine forward speed by hand. The pods were then stripped by the rotor. The stripped material was collected and separated into whole pods; damaged pods and impurities (leaves, roots and stems). The unstripped pods were manually

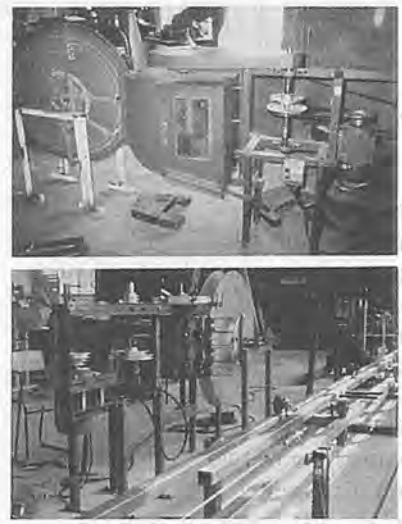

Fig. 3 (a, b) The groundnut harvester test-rig.

removed from the plants and all these were weighed and expressed as a percentage of the total pod input. Six forward/lifter speeds and six pod stripping speeds were used to asses the machine pod stripping effectiveness; total pod stripping loss and stripping power consumption.

Definitions and calculations were as follows:

1. The acceptable orientation to lift plants is straight (radial to discs) with no stems hanging out of the lifter.
2. Total pod input is the total number of pods on plants per/test run before feeding into the machine.
3. Stripping effectiveness (%) = [(total pods stripped)/Total pod input] × 100.
4. Total pod stripping loss (%) = [(stripped broken pods) + (unstripped pods)/total pod input] × 100.

5. Stripping power consumption is the total power required to strip pods, break up plant stems and roots in the stripping volume, and power required to overcome the rotor inertia.

Results and Discussion

An individual analysis of variance was performed on each set of data. Comparison of the means was performed using the normal significant test (F-test followed by the LSD calculation).

Plant Lifting Orientation

The relationship of the forward/lifter speeds to give the required plant lifting orientation is shown in **Fig. 4**. The relationship is given by a linear equation ($Y = 1.05 \times - 0.04$) indicating that

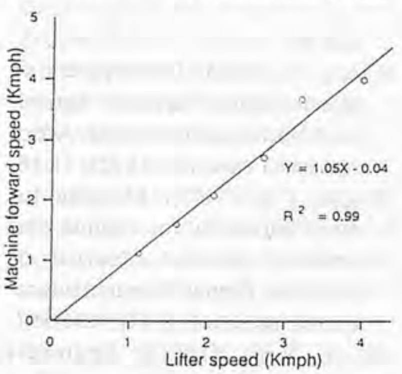

Fig. 4 Relationship between forward and lifter speeds for required plant lift mode.

the lifter speed should be approximately equal to the machine forward speed for the required plant lifting orientation. With this method of harvesting, this factor is important because if much of the plant stems are exposed out of the lifter, the quantity of impurities after stripping will be high, which makes it more difficult to clean the pods. The power requirement of the stripper is also likely to increase due to the effects of the exposed stems and increased trash in the cleaner section.

Rig Tests

A forward speed of 1 km/h and lifter speed of 1 km/h was chosen; and stripping speeds of 165, 207, 212, 250, 266 and 321 revolutions per minute were selected with a stripping finger spacing of 7.5 mm. The rig performance data is summarized in **Figs. 5** and **6**.

Pod Stripping Effectiveness

On all machine settings, it generally exceeded 80% and increase with an increase in stripping speed for the range of stripping speeds tested.

Total Pod Loss

The highest pod loss indicated was 15%. This dropped as the stripping speed increased due to reduction in pod damage as the stripping speed increased.

Stripping Power Consumption

Analysis of the different components of the overall power consumption indicated that the actual plant stripping power consumption is independent of stripping speed. However, the total stripper power requirement is exponentially related to the stripper speed (**Fig. 6**). This is due to the stripper rotor behaving like a fan as the speed increased. Thus it was clear that the pod stripping effectiveness could be increased and the pod loss reduced by operating the stripper at higher speeds without any significant increase in pod stripping power.

Total Power Requirement

Besides the lifting and stripping power, the other main power requirement is pulling the lifting share through the soil to cut the taproot and loosen the soil around the pods.

Total power requirement of a single row machine, including the draft requirement was predicted to be approximately 10 kW (13 h) (**Fig. 7**). This requirement is within the power range of the tractors (30 to 70 h) commonly used in Nigeria.

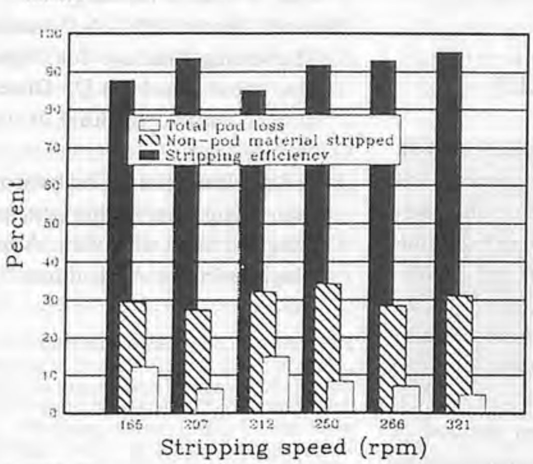

Fig. 5 Test-rig performance data summary.

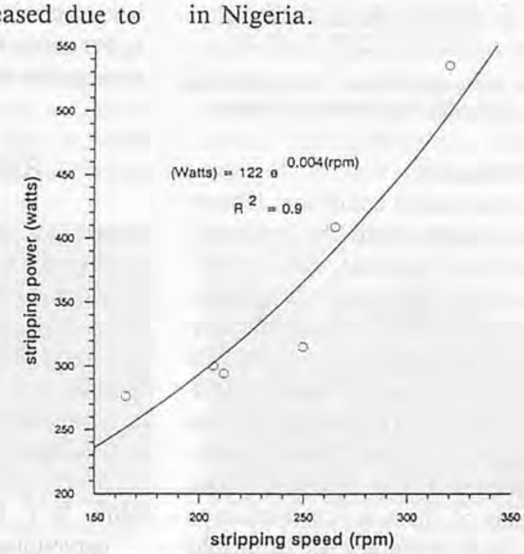

Fig. 6 Stripper power (overall) requirement.

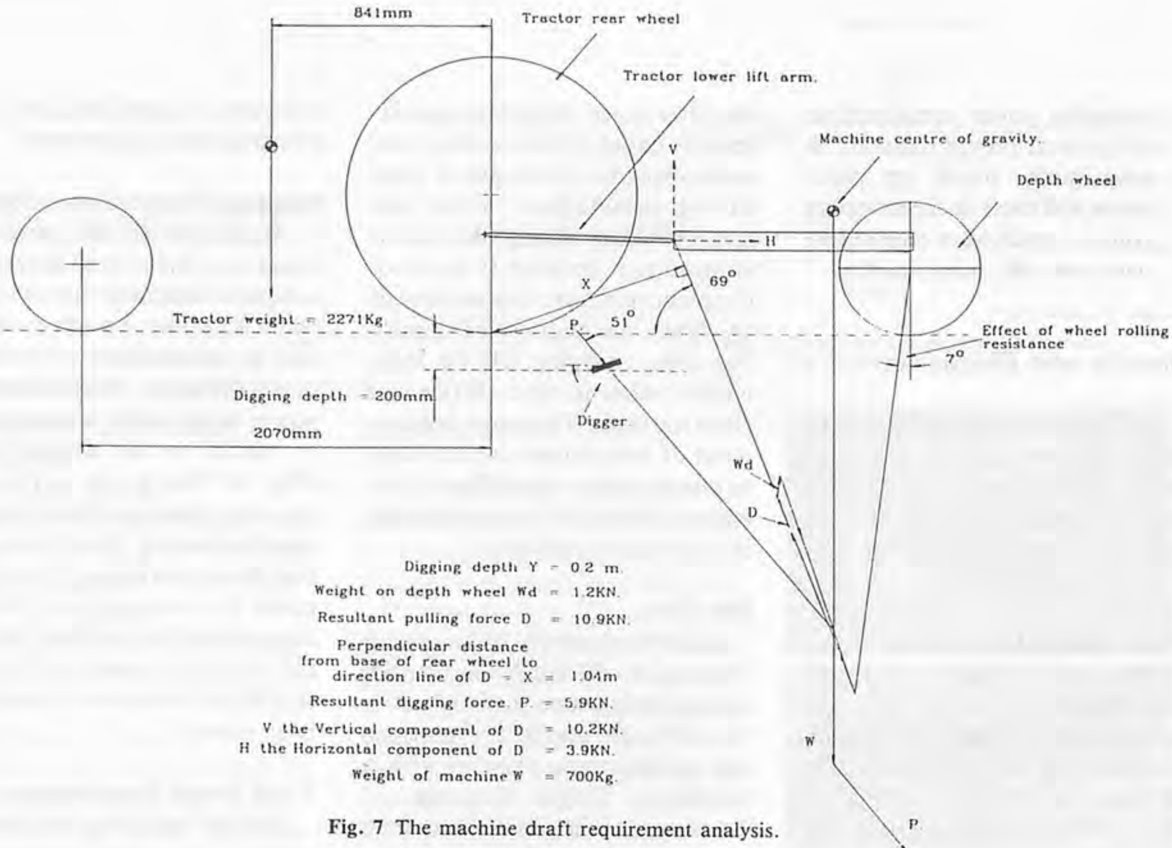

Fig. 7 The machine draft requirement analysis.

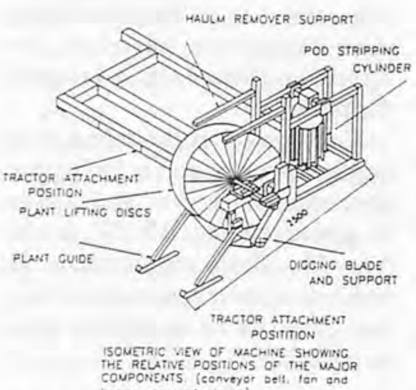

Fig. 8 An isometric view of the proposed groundnut harvesting machine.

Performance

In the present condition, labour requirement could be reduced from the manual 430 man-hours/ton to 20 man-hours/tonne at a capacity of 0.7 tonnes per day using two operators. Pod loss will be reduced from as high as 50% down to 15%. Haulm loss due to late harvesting could be completely eliminated. The theoretical cost analysis of the machine indicates that it is suitable for multiple (cooperative farming groups) ownership or use through machine service hire schemes both of which accomodate the present financial constraints of the farmers.

Conclusions

From the laboratory, rig tests and calculations, we concluded that a tractor-mounted, once-over harvesting machine is possible (**Fig. 8**) and would be suitable both technically and economically for manufacture in Nigeria for use by the farmers.

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Comparative Performance of Different Methods of Groundnut Threshing

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Abstract

Three groundnut threshers, namely; power-operated double drum thresher, power-operated single drum thresher and pedal-operated thresher were tested at their optimum speeds to thresh groundnut of variety AK-12-24. Their performances were evaluated and compared with those of conventional manual methods. It was observed that the power-operated double drum thresher, single drum thresher and pedal-operated thresher have a threshing capacity of 59 kg/h, 23.38 kg/h and 10.94 kg/h which leads to a threshing cost of Rs. 0.20/kg, Rs. 0.37/kg and Rs. 0.73/kg, respectively. The conventional method of pulling pods from the vines or by beating the pods over the edges of a stretched bamboo strip takes a very long time and have a capacity of 3.22 kg/h and 3.31 kg/h which leads to a threshing cost of Rs. 0.96/kg and Rs. 0.97/kg, respectively. Hence, the power-operated double drum thresher is preferred to either power- or pedal-operated single drum thresher to save labour, time and thus minimising threshing costs.

Acknowledgement: The authors are thankful to Prof. D.K. Das, Head of Dept., Farm Machinery and Power, Dr. S. Swain, Chief Research Engineer, FIDU, and Prof. S.C. Pradhan, Assoc. Prof., Power Tiller Scheme, CAET for their valuable suggestions and providing facilities for the research.

Introduction

In Orissa, groundnut is one of the most important oil seed crops. It is grown in an area of about 250,000 ha and its production is 14.34 quintals per ha which is the highest in India. The production of groundnut in Orissa has rapidly increased over the last 10 years and is expected to increase further in the coming decade. Therefore, suitable labour saving machineries should be used by the groundnut growers to tackle harvest and post-harvest operations for this crops. It is observed that early separation of pods gives not only sufficient time for drying but also in fetching good market price. In the conventional method, the groundnut are threshed generally by pulling the pods from the vines or by beating the pods over the edge of a stretched bamboo strip immediately after harvest or after spreading the plants under the sun for 24 to 48 h for drying. Moreover, the output of manual stripping is very low and dependent on the efficiency of the worker. Therefore, a labour-saving machine, i.e., mechanical threshing, helps a farmer for speedy and timely threshing and minimizes the tediousness involved in manual threshing.

Important factors affecting the mechanical threshing are pod moisture content, peripheral speed of machine and types of threshing elements. Keeping the same threshing element (peg type) in mind, three groundnut threshers were developed in CAET with

Fig. 1a Conventional manual hand picking of groundnut.

Fig. 1b Conventional manual beating of groundnut over the edge of bamboo strip.

different specifications. The comparative performance of the three groundnut threshers were evaluated for a most commonly grown groundnut variety of AK-12-24 of Orissa at different moisture content levels and their output were corrected at 14% moisture content (wb) and 40% pod vine ratio.

Objectives

The twin objectives of the study were: 1. To compare the performance of three groundnut thershers developed with that of conventional method, and 2. To recommended a suitable thresher for the local farmers based on good performance and low cost of operation.

Materials and Methods

The construction features of the double drum groundnut thresher are two threshing cylinders of dia. 33 cm and length of 45 cm each. The cylinders were made of 1.25 mm m.s. sheet and kept 15 cm apart on the same shaft. Vertical spikes (m.s. rod) of dia. 0.6 cm and length of 5 cm with smooth rounded ends were welded on the surface of each cylinder in staggered manner. A blower unit consisting of two blowers made of 1.5 mm m.s. sheet were mounted 15 cm apart on the same shaft. Two pulleys of 25 cm dia and 12.5 cm dia were mounted in the middle of the cylinder shaft and blower shaft, respectively, which were driven by the motor. A sieve

Fig. 2a Power-operated double drum groundnut thresher (0.5 hp motor).

Fig. 2b Power-operated double drum groundnut thresher (driven by power tiller).

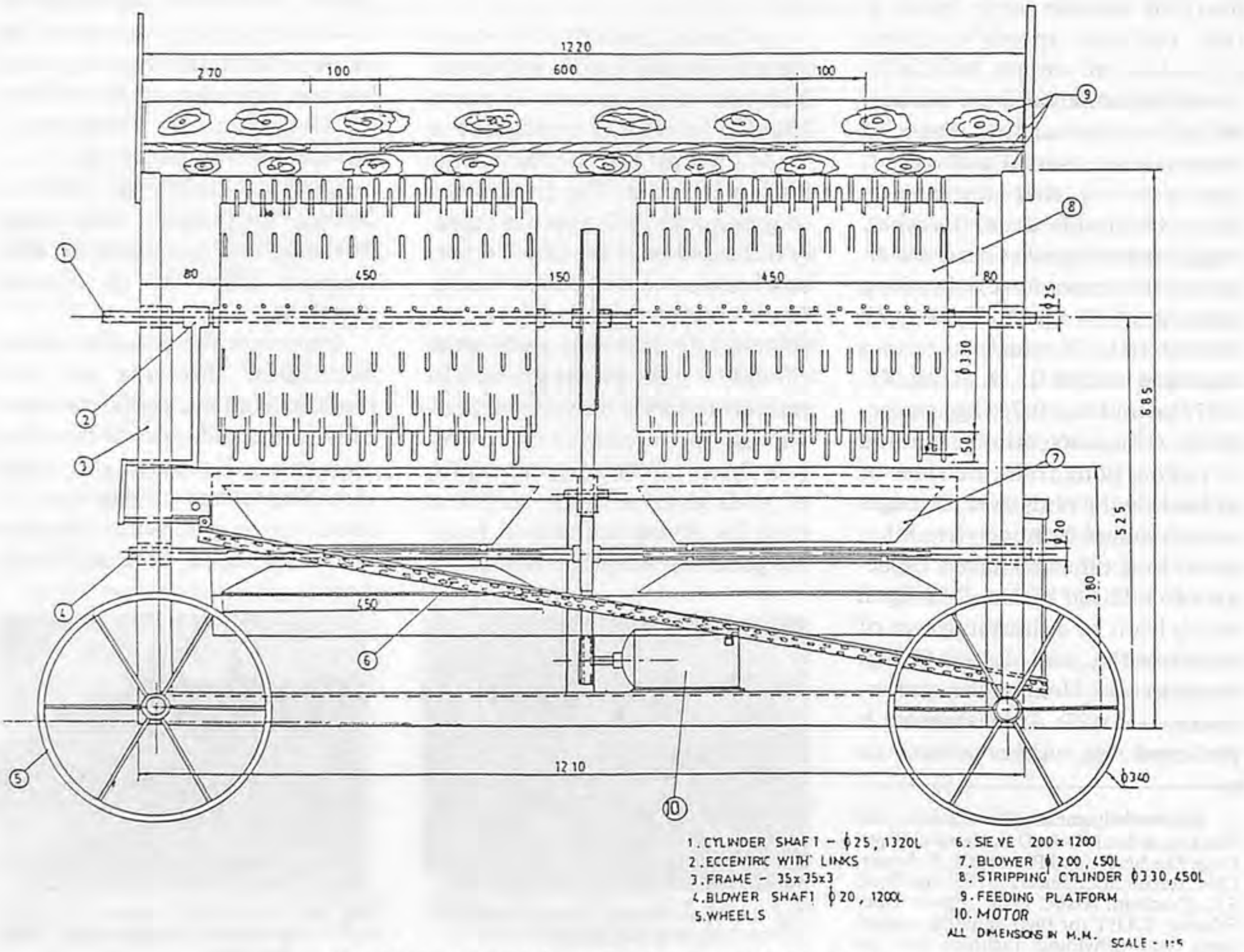

Fig. 2 Power-operated groundnut stripper (Double drum).

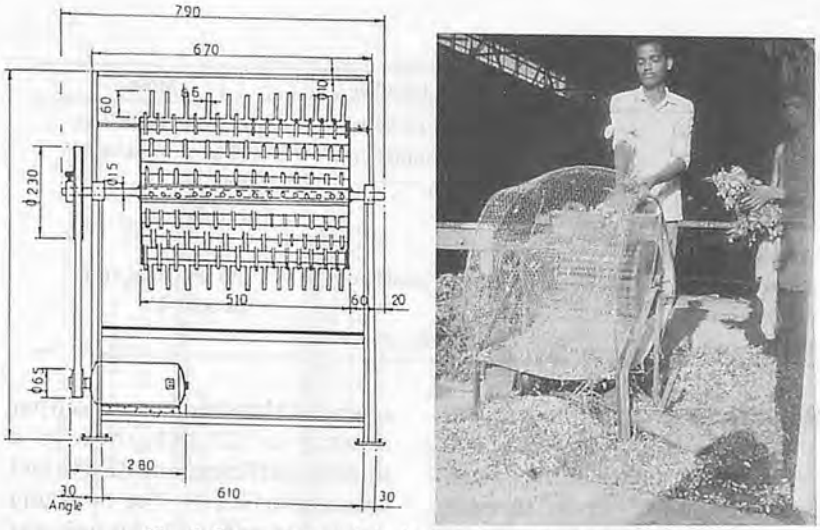

Fig. 3 Power-operated single drum groundnut thresher.

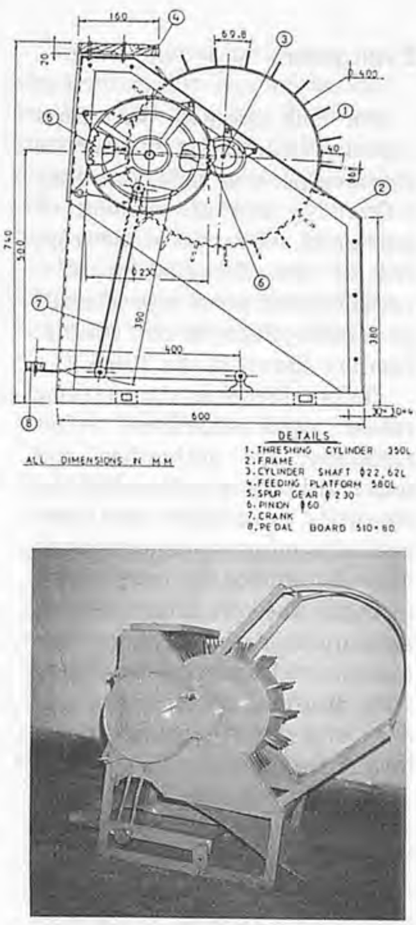

Fig. 4 Pedal-operated groundnut thresher.

and a shaker unit were provided in front of the thresher. This machine can be operated with 0.5 hp electric motor or by a power tiller/stationary engine. The details of the thresher is shown in **Fig. 2**.

On the other hand, the single drum thresher consisted of a threshing cylinder (slated) of dia 33 cm with a length of 45 cm. The vertical spikes of dia 0.6 cm with a height of 5 cm were mounted on the slats at a spacing of 3.5 cm apart in staggered manner. This unit was operated with a 0.5 hp electric motor. The details of the unit are shown in **Fig. 3**.

The pedal-operated groundnut thresher has a threshing cylinder made of 1.25 mm m.s. sheet of dia 40 cm and length of 35 cm. The vertical spikes of dia 0.6 cm with a height of 4 cm are welded on the surface of the cylinder in staggered manner. This unit was assembled with a set of gear and cranking lever attached to a foot pedal and was operated by a man/woman by moving the foot pedal up and down by foot. The details of the unit are shown in **Fig. 4**

Treatments

The following five treatments were evaluated. Their specifications are given in **Table 1**

i) Double drum groundnut thresher—power-operated;
ii) Single drum groundnut thresher—power-operaed;
iii) Single drum groundnut thresher—pedal-operated;
iv) Conventional method of pulling out pods from vines; and
v) Conventional method of bearing the pods at the edge of stretched bamboo strip.

Table 1. Specification of Groundnut Threshers

Particulars	Power-operated double drum thresher	Power-operated single drum thresher	Pedal-operated thresher
Make	CAET	CAET	CAET
Type	Power	Power	Power
Overall dimensions (cm)			
Length	122	85	58
Width	98	50	60
Height	92	95	74
Thresheing unit type	Cylindrical drum, peg tooth arranged in staggered manner	Cylindrical slated drum, peg tooth arranged in staggered manner	Cylindrical drum, peg tooth arranged in staggered manner
No. of threshing drums	two	one	one
Dimensions of main parts (cm)			
Cylinder dia.	33	33	40
Cylinder length	45	45	35
Height of pegs	5	5	4
Dia of pegs	0.6	0.6	0.6
Power transmission system	V-belt	V-belt	Gear and crank with pedal operated lever
Provision of blower	Provided	—	—
Method of feeding	Hold on type	Hold on type	Hold on type
Labour requirement	3 women/men	2 women/men	2 women/men
Cost (Rs.)	Rs. 2358.00 (excluding motor)	Rs. 1000.00 (excluding motor)	Rs. 1600.00

Evaluation

For each threshed, the output capacity, i.e., the quantity of pods threshed per unit time, threshing efficiency, moisture content of pods, pod/vine ratio of the crop, cost of operation (fixed costs + variable costs) per h were calculated. Assumptions for cost calculation are shown in the **Table 2.**

Before threshing, the pod/vine ratios were calculated. After threshing, the unthreshed and uncleaned pods were removed and cleaned manually and the pod/vine moisture content levels were determined by over drying method. The corrected threshing capacity for each threshing treatment was determined by taking 14% moisture content (wb) and 40% pod ratio by using the following formula:

$$W_1 = [W - \frac{W(m-14)}{86}] \times \frac{40}{R}$$

Where

W_1 = Corrected output capacity
W = Observed output capacity
m = Observed moisture content (w.b.)
R = Observed pod/vine ratio (%)

Table 2.

