International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.27, NO.1, WINTER 1996

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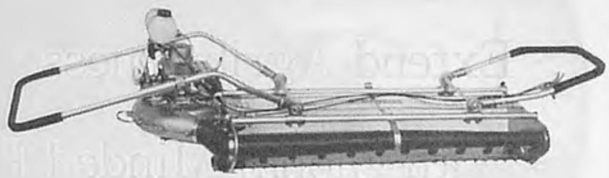

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AMA ABSTRACTS AND INDEX, 1971–1980

— A Key to Wealth of Information —

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

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

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

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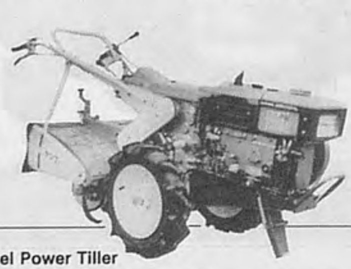

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International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.27, NO.1, WINTER 1996

Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

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

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

This is the 90th issue since its maiden issue in the Spring of 1971

EDITORIAL

Season's Greetings to Everyone!

The entire AMA staff extend to every reader the best wishes for a happy new year. Last year in Japan there were some big incidents such as a big earthquake in Kansai-area, the case of Aum-Shinrikyo, but it was a good year as far as agriculture and farm machinery industry are concerned, with a good harvest of rice and active domestic demand for farm machinery. Following the agreement at Ulguai Round, Japan imported about 0.4 million tons of rice last year. Three years ago Japan took an urgent measure to import 25 million tons of rice from many places of the world to cover rice shortage caused by a poor rice crop which was 26% less than an average year. Presently over one million tons of imported rice are in stock partly because it is not to consumers' taste.

The world faces a big change due to free trade of agricultural products. Some countries are benefitted by free trade, expanding their market to overseas and eventually encouraging domestic industry. Others are seeing difficulties for weak competitive position in world markets. As the most effective means to promote prosperity, the present world is adopting the principle of competition. Is that the only way for us? The expanding gap between developed countries and developing countries are seen everywhere. European countries, The United States and Japan are entering into informed society where the terms like ''multi-media'' and ''internet'' are going to be important key words. On the other hand, 60% of the world population have never used telephone. This information gap seems to expand more in the future.

As for agriculture, the free competition between the farmers in developing countries who own only 2-3 hectares of farmland in average and the farmers with more than 1 000 hectares farm seems quite nonsense. The principle of competition is not enough to make whole world better step by step. The thought that only the strong would prosper will lead us to miserable world. The United States, one of the most advanced nations in the world, is suffering from a large number of crimes and homeless people. What does this mean?

In considering agricultural mechanization in developing countries, to raise the power of whole average farmer must be of primary importance. Simply adopting the principle of competition to raise the strong will not offer a workable solution to the present and future situation. AMA has been published more than 25 years and during this period the economical gap between farmers in developing countries and the people in developed countries has been actually expanding, which will make it difficult to realize peaceful international society on earth.

We also have to direct our eyes toward the weak in agriculture in developing agricultural technology and agricultural mechanization. I hope that AMA continues to play an active part this year in achieving our objectives to solve the problems of world farmers.

With deep appreciation to everyone for the support to AMA.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January, 1996

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 27, No. 1, Winter 1996

Tests of Double-screw Paddy Field Tiller

by
Chen Jian
Assoc. Professor
Agric. Engineering College
Southwest Agric. University
Beibei, Chongqing
Sichuan 630716, China

Luo Hong
Chief Engineer
Agric. Mechanization Appraisal
Sta. of Chongqing City
Yongchuan, Chongqing
Sichuan 632160, China

Abstract

The double-screw paddy field tiller differs fully from other cultivators in having two screws which act as the traction device and at the same time prepare the soil. Tests were carried out to evaluate the performance of this new machine and to find ways of improving it. The trial results showed its adaptability, quite good mobility and high quality of cultivation but not so good manageability. In this paper, the influences of the screw diameter on the depth and width of cultivation, the energy consumption and quality of tillage were discussed. The phenomena of missing cultivation and re-cultivation were analyzed. A method of determining the tiller speed and the average screw pitch are presented. The problems to be solved are pointed out.

Introduction

Sichuan Province in southwestern China has about 3 million ha of paddy fields most of which are scattered among the hills and mountains where there are not usually roads for tractors traffic. In addition, a large part of the fields contain water perennially because of poor drainage, hence the deep and spongy soil can bear little weight and shear. Therefore, the fields were normally tilled by draft cattle. The economic problem, however, has caused the number of the farm animals to decline in recent years, hence some of the fields have been ploughed or dug by manual labor. Consequently, the double-screw paddy field tiller was designed by a Sichuan farmer named Liu Mingxiang several years ago and has since been improved and spread rapidly in the province. However, the design and manufacture of this machine should be further improved. For this purpose tests were conducted.

Acknowledgement: The authors wish to acknowledge the help of Senior Engineer and the former Chief Engineer of the Chinese Academy of Agricultural Mechanization Sciences Wang Wanjun in the modifying of this paper.

Structure and Principle

The tiller consists of an engine, a V belt drive, a clutch, a speed reducer, double screws and a hull. **Fig. 1** shows its structure. **Fig. 2** illustrates the machine that was used in the test.

As main part of the tiller, each of the two screws consists of two pitches of different lengths and a turn-soil board, as shown in **Fig. 3**. When the screws are driven

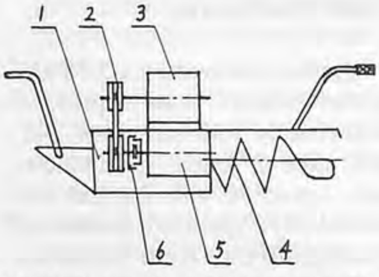

Fig. 1 Design of the double-screw paddy field tiller (1-hull; 2-V belt drive; 3-engine; 4-screw; 5-speed reducer; 6-clutch).

Fig. 2 The double-screw paddy field tiller used for testing.

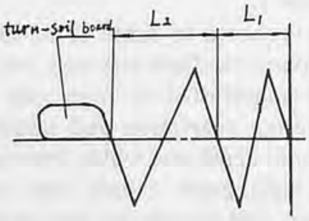

Fig. 3 Main components of the tiller screw.

to rotate their vanes, they cut into the soil and then push the soil behind. At the same time the axial component of the reacting force of the soil against the vanes makes the tiller move forward. As the back screw pitch is longer the cut soil is pushed away and broken by the back vanes and turned over the turn-soil board. The two cross components of the reacting force of the soil against the two screws oppose each other, which causes the tiller to advance basically straight.

Table 1. Test Results of Double-screw Paddy Field Tiller, Chongqing, Autumn, 1990

Item	Screw diameter (mm)		
	240	260	270
Depth of cultivation (cm)	11.9	13.2	13.8
Width of cultivation (cm)	39.7	41.4	42.5
Depth stability (%)	91.7	88.2	92.8
Width stability (%)	85.1	85.3	86.7
Covering of vegetation (%)	79.37	86.2	89.2
Velocity (km)	2.09	2.46	2.43
Energy consumption (kW)	3.05	3.24	3.36
Fuel consumption per unit area (g/m^2)	1.202	1.398	1.119
Noise by driver's ear (dB(A))	96	99	95
Noise outside tiller (dB(A))	84	85	84
Mass of caught grass (kg)	0.8	0.05	0.22
Mass of stuck soil (kg)	0.27	0.29	0.55
Surface level (cm)	1.64	2.63	1.24
Furrow level (cm)	2.62	2.45	2.42
Productivity (m/h)	757	761	920
Remainder of areas (%)	0.376	0.04	0.014
Areas missed (%)	2.266	0.964	0.776
Tiller mass (kg)	141	143	145

Test Conditions

A tiller powered by a 3.68 kW diesel engine and equipped sequentially with screws of 240, 260 and 270 mm in diameter was tested in the Agricultural Machinery Appraisal Station of Chongqing City from November to December, 1991 under the following conditions: Air temperature: 7-22°C; air pressure: 98-100.19 kpa; soil: Clayey loam; soil solidity: 13.67×10^4-20.33×10^4 pa; water depth in the field: 4.36-10.5 cm; former crop: rice; stub height: 31.3-38.2 cm; Average vegetation density: 1 120-2 215 g/m^2.

Results and Discussion

The test results are shown in **Table 1**.

As shown in **Table 1**, the tiller prepared the field very well, which was manifested in high rate of covering vegetation and stability of both depth and width, less mass of both grass caught and soil stuck, and the missed and leveler surfaces and furrows. This was because the double-screw can turn the soil like a plough and break it like a rotary tiller at the same time. In fact, the tiller's cultivating once is equivalent to conventional ploughing and harrowing three times. Besides, its productivity is over five times higher than that of draft cattle.

It may be seen in the table that small diameter screws are unfavourable to furrow, productivity and the covering of vegetation except energy consumption. In addition, it will cause a low speed and moving problems when tilling deep and spongy soil. Under the test conditions the best screw diameter is 270 mm. The tiller with this size of screws consumed 90% of the engine power and, therefore, is economical.

The depth and width of cultivation should be decided in accordance with the agro-technical requirements and are ensured by an appropriate screw diameter. The relation between the diameter and the depth or the width is that the larger the diameter is, the greater the depth and the width. In addition, the actual depth of cultivation is near the screw radius. Therefore, when the soil and field conditions are the same as, or similar to those in the tests the depth will meet the requirement provided the screw radius is just a little greater than the calculated depth. A larger radius, however, will be advantageous in covering the vegetation. On the other hand, if a radius less than the calculated depth is chosen the actual depth will fail to reach the standard.

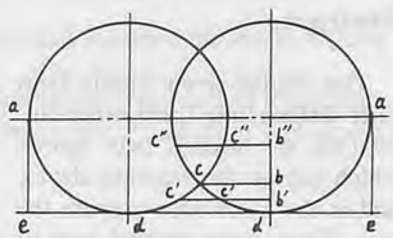

Fig. 4 Vertical section of the working double-screw.

Fig. 4 shows the vertical section of the working double-screw and makes the relationship between the depth and the width clear. If the depth is less than the radius the width increases when the depth does so. So long as the depth becomes greater than the radius, the width doesn't change any more but remains the maximum, a-a.

Owing to the special structure of the tiller, three parts of the field will miss being tilled and sometimes one part will be re-tilled, as shown in **Fig. 4**. Two of the three are enclosed by *a e d* on both sides of the double-screw suppose. The depth is equal to the screw radius. The two parts will beocme smaller along with the decrease of the depth and can be remedied in near tilling. The other part is *c'ddc'* if the depth is *db'* or *cdd* when the depth equals *db"*. In the former case even the topsoil will not be tilled while in the latter only the

Table 2. Velocities from Calculation (n = 261 r/min) and Tests

Screw diameter (mm)	240	260	270
Front screw pitch L_1 (mm)	90	140	120
Back screw pitch L_2 (mm)	200	200	220
The average of L_1 and L_2 (mm)	145	170	170
V_1, from substituting L_1 for L (km/h)	1.41	2.19	1.88
V_2, from substituting L_2 for L (km/h)	3.13	3.13	3.45
Va, from substituting La for L (km/h)	2.27	2.66	2.66
Vt, from tests (km/h)	2.09	2.46	2.43

furrows won't be level. Besides, in the latter case the part enclosed by *cc″c″* will be re-tilled. So *bd* is critical for re-tilling. When the depth is greater than it, there will be a part re-tilled, otherwise the part will not exist.

As the tiller is driven by the double-screw, its velocity can be calculated by using the formula:

$$V = 60\ nL/1\ 000\ 000$$

where
V = velocity, km/h
n = screw speed, r/min
L = Screw pitch, mm
This formula, however, does not involve screw slip that exists actually. In addition, because the front screw pitch L_1 is shorter than the back one L_2, as shown in **Fig. 3**, how to choose a pitch is the key to using the formula. By substituting n and L in it with 261 and L_1, L_2, La (the average of L_1 and L_2), respectively, velocities V_1, V_2 and Va for each of three different screws were obtained as shown in **Table 2**. This table also contains the actual velocities Vt from the tests. It is clear that each Va is close to the corresponding Vt. The screw slip may be considered responsible for the difference between them and so a slip coefficient f can be introduced as: f = Vt/Va. Then **Table 3** can be obtained from it where f is 0.91-0.92 in the table. Considering soil diversity, it is suggested that f be chosen from 0.85 to 0.95. Therefore,

$$V = 60nLaf/1\ 000\ 000$$
$$La = (L_1 + L_2)/2$$

As man's speeds of walking in paddy fields when handling the tiller range generally from 2 to 3 km/h, the average pitch of 145-195 mm is recommended. Among all tested, the size of 170 mm is the most suitable for the performance of the tiller.

Problems

1. Though weighing only about 145 kg and being possible for two men to transfer, the tiller needs to be further lightened.
2. The tiller makes too much noise which may injure the driver's health.
3. As the machine lacks a steering gear, the driver is under a lot of strain at changing its direction in the paddy fields.

Table 3. Calculation of Slip Coefficient f

Screw diameter (mm)	240	260	270
Va (km/h)	2.27	2.66	2.66
Vt (km/h)	2.09	2.46	2.43
f	0.92	0.92	0.91

Conclusions

1. A new kind of cultivator, the double-screw paddy field tiller can prepare various paddy soil very well and is particularly appropriate for small fields. The transfering of the tillage machines is inconvenient.
2. Better cultivation and higher productivity can be obtained from choosing larger diameter screws within engine power limits.
3. Screw diameter is a main factor for ensuring that the depth and width of cultivation meet the design requirements.
4. Three parts of the soil will miss being tilled and sometimes a part will be re-tilled, owing to the structure of the machine.
5. The velocity of the tiller can be calculated by using the formula: V = 60n Laf/1 000 000.
6. Under test conditions, a screw diameter of 270 mm and the average pitch of 170 mm are most appropriate for the performance of the tiller.
7. Further efforts should be made to research all main parts of the tiller and optimize every screw parameter so that its performance can be more improved.■■

Performance of Rotary Tiller Tynes Under Wet Land Condition

by
J.P. Gupta
Assoc. Professor
Faculty of Agricultural Engineering
Rajendra Agricultural University, Pusa
Samastipur 848125, India

K.P. Pandey
Professor
Department of Agricultural Engineering
Indian Institute of Technology
Kharagpur-721302, India

Abstract

Four different shapes of L-type rotary tiller tyne, namely; archemedian spiral, logarithmic spiral, circular curvature and straight edge were tested and evaluated at four different rotor speeds (146, 211, 327 and 427 rev/min) and two modes of operation (down-cut and up-cut). These tynes were tested at 1.33 km/h forward speed and 100 mm depth. The torque requirement, draft, vertical soil reaction forces and quality of puddling were recorded. Based on these data the specific energy requirement and puddling index were calculated. The performance index was evolved to visualize the combine effects of specific energy requirement and puddling index. Based upon the experimental result, the performance of a L-type tyne having archemedian spiral was found to be the best among all the shapes.

Introduction

Rice is one of the staple food crops in India. It is grown over an area of about 41 million ha comprising 30% of the world's total rice area (4). More than 50% of the total rice area is grown by the transplanting method. Land preparation for transplanted paddy differs greatly from other crops as it is the only crop grown under various degree of flooding. The basic characteristic of the prepared land is that it should be as compact and impermeable below the rooting depth as possible in order to impede the downward movement of the water to the maximum. The rootzone soil at the same time should be well pulverized and cultured for proper nourishment of the plant. These requirement may be obtained by using rotary tillers equipped with L-shaped rotary tiller tynes. These units pulverize and mix the soil more effectively, thereby reducing the number of operations necessary to prepare the puddled seed bed.

State of Technology

The rotary tillers are mostly equipped with two types of tynes, namely; pick type and L-type. The pick type tynes are used for tilling the soil for unsaturated soil condition whereas the L-shaped tynes are used for saturated soil condition (5). The L-shaped tynes may be classified as straight edge tyne and knife edge tyne. These tynes have great variation in their size and shape. The study carried out by Beeny and Khoo (2) reveals that the shape of the tynes have great effect on specific power requirement. The L-shaped tyne were found to require 30% higher specific power than C-shaped and L shaped also gave the greatest thrust on the vehicle. Adams (1), Sakai (5 and 6) and Hendrick (3) also made extensive studies in the past on the performance of different types of tynes. However, no scientific effort has been made to study the influence of shape of the tynes on their performance under Indian agro-climatic condition. This study was, therefore, undertaken in order to evaluate the comparative performance of four different shapes of the L-type tynes at four different rotor speeds and two modes of operation, i.e., down-cut and up-cut rotary system.

Materials and Methods

Experimental Tools

Four different shapes of an L-type tyne following logarithmic spiral, archemedian spiral, circular curvature and straight edge were selected for the study. The angle of sidelong portion and rake angle of the tyne were maintained constant at 60° and 65°, respec-

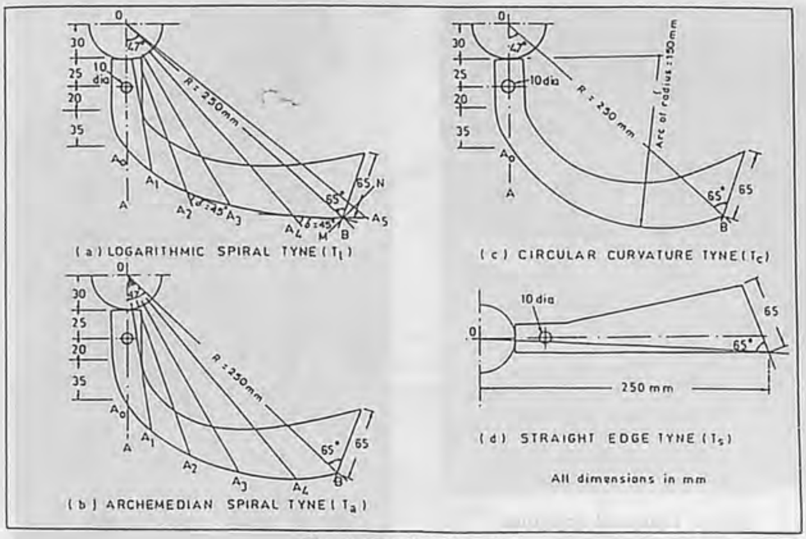

Fig. 1 Details of tools.

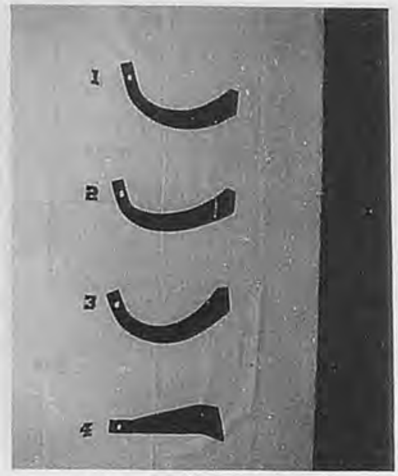

Fig. 2 Profile of tynes used in the study. 1. Archemedian spiral (T_a), 2. Logarithmic spiral (T_l), 3. Circular Curvature (T_c), and 4. Straight edge tyne (T_s).

tively. The inner radius (r_i) and outer radius (r_o) were fixed at 110 mm and 250 mm, respectively, (**Fig. 1**). The cutting edge of the logarithmic spiral was drawn by using the following equation:

$$r = r_i\, e^{\theta \cot \delta} \qquad \ldots(i)$$

where,

r = radial distance of the outer surface from the centre of rotation at an angular displacement of θ.

r_i = value of r when θ is equal to zero.
= 110 mm

θ = angular displacement, radian

e = 2.71828 and

δ = edge curve angle, deg.
= 45°.

The archemedian spiral tyne was drawn at a convolution angle of 47° which was adopted for logarithmic spiral tyne. The cutting edge of the tyne was drawn using the following equation of archemedian spiral.

$$r = r_i + \left(\frac{r_o - r_i}{\psi}\right)\theta \qquad \ldots(ii)$$

where,

r_o = outer radius of tyne
= 250 mm

ψ = Convolution angle of the tyne, deg.
= 47°

The circular curvature tyne was drawn maintaining the inner radius and outer radius at 110 mm and 250 mm. The convolution was maintained at 47°. The edge curve was maintained to circular shape (**Fig. 1c**).

The L-shaped straight edge tyne was drawn at zero degree convolution angle as shown in **Fig. 1d**. The cutting edge was maintaned straight. The other parameters of all the tynes were maintained constant. The weight of each tyne was 450 gm. The width of tyne at shank was 25 mm which was gradually widen to 65 mm at outer most portion. A view of the tested tynes is shown in **Fig. 2**.

Experimental Technique

The tynes were tested in the laboratory creating the actual field condition in the soil bin. Using the 'single shot technique' only one tyne was mounted on the rotor shaft for experimentation. The torque required by cutting tyne was measured through torque sensor. The tynes were tested at four rotary speeds of 146, 211, 327 and 427 rpm. The tynes were tested at a constant depth of 100 mm and at a forward speed of 1.33 km/h. The horizontal and vertical soil reaction forces were measured by using the extended octagonal ring transducer (**Fig. 3**). The tynes were tested under two modes of operation, namely; up-cut and down-cut rotary system.

Test Conditions

A uniform soil condition was maintained in the test. A 30 mm standing water was maintained over the soil surface (**Fig. 4**). The variability of test conditions was checked by recording cone index at six different places in the soil bin. The average value of cone index from zero to 150 mm depth was maintained at 137 kPa. The average value of soil moisture and bulk density were maintained at 14% and 1 760 kg/m^3, respectively, for a depth zone 30 to 150 mm.

Experimental Observations

During each test, the soil bin was prepared by using the processing trolley. It was then flooded to maintain the 30 mm standing water. The test trolley and other recording units were put on simultaneously to get the recording of torque horizontal and vertical soil reaction forces. Based on torque and horizontal forces, the specific energy requirement, defined as total energy per unit volume of soil tilled, was calculated. After the operation of each tyne, three rendon samples of puddled soils

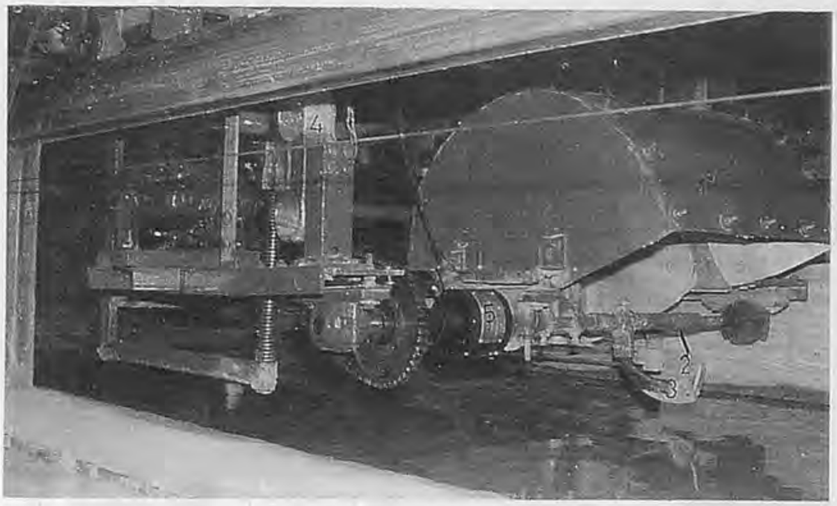

Fig. 3 Tool test trolley. 1. Hood, 2. Rotor shaft, 3. Tyne, 4. Extended octagonal ring transducer, 5. Torque sensor and 6. Chain and Sprocket drive.

Fig. 4 Experimental set-up. 1. Soil bin, 2. Side rail, 3. Soil processing trolle, 4. Tool test trolley, 5. Control panel, 6. Recording instrument and 7. Voltage stabilizer.

were collected from the test track to evaluate the puddling index defined as dry weight of suspended particles per unit weight of soil samples. The overall performance of the tyne was evaluated by evolving a performance index giving equal weights to the puddling index and specific energy requirement. Hence, the puddling index was divided by specific energy requirement.

Results and Discussion

The observed data were subjected to analysis of variance to find out the effect of tool shape and rotor speed on specific energy requirement, puddling index and performance index during both modes of operation. Based on suitable regression models, the performance curves were plotted to study the behaviour of independent parameters on tool performance.

Effects of Tool Shape on Specific Energy Requirement

The effects of tool shapes on specific energy requirement were studied at four rotor speeds and two modes of operation (**Figs. 5** and **6**). The trend shows that specific energy requirement increased significantly with an increase in rotor speed from 146 rpm to 427 rpm for all tools under both modes of operation. This was probably due to an increase in air resistance, centrifugal force in throwing the soil mass and rate of cutting. However, the change in mode of operation did not contribute much to the specific energy requirement (**Table 1**). The analysis shows that of four shapes tested, on an average, the archemedian spiral showed minimum specific energy requirements.

It was also observed that the torque requirements for cutting soil slices increased with an increase in rotor speed, while the horizontal components of soil reaction force decreased in all cases during both modes of operation. The horizontal component of the force was found to be negative during down-cut rotary system whereas it was positive during up-cut rotary system.

Effect of Tool Shape on Puddling Index

The observed data plotted in **Figs. 7** and **8** show that the puddling index increased with an increase in rotor speed for all the tools as well as for both modes of operation. This is supported by the findings of Admas and Furlong (1). The improved quality of soil puddle with an increase in rotor speed was presumably due to a decrease in bite length and increase in throwing velocity of the soil mass.

The quality of soil puddle was influenced significantly by varying the rotor speed, tool shape and mode of operation (**Table 2**). Based on quality of work done, the archemedian spiral tyne again showed the best performance indicating 8.45 to 34.30% higher puddling index than the other shapes. Of the two modes of operation, the up-cut rotary system was superior to the down-cut rotary system. This may be due to higher cutting velocity of the tyne obtained during up-cut rotary system, which resulted in better churning of the soil mass.

Effect of Tool Shape on Performance Index

Figs. 9 and **10** indicate that the performance index decreased with an increase in rotor speed from 146 rpm to 427 rpm for all tools during both modes of operation. This makes it clear that the rate of increase of specific energy requirement with rotor speed was much higher than that of the puddling index.

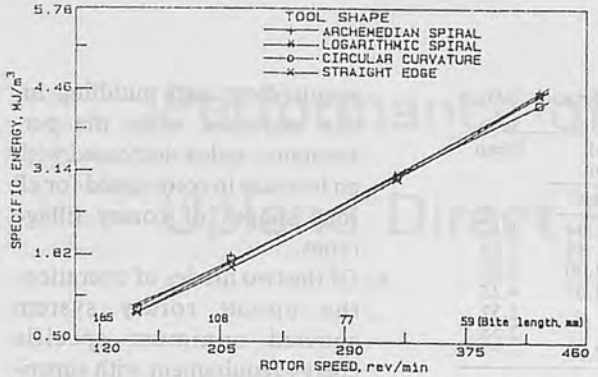

Fig. 5 Effect of rotor speed on specific energy requirements for different tool shapes during down-cut rotary system.

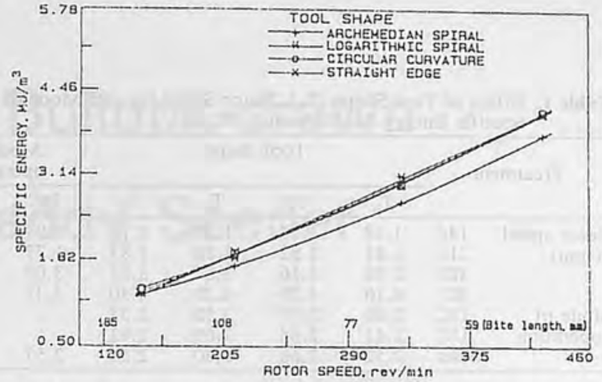

Fig. 6 Effect of rotor speed on specific energy requirements for different tool shapes during up-cut rotary system.

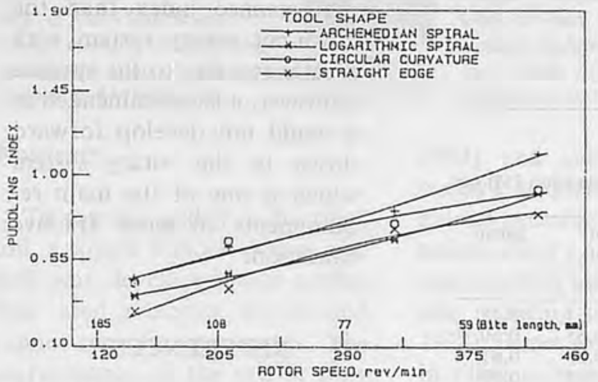

Fig. 7 Effect of rotor speed on puddling index for different tool shapes during down-cut rotary system.

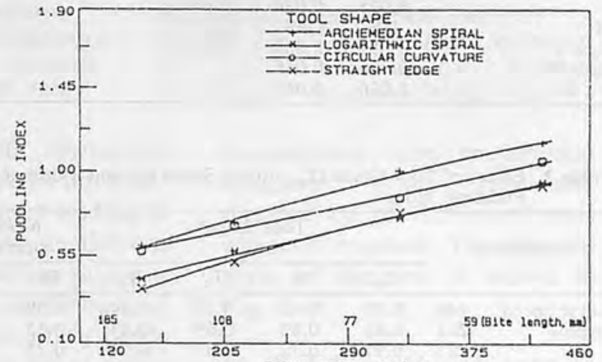

Fig. 8 Effect of rotor speed on puddling index for different tool shapes during up-cut rotary system.

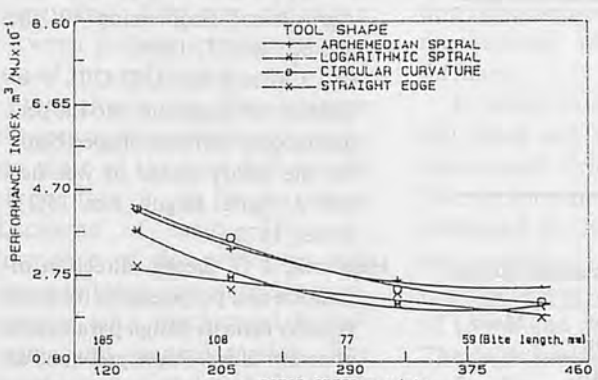

Fig. 9 Effect of rotor speed on performance index for different tool shapes during down-cut rotary system.

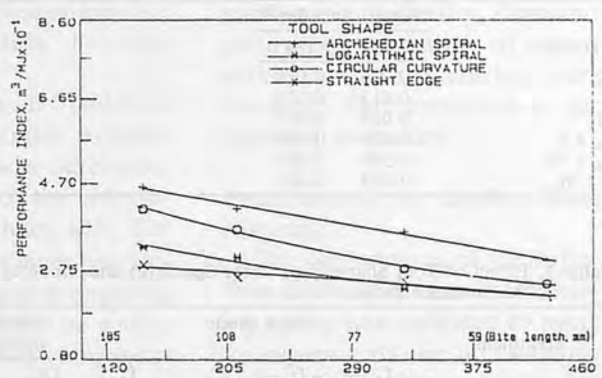

Fig. 10 Effect of rotor speed on performance index for different tool shapes during up-cut rotary system.

The statistical analysis presented in **Table 3** shows that the performance index was influenced significantly by rotor speed, tool shape and mode of operation. Of all the four shapes tested, the archemedian spiral tyne indicated the highest performance index. It gave 9 to 29% higher performance index then those observed with the other tynes. The up-cut rotary system was also observed to give 10% higher performance index than the down-cut rotary system.

Conclusions

The study led into the following main conclusions.

1. Of the four different shapes of an L-type tyne tested, the archemedian spiral gave the best performance.
2. The lowest rotor speed of 146 rpm gave minimum specific energy requirement while the highest rotor speed of 427 rpm resulted in maximum puddling index. This shows that for a fixed forward velocity, the rotor speed should be maintained at minimum as possible subject to the minimum desired level of puddling.
3. In general, the specific energy

Table 1. Effect of Tool Shape (T_p), Rotor Speed (n) and Mode of Operation (M) on Specific Energy Requirements, MJ/m^3.

Treatment		Tool shape				Mode of operation		Mean
		T_a	T_l	T_c	T_s	DC	UC	
Rotor speed (rpm)	146	1.18	1.14	1.22	1.14	0.99	1.34	1.17
	211	1.81	1.82	1.88	1.83	1.77	1.89	1.83
	327	2.92	3.16	3.07	3.05	3.09	3.00	3.05
	427	4.16	4.29	4.23	4.30	4.41	4.09	4.25
Mode of operation	DC	2.62	2.57	2.55	2.53			2.57
	UC	2.41	2.64	2.65	2.63			2.58
	Mean	2.52	2.60	2.60	2.58	2.57	2.58	

CD for	Significance level 5%	1%
T_p	0.025	0.034
n	0.025	0.034
M	NS	NS
T_p x n	0.051	0.069
T_p x M	0.036	0.048
n x M	0.036	0.048

Table 2. Effect of Tool Shape (T_p), Rotor Speed (n) and Mode of Operation (M) on Puddling Index.

Treatment		Tool shape				Mode of operation		Mean
		T_a	T_l	T_c	T_s	DC	UC	
Rotor speed (rpm)	146	0.53	0.41	0.52	0.34	0.39	0.51	0.45
	211	0.68	0.53	0.69	0.47	0.55	0.65	0.60
	327	0.92	0.72	0.82	0.76	0.75	0.87	0.81
	427	1.15	0.94	1.00	0.88	0.95	1.03	0.99
Mode of operation	DC	0.76	0.61	0.70	0.56			0.66
	UC	0.89	0.69	0.82	0.66			0.76
	Mean	0.82	0.65	0.76	0.61	0.66	0.76	

CD for	Significance level 5%	1%
T_p	0.013	0.018
n	0.013	0.018
M	0.009	0.013
T_p x n	0.026	0.036
T_p x M	0.019	0.025
n x M	0.019	0.025

Table 3. Effect of Tool Shape (T_p), Rotor Speed (n) and Mode of Operation (M) on Performance Index.

Treatment		Tool shape				Mode of operation		Mean
		T_a	T_l	T_c	T_s	DC	UC	
Rotor speed (rpm)	146	4.49	3.59	4.26	2.99	3.87	3.79	3.83
	211	3.80	2.94	3.70	2.57	3.07	3.44	3.25
	327	3.19	2.28	2.68	2.49	2.42	2.91	2.66
	427	2.78	2.19	2.36	2.04	2.15	2.54	2.35
Mode of operation	DC	3.22	2.71	3.16	2.42			2.88
	UC	3.91	2.80	3.34	2.62			3.17
	Mean	3.57	2.75	3.25	2.52	2.88	3.17	

CD for	Significance level 5%	1%
T_p	0.066	0.089
n	0.066	0.089
M	0.047	0.063
T_p x n	0.133	0.179
T_p x M	0.094	0.126
n x M	0.094	0.126

requirement and puddling index increased while the performance index decreased with an increase in rotor speed for all four shapes of rotary tillage tynes.

4. Of the two modes of operation, the up-cut rotary system showed minimum specific energy requirement with superior quality of puddling. It also indicated about 15% higher performance index than the down-cut rotary system with greater stability to the system. However, it is recommended as it could not develop forward thrust to the rotary system which is one of the main requirements of poor tractive condition.

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Performance of Bullock-drawn Upland Direct Paddy Seeder

by
D. Manohar Jesudass
Asst. Professor
Dept. of Farm Machinery
College of Agric. Engineering
Tamil Nadu Agric. University
Coinbatore-641003, India

V.J.F. Kumar
Assoc. Professor
Dept. of Farm Machinery
College of Agric. Engineering
Tamil Nadu Agric. University
Coinbatore-641003, India

M. Balasubramanian
Professor and Head
Dept. of Farm Machinery
College of Agric. Engineering
Tamil Nadu Agric. University
Coinbatore-641003, India

Abstract

To sow dry paddy in dry tilled soil, a simple bullock-drawn seed drill was developed with orifice flow seed metering device and runner type furrow opener. The performance of the orifice flow metering device was tested by varying the orifice diameter, agitator disc diameter clearance between bottom of agitator and top of the orifice plate and speed of the agitator disc. The clearance between agitating rotor and metering plate of the seed drill should be one mm or less for maximum discharge of seeds. The performance of the prototype was tested in black cotton soil in comparison with mechanical broadcaster and manual sowing. The germination of paddy in plot-sown using direct paddy seed drill was 49%, 33% higher than that of manual broadcasting and mechanical broadcasting.

Introduction

Rice is the staple food for most of the world's population and is grown in 38 m ha. Rice is a labour intensive and water intensive crop. It is transplanted in puddled soil. Labour requirement for transplanting paddy is high (R.D. Singh 1983) and suitable mechanical paddy transplanters are not available at present. Direct seeding of paddy offers a great potential over transplanting as a labour saving or cost reducing system (Ojha et al 1978). Direct seeding of dry paddy in tilled soils is by broadcasting which leads to non-uniformity of plant population and mechanization of subsequent operations like mechanical weeding becomes difficult.

In order to sow dry paddy in dry tilled soil a simple bullock-drawn seed drill was developed. The performance of the unit was evaluated in clay loam soil. The unit consists of six runner type furrow openers arranged at a spacing of 15 cm and mounted on a skid. The seeds are metered by means of orifice flow metering driven by the ground wheel. The seeds are placed at a depth of 2 cm and covered using drags or furrow closer.

