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VOL.28, NO.1, WINTER 1997

Special Issue:

The Farm Machinery Industry in Japan and Research Activities

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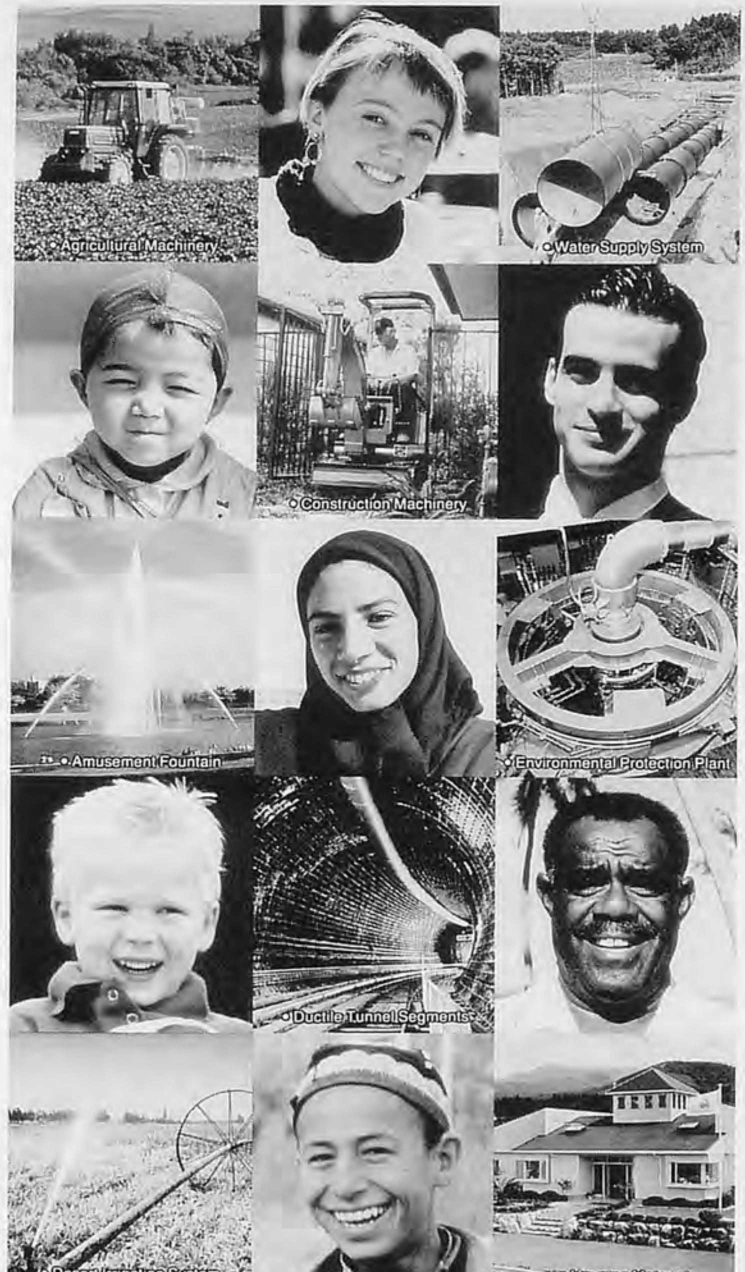

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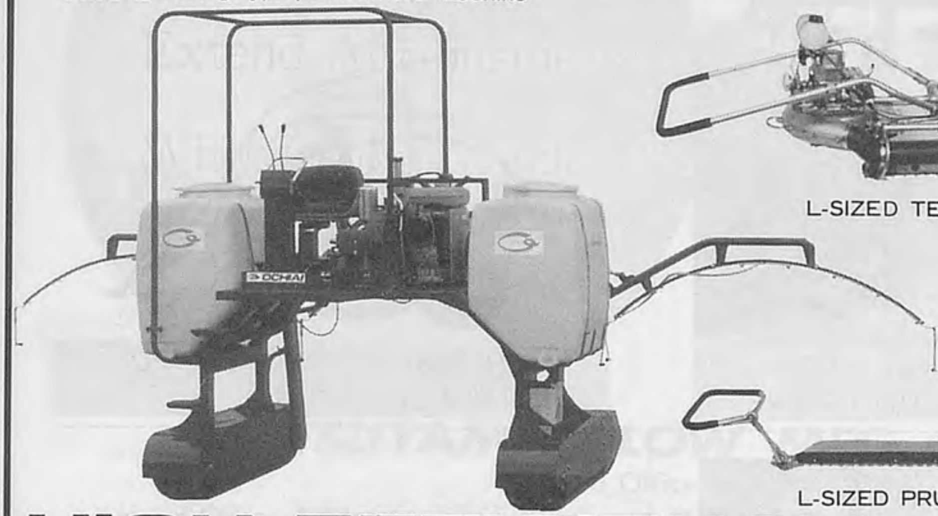