Item	Thresher	Motor
Life of thresher	8 years (2500 h)	15 years (15000 h)
Salvage value	5% of initial cost	10% of initial cost
Annual use	312.5 h	1000 h
Interest	14.5%	14.5%
Annual cost shelter	1.5%	—
Repair and maintenance cost	5% of initial cost	5% of initial cost
Power cost	—	Rs.0.70/kW
Labour cost	Rs. 25.00/day of 8 h	

Results and Discussion

The performance of the power-operated double drum thresher was evaluated and compared with those of the single drum power/pedal-operated groundnut thresher and conventional method using groundnut variety AK-12-24. The results obtained are presented in **Table 3** and **Fig. 5**.

The power-operated double drum thresher has an output capacity of 59 kg of pods/h with a threshing efficiency of 96.78% and a breakage of 1.0%. The threshing cost/kg of pods with this unit was Rs.0.20 which is much less than the cost of other method sof threshing in comparison (**Table 3** and **Fig. 5**).

The single-drum power-operated thresher has an output capacity of 23.38 kg/h with a threshing efficiency of 99.5% and breakage of 2.1%. The threshing cost/kg of pods with this unit was Rs.0.37 which is approximately half of that of the pedal-operated thresher (**Table 3** and **Fig. 5**).

The pedal-operated thresher has an output capacity of 10.94 kg/h with a threshing efficiency of 98.8% and a breakage of 3.4%. This higher percentage of breakage is probably due to higher pod moisture content during threshing. The treshing cost/kg of pod with this thresher was Rs.0.73 which is Rs.0.23/kg less than that of the conventional manual method of hand picking (**Table 3** and **Fig. 5**).

In conventional hand picking

Table 3. Threshers' Performance Test Results

Particulars	Power-operated double drum thresher	Power-operated single drum thresher	Pedal-operated thresher	Conventional method	
				Hand picking	Beating over bamboo strip
Power required	0.5 hp	0.5 hp	—	—	—
Labour required	3 women	2 women	2 women	—	—
Crop variety	AK-12-24	AK-12-24	AK-12-24	AK-12-24	AK-12-24
Optimum RPM	450	360	300	—	—
Peripheral speed (m/min)	608	486	452	—	—
Blower speed, rpm	900	—	—	—	—
Observed output (kg/h)	72.00	48.00	36.52	7.5	7.71
Pod/vine ratio (%)	42.85	63.00	96.00	98.95	98.85
Moisture content (w.b.)%	24.49	34.00	38.14	8.40	8.40
Corrected capacity (kg/h)	59.00	23.38	10.94	3.22	3.31
Threshing efficiency, %	96.78	99.50	98.80	100.00	96.94
Breakage, %	1.00	3.00	3.40	0.50	2.50
Cost of operation/h (Rs.)	12.00	7.78	7.54	3.12	3.12
Threshing cost/kg of pod (Rs.)	0.20	0.33	0.69	0.96	0.94
Cleaning cost/kg of pod (Rs.)	—	0.04	0.04	—	0.03
Total threshing cost/kg of pod (Rs.)	0.20	0.37	0.73	0.96	0.97

Both the power/pedal-operated single-drum thresher can be used by the small farmers. But where electricity is not available, the pedal-operated thresher is the only solution. The farmers who have their own Akhat paddy thresher (pedal-operated) can convert it into a groundnut thresher only by changing the threshing cylinder.

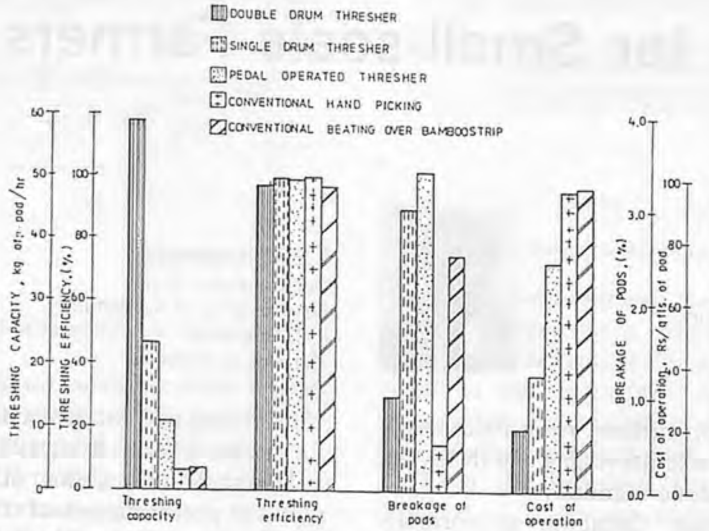

Fig. 5 Comparative performance of different methods of groundnut threshing.

Table 4. Breeak-even Use of Groundnut Threshing

Thresher	Breakeven use (ha)	Equivalent operating hours
Double-drum thresher	4.46	108.40
Single-drum thresher	4.14	253.92
Pedal-operated thresher	4.85	635.73

N.B.: $\text{Break even use (ha)} = \frac{\text{Annual ownership cost (Rs.)}}{\text{Custom rating (Rs./ha)} - \text{Operating cost of machine (Rs/ha)}}$

$\text{Equivalent operating hours} = \frac{\text{B.E.U. in max production (kg/ha)}}{\text{Capacity of machine, kg/h}}$

Average production of groundnut in Orissa = 1434 kg/ha

method and beating over the bamboo strip, the threshing capacity per hour per worker was 3.22 kg and 3.31 kg, respectively, which leads to a threshing cost/kg of pods to Rs.0.96 and Rs.0.97, respectively. This shows that threshing cost by both these conventional methods were almost similar but for workers' comfort and easyness, beating over the bamboo strip which is prefered by farmers when large quantities of groundnut are to be threshed.

Conclusion

The cost of operation as well as threshing cost/kg of pods is lowest for the double-drum thresher. Hence, where electricity is available or farmers with stationary engine/power tiller, this thresher can be used efficiently. Though this machine is of high cost as compared to the other threshers, it has a high output per unit time and its break-even use is only 108.4 h.

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Bean Thresher for Small-scale Farmers

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Abstract

A hand-operated bean thresher was designed, developed and tested at the Dept. of Agric. Engineering, Sokoine University of Agriculture, Morogoro.

The threshing mechanism is a rubberized wooden cylinder and a concave with rubber rasp bars. A winnowing mechanism was also incorporated in the design. The thresher was tested for its threshing capacity, threshing effectiveness, seed damage and winnowing effectiveness on two local bean varieties, TMO 241 and TMO 216.

Results obtained gave a threshing effectiveness of 82.26% and 85.6% for TMO 241 and TMO 216, respectively. Threshing capacity was 15 kg/h and 13.8 kg/h for TMO 241 and TMO 216, respectively. Seed damage was 2.7% for both bean varieties. Winnowing effectiveness was 94% at 360 rpm fan speed and the winnower throughput capacity was observed to be 240 kg/h giving 104 kg/h of clean seed.

Introduction

Bean (*Phaseola vulgaris*) is one of the most important pulse crops in Tanzania. It is widely grown and consumed in many parts of the country. Majority of bean producers are small-scale farmers whose plots are about 0.5 of a hectare. In such a scale of farming all the operations, from field preparation to harvesting and threshing, are done manually.

Bean threshing is normally done by women using the following methods:

i. Striking a heap of whole plants with sticks on bare ground, or mats or sisal bags;
ii. Trampling by animals; and
iii. Opening the pods by hand.

In the first two methods, severe damage is caused to the bean seeds resulting in low germination vigour. On the other hand, the method of opening pods by hand is tedious and time consuming.

Bean threshing machines exist in developed countries but are very expensive to buy and maintain. Their introduction to Tanzania has ignored the primary needs of the peasant farmer while concentrating on large-scale projects. New ideas and novel approaches are required to meet the following requirements:

i. Ability to thresh high-moisture crop and cause low levels of damage to the bean seeds;
ii. Higher threshing outputs compared to manual threshing; and
iii. Easy to construct, operate and maintain.

Mechanical methods which are used world-wide to thresh beans include the following categories:

i. Drum and concave made of steel
ii. Double belt type and
iii. Cylinder and concave made of rubber (Adolf et al, 1985)

Michael and Ojha (1978) reported performances of different sources of power for threshing. Engine-operated threshers were found to have the highest capacity (200-500 kg/h) followed by treading with bullock (144 kg/h), pedal-operated threshers (40-50 kg/h) and hand-beating (17-29 kg/h). However, the quality of winnowing depended on air velocity, its uniformity and rate of feeding of the material (Kashyap and Pandya, 1966).

Materials and Methods

A rubberized cylinder and concave type of thresher was designed and constructed. The cylinder was consstructed of wood 300 mm in diameter and 300 mm long. The log was fixed on a 20-mm mild steel shaft which was supported by two wooden bearings. The bearings were then fixed onto a 50 × 50-mm angle iron frame **(Fig. 1)**.

On the surface of the wooden cylinder, six strips of used tyres were bolted. Half of the strips were 6 mm thick and the other were 3 mm thick. The different sizes were then fixed alternatively. The cylinder was then connected to a power drive shaft through a bicycle chain.

The concave was made from a 16-gauge sheet metal. The lower part of the concave was connect-

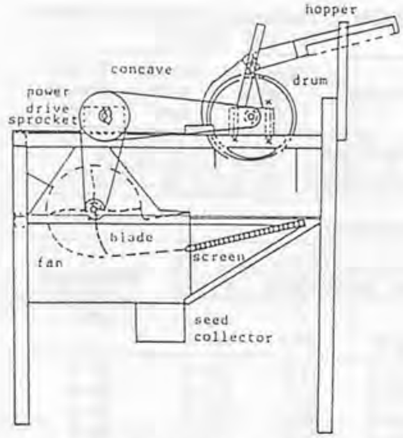

Fig. 1 A hand-operated bean thresher.

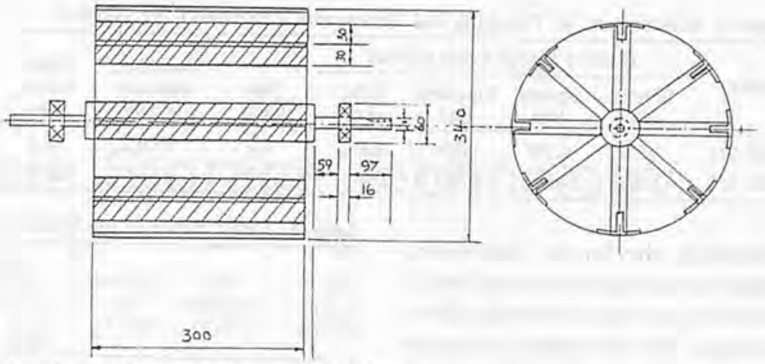

Fig. 2 Threshing cylinder: a rasp-bar drum.

ed to two moveable plates screwed on to the frame so as to enable adjustment of the clearance. Three used tyre strips were also fixed to the concave to serve as rasp bars (**Fig. 2**). The strips were 60 mm wide and 5 mm thick and were placed at 50 and 20 mm apart at the lower part of the concave.

A winnnower mechanism was also designed and constructed using a 16 guage mild steel metal sheet. A fan was constructed from a 20-mm mild steel shaft and four 360 mm × 210 mm-curved metal sheets to form fan blades.

The fan housing was made from metal sheets and fixed in such a way that the clearance between it and blades is 50 mm. The fan was fixed diagonally below the threshing mechanism. An air duct from the fan was inclined at 20°. Above the duct a screen with 16 mm holes was placed. The screen was located 280 mm below the drum (**Fig. 1**).

The fan was driven from the same power drive shaft as that of the drum through a bicycle chain. The arrangement was such that one person could operate the thresher.

Two bean varieties TMO 241 and TMO 216 at moisture contents of 13.0 and 16.7 (w.b.), respectively, where used to test the thresher. The time taken to thresh each sample was measured using a stop watch. After threshing, seeds which were completely separated from the pods were collected and weighed. Unopened pods were thumb-opened and the collected seeds were weighed separately. The ratio of the opened seeds to the total seeds in the sample was calculated to determine threshing effectiveness.

From the threshed beans a handful of seeds was randomly picked and weighed. Seeds which had visible cracks or pealed seed coat were sorted out and weighed. The ratio of the damaged seeds to the total seeds in the sample was calculated to determine percentage seed damage.

The performance of the thresher was compared with the traditional threshing method, that is, hand-beating. In this method threshing was done by placing the samples on grass, concrete or in a sisal bag. Threshing continued until the individual called for a rest. This was taken as the endurance time.

The performance of the winnowing mechanism was tested on two bean varieties, at 25% moisture content (w.b.). The test was conducted using a 0.75 Hp electric motor with variable pulley diameters so that the fan speed could be varied. Fan speed was measured using a tachometer while air velocity was measured using hot wire anemometer.

A one-kg mixture of hand-threshed seeds and chaff were allowed to fall from the threshing mechanism while the fan is rotated. After the operation, the material in the seed collector was weighed. The chaff in the container was separated by hand and weighed. Likewise, blown off material was collected on a canvas and weighed. The seeds contained in the shaff were sorted and weighed. The effectiveness of separation was then calculated as winnowing index from the relationship:

$$I = (a/(a + c))\ (d/b + d) \qquad (1)$$

where:

a = weight of seeds in the seed collector (kg)
b = weight of chaff in the seed collector (kg)
c = weight of seeds blown off with chaff (kg)
d = weight of chaff blow off (kg)

Traditional winnowing was also investigated. One kg of the threshed material was randomly selected and winnowing was done by an experienced farmer against a natural windbreeze blowing at about 3 m/sec. The time required to winnow the mixture was measured using a stop watch.

Results and Discussion

The average endurance time using hand-beating method was 9.5 ± 1.1 minutes. The time was not affected by the type of surface. Moreover, the output was not affected by the type of surface and whether in sack or not. The threshing output was 30.3 kg/h which is close to the value reported by Michael and Ojha (1978). **Table 1** shows the effectiveness of threshing and throughput capacity of the thresher.

From the results it is observed that the TMO 216 bean variety was easily threshed than the TMO 241 despite the higher moisture

Table 1. Effectiveness of Threshing and Throughput Capacity of the Thresher

Variety	Threshed average weight of seeds				Time (min)	Throughput cappacity (kg/h)	Effectiveness (%)
	Material (kg)	Opened (kg)	Unopened (kg)	Total (kg)			
TMO 241	2.154	0.396	0.086	0.482	8.6	15.0	82.2
TMO 216	2.458	0.380	0.064	0.444	10.7	13.8	85.6

Table 2. Performance Bean Seed Damage for Two Varieties

Variety	Weight of sample (gm)	Damage seeds (gm)	Percent damage (%)
TMO 241	39.37	1.14	2.6
TMO 216	52.1	1.5	2.8

content in the former. However, there was no significant statistical difference in the threshing effectiveness. The throughput capacity was higher in the TMO 241 than in the TMO 216. The difference could have been attributed to the higher moisture content in TMO 216 which decreased the flow of the material and hence causing frequent clogging.

Seed damage intensity was almost similar for the two bean varieties although they were at different moisture content levels. The damage was very low and could be considered negligible.

Table 3. Performance of the Winnowing Mechanism

Fan speed (m/s)	Air velocity (m/s)	Air flow rate (m^3/s)	Winnowing parameters based on 1 kg mixture				Winnowing index (I) (%)
			a+b (gm)	a (gm)	c (gm)	d (gm)	
418	12.8	1.026	679.4	655.6	51.0	269.6	85.0
392	12.0	0.962	645.0	637.0	39.2	315.8	87.9
384	11.5	0.923	478.0	664.0	26.4	295.6	90.0
371	10.3	0.821	446.0	420.4	20.0	534.0	94.0
360	9.0	0.723	435.0	420.0	0	56.5	80.0
346	7.4	0.592	719.0	575.6	0	280.5	78.0
320	6.8	0.542	725.0	565.5	0	275.0	63.3

Table 3 shows the performance of the winnower mechanism. It is observed that the best performance was obtained at 360 rpm fan speed. This fan speed gave an air velocity of 9.04 m/sec which is about 1 m/sec above the terminal velocity of beans reported by Adolf et al (1985). At this air velocity the winnowing index was 94%. The lower index at higher air velocities was due to some seeds being blown off with the chaff as the velocity was exceedingly higher than the seed's terminal velocity. At lower air velocity, on the other hand, the low index was due to chaff falling into the seed collector, that is, air velocity was insufficient to blow off the heavier chaff particles.

During winnowing 15 seconds were sufficient to complete the operation on 1 kg of the material. This gives a throughout capacity of 240 kg/h. On the other hand, traditional winnowing required 90 seconds to complete 1 kg of the material, which gives a throughput capacity of 40 kg/h. This value is about 16% that of the tested machine.

The low throughput capacity of the thresher could be increased by increasing the size of the drum both in diameter and in width. One way of increasing the throughput capacity is by preventing or minimizing clogging. This could be achieved by decreasing the distance between the rubber strips in the concave. Reducing the distance will prevent some of the material being trapped in between and ultimately reducing the clearance between the concave and the drum. Also, chopping part of the stems would reduce clogging.

The winnower was found to be very effective. However, its capacity is too high for the threshing unit. Its size should, therefore, be reduced so that it has the same capacity as the threshing unit. In so doing, the machine energy input requirement would be reduced substantially and, therefore, one person could operate it with less effort. To increase the mechanical efficiency, higher sprocket ratios for the power drive and drum and/or fan should be used.

Conclusion

A hand-operated thresher was designed and constructed. Although the machine was found to be low in throughput capacity compared to threshing done by hand the low seed damage makes it appropriate for threshing beans. Moreover, the capacity in hand-threshing did not take into account the winnowing time requirement. Once this is taken into consideration, hand-beating will have a throughput capacity of 10.9 kg/hr which is far less then that of the machine. The thresher is suitable to small-scale farmers.

It was difficult for one person to operate both the threshing and the winnowing units at the same time. When this was tried, enough air flow could not be obtained in the winnower to blow the chaff away. The energy required could be reduced by reducing the fan size and by using higher power drive sprocket/fan sprocket ratios so as to increase mechanical efficiency.

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Status of Grain Storage Technology in Bangladesh

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Abstract

It has been observed that the total annual food grain import of the public sector in Bangladesh is about 2 million tons which happens to be almost equal to the total post-harvest losses in the country (i.e., about 15% of the overall food grain production). It has also been shown that the losses during commercial storage alone is about 20%, among other post-harvest losses.

Prevention of storage loss appears to be one of the major factors to be considered in attaining self-sufficiency in food production. Common sense dictates that with the present trend of population growth, demand for food grain will grow along with increased storage capacity, both in the private (85%) and public (15%) sectors.

The present study suggests that it is necessary to pay immediate attention for the expansion of storage capacities and improvement of standard storage facilities in both sectors in Bangladesh. Otherwise, though the trend of storage loss may remain unchanged with the current standard of storage system, the quantity of post-harvest losses will be increased largely coming from storage losses.

Introduction

Bangladesh is an agricultural country. About 74% of the total land area is planted to rice which produces over 22 million tons of paddy annually (B.B.S., 1984). Due to increases in population, there is a gap between the quantity of food grain produced and quantity needed. So, every year Bangladesh has to import about 2 million tons of food grain to feed her people.

To minimize this food shortage, it is essential to reduce the wastage of food during storage. It has been reported that losses during commercial storage of paddy due to various causes is about 20% of the total stored paddy in Bangladesh **(Table 1)**. The FAO (1986) reported that post-harvest losses in Bangladesh represent about 15% of the total production. Paddy, wheat, maize, pulse and oil seeds are the major food crops of the country.

In most Asian countries, the weather is warm and moist with the ambient temperature and relative humidity. The distribution of paddy storage, damage and their causes during storage in some Asian countries are shown in **Table 2**.

In a tropical country like Bangladesh the temperature is very favourable for the fast growth of insects during food grain storage which contributes to the food deficit in the country.

Khan (1984) reported that procurement of food grain from external sources, storage, preservation, handling and distribution

Table 1. Commercial Storage Loss of Paddy and their Causes, Bangladesh.

Causes	Percent
Insects	10.00
Transit	5.00
Moisture	1.80
Rodents	2.70
Pilferage	0.20
Total	19.70

Source: World Bank through Carl. Bro. International and Others (1975)

Table 2. Distribution of Paddy Storage Damage and their Causes in Selected Asian Countries (in percent).

Country	Insect	Rodent	Moulds	Spoilage	Situation
Bangladesh[1]	10	2.7	—	5.2	Commercial levels
Philippines[2]	12	48	3	2	—
Vietnam[2]	10	40	—	25	Local market
Thailand[2]	8	50	—	8	Market level
India[2]	33	42	—	—	—

Source: 1. World Bank through carl Bro. International and Others, 1975.
2. Ritsuya Yamashita Laboratory of Agril. Process Machinery, Kobe University, Japan, 1975.

have attained great importance in the context of the need to develop the country's overall economy. The introduction of appropriate post-harvest technology in food grain procurement, handling, storage and in overall food grain management has become a great need: firstly, to prevent physical loss and secondly, to maintain a standard quality acceptable from nutritional as well as commercial point of view. Therefore, minimization of storage loss through improved methods and materials, including efficient storage structure, is an urgent need.

Existing Storage Practices in Bangladesh

Grain storage practices in Bangladesh can be divided into four categories: farm level storage, institutional level storage, commercial, and Government level storage.

About 85% of the total food grain storage is operated by the private sector, i.e., farmers, institutions, traders and millers. The balance is handled, stored and distributed by the Ministry of Food.

Farm Level Storage

Traditional storage structures used by farmers are made of indigenous materials readily available in the rural areas at low costs.

The size and use of these structures vary from region to region in the country. The common traditional structures are: *dole*, *gola*, *mossa*, *khari*, *jabar*, *pusa* bin, *matka*, *pitcher*, *kuthi*, bottle gourd shell, gunny bag, *jala*, kerosene tin, and steel drum. Huq (1980) estimated the farm level average losses of rice in different structures in Bangladesh to be 2.43%. Among them, the *dole* is the most common storage structure in Bangladesh **(Fig. 1)**.

Institutional Level Storage

There are many seed multiplication farms in Bangladesh: the Bangladesh Agricultural Development Corporation (BADC) farms; the Bangladesh Rice Research Institute (BRRI) farms; the Bangladesh Agricultural University (BAU) farms; and the Bangladesh Agricultural Research Institute (BARI) farms. These farms produce large quantities of grain for seed purpose and store them in their own godowns. During this storage, special care is taken for the preservation of seeds. Usually the moisture content of food grain is maintained at 12-13%. In the godown a small corrugated rectangular or circular bin is used **(Fig. 2)**. The normal capacity of each bin is 2-5 tons. On the floor and wall of each bin, two layers of bamboo mats are used for the prevention of direct heat transfer from the metal bin to grain. Different bins are made inside the godown for various varieties of food grain. Usually, rice is stored in bulk and bag storage **(Fig. 3)** are practiced by farm management people.

Commercial Storage

Wholesale businessmen and traders store food grains in gunny bags. They are not interested in investing on building standard warehouse. Usually they use a portion of their office/houses for storage which is closed and dark **(Fig. 4)**. They do not appreciate much the quantitative and qualitative losses in food grains.

The storage of paddy and milled rice with the rice millers is an important point for consideration. Their store houses are located nearby rice mill **(Fig. 5)**. Generally, the storage facility is made of brick with tin or thatched roof. The commercial storage sector uses the bag storage system. The capacity of each bag is 50-100 kg. Grains are filled in bags and

Fig. 1 Traditional storage structure, 'Dole'.

Fig. 2 Circular metal bin.

Fig. 3 Bag Storage.

Fig. 4 Trader's grain store.

Fig. 5 Miller's store.