Materials and Methods

Development of Direct Paddy Seeder

The unit consists of a levelling board cum-float, orifice flow metering mechanism, six runner type furrow openers attached to the levelling board, drag type furrow closer, rope type hitching attachment, ground wheel and shutter to cut off the flow of seeds whenever required. The line diagram of the unit is shown in **Fig. 1**.

Physical Properties of ADT 36 Paddy

The physical parameters of paddy are bulk density, thousand grain weight and angle of repose affecting seed metering performance were measured as per standard procedure.

Performance of Orifice Flow Metering

The performance of the orifice flow metering device while metering paddy was evaluated by using an experimental set up as shown in **Fig. 2**. This has provision for changing the orifice diameter, diameter of agitator disc and clearance between bottom of agitator and top of the orifice plate. Using the experimental set up, the test was conducted for orifice diameters of 6.7, 7.1 and 7.9 mm, clearance of 0, 1, 2, 3 mm, agitator disc diameters of 67, 80, 90 mm and speeds of 80, 100 and 120 rpm. At each setting the quantity of seed metered per hundred revolutions of the agitator disc was measured. The speed of revolution was varied by manual rota-

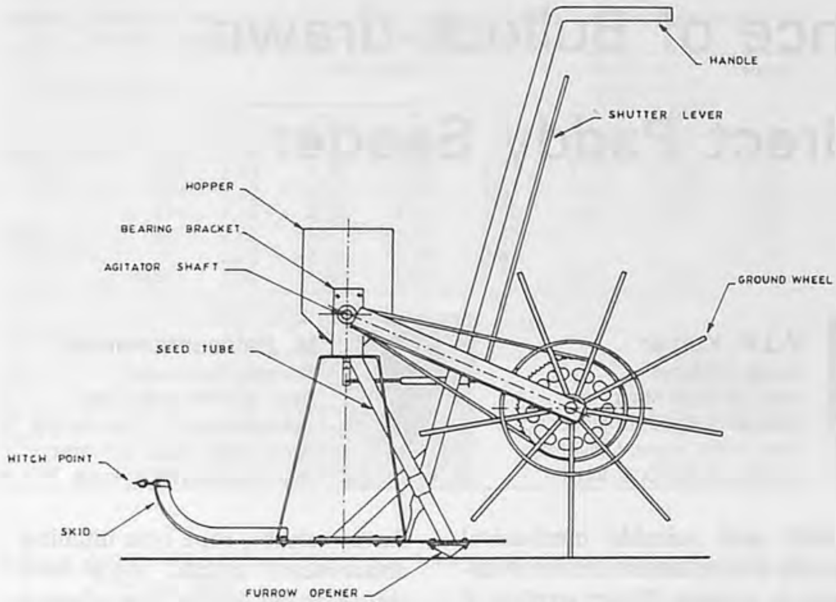

Fig. 1 Direct paddy seed drill.

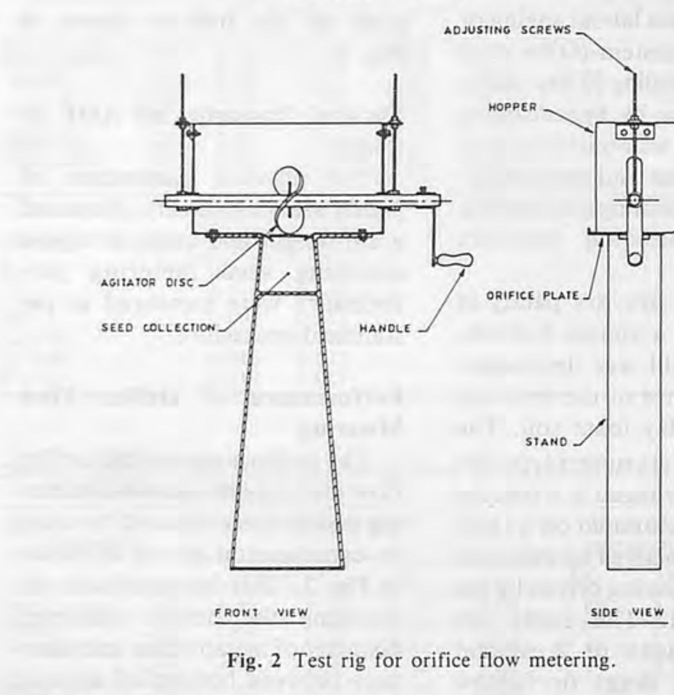

Fig. 2 Test rig for orifice flow metering.

tion of the handle. A graph was drawn between the clearance and seeds collected per hundred revolutions of agitator for various combinations.

Laboratory Calibration of Seed Drill

The prototype seed drill was calibrated in the laboratory for 6.7, 7.1, 7.9 and 9.5 mm dia metering plates at 1.5, 2.0, 2.6 km/h speed of agitating disc. The prototype was jacked and the seeds were collected below in each hopper. The ground wheel was cranked by hand at different speeds corresponding to the forward speed of the unit. The seeds discharged in all the furrow openers were weighed and the seed rate per hectare was calculated.

Field Evaluation of the Seed Drill

Field evaluation of the seeder was conducted in tilled dry black cotton soil for sowing dry ADT 36 paddy in comparison with centrifugal mechanical broadcaster and manual sowing. The experiment was conducted with randomized block design and the field was laid out. During the operation of the unit, the depth of placement of seeds, seed rate, draft, slip, coverage were recorded. The field was irrigated after sowing. The crop germination was observed and the seedlings in one square meter area were counted and recorded.

Results and Discussion

Physical Properties of ADT 36 Paddy

The physical properties that influence the flow of grain through an orifice viz bulk density, angle of repose, seed geometry and thousand grain weight were measured and presented in **Table 1**.

Seed geometry is an important factor that governs the size of orifice required. The bulk density of grain determines the hopper size. Thousand grain weight determines the seed rate.

Performance of Orifice Flow Metering

The effect of orifice opening diameter, diameter of agitator disc, clearance between agitator disc and metering plate and speed of agitation were studied for orifice flow metering mechanism to meter paddy. The relationship between the above parameters and seed collected for 100 revolu-

Table 1. Physical Properties of ADT 36 Paddy

Lengh, mm	:	7.46 - 8.17
Breadth, mm	:	2.97 - 3.9
Thickness, mm	:	1.42 - 2.01
Thousand grain weight, gm	:	22.0
Angle of repose, deg	:	32.5
Bulk density, gm/cc	:	0.6

tion of agitator disc is shown in Figs. 3-5.

Effect of clearance between rotor and metering plate — The observation indicates that the seed discharge is negligible when the clearance is above 3 mm, i.e., a clearance of more than 3 mm will make the agitation almost ineffective. As the clearance decreased from 3 mm the seed discharge increased rapidly. For a given clearance the seed discharge increased with an increase in diameter of the agitating disc. A linear relationship existed between seed discharge and clearance for different disc diameter and orifice openings except for some combinations of disc diameter where the seed discharge decreased when the clearance is reduced from one to zero mm. Hence, it is concluded that maximum quantity of seed is metered when the clearance is one mm or less. In the case of 67 mm dia disc, data could not be recorded for the clearance of less than one mm as this adjustment could not be obtained in the experimental set up.

Effect of disc diameter — The disc diameter has a distinct effect on the seed metered per hundred revolutions. A reduction in diameter of disc from 90 mm to 80 mm decreased the quantity of seeds metered by 30% at 80 rpm and 100 rpm and one mm clearance. A reduction of diameter from 90 mm to 67 mm caused 70% reduction in seeds metered at one mm clearance indicating that a larger disc diameter aided a better flow of seeds due to intensified agitation.

Effect of orifice plate diameter — It was observed that for a particular disc diameter and clearance, there was no appreciable change in the discharge from different orifice plates. This may be due to the minimal difference in the diameter with respect to length of seeds. In 90 mm and

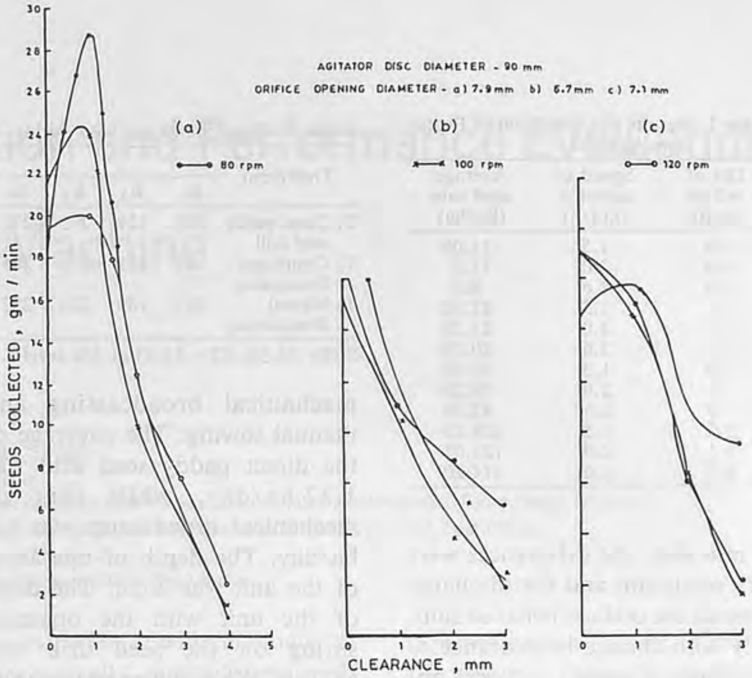

Fig. 3 Effect of disc, orifice dia and clearance on seed rate.

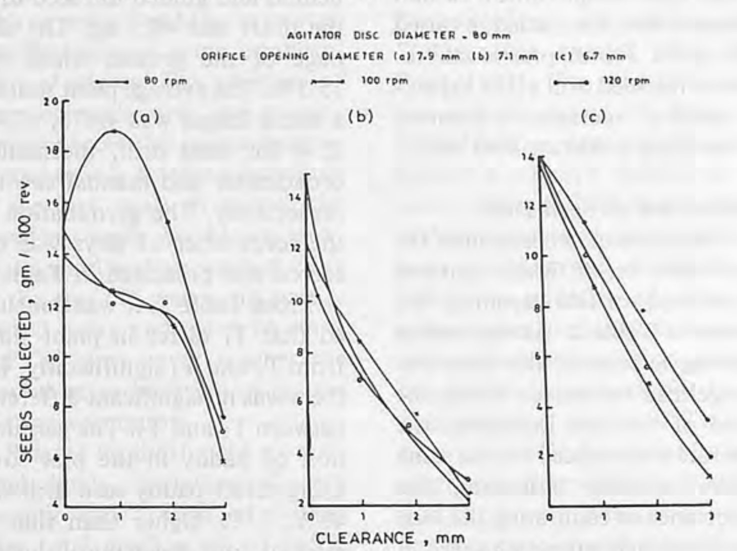

Fig. 4 Effect of disc, orifice dia and clearance on seed rate.

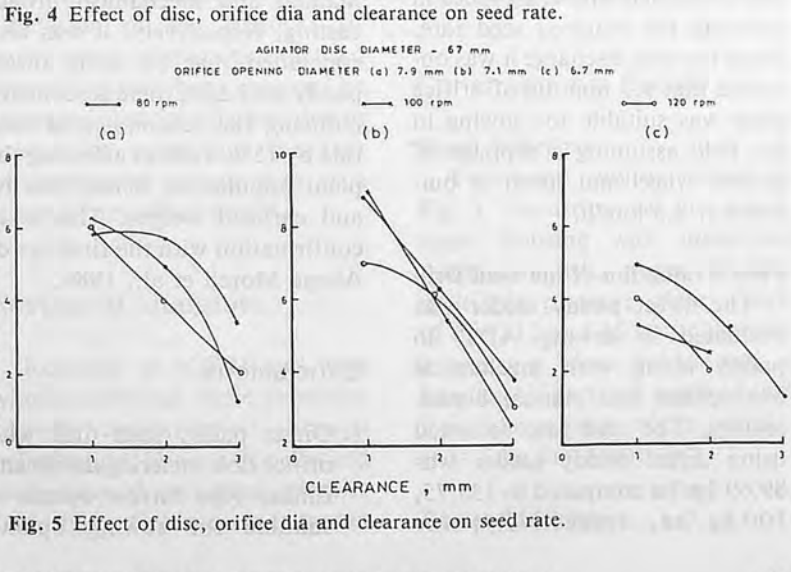

Fig. 5 Effect of disc, orifice dia and clearance on seed rate.

Table 2. Results of Calibration of Prototype Agitator

Dia of orifice (mm)	Speed of agitator (km/h)	Average seed rate (kg/ha)
6.4	1.5	11.05
6.4	2.0	11.0
6.4	2.6	9.5
7.1	1.5	21.33
7.1	2.0	23.28
7.1	2.6	20.28
7.9	1.5	65.08
7.9	2.0	59.20
7.9	2.6	42.38
9.5	1.5	128.28
9.5	2.0	121.05
9.5	2.6	114.20

80 mm disc, the differences were very minimum and the discharge from all the orifices behaved similarly with change in clearance.

Effect of speed — It was observed that except for the 80 mm diameter disc, the discharge varied with speed. Hence, precise calibration of the seed drill at the expected speed of operation is essential to ensuring a correct seed rate.

Calibration of Seed Drill

The results of calibration of the seed drill at different agitator speed and orifice opening are shown in **Table 2**. As the orifice opening increased, the seed discharge also increased. When the speed of the unit increased, the seed rate was reduced for the same orifice opening indicating the importance of calibrating the seed drill at the field operating speed in ensuring the required seed rate. From the seed discharge it was observed that 9.5 mm dia of orifice plate was suitable for sowing in the field assuming a slippage of ground wheel and speed of bullocks at 2.5 km/h.

Field Evaluation of the Seed Drill

The direct paddy seeder was evaluated in sowing ADT 36 paddy along with mechanical broadcaster and manual broadcasting. The seed rate recorded using direct paddy seeder was 89.69 kg/ha compared to 135.75, 100 kg/ha, respectively, for mechanical broadcasting and manual sowing. The coverage of the direct paddy seed drill was 1.32 ha/day, while that of mechanical broadcaster was 1.6 ha/day. The depth of operation of the unit was 2 cm. The draft of the unit with the operator sitting on the seed drill was 66.3 kg. When the operator stood behind and guided the seed drill, the draft was 40.5 kg. The slippage of the ground wheel was 15.3%. The average plant stand in a metre length was 49.75, 37.43, 33.4 for seed drill, mechanical broadcaster and manual sowing, respectively. The germination of the seeds after 15 days was observed and presented in **Table 3**.

Table 3. Plant Stand ADT 36 Paddy

Treatment	Plant Stand/m^2										
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Mean
T_1 Direct paddy seed drill	335	321	275	237	255	226	322	309	341	364	298.5
T_2 Centrifugal Broadcaster	191	251	279	205	248	219	191	251	189	222	224.6
T_3 Manual Broadcasting	235	189	225	237	236	191	169	212	141	169	200.4

SED: 26.38, CD: 55.43 at 5% level.

From **Table 3**, it was concluded that T_1 differ in plant stand from T_2 and T_3 significantly. But there was no significant difference between T_2 and T_3. The germination of paddy in the plot sown using direct paddy seed drill was 49%, 33% higher than that of manual and mechanical broadcasting, respectively. It was also concluded that by using direct paddy seed drill, there is scope for reducing the recommended seed rate by 15% without affecting the plant population, hence tillering and earhead weight. This is in confirmation with the findings of Aliaga Morell et al., 1986.

Conclusions

1. Direct paddy seed drill with orifice flow metering device and runner type furrow opener is suitable for sowing upland paddy.
2. The plant stand obtained in plot sown using direct paddy seeder was significantly different at 5% level than that of mechanical broadcasting and manual broadcasting.
3. The clearance between the agitating rotor and metering plate of the seed drill should be one mm or less for maximum discharge of seeds. The agitating disc diameter of 90 mm gave consistent discharge of seeds.
4. To maintain correct seed rate in field condition, the unit should be calibrated at the expected speed of operation.

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Design, Construction and Performance Evaluation of Seed Pelleting Machine

by
Jai Singh
Officer
Special Duty and Project Coordinator Post Harvest Technology Scheme
Central Institute of Post Harvest Engineering and Technology
PAU Campus
Ludhiana-141004 (Pb.) India

Abstract

Three types of seed pelleting machines, namely; (i) hand actuated extrusion type; (ii) power operated extrusion type; and (iii) manually-operated tyre type, were designed, constructed and evaluated for seeding grasses and pasture legumes at the Indian Grassland and Fooder Research Institute, (IGFRI) Jhansi, India. Among the different pelleting materials tried, clay soil gave the best performance. Pelleted seeds exhibited significantly higher plant establishment and forage and seed yield in *Cenchrus ciliaris* grass and *stylosanthes* species of pasture legumes. The pelletized seeds were also easy to broadcast manually or through aircraft and drilling by grain drilling machines.

Introduction

The physical characteristics of tropical grass and pasture legume seeds, viz., tinyness, hairyness, extended appendages (awns), lightness in weight, etc. do not allow the seeding operation to be simple and smooth as in grain crops. While sowing manually or mechanically, most of these seeds fall in bunches due to inter-woven hairs or awns resulting in uneven distribution and poor establishment of plants. The problem of overseeding the vast, less or completely inaccessible, waste lands in limited time is further aggravated by the fact, that; (i) part of the broadcast seeds are blown away by the wind and/or washed away by the run off water; (ii) part is carried away and eaten by ants; and (iii) part never reaches the ground ue to interception by the existing vegetation.

Pasture establishment on marginal lands, including *Gochar bhoomi* and fringes of forests after total eradication of native vegetation or old tussocks of native grass although give assured establishment but cannot be recommended for all cases due to prohibitive costs and the fear of accelerated soil erosion as a result of soil disturbance.

Review of Literature

Research at IGFRI and elsewhere show that these problems can be circumvented through pelletization. Sowing of pelletized seeds have shown great promise for the *Sehima nervosum* (Shankarnaryan at al, 1969 in *Chrysopogon fulvus* (Kanodia and Patil, 1981), ub *Cenchrus ciliaris Dichanthium annulatum* and *Stylosanthes species* (Rai and Patil, 1985). The pelletized seeds can also be drilled by using the IGFRI drill, or dropping the seeds behind a country plough or by aerial method. With this in view, different tools and machines have been designed and developed at IGFRI to pelletize all types of grasses, pasture legumes and tree seeds. The hand pelletizer is suitable for laboratories or for small-scale pelleting operation. The tyre type is suitable for distant places where power availability is scarce and the power machine is useful for commercial seed enterprisers.

Constructional Details

Hand Pelletizer

This hand tool is shown in **Fig. 1** consisting of an auger, auger housing with integrated feeding mouth, a set of five multihole pressure plates, each of 6, 8, 12 and 15 mm diameter, a pressure plate holder and a handle. All parts are made of cast iron. The capacity of the pelletizer is 5 kg dry pellets/h.

Power Machine

Acknowledgments: Heartfelt thanks are due to the Director, IGFRI, Jhansi for providing facilities for the study.

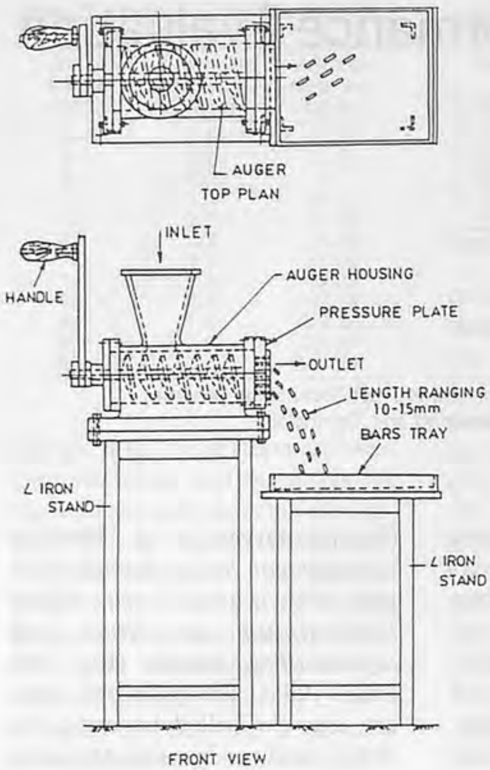

Fig. 1 Hand-operated seed pelleting machine.

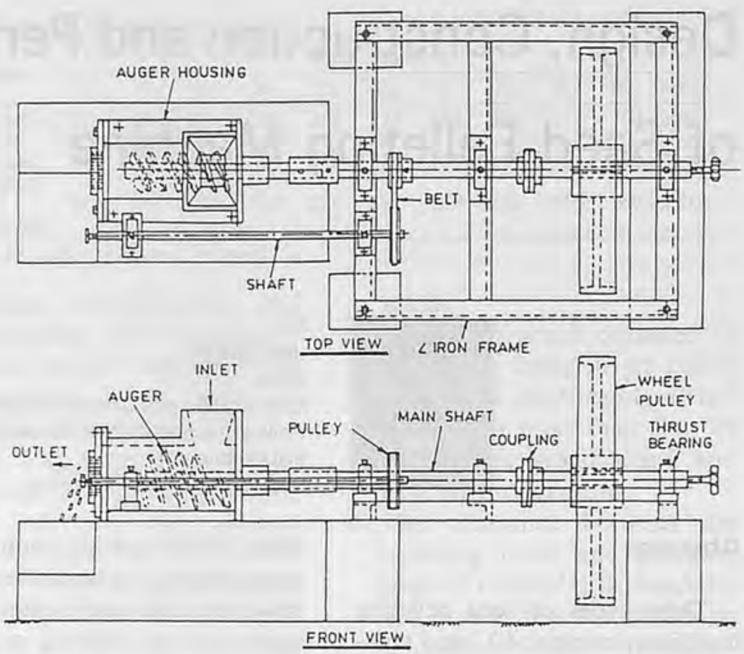

Fig. 2 Power-operated seed pelleting machine.

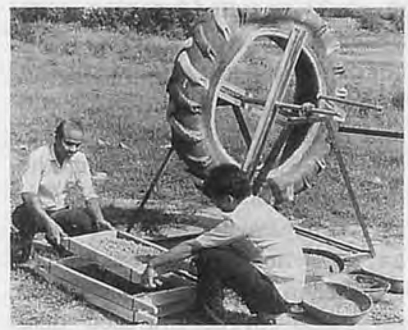

Fig. 3 Tyre type seed pelletrying machine.

The pelletizer is operated by a 7.5 kW electric/diesel motor **(Fig. 2)**. The machine consists of an angle iron frame for mounting all the components, an auger, an auger housing with integrated feeding mouth, a main shaft with socket joint to drive the auger, sets of five multi-hole (6, 8, 10, 12 and 15 mm diameter) pressure plate, pressure adjusting mechanism and a flat pulley and belt arrangement for power transmission from the motor. The auger revolves at 200 rpm. The production capacity of the machine is about 120 kg dry pellets/h.

Tyre Type

This is a manually operated device consisting of a tractor rear wheel unserviceable tyre mounted vertically on a shaft supported on an angle iron frame with the help of two ball bearings and a crank handle to rotate the tyre and a set of 5, 8 and 10 mm sieves for grading the pellets of different diameters **(Fig. 3)**. Using this equipment, about 60 kg dry pellets can be prepared in an hour.

Method of Operation

A mixture of seed and clay soil in 1.5 proportion on weight basis is prepared at 10-12% moisture content (wb). For the hand pelletizer and power machine, this soil-seed mixture is fed into the auger housing through the feeding mouth. The revolving auger pushes the mixture along the auger housing towards the multi-holes of the pressure plate in the form of 10-15 mm long pellets.

For the tyre type machine, the dry mixture of seed and soil is placed in the tyre concave in batches of 5 kg each. The tyre is rotated on its axis in vertical plane by the crank bandle while sprinkling water on the mixture. In this process the mixture goes up and rolls back and as a result of continued cascading action for 10-15 min, the soil is transformed into spherical balls embodying the seeds which are called pellets. In all cases the pellets are sun dried and stored for sowing.

Testing and Evaluation Results

Number of Seeds Per Pellet

The number of seeds per pellet varied proportionately with the size of pellet and seed rate applied. However, on average, the number of seeds per pellet in *C. ciliaris* and *Stylo* species ranged between

Table 1. Effect of Pelleting by Power Machine on Viability of Different Seeds in Laboratory

Crop/Seed	Viability % (mean value)	
	Pelleted	Non-pelleted
Stylo	34.16	38.58
Siratro	36.57	41.04
Subabool	39.15	43.63
Desibabool	37.1	41.72
Cenchrus ciliaris	32.81	36.10

Table 2. Effect of Pelleting on Establishment of *Dichonthium annulatum* and *Cenchrus ciliaris* Population/ha

Treatment	*Dichanthium annulatum*			*Cenchrus ciliaris*		
	1st year	2nd year	Mean	1st year	2nd year	Mean
Without pelleting	77 500	51 666	64 583	67 916	47 916	57 916
With pelleting	81 250	58 750	70 000	67 500	60 000	63 750
SEM +	16 500	5 055	9 885	11 000	2 145	6 365
C.D. at 5%	NS	NS	NS	NS	6 463	NS

Table 3. Effect of Pelleting Materials on Establishment of *Stylosanthes species*, Population × (10^3/ha)

Pelleting Material	*Stylo guianensis*	*Stylo hamata*	*Stylo scabra*	*Stylo viscosa*	*Stylo humilis*
Without pelleting (P_0)	600	3 680	2 688	3 968	3 300
Pelleting with clay soil (P_1)	680	4 520	1 880	5 640	3 560
Pelleting with clay soil + FYM (P_2)	948	6 160	1 680	3 628	3 780
Pelleting with clay soil + SSP (P_3)	668	5 240	2 280	2 880	2 640
Pelleting with clay soil + FYM + SSP (P_4)	488	3 700	1 580	3 288	2060
SEM 466					
CD at 5% NS					

Table 4. Effect of Pelleting on Dry Matter Yield (t/ha) of *Stylosanthes* species

Pelleting Material	*S. guianesis*	*S. hamata*	*S. scabra*	*S. viscosa*	*S. humilis*	Mean
P_0	0.18	4.83	0.67	5.09	2.36	2.63
P_1	0.39	5.23	1.16	5.12	2.21	2.82
P_2	0.26	4.51	0.76	5.99	2.30	2.74
P	0.39	3.59	1.09	5.70	2.39	2.62
Pelleting with clay + Farm Yard Manure + SSP	0.34	5.05	0.69	6.14	1.56	2.75
Mean	0.30	4.66	0.87	5.61	2.16	—
SEM ±	0.32					
C.D. at 5%	1.0					

2 and 6 for a pellet of 6-8 mm diameter adn 10-12 mm long cylindrical pellets. The seeding rate was 6 kg/ha.

Pellet Strength for Mechanical Seeding

The test for the pellets was conducted by dropping them on concrete floor from a height of 2 m, 10 times, The text results indicated that pellets retained 88% of their original weight by the end of 5th fall and 67% after the 10th fall, showing thereby adequate strength of the air dried pellets to be taken for sowing using seed drills or dropping by air.

Effect of Pelleting on Seed Viability

The test results given in **Table 1** on *Stylo, Siratro, luceana luceacephala* ("subabool") "desibabool" and *Cenchrus ciliaris* showed 9-11% decrease in germination as a result of pelleting by power machine. However, such difference was not noted in the use of the hand pelletizer and tyre type machine (**Table 1**).

Effect of Pelleting on Plant Establishment in Grasses

Randomized and four times replicated experiments were conducted at the Central Research Farm of IGFRI, Jhansi for two consecutive years to study the effect of pelleting on plant population and plant vigour in *Dichanthium annulatum* and *C ciliaries*, Pelletised and non-pelletized seeds were sown at the rate of 6 kg seed/ha in prepared land on July 16 for the first year and July 14 for the 2nd year. Harvesting was done in of the 2nd week of November for both years. Data presented in **Table 2** show significantly higher plant population in *C. ciliaris* during the second year. Also, higher establishment was recorded due to pelleting of seeds in both years and for both grasses. However, the results in *D. annulatum* were not statistically significant. The number of tillers per plant was higher by 10% and the base diameter by 15% for the pelleted seeds.

Effect of Pelleting on Plant Establishment in Pasture Legumes

Studies were conducted with four materials of pelleting (pelleting with clay soil, clay soil + farm yard manure (FYM), clay soil + SSP and clay soil + FYM + SSP) and a control (without pelleting in five species of *Stylosanthes viz. S. guianensis. S. hamata. S. scabra. S. viscosa, and S. humilis* for two consecutive years at the Central Research Farm of IGFRI, Jhansi. Line sowing was done at the rate of 6 kg seed/ha on July 8, for the first year after through land preparation.

The data presented in **Table 3** show plant population after one year growth. It showed higher establishment of pelleted seed in all the species of *Stylosanthes* except *Scabra*. It was highest (44% in *hamata*). The different pelleting materials also affected the establishment but was not statistically significant.

Table 5. Effect of Pelleting Material on Seed Yield (kg/ha) of *Stylosanthes* species

Pelleting Material	*S. guianesis*	*S. hamata*	*S. scabra*	*S. viscosa*	*S. humilis*	Mean
P_0	31.3	298.5	97.3	16.9	26.7	96.1
P_1	25.9	324.5	156.1	10.1	114.8	126.3
P_2	57.3	587.6	85.3	31.4	74.7	164.1
P_3	42.1	324.3	58.1	11.9	56.9	100.7
P_4	37.8	303.7	94.4	11.5	50.4	99.7
Mean	37.8	369.7	98.3	14.3	64.7	—
SEM ±	16.5					
CD at 5%	50.8					

Effect of Pelleting on Forage Yield

Table 4 shows a slight increase in the forage yield in all the cases as a result of pelleting. even though significant difference were not observed.

Perusal of data in **Table 4** revealed that the leguminous forage yield increased as a result of pelleting for all cases except in S.V *humilis*. It was highest in *guianesis* (117%) followed by 73% in *scabra* and 18% in *viscosa*.

The results show the need for a specific pelleting material for maximum dry matter yield in *Stylosanthes* species. However, the difference was not significant. pelleting with clay soil produced the highest dry matter.

Effect of Pelleting on Seed Yield

Studies on the effect of pelleting on seed yield showed significantly higher seed yield for all species of *Stylosanthes*. Maximum yield (164 kg/ha) was obtained when + pelleting was done with clay soil + farm yard manure, followed by clay soil (126) kg/ha). The average yield in non-pelleted plots was 96 kg/ha (**Table 5**).

Conclusion

From this study, the results indicate that pelleting grass and pasture legume seeds with clay soil in 1:5 seed:soil ratio gave better performance over the non-pelleted seeds. All the three types of machines can be used for pelletisation purposes depending upon specific situation.

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An Appraisal of Village-level Grain Storage Practices in Nigeria

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

D.O. Olumeko
Head
Crop Storage Unit
Federal Dept. of Agriculture and Rural Development
Moor Plantation
Ibadan, Nigeria

Abstract

Grain storage practices at village-level in Nigeria vary according to the climatic zone and the socio-economic level of the inhabitants. A survey was undertaken to appraise these practices. The country has three climatic zones: the sudan savanna, guinea savanna, and the rain forest zones. These represent the north, middle belt and the south, respectively.

Results show that the performances of existing storage structures in the country were not satisfactory. The main structures were mud *rhumbus*, thatched *rhumbus*, underground pit, vertical poles, gourd, earthen pots and bag and plastic containers. Most of the structures were not moisture- and rodent-proof, and were without adequate inlet and outlet facilities.

The suggested improvements included the following, among others: discontinuation of the thatched rhumbu due to high rates of pest and rodent infestation and constant fire occurrence; provision of the mud rhumbu with strong elevated base and inclined steel outlet with application of waterproof mud plaster; replacement of existing underground pit structure with underground reinforced concrete or brick masonry structures; and ventilation of the local crib and keeping the width at 0.7 m or less.

Acknowledgement: The authors are grateful to the Crop Storage Unit of the Federal Department of Agriculture and Rural Development, for providing the facilities for the work. We wish to acknowledge the contribution of Mr. B.R. Birewar.

Introduction

Nigeria is situated in the tropical zone but exists in three climatic zones: the tropical rain forest zone of the south (over 3 000 mm rainfall), the guinea savanna of the middle belt (500-2 000 mm rainfall), and the semi-arid sudan savanna of the north (about 500 mm or less rainfall). It has a comparatively year-round high temperature (average 28°C) that poses no serious limitation to the growth of tropical agricultural crops.

The vegetational zones largely reflect the type of grains grown. In the tropical rain forest of the south with its luxuriant tree growth, frequently inter-twined with lianes and epiphytes, the major grains are maize, rice and some cowpeas. The Guinea savanna of the middle belt, which is a belt of deciduous trees and mixed grasses, with dry season varying from 80 days in the southern half to about 140 days in the northern part of the zone grows mainly maize, rice, millet and sorghum. In the northern sudan savanna with tall grass and acacia trees and annual rainfall of less than 1 000 mm and as low as 500 mm in the upper northern region, the major grains are wheat, milllet, sorghum and rice. In the north, the rainy season could be as short as 3 months, compared to about 10 months in the southernmost part of the country.

There are three main categories of farmers in Nigeria: the rich and enlightened few (10%); the intermediate, half-literate, plenty (80%); and the dwindling, old, illiterate and poor group which forms 10% of the farming population (Igbeka, 1981). The intermediate farmers produce more than 85% of the food consumed in the country. Their average farm size is 1-5 ha. Some of them include unemployed high school graduates. The Nigerian Government has come up with incentives to help this group of farmers through interest-free loans and subsidized land preparation costs and inputs. This has increased production per hectare but the storage systems among these farmers have remained inadequate. High losses, especially in the humid south, have been reported due to mold and pest infestation.

This study was, therefore, undertaken in order to evaluate or appraise the existing village-level storage and suggest improvements and modifications. This report is based on the work done in 1990 (Olumeko, 1991).

Methodology

Field workers and enumerators were used in the survey. Questionnaires that were simple to administer and easy to analyze were formulated (Olumeko, 1991). One set of the questionnaires was for the farmers while another set was for government establishments. In addition to the questionnaires, personal interviews were employed. The farmer's questionnaire was to give the following information: type of structure, capacity, material of construction, age, cost of construction, annual maintenance cost, commodity stored, approximate length of storage, storage problems and losses. The farmers were also asked if they would be ready to accept improved or new type of structures. Visual observations were made of the structures to appraise their defects, state of the grains in storage and other relevant information.

The questionnaire for the government establishments was designed to collect information on government involvement in storage; level of operation and extent of involvement.

Results and Discussion

Before discussing the storage structures, it is pertinent to understand the harvesting culture and time. The time of harvesting varies slightly throughout the agro-climatic zones. In the humid south, the harvesting period is between August and December which spans through the period of rains to the dry season. On the other hand, the harvesting period in the north is between September and January which are quite dry months in this region, while in the middle belt, harvesting is done between September and December. **Table 1** gives the harvesting periods of different crops in the north and south.

Table 1. Harvesting Period of Different Crops in Nigeria

Crop	North	South
Rice	Upland-October/November Deep Flooded December/January	Upland-September/October Deep Flooded December/January
Maize	September/October	August
Cowpea	August/September	November/December
Soybeans	August/September	November/December
Sorghum	September/October	—
Millet	August	—
Wheat	April/May	—

Harvesting is usually done by hand using sickle, cutlasses and other simple tools. Grains may be stored in threshed or unthreshed forms. If threshed or shelled, they are then sundried and manually winnowed before they are transferred to appropriate storage structures.

The appraisal of the structures together with recommendations are hereby discussed according to zones.

The Sudan Savanna

The zone includes Sokoto, Katsina, Kaduna, Borno, and Gongola states. The prominent structures found in this zone include mud rhumbu, thatched rhumbu and underground pit.

Mud rhumbus — The physical structure of the mud rhumbus varies from village to village, but the most common type is the outdoor type. This is circular in cross-section and supported on stone pieces or pillars which are about 35-50 cm above the ground **(Figs. 1 and 2)**. The floor is made of wood and plastered with mud, while the wall is made of specially prepared mud, which is built by adding 2-3 layers daily. The roof is conical and made of thatch. In some places like Zaria and Sokoto, the conical roof is made of mud while in others like Kano, the top is completely open and covered with flat thatch. The average size is about 185 cm in diameter and the height ranges from 80 cm to 180 cm. The capacity ranges from 2 000 kg to 4 000 kg. The smaller capacity rhumbus (500 kg-2 000 kg) have higher elevations ranging from 60-90 cm above the ground. The elevated rhumbus have rat guards and could be rectangular in shape. They could also have small inlet/outlet half-way up on the wall.

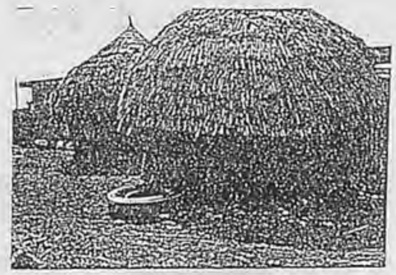

Fig. 1 Circular mud rhumbu.