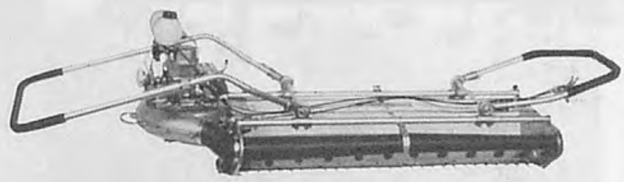

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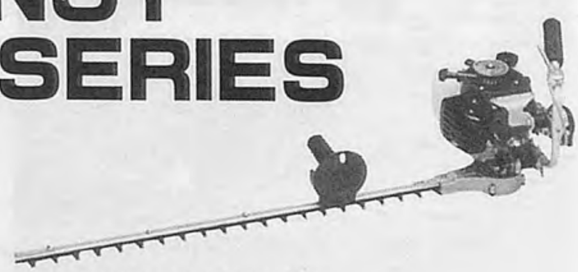

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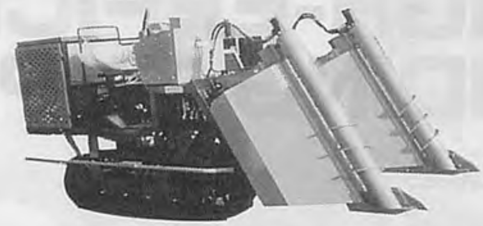

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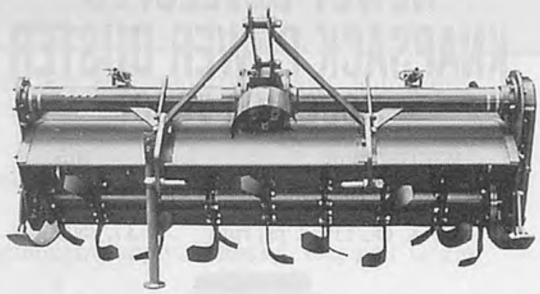

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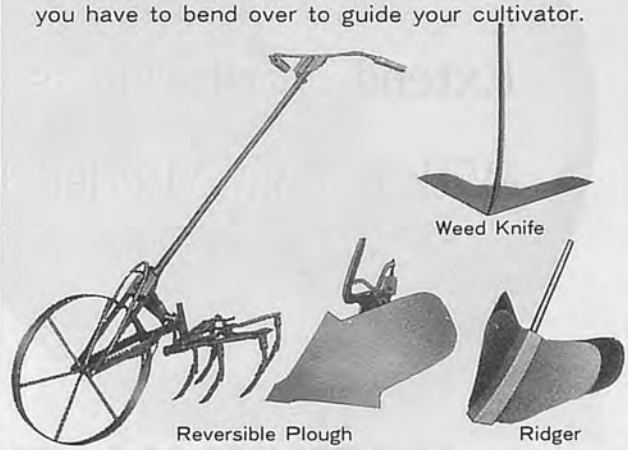

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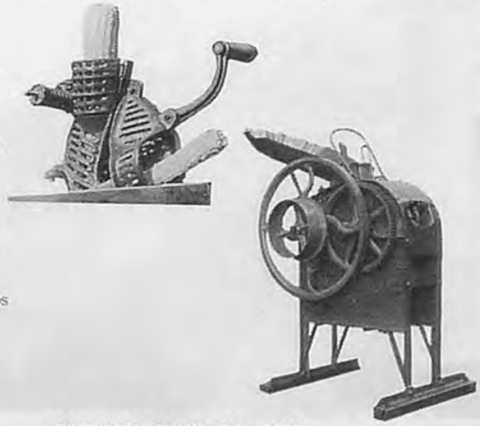

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As the AMA enters its 13th year of publication this year, the Editorial Staff deems it appropriate to commemorate the event by publishing "Abstracts and Index 1971-80" in May, 1983 for only ¥2,000 a copy, including sea mail postage.