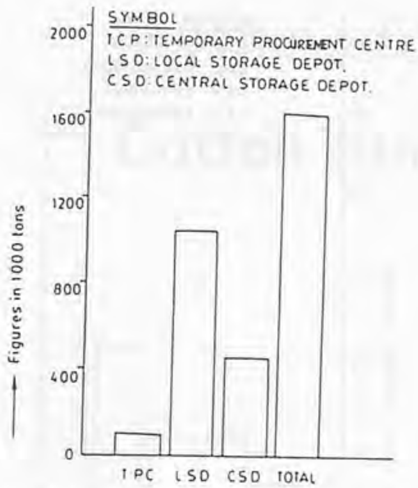

Fig. 6 Storage capacity of warehouses at Directorate of Food.

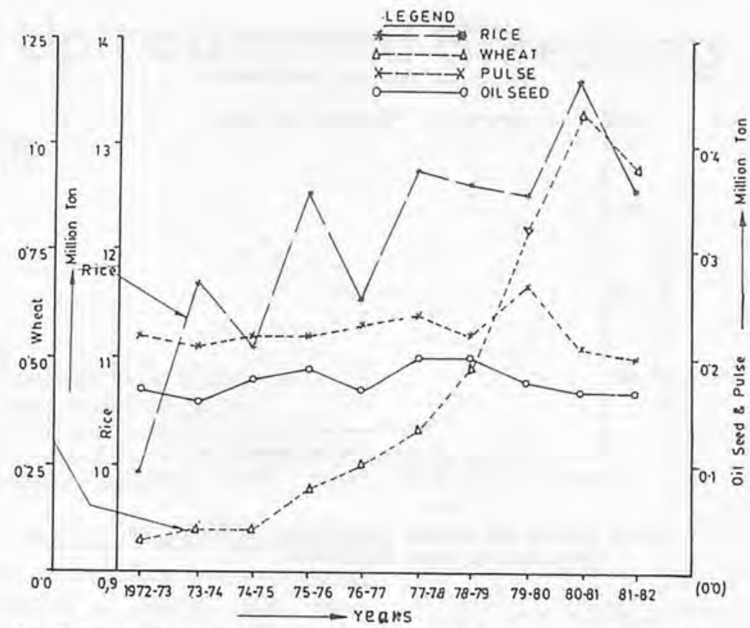

Fig. 7 Trends of major food crop production over 10 years in Bangladesh.

piled up in a stock on dunnage for final storage. Food dealers, traders and millers store grain for commercial purposes.

Government Storage

The Directorate of Food, Government of the People's Republic of Bangladesh is concerned in food grain storage. It is the main organization in the country that procures, preserves and distributes food. There are 400 temporary procurement centres (TPC), more than 600 local storage depots (LSD), 12 central storage depots (CSD) and 4 operating silos in Bangladesh. The BBS (1989) reported that the total storage capacity of different warehouses of the Food Department is about 1.6 million tons (**Fig. 6**).

Food Grain Production

Rice is the staple food in Bangladesh and wheat is the second most important food crop. More than 80% of the population depend on agricultural food crops like rice, wheat, pulse and oilseed. The trends of their total annual production over the last ten years are shown in **Fig. 7**.

Food Grain Procurement

Food grain is procured from both internal sources in the country and from abroad. The temporary procurement centres are located in the surplus food growing areas. For stabilization of price of the grain, the government starts to buy food grains with a standard price. During the rainy season, farmers bring wet paddy (above 14% moisture content) for selling to procurement centres which is usually refused by the buyer. The production and internal procurement of rice and wheat in the country are given in **Table 3**.

Table 3. Production and Internal Procurement of Rice and Wheat, Bangladesh.

Years	Internal procurement (Figures in 1000 tons)		Net production (Figures in 1000 tons)		% of procurement out of net product	
	Rice	Wheat	Rice	Wheat	Rice	Wheat
1979-80	225	120	12 540	810	1.79	14.81
1980-81	840	176	13 660	1 080	6.15	16.29
1981-82	285	13	12 600	950	2.26	1.37
1982-83	168	24	14 220	980	1.18	2.45
1983-84	149	124	14 156	1 175	1.05	10.55
1984-85	134	215	14 266	1 420	0.94	15.14

Source: BBS (1989).

From the total production, 10% of food grains represent for seeds, feeds and wastage. The requirement of food grain import is determined by deduction of the available quantity from the total food demand for the population. When the national shortage of food is assessed, the government finalizes arrangements for food aid or import. The total internal and external procurements of wheat and rice from 1979-80 to 1982-85 are shown in **Fig. 8**.

Silos

There are 5 modern grain silos in Bangladesh of which four are operated at present. These silos were constructed by Directorate of Food of the then Pakistan government in the late 1960s. Bulk storage practice exists in all silos of Bangladesh. They are constructed at four different places of the country; namely, Chittagong, Narayangonj, Ashugonj, and Santahar. Samajpati and Pedersen (1988) reported that the average

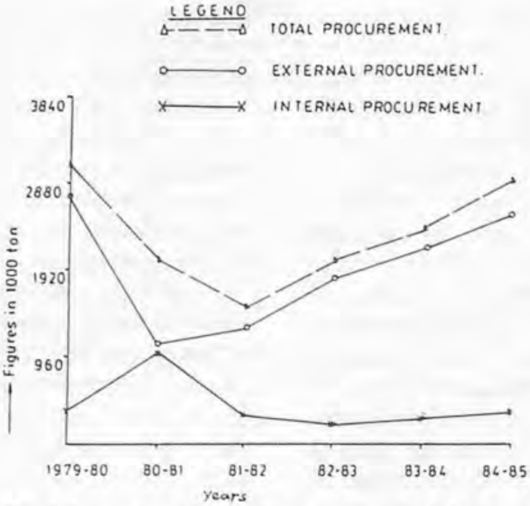

Fig. 8 Internal and external procurements of food grain, Directorate of Food, Bangladesh

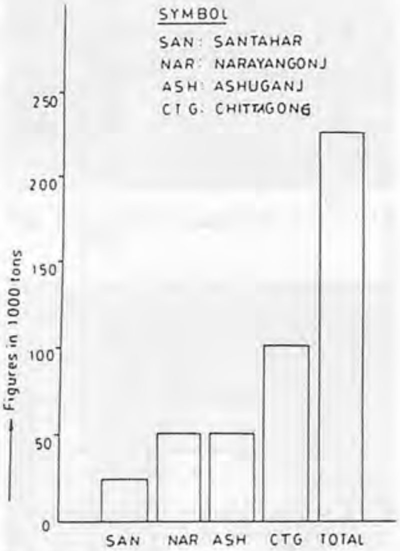

Fig. 9 Storage capacity of food silo in Bangladesh.

grain loss in silos is about 7.7%. These losses could be reduced by practising short period of storage, regular turning the grain and fumigation. The silos are operated mechanically. The capacities of the silos are shown in **Fig. 9**.

The storage bins of silos are vertical units made of continuous slip-form concrete. The cells have circular, star, and semi-circular sections each with capacity of 750, 450 and 175 tones. The capacity of the silos varies but the design are similar. The silos operate as receiving and transit depots for imported food grains.

Conclusions and Recommendations

From the above discussion it is clear that grain storage practices play important role in the post-harvest management of food crops. About 85% of the total storage is practiced by the private sector and remaining 15% by hte Directorate of Food. Many investigators are agreed that storage losses are needlessly high but can be reduced significantly through proper practices. Every year the country has to import about 2 million tons of food grain from abroad which is equivalent to the total post-harvest losses in the country. For the better food grain storage management, the following are recommended.

1. Improved method and storage structure should be developed and introduced at the farm and commercial levels.
2. At every procurement centre, the Directorate of Food should construct mechanical paddy drier for providing drying facilities for the centres themselves and for the farmers with a view to increasing the storability of grains without deterioration.
3. Research and development works should be strengthened regarding existing storage and handling system in Bangladesh.
4. To keep the grain in good quality in the traditional storage structures, wherehouses and silos, a feasible and efficient storage system should be developed and maintained throughout the storage period.

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Machine for Uprooting and Shredding Cotton Stalks

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Introduction

Uzbekistan is the main producer of cotton in the former USSR. It produces more than 60% of all-union crops. Uzbekistan is also the main producer of machinery for cotton seeding, growing and harvesting. The country has original machines for these purposes.

There are many original devices for hand-pulling and mechanized clearing of cotton stalks from fields in the world (1, 2, 3).

There are a lot of stalks left on the fields after cotton harvesting. The stalks are valuable raw material for agriculture and industry. The rural population use stalks as fuel and litter. The industry uses stalks for producing cellulose, furfurol, spirits, building materials, etc.

Mechanization of cotton growing and harvesting is very important, especially in virgin lands with low population density. Mechanization of cotton stalk harvesting has also considerable importance. It is important to uproot stalks and utilize them for disinfecting soil from bacterial wilt and other diseases.

Previous Works

There are many original devices for hand-pulling and mechanized clearing of cotton stalks from fields in the world (1, 2, 3).

There are few types of cotton stalks harvesting machines in Uzbekistan. Usually, the stalks are harvested by uprooters KV-4A and KV-3.6A (row distance is 0.6 m and 0.9 m). These four-row machines consist of frame, 4 blades, guiding lattices, 4 star-shaped feeders and conic reduction gears (**Fig. 1**). Such machine uproots stalks from 4 rows and lays stalks into collected strips (**Fig. 2**). The stalks are dried by sun and bundled by hand or by baler for further usage. These machines are fabricated by agricultural machine-building plants in the country.

The head specialized design bureau (HSDB) of cotton machinery and SAIM together build 2-row, uprooters-shreadders KI-1, 2 and KI-1, 8. They consist of a frame, 2 blades, 2 coupled pulling cylinders, and 2 cutting cylinders and pipes. The machine is mounted on tractor and it uproots cotton stalks by blades and pulling cylinders (**Fig. 3**). The uprooted stalks are shredded by knives of cutting cylinders and conveyed by pipes into a following trailer.

At the present time, the

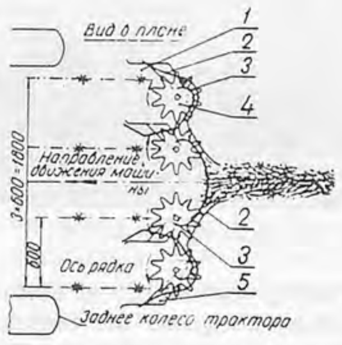

Fig. 1 KV-4A uprooter's scheme; 1-row of cotton stalks; 2- and 3-guiding lattices; 4-star-shaped feeder; 5-blade.

Fig. 2 Uprooter KV-3, 6A.

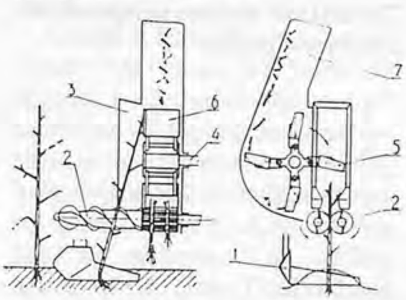

Fig. 3 Uprooters-shredders KI-1, 2 and KI-1, 8: 1-blade; 2-coupled pulling cylinders; 3-guide; 4-shaft; 5- and 6-knives; 7-pipe.

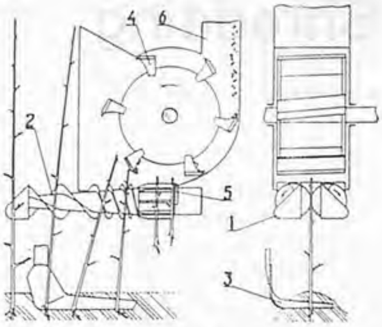

Fig. 4 KIV-4 uprooter-shredder's scheme: 1-guide; 2-coupled pulling cylinders; 3-blade; 4-cutting cylinder; 5-counterknife; 6-pipe.

Fig. 5 Uprooter-shredder KIV-4.

STAIME and HSDB of cotton machinery together are working out four-row uprooter-shredder KIV-4. The machine is semi-mounted with two gauge wheels and is powered by PTO and is shaft-driven. It consists of a frame, 4 blades, 4 coupled pulling cylinders, 4 cutting cylinders and pipes. The machine works as well as KI-1, 2 and KI-1, 8 (**Fig. 4**). The shredded stalks are also conveyed by pipes into a parallel trailer. The KIV-4 can also throw out shreaded stalks in the field if guides are mounted in place of pipes (**Fig. 5**). The SAIME has one sample of this uprooter-shredder.

Table 1. Agricultural Index of Uprooters-shredders

Index	KIV-4				KI-1,8
Speed of machine, m/s	0.73	1.00	1.30	1.56	1.64
Completeness of uprooting, %	99.62	98.65	98.70	98.77	98.47
Completeness of collection uprooted stalks, %	94.95	96.38	96.50	96.45	94.04
Structure of shredded stalks by length of cutting in %					
less 10 cm	91.62	90.81	89.73	89.65	72.12
from 10 till 15 cm	6.71	6.40	8.52	7.58	11.43
more 15 cm	1.67	2.79	1.75	2.77	16.45

Results and Discussion

The results of trials of KIV-4 and KI-1, 8 under laboratory and field conditions is shown in **Table 1**. The trials were carried out in the irrigated cotton area in Syr-Daria province. The cotton variety is Tashkenti; average height of plants is 101.4 cm; average width is 34.0 cm; average diameter at ground surface is 1.0 cm; density of plants is 100.8 thousand per hectare. The moisture content levels in shredded stalks were 31.35-33.23%.

Table 1 shows that the completeness of uprooting and collection of cotton stalks using KIV-4 and KI-1,8 satisfy the needs of agricultural technology, because they must be not less than 96% and 92%, respectively. The structure of shredded stalks by length of cutting of KIV-4 satisfy the needs of shredding, but one of the KI-1,8 does not satisfy because the quantity of shreds was less than 10 cm by length. The uprooter-shredder KIV-4 can satisfy needs of American farmers by length of cutting because one for their needs must be 15 cm (4).

Conclusion

Four-row uprooter-shredder KIV-4 can satisfy the needs of Central Asian and American cotton producers as they are useful for harvesting of cotton stalks.

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Needs and Prospects of Mechanizing Indian Agriculture

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Introduction

India today presents a diverse picture of development in agriculture. Indian farmers are slowly picking up modern techniques of crop cultivation and management such as using better and improved seeds, fertilizers, pest and weed control methods and better land preparation.

Agricultural production has increased significantly in the last 20 years even as it is outpaced by the country's booming population. The magic formula of the Green Revolution and HYV-fertilizer-irrigation are fully exploited. Moreover, the driving force of the Green Revolution, i.e., irrigation water, is also limited and is becoming scarce in many parts of the country. Therefore, there is at present a need for using other inputs for enhancing production. One of the vital inputs is farm mechanization for timeliness of farm operation and in reducing post-harvest losses.

The first step in making public policies and adopting new strategies is to review the present status. This paper presents the status of agriculture and food demand during the coming years. Methods of increasing agricultural production are suggested with special emphasis on the role of farm mechanization in increasing agricultural productivity.

Agricultural Growth Rate

Agricultural growth rate in India since the mid-sixtes has proceeded in cycles of sudden jump in one year followed by three or four years of stagnation around the peak point reached earlier, before the next jump comes. From 98 million tonnes in 1967-68 compared to the previous best of 89 million tonnes in 1964-65 and 74 million tonnes 1966-67, production moved to the next peak of 108.5 million tonnes in 1970-71. True to its cyclical character, for the next four years it remained stationary around that level. The next jump came in 1975-76 when it shot up to 121 million tonnes, to be followed again by three years of stagnation. The next peak was reached in 1978-79 when grain output rose to 132 million tonnes. Four years of decline and stagnation followed in grain production. In 1983-84 came the next spurt to 152 million tonnes. Since then the story has been that of stagnation in the subsequent two years, and of sharp decline in next two years. There was record food production of 170 million tonnes during 1988-89 due to good weather. As compared to 1983-84 there was an increment in production by 18 million tonnes but this increase on food front does not seem to be encouraging because during this period, population rose by another 50 millions.

The country has a vast number of genetically diverse livestock resources. Further, large efforts have been made to improve their production and productivity in the last two decades. This is reflected in an incredase in the last 20 years of milk production from 22.5 million tonnes to 45 million tonnes, egg production from 5.3 million to over one billion and broiler production from 4 million to over 100 million.

Current Food Grain Availability

A myth is being floated that the country has become self-sufficient in food, even though the country continues to depend on large imports of food grains. In 1988-89, India imported 2.01 million tonnes of wheat from U.S.A. costing $243.36 millions, 0.65 million tonnes of rice from Thailand and Vietnam costing $166.76 millions and 0.08 million tonnes of maize from Argentina costing $10.15

millions. On July 1 1989, the stock position of wheat was 13 million tonnes and that of rice was 2.9 million tonnes.

Food availability per person in the country is about 200 kg per capita per year whereas the recommended rate by Food nutritionist is 225 kg per year. Therefore, the country should produce at least 200 million tonnes of food grain to feed a population of over 850 million.

Pulses are the main source of protein for Indians. Inspite of the importance of pulses in the daily diet and agricultural production, their production has not increased proportionately to the increase in the cereal production. Over the past three decades the area, production and productivity have been swinging between 22 and 24 million ha, 10-14 million tonnes and 475-550 kg/ha, respectively. Since 1951 the population has quadrupled but the pulse availability per capita per day declined from 64 g to 36 g against the recommended 80 g of pulses. India will need about 25 million tonnes of pulses by the year 2000. With the present research and production inputs it seems quite difficult to achieve the requirement since pulses are grown on marginal lands and are prone to pest invasion and farmers tend to shift to more stable crops like wheat and rice.

New Orientation in Agricultural Production Policies

Indian agriculture needs a new orientation and technology to meet the country's food requirement for the coming years. The HYV-fertilizer-irrigation technology has reached a plateau in its potential for imparting growth to Indian agriculture. For future growth in this sector, the country has to look to new biotechnologies that are cost efficient as well as more in conformity with "natural climatic order" in the country which is largely rainfed agriculture and is bound to remain in the forseeable future. Of total area cultivated, over 70% is rainfed contributing only 40% to national agricultural production. Thus, about 60% of the total grain yield comes from 30% of irrigated area. From the 400 districts in the country, nearly 300 of these are virtually dependent upon rain. These are also the areas where majority of the rural population lives below poverty line. Interestingly, these districts produce the major part of protein, oil and fiber crops which are the major inputs to the agro-based industries. Stabilizing and elevating crop production in these areas should, therefore, hold the key to achieving stability of agricultural production and ensuring continuous supply of raw material to various food processingplants. Such efforts will not only help in easing poverty in dryland areas but will stabilize the life of people. The technologies needed to foster agricultural growth in this country have to be relevant to rainfed agriculture instead of irrigated agriculture. No doubt, the HYV-fertilizer-irrigation technology has played an historic role in giving the country its Green Revolution but it has outlived its utility. The problem today is to achieve a decisive breakthrough in raising land productivity and labour in rainfed agriculture and reducing instability in the agricultural production. This is precisely the reason why the Government has laid great emphasis on the development of dryland farming in the VIII Five Year Plan. A new technology has to be given to the Indian agriculture if the needed 4-5% growth rate has to be obtained in meeting the country's food demand in the coming years.

Increasing Agricultural Production through Farm Mechanization

There is no doubt that the production of food needs to be increased substantially over the coming decades. It would be naive to assume that an increase in the level of agricultural mechanization alone will be sufficient to achieve higher levels of farm production. It would be equally naive to assume that farmers can meet the food production targets of the coming years without access to more and better farm power and improved implements and equipment to utilize that power effectively and efficiently.

The process of mechanization contributes to agricultural development in several ways, but primarily through enhancing the power, process and precision of farm operations. Often, it augments the power used in farming operations by substituting power sources; first, substituting draught animal power for human labour; and second, mechanical for draught animal. Mechanization can improve yields through the improvement of water control, better soil preparation for planting, more efficient weed control, pests and disease management, proper and timely harvesting, handling, drying, storing and processing of food, feed and fibre crops. Timeliness of all these operations enhances yields of individual crops, maximizes the efficient use of each unit area of land throughout the growing season and reduce the drudgery of traditional farming.

A number of studies conducted in various parts of the country indicate that land productivity can be increased by 5-10% by proper tillage, 10-15% by using improved methods of seed placement, 10-15% by timely intercultural operations, 10-15 per cent by protecting the crops from diseases and pests, 10-15% by timely harvesting and 5-10% by using modern methods of crop threshing (Giles 1975, Kahlon 1976, Sharma et al. 1989). The average increase in the yield is about 10-20% through mechanization.

During the last 15 years, inspite of best efforts to increase the use of other inputs like improved seeds, fertilizers, plant protection chemicals, irrigation water, the productivity of food grains has not increased beyond 170 million tonnes. The production is more bleak in the case of pulses and oil seeds. One of the major reasons for this is the low level of utilization of agricultural machinery for timely and judicious application of the above inputs (Kachru and Srivastava 1989). If appropriate hardware is used, it will not only maximize efficiently these inputs but will also save the costly inputs. A simple example of using seed-cum-fertilizer drill will substitute this statement (Giles 1975, Kahlon 1976, Sharma et al. 1983, Srivastava 1984, Kachru and Srivastava 1989, Sharma et al 1989).

(1) Saving in time and labour reduce the cost of sowing as follows:
Saving in time : 50-75%
Saving in cost : 45-80%
Increase in productivity of labour : 300-800%
Increase in productivity of animals : 200-400%

(2) Proper placement of seeds and fertilizers provide better plant population and high yields as follows:
Increase in yield : 5-100%

(3) Affecting timeliness in operation increases production as follows:
Increase in yield : 12-80%

(4) Savings in seeds and fertilizer results from their precise placement as follows:
Savings in fertilizer: 25-55%
Savings in seeds : 25-50%
Increase in productivity of inputs : 45-100%

(5) Better seed emergence due to proper soil coverage and tempting in different soil moisture conditions result in higher yields as follows:
Increase in plant population : 3-25%

(6) Savings in energy by the use of seed drill as follows:
Savings in energy : 45-55%

(7) Reducing drudgery on the part of humans and animals
Depending upon the number of rows of the drill, the drudgery on human and animals is reduced by 50-80%.

Present Status of Farm Mechanization

The extent of farm mechanization in any region or country depends mainly upon the availability of power on the farm to carry out different operations. **Table 1** presents the details of estimated power available in Indian agriculture.

Human Power

The total number of agricultural workers for 1990 is estimated at about 214 million. The human power contributes about 11.2% of the total power available for agriculture. Operations like sowing, transplanting of crops and vegetables, hoeing, weeding, harvesting, etc. are best performed manually. The main work of human power is to control animal power.

Animal Power

It is estimated that about 80 million draught animals work on Indian farms. The total number of bullocks is about 72 millions. Other animals used in agriculture are buffaloes, camels, horses, mules, etc. The animal power amounts to 26% of the total power available. Animal power is used for land preparation, intercultural operations, water lifting devices, threshing, and transport of agricultural inputs and products as well as the farmers themselves.

Oil Engines

The amount of energy available from stationary oil engines is 16 875 MW constituting about 14.7% of total energy available. During the last two decades the number has increased from 3 million to 4.5 million. Oil engines are basically used for pumping irrigation water, running threshers and processing units, etc. The 3.7 kW (5 hp) oil engines are most popular among farmers.

Farm Tractors

Tractors play an important role in the development of Indian agriculture. There are over 10 manufacturers of wheel tractors in India at present. All manufacturing units have attained full indigenization. The production of tractors has increased tremendously. The Indian tractor industry has a licenced capacity of 170 thou-

Table 1 Availability of Farm Power from Various Sources

Source	Number (Million)	Unit Power (W)	Total Power (MW)	Percent
Human	214.00	60	12 840	11.20
Animals	80.00	375	30 000	26.17
Mechanical				
- Stationary oil engines	4.50	3 750	16 875	14.72
- 4 wheel tractors	0.85	30 000	25 500	22.24
- 2 wheel tractors	0.07	6 000	420	0.37
Electrical power				
- irrigation pumps	6.00	3 500	21 000	18.32
- agricultural processing			8 000	6.97
Total			114 635	100.00

sand tractors per year and installed capacity of 110 thousand tractors per year. Today the Indian tractor industry is ready to meet the country's demand of tractors. Most of the manufacturers are using locally fabricated components. This has resulted in the development of local industry of components like batteries, tyres, gears, castings, dynamos, fuel pumps, etc. At present over 850 thousand tractors are operational in India.