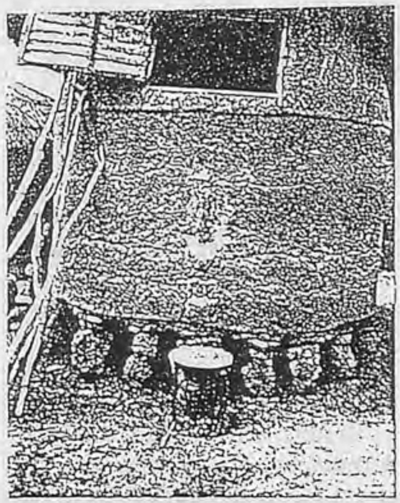

Fig. 2 Mud rhumbu.

Observations

(1) Most of the structures were found to have low elevated base, making them easily accessible to rodents. Even where the structures

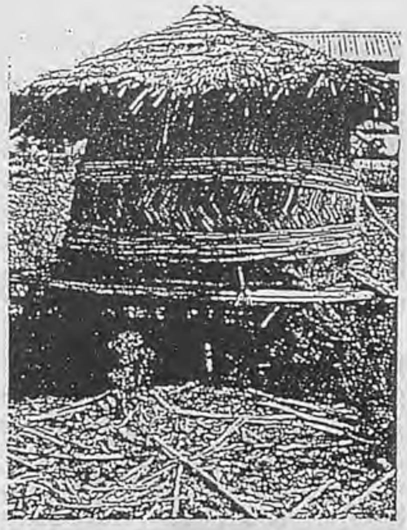

Fig. 3 Thatch rhumbu showing reinforced wall.

had comparatively high elevation, the supporting pillars were rough and the rat guards not properly installed.

(2) The loading and unloading facilities are inadequate and inappropriate.

(3) The structures were not moisture-proof and air-tight, therefore, pest control through fumigation is not possible.

(4) The supporting pillars were weak so the structure could easily be blown down by heavy strong winds.

(5) The wood in the structures (floor) were found to be attacked by termites.

Thatched rhumbus — These are commonly found in the north-east parts of the zone, which include Borno and Gongola states. Grains are usually stored in unthreshed or unshelled forms. They are cylindrical in shape, with floors made of woven grass stems or fibres and overhanging conical roof made from straw or grass **(Fig. 3)**. The top acts as the inlet and outlet for the grains and the capacity ranges from 1 000 kg to 2 000 kg. The structure normally is supported on low wooden structure or by stones. The wall is provided with tension rings in two or three positions using local rope materials ('kaba' or 'geza').

Observations

The thatched rhumbus have

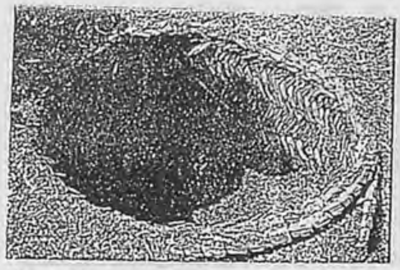

Fig. 4 Typical underground pit in use.

been found to be very inadequate and inefficient. The defects include:

(1) High risks of fire and theft; tons of grains have been lost to fire.

(2) The structure is not moisture-proof nor air-tight.

(3) The base is very low, thus making it rodent-vulnerable.

(4) There are no suitable loading and unloading facilities.

Underground pit — This is commonly found in the Sahel part of the Sudan Savanna zone where the water table is low. The pit, which may be either round or square in cross-section is 2-3 m deep and 1.5-3 m in diameter or square **(Fig. 4)**. Usually, the pit is lined with straw mat (*zara*) with corn husk padding of 30-40 cm between the wall and straw lining. Also, a layer of husk padding or insulation is provided at the bottom of the pit. After loading grains into the pit, it is covered with a polyethylene or metal sheet, and then a layer of husk before and finally layers of laterite. The pit capacity is 2-3 t and grains are usually stored in threshed or shelled form.

Observations

(1) Grains stored in this structure are, to some extent, protected against insect attack because of reduced oxygen levels.

(2) The structure is easy and cheap to construct and requires minimum materials; the same site can be used for up to eight years but with annual re-digging and cleaning.

(3) Grains stored in pits were found to undergo changes in texture, appearance and flavours. Also, the viability of these grains

Fig. 5 Mud rhumbu in Saki.

have been found to be quite low.

(4) The structure is not rodent-proof and sometimes termites can invade the grain if the pit is located in a termite zone.

(5) It is difficult to empty and clean the structure.

The Southern Rain Forest Zone

This area includes Lagos, Ogun, Oyo, Ondo, Rivers, Cross-River, Akwa-Ibom, Anambra, Imo and some parts of Bendel states. The rainfall is high, hence high humidity. The storage structures vary from mud rhumbu in the northern part of this zone to crib and platform in the southernmost parts. In this zone, indoor small storage structures are common. They include plastic containers, gourds, earthen pots and metal containers.

Mud rhumbus — These are similar to those found in the norhtern zone but conical in shape **(Fig. 5)**. In some cases, there may be partitions inside to enable the farmer to store different types of grains at the same time. The problems observed are the same as in the north.

Maize crib — This structure is very common in all the states of the zone. It is rectangular in shape with width ranging from 0.6-4.0 m and ventilated sides made either of bamboo or palm frond stalks, or planks or grass stalks, or wire netting reinforced with wood. The roof could be of thatch or corrugated metal and overhangs to protect the structure from rainstorm. The floor elevation ranges from 0.6-1.2 m and, in some cases, the structure has either a wooden or metal door for loading and unloading the grain.

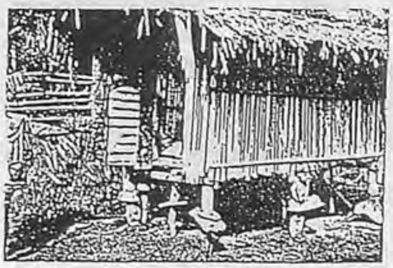

Fig. 6 Crib with bamboo wall.

Maize could be stored in either husked or unhusked form and the capacity varies from 1 to 4 t **(Fig. 6)**. The structure is fairly efficient depending on the material and manner of construction. It was observed that most of the structures required modifications. They had no rat guards and some of them had no inlet and outlet doors. There are no standards as regards the width and height of the structures.

Platform — This structure is used to store maize (husked or unhusked), panicles of rice paddy and cowpea pods. The platform, made of wood, is usually raised 1-5 m above the ground level and sometimes has thatched roof; most of them are open. The capacity ranges from 200 kg to 2 000 kg **(Fig. 7)**. Sometimes the platform could be indoors by a fireplace.

The structure was found to be very inefficient and leads to high losses due to rodents, insects, termites, and moisture. It is prone to pilfering and fire hazard.

Domestic or indoor storage — The structures used are small in capacity (20-100 kg) and are for seeds and grains for family consumption. They include plastic containers, gourds, earthen pots and metal containers **(Figs. 8, 9** and **10)**.

Some of these structures have been found to be very effective in storing grains for a long time with minimum losses. Sometimes, the grains are mixed with local insecticides like pepper, ash, and special species of leaves. For large quantity storage, a large number of the structures are required. The earthen pots and gourds were found to be very fragile.

Fig. 7 Typical platform structure.

The Guinea Savanna Zone

This covers Kwara, Benue, Niger, Plateau, and the northern parts of Bendel and Oyo states. The storage structures found in this zone include partly those found in the north and partly those in the south. They are the mud rhumbu, thatched rhumbu, platform, earthen pot and crib.

The mud and thatched rhumbu are almost similar to those in the north with little modifications in their shapes and capacities. The defects and problems encountered are also similar to those in the north.

The platform structures are usually 1.5-2.0 m above ground level and like in the southern zone, the grains are stored unthreshed. They are normally open and only covered with leaves or grass when it rains. Like in the south, the losses due to this structure are high due to insect, rodent and rain damage. Also, it is prone to pilfering and fire hazard.

The earthen pot storage, normally found in Bida of Niger State, is made of burnt clay. The shape is different from that in the southern zone and it is also smaller in capacity. The disadvantages of the pot include fragility and size.

General

One storage system which is common in all parts of the country is bag storage. The bag could be made of jute, hessian, polyethylene or plant fibres. The bag storage has been found convenient for bulk storage of shelled or threshed grains, as the bag is very convenient in transporting the grains.

Fig. 8 Plastic containers for storing maize.

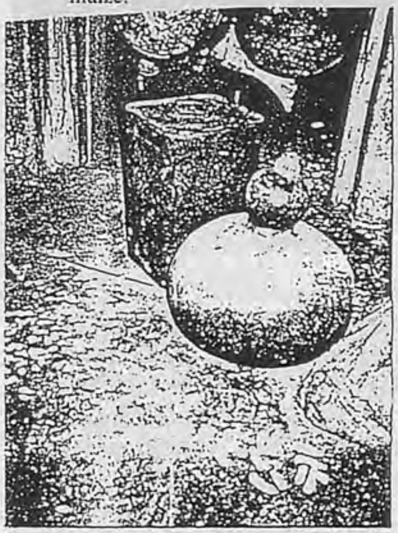

Fig. 9 Typical gourds for storage purposes.

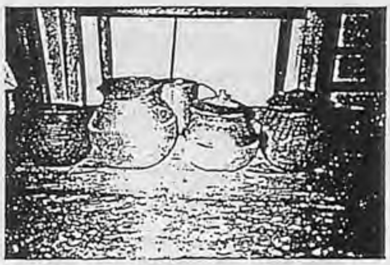

Fig. 10 Earthen pots common in Oyo, Ondo, Imo and Anambra States.

Observations

The warehouse where these bags are stored are not well constructed. Hence, there were losses due to rats, insects and rain. Sometimes, the bags give way during handling due to wear and tear as a result of many times of re-use.

Recommendations

The recommendations here include suggestions made to improve the specific structures and the storage facilities in Nigeria. In making these suggestions, many factors have been taken into consideration. In fact, some of the improved designs have been fabricated and are being tested by farmers under the supervision of the Crop Storage Unit of the Federal Department of Agriculture and Rural Development of Nigeria. Details of these recommendations and designs are given by Olumeko (1991).

(1) Due to the high risks involved with the thatched rhumbus, it is recommended that this structure be discouraged and discontinued; the same goes for the open platform structure.

(2) The mud rhumbus was modified and redesigned. The new design corrected all the defects found in the traditional ones. The capacity ranges from 1.5 to 2.5 t and the base of 0.8 to 1.0 m height was made of brick and covered with reinforced concrete floor **(Fig. 11)**. It has an inlet at the top and an outlet at the base. The body is made of cement plaster inside and waterproof mud plaster outside. With this design, it is possible to fumigate or apply insecticides.

(3) The farmers were discouraged from using earthen pots and gourds which are fragile and susceptible to insect infestation. Instead, small- to medium-sized metal bins made of galvanized sheets have been suggested and designed **(Fig. 12)**. The metal bin is 400-1 000 kg in capacity and has an inlet at the top and an outlet at the inclined base. Pest control is made easy with this structure.

(4) The crib has been found to be an effective storage structure throughout the country. It is, therefore, recommended that it be fully adopted but in a modified form. The modified modern crib which takes into account the climatic conditions has been suggested. It has a width of 60 cm in the humid south to 2 meters in the Sudan Savanna. It is made of wire mesh reinforced with wood. Also, rodent guards are installed (Igbeka, 1983). This design is already being used by the semi-literate farmers in the south.

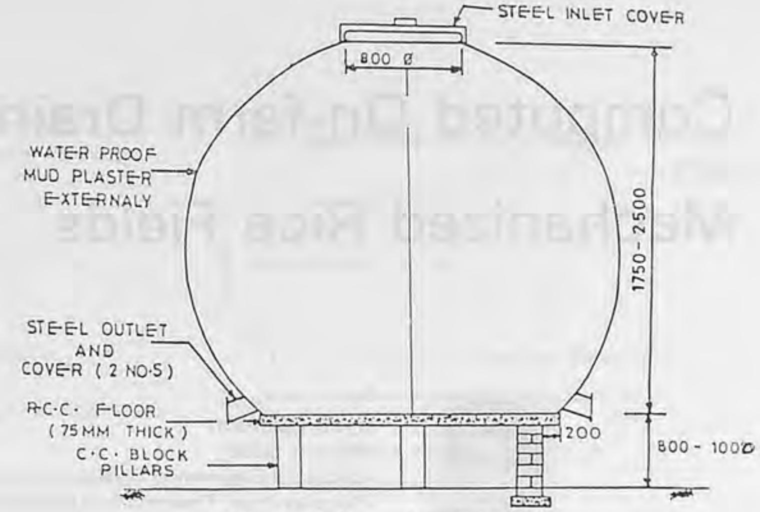

Fig. 11 Redesigned mud rhumbu.

(5) The underground pit could be improved upon if it is necessary to use such a structure. A permanent brick masonry or reinforced concrete structure is suggested. This will eliminate water seepage and make it easy for hygienic measurement.

(6) An improved warehouse design that is cheap and easy to construct is recommended.

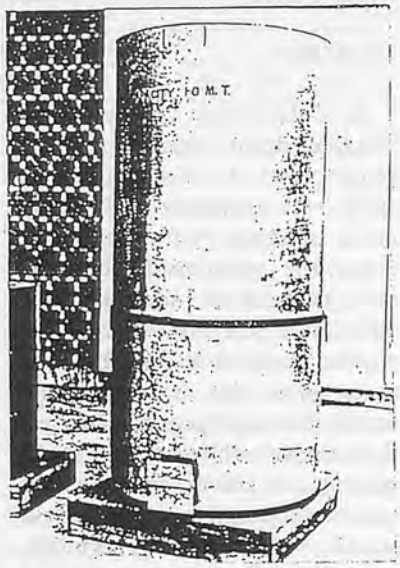

Fig. 12 I.O M.T metal bin.

Conclusion

The modern post-harvest technologies can be applied to improve the food security at the village level. But the process should first take into consideration the existing technologies of the people. The farmers will readily accept a concept or technology that builds upon or improves that which they are used to rather than one which imposes a totally new idea.

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Computed On-farm Drain Spacing for Mechanized Rice Fields

by
Ayob Katimon
Research Officer
Agricultural Engineering Division
Malaysian Agric. Research and Development Institute
GPO 12301, 50774 Kuala Lumpur
Malaysia

Abstract

A field study to investigate suitable drain spacing for the requirement of a mechanized rice field was conducted. Possible drain spacings were computed using the relationship between the progression values in field cone index, soil moisture content, ground water level and the distance from the drainage canal during drainage process. Regression analysis shows that a drain spacing of 160 m and less are suitable to providing a good field condition for machine mobility, especially during mechanical harvesting. These results may be used as a guideline for the design layout of mechanized rice field of similar soil condition in other parts of Asia.

Drainage System in Rice Fields

Traditionally, a drainage system in rice fields has been designed to cater to the following purposes: 1) removal of excess standing water due to runoff after a rainstorm to prevent submergence or lodging of rice crops; and 2) draining-off irrigation water for mechanized operation prior to harvesting.

Drainage system in rice fields is governed by the first requirement due to high intensity of rainfall resulting in large volume of discharge. Another important aspect of drainage relates to the development of soil bearing pressure (indicated by cone index) to permit mechanized operation. The bearing pressure of soil is dependent on soil moisture status and groundwater level (Shahrin et al 1989, Ezaki et al 1976) which is directly related to the performance of an on-farm drainage performance. A good on-farm drainage design must not only be capable to drain-off surface water but also to remove excess soil water in order to promote a good bearing pressure in the soil. Therefore, it is important to develop a specific on-farm drainage design to meet the machine mobility requirement in rice fields.

This paper reports on the findings of a field study to determine an appropriate on-farm drain spacing for mechanized rice fields. It aims to provide a reasonable guideline on the effect of an on-farm drain facilities to the requirement of machine mobility in rice fields.

The Experiment

The study was conducted in a 1.2-ha plot in a newly rehabilitated rice field located in Permatang Pauh, Seberang Perai, Malaysia during the dry season in 1987. The plot was provided with an on-farm drain of 1-m depth, trapezoidal shaped, along one side of the field. The soil was silty clay loam and its physical characteristics are presented in **Table 1**. Data on cone index (CI), soil moisture content (MC) and ground water level (WL) at points of different distances from the drainage canal were recorded during 17 days of soil drying process prior to harvesting. The dimension of the on-farm drainage canal was 1-m deep with trapezoidal shape.

Using simple regression method, a relationship between the measured cone index, soil moisture content and groundwater level and the distances from the drainage canal was carried out. The output of these relationship was recorded and a possible on-farm drain spacings were then computed using the relation

Table 1. Physical Properties of Soil in Study Site

Soil depth (cm)	Mechanical Analysis			Bulk Density (g/cm^3)
	%Clay	%Silt	%Sand	
0-10	34	38	28	0.94
10-20	42	38	20	1.12
20-30	40	40	20	1.27
30-40	40	42	18	1.18

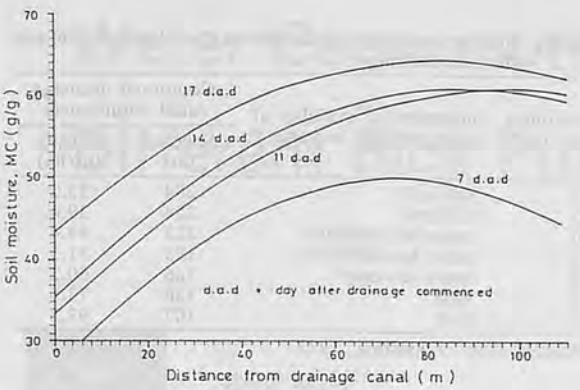

Fig. 1 Changes in soil moisture due to the distance from drainage canal.

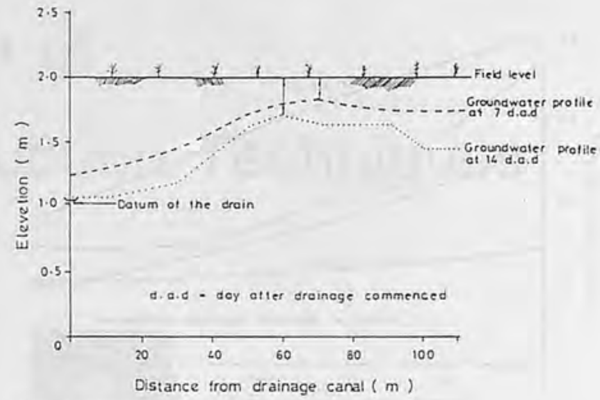

Fig. 2 Observed groundwater profile.

equation.

Soil Moisture vs. Drain Spacing

Moisture status in the soil can indicate the drainage status of the rice field during soil dessication process. **Figure 1** shows the trend of the relationship between the soil moisture status and the distances from the drainage canal at different days after the beginning of the drainage process. The soil moisture status was measured gravimetrically. The curves were best explained using quadratic equation. The best fit was obtained when the field had gone through 14 days of the drainage process. The relationship is written as follows:

$$MC = 33.16 + 0.56x - 0.029x^2, \quad R^2 = 0.92$$

where:

MC = average soil moisture for 0-30 cm depth (g/g)

x = distance from the drainage canal (m)

R^2 = regression corelation

Differentiating the equation above and equating to zero, we get:

$dMC/dx = 0.56 - 0.0058x$

$dMC/dx = 0$ (maximum point at which MC is not influenced by the distance from drainage canal anymore)

therefore,

$$0.56 - 0.0058x = 0$$
$$x = 0.56 - 0.0058$$
$$x = 96.55 \text{ m}$$

Here x is considered as the farthest point that could be influenced by the drainage canal. Therefore, if soil moisture content alone is to be used in the drain spacing computation, the suggested drain spacing would be 2x or 191.10 m.

Table 2. Rate of Groundwater Lowering According to Distance from Drain and Drying Period

Drying period (day)	Distance from Drain (m) 10	20	30	40	50	60	70	80	90	100	110
1-7	6.28	5.85	5.86	5.00	4.85	3.71	3.42	4.42	5.28	5.28	4.14
7-14	2.50	3.40	3.85	3.86	1.29	1.28	NA	1.57	3.00	NA	NA

Groundwater Level vs. Drain Spacing

The condition of groundwater level in the field can contribute toward the development of soil strength (indicated by cone index) in the rice fields. **Figure 2** shows the trend of the measured groundwater level profile compared to that of field surface and the base of the drainage canal. The groundwater level were recorded from a series of observation holes constructed at 10 m spacing perpendicular to the drainage canal. As shown, the shallowest point in groundwater level was at point about 60-70 m away from the drainage canal. Points at farther distance do not seem to be influenced by the drainage canal. If groundwater level alone was used to compute the drainage spacing, it could be spaced at 140 m apart. **Table 2** indicates the rate of ground water lowering rate during the field drainage process.

Cone Index vs. Drain Spacing

A good on-farm drainage design in a rice field must consider the development in soil strength to accommodate machine mobility. The higher the cone index value, the easier the machine can move. Under such condition, machine bogging and soil structure deterioration would be minimized. **Figure 3** shows the relationship between the average soil cone index values at 0-30 cm soil depth relative to the distance from the drainage canal. The cone index values were measured using cone penetrometer Model MARUTO

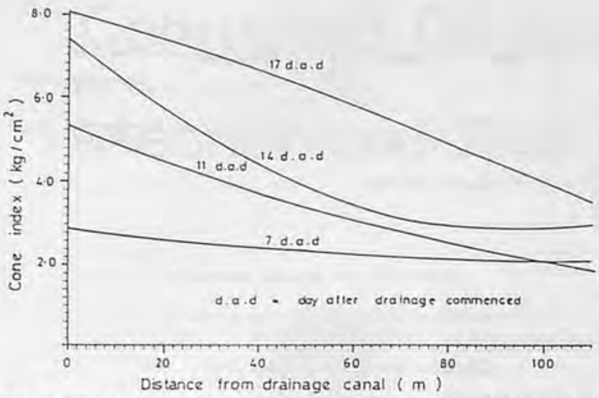

Fig. 3 Changes in soil cone index as affected by distance from drainage canal.

Table 3. Possible Drain Spacing Relative to Cone Index of Soil and Machine Mobility

Cone Index (kg/cm^2)	Judgement of mobility of large combine harvester*	Computed drainage canal requirement	
		Spacing (m)	Density (m/ha)
1.0	difficult	284	35.2
1.5	difficult	254	39.4
2.0	more less difficult	225	44.4
2.5	more less difficult	195	51.3
3.0	more less easy	166	60.2
3.5	easy	136	73.5
4.0	easy	107	93.5

*Extracted from Nakayama, 1983.

S-44 (Maruto Testing Machine Company 1985) with a cone base of 6.45 cm^2. A negative relationship is obviously seen. Even though the trend seems to be best explained using a curvelinear analysis, statistical analysis showed that a better fit was obtained from a linear regression analysis. The best fit was obtained from 14 days after drainage and written as follows:

$$CI = 5.82 - 0.034 \times , R^2 = 0.78$$

where:
CI = Cone Index (kg/cm^2)
x = distance from the drainage canal (m)
R^2 = regression correlation

Therefore, if the cone index alone was considered in the drainage design for mechanized rice fields, the possible drain spacing that are suitable for desired CI value can be computed using CI-distance equation. **Table 3** tabulates the result of the computation.

Selection of Suitable Drain Spacing

To select a suitable drain spacing for a mechanized rice field, certain criteria that are related to soil CI values have to be followed. As suggested by some researchers (Tada 1987, Nakayama 1983), cone index values of the field should be used to judge the machine mobility at field level. Using the mobility requirement for a large combine harvester as a guide, **Table 3** illustrates the estimated drain spacing requirement in the mechanized rice field as obtained from the cone index-distance from drain relationship equation of this study.

Conclusion

This paper emphasizes that an appropriate drainage networks at farm level is important in mechanizing the field operation. The selection of drain spacing must consider the soil bearing pressure requirement for the mobility of field machineries. It must also consider the performance of soil water removal and groundwater lowering for a better soil bearing development. The experimental result indicates that a drain spacing of 160 m or less is desirable to promote an appropriate CI values for large field machine. The drain should be deep enough (at least 1-m depth) to promote a better internal drainage process.

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Water Consumption of Different Rice Production Techniques

by

Abdul Majid
Senior Scientific Officer
Farm Machinery Institute
National Agricultural Research Centre
Islamabad, 45500 Pakistan

A.S. Khan
Director
Farm Machinery Institute
National Agricultural Research Centre
Islamabad, 45500 Pakistan

S.I. Ahmad
Director
Seed Multiplication Programme
National Agricultural Research Centre
Islamabad, 45500 Pakistan

M.A. Zaidi
Asst. Agri. Engineer
Farm Machinery Institute
National Agricultural Research Centre
Islamabad, 45500 Pakistan

Abstract

In Pakistan, the average rice yield is considerably low (2 t/ha) compared to potential (6 t/ha). This is mainly due to inadequate plant population. The contractual manual transplanting of rice seedling has been unable to achieve the desired plant population. Research efforts were initiated to develop direct sowing of rice technology as an alternate to transplanting.

In 1988, the effects of first irrigation schedule on direct-dry cultivation of rice were studied at Millat Tractor Ltd. Farm, Lahore. Water requirement of rice crop could not be evaluated precisely due to unusual early rainfall after sowing, and flood appearance in the month of September. However, water requirement of transplanted rice was maximum (143 cm) whereas water requirement of direct dry-rice cultivation was considerably low (99 cm). Studies on water requirements of various rice growing techniques in 1989 at Gujrat reveal that water consumption by direct dry seeding compared favourably with the transplanting technique.

Direct dry sowing of rice technique gave the highest rice yield of 5 377 kg/ha which was 10% higher than the transplanted rice due to adequate plant population. A combination of mechanical and chemical weeding was found to be a suitable approach for weed control in direct-dry rice cultivation.

Acknowledgements: The authors express their deepest appreciation to the Pakistan Agricultural Research Council and the Pakistan Council of Research in Water Resources for granting the permission and funds to conduct this study, respectively. A very special thanks to M/S Millat Tractors Ltd. Pakistan, for their kind cooperation to make this study possible.

Introduction

Rice is both food and cash crop in Pakistan. Besides being number two food crop of Pakistanis, rice is one of the major export commodities in the agriculture sector.

In Pakistan, rice crop is established by contractual manual transplanting of paddy seedlings. Transplanting involves raising of rice seedlings, land preparation in standing water (puddling), and transplanting of seedlings. These are not only difficult operations but also consume approximately 20-25% more water than that of the total quantity required by paddy crop (De Datta, 1981). Furthermore, manual transplanting results in non-uniform and inadequate plant population (Khan et al, 1979) which is one of the major reasons for low rice yields in Pakistan. Yamada (1961) studied the effect of spacing and reported that higher planting densities produced maximum total dry matter and grain yield per unit area. Lower number of seedlings per unit area decreased paddy yield from 11% to 20% (Annonymous, 1987). Besides higher water requirements, other disadvantages of puddling are deterioration of soil structure, more wear and tear of farm machinery, and late sowing of wheat in rice harvested fields. Approximately 35-40 kg/ha/day reduction in wheat yield was reported when sown after 20th of November (Hobbs, 1986 and Randawa et al, 1981).

In an effort to mechanize paddy transplanting in Pakistan, both root-washed seedling and mat-seedling type transplanters were tested for their suitability. These machines were not suitable because they require precise field levelling, high soil organic matter, proper water management, and high technical skills for nursery raising. Such type of situation demands the replacement of transplanting by a convenient rice growing technique.

Direct sowing of rice does offer a suitable substitute to transplanting. It needs minimum labor and insures timely sowing of both rice and wheat crops. Shad and De Datta (1987) found that direct sowing of rice increased the yield of rice. Direct sowing can be done either by drilling or broadcasting. Drilling is the most efficient method because of low seed requirement, uniform sowing in lines, and uniform crop stand. Also, it reduces the cost and labor requirement to nearly one-third that of the transplanting method.

In Pakistan, efforts have been made to sow rice crop by broadcasting of both pre-soaked and sprouted seeds in puddled fields but these methods failed due to high water requirements, difficult working conditions and special machinery needs.

Water is a very important factor in paddy production. Aujla et al, (1984) reported a 12% decrease in paddy yield due to the depletion of available water before the ensuing irrigation. The Farm Machinery Institute of PARC initiated a pilot study in 1985 on various rice-crop-establishment techniques. Direct-dry seeding of rice was found the most suitable alternate to the conventional transplanting. Majid et al, (1986) reported maximum rice yield of 5 t/ha with direct sowing of rice, registering an increase of 35% over traditional method of paddy transplanting. Weed infestation was a serious problem in direct dry-seeding of rice. Rao et al, (1986) reported significant increase in density and biomass of weeds with direct-seeded rice rather than transplanted paddy and 8% more grain yield compared with direct seeding.

Same work was reported on the response of direct-dry-seeded rice to various irrigation schedules. The estimated saving of irrigation water has been reported. In the absence of quantitative information on water requirements of various rice growing methods, there existed enough justification to measure the actual water requirement of rice cultivation under varying rice- crop-establishment techniques. The study also compared the benefits of three direct-seeding methods of rice production with manual transplanting.

Materials and Methods

Initially, the effects of first-irrigation scheduling were studied at the Millat Tractor Ltd. Farm, Lahore during 1988. The soil was characterized as loam with PH 8.1, organic matter (OM) 2.3%, No_3-N 4.9 ppm, phosphorus 8.6 ppm, and potash 78 ppm. Treatments included in this study were:

T0 Puddled transplanting (check plot);
T1 Direct-dry sowing + first irrigation 10 DAS,
T2 Direct-dry sowing + first irrigation 15 DAS,
T3 Direct-dry sowing + first irrigation 20 DAS,
T4 Direct-dry sowing + first irrigation 25 DAS.

In 1989, two types of studies were laid out at the farmers' fields in Gujrat District. Experimental soils were characterized as loam-clay and clay-loam. The fields were planted to wheat crop previously. These studies were:

Water Requirement of Various Rice Growing Techniques

i. Broadcast of pre-germinated seeds on puddled soil (CMP-method),
ii. Broadcast of pre-germinated seeds on dry, prepared flooded soil (WSP-method),
iii. Direct-dry sowing of rice (FMI-method),
iv. Line transplanting, and
v. Conventional transplanting.

Weed Control Studies in Direct Dry Rice Cultivation

i. Stomp @ 1.4 kg/ha), (N- (1-Ethylpropl) 3,4-dimethyl-2,6-dinitro benzenamine)
ii. Ronstar @ 0.7 kg/ha, (2-tert-butyl-4-12,4-dichloro-5-Isoprophyloxyphenyl)-1,3,4-oxadiazoline-5-one)
iii. Machete @ 1.0 kg/ha, (N-(butoxymethyl)-2-chloro-N-(2,6-diethylphenyl)-acetamide)
iv. Mechanical weeding and machete @ 2.0 ℓ/ha,
v. Hand weeding, and
vi. Control (check plot)

Fine-rice variety, Basmati-385, was used as the test crop. Soaked seeds of rice were drilled directly into the soil at field capacity under direct-dry-sowing method, whereas paddy seedlings were transplanted manually in the check plots. In direct-wet-sowing methods, pre-germinated seeds were broadcast onto the wet-(puddled/flooded) soil. Equal amounts of fertilizer in the form of Diammonium Phosphate (DAP), Urea, and Potash were applied to each treatment in addition to other standard treatments. The experiment was designed with randomized complete block technique with four replicates. Beyond the first irrigation after sowing, onward irrigation was scheduled with two-day intervals to each plot. Cut-throat flume was used to measure the irrigation water sup-

Table 1. Water Requirements of Direct-dry-rice Cultivation and Paddy Transplanting

Month	Water Requirements (cm)				
	Paddy trans-planting	Direct dry-sowing			
	T0	T1	T2	T3	T4
June	7.6*	16.4	10.0	10.0	10.0
July	67**	17.0	15.2	10.0	10.0
August	38.2	47.6	39.7	20.1	17.6
September	30.0	46.4	34.6	26.8	22.1
October	Flood Appearance				
Total	142.9	127.4	99.5	66.9	58.5

* Water used for nursery raising.
** Water used for puddling and transplanting, etc.

plied to each plot. The soil-moisture-depletion rate was recorded up to the first irrigation after sowing by using a soil moisture meter. The grain yield of rough rice or paddy was recorded at 25% moisture content. Crop yield, yield components, and water-requirement data were collected and statistically analyzed.

Results and Discussions

In 1988, water requirement could not be evaluated due to unusual adverse weather problems, i.e., early rainfall after sowing and flood appearance in September. However, the total water applied to crop is presented in **Table 1**. The data show that water requirement of direct-dry-rice cultivation in "water" condition decreased to 99 cm due to the elimination of nursery raising, puddling operation and delaying of first irrigation after sowing. The early-season saving of water compensated for the increased water percolation in the direct-dry cultivation.

The total water requirements and monthly volume of water applied to rice crop in 1989 is presented in **Table 2**. Direct-dry-sowing method (FMI-method) consumed 96 cms of water, whereas CMP-method and WSP-method (direct-wet-sowing methods) used 80 cms and 167 cms of water, respectively. The lowest water consumption for transplanting observed was due to

Table 2. Water Consumption (cms) in Various Locations

Location (Gujarat)	Method of Crop Establishment			
	CMP	WSP	FMI	Transplanting
		June		
Haryawala	22	25	12	—
Mangowal	50.3	70.4	20.3	—
Dudhra	36.4	35.7	20.4	—
Average	36.2	44	15	32.0 *
		July		
Haryawala	17.1	32.8	9.9	15
Mangowal	19.8	54.3	23.2	12.2
Dudhra	27.0	90.0	47.8	20.5
Average	21.3	59	27.0	16.0
		August		
Mangowal	11.4	24.9	21	10.2
Haryawala	—	—	—	—
Dudhra	7.8	61.7	55.6	14.1
Average	9.6	43.4	38.3	12.2
		September		
Mangowal	18	26.9	17	15.1
Haryawala	—	—	—	—
Dudhra	8.7	14.7	15.3	13.1
Average	13.4	20.8	16.2	14.1
Total for June-Sep.	80.5	167.1	96.5	74.3

CMP: Broadcasting of pre-germinated seed in puddled soil.
WSP: Broadcasting of pre-germinated seed in dry-prepared-flooded soil.
FMI: Direct drilling of pre-soaked seed in "Wattar" soil.
*: Estimated water use for nursery and puddling operation in one pass.

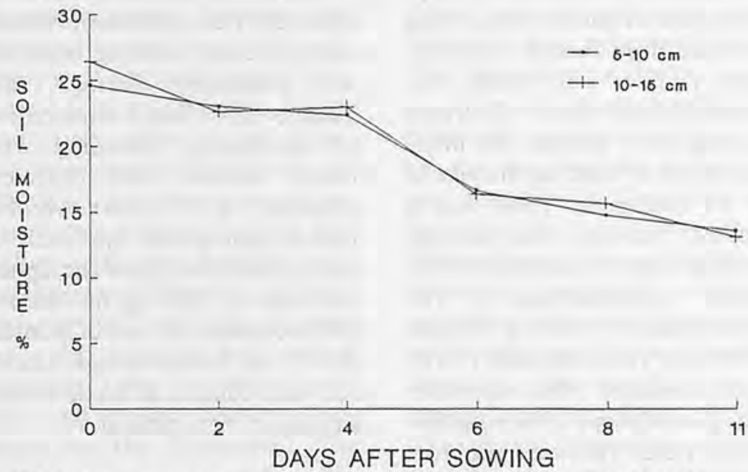

Fig. 1 Soil moisture depletion rate after sowing till first irrigation (1989).

the significant reduction in puddling period because of modern equipment such as wet rotavator. Normally using traditional equipment, a farmer consumes 140 h/ha, while the use of wet rotavator with four-wheel-drive tractor accomplished the same job in better quality in 10 h/ha. The WSP-method used maximum volume of water which was 73% higher than that of the FMI-method.

The soil-moisture-depletion rate is shown in **Fig. 1**. Depletion rate indicate that enough moisture

Table 3. Yield of Rice under Various Planting Techniques

Planting Technique	Yield (kg/ha)
Transplanting, T0	3 666
Dry sowing + first irrigation 10 DAS, T1	3 453
Dry sowing + first irrigation 15 DAS, T2	3 109
Dry sowing + first irrigation 20 DAS, T3	1 889
Dry sowing + first irrigation 25 DAS, T4	1 282

DAS: Days after sowing.

(14%) was present in the soil up to 10 days after sowing. Therefore, the first irrigation can be delayed until 10 days after sowing (DAS) without any risk. This data

Table 4. Effect of Various Rice-crop-establishment Techniques on Paddy Yield

Techniques	Tillers (m^{-2})	1 000 grain weight (g)	Grain yield (kg/ha)
FMI	279.5 AB	22.2	5 377 A
WSP	285.7 A	21.2	3 826 B
CMP	281.8 AB	19.0	3 820 B
L. Transplanting	187.2 BC	22.3	5 126 AB
C. Transplanting	157.9 C	22.5	4 990 AB
S.E. (0.05)	92.9	N.S	1 447
C.V. (%)	20.6	8.7	16.2

FMI: Drilling of pre-soaked seeds in "Wattar" soil.
CMP: Broadcasting of pre-germinated seeds onto puddled soil.
WSP: Broadcasting of pre-germinated seeds onto dry prepared flooded soil.
L. Transplanting: Line transplanting.
C. Transplanting: Conventional transplanting.

Table 5. Effect of Different Weeding Measures on the Yield and Yield Components of Direct Dry Sowing of Rice

Weeding measure	Tillering (m^{-2})	1 000 grain weight (g)	Grain yield (kg/ha)
Mech. weeding + machete	399 A	24.2 A	5 089 A
Ronstar	239 B	22.5 B	3 141 B
Stomp	263 B	20.0 C	3 704 B
Machete	263 B	20.5 C	2 984 B
H. weeding	233 B	20.5 C	2 434 B
W. Check	216 B	20.1 C	2 986 B
S.E. (0.05)	86	1.3	1 171
C.V. (%)	17.7	3.4	19.0

Note: Unlike letters in each column show significant differences at $P<0.05$.

should have been taken for at least 15 DAS but had to be given up for technical and logistic reasons. Nevertheless, it is assumed that the first irrigation can be delayed to 15 days after sowing since the wilting-point-moisture level of medium-heavy soil (about 10%) is about 4% below the moisture present 10 days after sowing.

The effect on rice yield in delaying the first irrigation after sowing is obvious from **Table 3**. The maximum yield of 3 666 kg/ha was obtained in the case of the transplanting (T0), whereas the minimum yield of 1 282 kg/ha was in the T4 treatment. There was a trade-off between water savings and crop yield. As compared with manual transplanting, T1 (10 DAS) saved 11% water at the cost of 6% less yield whereas T2 (15 DAS) consumed 30% less water at the cost of about 15% reduction in crop yield. The weed problem was one of the major factors responsible for low crop yield in the case of T1 and T2. However, this yield gap could very well be reconciled by better weed-control measures. These results confirm the findings of previous studies (Aujla et al, 1984). Further, delay in the first irrigation caused unaffordable reduction in paddy production. Therefore, T2 treatment was considered the most appropriate for further work in this area.

Yield and yield components data of different rice-crop-establishment techniques is presented in **Table 4**. The maximum rice yield of 5 377 kg/ha was obtained in the case of direct-dry-sowing technique (FMI method), whereas the minimum yield of 3 820 kg/ha was produced by the direct-puddling method (CMP-method). There was a 10% increase in rice yield by direct-dry sowing method over conventional method of transplanting.

Weed is a serious problem in direct-dry-rice cultivation. A study with different weeding measures was conducted during 1989. **Table 5** shows that a combination of mechanical (weeding with rotary weeder) and chemical (Machete @ 2 ℓ/ha) weeding found appropriate approach to weed problem and gave the highest rice yield of 5 089 kg/ha. Among the weedicides, the use of Ronstar @ 0.72 kg/ha was found suitable for weed control in the direct-dry sowing of rice method.

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Traditional Systems and Application of Modern Irrigation Techniques in the Sultanate of Oman

by
Hayder A. Abdel Rahman
Assistant Professor
Soils and Water Department
College of Agriculture
Sultan Qaboos University
P.O. Box 34 Al-khod Postal Code 123
Sultanate of Oman

Abstract

Growing needs and limited water resources have prompted efforts for water conservation in the Sultanate of Oman. The traditional surface irrigation systems of Aflaj provide 71% of the water supply and irrigate 55% of the cropped area with overall efficiencies in the order of 30%. The need for water conservation initiated government efforts to encourage farmers to adopt modern irrigation systems of sprinklers, trickle and bubblers, coupled with agronomic management, institutionalization and augmentation of resources by desalinization, wastewater treatment, fog collection and rainwater harvesting through recharge dams. More areas in the Sultanate are now being put under modern irrigation systems. The government bears up to 75% of the overhead cost for farms less than 4.2 ha. All new allocations of land for agriculture by the government are required to use modern irrigation systems. Nevertheless, modern irrigation systems still comprise less than 10% of the cultivated area in the Sultanate.

* Journal Article No. 930106. College of Agriculture, Sultanate of Oman.

Introduction

The need for water has grown steadily in the Sultanate over the past years. Agricultural operations account for most of the water used with varying estimates of up to 85-90% of the total water consumed. The contribution of the agriculture sector to the Gross National Product (GNP) is around 3%. With an annual population growth rate of about 3.1% (1.387 million in the 1991 estimates) and increasing contribution of the industry in the GNP (51%), the need for water is getting into critical situations. **Table 1** shows the areas cultivated and crop water requirements in the Sultanate. The Batinah region accounts for 57% of the area cultivated and 53% of the crop water requirements of the country. Different estimates have been made for the water requirement based on types of crops, areas and locations mostly using the Penman or Blaney-Criddle methods. The total requirements ranged between 900 and 1 300 million m^3 year (4). **Table 2** gives the crop production by areas and yields. Fruits and vegetables make up 60% and 9.8% of the area, respectively, whereas field crops, mainly alfalfa, comprise 17.8%. Dates are the main fruit crops grown constituting 75% of the fruit crop area and about 46% of the total area cultivated in the Sultanate (2).

In any conservation or modernization program, crop types, water requirements and areas cultivated have to be inventoried. The Sultanate has limited water resources with diverse rainfall patterns and occurrence within the country. Regular rainy seasons are only found in the Dhofar mountains in the south and Hajar mountains in the north. The interior regions (which constitute around two-thirds of the country) receive less than 50 mm of rainfall annually. The rainfall in the coastal areas is about 100 mm. The Hajar mountains receive 100-300 mm and the monsoon affected Dhofar regions receive about 200-300 mm annually. Groundwater is the major source, but there are few surface water flows in the upper reaches of wadis (valleys) in the northern mountains. Flow occurs only during storms and reach the sea, a certain amount of which recharge the wadi beds and flood plains. **Table 3** gives an account of the regional ground water balance in the country. The estimated annual recharge is around 1 240 million cubic meters (MCM). With 1 308 MCM used for agriculture and 13.8 MCM of water supply, the

Table 1. Cultivated Area and Water Use in Oman

Region	Cultivated Area (ha)	Water Requirement (MCM)
Batinah	31 207	686.554
Sharqiya	8 615	206.760
Dakhliya (Wusta)	2 109	63.270
Dakhliya	5 619	168.570
Dhahira	5 603	134.472
Southern	1 488	35.712
Total	54 641	1 295.338

Source: JICA (1990).

Table 2. Crop Production, by Area and Yield 1988

Crop	Area (ha)	Yield (t/ha)
Vegetables		
Tomato	1 212	22.19
Pepper	610	9.02
Onion	560	13.75
Garlic	150	8.00
Okra	53	13.21
Water melon	1 250	19.04
Musk melon	625	13.12
Cabbage	770	23.25
Potato	140	25.00
Sub-total	5 370	—
Field Crops		
Alfalfa	8 870	38.00
Wheat	468	1.50
Tobacco	409	4.89
Sub-total	9 747	—
Fruits		
Dates	25 000	4.00
Lime	2 400	10.83
Mango	3 780	2.01
Banana	1 625	13.60
Coconut	328	16.77
Sub-total	33 133	—
Others	6 651	—
Total	54 901	—

Source: Ministry of Agriculture, 1988.

Table 3. Regional Groundwater Balance

Region	Region Name	Catchment Area (km^2)	Mean Annual Precipitation (mm)	Mean Annual Precipitation (MCM)	Runoff Rate (%)	Catchment Runnoff (MCM)	Flood Loss (MCM)	Ground water Recharge (MCM)	Estimated Agri. Use (MCM)	Water Supply (MCM)	Ground water Balance (MCM)
1	N. Batinah	4 860	137	665.82	40.0	266.3	26.1	240.2	321.3	0.0	−81.1
2	S. Batinah	7 757	125	969.63	35.0	339.4	22.5	316.9	428.5	8.7	−120.3
3	Dhahira	7 143	135	964.31	20.0	192.9	56.3	136.6	134.5	0.6	1.5
4	Dakhliya	4 280	168	719.04	30.0	215.7	58.3	157.4	168.6	3.2	−14.4
5	Sharqiya	10 597	105	1 112.69	25.0	278.2	46.2	232.0	206.8	1.1	24.1
6	Musandam	693	225	176.72	20.0	35.3	5.3	30.0	13.4	0.2	16.4
7	Al Janubiya	3 655	156	570.18	25.0	142.5	15.8	126.7	35.7	0.0	91.0
Total		38 985	133	5 178.37	28.4	1 470.3	230.5	1 239.8	1 308.8	13.8	−82.8

Source: JICA (1990).

deficit is about 82 MCM (4). The situation is even worse in the Batinah which cultivates more than 57% of the area in the Sultanate and the groundwater deficit is about 200 MCM annually. Over-pumping has led to lowering the groundwater table and seawater intrusion. Even though these estimates put the Southern region on the positive side, other estimates give it a slightly negative edge. This situation has triggered a nationwide campaign for water conservation and augmentation. Water conservation measures include efficient use, modernization of the irrigation systems, agronomic management and institutionalization. Augmentation is done by desalinization, treated wastewater use, water harvesting by recharge dams and use of brackish water (1).

The desalinization plants installed in the Sultanate have an annual output of 31 MCM which is about 2.5% of the Gulf Countries Council production. The 1986 yearly census shows that desalinization plants supplied about 86% of the water produced in the capital area for domestic use (2).

Wastewater treatment and reuse has been practiced in the Capital area where 25% of the population lives. The urbanization rate in the Sultanate is about 8.8%. There are two major treatment plants in Darsait and Ansab with capacities of 11 500 and 5 400 m^3/day and other small plants with a total capacity of 3 400 m^3/day (1). The treatment plants run by Muscat Municipality are used to irrigate ornamental shrubs and trees in the Capital area. The 10 MCM wastewater annually produced is virtually used up in the summer, but about 30% is discharged into the sea during off peak seasons. It is worth mentioning here that the quality produced is of very stringent standards, to eliminate any health hazards.

The amouont of rain water lost yearly to the sea and desert is estimated as 120 MCM. To catch part of this water and avoid seawater intrusion into the groundwater, recharge dams have been built across the country as a water harvesting techique. A master plan prepared by the Ministry of Agriculture and Fisheries (1986), to utilize rainwater lost to the sea or desert, suggests construction of 58 recharge dams which would add about 80 MCM annually to the ground storage (5). The actual amount of water caught depends on the rainy season and the engineering and hydrologic nature of the dam. About 11 dams were constructed in 1985-1991, the biggest being on Wadi Al-Khod capable of storing 14 MCM annually and built at a cost of about 6 million Omani Rials ($15 million).

Traditional Irrigation — The Aflaj Systems

Omanis practiced agriculture since ancient times. They used to grow date palms and household vegetables in valley depressions and around dwellings. The *Aflaj* (sing. *falaj*) were built by tapping the groundwater with a sub-horizontal tunnel whose rate of descent is less than that of the ground surface. Water is eventually brought to the surface and flows continuously throughout the year. Ventilation and inspection vertical shafts were dug along the tunnel at about 20 m internals (**Fig. 1**). There are about 6 000 active aflaj in the Sultanate providing 71% of Oman's water supply and irrigating 55% of the cropped land (3). There are generally of two types: *Ghayl and Dawadi* (*Qanat*). *Ghayl* designates the phenomenon of perennial flow in the upper gravels of wadi beds. Although such flow can occur throughout the mountain zone whenever a rock bar or other construction confines the wadi course, the discharge is highly seasonal and it is only in the larger catchments of central Oman that it assumes any importance as a regular course of irrigation water. Of

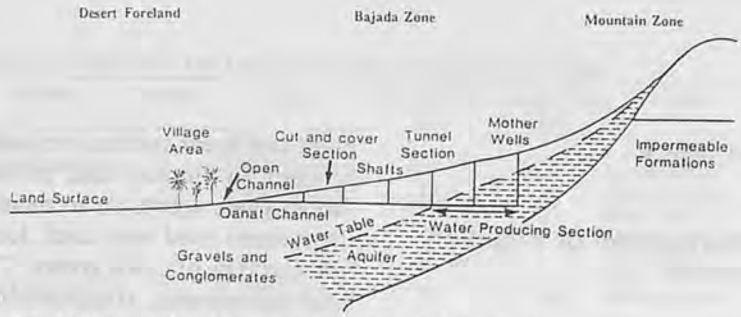

Fig. 1 Cross section of a qanat (Falaj) in piedmont zone.

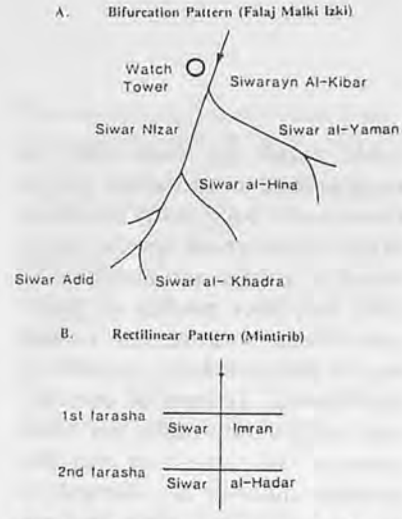

Fig. 2 The two basic patterns of a *Falaj* network.

itself the flow is easily tapped, but transporting it to the site where it may be used often involves constructing a special channel.

Dawadi or *Qanat* is a man-made water mine in which the water stored in an aquifer is brought to the surface by means of the tunneled conduit. The length of this tunnel is about 3 to 9 km while 20 m is probably a reasonable average depth for the mother well. The falaj water is regarded as communal property and the individuals have no rights to it. At the very top of the falaj, where it first comes to the surface is an opening where drinking water is drawn (the *Shari'a*). This is the first permitted use of water and access to it is free for all. From there the water runs in a well constructed channel towards the village and quite often this section is partially covered. On a large falaj, the first split may occur high up this main stream (*Qaid*), but in smaller ones division does not take place until the falaj reaches the cultivated area. Where the falaj flows through the built area of a village, the channel is normally covered and special access to water are constructed. The order of domestic usage is first for drinking, then bathing facilities with women sections clearly separated downstream, and finally the "*mughsala*" for washing the dead. No diversion of the falaj for private or public purposes is permitted in the residential areas. An exception sometimes occurs in case of a major fort and mosques may have a direct access for the purpose of ritual ablutions.

The number of divisions of the principal water channel for irrigation purposes depends on the volume of flow. Where there is considerable variation in base flows, some of the channels of this primary network are only opened when water is plentiful (*ayam Al Khasob*). Divisions take place at certain fixed points and the resulting network of channels (*ghyaz* or *sawagi*) takes one of the two patterns: bifurcation which is the most common, and the rectilinear pattern (**Fig. 2**). Branching out from the primary channels of the main network are the laterals which feed the gardens and these in turn split into smaller channels which lead to the individual plots (*jilab*). The system of shareholding of the falaj water is complex and varies from one place to another in Oman. Basically, the main system of water shareholding is the "*Dawran*", i.e. rotation or cycle by which the falaj water is distributed to individual farms every 7-10 days. The cycle (*Dawran*) starts from Friday to Thursday and each shareholder will obtain his share once a week on the average. Irrigation time is based on a local timing based on sound astronomical principles. Subdivisions of the day and night (*badas*) are assessed by observing the sun's shadow and movement of stars. The shareholder has the freedom of buying or selling a share of "*Athar*" which is about half an hour of irrigation time, a *bada* being 12 h, in an auction. Administratively, an agent (*Wakil*) is responsible for the financial duties. The routine maintenance is carried out by laborers, including the supervisor "*Bayadir*". The water seacher "*Basir*" divines the location of the underground water and advises how to improve the falaj supply. The "*Awamir*" are experts in working underground in the hard rocks and conglomerates at the head of the falaj. Water distribution in a big falaj is administered by an overall supervisor "*Arif*", but the "*bayadir*" can do the job in smaller aflaj. Other falaj officials include a bookkeeper "*Amin Al-Daftar*", his clerk "*Katib*" and the auctioneer "*Dallal*". There is a considerable variation in the aflaj discharge throughout the year. Whereas some aflaj have a rather steady flow with little variations, some might dry out parts of the year or until groundwater recharge is enough to cause flow. A study of some of the Dhahira aflaj systems reveals an average flow rate of about 23 ℓ/sec, ranging from less than one to over 165 ℓ/sec.

The 1981-1985 Ministry of Agriculture and Fisheries plan estimated that 80% of the 6 000 active alfaj are in need of repair at a total cost of 80 million Omani Rials (about $200 million) (7). However, less attention is given to the on-farm systems of distribution and efficient water use. Surface irrigation systems generally yield efficiencies in the order of 30%, and the spread of some aflaj over a wide gravel or earth bed could result in losses due to seepage and evaporation where there is no confirming channel. Water losses could also be attributed to leakage and breakage as well, and poor grading of channels. Water wastage also occurs due to the disorderly patterns of distribution. Tenants of one section do not necessarily get their share at the same time and the primary channels are allowed to dry up before irrigating adjacent fields every time. Land and water right augmentations increase channel losses. Finally, the nature of the cycle (*Dawran*) or frequency of irrigation which could go up to 10 days, does not allow cultivation of high value crops and could lead to water stress during the hot, dry days of the summer.

Modernization of irrigation systems should be coupled with increasing efficiency of the present aflaj irrigation system. Channel lining, provision of improved dams and cisterns (*Ligil*), more rational water distribution and modification of water rotation to suit crop requirements, and efficient on-farm irrigation are but some of the solutions to be approached. Methods to improve the performance of surface irrigation can be grouped into those that increase uniformity of intake opportunity time and those that decrease spacial variability effects. Surface irrigation models could be useful in simulating changes in performance as a function of flow rate and irrigation time and avoids costly exercise of testing multiple combinations of flow and time. Thus, surface irrigation systems can be optimized for maximum profit, considering flow rate and irrigation time as design variables. This should be one of the main objectives targeted, and an increase in production of high value crops would mean more revenues for the Omani farmers which give an incentive for better falaj maintenance.

Modernization of Irrigation Systems

Adoption of modern irrigation techniques for water application has been sought in the Sultanate as part of a comprehensive water conservation program. Water conductance through closed conduits, and airborne application through sprinklers or point delivery by emitters and bubblers greatly improve conveyance, application, storage and distribution efficiencies with the ultimate result of maximizing yields and consumptive use efficiency. The Ministry of Agriculture and Fisheries (MAF) in collaboration with Oman Bank of Agriculture and Fisheries (OBA) have set a number of technical criteria and specifications based upon the latest available technology for modern irrigation systems that suit small farms in Oman. Standardized equipment and materials with optimum designs are to be implemented. The three main systems considered are the sprinkler, drip and bubblers. Permanent solid set or hand moved semi-portable sprinklers are used for fodders and field crops, the choice being left to the farmers depending on their budget and labor availability and skill. Drip systems are confined to vegetables, whereas bubblers are used for all types of trees. Center pivot and linear systems are mainly used in limited and private farms. **Table 4** gives an account of the systems used with area, location and type of crops grown. The land topography, fragmentation and ownership, together with the cost, does not encourage the use of center pivot systems on large scale. A 400-m center pivot system would cost up to 40 000 Omani Rials ($100 000) with cost of pump, pipes and fitting extra. A solid set sprinkler system costs about 12 R.O. per 6-m, 50.8 mm aluminum pipe, 1.5 R.O. for the riser and 3.0 R.O. for the sprinkler head. A drip system would cost about 0.05 R.O. per meter of PVC pipe and 0.125 per emitter. There are about 25 dealers in the country representing leading companies in irrigation technology.

In their effort to modernize the systems of irrigation, the Ministry of Agriculture and Fisheries in collaboration with the Oman Bank of Agriculture and Fisheries have managed to implement irrigation systems in about 450 small farms covering 218 ha in various regions during the period 1987-89, in addition to some large scale governmental farms (6). A recent count showed a total of 2 650 ha of land having modern irrigation systems installed as indicated by **Table 5**. The MAF in collaboration with FAO Soil Survey team is introducing the systems in the Batinah on 2.92 ha units and 637 farms received standardized sys-

Table 4. Sewage Treatment Plants, Muscat Municipality

Name of S.T.P.	Design Capacity m^3/day	Present Flow m^3/day	Design Standard BOD:S.S: NH_3(N)	Reuse for Irrigation m^3/day
Darsait	10800	11500	10:10:1	8000 to 11500
Al-Ansab	12000	5400	10:10:1	2000 to 5000
Shati Al-Qurm	1350	800	10:10:1	800
Mabella	1920	700	10:10:1	—
Al-Khod	1200	700	20:30:-	—
Bowshar	400	400	10:10:1	—
Al-Amerat	600	600	20:30:-	—
Jibroo	70	100	10:10:1	50
Al-Aynt	60	100	10:10:1	—
Total	28400	20300	—	17350

Source: Muscat Municipality (1992).

Table 5. Center Pivot and Linear Irrigation Systems (LS) in Oman

Region	Number	Type	Area/System (ha)	Total Area (ha)	Crops
Batinah					
Sohar Sunfarms	7	IRRI France	50	350	Rhode grass,
	2	IRRI France	40	80	potato, carrot,
Diwan	1(LS)	IRRI France	100	100	green beans, lettuce, tomato, beet roots, onion
Barka (Tawous)	2	Reinke (USA)	20	40	Rhode grass
Southern					
Salalah					
Dhofar Cattle	3	Valley (USA)	50	150	Rhode grass
and Girzir	2	Valley (USA)	32	64	Rhode grass
	1	Valley (USA)	70	70	Rhode grass
	1	Valley (USA)	60	60	Rhode grass
	1	Valley (USA)	57	57	Rhode grass
Animal Wealth	2	Valley (USA)	45	90	Rhode grass
(MAF)	1	Valley (USA)	25	25	Rhode grass
Najd					
Doka	1	Valley (USA)	50.2	50.2	Rhode grass
	1	Valley (USA)	18.6	18.6	Rhode grass
	1	Valley (USA)	38.4	38.4	Rhode grass
Harlat Al-Raka	1	Valley (USA)	12.5	12.5	Rhode grass
	2	Valley (USA)	28.2	56.4	Rhode grass
Marmoul (PDO)	1	Valley (USA)	60	60	Rhode grass
	2(LS)	Valley (USA)	15.5	31	Rhode grass, maize, sunflower, wheat, onion, potato
Total	29+3LS			353.1	

Source: Compiled by the author.

tems. An inventory of all farms with modern systems would be made as part of the Agricultural Census. However, all estimates show that less than 10% of the 54 000 ha cultivated in the Sultanate have adopted the modern systems as yet.

To encourage farmers, the Oman Bank of Agriculture and Fisheries used to provide credit at nominal interest rates, but some farmers indicated that costs were beyond their reach. Further incentives were made through the government bearing 75% of the overhead cost for areas less than 4.2 ha, 50% for areas greater than 4.2 but less than 21 ha and 25% for areas more than that. Use of modern irrigation systems is now mandatory for all new lands allocated by the government. An extensive extension program is underway to explain the advantages and benefits to be gained from using such systems. The MAF is working with all parties concerned in a targeted program to introduce and implement modern irrigation systems in the Sultanate.

Conclusion

Modernization of irrigation systems in the Sultanate of Oman is sought as part of an integrated program for water conservation. Government efforts in this respect should continue through subsidy and extension work. More attention should be given to improve water conveyance through the *aflaj systems* and increase the on-farm irrigation efficiencies. Cultivation of high value crops would give an incentive to farmers to maintain their *aflaj* and adopt modern systems or irrigation. A careful balance has to be made between reducing the demand for water by maximizing the water use efficiency and augmenting the supply with minimum cost. Better crop management and leaching requirements should be developed for different crops and soil types and salt balance within the root zone should be maintained to within tolerable limits. The best features of the traditional *aflaj* systems should be combined with the benefits of modern irrigation technology.

Table 6. Introduction of Modern Irrigation System in Oman, 1991/92

Project	No. of Farms	Area per Farm (Fed)	Total Areas	
			Feddan	Hectare
Sheep and goat	103	2	206	86.52
MAF/FAO (Batinah)	637	7	4459	1872.78
Other regions	329	5	1645	690.9
Total	1069	—	6310	2650.2

Source: Compiled by the author.

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Status of Rice Processing Technology in Bangladesh

by
Mohammad Abdur Rahman
Agricultural Engineer
Farm Machinery and Post-harvest Technology Div.
Bangladesh Rice Research Institute
Gazipur-1701, Bangladesh

Md. Abdul Kaddus Miah
Senior Agricultural Engineer
Farm Machinery and Post-harvest Technology Div.
Bangladesh Rice Research Institute
Gazipur-1701, Bangladesh

Akhter Ahmed
Senior Agricultural Engineer
Farm Machinery and Post-harvest Technology Div.
Bangladesh Rice Research Institute
Gazipur-1701, Bangladesh

Abstract

Rice is processed in Bangladesh by traditional device (dheki), small, large and automatic rice mills. The processing loss is very high, due mainly to traditional processing methods and use of inefficient machinery. The advantages and disadvantages of different rice processing units are discussed in this paper. Among all, rubber roll huller may be used in Bangladesh for better milling outturn and quality of rice.

Introduction

Rice is the staple food of Bangladeshi people and covers about 80% of the cropped area. The total production of milled rice is about 18 million t (mt). Rice processing includes parboiling (soaking and steaming), drying and milling in order to obtain milled rice. In a few places parboiling practice is not followed. They get milled rice by milling raw paddy. More than 80% of rice produced in the country is processed in villages and less than 20% rice is processed in commercial rice mills.

Milling is the final step in rice post-harvest processing. It includes pre-cleaning, destoning, husking, bran removal, cleaning, and grading.

The types of rice mills and the manner of operations significantly affect the recovery and quality of milled rice. During all operations performed in harvest and post-harvest processing of rice, milling loss is major. With a total loss estimate of only 6% from about 11.32 million t of brown rice produced in Bangladesh in 1983-84 (Year Book, 1985), there was a total loss of about 0.67 million t of edible rice, worth about US$170 million. This quantity of rice could have been used to feed a population of about 6 million for a year.

Maramba (1953) observed that a rubber-roll huller combined with an Engleberg huller which is used as a whitener, gave a low milling outturns but higher than that by the Engleberg alone. Obungen (1960) found that 1% of the grain was brokens in the rubber-roll huller while 14% was brokens in the Engleberg machine by using the same machine in a separate study.

Camacho, et al. (1975) found that the rubber-roll huller has a better husking performance compared to that by the disc-cone rice mill.

Efferson and Sengelman (1986) reported that rubber-roll huller made 2% to 4% higher total yield and one-half the broken grain from a given quality paddy than that made by stone-disc huller. Multi-pass milling showed to be the best method of reducing the amount of broken grains.

Toquero, et al (1977) conducted commercial milling tests in the Philippines and found that rubber-roll huller gave the highest milling recovery. Stone-disc cone and steel huller (Engleberg) followed in that order. Systems employing multi-pass milling obtained higher head rice recoveries ranging from 72% to 78% compared to single pass milling systems.

Wimberly (1972) reported that modern mills (automatic rice mill) using rubber-roll huller combined with abrasive and friction whiteners gave an average over-all increase in total rice recovery of 2.5% over a disc-huller type rice mill and 6.6% over the Engleberg mills.

The head rice yields in the modern mills averaged 6.1% (1.9-12.9%) more than the yield in sheller mills and 15.1% (6.9-24.7%) more than that by huller mills for raw paddy. The increase in total rice yields in the modern mill averaged 0.8% (0.0-1.3%) over that in sheller mills and 1.6% (0.3-2.5%) over that in huller mills for parboiled paddy (Wimberly, 1983).

Rice Milling Problems

There are many problems in this regard but the following are the main ones:

i) Improper construction;
ii) Improper adjustment and maintenance;
iii) Incomplete or wrong arrangement of milling machine resulting in inefficiency and losses;
iv) Lack of skill of manpower and technical know how;
v) Short supply of paddy in the large and modern rice mills and underutilization of full efficiency;
vi) Unavailability of machine parts;
vii) Inadequate parboiling treatment and drying problems;
viii) Lack of capital;
ix) Rainy season and problem in drying;
x) Electricity failures;
xi) High cost of electricity; and
xii) Short supply of fuel.

However, the good quality and maximum milling outturn of milled rice may be obtained if appropriate parboiling and proper drying facilities are observed. In order to get better performance of the rice mill, the operator should be properly trained. Paddy supply should be ensured to run the milling unit for uniform supply of milled rice throughout the year for cost effectiveness.

It is needless to say that improvement in the yield of milled rice is an indirect means of increasing rice production and a reduction of brokens in milled rice is vital for improving the quality of rice.

Existing Rice Processing Systems

Paddy processing is the process of removal of hull and bran from the paddy in order to produce milled rice. There are many traditional and improved rice processing techniques in Bangladesh and some of them are discussed here.

Traditional Rice Mill (Dheki)

Dheki is the conventional rice milling device used by rural women since ancient times. Usually women are engaged for this milling operation (**Fig. 1**). It is made of wood and operated manually. It's capacity is about 0.005 t of brown rice per labour hour (Jabber 1982). This practice is laborious, very time consuming and associated with low milling outturns. But the milling quality of rice is good, particularly for human health due to the unremoved Vitamin B in the rice grains for unpolished rice.

Small Rice Mill

The operation using small rice mills consist of the following: Paddy soaking in tanks, parboiling, drying the paddy in the sun on concrete or mud floor and milling. The milling operation can be seen in **Fig. 2**. It follows the hulling and polishing process into one operation causing higher percentage of brokens and mixing the hull with the bran. The capacities of these mills are more than one

Fig. 1 Traditional milling device (*dheki*).

Fig. 2 Milling operation of paddy in Engleberg huller.

Fig. 3 Soaking and steaming of paddy.

Fig. 4 Paddy drying floor.

t/h.

Large Rice Mills

Large rice mills employ a slightly improved system for rice processing. The operation consists of steaming the paddy before soaking, soaking the paddy in concrete tanks, parboiling by steaming (**Fig. 3**), drying in the sun on concrete floor (**Fig. 4**) and husking and polishing the grain in separate operations using Engleberg-type rice mills. These rice mills have neither a paddy cleaner nor rice grader. The capacities of these mills range from 1 to 1.5 t/h.

Automatic Rice Mills

These mills use modern techniques for rice processing. The paddy is pre-cleaned before soaking in water at high temperature and parboiled under pressure by steaming. Then the paddy is dried in a dryer and husked by rubber roll huller, or disc huller. The unhusked paddy is separated from the brown rice by a paddy separator and is recycled back to the huller. Brown rice is polished by a cone-type polisher, Engleberg or aerated roller polisher. Milled rice is graded according to head rice, large brokens, small brokens and the processing capacity is about 2 to 3 t/h.

Parameters Affecting the Milling Outturns

Rice processing is an important aspect in rice production, distribution and consumption. Rice processing begins at harvest and continues in the chain of activities until its consumption as milled rice.

Milling facilities suffer most seriously from low rates of operation due to short supply of paddy and also spare parts. A rice mill cannot be operated efficiently unless the quantity of paddy collected is equivalent to the milling capacity. Larger rice mills find it more difficult to collect adequate quantity of paddy easily. The single duct (local design) paddy steaming process is inadequate for uniform parboiling rice. The automatic rice mills seldom function due to short supply of paddy (Ahmmad, 1980).

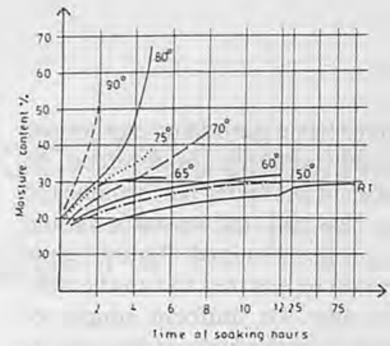

Fig. 5 Water absorption by a variety of Indian paddy in relation to temperature (°C) of steeping water. RT = room tempetature. (Source: Bhattacharya. Subba Rao and Swamy, 1966)

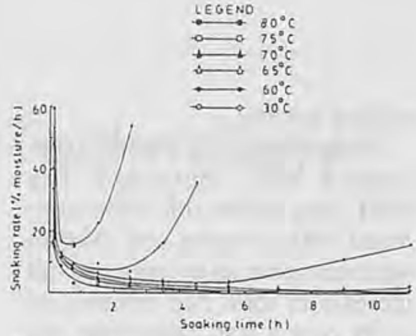

Fig. 6 Soaking rate versus time for IR8 at different temperatures. (Source: Ali & Ojha 1975)

Moreover, the milling outturns of rice in commercial mills is seriously affected by the improper process of soaking, steaming, drying, moisture content and grain length/breath ratio.

Soaking

Paddy is a hygroscopic material which can absorb water both as a vapour and liquid and thereby swells. The process of simultaneous water absorption and swelling is known as soaking or steeping. Soaking temperatures of water and soaking time affect the milling yield and quality. Burhan Uddin (1987) reported that the soaking temperature of 75°C to 80°C for a period of 3 to 3.5 h gives optimum milling outturns. According to Bhattacharya et al (1966) **Fig. 5** shows the quantity of water absorbed in time is related to the different temperatures. It is estimated that starch gelantinizes at 75°C. A moisture content in the grain of about 30% appears the very lowest reaching the core. This can be achieved without increasing the quantity of absorbed water with temperatures below 50°C and steeping times varying from 12 to 60 h. During cold soaking at ambient temperature (20-30°C) it takes 36 to 48 h to reach 30% moisture content. During this process starch fermentation occurs and may cause an off-flavour and can lead to excessive development of fungi and mold in the paddy.

Wimberly (1983) also reported that during hot water soaking (60-65°C), faster rate of water absorption is observed and the grain reaches a moisture level of 30-35% within 2 to 4 h depending on the variety and respiration without fermentation occurring. Initially, the rate of soaking is very high at all temperatures, but it gradually decreases with increased soaking and tends to zero at soaking temperatures of 30 and 60°C as shown in **Fig. 6** (Ali and Ojha, 1975a).

Steaming

During steaming, soaked paddy is exposed to steam heating for a given duration and the rice starch is gelantinized. The moisture content of the paddy increases to about 38% during steaming. Over steaming resulted in over-opening of husk components by bulging out of endosperm which initiates surface scouring during milling and the resultant ground particle being lost into the bran. On the other hand, under-steaming retards gelatinization towards the center of paddy which is identified by a white area at the center when viewed after dehusking by hand peeling. Under gelantinized grains have less strength (Itoh, 1983) and may easily break when milling. By steaming the paddy with non-pressurized steam (at 100°C), only small variations are found in the colour and quantity of soluble starch and in the amount of swelling of the milled parboiled rice (Gariboldi 1972). But in the case of pressurized condition, usually 1 to 5 kg/cm^2 pressure is used for steaming of paddy (Araullo, E.V. et al, 1976).

The increase in volume and increase in soluble starch of milled parboiled rice at different steaming temperatures may be seen in **Figs. 7** and **8**, respectively (Roberts, Kester and Keneaster, 1954). As **Fig. 7** shows, when the steaming temperatures increase from 65°C to 93°C, the volume expansion of paddy remains unchanged. But again increases in volume when temperature increases from 93°C to 128°C. However, the soluble starch content also increases with the increased temperatures (**Fig. 8**).

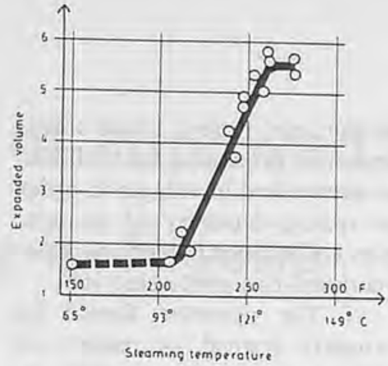

Fig. 7 Increase in volume of milled parboiled rice steamed at different temperatures and after exposure to a stream of air heated to 121°C. (Source: Roberts, Potter, Kester and Keneaster, 1954)

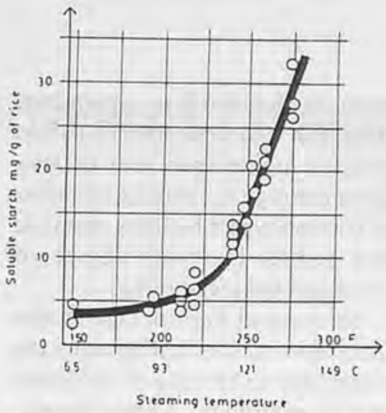

Fig. 8 Soluble starch content of milled parboiled rice after steaming at different temperatures. (Source: Roberts, Potter, Kester and Keneaster 1954)

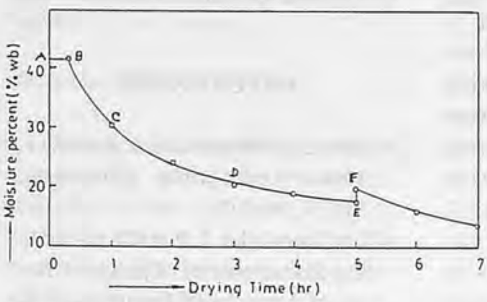

Fig. 9 Variation of moisture content of Pajam (soaking temperature 80°C) with drying time (sun-drying). AB = Heating period; BC = Constant rate period; CD = First falling rate period; DE = Second falling rate period; and EF = tempering for 2 hrs. (Source: Burhan Uddin, et al. 1987)

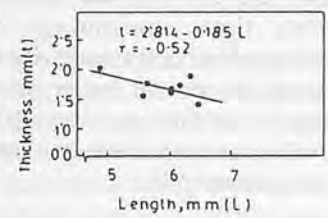

Fig.10 Relation between length and thickness of brown rice. (Source: Sarker N.N 1989)

Drying

Drying of paddy is a process of removal of undesirable moisture from the grain; it is often called moisture extraction. In the drying process heat is used to evaporate the moisture from the grain and moving air to carry the evaporated moisture. Rapid drying in the sun or with hot air causes higher breakage during milling and reduces milling outturns. Bhattacharya et al. (1967) observed that when parboiled paddy was dried rapidly without tempering, a steep moisture gradient stress developed between the surface and center of the kernel. At a certain stage the kernel relieved the stress by cracking. These cracks are irreversible and set up lines of weakness along which fracture easily occur when processed in a rice mill. **Fig. 9** shows the general nature of moisture removal from the paddy (Pajam) during drying (Burhan Uddin, 1987). The total drying time was 6-7 h at temperature of 31°C to 37°C. Two h tempering after 5 h of drying as shown in the figure, resulted in a homogeneous distribution of moisture throughout the grain.