Two-wheel tractors, namely; power tillers are also being manufactured in India by six local manufacturers. They have a licenced capacity of 30 000 units per year for power tillers ranging from 5 to 15 kW. The power tillers are not very popular in India except in paddy-growing regions. Power tillers are basically for low land cultivation so they did not get much popularity in upland cultivation. Because of low demand only 3 000 power tillers are manufactured per year.

Electricity

It is the age of electricity which has simplified "uses." The Indian agricultural sector consumes about 14 per cent of electricity generated in the country. Electrical power is used mainly for driving the electric motors of irrigation pumps, threshers and processing units. In India mostly 2-7 kW (3-10 hp) electric motors are preferred by the farmers.

Extent of Farm Mechanization by Group

Of the total farm families in India about 70% have small holdings (<2 ha), 26% medium holdings (2-10 ha); and only 4% possess large holdings (>10 ha). These groups cultivate 20%, 48 per cent and 32% of total cultivable area, respectively. **Table 2** shows the utilization of farm power and equipment by farmers of different categories.

The farmers owning less than 2 ha of land are poor cultivators whose earnings are meagre. They can not afford costly tools and equipment. Human and animal power are their main source of power on the farm and use indigenous plough for land preparation and intercultural operations. Human power is used for dropping the seeds in the seed tube, weeding, harvesting and threshing of crops.

The medium-sized group of farmers cultivate about 48% of the land area. They are enthusiastic and always ready to accept and use modern techniques of cultivation. This group of farmers use animal and human power as permanent source energy and hires tractor for operations like land preparation. Most of the medium-category farmers have electric or diesel pump sets. Harvesting is done manually by sickle. Threshing of the crop is done either by animals or by power threshers. This group of farmers often hire tractor with tillage equipment for land preparation, threshers and water from neighbour's well or tube-well. They look for a better and prosperous future.

The large-sized group of farmers cultivate about 32 per cent of total cultivable area. As might be expected this group of farmers have a sound financial position. They have enough money to invest on land development, creating facilities for judicious irrigation,

Table 2 Farm Power and Machinery Utilization, by Group of Farmers

Source of power/	Category of Farmers		
Farm operation	Small-sized Farmers (<2 ha)	Medium-sized Farmer (2-10 ha)	Large-sized Farmer (>10 ha)
Source of power	Animals	Animals Hiring of tractor for land preparation and transportation	Animals Ownership of tractor
Land preparation	Indigenous plough, Blade harrow, 3-tyne Cultivator, Comb harrow, Disc harrow, Bund former, Planker	Indigenous plough, Blade harrow, 3-tyne Cultivator, Comb harrow, Disc harrow, Bund former, Planker, Tractor monuted M.B. and Disc plough, Cultivator	Indigenous plough, tractor operated M.B. and Disc plough, Cultivators, Puddlers, Disc harrows
Seeding	Broadcasting, Seed tube attached to indigenous plough, Transplantation by hand	Broadcasting, Seed tube attached to indigenous plough, Transplantation by hand	Broadcasting, Seed tube attached to indigenous plough, Transplantation by hand, Tractor operated seed drills
Interculture Indigenous plough operations	Hand tools, Indigenous plough	Handtools, Indigenous plough	Hand tools Tractor operated cultivators
Pest control	No pest control	Hand and foot operated sprayers	Hand and foot operated sprayers
Manure and fertilizer application	By hand	By hand	By hand
Harvesting of crop	By hand and Sickle	By hand and Sickle	By hand and Sickle Reapers, Combines
Threshing	By hand and animals	By hand and animal drawn threshers, Power threshers	By hand and animal drawn threshers, Power threshers

own right type of implements and equipment and purchase and apply farm inputs for high crop yield. They use tractors and animal power on farm; the former for land preparation. Seeding is done manually or by seed drills. Nowadays seed drills are becoming very popular but their number of still moderrate. Intercultural operations are done manually. For weed and pest control, foot-and hand-operated sprayers are used. Harvesting of crop is done by sickle. In the States of Punjab, Haryana and Northern Rajasthan, harvesting is done by reapers and combine harvestors. Threshing of crop is done by power threshers. Most of the farmers in this category own threshers. They have assured source of water as in most cases, their tubewell or open well are fitted with electric or diesel pump set.

Farm Machinery Equipment Production

Animal- and tractor-drawn implements such as ploughs, harrows, puddlers, cultivators, levellers, scrapers, seed drills, planters, olpad threshers, Persian wheels, sugarcane crushers, etc. in large numbers are used in India. These implements are manufactured locally. At present there are over 3 000 registered units in various States manufacturing agricultural equipment. In addition, a large number of artisans and small-scale workshops are also engaged in the manufacture of farm equipments.

Over 500 manufacturers are currently engaged in the manufacture of power-operated agricultural implements such as ploughs, disc harrows, tillers, seed-cum-fertilizer drills, levellers, puddlers, reapers, threshers, sugarcane crushers, potato diggers, groundnut diggers and decorticators, trailers and chaff cutters. In addition, there are manufacturers for agricultural processing units such grinders, rice hullers, cutting machines, pulpers, juice extractors and oil extractors.

During the last decade, India exported agricultural equipment to some countries in South-east Asia, Africa and the Middle-east. However, the manufacture of self-propelled combine harvesters, high-power tractors, transplanters and forage harvesting machines is very limited and on demand only.

Problems of Farm Mechanization in India

In the last decade, the farm machinery tractor industry in India has made an impressive growth. Inspite of the efforts made by both Government and private agencies to popularize the machines among farmers (except few machines, e.g., threshers and irrigation pump sets), nothing much is widely adopted by Indian farmers the main reason being that farmers generally doubt the efficiency and return from machines. In addition, there are some other constraints in farm mechanization programmes in the country such as those listed below:

(1) Lack of awareness on the part of most of farmers about different aspects of agricultural machinery uses.
(2) Lack of regional farm mechanization policy for the manufacture, sale and distribution of farm machines and prime movers. India is a large country with immense diversity in crop cultivation practices. Up to the present time, mechanization in India is carried out under a single national policy and very little emphasis is given to regional policies to promote the manufacture, sale and distribution of farm machinery.
(3) Inadequate facilities for repair, maintenance and after sale service of farm machineries.
(4) Lack of dialogue between manufacturers of machines and users.
(5) Inadequate supply of graded material and high cost of raw materials, leading to high initial cost of implements and poor quality of farm machines. It has been observed in the country that the cost of machines is cut at the price of quality of their materials. This is one of the major causes of mechanical failure of the machines. Moreover, there is very limited quality control over agricultural machines.
(6) Non-availability of spare parts.

Actions for an Improving Farm Mechanization

History indicates that mechanization takes place or is closely related to the shortage of human labour and industrial development. In India the agricultural population is likely to increase in the coming years, hence Indian agriculture should not be mechanized because of shortage of agricultural labour but for the sake of: obtaining timeliness of farm operations, reducing the production cost, getting more thorough work like land preparation, seeding, weeding, harvesting, removing drudgery in number of farm operations like transplanting paddy, weeding, minimizing loss of crop during threshing and transportation and for the betterment of the life of farmers and their families.

Therefore, there is need to design implements and equipment which should increase the productivity of land and labour without reducing the job potential for the young farmers.

At the present time, there is talk of formulating agricultuural mechanization strategies for the implementation of necessary mechanization inputs required for agricultural industry. But this more should be carried out in the framework established by national development objectives and policies and must be aimed at optimizing the effective and efficient delivery and support of mechanization to the farmers. In order to promote the utilization of farm machines by farmers, it is necessary to develop their confidence in using the machineries and the advantage of farm mechanization.

Farm mechanization and development should be reoriented. Research must be undertaken in a problem-solving context and an honest definition of these problems as they exist at the farm level.

The farm machinery industry in India, unfortunately, is not involved in agricultural development programmes. Emphasis should be given on the utilization of the potential of small- and medium-sized machinery manufacturers whose experience and flexibility have so far not been fully utilized and economically exploited.

Conclusions

The most startling conclusion that emerges from the analysis of the recent official statistics is that during the 1980s the growth in food grain production was outpaced by the increase in India's population. At the present time, India is back where it was 20 years ago, i.e., when the Green Revolution was launchhed. The 1990s will constitute a critical decade in the country's agricultural development. India will have to add to total production in the coming decade as much quantity of grains as it produced in the last two decades. To be sure, India needs a new redirection and potential agricultural strategies to increase agricultural production and feed the growing population of the 1990s.

Even as efforts have continuously been made since two decades ago to mechanize the Indian agriculture, only marginal success has been achieved. Today, there is need to mechanize Indian farming not only for increasing production but also to reduce production cost, drudgery in many of the farm operations and making the farmer's life better. It is anticipated that mechanization seeding, transplanting, harvesting and threshing are likely to take place at a faster rate in the coming years.

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Optical Properties of W. Navel and Hamlin Oranges Regarding Mechanical Harvesting and Sorting

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Abstract

In this research the optical properties of W. Navel and Hamlin oranges which are important for export and domestic consumption in Turkey are investigated.

The research was done in two steps. In the first step, samples of Hamlin and W.Navel oranges during maturity period were taken weekly and their reflectance properties were measured at the visible spectrum. For this measurement, a CR-100 Minolta chromameter machine was used. In the second step the same sample's juice were measured using Ct-100 Minolta chromameter. In conclusion, the light reflectance and transmittance values of the oranges were evaluated according to the CIE (the Commission International de l'Eclariage) specialized graphics and by the aid of these graphics suitable wavelength were determined for sorting and estimating the maturity period for the sample oranges.

Introduction

The increasing economic importance of food materials together with the complexity of modern technology for their production, handling, storage, marketing and utilization demand a better knowledge of the significant physical properties of these materials. Quality is commonly associated with the degree of a product or materials (Essex, Finney 1961). The physical properties that differentiate individual units of a product are signified in determining the degree of acceptability of the product to the buyer.

Quality factors in food can be divided into three major areas; color, flavor and texture (Francis, Clydesdale 1975). Each can be handled in an objective manner, but if the color is unacceptable there may be little point in considering the flavor and texture. Color and appearance are usually the primary bases of acceptance or rejection of food. Yet, important as this may be, there is surprisingly a wide variation in color which fit within preconceived notions of what the acceptable color of food should be.

The concept of acceptable color of a given food stuff is obviously governed by many factors such as geography, packaging, age of population, education and economics. Color control in foods is employed for three main reasons. One is standardization of product from a quality control point of view. A consumer expects all units of a certain brand of food to be of the same color. The second is the use of color as an index of economic worth, for example, optimum maturity of tomatoes is associated with optimum color and flavor development. The third is to improve the quality of a given product. This applies mainly to the manufactured food or food ingredients in which food technology has freedom to manipulate the color as one aspect of quality.

Considering these problems the present research was done on the optical properties of W. Navel and Hamlin oranges which are important for export and domestic consumption in Turkey.

Previous Studies

The studies related to this subject and their findings can be summerized as follows:

Palmer (1961): The reflectance properties of potatoes differed markedly from those of soil clods to suggest that reflectance may be used to distinguish between them electronically. Peak reflectance occurs at 800-900 nm and there are absorption bands in the region of 325-400 and 1000 nm.

Mohsenin, et al. (1981): One of the most prominant applications of x-ray have been in the detection of insect infestation and damage evaluation for wheat, rice and dried peas to the extent that insect evaluation by x-ray technique is now considered routine testing.

Bowman (1985): A research based on moisture measurement by infrared reflectance in the near infrared well-established commercial technique for high-value products such as tobacco and pharmaceutical. The surface of the sample is illuminated alternately at two different wavelengths, one at which the light reflectance is substantially independent of moisture content. The ratio of the reflectance at these two wavelengths yields a negative correlation with wet basis moisture content.

Chandra, Singh and Chen (1985): An electro-optical technique was employed to formulate standards for the separation of rough rice, and brown rice from polished rice and pecks and rough rice from brown rice. A Perkin-Elmer model 330 spectro photometer was used to measure and plot the reflectance of different fractions at various wavelengths of light.

Krivoshiev, Georgiev and Damyanov. (1985): Their work discusses some results of investigations on undestructive pattern recognition of external and internal defects in potatoes by means of their light permeability in the visual and IR spectral band.

Bagans and Herold (1985): A survey on tendencies in the development of automatic devices for quality-separation of agricultural products is presented. Measurements for damage-detection on apples and other agricultural products were drawn.

Other authors that have done some work to the subject are Essex, E. Finney (1961), Hall, Carl (1972), Woodroof (1973), Francis, F.J. Clydesdale (1975), Birth (1976), Blanchertz (1984), Kavamura, N (1985), Delwiche (1987), Dooantan and GΣzel (1987).

Materials and Methods

This research was done at the circulation capital Ω.University of Agricultural Faculty. The W. Nävel and Hamlin orange varieties were used as the materials. First the reflectance of light at the visible band was measured and the transmittance of light through the juice of fruits were measured. For this reason, the Minolta chromameters (CR-100 and Ct-100) were used.

The Minolta chromameter CR-100 is the lightest, most compact tristimulus color analyzer for measuring reflectance of subject color. Utilizing high-sensitivity silicon photocells filtered to match CIE (commission international de I, Eclariage) standard observer response, the chromameter CR-100 assure supreme accuracy and repeatability. Readings are taken through the measuring head, processed by the built-in microcomputer and presented digitally on the custom-designed liquid crystal display. The measuring head provides a choice of two standard CIE illuminant conditions: illuminant C (6774 K) and illuminant D65 (6504 K).

It is the world's lightest, most compact tristimulus color analyzer for measuring the transparence of fluids. Readings are taken with immersible measuring probe are processed by the built-in microcomputer and presented digitally in the custom designed liquid-crystal display.

A pulsed xenon arc (PXA) lamp in a mixing chamber provides even diffused lighting through the sample liquid. Six-high-sensitivity silicon photocells, filtered to match the CIE standard observer response, are used by the meter's double-feed back system to measure both incident and transmitted light.

Sampling

The samples were taken weekly (10 samples from each tree). The light reflectance was measured at the visible spectrum band for three points (head, equator and tail) of the fruits. Then the tristimulus value Y and the chromaticity coordinates x and y were evaluated according to the CIE system (see Appendix 1). Then the percentage of light transmittance of the fruit juice was measured and the tristimulus value Y and chromaticity coordinates x and y due to CIE standard observer system were obtained. The suitable wavelength for the light reflectance and transmittance during the maturity time was obtained.

Results and Discussion

As mentioned above the samples were taken weekly. The relationship between their dimensions and weights during the maturity time were calculated by a packed program in the Department of Agricultural Mechanization.

The width and height of the W. Navel oranges were measured on a weekly basis. Then the average height and width were determined. The relationship between height and width is shown in **Table 1**.

As it can be seen in **Table 1** the statistical difference between height and width is negligible. **Fig. 1** shows that there is a linear relationship between weight and

Table 1. Height-width Relationship of W. Navel Oranges

W. Navel	Height	Width	Number of Measurement
X	79.65	77.02	99
S	4.81	3.11	99
S	23.19	9.67	99

Table 2. The Height-width Relationship of Hamlin Oranges

Hamlin	Height	Width	Number of Measurement
X	57.63	58.46	99
S	3.60	4.09	99
S	13.02	16.73	99

dimension during the maturity period of the fruits.

The same measuring method was also used for the Hamlin oranges. The results are shown in **Table 2** and **Fig. 2**. The height-width average is used as a single value (**Fig. 2**).

Light Reflectance Measurements for W. Navel Oranges

Reflectance was measured in the electromagnetic spectrum at the visible light (400-760 nm). As the samples were taken weekly the average of the measurements were calculated as single values.

Fig. 3 shows the change of the chromaticity coordinates x, y versus maturity period. According to the CIE chromaticity diagram, the values measured for the ninth week coresponds to the dominant wavelength 582 nm. At this vavelength the color of fruit became orange and was suitable for harvesting (**Fig. 3**).

There is a direct relation between brightness (tristimulus value Y) and maturity of W. Navel oranges. As seen in **Fig. 4** the first eight-week brightness increased normally, but at the ninth week it showed sharp increment which resulted from a frost that existed during the experiment in the region.

Light Reflectance Measurements for Hamlin Oranges

The same calculation methods were used for Hamlin oranges the results of which are shown in **Fig. 5**.

Fig. 5 shows the change of chromaticity coordinates x, y versus maturity period. Due to the CIE chromaticity diagram the values for the seventh week corresponds to the dominant wavelength 600 nm. At this wavelength the color of fruit changed into red. There is a direct relation between brightness and maturity. The same condition

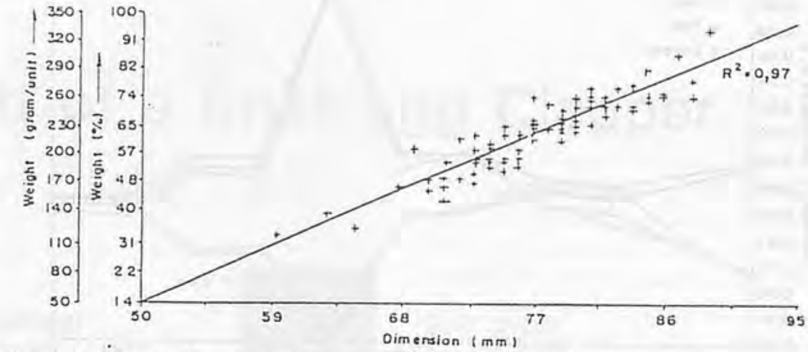

Fig. 1 Weight vs dimension of W. Navel oranges during the maturity time.

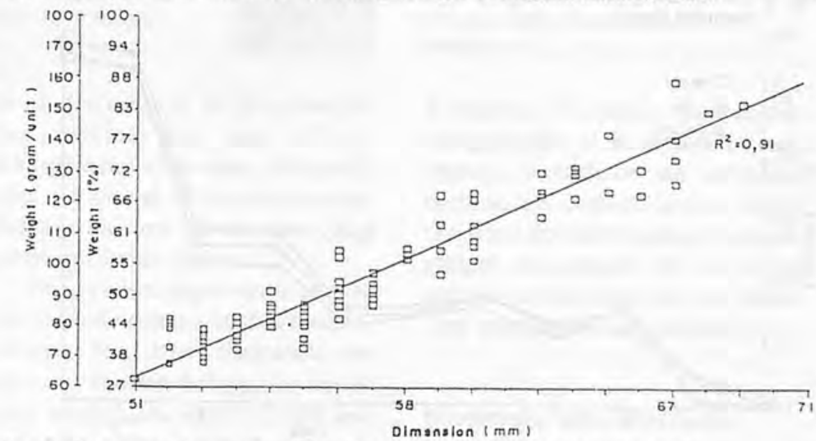

Fig. 2 Weight vs dimension of Hamlin oranges during the maturity time.

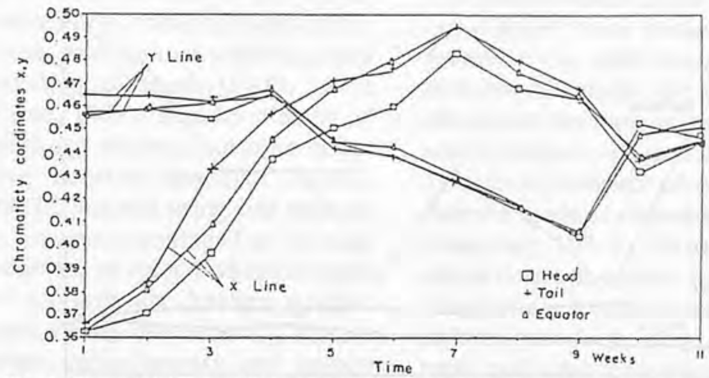

Fig. 3 Chromaticity coordinates x,y by reflectance of W. Navel oranges during maturity time.

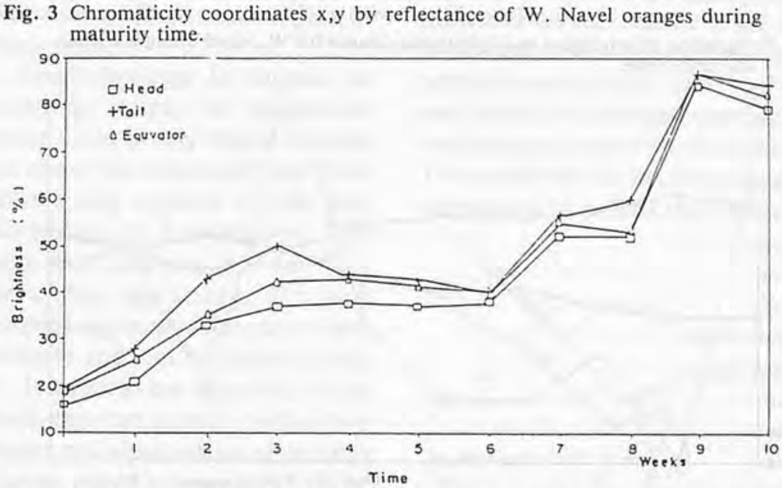

Fig. 4 Brightness variation for W. Navel oranges during the maturity time.

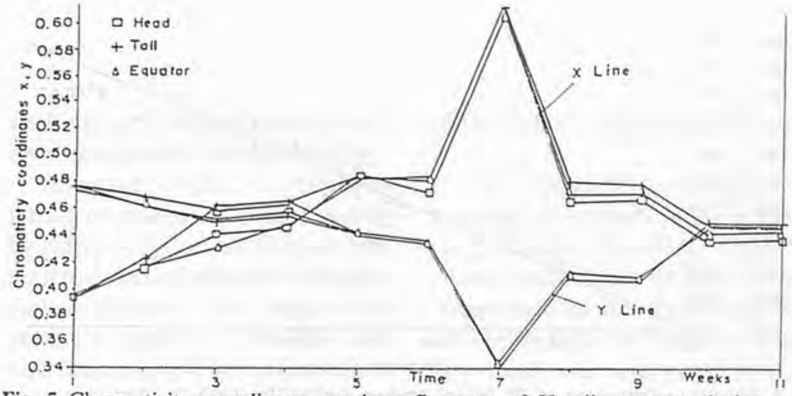

Fig. 5 Chromaticity coordinates x,y by reflectance of Hamlin oranges during maturity time.

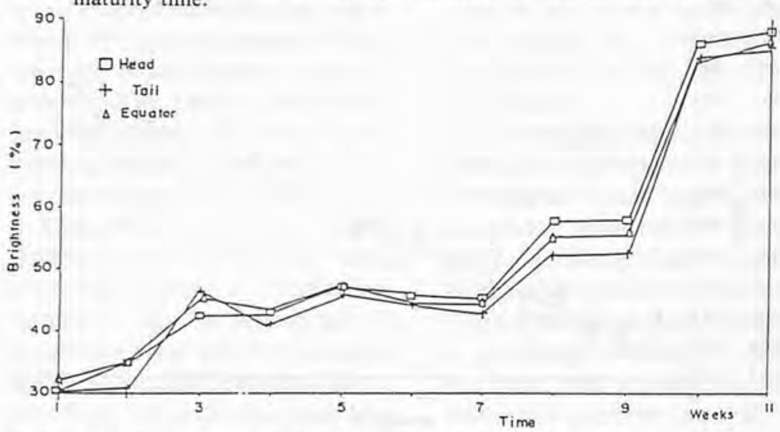

Fig. 6 Brightness variation of Hamlin oranges during the maturity time.

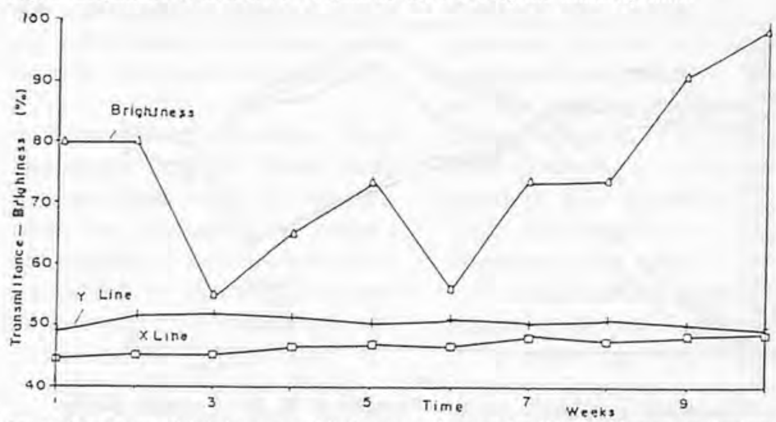

Fig. 7 Variation of brightness and light transmittance for W. Navel oranges during maturity time.

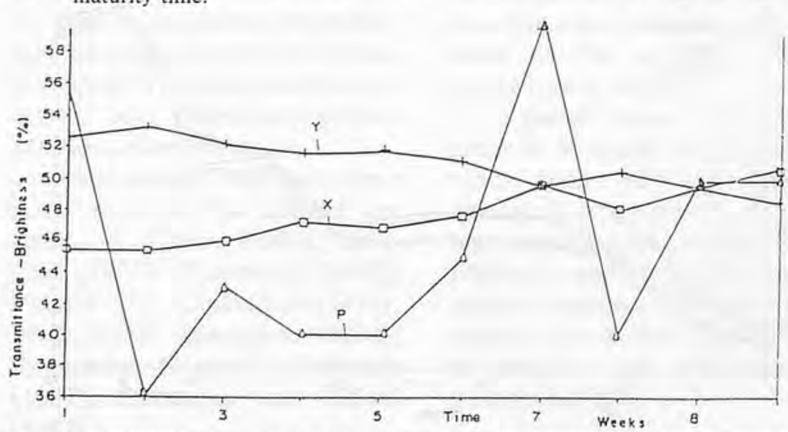

Fig. 8 Variation of brightness and transmittance for Hamlin oranges during the maturity time.

existed for Hamlin oranges.

Light Transmittance Measurement for W. Navel Oranges

After measuring the light reflectance of the orange samples at the visible band, the light transmittance of the fruit juice were measured by the CT-100. Minolta chromameter. The graph which was obtained from the samples on a weekly basis is shown in **Fig. 7**.

The percentage of light transmitted through the fruit juice during the maturity period was 48%. From the ICE diagram, this value corresponds to 573 nm.

At the beginning of the maturity period the highest and lowest limits for the juice lightness was between 55% and 75%. As the fruits mature this value was increased to 98%.

Light Transmittance Measurement for Hamlin Oranges

The same calculations were done for the Hamlin oranges. **Fig. 8** shows the results.

As seen in **Fig. 8** the variation of light transmittance through the fruit juice for x and y coordinates at the fifth week is approximatly 50% and correspond to 952 nm.

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(Continued on page 63)

Development of a Snail-egg Clapper

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Abstract

The golden apple snail (*Pomacea lineata Spix.*) is a major rice pest in the Philippines. Chemical control is expensive and has detrimental effects on the environment. A device called a 'snail-egg clapper' was developed at IRRI, to allow an operator to smash the snail-egg masses on the spot, on rice plants and vegetation, without stooping. It is simple in construction, easy to operate, inexpensive and can be fabricated with locally available materials. It was tested and found to be effective and rapid in operation. It does not cause any damage to rice plants.

Introduction

The fresh water snail (*Pomacea lineata Spix.*), better known as golden apple snail or golden kuhol feeds voraciously on succulent aquatic plants, young rice seedlings and *Azolla*. Golden snail is a major rice pest in the Philippines (Adalla and Rejesus, 1989). An estimated rice area of over 400 000 ha is infested with snails in the country. It causes as much as total destruction in germinating rice seedlings and over 20% in transplanted rice when the seedlings are young. The most serious damage occurs in the low lying portion of rice fields.

The golden apple snail can be controlled with organotin molluscicides, but these chemicals are toxic to human beings, livestock and aquatic life such as fish and tadpoles. Other control measures include installation of screens on water inlets, releasing ducks in rice fields and manual collection and crushing of snails (FAO, 1889; Tacio, 1989). Regular picking of snail-egg masses is also an effective control measure (ICIPE, 1987), but is a tiring job because it requires stooping. Use of snail collector or *salaan* which is made of an ordinary kitchen strainer with a long handle and a scraper plate, helps in easy and speedy collection of snails and scraping of snail eggs.

Snails lay eggs in clusters on standing crops, on vegetation along dikes or any object sticking up above the water surface. Each cluster may contain 25-500 eggs depending on breeder size. The eggs start hatching in about 7-14 days after egg laying. The pink colored egg masses are easy to see, delicate and can be crushed easily. It implies that smashing of the snail-eggs can be done within two weeks and destruction of one egg cluster would mean getting rid of as many snails as are the eggs in a cluster. Therefore, it was envisaged that destruction of egg masses would be an effective method to control snails. Thus the need for developing a simple gadget to smash the snail-egg masses on the spot, on rice plants and vegetation was identified.

Materials and Methods

A simple device called a 'snail-egg clapper' was designed and developed at IRRI, to allow an operator to smash the snail-egg clusters on the spot, on rice plants and vegetation, without stooping. The device consists of a pair of clappers made of sheet metal, each measuring 100 × 150 mm. The clappers are mounted on a 1-m long handle made of black iron pipe or wood. A lever, a nylon rope, and a rubber spring are also mounted on the handle **(Fig. 1)**. When the rope is pulled, the clappers move away from one another and when it is released suddenly, the clappers close with an impact. To operate the device, the clappers are opened by pulling the rope and

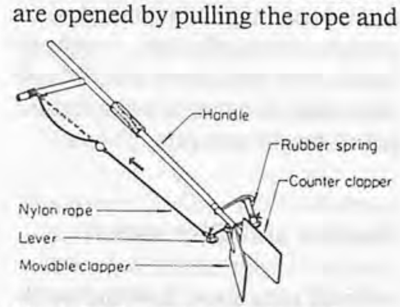

Fig. 1 Snail-egg clapper assembly.

Acknowledgements: The authors are thankful to Dr. M. Yamauchi and Mr. D.V. Aragone for conducting a collaborative experiment to evaluate the feasibility of using the snail-egg clapper on rice plants. The assistance of Mr. E.F. Cabrido, Mr. W. Silon, Ms G.U. Malabanan and Mr. J.R. Abengania is appreciated.

aligned on the rice plants or vegetation, to get the egg mass between them, then the rope is released. The clappers close with an impact on the egg mass, resulting in their destruction. The magnitude of impact delivered by the clappers can be adjusted by loosening or tightening the rubber spring. The snail-egg clapper is light weight (800 g) and can be carried in one hand. Its estimated cost is less than US$2.00.

Experiments were conducted in randomized block design with six replications to evaluate the performance of the snail-egg clapper and to compare with *salaan* and hand-picking of snail-eggs. Observations regarding area covered, time required and number of egg-masses despatched or dropped off the plants were recorded for determination of work rate in terms of egg masses crushed per unit time, and field capacity in terms of area covered per unit time. Another trial with 8 replications was conducted to study the effect of clapper impact on the growth of rice plants (IR58). Rice plants were grown in pots and each pot was treated as one plot. The rubber spring of the clapper was set to impart high impact (47.5 g) and mild impact (25.6 g), on the plant for an opening of 5 cm at the clapper edges. Both the settings were hard enough to smash snail-eggs. The clapper was used at two stages of plant growth, e.g., at 3 weeks after seeding and at panicle initiation. Observations were taken to record visible damage to plants and adverse effect on their growth in terms of plant height, weight of plant, root and shoot weight and their ratio, number of panicles and grain weight per pot.

Results and Discussion

Field tests show that the snail-egg clapper performs effectively

Fig. 2 Snail-egg clapper in use.

and permits an operator to smash the snail-egg masses on the spot without stooping **(Fig. 2)**. Its performance was superior to the egg collector *salaan*. The work rate of the clapper (mean 18.9 egg mass/min; CV 12%), was about 1.7 times higher than the work rate of *salaan* (mean 11.2 egg mass /min; CV 8%), in terms of number of egg clusters dispatched in one minute **(Table 1)**. It was observed that while using *salaan* over 32% of egg-masses or their parts, dropped off the plant or bounced off the *salaan* and fell in the field. Whereas, in the case of the clapper less than 4% of the egg-masses were left partly uncrushed or they dropped off the plant before being smashed. It was also observed that while scraping egg masses with *salaan* the tillers would bend, and sometimes it became necessary to support them in order to scrape the eggs. This was one of the reasons for the slow work rate of the *salaan*.

Field capacity of the snail-egg

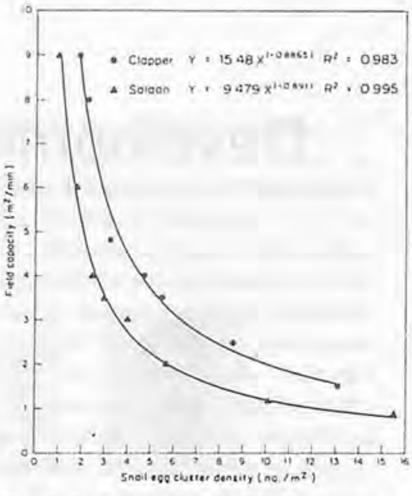

Fig. 3 Field capacity of snail-egg clapper and salaan.

clapper depends on the population of egg clusters per unit of land area. This varied from 1.6 m^2/min to 9 m^2/min as the egg cluster population density varied from 13 to 1.88 egg clusters/m^2 in the field. The clapper had a higher field capacity than the *salaan* at all the egg cluster density levels **(Fig. 3)**. The field capacity of the clapper was found to be 35-70% higher than that of *salaan* and 5-10% higher than hand picking of snail-eggs under similar conditions.

The experiment on the effect of the clapper impact showed that no visible damage occurred to the rice

Table 1. Performance of Snail-egg Clapper and Salaan Compared with Manual Picking of Snail Egg Masses, IRRI Fields 1991.

Equipment	Egg mass density (no/m^2)	Egg masses crushed (no/min)	Egg masses missed (%)
Clapper	5.6	20.3	3.9
Salaan	6.46	11.2	32.6
Hand picking	5.48	18.9	0.0
LSD	1.02	3.73	14.3

Table 2. Effect of snail-egg clapper impact (high/mild) on growth indicators of rice plant.

Impact	Timing	Plant Ht (cm)	Panicle no./pot	Plant Wt (g/pot)	Shoot Wt (g/pot)	Root Wt (g/pot)	Root /Shoot ratio	Grain Wt (g/pot)
Mild	3 WAS	90.3	24.0	78.3	72.6	5.6	0.072	34.7
High	3 WAS	87.7	25.0	76.8	70.3	6.5	0.084	33.9
Mild	PI	90.6	21.3	75.1	69.5	5.6	0.074	36.0
High	PI	89.7	22.3	74.0	67.5	6.4	0.087	33.9
No Clapping	—	89.4	23.4	79.6	72.6	7.0	0.087	36.8
LSD (5%)	—	3.41	2.70	9.65	8.64	1.66	0.0162	7.15
Statistical Significance	—	NS	NS	NS	NS	NS	NS	NS

WAS = Weeks after seeding. PI = Panicle initiation.

plants when it was used at both mild and high impact settings. There was no significant difference ($P < 0.05$) in the growth indicators (plant height, weight of plant, root and shoot weight and their ratio, number of panicles and grain weight per pot) of the rice plants treated with the clapper and the untreated ones (**Table 2**).

Conclusions

The snail-egg clapper is an effective and efficient tool for dispatching snail-eggs laid on rice plants or other vegetation in the field. It is superior to the *salaan*. Dispatching snail-eggs with the clapper is faster and less tiring than manual picking, because it enables an operator to dispatch snail-eggs without stooping. It is simple in construction and can be fabricated cheaply with locally available materials.

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The Present State of Farm Machinery Industry

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Outlook of Agriculture

Trend of Agriculture

In 1992 Japanese economy is continuing to be a business recession as well as last year.

In 1992 food consumption was slightly higher than that of the previous year, while agricultural production was lower. The imports of agricultural products are on the increase. In 1991 the imports reached $27.4 billion, which means that Japan is the greatest food importing country. In Japan, feed cereals, soybean, wheat and so on depend on the imports from foreign countries. Self-sufficiency ratio of cereals ended in 29%. This figure is the low rate of all the advanced countries. Population mainly engaged in farming (commercial farm households) in 1992 decreased by 2.3% over the preceding year to 4,520,000 persons. The aged persons over 65 years old forms 37.7% of the population.

Farm houses has showed a rapid decrease lately; now are 3,690,000 farm houses. Those dealing agricultural products were 77%. Arable land was 5,170,000 ha in 1992, which decreased by 0.4% over the previous year.

Agricultural income of farm household (commercial farm households) in 1992 increased 0.6%, compared with the previous year. The total income including the income from non-agriculture, annuity and present, etc. is taking a favorable turn.

In Japan, food life has varied since 1970's. While, rice, oranges, milk, eggs and so on have been overproduced. Food industry has developed and the imports of agricultural products has shows a sharp increase.

In Japanese agriculture, it is requested to reduce production cost, increase people destined to bear agricultural production, produce various products satisfying consumer's 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. Thus, consistent system of low land rice has been completed. 99% of rice transplanting and 99% of rice harvesting have been mechanized. As to rice, working hours per 10 a decreased to 41.1 hours—they were 117.8 hours in 1970.

In recent years farm machinery for rice crop is developed to be largersized, higher-efficient and more commonly used. In addition, farm machinery for field crops and livestock farming is being developed and improved, which had been lagged behind so far. Whatever types it may be, farm machinery is expected to be invented and improved positively from various points of view, such as performance ability, safety and cost reduction.

Followings are the number of popularization of farm machinery as of Jan. 1, 1993: riding tractor reached 2,004,000 units; walking tractor 1,743,000; rice transplanter 1,866,000; head feed combine 1,158,000 **(Table 1)**.

Shipments of major farm machinery in the domestic market in 1991 are as follows: riding tractor reached 89,000 units (those under 30PS were 71,000; those over 30PS were 17,000); walking tractor 199,000; rice transplanter 80,000; power reaper 30,000;

Table 1 Major Farm Machinery on Farm

Unit: Thousand

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1985	2,579	1,854	1,993	2,151		1,518	1,109	1,473
1986	2,554	1,834	2,098	—	—	—	1,150	—
1987	2,682	1,904	2,179	—	—	1,275	1,201	1,378
1988	2,674	1,985	2,199	1,408	1,674	—	1,244	—
1989	2,654	2,049	2,205	—	—	—	1,258	—
1990	2,185	2,142	1,983	1,871		1,298	1,215	1,282
1991	1,765	1,966	1,904	—	—	—	1,169	—
1992	1,786	2,003	1,881	—	—	—	1,158	—
1993	1,743	2,041	1,861	—	—	—	1,158	—

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
1985	195,589	103,859	126,967	128,353	136,970	49,908	95,676	78,304
1986	184,005	109,101	122,441	132,447	133,479	52,234	88,997	74,636
1987	184,885	90,940	101,942	140,635	123,674	44,746	79,278	66,662
1988	213,941	90,261	84,531	144,705	108,958	39,950	66,618	59,666
1989	214,806	89,676	88,444	168,232	110,969	36,789	65,046	58,614
1990	205,944	95,691	89,139	183,820	107,227	37,117	65,247	51,954
1991	197,919	88,860	83,351	173,482	105,549	30,269	59,485	52,347
1992	199,141	88,754	80,105	184,016	105,028	20,888	60,941	52,275

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

combine 60,000 (standard types were 394); grain dryer 52,000; huller 360,000 (**Table 2**). This shows a tendency that rice transplanters are decreasing in number and that tractors and combines with higher-horsepower, are increasing in number.

Recently more and more used farm machineries are distributed. But in 1990 the demand shows a decreasing tendency. The rate of used farm machinery in the total sales amount is as follows: riding tractor forms 40%; rice transplanter 33%; combine 35%.

Measure of Farm Mechanization

The budget of agricultural, forestry and fishery for 1993 amounted to ¥3,368.8 billion, which shows an increse of 1.4% compared with the preceding year.

The important measures are as follows:

We must strive for promoting advanced agricultural management, such as well-stabilized or incorporated organization.

Agricultural fields are improved as planned and steadily.

To establish the system for the effective use of high land.

To make paddy, agricultural fields and stock breeding productive and vitalized.

To put high-performance machinery into effect, and distribute and fix the new type of milker.

To notify the indication of the food and secure its safety.

To establish the sustainable agriculture.

To rear forest resources with various kinds of wood and excute the plan for forest finance.

Enterprises for agricultural mechanization are incorporated into the above-mentioned measures. The budget is ¥169.4 billion; this is for subsidiary measure of the introduction of farm machinery.

Among these subsidiary enterprises, agricultural production, processing and distribution are consolidated to introduce farm machinery. Farm machinery and facilities for personal use and community use are developed and used to consolidate fields. Enterprises are being strived to organize farming workers, to consolidate banks for farm machinery and to reduce production cost.

Movement of Farm Machinery Industry

The output of farm machinery, which increeased sharply in 1973 and 1974, amounted to ¥659 billion in 1977. But it decreased sharply to ¥536.7 billion in 1978 because farmers were unwilling to invest money in farm machinery under the popularization of rice crop machinery and under the policy of reducing the acres for rice planting, which aims at adjusting overproduction.

Ever since, except for ¥627.3 billion in 1980, the output remained about ¥500 billion p.a. The output has a gradual increase to ¥638.2 billion in 1984, ¥667.8 billion in 1985 and ¥674.3 billion in 1986. In spite of these increasing tendency, in 1987 the output decreased ¥500 billion again. Since then, it remained about the ¥550 billion level in 1987, and in 1992 it was ¥576 billion. (In addition, it was the worst-harvested season these days in 1993.)

While the whole economy is being depressed in Japan, the farm machinery companies are striving for developing another demand, extending subcontracted production with other industries, finding fields other than farm machinery and business tie-up to maintain the management. The constitution is being consolidated to improve working hours, wages and working surroundings so that more and more young labourers may settle. The tendency for the development is toward the machine for vegetables and regional crops.

Table 3 Yearly Production of Farm Machinery

Unit: Number, Million Yen

Year	Farm machinery total		Riding type tractor		Walking type tractor		Rice transplanter		Power sprayer		Power duster		Blower sprayer	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1985	—	667,895	209,652	247,100	278,581	41,398	132,909	53,835	170,968	10,479	222,877	7,755	7,200	8,361
1986	—	647,265	209,078	254,010	268,307	37,026	134,433	64,541	157,774	9,754	184,132	6,374	7,121	9,535
1987	—	585,810	179,884	215,379	276,286	38,778	92,861	50,181	144,734	8,396	165,241	6,028	6,231	8,296
1988	—	549,854	172,761	209,278	276,684	37,644	81,022	43,554	181,805	9,851	161,763	5,999	8,696	9,958
1989	—	553,368	157,544	197,947	275,629	38,735	87,615	46,337	184,098	10,015	156,802	5,845	9,901	9,400
1990	—	585,561	115,939	198,557	269,027	38,248	91,141	52,462	220,528	12,339	149,789	5,575	9,565	9,514
1991	—	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)	—	575,700	147,800	189,100	234,300	35,200	81,700	54,700	174,100	7,200	139,000	6,100	9,100	12,600

Year	Grain reaper		Brush cutter		Power thresher		Grain combine		Rice husker		Dryer		Grain polisher	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1985	51,061	12,274	1,350,990	24,573	42,901	15,163	102,593	157,222	80,231	19,661	76,571	42,634	75,314	3,843
1986	55,587	13,777	1,496,433	27,191	41,295	15,246	93,080	150,188	72,000	19,060	73,798	44,590	66,891	3,537
1987	45,867	10,292	1,421,007	24,569	29,126	10,430	78,656	131,265	57,087	16,300	65,378	44,192	61,367	3,083
1988	41,204	9,313	1,546,010	26,160	24,811	8,900	64,412	117,132	49,866	13,137	58,097	37,649	58,982	2,932
1989	37,291	8,841	1,689,181	28,501	23,835	9,005	64,789	127,309	47,478	13,900	55,537	35,244	61,298	3,223
1990	42,502	11,110	1,601,652	25,798	22,634	9,118	68,993	138,396	60,004	18,332	59,269	39,990	58,500	4,871
1991	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)	27,000	7,100	1,650,000	28,300	12,300	4,800	65,500	149,500	42,000	13,200	55,400	43,600	40,800	3,900

Source: "Survey of Status of Machinery, Production" by the Ministry of Interntional Trade and Industry. Data by Japan Agr. Machinery Manufacturers' Assn. and Land Internal Combustion Engine Manufacturer's Assen.
Note: Data for 1993 are forecast by Farm Machinery Industrial Research Corp.

Table 4 Farm Equipment Distributor and Sales Value

Unit: Million yen

Year	No. of retailers (1)	Employes	Annual sales value (2)	Inventory	Square meters of shop m^2	Annual sales value (2)/(1)
1976.5	8,417	43,819	811,535	199,672	740,785	96.4
1979.6	9,257	48,548	1,007,298	159,772	898,854	108.8
1982.6	10,084	49,081	1,018,983	164,269	1,005,546	101.0
1985.6	9,142	43,921	946,507	144,837	985,453	103.5
1988.6	9,444	45,952	1,015,304	159,798	923,726	107.5
1991.6	9,480	45,705	1,158,924	170,104	984,700	122.2

Source: Ministry of International Trade and Industry.

Table 5 Handling of Farm Equipment by Agricultural Cooperative Association (1991 Business Year)

Unit: Million yen

Business year	Total number of coops. surveyed	Purchase in this term	Of which purchased through affiliated organs	Amount of supply and handling
1985	4,242	345,606	268,640	378,441
1986	4,194	351,484	275,591	383,023
1987	4,117	333,131	260,530	364,716
1988	3,976	337,970	259,915	379,709
1989	3,717	308,833	237,383	340,989
1990	3,591	349,521	268,763	375,660
1991	3,466	343,138	261,107	381,326

Source: "Statistics on Agricultural Cooperatives—1991 business

Trend of Farm Machinery Production

In 1992 the amount of farm machinery production was ¥576.0 billion, which decreased by 6.4% over the previous year. While, the amount of shipment was ¥582.1 billion, which increased by 1.4% over the previous year. In consequence, stocks are on the decrease.

Production of the major farm machinery is as follows: riding tractor decreased by 1.7% over the preceding year to 146,000 units. Seeing by h.p., those under 30PS amounts to 117,000 units, and it has 80.1% share. Those of higher horse power shows an increasing tendency, while the whole production is decreasing.

The production of walking tractor amounted to 246,000 units, which showed a decrease of 9.2% over the preceding year.

The production of combine, which is next to riding tractor is 66,000 units. This is an decrease of 9.9% over the preceding year.

Followings are the production of other types of farm machinery: rice transplanter amounted to 81,000 units (a decrease of 7.5% over the preceding year); binder 31,000 units (a decrease of 18.4% over the preceding year); thresher 13,000 units (a decrease of 37.4% over the preceding year); grain dryer 52,000 units (a decrease of 10.2% over the preceding year); huller 50,000 units (an increase of 18.1% over the preceding year); bush cleaner 1,890,000 units (an increase of 14.0% over the preceding year) (**Table 3**).