Moisture Content

The moisture content (MC) has a profound effect on milling quality. Too high or too low moisture content of grain seriously affects the milling outturns. A quick rate of moisture removal also reduces the milling output. However, for a better milling output, usually the 14% MC (wb) is needed but it varies from variety to variety of paddy.

Grain Length

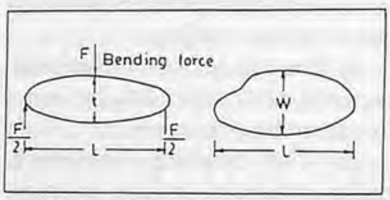

Fig. 11 Physical dimensions and forces acting on a rice grain during milling operations. (Source: Sarker N.N 1989)

Long grain varieties are more susceptible to breakage than the short grain varieties during milling. Sarker and Farouk (1989) described that the thickness of grains do not always increase proportionately with the length of grain (**Fig. 10**).

However, the millers usually receive both long and short grain paddy from different farmers. Therefore, the longer grain is subjected to higher degree of bending stress due to less length-breath ratio during milling operations (**Fig. 11**). The flow ability of short grain is higher than that of long grain through the milling chamber of friction type whitening machine and results in lower degree of breakage during milling.

Sarker and Farouk (1989) also reported that the milling outturns varies due to the use of different milling equipment. Using conventional method "dheki" gives higher milling outturns (69-74%, Av. 71.77%) than the Engleberg rice mill (65-70%, Av. 67.97%). But the conventional method is very time consuming. Now modern mill (automatic rice mill) using rubber-roll huller produce higher milling recovery (about 70%) and also better quality rice than other mills.

Suggestions and Recommendations

i) The existing steaming process should be modified for uniform steaming of paddy in order to help minimize processing losses during milling.

ii) The degree of milling should be restricted within 7-8% for maximum milling recovery.

iii) The existing Engleberg huller machines in the country should be replaced by the Japanese type rubber-roll huller in order to increase milling recovery and improve the quality of milled rice.

iv) As the total rice production in the country is adequate, proper rice processing units and their spare parts should be made available in the market for smooth operation of the rice milling industry.

v) About 40% the *Thanas* of Bangladesh is being energized by Rural Electrification Board (REB) at this moment. The Rural Electrification Board has target for 100% electrification of rural areas in the near future, hence small-scale rice processing units should be introduced in villages in order to reduce drudgery of women, who are engaged in laborious conventional rice processing job.

vi) The operator should be properly trained in respect of machines and milling quality.

vii) In order to run the rice processing industry throughout the year, the Government should give more emphasis on proper planning, execution and proper marketing systems of milled rice.

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Development of Improved On-farm Grain Drying Facility in Nigeria

by
B.R. Birewar
Former Storage Specialist, CFTC
Crop Storage Unit
Federal Department of Agriculture
Moor Plantation, Ibadan
Nigeria

Abstract

The traditional method of drying grain under sun heat is not possible under adverse weather condition, particularly in high rainfall areas. Similarly, the smoke drying method for drying of maize cobs was found quite uneconomical, ineffective and inefficient. Therefore, a simple design of natural draught fuel operated on-farm crop dryer of 0.15 m^3 or 110 kg. capacity for maize using agricultural waste material was developed at the Crop Storage Unit of the Federal Department of Agriculture, Ibadan, Nigeria and tested for drying of maize. As per performance test results, it was found satisfactory. The average rate of extraction of moisture was 0.9%/h. It is now being popularized in the country for drying of different foodgrains.

Acknowledgements: I express my sincere gratitude to Engr. A.E. Talabi, Deputy Director and Head of Storage Division, Federal Department of Agriculture, Abuja for his continuous encouragement and valuable help rendered from time to time in carrying out this CFTC assignment. My thanks are also due to Mr. D.O. Olumeko, Head of Unit, Mr. P.U. Ajayi and Mr. Affowowe, Agricultural Engineers, Crop Storage Unit, Ibadan for their technical assistance and cooperation in carrying out this project.

Introduction

Drying is the method of conditioning the grains by removing moisture to an optimum level in order to preserve its quality and nutritive value for food, feed and viability for seeds.

The grains are required to be stored at an optimum moisture content to prevent biological deterioration. The maize is usually harvested at high moisture level (i.e., 17-18%) and if stored as such, it deteriorates in quality very rapidly. Similarly, drying of maize, groundnut and wheat is equally important since these crops are attacked by storage fungi at high moisture content, some of which produce toxins and are harmful to human beings, animals and birds. Improper drying of groundnut leads to mould damage and aflatoxin contamination.

The traditional method of drying grain under sun heat is not possible under adverse weather conditions. In high rainfall areas like coastal region and southern states (River, Cross-River, Anambra, Bendel states, etc.) of the country the relative humidity in the air during the major part of the year is quite high. Therefore, sun drying of grains is not effective. Similarly, the smoke drying method is quite common in the entire southern region of the country where maize cobs in dehusked form are dried with the hot fumes or smoke generated from a fire. This method has the following disadvantages: drying is uneven and slow; some grains may get overdried and burnt; sometimes the cobs may fall into the fire and burn completely; grain drying efficiency is low; and fuel consumption is high.

In view of the above, the natural draught fuel operated on-farm crop dryer using agricultural waste material was designed, constructed and tested at the Crop Storage Unit of the Federal Department of Agriculture, Ibadan, Nigeria under the technical assistance of the Commonwealth Fund for Technical Co-operation (CFTC) during the period 1987-90.

Materials and Method of Construction

A dryer of 0.15 m^3 or 110 kg batch holding capacity for maize using cheap fuels like firewood, husks and agricultural waste material was designed and constructed as shown in **Figs. 2a** and **2b** and a photograph. The principle of operation is based on transfer of heated air when fuels like firewood, husks, dry plant stock,

Fig. 1 Natural draught fuel operated crop dryer.

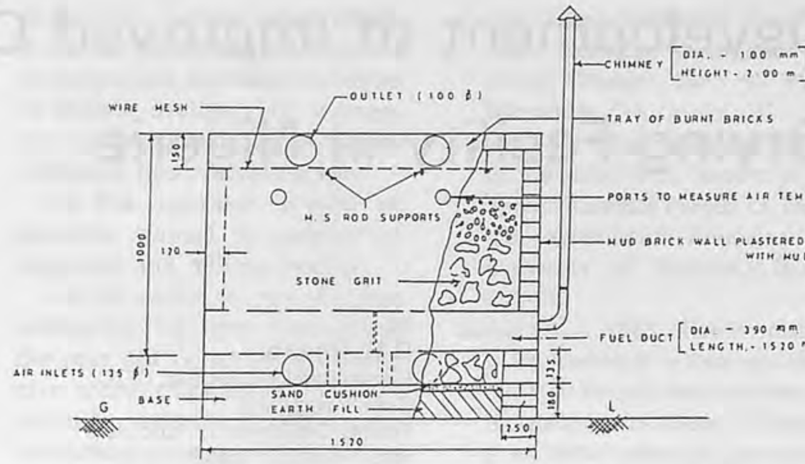

Fig. 2a Schematic sketch of drying facility.

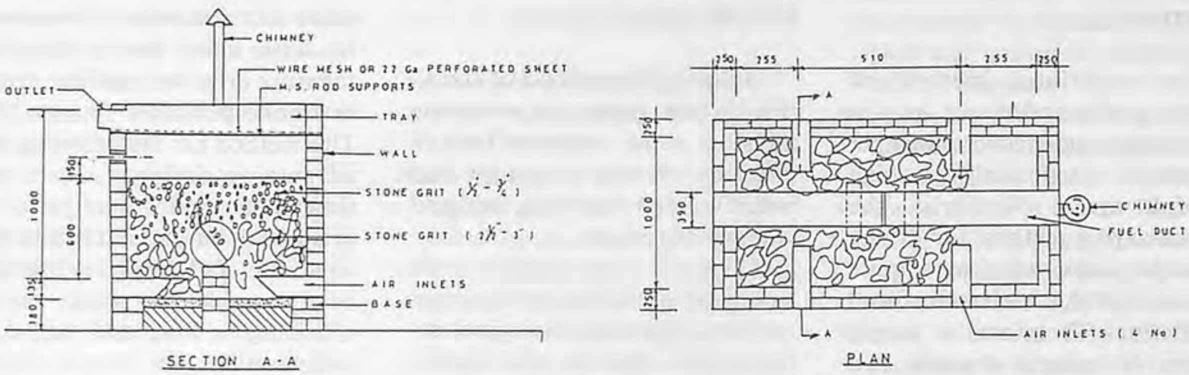

Fig. 2b Sketch of natural draught fuel operated crop dryer (capacity — 0.15 m^3 or 110 kg maize).

peanut shell, maize cobs, etc. available on the farm is burned in the fuel duct. The surrounding air is heated and moves up through the wet grain. Due to the movement of hot air in upward direction, a vacuum is created in the plenum chamber and fresh air enters through air inlets which are provided at the bottom. In this way there is a continuous movement of hot air through the wet grain as drying takes place.

The principal parts of the dryer are base, fuel duct, chimney, plenum chamber, tray, air inlets, and outlets. The base is constructed of burned bricks laid in cement mortar to a height of 180 mm above ground level. Four steel pipes of 135 mm diameter, two on each side, are placed at the floor level as air inlets as shown in the Figure. Two empty carbide drums of 390 mm diameter and 760 mm long are welded together and placed on 250 mm thick brick masonry wall 315 mm above the ground level as a fuel duct. A chimney of 100 mm diameter and 2 000 mm long is connected to one end of the fuel duct. Further, wall construction work for the plenum chamber is of unburnt bricks laid in mud mortar. The space surrounding the fuel duct in the plenum chamber is filled with crushed stones, using bigger stone pieces (2 1/2″ - 3″) at the bottom and small pieces (1/2″ - 3/4″) at the top as an absorbent to store heat. A wire mesh or 22 Ga M.S. perforated sheet supported on M.S. bars is provided at the top to

Table 1. Material and Labour Required for Construction

Material	Quantity
Bricks, 250 × 120 × 60 mm size	200
Mud bricks, 250 × 120 × 60 mm size	300
Cement	2 bags
Empty carbide drums, 390 mm dia. and 760 mm long	2
Wire mesh or 22 Ga M.S. perforated sheet of 8′ × 4′ size (1.5 - 2mm dia. holes)	2/3 sheet
M.S. bar, 12 mm dia. (5 pieces of 1.5 m long each)	7.5 m
Crushed stone, 2 1/2″ - 3″ size	0.14 m^3 (5 cft.)
Crushed stone, 1/2″ - 3/4″ size	0.07 m^3 (2.5 cft.)
Steel air inlets, 135 mm dia.	4
G.I. sheet outlets	2
G.I. or M.S. sheet chimney, 100 mm dia. and 2.0 m long	one
G.I. or M.S. pipe ports, 25 mm dia.	2
Labour	
Mason	4 mandays
Helper	4 mandays

hold the wet grain. Further, construction work using burned bricks in cement mortar is carried to the height of 150 mm to form a tray for holding wet grains. The structure is plastered with mud mortar inside as well as outside. Two ports for fixing thermometers to measure the temperature of drying air in the front wall section and two steel outlets in the tray for unloading the grains are also provided.

The list of available materials required for construction of the dryer is shown in **Table 1**.

The approximate cost of construction of the dryer was ₦1 200.00. Although this dryer was developed for 110 kg capacity for maize the designs of higher capacities ranging from 165 to 330 kg can be developed.

Performance Tests and Results

The dryer was filled with maize to full capacity. The performance tests assessed its grain drying efficiency. The test was conducted with two batches of maize with 18.0% initial moisture content. Firewood was used as fuel. The temperature of drying air ranged between 30 and 85°C. The moisture content of grain was reduced to 11.0% in 7.50-8.00 h of operation. The average reduction of moisture content was 7.0% in 7.75 h. The average rate of drying was 0.9%/h.

Initially, after burning the fuel it takes nearly one hour for the stone to absorb heat which is conducted for 10 to 12 depending upon the maximum temperature built up. The temperature of drying air was moderate. However, agitation of grain was necessary from time to time to avoid overdrying. The temperature of drying air can be controlled by adjusting the supply of fuel.

Performance test results obtained was satisfactory. Therefore, it was recommended for its popularization in the country.

The main advantages of this dryer are: (1) It is simple and easy to construct from locally available materials; (2) It is easy to operate; (3) It requires cheap fuel or any agricultural waste material available on the farm, hence economical; (4) It does not require any electric blower for its operation, hence can be operated in areas where there is no electricity available; (5) It is cheap as compared with mechanical dryers and, hence within reach of farmers; and (6) It can also be used for drying other commodities of foodgrains, chillies, ginger and termeric.

Implementation of Programme

With a view to popularizing this improved on-farm crop dryer in the country the five zonal offices or demonstration centres of Crop Storage Unit (CSU) of the Federal Department of Agriculture were established at Ilorin (Kwara state); Dan-Hassan (Kano state); Gwagwalada (Abuja); Ijebu-Ode (Ogun state); and Ugwuoba (Anambra state) representing five different agro-climatic zones in the country. The dryer was constructed at each of the demonstration centres for trial, demonstration and training purposes.

Conclusion

The traditional method of grain drying in Nigeria is neither effective nor economical. The natural draught fuel operated on-farm crop dryer designed and developed at the Crop Storage Unit, Ibadan was suitable and proved efficient for drying maize. It may also equally prove suitable for drying other commodities of foodgrains, chillies, ginger and termeric. The dryer is comparatively cheap and the cost of operation is low; hence, may prove quite promising at the farm level in the country.

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Estimation of Grain Post-production Operating Methods

by
He Yong
Assoc. Professor
Agric. Engineering Dept.
Zhejiang Agric. University
Hangzhou, Zhejiang 310029
P.R. China

He Yong-sheng
Professor and Vice President
Zhejiang Agric. University
Hangzhou, Zhejiang 310029
P.R. China

Abstract

Based on the analysis of present situation and characteristics of grain post-production system in Zhejiang province, a multi-objective comprehensive evaluation model was used to evaluate seven treatment operations of grain post-production system using four indexes, i.e., cost, efficiency, grain quantity loss and grain quality indexes based on a survey at Jinhua, Jiaxing and Ningbo in Zhejiang province in 1987-1989. The appraisal results will help farmers and provincial governors to make the best choice and improvement of technology and equipment for grain post-production treatment operations.

Introduction

Grain post-production system is a series of processes beginning from harvesting to consuming rice which includes such operations as harvesting, threshing, cleaning, drying, storing, transporting, processing. The process is influenced by social, economic, natural and technical factors. According to the census of FAO, the average rate of grain post-production losses is about 10%, the rate in developing countries are as high as 20-40%. Some 40-100 billion kg of grain is lost yearly based on the rate of grain post-production losses of 10% to 25%.

People always pay great attention to pre-production and production system and the post-production process is taken for granted by farmers as well as by provincial governors. Grain post-production in China has a dual character, that is, the treatment of grain post-production is undertaken both by farmers and the government. About 80% of the total yield is stored, processed and consumed by farmers themselves, only 20% is purchased, stored, transported, processed and sold by the government. Therefore, farmers undertake most of the work and processes, especially after carrying out the policy of family responsibility system. The collective grain production is converted into family managing unit which makes the farmer's task heavier. There is a severe loss and waste in grain post-production system in the country because of the shortage of techniques and equipment used in post-production treatments, lack of machines and tools. Therefore, in order to assess grain loss, quality condition, operation cost and efficiency of each post-production operation should be understood in order to reduce loss and cost, raise efficiency and improve rice grain quality.

Materials and Methods

Choice of Trial Spots

Considering the situation of agricultural production in Zhejiang province and the difference in geography, weather conditions and economic levels in each region, Jinhua, Jiaxing and Ningbo were selected as three trial spots. Work style and machines and tools of grain post-production system in these spots are widely representative. The trial was done through a survey of 27 farmer households in 9 villages in the study areas.

Contents and Methods of Trial and Investigation

The measurement of grain losses during the grain treatment process was done based on the paper (Toquero et al., 1983) as well as the actual condition in the villages. Each rate of loss was corrected for standard moisture content of calculated output of grain.

*This paper is part of the project "Grain Post-harvest System Analysis in China", which is funded by the IDRC, Ottawa, Canada.

Measurement of grain quantity losses in storage — Grain quantity loss during storage means the losses due to rats, insect, pathology and physiologic disintegration. It is connected with storing ways and storing time. We determined the grain quantity loss in the study areas storing rice in Zhejiang province.

Determination of grain quality indexes — Excluding quantity losses, there is still the problem of grain quality loss. During post-production treatment process, especially storing process, quality deterioration of grain has been influencing the health of human beings and animals, and the production of agriculture because of biological factors such as the germination percentage and rate of infected grain. We mainly determined quality indexes in different drying time (timely drying, drying after 5 day's setting aside) and the influence on the quality indexes with different storing methods (wooden cabinet, stack by bamboo mat, stack on the ground).

Evaluation Method of Treatment Techniques and Equipment in Post-production Operations

In order to improve grain post-produciton system, treatment ways in each operation of the total system should be analyzed one by one. Techniques and equipment applied in each operation should be comprehensively evaluated using four indexes, i.e., losses, cost, efficiency and grain quality. Therefore, it is a multi-objective comprehensive appraisal problem to evaluate techniques and equipment in each operation, a comprehensive appraisal model (Chen Yongyi et al., 1983; He Yong et al., 1992) can be used in the analysis. If the comprehensive evaluation system is of two degrees, dividing the evaluation indexes into n indexes, the sub-index number of the *ith* index is k, so the comprehensive evaluation model is:

$$B^* = A \cdot R = A \begin{bmatrix} A_1 \cdot R_1 \\ A_2 \cdot R_2 \\ \cdots \\ A_n \quad R_n \end{bmatrix} = A \begin{bmatrix} B_1 \\ B_2 \\ \cdots \\ B_n \end{bmatrix} = (b_1^* \cdot b_2^*, \ldots, b_p^*) \qquad (1)$$

Where: $A = (a_1, a_2, \ldots, a_n)$, refers to a row matrix of weight distribution among n indexes; a_i is the weight of the *ith* index, $\sum_i a_i = 1$ should be met: $R = (A_1 \cdot R_1, A_2 \cdot R_2, \ldots A_n \cdot R_n)^T = (r_{ij})_{nxp}$ is the general evaluation matrix; $A_i = (a_{i1}, a_{i2}, \ldots, a_{iki})$ is a row matrix of weight distribution of the *ith* index; a_{ik} is weight of the *kth* sub-index of the *ith* index; R_i is hte evaluation matrix of the *ith* index; $B_i = A_i \cdot R_i$ is the comprehensive evaluation result of the *ith* index; P is the number of treatment techniques or ways to be evaluated; $i = 1, 2, \ldots, n$; $k = 1, 2, \ldots, k$; $b_j = \sum_i a_i \cdot r_{ij}$.

Determination of the appraise matrix R or R_i: r can be calculated with one of the two following formulae if the concrete value x_{ij} in each treatment technique or method is known.

The largest value of the index x_{ij} is supposed to be optimum, so,

$$r_{ij} = \frac{x_{ij}}{\sum_{j=1}^{p} x_{ij}} \qquad (2)$$

The smallest value of the index x_{ij} is supposed to be optimum, so,

$$r_{ij} = \frac{1 - \frac{x_{ij}}{\sum_{j=1}^{p} x_{ij}}}{p - 1} \qquad (3)$$

$(i = 1, 2, \ldots, n; j = 1, 2, \ldots, p)$

The evaluation matrixes in this paper are all calculated using the above formulae.

Results and Analysis

In this paper, the grain losses were accumulatively calculated by giving weight to practical measured datum (the rate of weight of spring grain, early rice and late rice is defined as 0.1 : 0.4 : 0.5 based on unit output and actually planting areas) in each operation. Treatment efficiency was calculated based on the average time used in unit area crops, including spring grain (early and late maturing rice varieties). Operation cost refers to average cost invested in one season's crops post-production treatment, including labor cost, oil and electricity cost, machine depreciation charge, and repair charges. It is the function of annual work hours of the machinery (X) and daily labor value (L). The data on grain loss, treatment efficiency, operation cost measured in every operation are shown in **Table 1**.

Using the Analytic Hierarchy Process (AHP) (Gass, S.I., 1986), in reducing loss in post-production system is thought the most important. Reducing cost comes second while treatment efficiency and grain quality are still neglected by farmers. Therefore, when evaluating each operation, the decision of each index weight is based on this principle: the matrix of weight distribution of grain loss, treatment efficiency and operation cost is: A = [0.4, 0.2, 0.4]. Using formula (1)-(3) to calculate appraisal matrix R, we can obtain the comprehensive evaluation results having relation with different work hours of a machinery in a year (X) and different daily labor value (L).

Harvesting Operation

More than 95% of the paddy in

Table 1. Grain Loss, Treatment Efficiency and Operation Costs

Item	Rate of Grain Loss (%)	Treatment Efficiency* (h/ha)	Operation Cost (yuan/ha)
Harvesting			
Sickle	0.43	146.40	16.2L + 6.45
Combine	1.82	9.45	12564/X + 58.5
Threshing			
Pedal thresher	0.80	143.25	12L + 15.75
Motor thresher	1.52	100.50	8.4L + 39.15
Combine	1.56	9.45	12564/X + 58.5
Cleaning			
Wooden winnower	1.19	283.5	6L + 1.5
Electric blower	3.10	337.5	5.4L + 6.45
Mechanical vibrating (screen combined with an electric blower)	1.34	465.0	1.95L + 19.2
Dring			
Sunlight	1.56	0.18	8.4L + 13.8
Storing			
Wooden cabinet	2.89	/	12.45
Stack by bamboo mat	4.67	/	10.50
Stack on the ground	8.14	/	7.95
Transporting			
Boat, vehicle, basket, etc.	0.97	/	/
Processing			
Rice mill	2.74	/	/

* Treatment efficiency in cleaning operation is calculated using unit kg/h. The rest of the indexes use unit ha/h.

Table 2. Comprehensive Evaluation Results of Harvesting and Threshing Operation*

Daily labor cost (yuan)	Cost of Using Combines (ha/year)				
	3.33	6.67	10.0	13.33	16.67
Harvesting					
3	[0.68,0.32]	[0.64,0.36]	[0.62,0.38]	[0.61,0.39]	[0.60,0.40]
5	[0.65,0.35]	[0.61,0.39]	[0.58,0.42]	[0.57,0.43]	[0.56,0.44]
7.5	[0.62,0.38]	[0.58,0.42]	[0.55,0.45]	[0.54,0.46]	[0.53,0.47]
10	[0.60,0.40]	[0.55,0.45]	[0.52,0.48]	[0.50,0.50]	[0.49,0.51]
15	[0.56,0.44]	[0.51,0.49]	[0.48,0.52]	[0.47,0.53]	[0.46,0.54]
20	[0.53,0.47]	[0.48,0.52]	[0.46,0.54]	[0.44,0.56]	[0.44,0.56]
Threshing					
3	[0.38,0.35,0.27]	[0.37,0.34,0.29]	[0.36,0.33,0.31]	[0.36,0.33,0.31]	[0.36,0.33,0.32]
5	[0.37,0.35,0.28]	[0.36,0.33,0.31]	[0.35,0.33,0.32]	[0.35,0.32,0.33]	[0.35,0.32,0.33]
7	[0.36,0.34,0.30]	[0.35,0.33,0.32]	[0.34,0.32,0.34]	[0.34,0.32,0.34]	[0.34,0.32,0.35]
10	[0.36,0.34,0.31]	[0.34,0.33,0.33]	[0.34,0.32,0.35]	[0.33,0.32,0.35]	[0.33,0.32,0.36]
15	[0.34,0.33,0.32]	[0.33,0.32,0.35]	[0.32,0.32,0.36]	[0.32,0.31,0.37]	[0.32,0.31,0.37]
20	[0.34,0.33,0.34]	[0.32,0.32,0.36]	[0.32,0.31,0.37]	[0.32,0.31,0.37]	[0.31,0.31,0.38]

* In harvesting operation, the two numbers in brackets are the comprehensive evaluation values of sickle and combine, respectively. In threshing operation, the three numbers in brackets are the comprehensive evaluation values of pedal thresher, motor thresher and combine, respectively. The large numerical value is optimum.

Zhejiang province is harvested using the manual sickle. Only a few regions have better technological and economical condition and developed rural enterprises that use combines (mostly the use Huzhou 100-B type combine). Because of the great loss of harvest shattering loss (including the loss of flying off from the whole combine) and standing loss, the total losses of using the combines is greater than that using the sickle.

Operation cost is connected with daily labor cost L (yuan/day) and annual work hours of combine X (ha/year). The higher daily labor cost is high per hectare using the manual sickle. The more annual work hours of the machine is, the lower per ha operation cost. The comprehensive evaluation results of the two harvesting ways are shown in **Table 2**. From the results, low daily labor cost of usign sickle is evident. However high daily labor cost and greater annual work result in better comprehensive benefits of using the combine.

We analyzed the sensitivity of evaluation results. When the grain is in short supply, the stress is to reduce grain losses, the weights of loss, efficiency and cost are 0.6, 0.2, 0.2, respectively. When the grain supply is surplus, the stress should be to reduce cost. The weights of the three indexes are 0.2, 0.2, 0.6, respectively. When most of the farmers experience lack of farm hands, the stress should be to improve efficiency. The weights are 0.2, 0.6, 0.2, respectively. If L = 10 yuan/day, X = 10 ha/year, the comprehensive appraise values could be obtained using the above weights. The values are [0.59, 0.41], [0.45, 0.55], [0.29, 0.71], respectively. Using sickle is beneficial in some cases while in other cases, the use of combine is profitable.

Threshing Operation

Of the three main threshing methods in Zhejiang province, the loss in using pedal thresher is the least and using combine is highest work efficiency. The comprehensive evaluation results of the three methods are shown in **Table 2**. The sensitivity analysis using changed weight indicates that if the stress is laid on grain loss, the comprehensive benefits of using pedal thresher is better while in other case, using combine is still the best.

Cleaning Operation

The loss, efficiency and cost of wooden winnower, electric blower and mechanical vibrating sieve or screen combined with an electric blower are shown in **Table 1**. The total loss in using electric blower is greatest and that of using wooden winnower is the least. Work efficiency of mechanical vibrating screen combined with an electric blower is highest. Electric blower comes second. The comprehensive evaluation values of the three cleaning methods are shown in **Table 3**. From the results, the comprehen-

Table 3. Comprehensive Appraisal Results of Cleaning Operation

Daily Labor Value (yuan/day)	Wooden Win-nower	Electric Blower	Mechanical Vibrating Screen Combined with an Electric Blower
3	0.352	0.285	0.364
5	0.343	0.281	0.376
7.5	0.337	0.279	0.385
10	0.333	0.277	0.390
15	0.329	0.275	0.395
20	0.327	0.274	0.398

Table 4. Influence on Grain Quality, by Storage Method*

Storage Method	Germination Percentage (%)			Acid Value (KOH mg/100 mg dried weight)			Yellow Kernel Rate (%)		
	Early Variety	Late Variety	Average	Early Variety	Late Variety	Average	Early Variety	Late Variety	Average
Wooden cabinet	−1.43	−9.90	−5.67	9.27	26.7	17.99	1.43	4.10	2.72
Stack by bamboo mat	−3.43	−39.9	−21.67	14.27	39.0	26.64	3.98	6.30	5.14
Stack on ground	−12.00	−46.90	−29.45	27.95	38.5	33.23	8.96	6.80	7.88

* The numeral values refer to the variation between pre-storage and post-storage. The storage time for the early maturing variety is from August to December. The late maturing variety is from December in 1987 to July.

sive benefits of mechanical vibrating screen combined with an electric blower is the highest under various daily labor values. The sensitivity analysis using changed weight also shows the same results.

Drying Operation

Most of the farmers dry paddy in sunlight at present. Grain loss, work efficiency and cost of drying operation are shown in **Table 1**. In order to determine the influence on the grain quality under delayed drying condition, comparing trial in nine farmer households of three trial spots indicates that if drying is delayed, the average weight of 1 000 grains of early and late maturing rice varieties is decreased by 0.32 g. Germination percentage is reduced by 5.86%. The rate of broken kernels increased by 5.96%. The rate of immature or diseased rice grains increased by 1.33%. Delayed drying mainly is influenced by the weather condition.

Storing Operation

The farmer's paddy is usually stored in three ways: in wooden cabinet, stack by bamboo mat and stack on the ground. In order to evaluate the storing methods, grain loss, cost and grain quality are mainly considered. The measured results of the three indexes are shown in **Table 1** and **Table 4**. Of the storage losses, that resulting from rat infestation is the greatest; mildew and insect damage comes second. Of the three storage methods, loss with the wooden cabinet is the least, while the loss of grain stacked on the ground is the greatest. Evaluating the three quality indexes using equal weights also indicates that the wooden cabinet is the best, the way of stack on the ground is the worst. Evaluating the three storage methods with the three indexes, i.e., loss, cost and grain quality, the weights are 0.4, 0.4, 0.2, respectively. Obtaining the comprehensive evaluation results b = [0.366, 0.337, 0.297]. Therefore, the comprehensive benefit of using the wooden cabinet is the best. The sensitivity analysis using different weights also indicates that the best storage methods is using wooden cabinet.

Transporting and Processing Operations

The ratio of equipment used to transport grain is boat 51.5%, handcart 27.5%, basket 13.14%, tractor 7.2%, others 0.4%. The main processing of rice in the countryside is milling. The rice mills used in Zhejiang province is Zhejiang No. 2 rice mill which was made in the 1960s. The milling loss is defined as the difference between the rate of milled rice using rice mill in the village and the rate of milled rice using rice mill in the laboratory. The milling loss is 2.74%, on the average.

Conclusion and Recommendation

Grain post-production system in Zhejiang province mainly depends on manual power. The efficiency of post-production treatment is comparatively low because of the small farms scale and the shortage of techniques and equipment. The average loss of grain from harvesting to storing and processing is as high as about 15%. Accordingly, there are about 600 billion kg grain lost during the post-production treatment. Therefore, reducing grain post-production losses can be considered as an important way to increasing rice availability.

The studies show that a great potential can be explored by improving the post-production techniques and equipment. It seems worthwhile to invest in post-production system. Since post-production loss is high and the post-production techniques and equipment are relatively simple. Replacements and improvement of post-production techniques and equipment may be acceptable to the farmers. For example, in grain storage, to design and develop the simple and suitable equipment such as wooden cabinet, concrete cabinet etc. to store grains may reduce losses and improve grain quality greatly. At the same time, it is suggested that grain be stored collectively in some regions where conditions are favorable New types of rice mills and cleaning and winnowing machines should be designed, tested and widely spread after testing them.

Grain post-production is a separate and dynamic system. System analysis actually is a problem of multi-objective comprehensive evaluation. The evaluation parameters are grain loss, treatment efficiency, operation cost and grain quality. A multi-objective appraisal model was used to evaluate the techniques and equipment in each grain post-production operation taking into account different labor force resource and social and economical conditions. At the same time, a sensitivity analysis was done for each parameter using changed weights. The evaluation results should help farmers and provincial governors to make the best choice and improvements in the grain post-production system.

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New Co-operating Editor

Ahmed Abdel Khalek El-Behery

Date of Birth: 10 August, 1945
Nationality: Egyptian
Qualifications:
- 1967 BS. General Agriculture, Zagazig University
- 1982 Diploma in Mechanization, Monsoura University
- 1983 MSc. Agricultural Mechanization, Zagazig University
- 1995 PhD. Agricultural Engineering, Purdue University / Zagazig University

Experience:
- 1992-1994 Machinery Modification and Testing Purdue University, Indiana, U.S.A.
- 1990-1992 Consultant of Livestocks on mechanical equipment of Livestocks teed production (PBDAC, APCP). (USAID) Cairo, Egypt. Provide technical assistance services in the capacity of Agricultural Engineering Specialist.
- 1987-present Supervisor of Technology Transfer Section, Agricultural Engineering Research Institute - A.R.C.
  - * Selecting and demonstrating agricultural equipment in old and new reclaimed land. (Ministry of Agriculture).
  - * Advisor on training activities.
  - * Planning, implementing and assessment of on-farm equipment.
- 1979-1981 Consultant, World Bank Project, served as a technical consultant to the Monofia/Sohag World Bank Project.
- 1978-1979 Director, Tractor Rental Station, directed the operation a tractor rental station in the Monofia governorate.
- 1976-1978 Mechanization Inspector, inspected various agricultural machinery and equipment for the Land Reform Organization of the Egyptian Ministry of Agriculture.
- 1967-1976 Agricultural Engineering Supervision, as an employee of the Land Reform Cooperative in the Behera governorate, designed annual crop rotation plans for 1 400 feddans. ■■

Field Evaluatoin of a High-clearance, Two-wheeled Tractor Designed for Local Manufacture in Mexico

by
Arturo Lara-López
Professor of Mechanical Engineering
University of Guanajuato
Lascurain de Retana No. 5, Guanajuato,
Gto. 36000, Mexico

Abstract

The design and field performance of a high-clearance, two-wheeled tractor is reported in this article. Field operations include primary and secondary tillages, planting, row crop cultivation, spraying and local transportation. The tractor was primarily designed for primary tillage and cultivation on the main crops of the country: corn, sorgum, wheat and barley. The design of the tractor is especially oriented toward manufacture by medium-sized companies, and incorporates a mechanical transmission based on belts and chains. No special steels are needed, and a reduced number of machining operations are required. The annual cost of the tractor has been calculated and found to compare favorably with the price of tractor contracting services.

Acknowledgement: The development, testing and evaluation of the tractor were sponsored by research grants from the Jastro-Shields Research Scholarship, National Council of Science and Technology of México (CONACyT), Ministry of Education of México (SEP) and Organization of American States (OEA).

The research and development of the initial prototype were generously supported by the University of California at Davis.

The evaluation of the tractor and the design of the final prototype and its implements were kindly supported by the University of Guanajuato, Mexico.

The guidance provided by Professor William J. Chancellor and advice obtained from Professors Robert A. Kepner and M. Stephen Kaminaka were of much help in solving a number of design problems in the development of the initial prototype.

Finally, contributions of students of the University of Guanajuato in the development and testing of implements were highly relevant for the project.

Introduction

México's arable land consists of 24 million ha distributed in 2.8 million farms. Seventy-five percent of the farms have an average land area of 7.9 ha. The main crops and ratio of land planted to each crop are given in **Table 1**. The total number of tractors is approximately 175 000 units. The distribution of tractor sales in relation to tractor power in the period 1988 to 1991 is presented in **Table 2**, (Club of Bologna, 1991). Tractors with power ratings lower than 19 kW virtually do not exist in the market. Power distribution is in the order of 0.16 kW/ha, which is significatively lower than that calculated for minimum cost (0.6 kW/ha) (Lara-López, 1991). The major crops require a tractor with enough clearance for row cultivation and also enough traction capability for primary tillage. For farms of 10.5 ha (average farm size for traditional and subsistence sectors) an optimum power rating for the major crops of 6.3 kW was calculated. A prototype of a tractor intended as an alternative for economic plowing of small farms in México was developed and reported (Lara-López et al, 1982). A number of tractors of this design were fabricated in México by local manufacturers. Some of those were used for field testing and experimentation with implements required for major crops. In this article some of the results obtained during field testing are reported and compared with data on other alternatives available to small farms.

Table 1. Major Mexican Crops

Crops	Percent of cultivated land
Corn	31.7
Sorgum	7.8
Beans	7.4
Wheat	5.1
Coffee	2.2

Table 2. Sale of Tractors, in by Size

Size	Sales from 1988 to 1991 (unit)
I (15-35 kW)	915
II (30-75 kW)	28 047
III (60-168 kW)	6 882

Machine Design

Most of the features of the original prototype were main-

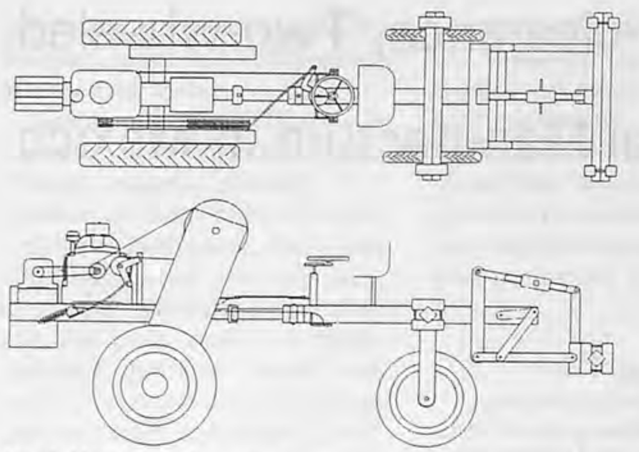

Fig. 1 Machine configuration.

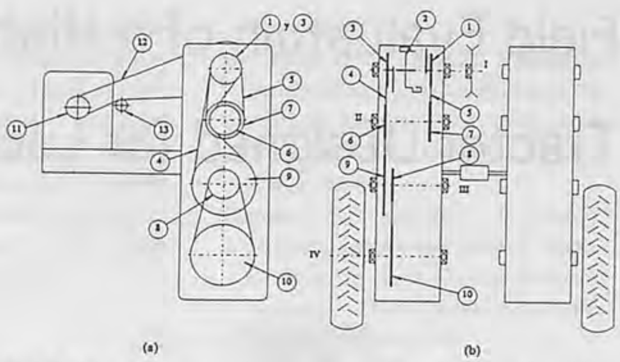

Fig. 2 Side view of power transmission (a). Front view of tractor (b).

tained in the commercial machines. **Table 3** shows some of the technical characteristics of the machine.

The machine configuration is shown in **Fig. 1**. Power transmission consists of three stages from the engine to the wheels. Each one of the two drive wheels is powered from the engine independently of the other. The first stage consists of a shielded V-belt drive with an idler tensioning device which may regulate the speed of each wheel. The tensioning device is used as a general clutch and also as a steering mechanism. In addition, for more precise steering, this is assisted by a four-bar linkage controled by the operator with a hand wheel. **Table 4** in conjunction with **Fig. 2** gives some of the details for the power transmission.

Axle I is always rotating in the same direction. Forward movement occurs when coupler (2) engages sprocket (3) then chain (4) makes sprocket (9) turn in the same direction. Sprocket (8) is keyed to shaft III and rotates together with sprocket (1). At the same time sprockets (6), (7) and (1) rotate freely in the opposite direction. Reverse movement happens when coupler (2) engages sprocket (1). Then sprocket (6) drives sprockets (3) and (9) in the opposite direction.

During the design process, special attention was paid to the structural reliability of the machine and its implements. Stress analyses of the tractor and its implements were carried out by analytical methods and by finite element analysis, simulating the structure performance under constant maximum load conditions and also under condition representing impacts on plowing tools with hypothetical rigid obstacles, (Cervantes-Sánchez and Lara López, 1984), (Valdivia-Hernández and Lara-López, 1984). The power transmission was tested in the laboratory under severe conditions (Lara-López et al, 1982).

Field Performance

Attachments for tillage, spraying and local transportation have been adapted to the tractor and tested in fields of corn, sorghum, beans, wheat and barley during seven years of normal work. Some variables have been recorded during short periods of time while the tractor operated in normal conditions, as an approximation of tractor field performance. **Table 5** shows the average values of such records.

The speed of the tractor was calculated by dividing the length of a furrow by the period of time taken by the tractor working from the beginning to the end of such a furrow. The values of average speed are the mean of field test values.

The effective width was determined by dividing the width of the land area worked during the period of the field test by two times the number of out-and-back rounds completed.

The working depth was measured by a steel scale in several locations of the tilled area. Values of working depth presented in **Table 5** are the means for the field tests.

Travel reduction (slippage) was

Table 3. Technical Machine Characteristics

Engine	9 kW (12 hp) at 3 600 rpm, gasoline, air cooling
Mass of the tractor, kg (with weights)	696
Mass of the sulky, kg	82
Maximum working speed, km/h	5
Backward speed, km/h	3.42
Maximum expected draft, N	3 800

Table 4. Main Power Transmission Components

1. Sprocket, 13 T, P40
2. Coupler.
3. Sprocket, 13 T, P40
4. Chain, P40
5. Chain, P40
6. Sprocket, 13 T, P40
7. Sprocket, 13 T, P40
8. Sprocket, 13 T, P50
9. Sprocket, 70 T, P40
10. Sprocket, 60 T, P50
11. Pulley, 150 mm diam.
12. V-belt, section B
13. Idler pulley, 150 mm diam.

Table 5. Average Values Recorded and Calculated During Normal Field Operation

Field operation	a / b	Average speed km/h	Effective width mm	Working depth mm	Travel reduction %	Field capacity ha/h	Field efficiency %	Draft kN	Tractive efficiency %	Fuel consumption L/ha
Chisel harrowing	a	3.10	1 600	100	19.00	0.476	96.00	2.52	68.00	7.18
	b	4.10	1 600	100	20.00	0.604	92.00	—	66.00	7.96
Plowing	a	3.23	306	172	14.07	0.0774	74.50	1.86	68.50	54.78 [d]
	a	3.37	250	200	22.70	0.0705	83.70	—	—	31.46
Disk harrowing	b	3.33	1 133	100	26.00	0.33	83.08	3.30	62.00	9.85
Planting	a	3.40	1 600		7.00	0.36	66.00		70.20	
Primary row cultivation	a	2.95	1 600	60	19.00	0.46	99.00	2.30	70.30	7.56
Secondary row cultivation	a	3.13	1 600	190	20.30	0.459	96.85	2.51	66.70	7.25
Spraying	b	4.37	7.14			2.25	92.00 [c]			

[a] Walking option
[b] Riding option.
[c] Time spent in filling hte tank is not considered.
[d] Engine adapted for kerocene.

Table 6. Economic Parameters of Tractor Operation for Central Region of México

Item	Parameter
A (annual fixed cost per unit of initial price)	0.22
B (energy cost U.S.$/kWh)	0.2441*, 0.276
C (operator's wage U.S.$/h)	1.61
D (average penalty for delay in job completion U.S.$/ha h)	0.057
K (initial cost per rated kW of tractor and implements)	471*, 591.5
M (total number of working hours available per year)	1 000
W (annual work per hectare kW h/ha)	64*, 90

*Values corresponding to conservation tillage.

calculated by the following equation:

$$S = \frac{L_f - L_l}{L_f} 100 \qquad (1)$$

where:

S = Travel reduction in percentage.

L_f = Distance traveled by the tractor, free of load on hard ground (concrete) in ten revolutions of the drive wheels.

L_l = Distance traveled by the tractor, under normal working conditions, in ten revolutions of the drive wheels.

Field capacity for each test was calculated by dividing the total area worked are by the period of time spent from the beginning of the first round to the end of the last one.

Field efficiency was calculated for each test as the ratio of the area that the tractor completed, to the area that the tractor would work operating at the average speed of the test and using the nominal width of work, as shown by the following equation.

$$FE = \frac{100 A_w}{VW\Delta T} \qquad (2)$$

where:

FE = field efficiency, %

A_w = worked area during the test, m^2

V = average speed, m/s

ΔT = recording period of time, s

W = nominal working width.

Draft and other forces on the tractor were calculated from an analysis of the mechanics of the tractor considering as data the location of the tractor center of gravity, tractor weight, slippage and direction of force on the tillage tool, (Cervantes-Sánchez and Lara-López, 1984), (Colín-Venegas and Lara-López, 1981), (Lozano-Lucero and Lara-López, 1982).

Once forces on the tractor were determined, tractive efficiency was calculated directly from the following equation, (ASAE, 1990):

$$TE = (1-s)\left[1 - \frac{\frac{1.2}{Cn} + 0.04}{0.75(1-e^{-0.3Cns})}\right] \qquad (3)$$

Table 7. Cost of Contracting Tractors for Tillage.

Operation	Cost U.S.$/ha	Percent of cost
Subsoiling		
Plowing	58.06	20.22
Harrowing (2 passes)	48.39	16.85
Leveling	64.52	22.47
Planting	19.35	6.74
Cultivation (2 passes)	32.26	11.24
	64.52	22.48
	287.10	100.00

Fig. 3 Two wheeled tractor with sulky during chisel harrowing.

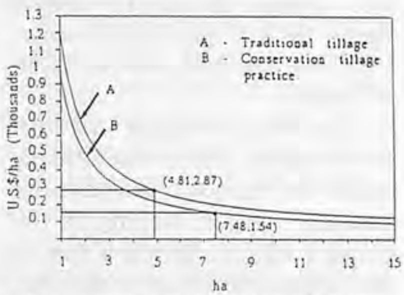

Fig. 4 Annual cost per hectare of the two-wheeled tractor as function of land area worked.

Cn is a dimensionless number depending on cone index of soil and on tire dimensions.

It is important to mention that initial field conditions include the presence of crop residues and furrows. Direct plowing under such condition for a small tractor is difficult, requiring initial smoothing of ridges and furrows by chisel harrowing. Under such conditions, traditional practice includes chisel harrowing, plowing, disk harrowing, furrowing, planting, primary cultivation and secondary cultivation. For direct planting practice, the first four operations are eliminated. The annual cost for the tractor is given by the following equation, (Chancellor, 1969):

$$\text{Annual Cost} = AKH + BLW + \frac{LW(C + LD)}{H} \quad (4)$$

In this equation, the independent variable is normally the power H. Parameters are given in **Table 6**. However, in this case the power of the tractor is 9 kW and the cost becomes a function of the land L as shown in **Fig. 3**.

The value for W corresponds to conditions for a single crop per year. This is the most common case because in the central region only 15% of the land is irrigated and cultivated two times per year.

The most common tillage system in México is that of custom-hire tractor service to several farms by a single large tractor. Cost of tillage operations are given in **Table 7**.

The cost of tillage for this system under conservation tillage could be reduced substantially including only subsoiling as the primary tillage operation due to the frequent existence of high clay soils. In such a case the cost of tillage per hectare would be in the order of U.S.$155.

It can be seen from **Fig. 4**, that for the case of traditional tillage practice, the cost of operating the small tractor is smaller than the cost of the hired tractor if the cultivated land is larger than 4.81 ha. For conservation tillage, both costs become equal for 7.48 ha.

Discussion and Conclusions

Local medium-sized manufacturers make small groups of tractors using components and materials available in the national market and applying conventional manufacturing techniques, with only a small tooling investment. However, due to very limited capital for market establishment the manufacturers were obligated to take on normal maintenance and repair type jobs, leaving them no time for the production of tractors.

The tractors were tested in a field of eight hectares in normal conditions during seven years with normal function of the power transmission and with no failure of the structure. Field repairs were normally done by the operator or by a local repairman.

Implements especially designed for the tractor showed a tractive requirement in accordance with tractor capability, as illustrated by values of slipage and tractive efficiency.

In accord with the results of the economic analysis the tractor of 9 kW (12 hp) has an annual cost lower than the rental tractor service system for land areas over five hectares in the case of traditional tillage practice and over eight hectares, in the case of conservation tillage.

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The Present State of Farm Machinery Industry

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

Outlook of Agriculture

Trend of Agriculture

In 1994 Japanese economy is continuing to be a business recession as well as last year.

In 1992 agricultural total products was ¥7 300 billion it occupied 1.6% of GNP. The imports of agricultural products are on the increase. In 1993 the imports reached $30.4 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 was under 30%. This figure is the lowest rate of all the advanced countries. On the other hand, agricultural exports was $1.5 billion.

Population mainly engaged in farming in 1993 decreased to 3 380 000 persons. It was 5.2% of total working population. Farm houses has decreased rapidly; in 1994 are 3 644 000 farm houses. And, commercial household was 2 787 000 (72%) farm houses.

Arable land was 5 120 000 ha in 1993, Arable land per one farm family was about 1.4 ha very small.

Agricultural income of farm household (commercial farm households) in 1993 was ¥8.83 million, but agricultural in come was only ¥1.64 million.

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

Trend of Farm Mechanization

Agricultural mechanization in Japan has remarkably progressed in the field of low land rice, chief crop, in a short period since 1955. Rice production for 1994, almost planting and harvesting have been mechanized. As to rice, working hours per 10 a decreased to 37.6 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. Form 1993 Japanese government started the program developing the new high-tech machine to make farm working efficient and to reduce farm burden.

By 1994 those have been on the market such as bigsize multipurpose combine and vegetable grafting robot so on eight types machines. And they have started unification of type for growing vegetables.

In 1995 Ministry of Agriculture Forestry and Fisheries made a committee which studied method to reduce cost of farm product materials like farm machines. Those farm product materials are major parts of farming cost.

Followings are the number of popularization of farm machinery as of Jan. 1, 1994: riding tractor reached 2 060 000 units; walking tractor 1 169 000; rice transplanter 1 834 000; head feed combine 1 149 000 (**Table 1**).

Shipments of major farn machinery in the domestic market in 1994 are as follows: riding tractor reached 89 000 units (those under 20PS were 30 000; those 20 ~ 30PS 39 000; 30 ~ 50PS 13 000; over 50PS were 6 600); walking tractor 172 000; rice transplanter 82 000; power reaper 23 000; combine 61 000 (standard

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
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	1,866	—	—	—	1,158	—
1994	1,669	2,060	1,835	—	—	—	1,149	—

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
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	36,269	59,485	52,347
1992	199,141	88,754	80,105	184,016	105,028	20,888	60,941	52,275
1993	169,946	82,472	79,798	194,902	100,251	22,622	57,102	51,055
1994	172,471	88,501	82,210	162,422	98,266	22,589	60,741	57,070

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

types were 255); grain dryer 57 000; huller 36 000. A safety cabin and a safety frame for tractor which are devoted to guarding operator increased sharply. This shipment was 60 000 units. **(Table 2).** This shows a tendency that rice transplanters, tractors and combines with higher-horsepower, are decreasing in number.

Recently more and more used farm machines are distributed. The rate of used farm machinery in the total sales amount is as follows: riding tractor forms 40%; waking tractor 21%; rice transplanter 30%; combine 33%.

Movement of Farm Machinery Industry

Japanese farm machine production output increased rapidly from 1973 to 1974. It recorded to ¥659 billion in 1977. But rice-related machines have developed all over this country, and government begun the policies that restrict the rice production to improve overproduction rice. It makes farmers reduce their incentive to buy machines. As a result, machine production output decreased to ¥536.7 billion rapidly in 1978.

After this, excepting ¥627.3 billion in 1980, it continued level of ¥500 billion. Developing in the overseas market and added high value products rose its figure to ¥638.2 billion in 1984, 667.8 in 1985, 674.3 in 1986. But in 1987 it reduced the to level of ¥500 billion. And by the skin of the teeth, it reached to the level of ¥600 billion in 1991. It is sluggish. In 1994 a great disaster of preceding year make farmers to cut down on buying machined, everyone thought it would occurred. A total amount of agriculture machines production rose above ¥600 billion, because of rice-related machines, especially grain-dryer and rice milling machine had strong demands in spite of expectation.

1st September 1995, Products Liability law [PL law] became effective. Farm machinery industry enforced the system of more safety of products. At the same time, they were busy with rising a quality of manual, affix caution label to the products, holding meeting for studying PL law especially dealers.

Farm machinery industry developing machine for vegetable and orchard which have weak demands, machine for rice which have multi-purpose. In order to reduce the cost of crops and resolve the shortage of farm power.

Trend of Farm Machinery Production

Farm machine production in 1994 amount to ¥606.3 billion (an increase of over the preceding year). It was expected that farmer showed very weak buying power of the farm machine, because of the preceding disaster. But rice-related machine especially grain-dryer and rice milling machine rose like as tractors, it protected whole industry dropped.

Production of the major farm machinery is as follows:

Riding tractor 156 039 units increased by only 0.6% over the preceding year. Seeing by h.p., those under 20PS amounts to 56 067 units, 20 ~ 30Ps 60 981 units, over 30PS 38 991 units.

The production of walking tractor amounted to 212 539 units, which showed a decrease of 8.3% over the preceding year. Under 5PS was 134 870 units, over 5PS 77 669 units. The production of combine, which is next to riding tractor is 61 242 units. This is an decrease of 0.9% over the preceding year.

Followings are the production of other types of farm machinery: rice transplanter amounted to 85 837 units (a increase of 1.0% over the preceding year); grain dryer 62 044 units (an increase of 10.6% over the preceding year); huller 42 115 units (a increase of 1.1% over the preceding year); binder 21 033 units (a decrease of 22.9% over the preceding year); thresher 11 422 units (a decrease

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
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	—	588,627	146,115	186,983	225,564	33,738	84,980	58,344	165,909	6,899	134,901	5,985	8,559	12,155
1994	—	606,279	156,039	198,278	212,539	30,921	85,837	66,726	141,556	6,569	123,268	5,670	6,260	8,261
(1995)	—	629,700	163,200	214,000	207,600	27,200	90,300	70,700	150,100	6,900	132,100	6,400	6,900	11,100

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
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	27,286	7,173	1,588,837	27,399	11,663	4,562	65,192	149,867	41,664	14,129	56,079	44,224	40,368	3,844
1994	21,033	5,379	1,554,478	28,726	11,422	4,439	61,242	148,537	42,115	14,680	62,044	49,846	53,514	5,493
(1995)	25,000	6,500	1,537,000	28,300	11,700	4,400	63,600	155,500	50,100	18,700	65,400	54,300	56,700	6,800

Source: "Survey of Status of Machinery, Production" by the Ministry of Interntional Trade and Industry. Data by Japan Agr. Machinery Manufacturers' Assn. and Land Internal Combustion Engine Manufacturer's Assen.
Note: Data for 1995 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 m²	Annual sales value (2)/(1)
1979.6	9,257	48,548	1,007,298	159,772	898,854	108.8
1982.6	10,084	49,081	1,018,983	164,269	1,005,546	101.0
1985.6	9,142	43,921	946,507	144,837	985,453	103.5
1988.6	9,444	45,952	1,015,304	159,798	923,726	107.5
1991.6	9,480	45,705	1,158,924	170,104	984,700	122.2

Source: Ministry of International Trade and Industry

Table 5. Handling of Farm Equipment by Agricultural Cooperative Association (1993 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
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
1992	3,204	354,728	268,393	388,031
1993	2,905	353,340	267,609	388,337

Source: "Statistics on Agricultural Cooperatives—1993 business

of 2.1% over the preceding year); bush cleaner 1 554 478 units (a decrease of 2.1% 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 1994, the retail shops were recorded to about 8 800, the employees amounted to 43 000 persons, and the annual sales amounted to ¥1 130.0 billion **(Table 4)**.

According to the governmental survey by Ministry of Agriculture, Forestry and Fisheries, the total sales of farm machinery by Agricultural Cooperative Association reached ¥388.3 billion in 1993 (¥388.0 billion in 1992) **(Table 5)**.

Great disaster in 1993, everyone predicted that farm machine demand in 1994 and 1995 would reduce. But farmers bought machines eagerly. Sales of traders and Agricultural Cooperative Association ended up increased. In a long term, it is predicted that demand of farm machined will decline, dealers face to a important problem to improve management structure.

Export and Import of Farm Machinery

Export

In 1994 the exports of farm machinery amounted to ¥120.1 billion, which showed an decrease of 3.6% over the preceding year. The ratio of the exports to the total production amounts to ¥606.3 billion ended in 20%.

Seeing by the shipments, ¥60.6 billion for North America, 25.2 billion for Asia, ¥23.5 billion for Europe, ¥21.7 billion for EU. For North America increased by 24%, reflection on American economy was in good condition. Export for U.S. is tractor ¥45.2 billion (62 200) units, which is a major part. Total amount for U.S. is ¥57.0 billion.

As for the types of farm machinery, tractor was chiefly exported: 89 023 units were exported in 1994 (the total production was 156 039 units). It amounts to ¥62.5 billion. Seeing by horse power, those under 30PS amounted to 65.089 units, those from 30 to 50PS 20 560 units, those over 50PS 3 374 units.

Table 6. Export of Farm Equipment 1994

Unit: FOB Million Yen

Year	Unit	Value	Ratio	Major destinations
1988		130,492		
1989		131,042		
1990		132,757		
1991		129,943		
1992		143,891		
1993		124,505		
1994		120,079	100.0	U.S.A., Korea, France, Taiwan
Power tiller	48,097	3,438	2.9	France, U.S.A., Germany
Wheel tractor	89,023	62,514	52.1	U.S.A.
Seeder, Planter	6,087	2,563	2.1	Taiwan, Korea, Germany
Power sprayer	25,937	924	0.8	Taiwan, Malaysia, Mexico, Korea
Duster	12,586	350	0.3	Taiwan, Korea, Malaysia
Lawn mower	67,781	4,901	4.1	U.S.A., France, Korea, Germany
Brush cutter	916,508	20,824	17.3	U.S.A., France, Korea, Germany
Mower	64,864	2,549	2.1	U.S.A., Korea, Singapore
Combine	1,649	3,482	2.9	Taiwan, Egypt, Korea, Peru
Chain saw	148,816	2,774	2.3	U.S.A., France, Italy
Other	—	15,760	13.1	

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

Table 7. Import of Farm Equipment 1994

Unit: CIF Million Yen

Year	Unit	Value	Ratio	Exporters
1988		23,095		
1989		27,245		
1990		33,205		
1991		26,598		
1992		25,778		
1993		25,578		
1994		27,779	100.0	U.K., Germany, France
Wheel tractor	4,544	13,443	48.4	U.K., France, Germany
Pest control machine	1,952,740	1,000	3.6	U.S.A., Taiwan, Israel
Lawn mower	29,934	1,959	7.1	U.S.A., Sweden, Germany
Mower	2,701	899	3.2	France, Netherlands, Denmark
Hay making machine	1,772	897	3.2	France, Germany, U.S.A.
Bayler	735	1,004	3.6	U.S.A., Netherlands, Germany
Combine	83	1,102	4.0	Belgium, Australia, Germany
Chain saw	80,766	1,913	6.9	Germany, Sweden
Other	—	5,562	20.0	

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

Major farm machinery, next to tractor, is bush cleaner. The total exports were 916 508 units, ¥20.8 billion.

The exports of other farm machinery are as follows: walking tractor 48 097 units; lawn mower 67 781 units; grass mower 64 864 units; chain saw 148 816 units etc. **(Table 6)**.

Import

In 1994 the imports of farm machinery amounted to ¥27.8 billion, which means a increase of 8.6% over the preceding year.

Followings are the major imported farm machinery: tractors 4 544 units (those more than 70PS were 3 641 units of all the tractors); chainsaw were 80 766 units. 47% of the tractors 2 118 units were imported from U.K. **(Table 7)**.

Trend of Research and Experiment

The surroundings of Japanese agriculture are very hard, because of claims for opening the market for agricultural products by U.R. settlement, consumer's various favor, the increase of the aged and the females as farmers, being called for the contribution to solve the environmental problems.

That's why the structural and technical reforms in Japanese agriculture are requested urgently.

Researches are chiefly made for high performance, automatic and popularized farm machinery in order to reduce cost in the production of agricultural products. Electronics and mechatronics are positively adopted for their technology. It is expected that technology for farm mechanization will be applied to biotechnology.

In 1993, the law promoting agricultural mechanization was revised. "Urgent Development Program" which is promoting the machine has a weak demand, but has a strong needs, is going ahead. As a result, one of them like vegetables grafting machine is on market.

Regarding tillage, tillage and ridge making are being studied to save the energy. The technology for leveling ground in large fields is also studied for practical use.

Regarding transplanting low land rice, the method of partridge rice transplanting is being developed.

In the field of vegetable farming, the method of plantnursing control, a robot for grafting and the all automatic transplanters for leaf-vegetables, are being studied.

Regarding fertilization and seeding, cultivation and seeding with one process, non-cultivating seeding of field crops and the method of precise one seed seeding ... etc., and various studies are continuing.

Regarding harvesting, large multi-purpose combine and whole harvesting-type machine were developed.

In rice mechanization, we still have problems such as walking work in weeding and chemical application. In such field, a riding machine for rice management in order to save the work is in under developing.

Regarding harvesting, harvesting machines for vegetables and tomato (including harvesting robot) are under developing. And a cutting roll baler and harvesting machine for fruits have developed.

In the field of post-harvest, a rice quality measure machine and a fruits quality measure machine without any damage are under developing. ■■

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The Japan Farm Machinery Manufacturers' Association at a Glance

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

Today, agricultural machinery is indispensable for farmers, the key link in agricultural modernization and expansion of food production.

The Japan Farm Machinery Manufacturers' Association (JFMMA) is a nation-wide representative organization of the agricultural machinery makers of Japan. The association, through the cooperation of its member companies, seeks ways to solve a wide range of tasks in such fields as technical development, safety and export promotion, with the ultimate aim of furthering the sound growth of the agricultural machinery industry as a whole.

Established
June 2, 1939

Members
Ordinary Members
100 companies
Organization Members
4 Bodies
Supporting Members
7 Companies

Directors

President	1
Vice-Presidents	6
Managing Directors	2
Full-time Director	1
Directors	27

Organization

Committees

JFMMA
- General Affairs and Planning Committee
- Standardizatoin Committee
- Internationalization Promotion Committee
- Distribution Planning Committee
- Vehicle Planning Committee
- Parts Planning Committee
- Labor Planning Meeting

Sectional Meetings

JFMMA
- Tractor Sectional Meeting
- Power Tiller Sectional Meeting
- Implements Sectional Meeting
- Rice Transplanter Sectional Meeting
- Garden Tools Sectional Meeting
- Paddies Weeder Sectional Meeting
- Plant Pest Control Sectional Meeting
- Grain Huller Sectional Meeting
- Rice Grader and Winnower Sectional Meeting
- Harvester Sectional Meeting
- Brushcutter Sectional Meeting
- Dryer Sectional Meeting
- Straw-processing Machine Sectional Meeting
- Cutter Sectional Meeting
- Grain Processing Machine Sectional Meeting
- Farm Transport Vehicle Sectional Meeting
- Overseas Trade Sectional Meeting

*This article is based upon the introduction broachures published by JFMMA.

Activities

JFMMA is working for the rationalization of the farm machinery manufacturing industry in order to promote the industry as a whole. The end in view is to hasten agricultural development. In pursuit of these objectives, JFMMA undertakes the following activities:

Relatons with Government

Proposals and requests to Government and cooperation with it in regard to industrial policy, agricultural policy, taxation, and counter-measures on behalf of medium and small enterprises.

Technology

Standardization of parts and components. Cooperation with JIS and ISO. Requests for, and cooperates in governmental inspection, certification and safety test of machinery, etc.

Safety

Collection and distribution of internal and external information on safety requirements. Enlightenment on safety practices. Standardization of safety symbols.

Patents

Thorough knowledge of industrial lproperty rights system; promotion of respect for and efficient use of industrial rights; collaboration with the Patent Office.

Distribution

Assurance of adequate supply of spare parts. Promotion of respect for the principles of Fair Competition codes. Solicitation of displays at exhibitions and expositions from members.

Internationalization

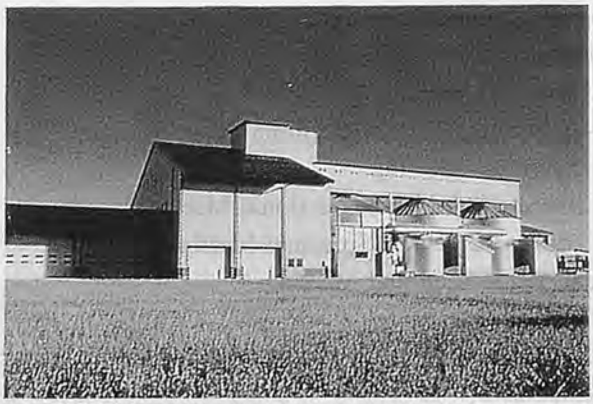
Research and study on international affairs for the farm machinery industry. Promotion of orderly, export practices and formation of conciliatory order. Collection and distribution of information on overseas market trends. Cooperation with overseas economic development assistance programs/projects.

Activities on consignment and subsidy

Standardization of farm machinery and parts. Planning on safety improvements. Studies for trends in foreign farm machinery.

Other

The collection, analysis and distribution of information on the manufacture, delivery, export, import and domestic demand for farm machinery. Monthly publication of the JFMMA magazine, "Nogyo Kikai Jōhō" (Farm Machinery Information). Liaison and Collaboration with related organizations and associations. ■■



The Outline of Activities Conducted by Laboratory of Agricultural Machinery, Kyushu National Agricultural Experiment Station

by
Hatsuki Nishida
Head
Laboratory of Agricultural Machinery
Department of Lowland Farming
Kyushu National Agricultural Experiment Station
2421, Nishigoshi, Kikuchi, Kumamoto 861-11, Japan

Background and Main Studies

Kyushu Agricultural Experiment Station is located in Kyushu-Okinawa region. This region is suitable for farming in terms of climate. It is the southernmost part of Japan. The southeastern part of Kyushu island is warm and Okinawa is in the subtropical zone. The temperature is generally high and there is much sunshine and rain (1 500-3 000 mm).

The climate, however, poses the risk of crop diseases and harmful insects. Damage from flood and wind cannot be ruled out, because this region is occasionally hit by downpour and typhoon.

With its scale and variety of farm products, agriculture has made a great contribution to both the economic growth and the conservation of the environment in Kyushu. It has an approximately 13.6% of the entire cultivated area of this country; 714 000 ha. Products include rice, wheat, feed grain, crops to be processed, and so forth.

Recently, however, Kyushu has been experiencing difficulties such as the overproduction of rice, orange, and milk as well as the decline of competitiveness. Kyushu Agricultural Experiment Station has been involved in experiments and studies with the view of overcoming farming problems peculiar to Kyushu region as mentioned above.

The following is the main studies carried out at this organization.

1) Evaluation and utilization of local agricultural resources.
2) Establishment of a system for the development of management methods for highly productive farming.
3) Breeding of superior crop cultivars suited to warm climates.
4) Improvement of crop productivity, quality and establishment of cultivaiton techniques.
5) Improvement of major livestock productivity, quality and establishment of breeding techniques.
6) Establishment of techniques for the preservation of cultivated land and the improvement of its prouctivity.
7) Preservation of the environment in ecosystems of agricultural lands.
8) Establishment of systems for the rational distribution and utilization of agricultural products.
9) Establishment of integrated pest management.
10) Introduction and preservation of genetic resoruces, and accumulation of research technology informations.

Brief Historical Outline and Organization

In 1950, Kyushu Agricultural Experiment Station was inaugurated by consolidating several experimental sites. Since then, we have reorganized our structure several times as indicated below:

April 1950

Kyushu National Agricultural Experiment Station founded by combining with several experiment stations.

April 1951
Combined with several crop breeding stations in prefectures.

May 1951
Environment Division separated into Environment Divisions I and II.

May 1957
Technology Liaison Department founded.

April 1960
Division of Upland Field Farming and Division of Tea-growing founded.

April 1961
General Affairs Division founded.

Dec. 1961
Horticulture, Land Reclamation and Tea-growing Divisions become Kurume Branch of Horticultural Research Station, Saga Branch of Agricultural Engineering Research Station, and Makurazaki Branch of Tea Research Station, respectively.

April 1962
Laboratory of Farm Machinery

April 1970
Grassland Research Division founded.

April 1982
Planning Liaison Department renamed Research Planning and Management Division; Saga Branch of the Agricultural Engineering Research Station and Lowland Crops Division reshuffled and combined into newly-founded Farm Utilization Division.

Dec. 1983
Combined with Kyushu Branch, National Sericultural Experiment Station.

April 1987
Plant Biotechnology Laboratory founded.

Sept. 1988
Farm Utilization Division located at Saga Prefecture was abolished.

Oct. 1988
The Station was fully reorganized into the present

- Director General
  - Deputy Director General
  - Dept. of Research Planning and Coordination
    - Research Planning Section
    - Research Cooperation Section 1
    - Research Cooperation Section 2
    - Research Information Section
    - Library and Information Section
    - Field and Animal Management Section
    - Research Project Team 1
    - Research Project Team 2
    - Research Project Team 3
  - Dept. of General Administration
    - General Affairs Section
    - Accounting Section
    - Purchasing Section
    - Chikugo Office
    - Tanegashima Office
    - Miyakonojo Office
    - Miyazaki Office
  - Dept. of Recalcitrant Disease and Pest Management
    - Laboratory of Plant Disease Ecology
    - Laboratory of Plant Disease Control
    - Laboratory of Virus Diseases
    - Laboratory of Insect Pest Behavior
    - Laboratory of Insect Pest Control
    - Laboratory of Pest Management Systems
    - Laboratory of Plant Nematology
  - Dept. of Rural Development
    - Laboratory of Reigional Planning
    - Laboratory of Farm Management
    - Laboratory of Marketing Systems
    - Laboratory of Agricultural Organization
    - Laboratory of Resource Evaluation
    - Laboratory of Rural Engineering
  - Dept. of Crop Breeding
    - Laboratory of Plant Biotechnology
    - Laboratory of Soybean Breeding
    - Laboratory of Sugarcane Breeding
    - Laboratory of Mulberry Breeding and Sericulture
    - Laboratory of New Industrial Crops
    - Laboratory of Crop Quality
    - Laboratory of Storage and Processing
  - ※ Dept. of Lowland Farming
    - Laboratory of Breeding Methods for Stress-tolerance
    - Laboratory of Rice Breeding
    - Laboratory of Wheat Breeding
    - Laboratory of Barley Breeding
    - Laboratory of Crop Eco-Physiology
    - Laboratory of Weed Control
    - Laboratory of Lowland Soils
    - Laboratory of Agricultural Machinery
    - Field Management Section
  - ※※ Dept. of Upland Farming
    - Laboratory of Upland Crop Genetic Resources
    - Laboratory of Sweet Potato Breeding
    - Laboratory of Corn Breeding
    - Laboratory of Cropping Systems
    - Laboratory of Farm Operation Mechanization Systems
    - Laboratory of Upland Soils
    - Laboratory of Upland Crop Utilization
    - Field Management Section
  - Dept. of Animal Production
    - Laboratory of Animal Breeding and Reproduction
    - Laboratory of Animal Nutrition and Feed Resources
    - Laboratory of Animal Environment Physiology
    - Laboratory of Meat Animal Production
  - Dept. of Grasslands
    - Laboratory of Pasture Plant Introduction
    - Laboratory of Pasture Plant Breeding
    - Laboratory of Forage Crops
    - Laboratory of Grassland Management
  - Dept. of Agro-Environmental Management
    - Laboratory of Soil Genesis and Fertility Evaluation
    - Laboratory of Soil Conservation and Improvement
    - Laboratory of Soil Microbiology
    - Laboratory of Agro-Meteorology

Fig. 1 Organization.
*located at 496, Izumi, Chikugo, Fukuoka 833, Japan
**located at 6644, Yokoichi, Miyakonojo, Miyazaki 885, Japan

research Divisions.

April 1991

Director-General, and four Departments, i.e. Research Planning and Coordination, General Administration, Recalcitrant Disease and Pest Management, Agro-Environmental Management, moved from Chikugo, Fukuoka to Nishigoshi, Kumamoto.

Oct. 1991

Research Information Section, Laboratory of New Industrial Crops, Laboratory of Storage and Processing and Laboratory of Animal Nutrition and Feed Resources Founded.

Oct. 1993

Combined with Laboratory of Plant Germplasm Evaluation, National Institute of Agrobiological Resources.

Laboratory of Upland Crop Genetic Resources and Laboratory of Upland Crop Utilization founded.

In the meantime, we have expanded our activities as a leader of developing agricultural technologies in Kyushu and Okinawa region. Kyushu Agricultural Experiment Station is now located at 3 sites; Nishigoushi-cho, Kikuchi, Kumamoto Prefecture; Chikugo, Fukuoka Prefecture; Miyakonojo, Miyazaki Prefecture. **(Fig. 1)**

Activities of Laboratory of Agricultural Machinery

Our Laboratory was established in Chikugo, Fukuoka Prefecture in 1962. Since then we have been working on the system of mechanized cultivation of rice, wheat, and soybean. The system uses medium powered tractors as main machinery. Our theme is "labor saving and decrease cost". Under this theme, we have been engaged in the fields of utilization and development of farm-machinery and study of farm-work system.

Another field of our work is the system of mechanized cultivation of vegetable. There has been a strong demand for the development of farm-machinery for vegetable growing, which has started in paddy fields in recent years. In response to that, we have been developing vegetable cutting machinery and examining labor science of vegetable farming.

A couple of our studies and activities in detail are shown below.

Development of Direct Sowing Rice Seeds

We have been working on the development of direct sowing rice seeds from the viewpoint of labor saving and decrease cost.

In Japan, transplant culture is prevalent in rice growing; seedlings are raised high enough in seedbed and transplanted into paddies. In order to saving, the burden of this process, machinery of direct sowing rice seeds, which satisfies local needs, is now being developed across the country.

Our laboratory is no exception to this trend. We have already manufactured a machine **(Fig. 2)** for experiment. It is designed to do sowing seeds while puddling.

It drops rice seeds behind its rotavator and then put them into soil slightly with its cage wheel.

In addition to the benefit of labor saving from direct-sowing, the machine has another merit; decrease cost. It can do broadcasting and rotavating of wheat cultivation. Thus the multipurpose use of the machine allows us to decrease cost of machinery in the rice and wheat double cropping system.