Trend of Farm Machinery Market

In Japan distribution system for farm machinery is roughly divided into two major channels: the traders concerned and Agricultural Cooperative Association. As of June 1991, the retail shops were recorded to about 9,480, the employees amounted to 46,000

Table 6 Export of Farm Equipment 1992

Unit: FOB Million Yen

Year	Unit	Value	Ratio	Major destinations
1985		190,305		
1986		150,792		
1987		135,354		
1988		130,492		
1989		131,042		
1990		132,757		
1991		129,943		
1992		143,891	100.0	U.S.A., Korea, France
			100.0	U.S.A., Korea, France
Power tiller	—	4,611	3.2	France, Germany, Italy
Wheel tractor	56,666	55,595	38.6	U.S.A.
Power sprayer	69,041	1,744	1.2	Korea, Taiwan, U.S.A.
Duster	47,362	532	0.4	Taiwan
Lawn mower	—	10,927	7.6	France, U.S.A.
Brush cutter	107,794	31,603	22.0	U.S.A., Italy, France
Mower	9,872	2,519	1.8	U.S.A., Korea
Combine	362	12,692	8.8	Korea, Taiwan
Blade, knife	220	2,010	1.4	U.S.A., Korea, Italy
Chain saw	—	5,063	3.5	U.S.A., Italy, France
Other	—	16,595	11.5	

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

Table 7 Import of Farm Equipment 1992

Unit: CIF Million Yen

Year	Unit	Value	Ratio	Exporters
1985		15,303		
1986		17,425		
1987		20,949		
1988		23,095		
1989		27,245		
1990		33,205		
1991		26,598		
1992		25,778	100.0	Germany, U.S.A., U.K.
			100.0	U.K., Germany, U.S.A.
Wheel tractor	3,242	10,906	42.3	U.K., France, Germany
Pest control machine	1,336,596	1,478	5.7	U.S.A.
Lawn mower	61,338	2,252	8.7	U.S.A.
Mower	1,558	838	3.3	France, Netherlands, Denmark
Hay making machine	1,157	555	2.2	Germany, France, Netherlands
Bayler	1,021	1,513	5.9	Germany, France, U.S.A.
Combine	65	966	3.7	Belgium, Germany
Chain saw	44,542	1,588	6.2	Germany, Sweden, U.S.A.
Other		5,682	22.0	

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

persons, and the annual sales amounted to ¥1,015.9 billion.

According to the governmental survey by Ministry of Agriculture, Forestry and Fishery, the total sales of farm machinery by Agricultural Cooperative Association reached ¥381.3 billion (¥375.7 billion in 1991).

Under the declining demand for farm machinery, the farm machinery distribution industry has begun to improve the working environment: aiming at dissolving the shortage of hands and the settlement of the employment. In addition, the industry is striving for expanding facilities and nationalizing the management.

Export and Import of Farm Machinery

Export

In 1992 the exports of farm machinery amounted to ¥143.9 billion, which showed an increase of 10.7% over the preceding year. The ratio of the exports to the total production amounts to ¥576.0 billion ended in 25.0%.

Seeing by the shipments, except Central and South America, each region has increased, comparing with those of preceding year. The exports for the United States, the largest market, reached ¥40.9 billion, which forms 28% of the total exports.

As for the types of farm machinery, tractor was chiefly exported: 70,500 units were exported in 1992 (the total production was 146,000 units).

Seeing by horse power, those under 30PS amounted to 51,600 units, those from 30 to 50PS 14,400 units, those over 50PS 4,500 units.

Major farm machinery, next to tractor, is bush cleaner. The total exports were 1,305,000 units.

The exports of other farm machinery are as follows: walking tractor 56,700 units; lawn mower 108,000 units; grass mower 56,000 units; chain saw 227,000 units etc. **(Table 6)**.

Import

In 1992 the imports of farm machinery amounted to ¥25.8 billion, which means a decrease of 3.1% over the preceding year.

Followings are the major imported farm machinery: tractors 3,000 units (those more than 70PS were 2,436 units of all the tractors); chainsaw were 45,000 units. Half of the tractors were imported from U.K. **(Table 7)**. ■■

Introduction to the Department of Agricultural Engineering Tottori University

by
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The Tottori University at a Glance

The Tottori university is one of 95 national universities in Japan. It was established on May 31, 1949 together with 69 other national universities. Before World War II only a select few could attain higher education. Thereafter, the Ministry of Education, Science and Culture decided that every prefecture should have at least one national university in order to offer equal chances for higher education to the Japanese people. Thus the Tottori University was established.

At the time of its establishment in 1949, the university was a combination of five schools (Tottori School Teachers' Training Institute, Tottori Young Men's School Teachers Training Institute, Tottori Professional School of Agriculture and Forestry, Yonago Professional School of Medicine and Yonago Medical College). It consisted then of three faculties (Education, Medicine and Agriculture), each located in different laces. In 1966 an entirely new campus was built in Koyama, enabling all of the faculties, except the School of Medicine, which remained in Yonago, to be located in one place. The faculty of Engineering was also established in 1965, a year before the university moved to Koyama.

As the university has grown in size and scope, various changes have taken place. Some of these recent changes include the addition of a new department to the Faculty of Education, the establishment of the United Graduate School in the Faculty of Agriculture and organizational innovations at the Faculty of Engineering. These reforms are expected to help the university develop further.

One of the most important goals of the post-war higher education in Japan, in addition to the specialized study and professional training in respective faculties mentioned above, is to endow students with a wide range of knowledge. To achieve this aim, emphasis has been put on general Education. Students are required to study subjects in the humanities, science and natural science, basic course common to all students and specialized foundation course for each faculty in order to gain a broader view of life and the world.

The Miura campus in Tottori City, consisting of the Faculties of Education. Engineering, Agriculture and General Education, is situated on the broad, flat top of Koyama Hill, overlooking Lake Koyama to the west, and the rising steps of mountain ranges beyond the lake. Tottori City, the capital of Tottori prefecture, has a population about 143,000. Its center is some five kilometers to the east of the campus, close enough to be convenient, yet far away enough from distraction or noise. Immediately to the north is the suburb of Koyama, then the airport, then the

Sea of Japan with its cliffs, beaches and fishing villages.

The campus itself is quiet and spacious, the buildings interspersed with greenery, making it a pleasant place for students, teachers and staff members to study and work.

The Tottori area is abundant in historical sites, some associated with mythology, and is famous for its many hot springs as well as National Park, which contains the largest sand dunes in Japan.

The Yonago Campus, consisting of the Faculty of Medicine, the University Hospital and the College of Medical Care Technology is situated in Yonago City, a city of about 133,000 people located by the sea of Japan. Yonago lies about 90 kilometers west of Koyama, under the shadow of Mt. Daisen, an extinct volcano of 1,711 meters high which is sometimes referred to as "Hohki Fuji" because of its resemblance to faraway Mt. Fuji (Hohki is the old name of this area). Daisen is the highest mountain in the Chugoku District of Japan, and its National Park attract skiers in winter, and pilgrims and hikers at all times of the year.

Faculty of Agriculture

The Faculty of Agriculture of Tottori University is one of the nation's highest ranking and most prestigious institutions of agricultural education, research, extension and international programs.

The history of the Faculty goes back to the tottori Agricultural College founded in 1920 as the third school of agricultural science at college level in Japan. The College was initially composed of two departments: Agronomy and Agricultural Chemistry. Later the College gradually expanded adding in 1939, the Verterinary Science in response to a growing demand for veterinary doctors at that time, in 1942 Forestry and in 1946 Agricultural Engineering. After World War II, the College became a university level institution designated as 'the Faculty of Agriculture' of Tottori University in accordance with the reforms in the educational system of the country during 1949. Later, in 1958, the Faculty added the Sand Dune Research Institute as the nation's sole institution for sand dune and desert study, and in 1967 the Farm Economics Department as well as the Graduate School of Agriculture due to rapid advances in science and technology in recent years. The Faculty was greatly reorganized in 1987 to meet new social demands through a regrouping into two scientific clusters: Agriculture and Forestry Science (8 departments) and Veterinary Sciences (9 departments).

The Faculty enrolls annually 235 undergraduate and 95 graduate students in more than 40 programs of study for careers in agriculture, agro-business and veterinary medicine. At presnet more than 10 thousand graduates from the Faculty are engaged actively in various fields; both domestically and internationally. The faculty is freely accessible to overseas scientists and students though diverse channels such as the Overseas Study Program, the International Exchange Program for Cooperative Research and Foreign Student Scholarships sponsored by the Ministry of Education, Science and Culture of Japan, and Inter-University Collaboration. The future-oriented activities in teaching and research of the Faculty are being effectively implemented, thanks to the Tottori University's proud tradition in agricultural science, which is known for its principle that "good research leads to improved education that redults in a good crop of successful students."

Cluster of Agriculture and Forestry Sciences

This cluster contains 8 departments: Agricultural Production, Bio-resource Science, Agricultural Chemistry, Forestry Science, Environmental Science, Agricultural Engineering, Farm Business Management, and Agricultural information Science. Besides these, the Sand Dune Research Institute, the University Forests, and the two Development Laboratories of Japanese Pears and of Hardwoods also share the responsibility for research and education with the department. The educational mission of this cluster is to produce creative, positive and intellectual students in the profession who can take a broad scientific view of human needs and the earth's renewable bioresources, and hence, can cope with the difficulties and rapid changes which often confront agriculture.

During the first and second years, all undergraduate students study not only general education subjects but also basic core subjects of agricultural science and field work in order to understand the present status of agriculture. Students in the third year concentrate on professional and specialized subjects in the various departmental courses under their teachers' guidance. Senior students major in one of the undergraduate programs, do research on a specified project under the direction of a personal advisor(s) in the field, and submit a bachelor's thesis.

Department of Agricultural Engineering

The courses in this department are designed to provide its students with an understanding of the roles that science and technology play in the field of agriculture and agricultural productivity. This department also carries out detailed studies in agricultural production and environmental engineering through the application of civil engineering and mechanical engineering technologies.

The scientific research work of this department is directly related to the improvement of agricultural productivity. The agricultural production environment is defined so as to include the biological environment, the labor environment and the living environment in agriculture.

This department consists of two majors fields of study: a major in Irrigation, Drainage and Reclamation Engineering and another in Agricultural Machinery.

The department has 9 divisions, manned by 4 professors, 3 associate professors and 2 research associates. The department strives to instill in students a fundamental knowledge and an understanding of applied techniques in the nine areas of the two department majors.

After admission, students immediately begin academic work in the two major areas of study. In their fourth year, they are separated again into one of the nine division in order to conduct individual research for the Bachelor's degree.

Courses Available

Irrigation, drainage and reclamation engineering major:

Irrigation and drainage, Water resource planning, Agricultural hydraulic structure engineering, Land reclamation engineering. Agricultural materials engineering.

Agricultural machinery major:

Agricultural machinery and implements, Farm power and machinery, Agricultural process machinery, Environment control engineering

Staff

Professors
- Ishihara, Akira, D. Agr.
- Nomura, Yasuji, D. Agr.
- Komatsu, Minoru, D. Agr.

Associate Professors
- Watanabe, Shohei, D. Agr.
- Iwasaki, Masami, D. Agr.
- Hattori, Kunio, D. Agr.

Research Associates
- Misao, Yoshiaki, D. Agr.
- Morii, Toshihiro, M. Agr.

Graduate School of Agriculture

The Graduate School of Agriculture consists of the following six Master's programs: Agronomy, Agricultural Chemistry, Veterinary Science, Forestry, Agricultural Engineering and Agricultural Management. These graduate courses have the same academic calendars as undergraduate courses.

Masters degrees are awarded upon completion of two years of residence at the Graduate School of Agriculture, the completion of the required units for the course, the writing of an approved dissertation and the passing of a final examination.

The organization of education and research in the Agricultural Engineering of the Graduate School of Agriculture is as follows:

Graduate Program in Agricultural Engineering

This program offers advanced courses in agricultural engineering. The program has 7 research laboratories, including 8 professors and 7 associate professors. Courses in the division include irrigation, drainage and reclamation engineering, agricultural machinery, agricultural meteorology and arid agricultural engineering.

The 7 research laboratories of the program are: Irrigation and Drainage, Agricultural Hydraulic Structure Engineering, Land Reclamation Engineering, Agricultural Machinery and Implements, Farm Power and Machinery, Agricultural Meteorology, Hydrology and Irrigation.

Research Topics

Studies on water consumption and water management. Studies on concrete made with lower qualitative aggregates. Reuse of waste for agriculture. Development of machinery and implements for field work and processing and mechanization systems in sandy land agriculture. Studies on the development of all-purpose type traction aids and automatic control systems for farm tractors. Studies on the characteristics of agricultural micro-meteorology in sand dune areas and arid land areas. Studies on water management at upland field under salt-affected conditions.

Arid Land Research Center

This Center was formed in June 1990 to replace the Sand Dune Research Institute which was originally established by the Faculty of Agriculture of Tottori University and financed by the Japanese Government since 1958. The Center is situated at the coastal sand dune area in Tottori. The sand dunes were developed due to an accumulation of sand drifts deposited by the Sendai River.

In 1923, research on agriculture at the sand dunes began, and windbreak trees were planted to protect crop plants from the drifting sand. On the other hand, studies on development of agriculture in arid land have been conducted since 1972.

The Center is divided into four divisions focusing their research on: (1) basic and applied studies on desertification; and (2) agricultural problems of some selected arid areas in the world. In fact, there are not any other arid lands or deserts in Japan, and the number of Japanese researchers who study these problems is quite small. The Center was reorganized, and more researchers were put on staff to further vitalize research and studies seeking revegetation and agricultural developoment in arid areas in the world.

Joint-Use Research Fields and Facilities

Aridtron

The facilities consist of three main parts;

(1) Two large green houses, maintained no-rainfall condition
(2) Growth chambers, simulating high temperature and low humidity
(3) Computer system, employed to maintain the meteorological condition in the growth chambers.

Fields

Meteorology, irrigation and hydrology experiment field	20,000m^2
Sand drift experiment field	320,000m^2
Forest for wind break	360,000m^2
Ecological experiment field	180,000m^2
Crop growing field	88,700m^2
Green houses	1,300m^2
Others	1,844m^2
Total research field	978,344m^2

The United Graduate School of Agricultural Sciences

The United Graduate School for the three-year doctoral course in agricultural sciences was established as an independent institute in Tottori University in 1989. The Shimane and Yamaguchi Universities joined Tottori University and professors and research facilities of the Master's Courses of Agriculture in Tottori University, Shimane University and Yamaguchi University collaborated in establishing this Graduate School.

The aim of the United Graduate School is to train researchers with advanced technical ability and a profound knowledge of bioproduction, bioenvironment, advancement of these fields of science and the development of related industries. The United Graduate School accepts students from foreign nations in all parts of the world.

Education

(1) Students may apply to study under the guidance of a major professor among the teaching staff of three organizing universities. The United Graduate School then coordinates the placement of students.
(2) One major professor and two other professors (of which one professor must belong to the different university from that of the major professor)
(3) A student comes to study at one of three universities to which his/her major professor belongs. Students can avail themselves of facilities of the other universities.
(4) Education of students is conducted mainly by research instruction, including group seminars.

Seven Unions of department in three courses of specialization are set up in the United Graduate School.

Graduate School

Agriculture Division
- Bioproduction Science
- Environmental Science in Agriculture and Forestry
- Agricultural Management and Information Science

United Graduate School of Agricultural Sciences
- Bioproduction Science
- Bioenvironment Science
- Bioresources Science
  (Courses/Science)

Research Activities in Agricultural Machinery

The following research activities have been carried out in the two laboratories related to Agricultural Machinery, and Farm Power and Machinery.

Laboratory of Agricultural Machinery and Implements:

1) Farm mechanization of sand dune agriculture;
2) Performance of pest control machine in orchard;
3) Physical properties of vegetables for harvesting and processing mechanization; and
4) Development of planting and procesing machine for root crop.

Laboratory of Farm Power and Machinery:

1) Studies on Automatic Working Mechanisms of Agricultural Tractors;
2) Studies on Automatic Traveling Control of Riding-type Rice Transplanters;
3) Studies on Automatic Steering System of Farm Tractors; and
4) Studies on Mechanical Subsoil Breaking.

International Exchange

For Japan to contribute to the world, it is essential for the Japanese people to promote international understanding and cooperation. Recently, the internationalization of Japanese universities was recognized as being particularly important. In Tottori University we send faculty members and students to Nevada in the United States of America for a summer institute every year. The number of faculty members who visit foreign universities or institutions for joint research or international symposiums or seminars is also increasing.

Foreign researchers have begun to come to the University for joint research so that international academic exchange can become a little bit more lively. Moreover, the number of foreign students who wish to be admitted to the University is increasing every year. They come from all parts of the world. The University is now making utmost efforts to improve living conditions and environment in order to admit them.

The University established an International Exchange Commission in 1985 and set up an organization to promote international exchange. So far the University has officially concluded an international exchange agreement with seven universities, two colleges, and one institution.

Foreign Researchers

Acceptance of Foreign Researchers

Foreign applicants considered for research fellowhsip shall be those who conduct joint research with the academic staff of the University and those who are deemed equivalent in status or academic achievement to the faculty of the University, i.e., Professor, Associate Professor, or Research Associate. The research period shall not be more than 12 months. An extension may be permitted on the basis of mutual consultation. The cost of travel and maintenance must be paid by the researchers. Research extension may be permitted on the basis of mutual consultation. The cost of travel and maintenance must be paid by the researchers, but research expenses, in principle are paid by the University.

Foreign Students

Foreign students accepted by the University are divided into three categories, undergraduate, graduate and research students.

Undergraduate Students

Students enrolled are required to take four years of study (six years in the case of students of medical and veterinary sciences) to graduate from the University. During the first two years, all students take courses at the Faculty of General Education in the following subjects: a) general education, including liberal, social, and natural sciences, b) foreign languages, c) health and physical education, and d) basic subjects necessary for students' fields of specialization. Students are also introduced to some specialized subjects during the first and second academic years. Students in the third and the fourth years take courses in their fields of specialization at each Faculty (in the case of students of medical and veterinary sciences, this applies from the third to the sixth year.) Students who have satisfactorily completed the required number of credits (hours in the School of Medicine) in compliance with the regulations of each Faculty are awarded the Bachelor's degree (Gakushi).

Graduate Students

For graduate studies at the University, diverse secialized courses of science are available. Graduate students are subdivided into two categories: a) regular graduate students in Master or Doctor degree courses, b) non-degree students in one-year special course at graduate level (Senkoka gakusei).

Regular graduate students—The tottori University has four Graduate Schools: Medicine (Doctoral course, four years), Engineering (Master's course, two years), Agriculture (Master's course, two years), and Agricultural Sciences (Doctoral course, three years). The degree of Master (Shushi) or Doctor (Hakushi) is conferred only upon those who have completed the course work at the masteral or the doctoral degree level, with the required credits in their specific major subjects, and who have passed the examination on their thesis for the degree at each level.

Non-degree students in one-year graduate course—The Faculty of Education offers a special one-year course of education at graduate level for those who want to study intensively a specific area of educational science, without earning a degreee.

Research Students (non-degree)

The university also offers research students programs for those who wish to do research work on a specific subject at the under-graduate or graduate level under the guidance of a university faculty member. The duration of such programs is usually one year. However, under special circumstance, this can be extended. Enrollment of research students takes place either in April or October each year. Provision for admission even in the middle of academic year is also possible for special applicants with meritorious qualifications. ■■

Introduction to the Laboratory of Agricultural Machinery Department of Agro-environmental Science Obihiro University of Agriculture and Veterinary Medicine

by
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Introduction

The Obihiro University of Agriculture and Veterinary Medicine was established in April, 1941 as the Obihiro Higher Technical School of Veterinary Medicine. Later the school created related courses such as dairy science and agricultural science. The school officially became a university and was renamed Obihiro Zootechnical University in 1949. The name was changed to its present English designation, Obihiro University of Agriculture and Veterinary Medicine in 1974.

The University has only the Faculty of Agriculture and Veterinary Medicine, and offers undergraduate and graduate programs. The University annually accepts 266 freshman students, 56 for masteral course and 12 of doctoral course students. Six departments (except the Department of Veterinary Medicine) where reorganized into three departments in 1990; Animal Production and Agricultural Economics, Agro-Environmental Science and Bioresource Chemistry. In addition to these four departments, the Division of Liberal Arts conducts courses in general education for undergraduate students in their first two years.

The Graduate School offers a two-year course of study for a Master's degree. It consists of six divisions; Animal Science, Agricultural Chemistry, Agricultural Engineering, Grassland Science, Agricultural Economics and Agro-Environmental Science. The Department of Veterinary Medicine is affiliated with the United Graduate School of Veterinary Sciences: Gifu University, together with the Departments of Veterinary Medicine of Iwate University, Tokyo University of Agriculture and Technology and Gifu University. This Graduate School offers a four-year course of study for a Doctor of Veterinary Science degree.

The Obihiro University of Agriculture and Veterinary Medicine is situated in Obihiro City in Hokkaido located about 1000 km north-east of Tokyo. It takes 95 minutes from Tokyo by plane.

Department of Agro-environmental Science

This Department aims to conduct extensive research on agro-ecosystems with special reference to agricultural, natural and biological resources. To meet the recent technical innovations and internationalization, it also attempts to train scientists, engineers, leaders, teachers, business people and others who will contribute to a wide range of subjects in the field of agro-environmental science.

For these reasons, the Department provides the following three categories for education and research work. (1) Feed production in relation to forage crops, improvement of crops, grassland management and utilization, and interaction between agro-environment and its surroundings, including their preservation and management. The category consists of laboratories for Forage Crop Science, Grassland Science, and Preservation and Management of Ecosystem. (2) Management and utilization of soil and water resources in an agro-environment, and engineering for land use in crop field regions, dairy-industrial regions and their surroundings. The category consists of a Laboratory of Land Resource Science and Engineering. (3) Agricultural machinery, feed processing, livestock housing and its equipment, and mechatronics applied to the agricultural production systems. The category consists of a Laboratory of Agricultural Machinery.

Laboratory of Agricultural Machinery

The Laboratory of Agricultural Machinery was established in April, 1951 as a Laboratory of Farm Mechanics No. 1 in the Department of Dairy Science. The first faculty staff was Dr. Tetsuya Ono, former professor of the Laboratory of Farm Power and Tractors.

The Department of Agricultural Engineering was established in 1963 consisting of two laboratories; Farm Power and Tractors and Field Machinery. Two other laboratories of the department, Soil and Water Engineering and Machinery for Animal Husbandry, were established in 1964 and 1965, respectively.

The laboratories of Farm Power and Tractors, Field Machinery and Machinery for Animal Husbandry were combined and reorganized into the Laboratory of Agricultural Machinery in April, 1990 along with the reorganization of the undergraduate school. The Laboratory of Soil and Water Engineering was reorganized into the Laboratory of Land Resource Science and Engineering.

Present Staff

Though three laboratories of the undergraduate school were combined and reorganized into the Laboratory of Agricultural Machinery, the current staff members are shown separately by three laboratories as the graduate school (Master's Program) still consists of six courses, including Agricultural Engineering.

Field Machinery

Prof. Keiji Miyamoto, Ph.D. (Agr.), Head of Laboratory

Assoc. Prof., Kiyoaki Matsuda, Ph.D. (Agr.)

Asst. Prof., Tadatoshi Satow, Ph. D. (Agr.)

Machinery for Animal Husbandry

Prof. Hidehiko Takahata, Ph.D. (Agr.)

Assoc. Prof., Hideo Hoshiba, Ph.D. (Agr.)

Asst. Prof., Kazutaka Umetsu, Ph.D. (Agr.)

Farm Power and Tractors

Prof. Tetsuji Taniguchi, Ph. D. (Agr.)

Assoc. Prof., Ko-ichi Ohtomo, Ph.D. (Agr.)

Asst. Prof., Tadashi Kishimoto, Ph.D. (Agr.)

Course Offerings

The courses offered at the present time are Farm Machinery, Grassland Machinery, Machinery for Animal Husbandry, Agricultural Processing Machinery, Tractor Mechanics, Livestock Housing and Equipment, Principles of Mechanical Engineering, Energy and Power Utilization, Practice in Computer Application to Agricultural Machinery, Practice and Experiments in Agricultural Machinery.