Development of Trenching Underdrainage Method

Rice is now in the state of overproduction. And consumers needs for farm products have become varied. Therefore, it has become necessary to use paddies for multiple purposes. One of options is to grow crops other than rice. However, there is one problem. Unlike rice paddies, the drainage of rainwater is the most important element of cropland and should be done quickly.

Fig. 2 Newly developed direct sowing machine.

Fig. 3 State of emergence.

Fig. 4 Newly developed trenching drainer.

Currently, vibrating mole drainers are available for this work. They are developed for farmers and can be operated by medium powered tractors. However, the drainers vibrate so heavily that it is very hard for an operator to work on them for many hours.

At this station, we have developed a trench drainer **(Fig. 4)** to replace the existing drainers. Our drainer digs trenches, 3 cm wide and 30 cm deep approximately. It helps quicken removing rainwater from the surface soil. The vibration is also much less compared with the existing drainers.

Measure of Stress Source of Farm-work

One of aims of mechanized farming is to ease the work volume of farming, releasing farmers from the hardship of farm-work. Much progress has been made in the field of rice and wheat growing work across the country, but not as regards to vegetable. So, we have decided to add the study on farm-work of vegetable farming to our activities.

Currently, we conduct a survey on working hours, working conditions, and work volume of strawberry-growers throughout the year in an effort to define labor science and formulate measure of labor intensity for vegetable cultivation.

Study on Vegetable Cutting Machine

Japan has been slow in studying mechanized cultivation of vegetable, particularly so in the case of leaf-vegetable. There has been a growing demand of farmers for the development of machinery for cutting and carriage of vegetable crops. Although we have just started our study to meet this demand, we have already manufactured a vegetable cutting machine to be placed in tractors.

Fig. 5 Making index of farm-work stress. (heart rate counter is put on girl's body)

Rotary movement of tractor's PTO is converted into shuttle movement, which is used as power to operate the cutting machine. The machine has a hatchet-like blade and cut crops by moving the blade horizontally.

International Cooperation in Technology Made by Our Laboratory

Our laboratory have been active in sharing our experience in the development of farm-machinery for rice and wheat cultivation, whenever there have been requests for technological cooperation from developing countries. The following is the recent technological cooperation that we have extended.

Fig. 6 Measuring of farm-work stress. (heart rate counter is put on farmer's body)

Hatsuki Nishida: Project of increase wheat production in area along Yellow River within Henan Province, China, 1993

This project is now underway with technological cooperation from Japan. Our Laboratory made technological cooperation in mechanized cultivation of wheat.

Tatsushi Togashi: Development of Rice Reaper at Philippine Rice Research Institute, Philippines, 1994

Our Laboratory made technological cooperation in the development of rice reaper as part of mechanization scheme of rice harvest work in Philippines.

Zang Xiu Wang: Mechanized Cultivation of Wheat, China, 1995

He is a researcher in charge of the above mentioned project in China and now is staying at our Laboratory to receive training on mechanized cultivation of wheat and operation of machinery. ■■

Introduction to the Laboratories of Agricultural Engineering Saga University

by
Tokumi Fujiki
Professor
Department of Agricultural Sciences
Faculty of Agriculture, Saga University
Honjo 1, Honjo, Saga 840, Japan

General Information of Saga, Japan

Saga National University is located at Saga in Saga Prefecture, being approximately 1 200 km distant from Tokyo. The archipelago of Japan is formed of four major islands. Saga Prefecture is situated on the island of Kyushu, the southernmost of the four. The Kyushu district is called the Silicon Island with many micro electronics firms and also is a major agricultural area of Japan. Saga Prefecture has served as a gateway to the Asian continent, introducing culture from China and the Korean peninsula into Japan since ancient times. To the rest of Asia, Saga Prefecture is closer than any other prefecture in Japan. The Saga Plain is one of the three largest plains in Japan and is blessed with a mild climate and fertile soils. Saga is the prefectural capital with a population of 168 thousand. Saga Prefecture, rather a small one in Japan, covers an area of about 2 400 square kilometers, and has a population of 878 thousand. It is surrounded by Fukuoka Prefecture to the east, and Nagasaki Prefecture to the west, Genkai Sea to the north, and the Ariake Sea to the south, where the difference between high tide and low tide is about six meters.

Agriculture in Saga District

Agriculture spreads across the vast expanse of the Saga plains including a part of Fukuoka Prefecture. Rice production is a particularly strong point. Paddy harvest per acre is the highest in Kyushu and as of 1992 ranked seventh in Japan. The planted acreage for mandarin orange, onion, and lotus root ranks high nationally. In the Saga plains, vegetables and flowers in greenhouses, such as egg plant, cucumber, tomato, strawberry, asparagus, cyclamen, roses and chrysanthemum are very common products. Livestock and dairy farming are also successful in the northern tableland area. With the introduction of biotechnology and information technology in recent years, agriculture in Saga Prefecture continues to develop.

Undergraduate Education of Saga University

Modern society is rapidly changing and ground swells of information and internationalization are observed in every area of society today. The purpose of Saga University is to train students to be internationally minded and equipped with a creative intellect and cultural depth as citizens of a democratic society; able to contribute to academic and cultural progress and to the development of local communities.

Saga University is mainly organized into 4 faculties, as shown in **Table 1**.

The academic year is divided into two semesters as follows:
First Semester:
April 1 ~ October 10
Second Semester:
October 11 ~ March 31 of the following year

The school year includes summer vacation from July 11 to

Table 1.

	Academic staff	Undergraduate students	Graduate students
Faculty of Education	90	1 102	57
Faculty of Economics	45	1 359	28
Faculty of Science and Engineering	141	2 375	333
Faculty of Agriculture	53	703	85
College of Liberal Arts	45		
Institutes and Library	12		
Total		5 539	503

Table 2. Departments and Laboratory divisions in Faculty

Department	Course	Division
Agricultural Sciences	1. Agro-biology	Crop Science, Crop Ecology, Improvement of Tropical Crops, Agricultural Production Engineering, Animal Sciences, Animal Production and Management
	2. Agricultural Information Science	Economics and Management of Food Production, Economics of Marketing and Information, Agricultural Systems Information and Technology, Agricultural Water Supply and Management, Agricultural Land Information and Engineering
	3. Agricultural Environmental Engineering	Soil Physics and Hydrology, Agricultural Hydrotechnics, Agricultural Soil Engineering, Agricultural Machinery, Environmental Science of Tidal Flats.
Applied Biological Science	1. Biotechnology and Plant Breeding	Gene Engineering, Cell Engineering, Plant Propagation, Plant Genetic Resources, Genetics and Plant Breeding
	2. Plant Protection and Soil Fertility	Soil Science, Plant Nutrition, Entomology, Nematology, Plant Pathology, Plant Virology
	3. Biofunctional Chemistry	Biochemistry, Life Chemistry, Microbial Genetics and Biotechnology, Applied Microbiology
	4. Food Resource Science	Food Resource Chemistry, Food Science, Food Chemistry, Food Hygienics, Nutritional Biochemistry

September 10, winter vacation from December 25 to January 7 of the following year and spring vacation from April 1 to April 7.

Undergraduate Course by the Faculty of Agriculture

Saga University awards the Bachelor's degree in Agriculture to students who have completed all of the requirements leading to a four-year degree in the Faculty of Agriculture. There are two departments, Agricultural Sciences and Applied Biological Sciences.

Masters Degree Programs are available in the School of Postgraduate Studies. The Masters Degree Program requires two years for completion and aims at producing professionals with academic and technical expertise.

Doctoral Degree Programs, established April 1988, are available in the United Graduate School cooperatively conducted with Kagoshima University, Miyazaki University and University of the Ryukyus.

Food is essential for life. Of all human activities, the most important one for producing food is of course agriculture, through which the unlimited solar energy is converted into useful organic materials, using cultivated plants and, in turn, domesticated animals. To make this activity as efficient as possible, agricultural sciences have played key roles, especially in the production and use of food. A recent additional role of the sciences is to conserve and create a better environment suitable for us and for the next generation. The Faculty of Agriculture, Saga University is situated in an ideal location for the study and education of agricultural, food, agro-engineering, and environmental sciences.

The faculty has two departments; Department of Agricultural Sciences and Department of Applied Biological Sciences (**Table 2**). Annually about 170 students, including those from overseas, enroll in either of the two departments and begin to the courses leading to a Bachelor's Degree in Agricultural Science.

Masters Course

In order to keep up with the advancement of learning and culture and with changes in educational conditions, we developed Masters and Doctoral Courses, and welcome foreign students. In these various ways, Saga University is rapidly opening its doors to the world. We have arranged programs which will enable you to acquire the skills necessary to meet the challenges of the new age. Highly motivated foreign students are received warmly at Saga University.

The Masters course is in the same category as the Bachelor's course. The Students are required to complete a minimum of 30 credits. Twenty two of these credits must be from that of the major subject including 8 credits of special study. The school selects one advisory professor for each student with reference to the student's request. Research guidance will be given concerning subject matter such as graduate thesis writing and graduate research in a seminar format. Students will receive this guidance and start their graduate research from their first year of study.

The Doctoral Course at the United Graduate School

The United Graduate School of Agricultural Sciences, Kagoshima University is an independent 3-year Doctoral Course in Agricultural and Fisheries Sciences. Studies in these field are closely related to the local natural environment, climate and social conditions. The characteristics of each region have a bearing on the development of these studies. It was established in 1988 by the cooperation of the Masters Courses of Saga University (Agriculture), Miyazaki University (Agriculture), Kagoshima University (Agriculture and Fisheries) and Ryukyu University (Agriculture). The United Graduate School has four Courses and nine Major Chairs (*Rengo-Koza*). The United Graduate School aims at training researchers with a high level of technical ability and a thorough knowledge of biosciences. Another important function of our United Graduate School is to accept many foreign students from various countries, especially East and Southeast Asian countries.

Our intentions are to have the student acquire a profound knowledge about his/her specialty during a three-year Doctoral Course. The United Graduate School is aimed at not only cultivating university instructors but training specialists who work for national or local public and private research institutes and contribute to the development of industries allied to agricultural and marine resources.

Being enrolled in the United Graduate School of Kagoshima University, the student studies under the supervision of a Major Professor at one of the four universities to which the Major Professor belongs. Teaching staff members are nominated among the instructors of the four universities according to the specialty and wishes of students. The arrangement of students is reasonably coordinated among the four universities. One Major Professor and two tutors (Professor or Associate professor) are nominated by the United Graduate School to take charge of a student. Instruction of students is conducted in various research activities including united special seminars.

The Staffs Related to AMA

We belong to the Department of Agricultural Sciences. The divisions are Agricultural Production Engineering (Kojima), Agricultural Systems Information and Technology (Fujiki and Uchida) and Agricultural Machinery (Matsuo and Inaba). Because Japan has limited natural resources and farm land, there are strong demands for energy and labor saving, the improvement of machines and conservation of the environment, increasing productivity, and rationalization of processing and storage. We also deal with the development and improvement of machines, facilities, after harvest processing, storage and transportation of farm products, and software for them.

Research Interest of the Staff

KOJIMA Takayuki, Professor, Ph.D. (Agr): Horticultural Engineering, Environmental Control for Hydroponics Culture of Vegetables. Under-ground Irrigation, Methane Generation from Bio-waste, Near Infrared Spectroscopy, Mechanical Properties of Agricultural Products, Factory Production of Vegetables, and Nondestructive Quality Evaluation of Agricultural Products.

FUJIKI Tokumi, Professor, Ph.D. (Agr): Hydraulic Studies on Dusters and Sprayers, Grain Drying, Autonomic and Remote Control Systems, Electrical Sensing Devices, and Life Span of Machines.

UCHIDA Susumu, Assoc. Professor, Ph.D. (Agr): Computer Control of Machines, Programming by Machine Language, Physical and Thermal Properties of Grains for Drying and Storage, Air-flow Pattern in Storage Storehouse, Dehumidifying Dryer, and Image Processing Technology.

MATSUO Takaaki, Assoc. Professor, Ph.D. (Agr): Wheel Dynamics in Fields, Trafficability of Rubber Crawlers, Lug Motion in Fields, Thrust and Sinkage of Tracks, Vibration of Machines, and Drying of Onions.

INABA Shigeki, Asst. Professor, Master (Agr): Movability of Combine Harvesters, Autonomous Crawler Vehicles, Rolling Resistance of Track Rollers, Mechanics of Soil-vehicles, and Mechanization of Harvesting, Drying and Storage of Farm Products.

Recent Research

Prof. KOJIMA Takayuki: For effective mechanization in transplanting of vegetable seedlings, it is necessary as a pre-requisite to assure a satisfactory completion level that all cells in a tray are filled with healthy and uniform seedlings, and the process to produce such trays should be stable and consistent. A robot system for automatic seedling production in a nursery has been developed in cooperating with Professor KIM Ki Dae, Chungnam National University, Korea. The robot hand discards a poor seedling and replaces it with a healthy seedling.

Prof. FUJIKI Tokumi: Grain drying, especially rice drying, is an important matter of concern for the Japanese farmer and rice consumer because of the cost, labor and taste of the rice. It is said that conventional hot air drying has caused unsavory rice. So an air dehydrator and double cylindrical bin were adopted for drying and storing grains, wheat and rough rice. The center duct is used to discharge or exclude air which passed through the grain in the external cylinder. An adequate air volume and special techniques are needed to promote drying at the top of bin and at the peripheral parts.

Assoc. Prof. UCHIDA Susumu: A dehumidifying dryer and vertical augers were set in a useful scale bin, 8.23 m diameter and 6.73 m high. As a result, mixing of 2 kinds of rough rice at different moisture levels, 30 ton at 18.3% and 30 ton at 24.8%, was completed and drying was achieved to the same moisture 21.5% in 17 hours. Furthermore tests are carried out for practical use.

Assoc. Prof. MATSUO Takaaki: To keep the freshness of onions, drying characteristics including dimensions, hardness and color of onions were investigated. The fastest drying was achieved when wind velocity was 4 m/sec., the temperature 35°C and humidity 40%.

Asst. Prof. INABA Shigeki: Rubber crawler vehicles are widely used for off the road vehicles, such as agricultural and constructive machines. Design theories of the rubber crawler are being found for high speed and stable operation.

Information for Foreign Students

Saga University classifies foreign students under three categories; (A) under-graduate students; (B) graduate students; and (C) research students (*Kenkyusei* in Japanese). The foreign students enrolled in various faculties under the above three categories are as follows: 75 from China, 22 from Malaysia, 15 from Korea, 15 from Taiwan, 8 from Bangladesh, 8 from Indonesia, 5 from Africa, 3 from Central America and Total 196 students from 23 countries presently (1995).

Qualifications and Application Procedures for Admission

1. Admission Requirements

(A) Undergraduate Student

Admission test — Foreign students supported by the grants of Japanese Government and by their home Government are virtually admitted. Other students must pass the special entrance examination which is subjected to foreign students.

Applications who will study on private funds must also sit for the General Examination for Self-supported Foreign Students (*Shihi Gaikokujin Ryugakusei Toitsu Shiken* in Japanese) and the Japanese Langauge Proficiency Test administered by the Association of International Education, Japan.

Qualification — The applicant must be of non-Japanese citizenship and fall under one of the following categories:

(a) Those who have completed 12 years of schooling in their own countries other than Japan.
(b) Those who are 18 years of age and older.

It is essential that the applicant should have acquired sufficient all round proficiency in the Japanese Language since instructions and entrance examinations are given in Japanese.

(B) Graduate Student

Admission test — The applicant must pass either of the prescribed examinations (interview and/or written examination) held in September and February every year. In addition, the candidate must meet one of the following requirements in order to apply for the Masters program:

(a) Bachelor's degree from an accredited institution at the date of entrance.
(b) Completion of 16 years of schooling or equivalent in home countries and/or Japan.
(c) Recognition of having ability equal or superior to an average university graduate by the Graduate Committee of Saga University.

(C) Research Student (*Kenkyusei* in Japanese)

The students in this category will be selected by the examination of the documents submitted upon request from the respective faculties of the university.

Qualifications — The candidate must have one of the following qualifications:

(a) Those who have graduated from an accredited university or college.
(b) Those who have graduated from an accredited university or college (including a university or college where the total schooling is less than for 16 years) in a foreign country and/or Japan.

2. Application Procedures

The application procedure, subjects of the entrance examination and other necessary requirements can be received from the Students Affairs Office of the university. Please address inquire to:

Admission Division
Student Affairs Office
Saga University
1 Honjo-cho, Saga 840, Japan
(Tel. 0952-24-5191)

(A) Undergraduate Student

(a) Deadline of Application: 3rd week of January
(b) Application Materials:
   * Application form (provided)
   * Health certificate (form provided)
   * Certificate of graduation and official academic records
   * Personal history (form

provided)

* Two photographs (adhered to application form)
* Copy of application form for the General Examination for self-supported Foreign Students
* One piece of envelope with postal stamp of 350 Yen

(c) Examination fee of 15 000 Yen

(d) Date of entrance examination: 1st week of February

(B) Graduate Student and Research Student (*Kenkyusei*)

Following is the list of required documents which applicant must submit to the university with examination fee:

* Application form (provided)
* Official transcripts of certificates from the university or college given grades of various subjects taken
* Certificate of graduation from the final university or college
* Health certificate including the test of eye-sight, hearing test, tuberculosis and other disease test
* Letter of recommendation by the dean of the faculty or the guidance professor
* Personal history (form provided)
* A photograph (size: 4.5 × 4.5 cm)
* Alien registration certificate if the applicant is currently residing in Japan

Application form is available at the office of admission of the faculty from early July. Applicants are required to submit the documents specified above to the office of admission of the faculty by the end of August and/or the end of January of the following year. The expected date of entrance examination for graduate students is as follows:

	Application Date	Examination Date
1st Semester	August	September
2nd Semester	January	February

Cooperative Exchange Programs with Foreign Universities

Cooperative exchange programs have been signed between our Faculty and the colleges, faculties or departments of following five universities: College of Agriculture, Chonnam National University, Korea; Faculty of Agriculture, Khon Kaen University, Thailand; Faculty of Agriculture, Gadjah Mada Universiti, Indonesia; Faculty of Agriculture, Universiti Pertanian Malaysia, Malaysia; Department of Biology, College of Science, Technology and Medicine, University of London, U.K.

For the purpose of furthering friendship and promoting academic and educational cooperation, our Faculty and the above five universities agree to closely cooperate each other in carrying out the following particulars.

1. Exchange of professors, researchers and students.
2. The joint and/or collaborative researches, symposia and educational activities.
3. Exchange of information and materials relating to research and education in the areas of common interest. ■■

Intoduction to the Department of Agricultural Engineering Iwate University

by
Yoshinobu Ota
Professor Department of Agricultural Engineering
Faculty of Agriculture, Iwate University
3-18-8, Ueda, Morioka 020
Japan

Introduction

The Iwate University is located at the center of Morioka city (N39° 40′, E141° 10′), a prefectural seat of Iwate Prefecture in the Northeastern district of Japan. Morioka city is about 540 km north of the capital Tokyo and it takes about two and a half hours by the Tohoku Shinkansen (New super express). This city has a population of about 286 000 and is blessed with abundant nutural environment. It is a restful place lying between two mountain renges extending from south to north. Kitakami river joins with two other rivers at the center of the city and people enjoy watching the sweet fish (*ayu*) and salmon which sail in these rivers between summer and autumn. In winter, flocks of swan fly about in the skies of Iwate University campus.

This city stands at a central position in the northern region of the North-eastern district and has a terminal station of Tohoku Shinkansen line. The agricultural, forestry and livestock industries are extensively carried on in the surroundings of Morioka and the National and Iwate prefectural agricultural experiment stations are dotted within the suburbs of Morioka.

Iwate University was established in 1949, under the National School Establishment Laws, incorporating Morioka Agricultural and Forestry College, Morioka Technical College, Iwate Teachers' Junior College and Iwate Junior College for Young Men's School Teachers. The initial Faculties of Agriculture, Engineering and Education were later joined in 1977 by the Faculty of Humanities and Social Sciences, which was reorganized from the College of General Education. The Universitjy has also established Master's degree programs in Agriculture (1964), Engineering, Humanities and Social Sciences and Education. In 1990, Doctral programs were established for Agricultural Sciences and Veterinary Sciences while Engineering starts from 1996.

The Ueda campus consisting of four Faculties occupies a broad area of 43 ha. The number of staff is about 920, the number of undergraduate students is about 5 700, Graduate students (Master's program) 490 and Doctoral program students 108 in 1995.

Faculty of Agriculture

The parent of present Faculty of Agriculture is Morioka Agricultural and Forestry College, established in 1902 as the first National Agricultural College in Japan for the study of crop protection from cold-weather damage. In response to recent rapid changes in agriculture, a reorganization of agricultural education and research has been strongly required and was carried out 1991. The purposes of the reorganization were summarized in the follwing three points.

1) New educational and research systems were organized in response to a development of high technology in sciences such as biotechnology and information science, and to social needs

from environmental problems.

2) We recognize again roles of agricultural sciences as general sciences which produce, control and utilize organisms; we shall organize educational and research systems in order to engage in effective education and research.

3) We intend to create people of ability to cope with an internationalized age, and to expand our research abilities in response to the needs of local society.

For these purposes 44 small size laboratories in 7 departments were reorganized into 18 laboratories of middle size in 3 departments leaving 9 laboratories in the Department of Veterinary Medicine unchanged. **Figure 1** indicates four departments with 27 laboratories.

The Faculty of Agriculture is one of the leading faculties within National Universities in regard to the number of staff, the educational and research facilities and equipments. It possesses University Experimental Farm, University Livestock Farm, University Forests, Veterinary Hospital, Institute for Cell Biology and Genetics, Botanical Garden etc. The number of teaching and research staff is 120, the number of administrative staff is 80, Undergraduate students 1 060, Master's course students 105 and Doctoral course students 108.

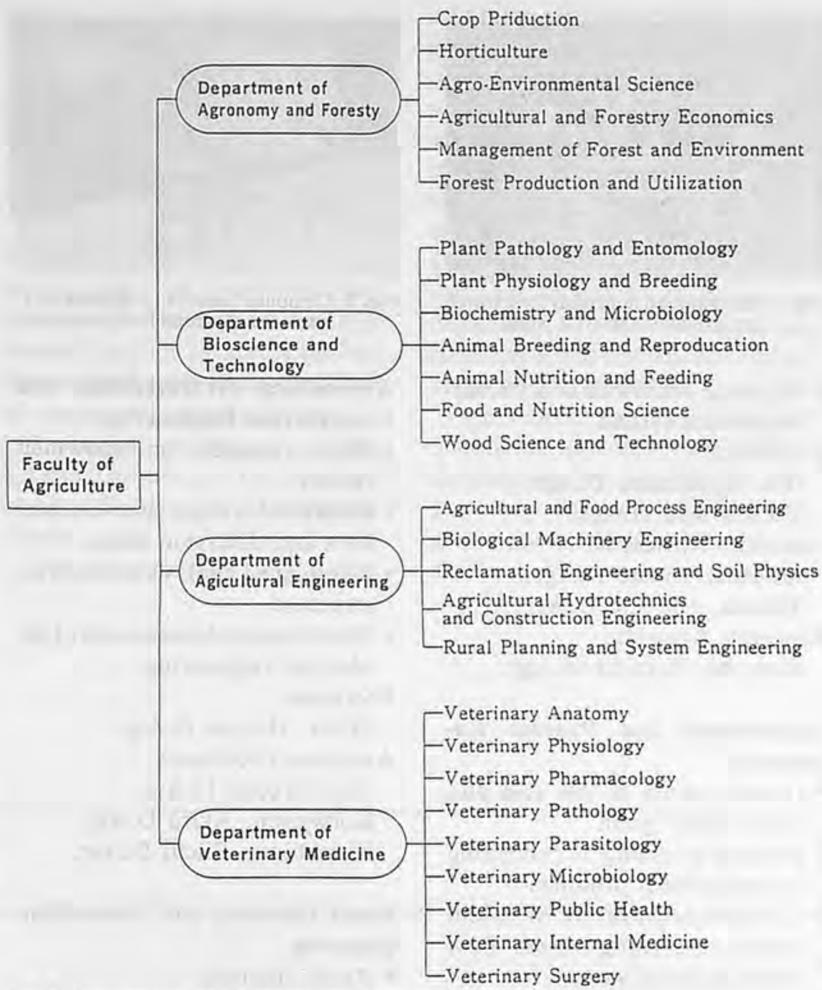


Fig. 1 Departments and Laboratories in Faculty of Agriculture.

Department of Agricultural Engineering

This department conducts special education and research on water and farm land as the foundation of the food production, agricultural machinery and facilities as the productive means, and farm rural community space as the life site, using the physical and engineering methods. We are not only individually deeply pursuing problems in the field of agricultural engineering, but also synthetically as one organic system.

The department is composed of two courses; Biological and Agricultural Engineering (BAE). and Agro-environmental Engineering (AEE). BAE course consists of the following two laboratories.

Laboratory of Biological Machinery Engineering deals with the design and development of agricultural machines and facilities concerned with processes from tillage to harvest, and the profitable employment technology.

Laboratory of Agricultural and Food Process Engineering deals with the processing and storage technology concerning farm products of postharvest and foods, and the utilization of the by-product from the biomass.

AEE course consists of three laboratories; Reclamation Engineering and Soil Physics, Agricultural Hydrotechnics and Construction Engineering, and Rural Planning and System Engineering. The main research activities and research staff under each laboratories are as follows;

Biological Machinery Engineering

- Soil cutting and tillage mechanism
- Dynamic interaction between a wheel and soils
- Steering characteristics and control of agricultural vehicles

Fig. 2 Experimental apparatus for a travel performance test of a wheel.

Fig. 3 Computer control of motion of a tractor-trailer combination model.

Fig. 4 Texture valuation test for boiled rice.

- Dynamic behaviour of a tractor-implement system

Professors
Ota, Yoshinobu D.Agr.
Torisu, Ryo D.Agr.
Associate Professors
Hiroma, Tatsuo D.Agr.
Takeda, Jun-ichi D.Agr.
Research Associate
Kataoka, Takashi M.Agr.

Agricultural and Process Engineering

- Developments of low cost and high quality grain
- Physical modeling on processing of agricultural products
- Continuous filtration of casein hydrolysate using vortex flow filtration system
- Quality evaluation and process control of pre-cooked frozen foods

Professors
Taneya, Shin-ichi D.Sc.
Nishiyama, Yoshio D.Agr.
Associate Professor
Miura, Makoto D.Agr.

Reclamation Engineering and Soil Physics

- Mechanism of consolidation processes of clay
- Soil physical problems of uncultivated paddy fields
- Structures of shear layers in soils and soft rocks
- Ultra micropore of soils

Professors
Kishimoto, Ryojiro D.Agr.
Koga, Kiyoshi D.Agr.
Associate Professor
Baba, Hidekazu D.Agr.

Agricultural Hydrotechnics and Construction Engineering

- Basic research on snowmelt runoff
- Relation between river channel bars and diversion dams
- Mechanical analysis of concrete structure
- Environmental assessment of geological engineering

Professor
Miwa, Hajime D.Agr.
Associate Professors
Fujii, Koichi D.Agr.
Kobayashi, Akira D.Agr.
Kurashima, Eiichi D.Agr.

Rural Planning and System Engineering

- Rural planning
- The human being and its environment
- Systems analysis in agricultural engineering
- Numerical analysis on water movement in soil

Professor
Koga, Yasumasa D.Agr.
Associate Professors
Fujii, Katsumi D.Agr.
Hirota, Jun-ichi D.Agr.
Lecturer
Fujisaki, Hiroyuki D.Agr.

Graduate School

Master's Program

The Graduate School of Agricultural Sciences consists of the following three master's courses: Agronomy and Forestry, Bioscience and Technology, and Agricultural Engineering. These graduate courses have almost the same academic calendars as the undergraduate courses.

Master's degree is awarded upon completion of two years of residence at the Graduate School of Agricultural Sciences, the completion of the required units for the course, the writing of an approved dissertation and the passing of final examination. The master's program in the agricultural engineering offers the advanced and special courses by the same staff in charge of the undergraduate education.

Doctral Program

The United Graduate School of Agricultural Sciences, Iwate University was established in 1990 as an education and research organization by the three Graduate Schools of Agriculture at Iwate, Hirosaki and Yamagata Universities. In 1994, Obihiro University of Agriculture and Veterinary Medicine (the Graduate School of Animal Husbandry) joined as a new constituent member. This school is run cooperatively by the four universities, each lacated in northern district of Honshu island (Tohoku) and Hokkaido, Japan.

We aim to contribute to advancement of agricultural industries and communities as well as agricultural sciences through education of excellent researchers and high-technological engineers endowed with highly specialized knowledge and ability. Furthermore, we will also devote ourselves to the education of foreign students who are rapidly increasing in Japan.

The United Graduate School is an independent three years Doctral Course separated from the Master's Courses. Eligible students are selected based on the results of the entrance examinations to evaluate their academic abilities, their research reports and other documents submitted. The entrance examinations consist of written tests and an oral test. The written tests cover abilities of foreign languages (English or Japanese) and a specialty subject to the examinees. The oral test focuses on the content of the master's theses of the examinees, and research plans to be done in the doctoral course.

International Exchange

Iwate University has been promoting the international cooperation in education and research service by accepting foreign students and researchers from all corners of the world. Out of 117 foreign students studying in Iwate University, 61 of them are in the Faculty of Agriculture (1995).

The students can be grouped into three categories; Those studying under the Ministry of Education (Monbusho) scholarships program, those studying with the assistance from their own governments and those studying on private funds. Application and selection of recipients of Japanese Government (Monbusho) scholarships are done through the recommendation of either the Japanese Embassy at the applicants country or Iwate University.

Applicants for the Graduate School are advised to contact the Department of Agricultural Engineering through the address given above, Fax. +81-196-21-6204. ■■

The Updated Version of the AMA Computerized Index Available

A computerized index of technical articles in Agricultural Mechanization in Asia, Africa and Latin America has been compiled for the year 1971 through 1994. Each citation includes truncated versions of the title, first and second authors' names and four keywords. Year, issue and page number of each article are given. The citations along with software for searching the database are all included on a single computer diskette for use with IBM compatible type computers.

Anyone wishing to receive this may contact William Chancellor, Biological and Agricultural Engineering Department, University of California, Davis, CA 95616, USA, and the database along with searching software and documentation will be sent by airmail on a 5 1/4-inch, 360 kbyte diskette. Those wishing some other type of diskette should send one formatted diskette with their request. There is no charge. Any special customs or postal designation or specifications required should be stated in the request. Annual updates will be available in the future.

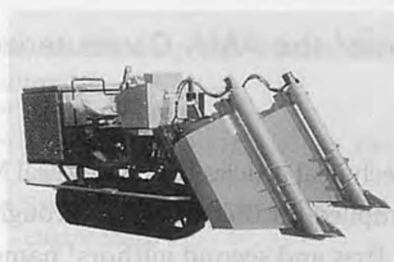
Main Products of Agricultural Machinery Manufacturers in Japan

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

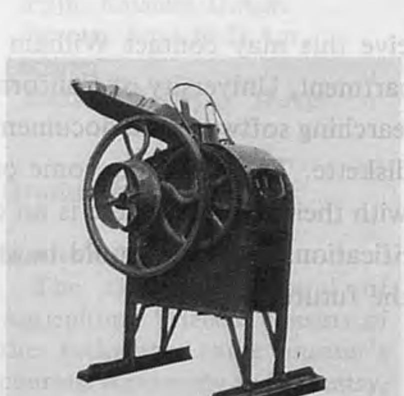
Introduced here are the main products of agricultural machinery manufacturers in Japan with a number of photographs.

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

NINJA — A Combined Use of High Pressure Cleaner and Agricultural Sprayer. Light weight and compact design for easy portability. Maximum working pressure of the pump is 65 kgf/cm^2. The unit is designed for duplicate applications for high pressure cleaning at 65 kgf/cm^2 and agricultural chemical spraying at 35 kgf/cm^2 by the operation of pressure regulator and it does not rise water temperature even while nozzle is closed. All the wetted parts are made of anti-chemical materials. **(ARIMITSU)**



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



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 hp diesel engine gives you the power you need to deal with all your mowing tasks quickly, while its efficient use of fuel makes it economical as well. Cutting width: 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.

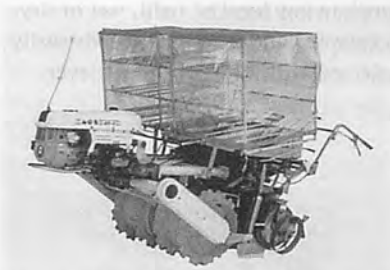
KUBOTA Combine Harvester SKY ROAD PRO 481-M. Easy-to operate, micro-computerized 4-line combine harvester that cuts down on time as well as crop. Equipped with many helpful mechanisms and a reliable water-cooled diesel engine. Max. output: 48PS/2700 rpm.

KUBOTA 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.

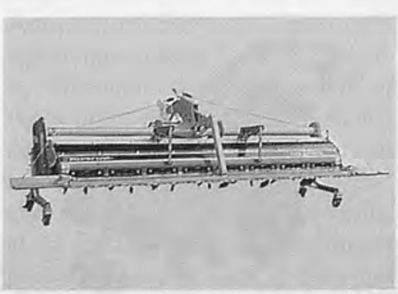
MAMETORA Vegetable Transplanter TP-3V. This machine is available in both pot and soil block in seedling transplanting. Application: all vegetable nursery.

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

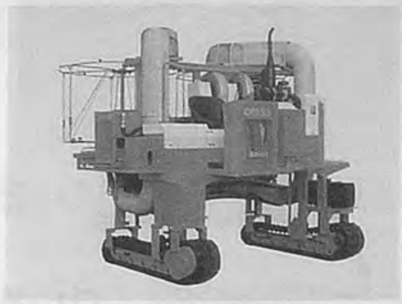
MARUYAMA Portable Power Sprayers MSO55D. Engine: Air-cooled, 2-cycle, output 22.6cc, Pump: Suction capacity 5.1ℓ/mm, max pressure 25kg/cm^2, Weight: 8.5kg.



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

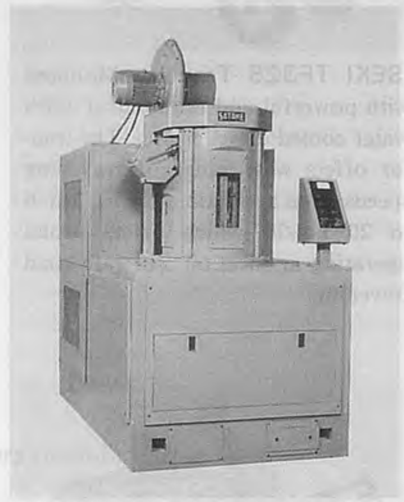


OCHIAI Riding Type Tea Picking Machine OM-25. Full working width cutter bar. Stepless speed control. Water-cooled Diesel engine 28.5PS.

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.

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



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

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

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

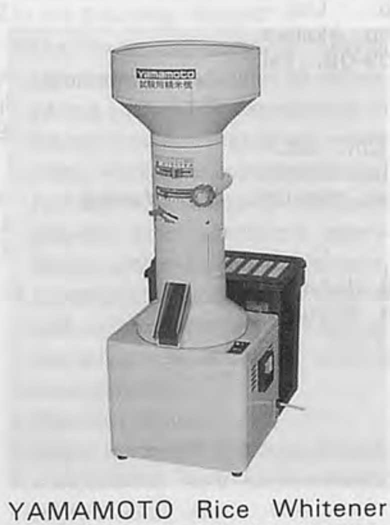
STAR Mini-Roll Baler MRB 0810. Automatic pick-up, rolling and ejection. One bale every 30 seconds. Handy bale size (50cm in diameter and 70cm long). Required tractor horsepower: 18-30 HP.

SUKIGARA Hand Cultivator. Here ia a new HAND CULTIVATOR to replace conventional hand agricultural implements! With this model, you can work more easily and efficiently from an upright position no longer will you have to bend over to guide your cultivator.

★ ☆ ★

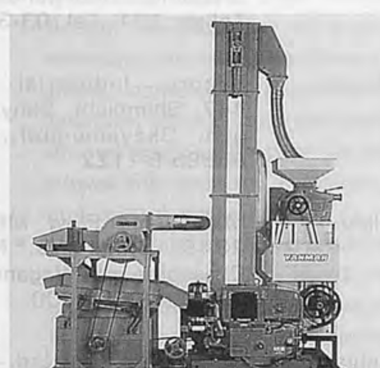
TIGER KAWASHIMA Rice Combi and Grader. Rice grading machine and automatic weighting and packaging.

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 × 0.5L × 1.2H.



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 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.