Current Research Activities

The main research activities and organizers at the present time are as follows;

Field Machinery

- Farm mechanization and composting of agricultural waste (K. Miyamoto)
- Characteristics of intra-row mechanical weeders (K. Matsuda)
- Automation of chemical application and prevention of drift in field boom sprayer (T. Satow)

Machinery for Animal Husbandry

- Energy production from agricultural and animal waste (H. Takahata)
- The study of animal-husbandry machinery (automatic animal weigher and automatic milking machine) (H. Hoshiba)

Fig. 1 Practice of tractor operation for students.

Fig. 2 Single tire tester in conjunction with soil-bin dynamometer car.

- Agricultural and animal waste management (K. Umetsu)

Farm Power and Tractors
- Analyses of soil compaction by agricultural vehicle tires (T. Taniguchi)
- Prediction of tractive performance in vehicle system (K. Ohtomo)
- Lug designing and wheel dynamics of agricultural wheels (T. Kishimoto)

Graduate School

The graduate school is intended for students who wish to expand their studies and knowledge in their fields of specialization toward higher degrees of Master and/or Doctor of Philosophy. The graduate school offers Master's Program (two-year course for Master of Agriculture) and Doctoral Program (four-year course for Doctor of Veterinary Science which is equivalent to a Ph.D. degree).

The Master's Program

The graduate school grants the Master of Agriculture to students who have (1) completed the prescribed thirty credits of study in their specialization, (2) submitted and defended a thesis and (3) passed the final examination. The period required for completion of the graduate course is normally two years, but it may be in less than two years for a student in good standing.

Applicants must satisfy one of the following conditions to be admitted to the Master's program;

(a) Be graduates from university or those who will graduate before March of the current school year.

(b) Have completed 16 years of education abroad and for those who will graduate before March of the current school year.

(c) Be approved as an applicant by the Japanese Ministry of Education.

(d) Be recognized by the University as having credentials equivalent to a university graduate.

(e) Have received a bachelor's degree from the National Institute of Academic Degree (NIAD).

(f) Have attended university for three years or more and be recognized by the University as having attained requisite credit for the graduate program with an excellent record.

The Master Course of Agricultural Engineering consists of three laboratories for agricultural machinery and a laboratory for irrigation, drainage and land reclamation. Laboratories of agricultural machinery are "Field Machinery", "Machinery for Animal Husbandry" and "Farm Power and Tractors", and that of irrigation, drainage and land reclamation is "Soil and Water Engineering".

The Graduate School of the Master Course will be reorganized in April, 1994 as the Undergraduate School were reorganized into three departments in 1990.

Doctoral Program

The Doctor of Veterinary Science is granted from the United Graduate School of Veterinary Sciences, Gifu University. It was established in 1990 with the cooperation of Obihiro University of Agriculture and Veterinary Medicine, Iwate University, Tokyo University of Agriculture and Technology and Gifu University.

The University is now applying to participate in the United Graduate School of Agricultural Sciences, Iwate University, except the Verterinary Science, which grants the Doctor of Agriculture. When the Ministry of Education, Science and Culture approves this application, the University will become one of the participating universities.

International Exchange

The Obihiro University of Agriculture and Veterinary Medicine has established international exchange program agreements with the Department of Agriculture and Forestry at the University of Alberta, Canada, and with the Department of Veterinary Medicine at the University of Asuncion, Paraguay. In addition, through the Student Exchange Program of the Japanese Ministry of Education student exchanges take place with the University of Paradeniya, Sri Lanka, the University of the Philippines, Seoul National University and Kon-kuk University, Korea, and the University of Munich, Germany.

As of June, 1993, 28 international students were studying at the University. The total number of international students accepted or sent abroad by the University through the Student Exchange Program were 140 and 88, respectively, in May, 1992.

International Student Enrollment and Scholarships

The University has been promoting international cooperation in education and research services by accepting international students and conducting research programs. All members of the research and teaching staff, including the advisory team for international students, are engaged in giving international students valuable guidance in studying and living in Japan. The international student exchange program of the University is a successful and highly valued program.

There are few scholarships available other than those provided by the Japanese Government for study at Obihiro University of Agriculture and Veterinary Medicine. Most of the international students at the University have scholarships funded by the Japanese Government. There are some international students who are studying at the University on either private funds or with assistance from their own governments.

Application and selection of the Japanese Government scholarships are classified into two categories.

(1) *Obtaining the recommendation of a Japanese Embassy abroad*

At the request of the Japanese Ministry of Education, Japanese Embassy abroad conducts a preliminary screening of the applicant through an achievement test. Based on the result of the test, the Japanese Ministry of Education selects the applicant as a recipient of the Japanese Government scholarship in consulation with the university which the student plans to attend.

(2) *Obtaining recommendation of a university*

Among the students who have been recommended by a university abroad and who have been admitted to a university in Japan through such programs as the Student Exchange Program as mentioned in "International Exchange", those who have obtained excellent grades and who need scholarships are recommended by a university in Japan to the Japanese Ministry of Education. The Japanese Ministry of Education then selects the recipients of the scholarships.

Applicants for the Graduate School are advised to contact the Laboratory of Agricultural Machinery, the Department of Agro-Environmental Science, Obihiro University of Agriculture and Veterinary Medicine Telephone No. 0155-48-5111. ■■

New Editor to AMA

Tariq Javed

Date of Birth: March 5, 1967
Nationality: New Zealander
Qualifications:
1992 Master of Philosophy (Agric. Eng.) Massey University (N.Z.)
1989 Bachelor of Agric. Eng. Univ. of Agriculture, Faisalabad, Pakistan

Work Experience
Project Engineer, School of Manufacturing and Mechanical Engineering, University of South Australia
Agriculture Engineer, Western Australian, Department of Agriculture, Merredin, WA, Australia
1991-92 Computer Consultant, Machinery Group, Agricultural Engineering Department, Massey University, Palmerston North, New Zealand
1992 Lab Supervisor, Department of Physics Massey University, Palmerston North, New Zealand
1990-92 Assistant Farm Manager, Dairy Farms in Kairanga, Aokautere and Kimbolton, Palmerston North, New Zealand
1990-92 Pasture Research Assistance, Machinery Group, Agric. Engineering Dept., Massey University, Palmerston North, New Zealand

Present Position:
Tecjnical Division, Kaneko Agric. Machinery Co., Ltd. Saitama-ken, Japan ■■

Outline and Activities of National Institute of Animal Industry

by
Mikio Kamo
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Introduction

In our National Institute of Animal Industry (NIAI), various and numerous research studies are in progress for the future livestock industry in Japan by using cattle, pigs, chickens, sheep, goats, rabbits, quails, honey bees and small experimental animals.

When compared with the culture of agronomic crops such as rice, the history of the animal industry in Japan is not long. During the last forty years, however, its production and consumption have made great strides both in quantity and in quality. Livestock products and their dietetic values will become more and more important to the Japanese.

A keypoint of the livestock industry, is to provide for consumers with fresh and safe products constantly at a reasonable price.

In response to these needs, continuous advancement and innovation of technologies are very important at each levels of production, processing and distribution.

In order to assume our duty to support the technical development and advancement scientifically and thereby to be the driving force on the livestock industry in Japan, NIAI is carrying out many studies and experiments, from basis to application, in the domains of heredity/breedind, reproduction, physiology, feed /nutrition, management and processing.

In promoting these research studies, we have prepared the basic investigational plans as follows:

1. Genetic elucidation of biological function of domestic animals and its application to breeding;
2. Elucidation of reproductive mechanisms in animals and development of proliferating techniques;
3. Elucidation and control of physiological and productive functions and behavior in domestic animals;
4. Elucidation and control of metabolic functions in domestic animals as well as effective utilization of nutrients in feeds;
5. Production of good and safe products and efficient utilization and distribution of animal products;
6. Establishment of techniques for animal production at high and stable yields and for environmental conservation; and
7. Promotion of basic research in livestock science.

History of NIAI

1916: National Institute of Animal Industry established in the Department of Agriculture and Commerce; Branch laboratories installated in Hokkaido, Tokyo, Chugoku and Kyushu.

1917: The main laboratory of National Institute of Animal Industry moved to Miyako-mura, Chiba-gun, Chiba-ken (present Chiba city).

1980: Translocated to the Tsukuba Science City.

Organization and Research Activities

Fig. 1 shows the overall organization of the NIAI. NIAI's research activities can be broadly classified as follows:

Genetic Elucidation of Biological Functions of Domestic Animal and Its Application to Breeding

In order to obtain various livestock products of high quality, it is essential to clarify genetically the biological functions of animals and poultry and, based on the informations obtained, to improve their producing ability.

For these purposes, we are trying to search for the genes which regulate economic traits of animals (for example, productivity, quality, reproductivity, adaptability to environment and disease resistance), to clarify the expression mechanism of their functions and to develop techniques for application of the findings to practice.

In developing a breeding technique on the basis of genetic informations, biotechnological and biometric genetic know-how is joined together to construct a new strategy.

[Key technologies for research and development / Key words]

Physical genetic map, Analysis of DNA polymorphism, Mechanism of gene expression, Heterosis, Transgenic animals, Introduction of foreign genes, Information on animal breeding, Selection theory, Establishment of improved strain, New breeding plan.

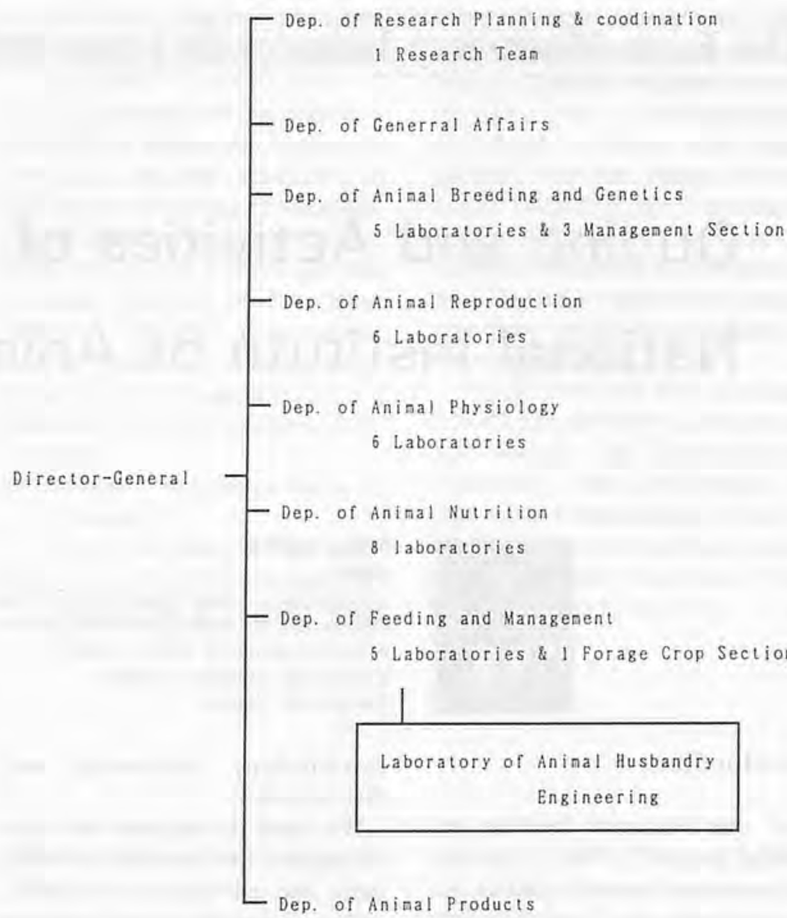

Fig. 1 Organization of NIAI.

Elucidation of Reproductive Mechanisms in Animal and Development of Proliferating Techniques

One of the fundamental elements which assure the economic efficiency of the livestock industry is the production of healthy newborns constantly by maintaining the reproductive cycle from fertilization through implantation, pregnancy and parturition. In our institute, therefore, through elucidation of the reproductive mechanism, many research studies are being carried out not only to clarify the mechanism that would dominate the initiation of phenomena including anestrus, early embryonic death, fetal resorption and loss of newborns, but also to develop preventive measures against such inconveniences. Moreover, we are making efforts to establish the frontier technologies such as in vitro fertilization, embryo cloning and sexing of sperm and embryo aiming at their practical application to produce cattle multiplets, clonal animals and newborns of the desired sex.

[Key technologies for research and development / Key words]

Endocrinal mechanism, Mechanism of pregnancy recognition, Mechanism of implantation, Embryonic death, Biogenic substances [Physiologically active substances], Embryo transplantation, Multiplets, In vitro fertilization, Nuclear transplantation, Separation of X- and Y-spermatozoa, Sexing of embryo.

Elucidation and Control of Physiological and Productive Functions and Behavior in Domestic Animal

To improve the productivity of farm animals and the quality of their products, the factors and mechanisms regulating physiological and productive functions should be understood.

For this purpose, many studies are in progress not only to clarify the mechanisms regulating the growth and production of meat, milk and eggs at the molecular, cellular, tissue and whole body levels but also to control these functions.

Moreover, the effects on the productivity of environment factors including ambient temperature, humidity, wind and photoperiod are being assessed to develop techniques to control these factors. We have been pursuing researches also on the activities of the nervous systems and behavior of farm animals.

[Key technologies for research and development / Key words]

Physiologically active substances, Endocrinal functions, Control of growth, Control of Lactation, Control of environmental factors, Stress, Adaptation to environment, Central nervous system, Control of feed intake, Behavior and habit.

Elucidation and Control of Metabolic Functions in Domestic Animals as well as Effective Utilization of Nutrients in Feeds

Investigations of nutrition and feeds should be promoted to improve the productivity of livestock and the quality of their products.

Research studies are carried out to elucidate the mechanisms of digestion, absorption and metabolism of nutrients, to understand the nutrient requirements dynamically and to develop techniques for controlling the utilization of nutrients.

As for the feed, the functional properties of feed are investigated to establish a method for evaluation of nutritive values and to develop new feed resources.

[Key technologies for research and development / Key words]

Digestion and absorption, Fermentation in the rumen, Metabolic function, Interaction among nutrients, Intermediate metabolites, Endocrinal mechanism, Nutrient requirements, Functional feed, Nutritive value and efficiency, Feed data base, Feed resources.

Production of Good and Safe Products and Efficient Utilization and Distribution of Animal Products.

The demand for healthy livestock products and excellent quality has become increasingly greater along with the diversification of Japanes eating habits. In addition, the extension of the distributional range requires techniques for keeping products fresh and for improvement in distributive machinery.

In this context, we are making efforts not only to clarify the optimal conditions to obtain such products but also to understand the metabolic mechanism of hazardous substances and to develop and utilize the preventive measures against contamination.

Furthermore, in order to meet diversified and upgraded consumer's needs, we are promoting research aimed at betterment of flavor and improvement of functional properties by using techniques such as modification of molecular structure.

[Key technologies for research and development / Key words]

Hazardous residues, Evaluation of Safety, Milk components, Flavor, Cheese ripening, Tenderization and ripening of meat, Nondestructive determination of meat quality, Identification of meat species, Lactic acid bacteria, Livestock by-products, Antigen structure, Immunomodulation, Functional properties of foods, Functional modification.

Technologies for Animal Production of High and Stable Yields and for Environmental Conservation

The livestock industry in Japan is proceeding toward a highly intensive form by enlarging the scale of farms and improving the productivity of animals. In such a situation, development of know-how is awaited to assure labor saving, economy in energies, strict control of the rearing environment and appropriate animal waste and wastewater treatment.

We are performing, therefore, many research to make use of biological information for each animal in its rearing system as well as to develop and evaluate animal housing, facilities and equipments. Moreover, the development of measures to prevent environmental pollution due to animal waste is being attempted using various techniques.

[Key technologies for research and development / Key words]

Measurement of biological informations, Rearing conditions, Monitoring and management model, Automatization, Environmental control in livestock buildings, Rearing system, Acceleration of composing, Methane gas, Removal of nitrogen and phosphorus, Control of malodor, Greenhouse effect gases.

Basic Research for Livestock Science in the National Institute of Animal Industry

With the advancement of practical research on animal industry, the urgent need for the basic knowledge which can support and promote it has been recognized.

They include, among others, the followings; techniques for storage, utilization and analysis/measurement of animal genetic resources, collection and compilation of information on the animal industry, and their application to practice.

[Key technologies for research and development / Key words]

Cryopreservation of sperm, oocyte and embryo, Evaluation of characteristics of genetic resources, Tracer, Nondestructive measurement of living animal and feed, Enumeration of bacterial count, Technologica trens in animal production, Fact information, Data bases.

Activities of Laboratory of Animal Husbandry Engineering

Our laboratory is made-up three research scientists whose common major is agricultural engineering. This laboratory is a unique in its existence because among all the laboratories in this institute it is the only one which adopts an engineering approach to studies of feeding and management. We intend to develop facilities and mechanization technologies which perform high quality and stable production. Therefore we aim to develop facilities and mechanization techniques in order to economize management and to improve labor and production environment. Specifically, we base research points on livestock behavior and on interface between livestock and environment. With this image of our laboratory, allow us to introduce one part of our recent researches.

As an index for evaluating the functions of livestock building from the side of livestock, our emphasis is on the behavior of livestock. We have been studying the relationship between behavior and stall which controls cow's posture and behavior inside the stall. We have been investigating how the stall length, width and kinds of stall fence have an effect on the time or frequency of standing up and lying down and on posture of lying down. We have been analyzing berhavior pattern of standing up and lying down. The results of this study will be used to design of desirable stall for cows.

Fig. 2 Analysis of cow's behavior inside the free stall.

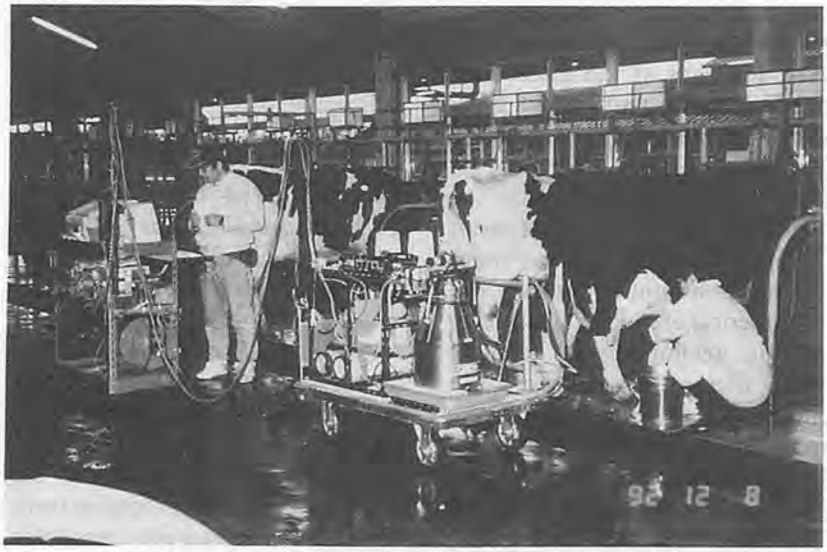

Fig. 3 Experiment of milking control techniques based on individual information of milk flow rate.

In order to achieve high accuracy in milking management techniques which adapts for characteristic of lactation for each milking cow, new theory of milking control we have been developing. This theory controls mechanical milking condition of the milker, that is, vacuum pressure, pulsator ratio and pulsation rate, using fuzzy control based on individual information of lactation. In the present stage it was observed that the milking time was shorter and milk flow rate was higher compared to ordinary milking.

Nonequilibrium thermodynamics was adapted to animal industry and evaluation method of livestock housing has been studied not only from the view of economics but also from the view point of energy and entropy which is regarded as an index of load on environment. The final goal of this study is to build a system of animal industry adapted to the region from the view point of circulation of substance. We already calculated the economics, energy balance and entropy balance in layer system including waste management in every region and housing type. Furthermore we proposed new index which explains load on environment per unit product.

The environment inside the livestock building should be controlled properly because it is associated not only with productivity but also with environmental problems and animal rights. Especially ventilation is a dominant factor of environmental control in livestock building. Therefore we have been studying the relationship between ventilation and the characteristics of distribution of environmental factor such as temperature, relative humidity, contaminant gas and dust etc. with model experiment or numerical simulation.

As mentioned above, we are performing primary and basic researches. ■■

National Federation of Agricultural Cooperative Association

by
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Trust Between the Farmer and the Consumer

ZEN-NOH's mission is simple and unambiguous; it is to ensure stable supplies of fresh, healthful, safe agricultural and livestock products and processed foods to Japanese consumers and to contribute to agriculture world-wide.

In order to achieve these goals, we work closely with member local primary-level Nohkyo agricultural cooperatives and prefectural economic federations. The resulting programs are carefully designed to reinforce the goodwill that exists between producers and consumers. The focus is on enhancing communications between ZEN-NOH and consumers by providing useful dietary and lifestyle information through television and other media, arranging tours for consumers to model farms and processing plants and by raising funds for various worthy purposes such as the promotion of farm products. All of these activities also provide ZEN-NOH with valuable feedback on evolving consumer preferences which we promptly pass on to producers.

We are uniquely positioned as an intermediary and coordinator between producers and consumers in supporting a diverse range of activities designed to ensure cost-effective agricultural production and healthy lives based on our in-depth understanding of what the market wants and what it can sustain.

Profile

Since its establishment in 1972 under the Agricultural Cooperative Society Law, ZEN-NOH has been a committed promoter of agricultural development in Japan. Through the cooperative efforts of member Nohkyo (primary-level agricultural cooperatives) and Keizairen (prefectural economic federations), we work to improve the productivity of farmers and their socio-economic status.

ZEN-NOH serves farmers through 3,128 Nohkyo and 62 federations. Through with them, ZEN-NOH supplies to farmers fertilizers, agro-chemicals, feeds, farm equipment and technologies for agricultural and livestock production, as well as daily necessities and household goods.

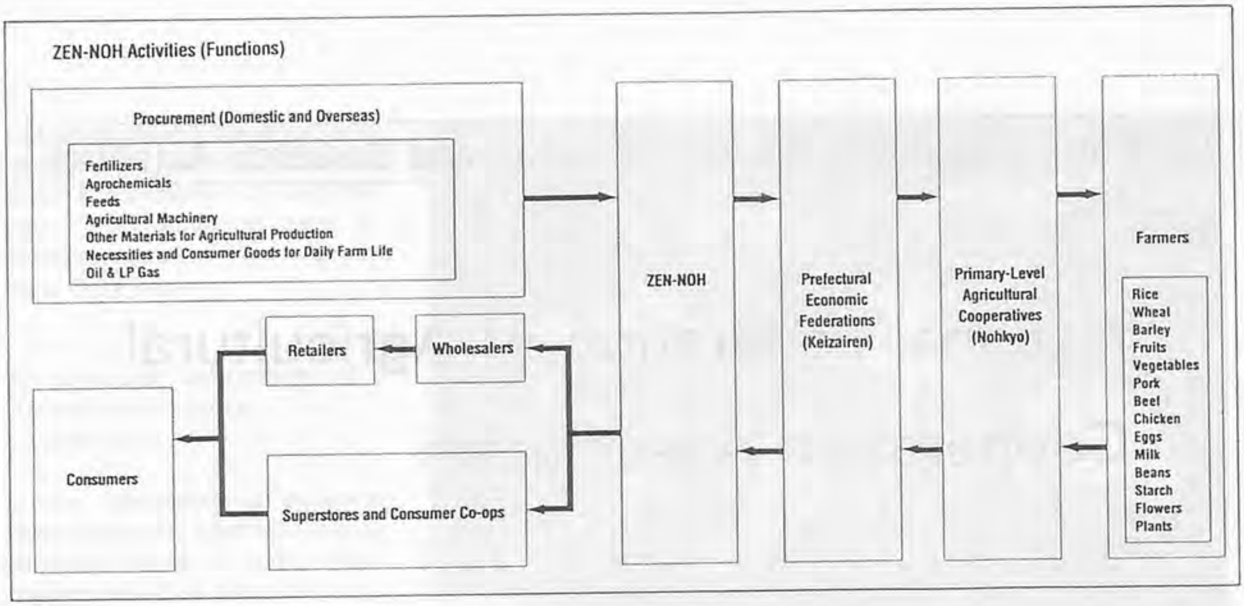
ZEN-NOH also collects, distributes and market agricultural and livestock products for farmers through its own nation-wide and international channels. In the fiscal year ending June 30, 1992, our operations generated a turnover of ¥6,934 billion.

Our organization benefits from a democratic structure which ensures that activities reflect needs at the grass-roots level. Three-fourths of the members of the Board of Directors of ZEN-NOH are elected from presidents of member prefectural federations.

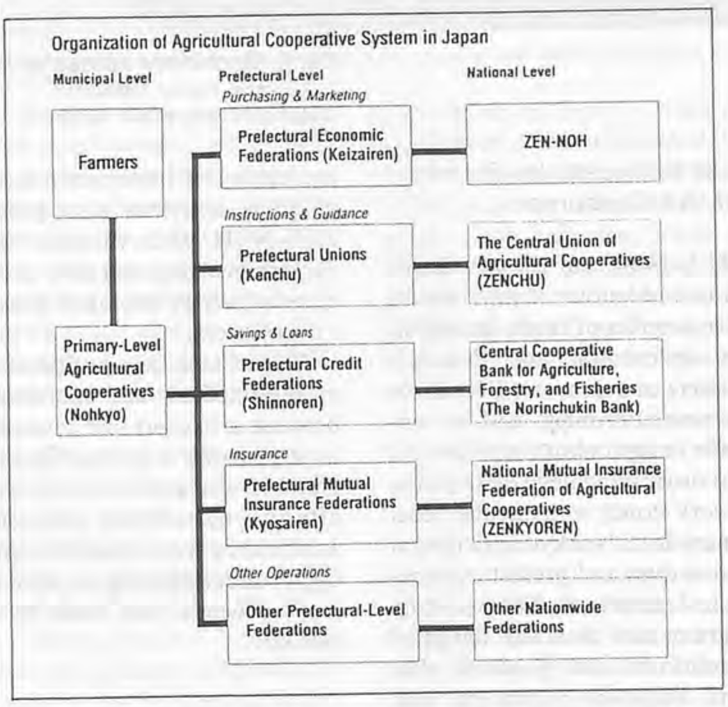
Aided by a solid structure and a record of successful programs, we look forward to making further contributions to agricultural development in Japan and overseas.

This article is based upon the introduction brochures published by ZEN-NOH.

ZEN-NOH: National Federation of Agricultural Cooperative Association



Serving Farmers and Consumers Through Role and Function Coordination



As an organization dedicated to the interests of both farmers and consumers, one of our aims is to guide the development of Japanese agriculture to maintain a stable supply of food to the country as a whole. Given this commitment, we undertake a broad spectrum of activities.

For example, on the supply side, we provide fertilizers, agrochemicals, feeds, machinery and equipment, and other vital materials for agriculture to the farming population. On the distribution side, we ship and market high-quality, fresh agricultural products to consumers at reasonable prices. For farmers, the results have been a steadily rising living standard fed by the economies of scale that we are able to deliver, including savings from bulk procurement of raw materials for feeds and fertilizers.

In order to respond to fast-changing and diversifying dietary lifestyles, we are currently expanding our educational programs for farmers supported by the development of various agricultural zones. At the same time, we are working to ensure coordination between producing areas (by assisting farmers with planned production) and distribution (based on broad national and regional perspectives).

ZEN-NOH is also active in rationalizing distribution systems. In addition to standardizing the quality and content of farm products, expanding distribution facilities and simplifying packaging, we are developing innovative distribution channels to link producers and consumers more directly.

We have established key distribution centers in the Tokyo and Osaka areas where superstores and consumer cooperatives can purchase fresh produce directly from producing areas. Through this advantageous system, developed in cooperation with producers, we ensure stable supplies to consumers, while promoting rational agricultural production.

Stripped to its essence, our goal is simple: to deliver healtful, fresh, and tasty food to the tables of people throughout the country.

Marketing Coordination

ZEN-NOH's sales operations are components of a comprehensive system extending from farm production to sales. Today, our sales activities are in the process of transformation, as they are focused on fair distribution of domestic agricultural and livestock products to consumers throughout the nation. While diversifying consumer values and needs in recent years have forced farmers to improve agricultural management methods, ZEN-NOH has since modified its activities to reflect these changes.

We are also responding to a trend toward the internationalization of agriculture with the expansion of promotional activities from domestic sales to export of agricultural and livestock products.

Domestic Sales Operations

In the domestic market we collect agricultural and livestock products from the farms and supply them, as well as finished products, to consumers. In the process, we give advice to farmers so that consumers might receive healthful, fresh, and tasty products. We also constantly monitor the domestic market situation to ensure on-time delivery to the destinations specified by customers.

We are now rationalizing the distribution mechanism and developing the market further to make sure that agricultural and livestock products are delivered efficiently at competitive prices.

Export Sales Operations

The internationalization of agriculture is a political issue. We interpret this as indicating the need to export Japanese agricultural and livestock products to overseas markets. ZEN-NOH has already undertaken export activities and market research for selected Japanese products in many overseas markets.

Purchasing

ZEN-NOH also helps to create and support an ideal environment for agricultural production. We take advantage of economies of scale by purchasing and supplying large volumes of farm inputs ranging from fertilizers, agrochemicals, feeds, packaging materials, and greenhouse equipment to motor vehicles, fuel, sundries, foods, apparel, home electric appliances and other essential daily items.

Purchases of agricultural items are carried out by collecting orders which are batched by category for cost-effective, planned procurement. We also meet constantly changing demand for non-agricultural merchandise to fulfil the lifestyle aspirations of farming households.

As a result of our purchasing systems, the farm family is able to be an efficient producer and to enjoy the same high level of material comfort as the urban dweller.

Overseas Activities

Japan relies heavily on overseas sources of raw materials. The raw materials used in agriculture for fertilizers, agro-chemicals and feeds, as well as LP gas and oil, are no exception. In order to find source, to procure and supplly quality materials to Japanese farmers in a way that promotes stability and cost-efficiencies, we engage in a wide range of activities overseas which extend from direct importing from producing countries to establishing procurement subsidiaries and chartering ocean-going vessels.

ZEN-NOH manages operating bases in Hong Kong, Sydney (Australia) and Düsseldorf (Germany) as well as subsidiaries in the United States.

Through U.S. offices in New York, Seattle and Tampa, the ZEN-NOH UNICO AMERICA CORPORATION is responsible for exporting fertilizer materials, feedgrains and other materials to ZEN-NOH in Japan. It is also in charge of financing procurement of exported commodities and sells quality Japanese beef, fruit, and vegetables in North America.

On the other hand, ZEN-NOH GRAIN CORPORATION, located in New Orleans, purchases, stores, and outships corn, sorghum, and soy beans with help from a St. Louis enterprise, Consolidated Grain and Barge Co., which collects grain from farmers.

To complement our overseas operations, ZEN-NOH maintains UNICOOPJAPAN, a domestic subsidiary with its own offices around the world, including ones in Bangkok, Prague, Beijing, Taipei and Moscow.

All of ZEN-NOH's operations are making major contributions to communities in their host countries and ultimately promoting a global agriculture system.

Laying Foundations for the Future

Agriculture today is seeing a rapid introduction of technological innovations. Consequently, one of our priorities is to establish agricultural technologies for a stable production of high-quality, high-yield farm products. This is undertaken by researchers and staff at our well-equipped research facilities — the Agricultural Technical Center, the Central Institute for Feed and Livestock, and the Institute for Animal

Health.

Specifically, the Agricultural Technical Center is currently researching and developing new food products and technologies. The staff there are also testing and inspecting the safety and quality of all products handled by ZEN-NOH, conducting seminars on a wide range of topics of train affiliated technicians and organizing educational tours of the facility to visiting agriculturists.

Recently developed at the center is a new hybrid of rice cultivars (F1) for use in processed foods such as *miso* (fermented soy bean paste), soy sauce, and rice cookies. Compared to standard rice cultivars, the F1 type features vigorous growth and high yield, with superior resistance to disease and pests, while it offers improved performance in challenging environments.

The Central Research Institute for Feed and Livestock attracted world-wide attention in November 1988 by announcing the successful production of a bovine offspring following the transfer of a frozen-thawed embryo derived from oocyte fertilized in vitro.

The Institute of Animal Health is currently engaged in research and development of a network system to integrate our activities with those of Nohkyo and prefectural economic federations. It is also establishing ZEN-NOH's own management information system. This initiative follows the launching of a nation-wide network system linking prefectural economic federations and their customers.

We expect our technological initiatives to be a valuable vehicle for boosting safety and efficiency in all sectors of agriculture.

Data on ZEN-NOH

Chairman and President
Moto Motohashi

Executive Vice Chairman
Keizaburo Banzai
Akimasa Kishi

Senior Managing Director
Yoji Yamashita

Managing Directors
Kikuya Aoki
Takuo Nishimura
Shingo Hirano
Susumu Ozaki
Hiroyuki Hama

Senior Standing Auditor
Hiroshi Yamase

Standing Auditors
Shoshichi Ohnuma
Hirooki Nishimura

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Telex: 222-3686, 222-3514
Fax: (03) 3245-7442, 3245-7443, 3245-7849

Branches
Sapporo, Tokyo, Nagoya, Osaka and Fukuoka

Agricultural Technical Center
Hiratsuka

Fresh Foods Distribution Centers
Tokyo, Yamato and Osaka

Wholesale Market for Fruits and Vegetables
Tokyo

Central Livestock Marketing Center
Tokyo

Central Egg Marketing Center
Tokyo

Central Research Institute for Feed and Livestock
Tsukuba

Institute of Animal Health
Sakura

Training Centers
Hokkaido, Tohoku, Okayama, Kyushu and Tsukuba

Overseas Network

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Fax: 802-7417

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Telephone: 2-232-5322, 2-232-5424
Fax: 2-233-1135

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4000 Düsseldorf 1, Germany
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Fax: 211-35-8480

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JL, MH Thamrin Kav 57
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Telephone: 021-390-3138～40
Fax: 021-390-3140

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Fax: 212-983-3086

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Seattle Branch
1001, 4th Avenue, Suite 3931, Plaza Bldg., Seattle, WA 98154 U.S.A.
Telephone: 206-343-0177
Fax: 206-343-0209

Zen-NOH UNICO AMERICA CORPORATION
Tampa Office
Sun Bank Bldg., Suite 807
315 E. Madison Street
Tampa, FL 33602 U.S.A.
Telephone: 813-228-6028
Fax: 813-223-4553

ZEN-NOH GRAIN CORPORATION
Two Lake Way Center, 3850 N. Causeway Boulevard, Suite 1100, Metairie, LA 70002 U.S.A.
Telephone: 504-831-3594
Fax: 504-831-2371 ■■

Main Products of Agricultural Machinery Manufacturers in Japan

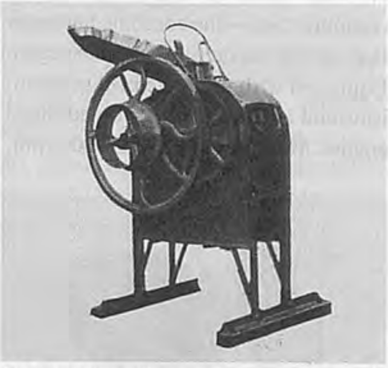
by
Shin-Norinsha Co., Ltd.
No. 7, 2-chome, Kanda Nishikicho
Chiyoda-ku, Tokyo 101, Japan

Introduced here are the 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.

The ARIMITSU Cold Fogger Model LVH-15NCS with self-cleaning nozzle system to be operated by the built-in micro computor. Trouble free, more advanced, and efficient equipment for greenhouse pest-control.

BUNMEI Sugarcane Harvester NB-11. The small walking type harvester. Mounted with 91 hp diesel engine. Working efficiency: 10 a/hour.



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.

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.

ISEKI TF325 Tractor. Mounted with powerful and economical 25PS water cooled diesel engine. The tractor offers wide range of travelling speeds from approximately 1.2 km/h to 20 km/h, which offers broad operating application and safe road travelling.

ISEKI SF300 Mower. The 28 bhp

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: 1524mm, Cutting height: 30-120mm, Mower weight: 190kg.

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 1.5 V 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 R_1-40. 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: 35PS/3000 rpm.

KUBOTA Power Tiller K120. With the Kubota power tiller, the preparation of the soil is easy and fast. It saves both time and energy, can work in any kind of field, wet or dry. 6 forward and 2 reverse speeds easily selected with only one shift lever.

MAMETORA Vegetable Transplanter TP-3V. This machine is available in both pot and soil block in seedling transplanting. Application: all vegetable nursery.

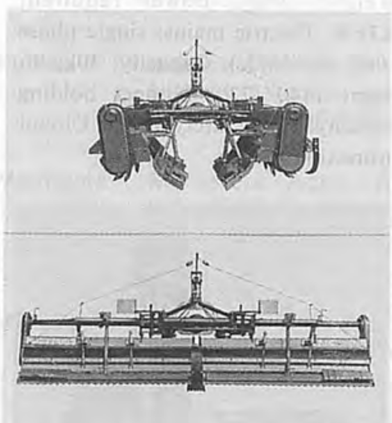
MAMETORA Power Cultivator SRV4V. Wide range use: cultivation to riding, Mounted with 7 PS engine.

MARUSHICHI Grain Milling and Grinding Machine. Efficient milling and grinding for barley, wheat, corn, soy, etc. Ground grains with tasty flavor. Fine tuning operation by single leverl. Motor: 1-2hp, Rpm: 250-350, Milling cap'ty/h: 50kg, Grinding cap'ty/h: 200kg.

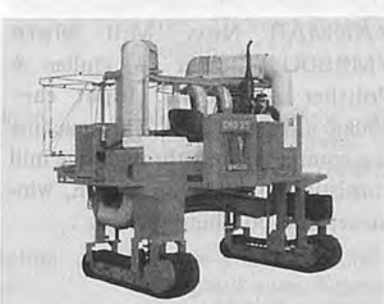
MARUYAMA Portable Power

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

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 × 2.



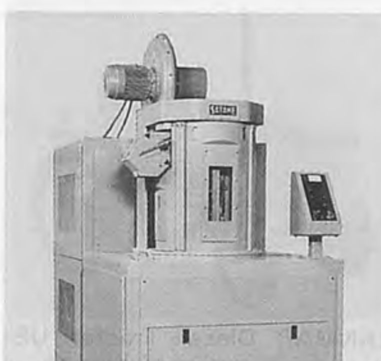
NIPLO Wing Harrow HW-4102B folded by hydraulic power for transport. Working width: 417cm; Required tractor horsepower: over 50.



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

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.



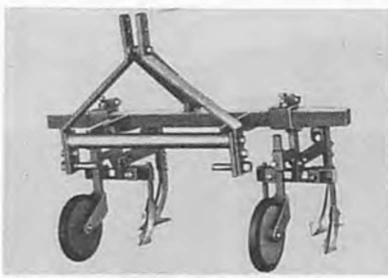
SATAKE New Rice Whiteness, Abrasive and Friction types, have high recovery, uniform & gentle milling, less installation space and high capacity. Model: VRM8A (Abrasive type) & VMA8A (Friction type) Capacity: 8 to 10 mt/h brown rice.

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.

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

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.

STAR Mini-Roll Baler MRB 0810. 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 Double Row Cultivator Model TBC. The row width can be controlled easily and quickly by adjusting each bolt at the left and right of tool bar. Row width: 600-900mm. Suitable working speed: 3-5km/h. Power required: 11-20HP.

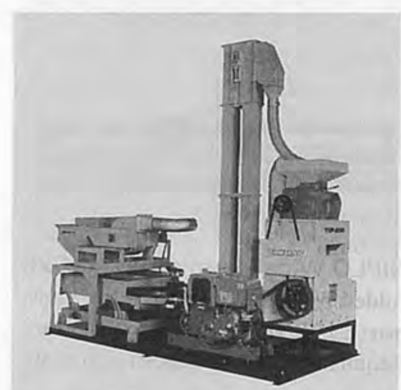
WORLD Squeezer LP-5. The world's first continuous rice-bran vegetable seeds oil extraction equipment (SQUEEZERS). Type: LP-5 (ring system), Capacity: 8kg/h (Rice bran 5), Residual oil: 15% (Rice bran 10%), Power required: 0.4kW, Net weight: 90kg, Cylinder pressure: 5ton, Size in m: 1W x 0.5L x 1.2H.

TACHIYAMA ROLL BALER RB904. Working width: 900mm, picking up and baling long straw, cut straw, grass and etc. working efficiency: 20-40 a/hour. Required tractor horsepower: 30PS or over.

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

YANMAR Diesel Tractor US Series. 5 models: 20ps, 25ps, 30ps, 35ps, 40ps. Compact, quiet and vibration-reduced diesel engines are mounted at the heart of these US series tractors. Engine: vertical, 4-cycle, water-cooled. Transmission: gear shifting. F8 × R2 or F9 × R3 Drive system. 4-wheel drive.

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 × W × L): 850 × 330 × 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 New Mill Mate YM650U. Cleaner + 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.

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NEWS

International Association on Mechanization of Field Experiments (IAMFE)

IAMFE News '93-1, Nov. 1993

IAMFE Secretariate transferred to Sweden

From Jan. 1, 1993 the IAMFE Secretariate is placed in Sweden. Egil Öyjord, President of IAMFE, will keep the President Secretariate in Norway as long as he is President of IAMFE.

The Executive Secretary and Treasurer of IAMFE is now Kenneth Alness, Department of Agricultural Engineering, Swedish University of Agricultural Sciences, S-750 07 Uppsala, Sweden.

Regional conference in China

A regional IAMFE conference will be arranged Oct. 17-21, 1994 in Beijing, China. An announcement folder, including call for papers and participation in poster and outdoor exhibition, should have been distributed to all members. Feel free to distribute this folder to anyone concerned and contact us if you need extra copies of the folder. The conference language will be English. Please send in abstracts and Preliminary registration before Dec. 31, 1993.

For detailed information, write directly to:

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1994 JSAM International Workshop on Agricultural Mechanization

April 6, 1994
Fukuoka, Japan

By Japanese Society of Agricultural Machinery

Sponsores by Tsukuba International Agriculture Training Centre; JICA; and Farm Machinery Industrial Research Corporation.

Dr. Seiichi Oshita, Chairman, Special Committee of Agricultural Mechanization in Foreign Countries, JSAM, has announced "1994 JASM International Workshop on Agricultural Mechanization" in "1994 JSAM Annual Meeting" expected to be held at Kyushu University, Fukuoka City, as follows:

Date and Time:
April 6, 1994, 09:30 – 16:00
Place:
Literature Campus, Kyushu University, Hakozaki, Higashi-ku, Fukuoka City
Official Language:
English
Special Guest Topic:
"Today's Status of Agricultural Mechanization in Korea" by Prof. Hak-kyun Koh, President, Korean Society of Agricultural Machinery
Total Number of Topics:
15 topics from 15 countries by JICA trainees and other experts
Attendance Fee:
¥1,000 (about $9)/person for proceedings (in English)

Many persons, interested in international co-operation and appropriate technologies of agricultural mechanization in developing countries, are expected to join discussions in the workshop.

2nd International Conference on Soil Dynamics (ICSD-II)

August 23-27, 1994
Silsoe College, Silsoe, Bedford
United Kingdom

The conference will concentrate on the reaction of soil to forces applied by any type of mechanical force. Research contributions covering a wide range of applications are invited: tillage, earthmoving, transport, traction, trafficability, mobility, soil handling, soil compaction, plant root growth, soil stability, soil penetration, soil cutting and simulation and modeling. Soil dynamics contributions from fields of research as far ranging as agriculture, forestry, construction, mining and military and space technology will be considered.

The proposed conference format is designed to encourage the informal presentation of papers and free discussion of recent important soil dynamics advances.

Afternoon tours and visits will include demonstrations and places/things of interest to those involved in soil dynamics.

Sponsored by Silsoe College (Cranfield University) Silsoe Research Institute, Department of Agriculutral Engineering (Auburn University), National Soil Dynamics Laboratory (USDA, ARS)

For further information, please contact:

Dr. Richard J. Godwin, Silsoe College, Cranfield University, Silsoe, Bedford MK45 4DT, United Kingdom. ■■

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

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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 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.
h. written on floppy disc.

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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.
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Articles for publication must contain one printed copy along with one copy on 3.5 inch floppy disk and black & white photographs for the articles.

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NEW TECHNOLOGY IN GRAIN POSTHARVESTING

by Ritsuya Yamashita
Professor emeritus of Kyoto University, Professor of Kinki University

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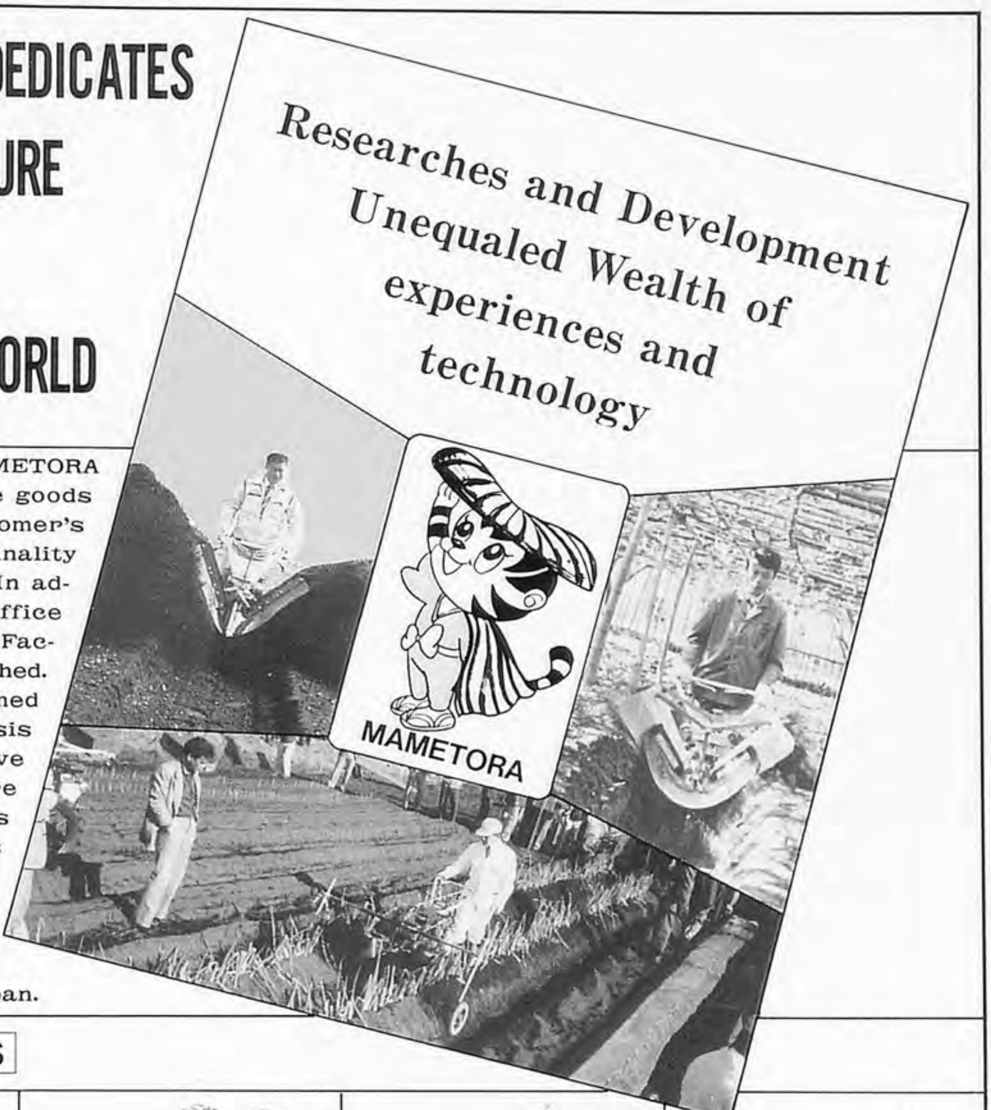

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