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

DIRECTORY

Arimitsu	Arimitsu Industrial Co., Ltd.—7-4, 1-chome, Fukae-kita, Higashinari-ku, Osaka, 537. Tel. 06-973-2010
Bunmei	Bunmei Noki Co., Ltd.—11-4, 1-chome, Korimoto-cho, Kagoshima-city, 890. Tel. 0992-54-5121
Chikuma	Chikuma Farm Machinery Mfg. Co., Ltd.—356, Yoshikawa-koya, Matsumoto-city, Nagano-pref., 399. Tel. 0263-58-2055
Daishin	Daishin Co., Ltd.—3-23-1, Yoyasu-cho, Ogaki-city, 503. Tel. 0584-75-5011
Iseki	Iseki & Co., Ltd.—3-14, Nishi-Nippori, 5-chome, Arakawa-ku, Tokyo, 116. Tel. 03-5604-7600
Kioritz	Kioritz Corporation—7-2, Suehirocho 1-chome, Oume-city, Tokyo, 198. Tel. 0428-32-6118
Kubota	Kubota Corporation—2-47, Shikitsu-Higashi, 1-chome, Naniwa-ku, Osaka, 556-91. Tel. 06-648-2434
Mametora	Mametora Agric. Machinery Co., Ltd.—9-37, 2-chome, Nishi, Okegawa-city, Saitama-pref., 363. Tel. 048-771-1181
Maruyama	Maruyama Mfg. Co., Inc.—4-15, 3-chome, Uchi-kanda, Chiyoda-ku, Tokyo, 101. Tel. 03-3252-2281
Minoru	Minoru Industrial Co., Ltd.—447, Shimoichi, Sanyo-cho, Akaiwa-gun, Okayama-pref., 709-08. Tel. 08695-5-1122
Niplo	Matsuyama Plow Mfg. Co., Ltd.—2949, Shiokawa, Maruko-machi, Chiisagata-gun, Nagano-pref., 386-04. Tel. 0268-35-0300
Ochiai	Ochiai-Shoji Co., Ltd.—58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-pref., 439. Tel. 0537-36-2161
Orec	Orec Co., Ltd.—23-4, Jyojima, Jyojima-cho, Mizuma-gun, Fukuoka-pref., 830-02. Tel. 0942-62-3161
Robin	Fuji Robin Industries Ltd.—35, Ohoka, Numazu-city, Shizuoka-pref., 410. Tel. 0559-63-1111
Sasaki	Sasaki Corp. Ltd.—1-259, Satonosawa, Towada-city, Aomori-pref., 034. Tel. 0176-22-3111
Satake	Satake Corp.—Ueno 1-19-10, Taito-ku, Tokyo, 110. Tel. 03-3835-3111
Shizuoka	Shizuoka Seiki Co., Ltd.—4-1, Yamana-cho, Fukuroi-city, Shizuoka-pref., 437. Tel. 0538-42-3114
Star	Star Farm Machinery Mfg. Co., Ltd.—1061-2, Kamiosatsu, Chitose-city, Hokkaido, 066. Tel. 0123-26-1123
Sukigara	Sukigara Agricultural Machinery Co., Ltd.—38, Sairinji, Yahagi-cho, Okazaki-city, Aichi-pref., 444. Tel. 0564-31-2107
Tiger	Tiger Kawashima Co., Ltd.—4290, Fujioka, Fujioka-cho, Shimotsuga-gun, Tochigi-pref., 349-13. Tel. 0282-62-3001
World	World Seiken Co., Ltd.—11-1, Yamazaki Ohiro, Tsuruoka-city, Yamagata-pref., 997. Tel. 0235-35-2555
Yamamoto	Yamamoto Co., Ltd.—404, Oinomori, Tendo, Tendo-city, Yamagata-pref., 994. Tel. 0236-53-3411
Yanmar	Yanmar Agricultural Equipment Co., Ltd.—1-32, Chaya-machi, Kita-ku, Osaka-city, 530. Tel. 06-376-6336 ■■

Club of Bologna — strategies for the development of agricultural mechanization

Conclusions and Recomendations of the 6th Full Members Session November 6-8, 1995 EIMA Show, Bologna, Italy

50 Experts from 25 countries attended the meeting - held under the auspices of CIGR -discussing a general subject on "*An appropriate agricultural mechanization in the various world regions*". The subject was subdivided into three main topics:

1) Methodologies for the identification of the optimum mechanization levels;
2) Technological levels needed in the various agricultural areas; and
3) Role of high technologies to contribute to the machine design and operations.

The meeting reached unanimously the following.

1. Methodologies for Identification of Optimum Mechanization Levels

Three key-note reports by E. Audsley (UK), P. Jannot (F) and G. Castelli and F. Mazzetto (I) were presented. Each summarizes the advances in modelling of mechanization management in the three countries.

On the basis of a wide-ranging discussion, the members drew the following main conclusions.

The use of computer-based mechanization modelling can significantly contribute to the identification of optimum mechanization strategies. The up-to-date research results on the subject show that the sector has greatly progressed in terms of both methodology (acquisition and transfer of data, identification of the various modelling techniques, definition of goals) and availability of appropriate computer programs.

The application of model-based systems will allow improved organization of farms in terms of crops grown and more rational use of farm equipment. This offers potential economic gains through improved efficiency of production.

For effective diffusion at farm level of the various models, it is necessary to overcome constraints such as:

- the difficulty of making available reliable farm data;
- the lack of education of farmers in the use of modelling technologies for decision making;
- the lack in several countries of effective extension services; and
- the difficulty of demonstrating the effectiveness of the results from the use of appropriate models.

Taking into account the above considerations, the following research priorities are identified:

- improved modelling methodologies incorporating factors such as risk, environmental impacts and other unquantifiables;
- automated data collection from machines engaged in the real farm operations; and
- interactive models for machinery management.

In developing farm model-based systems, due regard should be given to the following factors:

- for each agricultural region representative data must be collected and analysed on depreciation of tractors and other machines, repair costs, work rates, consumption of fuel and other energies, timeliness penalties from agronomic experiments, and environmental impacts;
- acceptability to the beneficiaries such as farmers, contractors and co-operatives with machinery sharing arrangements;
- flexibility of use;
- ability to identify and control risks;
- compatibility with environmental requirements; and
- in harmony with standards relating to machines and agricultural practices.

2. Technological Levels Needed in Different Agricultural Areas

Four key-note reports were presented covering the industrialized countries, south-asian, central and east-european and latin-american countries, respectively.

On the basis of the report presented by J.K. Schueller and W.A. Stout (USA), the Club Members recommend that the highly industrialized countries develop their mechanization policies to reduce production costs, improve product quality, safeguard workers' health and safety and protect the environment (soil, water, air). Taking into account the growing role of contractors, the members agree on the need to develop two main mechanization strategies, one to be used by contractors and machinery-sharing companies and one to be used directly by farmers.

These goals could be achieved through:

- for tractors: the optimization of tractor-implement combinations; low ground pressure high efficiency tyres and tracks; light weight design; the reduction of engine emissious; the reduction of energy losses; continuously-variable transmissions; mechanical front-wheel drive systems; suspensions for improved ride comfort; and sensing and control elements;
- for agricultural machines: precision farming technologies based on global positioning systems; technologies for tillage; innovations which reduce specific energy inputs and emissions; new machinery for biomass and other industrial crops; machinery with improved performance; sensors and related algorithms to control performance; and systems to minimize operator exposure to chemicals and to other health and safety risks.

These technologies are often too expensive for one manufacturer. The Club members, therefore, underline the need to support research co-operation and technology transfer between research institutes and/or the industrial sector.

The key-note report presented by G. Singh (India) underlined the development of indian agriculture over the last 45 years. At present, India is self-sufficient in food production through the increased use of high-yielding varieties and irrigation as well as the increase in power made available for agriculture through rural electrification and the introduction of locally manufactured tractors and other machines. By the year 2000, however, the total population of India will reach 1 billion, the agricultural area is subdivided into more than 105 million farms with an average size under 2 ha; the efficiency of use of the key agricultural inputs is still low and about 70% of total cropped area is dryland with low and variable crop yields.

Taking into account these major issues, the members recommended the local development of appropriate mechanization, with particular reference to the technologies for:

- environmental conservation;
- improvement of produce packaging and handling;
- development of rural agro-processing, including aquaculture and the utilization of agricultural wastes; and
- rationalization and development of modern irrigation systems driven by renewable energy sources.

The development of agricultural extension services and contractor services are crucial to achievement of these objectives.

On central and east-european countries, the members, on the basis of the key-note report by P. Kic (CZ), recognize the general difficulties of the various countries in transforming the centrally-planned economies into market economies. These difficulties have produced an economic recession in both the industrial and agricultural sectors within the former COMECON area, with the result that the agricultural machinery industry has drastically reduced its production. The present situation in the various countries is greatly different but there are some common characteristics, namely, the large numbers engaged in agriculture and the small farm size of a few hectares, despite, the continued existence of large cooperative farms.

The drastic reduction of industrial production in the last four years and the decrease in purchasing power of the farmers has limited introduction of appropriate mechanization and good farm management. Once the opportunity for the development of contractor services and shared machinery use was demonstrated, some small manufacturers and dealers were able to service the immediate agricultural needs. Joint ventures between local manufacturers and well-established international companies could continue this trend.

On the basis of this approach the members recommend that industrialized countries should promote the transfer of appropriate technologies to increase yields, decrease losses and improve environmental protection. Without resolution of the issue of land ownership, the development of cooperation between eastern and western manufacturers will be inhibited.

The key-note report presented by T.L. Wiles (UK) which highlighted several important issues linked to the development of agricultural mechanization in Latin America, confirms the considerable yet diverse need for mechanization of food and industrial crops on farms of widely varying sizes and management systems.

Levels of mechanization vary considerably through the region and it is not uncommon to find well-organized, highly mechanized agriculture alongside systems based almost exclusively on hand-labour, as is the case with all the coffee grown outside Brazil.

Case study examples were provided on agrochemical spraying and soil tillage to illustrate the need for appropriate mechanization to protect workers and the environment, to conserve soil and water and to assist timely planting. These are issues which are currently much more critical in this part of the world than in most developed agricultural countries.

Moreover, the appraisal confirms that simply transferring technologies from more developed countries into Latin America, is often inappropriate. Requirements are location-specific and must take into account the prevailing climatic, pedological, agronomic, structural and socio-economic conditions.

The members recommend the following principles for improved mechanization in Latin America:

- to pay particular attention to the local conditions, which require the development of appropriate systems and strategies which often differ from those of more developed countries; and
- to support links between agricultural engineering research institutions and equipment manufacturing companies as well as cooperation between Latin America and industrialized countries.

3. Role of Advanced Technologies in Machine Design and Operation

The key-note report by F. Sevila, J.M. Roger and B. Bonicelli (F) focussed mainly on mechatronics. This term is widely applied to machines operating with less direct human involvement.

These machines are being developed in response to new social, economic and technological trends:

- the development of highly-specialized types of farming;

- the reduced willingness of labour to perform some tasks; and
- the improved performance and decreasing cost of electronic components and software.

The members recognize that mechatronics for agricultural applications (including on-line sensors, signal, data and information processing systems, and electronically controlled actuators) tend to be more complex than the ones developed for other industrial applications.

Mechatronics should not be developed in isolation, but rather in cooperation between farmers, engineers, information technology specialists, and scientists. There is, of course, a need for the industry to develop specific expertise in its design teams which will allow them to make experienced decisions.

Procedures to discipline the design process have been identified. They include hierarchical system modelling to represent the mechatronic device throughout its development, and systematic representation of the reasoning for each step of the design.

Having recognized the advantages that the application of mechatronics can give to the agricultural machinery sector, the members recommend a coordinated effort for further development of these technologies.

- Taking into account that a limitation of the application of mechatronics is that agronomic and biological models, and appropriate sensors, are less advanced than mechatronic devices, greater efforts should be devoted by agronomists, biologists and physicists, to remedy this deficiency.
- Taking into account that most agricultural machinery manufacturers are of a small to medium size improved R&D cooperation between research institutions and industry should be stimulated in order to support the application of this innovative approach.
- A high priority is also given to adequate education of engineers, which should not be by isolated training but by focussing on the real needs of machinery and farming systems.

Japan Step up Assistance to ICARDA

(ICARDA News-Syria, October 1995)

Japan, the world's largest official aid donor, has increased its contribution to ICARDA from US$371 000 in 1994 to ¥56 950 000—about US$575 000—for fiscal year 1995.

In recent years Japan has contributed, on average, about US$ 370 000 directly to ICARDA's core funding annually. However, it also gives support to specific projects as well as considerable aid in kind, including scientific equipment and the secondment of Japanese scientists to work with ICARDA.

"Some US$280 000 of Japan's contribution for the fiscal year 1995 is directed towards two specific projects—on the nutrition and management of small ruminants, and on improvement of native pastures and rangelands. This is crucial to the region's future; not only because sheep and goats are important to the economy, but because it will help us fight the degradation of pasture through overgrazing, which has a direct bearing on soil erosion. Japan is helping in a direct way to keep soil where it is needed."

The balance of the contribution will go to ICARDA's unrestricted core budget and will help support a diverse range of activities that includes crop improvement, resource management, socioeconomic research and the development of sustainable agronomic practices.

Ever since ICARDA's foundation in 1977, Japan has been a supportive partner of the Center.

IRRI Celebrates 35 Years of Successful Rice Research

Thirty-five years of successful research aimed at improving the well-being of rice farmers and consumers were celebrated in September 1995 at the International Rice Research Institute (IRRI) in Philippines.

On two special "Days", IRRI opened its doors to two major groups of people who traditionally have been beneficiaries, and sometimes critics, of the Institute's research: non-government organizations (NGOs) and farmers.

Although many NGOs and farmers visit IRRI every year in their individual capacities, this was the first time IRRI had invited them to visit in large groups to see the research being done in Los Banos, and to discuss matters of mutual concern.

Ninety-one representatives from 34 NGOs attended the "NGOs' Day at IRRI" and made field visits to demonstration stations on the long-term study of biofertilizers, integrated pest management, small farm machines, methane emissions and climate change, the rice seed gene-band, biotechnology and the transgenic greenhouse and the new plant type ("super rice"). They ended the day with a broad-ranging open-forum discussion.

The "Farmers' Day at IRRI" attracted more than 600 Philippine farmers, provincial and municipal agriculturists, extension workers and agricultural technicians from four Philippine provinces. The farmers made field visits similar to the program for the NGOs, and also took part in an open forum after the field visits.

PIACENZA 96 — International Seminar of C.I.G.R. "New Use for Old Rural Buildings in the Context of Landscape Planning"

20-21 June, 1996
THe Catholic University, Piacenza, Italy

The landscape has become more and more regarded as a precious and irreplaceable heritage for this generation and those yet to come. In lands which have been farmed for centuries rural buildings are component of the landscape, and frequently the predominating one. It is thus important to preserve their external appearance, but their very survival depends on their having some meaningful use.

The aim of the seminar is to discuss the problems posed by the employment of old rural buildings in situations perhaps different from the ones for which they were constructed without compromising excessively their relationship with the landscape.

This is the first announcement of the International Seminar of the Second Technical Section of C.I.G.R.

The seminar is organized by the A.I.I.A. (Associazione Italiana di Ingegneria Agraria) and the Università Cattolica del Sacro Cuore di Piacenza.

A Joint International Conference on Agricultural Engineering and Technology Exhibition
Theme: Agricultural Engineering for Sustainable Development

December 15-18, 1997
Dhaka (Cosmopolitan Capital City), Bangladesh

Call for Papers

The organizing Committee is pleased to invite papers/posters on the following topics: 1. Power, Machinery and Farm Mechanization; 2. Irrigation, Flood Control, Water Resources and Management; 3. Soil and Water; 4. Post-harvest Technology; 5. Advances in Food Processing and Engineering; 6. Fruits, Vegetables Production, Handling, Processing and Packaging; 7. Physical and Chemical Properties of Bio-materials; 8. Agricultural Waste Management and Utilization; 9. Green House Engineering and Agro-Chemical Technology; 10. Electronic and Software Technology; 11. Automation and Control Technology; 12. Modeling with Finite Elements; 13. Research Planning, Management, Evaluation and Technology Transfer; 14. Sustainable Agricultural Systems and Modeling; 15. Weather and Environment Technology; 16. Appropriate Agricultural Technology; and 17. Bio, Solar, Wind, Renewable Energy and Technology.

Anyone involved in agriculture and food, directly or indirectly may, submit a paper.

Last date of submission of abstract (in English, 200-300 words): December 1, 1996.

Notice of acceptance: February 29, 1997.

Final paper ready: October 30, 1997.

Organizing and Participating Countries: Canada, China, Egypt, Ghana, India, Japan, Jordan, Kenya, Korea(s), Lebanon, Philippines, Papua New Guinea, Sierra Leone, Turkey, Thailand, Tanzania, United Kingdom, USA, United Arab Emirate, Vietnam and Bangladesh.

Send abstract by mail, fax or e-mail to one of the following:

1. Professor John Gerrish, Agricultural Engineering Department Michigan State University, East Lansing, MI 48824, USA. Fax: 517-353-8982, E-mail: gerrish@egr.msu.edu
2. Professor A.E. Ghaly, Technological University of Nova Scotia. P.O. Box 1000, Halifax, Nova Scotia, Canada B3J 2X4. Fax: 902-420-7551. E-mail: aeghaly@tuns.ca
3. Dr. M.A. Mazed, Director-General, Bangladesh Agricultural Research Institute, Joydevpur, Gazipur 1701 GPO Box: 2235. Bangladesh. Fax: 880-2-813032, Telex: 642401 SHERBJ.

Inquiry about registration, session, abstract, program, accommodation, travel and visa contact: Dr. Habib Chowdhury, Conference Convenor. Agricultural Engineering Department, Michigan State University. East Lansing, MI 48824. USA. Ph: 517-353-3883. Fax: 517-353-8982. E-mail: chowdhu2@pilot.msu.edu

Registration fee for developed countries is US$150.00; for South Asian (SAARC) and all developing countries, US$75.00; and for host country US$15.00. Special package deals (Luxury class or First class) are available upon request. The package deals include 4 days of accommodation, meals, airport service, technical tours, industry visit and cultural show. Luxury and First class packages will cost US$240.00 and US$120.00, respectively. Additional days can be arranged upon advance request. All international participants are required to confirm preregistration and package deal at the time of abstract submission. bank draft drawn in US dollar must be payable to **International Ag Engineering Conference 1997** and sent directly to Professor Shah M. Farouk, Chairman, Organizing Committee and Vice-Chancellor, Bangladesh Agricultural University, Mymensingh 2202, bangladesh by May 30, 1997. The conference is a non-profit venture. No funds are allocated to pay registration, accommodation, travel or any other costs of participants. ■■

Clean Water-Clean Environment-21st Century
Team Agriculture-Working to Protect Water Resources

(USA)

This conference proceedings was sponsored by the Working Group on Water Quality — U.S. Department of Agriculture and coordinated by ASAE.

This three volume set will provide you with the newest adoptable technologies to reduce agricultural impacts on water quality. Accomplishments in water quality programs during the last five years as reported by "Team Agriculture" are featured in the following three volumes:

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Volume II: Nutrients
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This proceedings discusses the mutual implications of agricultural and water quality issues; and will help you identify emerging concerns; develop strategies to protect or enhance water quality in economically, socially, and environmentally responsive ways; and provide you with strategies to effectively communicate to the public and educate the farming community.

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Microirrigation for a Changing World: Conserving Resources / Preserving the Environment— Proceedings of the Fifth International Microirrigation Congress

(USA)

Microirrigation is a beneficial tool for improving world food production while conserving water and energy resources and preserving the quality of our environment.

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Versatility of Wetlands in the Agricultural Landscape

(USA)

edited by Kenneth L. Campbell

The preservation, restoration, functions, and uses of wetlands have become important issues throughout the world during the past several years. This proceedings, held September 17-20, 1995, in Tampa, Florida, will benefit policy makers, consultants, soil scientists, biologists, ecologists, and engineers in both the public and private sectors. Learn more about issues and developments related to the role of wetlands in the agricultural landscape.

Highlights include:
- Water Resources
- Wildlife and Habitat Protection
- Alternative Uses of Wetlands

Discover the broad range of technology applicable to alternative uses and management of wetlands in addition to wetland identification, restoration, and the various aspects of constructed wetlands.

These proceedings are published both in printed form and in an electronic form on CD-ROM media. The CD-ROM includes all necessary reader software for DOS, Windows, Mac, and Sun UNIX environments.

760 pages, 6 × 9 inches, softbound, $65.00 List, $55.00 ASAE Member.

Water Quality Modeling— Proceedings of the International Symposium

(USA)

The impact of chemicals associated with agriculture on water quality has been a major concern to scientists and engineers for several decades. Simulation models have been developed to incorporate the knowledge devevloped from field and laboratory studies of chemical fate and transport in the environment into a complete systems approach.

Experts provide you with the tools to improve the understanding of the complex interactions involved in the system, to better identify areas of inadequate understanding of the system, and to aid in making policy and management decisions concerning the use of chemicals in the agricultural environment.

This speciality conference brings together researchers working on water quality modeling. Basic research on process models and parameter estimation as well as the interests of end users of water quality models are featured in this proceedings.

539 pages, 6 × 9 inches, softbound, $44.00 List, $39.00 ASAE Member.

ABSTRACTS

The ABSTRACT pages is to introduce the abstracts of the article which cannot be published in whole contents owing to the limited publication space and so many contributions to AMA. The readers who wish to know the contents of the article more in detail are kindly requested to contact the authors.

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The Effect of Working Posture of Rural Women for Selected Farm Operations: Swaminathan, K.R., Dean, College of Agric. Eng.; S. Parvathi, Assist. Professor, Dept. of Bioenergy, respectively, Tamil Nadu Agricultural University, Coimbatore 641 003, India.

A study was undertaken in Coimbatore District to correlate the working postures of rural women and the energy expenditures for selected farm operations in cotton cultivation. It was concluded that inspite of the similarities in sowing and thinning operations in the postures, about 22% of increased energy expenditure was observed in thinning operation. However, the energy expenditure for sowing and hoeing was approximately 2 340 K cal. Energy required for cotton picking was the least. The study reveals that thinning operation was more tiring in view of energy requirement.

402

Development and Evaluation of a Manually-operated Rotary Cleaner cum-Grader for Green Gram: Kailappan, R., Assoc. Professor, Regional Research Station, Paiyur, Tamil Nadu, India; L. Gothandapani, Professor and Head, Dept. of Agric. Processing, Tamil Nadu Agricultural University, Coimbatore, India; R. Rajagopalan, Professor and Head, Regional Research Station, Paiyur, Tamil Nadu, India; R. Visvanathan, Assist. Professor, Dept. of Agric. Processing, Tamil Nadu Agricultural University, Coimbatore, India.

A manually-operated rotary cleaner cum-grader for green gram (*Vigna radiata L. Wilc Zek*) was developed and evaluated for its performance. The highest effectiveness of the unit was 0.778 at 3.0 degree slope of the sieve and 30-35 rpm speed of the rotor, irrespective of the feed rate. The capacity of the unit was 225 kg per hour. The cost of the unit is \$76.00 (Rs. 2 500.00) and the cost of operation is \$0.06 (Rs. 2.00) per quintal of green gram.

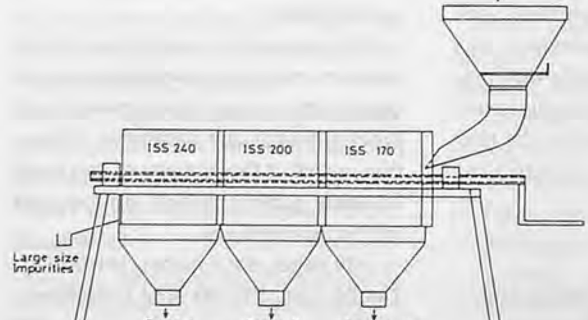

Fig. Manually-operated cleaner cum grader for green gram.

413A

A Simulation Model of Post-sowing Field Operations of Winter Season Fodder Seed Crops Part I Model Description and Validation: Chaudhuri, D., Senior Scientist, Central Institute of Agricultural Engineering, Bhopal; K.A. Rao, Professor, Agric. Engineering Dept., Indian Institute of Technology, Kharagpur; and P.P. Iyer, Senior Scientific Officer, Indian Institute of Science, Bangalore; respectively, India.

A stochastic simulation model of post-sowing farm operations is presented based on farming practices of a typical fodder farm. The Monte Carlo simulation techniques were used in the model. The model promises to incorporate variability, through it, of various the input variables as it was possible to determine range of output variables and forecast the effects of several management decisions. Most of the output variables in the model were validated at ±5% accuracy level. A few variables were validated at ±20%, accuracy level.

413B

A Simulation Model of Post-sowing Field Operations of Rabi Season Fodder Seed Crops Part II Prediction of Range of Output Variables and Indentification of Critical Variables: Chaudhuri, D., Senior Scientist, Central Institute of Agricultural Engineering, Bhopal; K.A. Rao, Professor, Indian Institute of Technology, Kharagpur; and P.P. Iyer, Senior Scientific Officer, Indian Institute of Science, Bangalore, respectively, India.

In Part I of this paper, the description of model to simulate post-sowing field operations of Rabi fodder crops was presented. In this Part II section, the prediction of range of output variables by obtaining their probability distribution is discussed. Also, critical variables affecting the model were identified by studying the patterns of change in values of output variables caused by changes in values of input variables. It was found that an increase in man-power availability did not affect the modél output significantly but an increase in labour cost significantly increased the total variable cost.

INSTRUCTIONS TO AMA CONTRIBUTORS

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

Criteria for Article Selection

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

a. are written in the English language ;
b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are printed, double-spaced, under 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.

Rejected/Accepted Articles

a. As a rule, articles that are not chosen for AMA publication are not returned unless the writer(s) asks for their return and are covered with adequate postage stamps. At the earliest time possible, the writer(s) is advised whether the article is rejected or accepted.
b. When an article is accepted but requires revision/modification, the details will be indicated in the return reply from the AMA Chief Editor in which case such revision/modification must be completed and returned to AMA within three months from the date of receipt from the Editorial Staff.
c. "The AMA does not pay for articles published. However, the writers are given collectively 5 free copies (one copy air-mailed and 4 copies sent by surface/sea mail) of the AMA issue wherein their articles are published. In addition, the main author is given an article on floppy disc with AMA true format. Co-authors can get a copy from main author.
d. Complimentary copies: Following the publishing, three successive issues are sent to the author(s).

Procedure

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

Format/Style Guidance

a. Article must be sent on 3.5 inch floppy disk with MS DOS format (e.g. Word Perfect, Word for DOS, Word for Windows.....) along with one printed copy.
b. The data for graphs and the black & white photographs must be enclosed with the article.
c. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
   i) a brief and appropriate title ;
   ii) the writer(s) name, designation/title, office/organization ; and mailing address ;
   iii) an abstract following ii) above ;
   iv) body proper (text/discussion) ;
   v) conclusion/recommendation ; and a
   vi) bibliography
d. The printed copy must be numbered (Arabic numeral) successively at the top center whereas the disc copy pages should not be number. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e.g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e.g., "Figure 1. View of the Farm Buildings".
e. The data for the graph must also be included.
f. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
g. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
h. Express measurements in the metric system and crop yields in metric tons per hectare (t/ha) and smaller units in kilogram or gram (kg/plot or g/row).
i. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
j. Convert national currencies in US dollars and use the later consistently.
k. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
l. When numbers must start a sentence, such numbers must be written in words, e.g., Forty-five workers..., or Five tractors..." instead of 45 workers..., or, 5 tractors.


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Y Pinar


P V Lang


A P Kaloyanov

A.M. Michael
Vice-Chancellor, Kerala Agricultural University, Vellanikkara, 680654, Thrissur Dt., Kerala State, India

T.P. Ojha
Dy. Director, General, Indian Council of Agricultural Research, Krishi Bhawan, Dr. Rajemdra Prassad Road, New Delhi-110001. Inida

S.R. Verma
Prof. of Agricultural Engineering, College of Agril. Engg., Punjab Agricultural University, Ludhiana - 141004, India

Soedjatmiko
Head of Subdirectorate of Agric. Engineering, Ministry of Agriculture, Jakarta, Indonesia

Mansoor Behroozi-Lar
President, Iranian Society of Agricultural Machinery Engineers, P.O. Box 31585-574, Karaj, Iran

Jun Sakai
Professor Emeritus, Dept. of Agric. Engineering, Faculty of Agriculture, Kyushu University 46-05, Hakozaki, Higashi-ku, Fukuoka 812, Japan (Mailing address: 31-1, Chihaya 2-chome, Higashi-ku, Fukuoka 813, Japan)

Bassam A. Snobar
Professor & chairman, Piant Production Dept., Faculty of Agriculture, University of Jordan, Amman, Jordan

Chang Joo Chung
Professor, and Dean, College of Agriculture and Life Sciences, Seoul National University, Suweon 441-744 Korea 103

Chul Choo Lee
Research Professor, Seoul Woman's University, Mailing Adress: Rm. 514 Hyundate Goldentel Bld. 76-3 Kwang Jang Dong Ku, Seoul, Korea

Imad Haffar
Associate Professor of Agric. Mechanization, Faculty of Agricultural Sciences, United Arab Emirates University, Al Ain, P.O. Box 17555 UAE

Muhamad Zohadie Bardaie
Professor and Deputy Vice Chancellor (Development Affairs), Universiti Pertanian Malaysia, 43400 UPM, Serdang, Selangor, Darul Ehsan, Malaysia

Madan P. Pariyar
Consultant, Rural Development through Self-help Promotion Lamjung Project, German Technical Cooperation, P.O. Box 1457, Kathmandu, Nepal

ElTag Seif Eldin
Mailling Address: Dept. of Agric Mechanization, College of Agriculture, P.O. Box 32484, Al-Khod, Sultan Qaboos University, Muscat, Sultanate of Oman

Allah Ditta Chaudhry
Professor and Dean Faculty of Agric. Engineering and Technology, University of Agriculture, Faisalabad, Pakistan

A.Q. Mughal
Professor, Faculty of Agricultural Engineering, Sind Agriculture University, Tandojam, Sind, Pakistan

Rafiq ur Rehman
Director, Agricultural Mechanization Research Institute, P.O. Box No.416 Multan, Pakistan

Reynaldo M. Lantin
Agricultural Machinery Expert, Regional Network for Agricultural Machinery, c/o United Nations Development Programme P.O. Box 7285 ADC Pasay City Metro Manila, Philippines

Ricardo P. Venturina
President & General Manager, Rivelisa publishing House, 215 F, Angeles St. cor Taft Ave. Ext., 1300 Pasay City, Metro Manila, Philippines

S. G. Illangantileke
Head, Dept. of Agric. Engineering, Faculty of Agriculture, University of Peradeniya, Sri Lanka (Mailing Address: Postharvest Specialist and Regional Representative South West-Asia, International Potato Center (CIP), Regional Office, IARI Campus, New Delhi 11012, India)

Sen-Fuh Chang
Professor, Agric. Machinery Dept. National Taiwan University, Taipei, Taiwan

Tieng-song Peng
Deputy Director, Taiwan Agricultural Mechanization Research and Development Center, FL. 9-6, No. 391 Sinyi Road, Sec. 4, Taiwan

Surin Phongsupasamit
Associate Professor, Dept. of Mech. Engineering, Faculty of Engineering, Chulalongkorn University, Ban 10330, Thailand

Chanchai Rojanasaroj
Research and Development Engineer, Dept. of Agriculture, Ministry of Agriculture and Cooperatives, Bang-Khen, Bangkok 10900, Thailand

Vilas M. Saloke
Associate Professor, Div. of Agric. and Food Engineering, Asia Institute of Technology, Bangkok, Thailand

Gajendra Singh
Professor and Deputy Director General (Engineering) Indian Council of Agricultural Research (ICAR) Krishi Bhawa, Dr. Rajendra Prasad Road, New Delhi-110001, India

Yunus Pinar
Associate Professor, Agric. Engineering Dept., Faculty of Agriculture, University of Ondokuz Mayis, Kurupelit, Samsun, Turkey

Pham Van Lang
Director, Vietnam Institute of Agricultural Engineering, Vien Truong, Vien Cong Cu Va Co Gioi Hoa Nong Nghiep Phuong Mai, Dong Da - Ha Noi, Viet Nam

—EUROPE—

Anastas Petrov Kaloyanov
Professor & Head, Research Laboratory of Farm Mechanization, Higher Institute of Economics, Sofia, Bulgaria

Pavel Kic
Associate Professor, University of Agriculture Prague, Faculty of Agric. Engineering, 165 21 Praha 6-, Suchdol, Czechoslovakia

Henrik Have
Prof. of Agric. Machinery and Mechanization at Institute of Agric. Engineering, Royal Veterinary-and Agricultural University, Agrovej 10 DK2630 Tastrup, Denmark

Giuseppe Pellizzi
Director of the Institute of Agric. Engineering of the University of Milano and Professor of Agric. Machinery and Mechanization, Via G. Celoria, 2-20133 Milano, Italy

Aalbert Anne Wanders
Staff Member, Dept. of Development Cooperation, Netherlands Agricultural Engineering Research Institute (IMAG), Wageningen, Netherlands

John Kilgour
Senior Lecturer in Farm Machinery Design at Silsoe College, Silsoe Campus, Silsoe, Bedford, MK45 4DT, UK ■■


P Kic


H Have


G Pellizzi


A A Wanders


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BACK ISSUES

(Vol. 26 No. 1, Winter 1995 ~)

NOTIFICATION

The editorial staff of AMA introducing some changes in editorial policy and requests contributors of articles for publication to observe following changes in order to improve communication process. These changes will play key role in facilitating the editorial process.

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.

Format Guidance

The floppy disk copy must contain the following format.

a. are written in english language;
b. are written in any of these format like DOS, Word for Dos, Word Perfect, Word Star, Word for Windows, Word for Macintosh and which should be written on the surface of the disc;
c. whole article must written in same format and style;
d. the pages on floppy disk must not be numbered;
e. the tables and figures titles must be numbered;
f. the data for the graphs must also be included.

The remaining Instructions to AMA Contributors are shown in the back side of AMA.

The editorial staff of AMA realize that some contributors still have difficulty to support these changes. In this case, please contact us. Please remember the articles in the new format will be given priority for publication.

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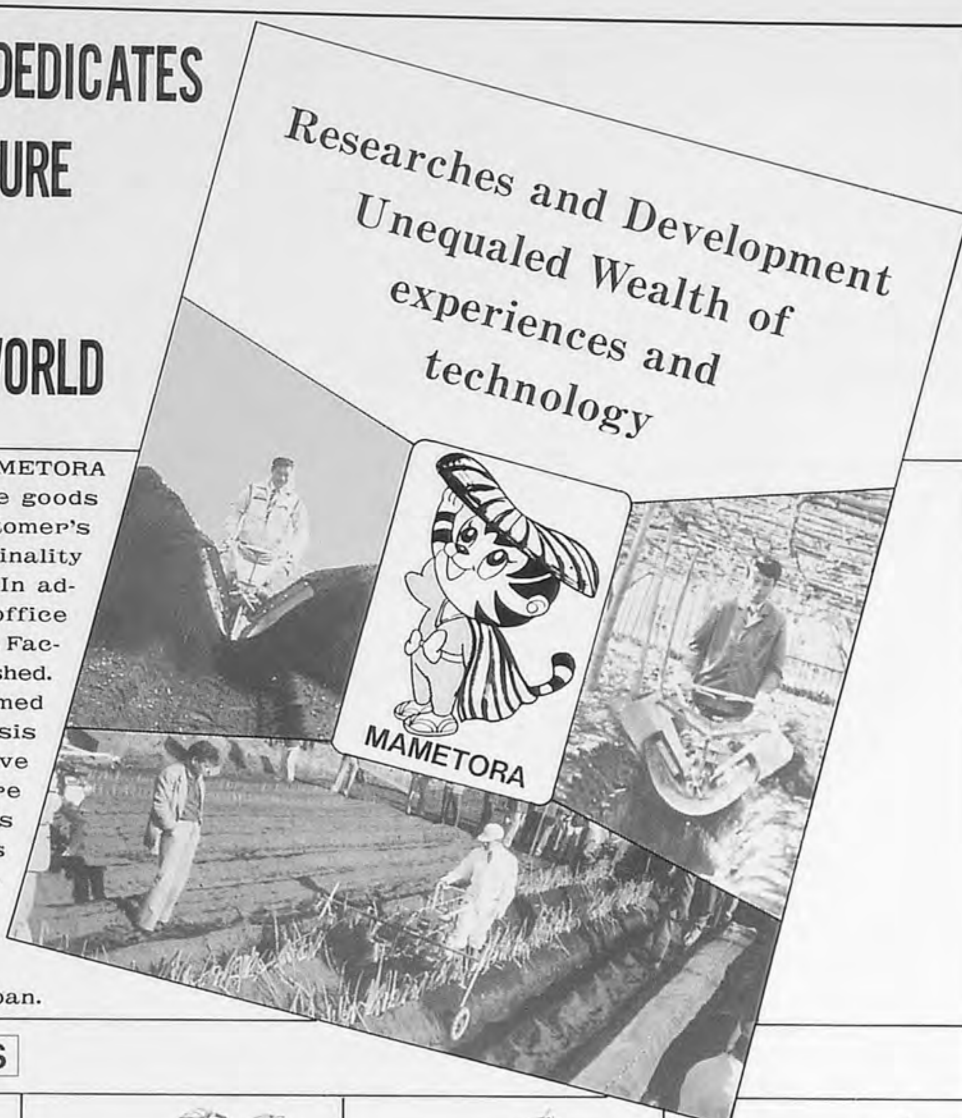

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