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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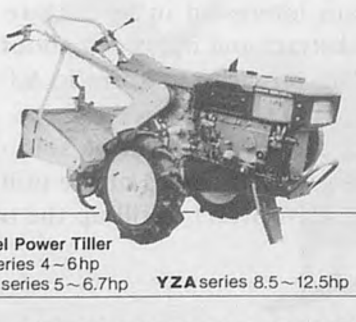

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This is the 94th issue since its maiden issue in the Spring of 1971

EDITORIAL

Hearty Congratulations to all of readers on the arrival of the New Year and allow me to extend all my good wishes for your lasting prosperity. We have only three years before entering into 21st century. Population burst that is creating serious concern seems not to calm down. National population in China has exceeded 1 200 million, 900 million in India and estimated to reach 200 million in Indonesia.

In last December the annual meeting of Asian Association for Agricultural Engineering and an International Agricultural Engineering Conference was held in Puna, India. It was noteworthy that the Minister of Agriculture in India announced the plan to invest 1% of Indian general farm output to agricultural research.

In order to ensure continually supplying enough food for expanding population with limited farmland, the most essential is to increase land productivity through sustainable agriculture without destroying environment. This urges us to develop high level science technology for new agriculture. On this account the investment to research activities is a key element to determine future direction of agriculture.

We have still many problems to be solved in agricultural mechanization. The need to design the machines fitting to the situation of developing countries, shortage of spare parts and insufficient reparing system, have been repeatedly a subject of discussion for the decades. Most of these problems remain unsolved. It is impossible to increase land productivity unless we offer a workable solution to these problems. Because we can only do effective, timely farm work with the aid of machine force.

An energy source to run machine is also an important problem. Fossil fuel like petroleum will be in short supply in next century and it will be needed to produce energy in agriculture. Effective utilization of biomas energy will be one of the keys in maintaining useful mechanization. The shortage of water resource is seen in many places of the world. In rice cropping or farming in a desert, there is a necessity for the development and spread of new technology for effective utilization of water resource, Destruction of ecological system, most prominent in forests, is going on and part of farm land is changing to deserts.

We must live under such circumstances. There exist more and more assignments in our profession. We must join our efforts and work together towards the solution. AMA wishes to be an effective means of communication also this year to link each of us.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
January, 1997

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 28, No. 1, Winter 1997

A Precision Wheel Torque and Weight Transducer for Most Common Agricultural Tractors

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Abstract

A precision wheel torque and weight transducer was developed for the most common agricultural tractors in the field. The standard wheel centre of an MF 3090 (Massey Furgeson 3090) tractor was replaced with the developed wheel torque transducer to measure the torque and forces acting on the tractor wheel. The wheel torque and weight transducer incorporated three load sensing clevis bolts. Its force measurement on the revolving wheel combined with the measurement of angular position of the wheel by a position transducer (shaft encoder) is used to determine the total horizontal and vertical components of forces. This article describes the construction, instrumentation and calibration of the wheel torque and weight transducer.

Acknowledgement: The authors would like to thank Engineers Hussain, Yousaf and Amar for their valuable contributions during the various stages in the development of the transducer.

Introduction

It is relatively easy to design a transducer to measure the torque transmitted to a tractor wheel. The main problem is in transmitting the torque signals from the revolving wheel to the stationary onboard data logging system. Also, it is difficult to measure the vertical and horizontal forces acting on a wheel in motion and there is no easily accessible interface between the revolving wheel and the tractor chassis.

A wheel torque meter with conventional strain gauge techniques was developed by Anderson et al (1974) to measure applied wheel torques. They used frequency modulated inductive coupling method to transmit torque signals from the revolving wheel to a stationary recorder on the tractor. The common method of measuring tractor axle torque is by using a set of strain gauges with slip rings mounted either at the outer end of the axles or on the top of the wheel mudguard to transfer the strain gauge signals to stationary recording equipment [Tompkins and Wilhelm (1982), Malcolm et al (1985), and McLaughlin et al (1993)]. Musunda et al. (1983) used a set of strain gauges and a commercially available FM (Frequency Modulated) telemetry system on the drive shaft of a four-wheel drive (4WD) tractor for torque measurement. The FM telemetry eliminated the use of slip rings.

Most of the wheel torque transducers developed are designed to work in specific tractors for the required precision and usually are quite expensive. There is need for a general precision wheel torque transducer suitable for the most common agricultural tractors in the field. To fulfill this objective the department of agricultural engineering at King Saud University had developed two-wheel torque and weight transducers, one for the front wheel and the other for the rear wheel suitable for any common tractors as part of a collaborative program with Silsoe College, UK. The wheel torque and weight transducers were fitted on an MF 3090 tractor and tested for its performance by conducting field tests.

System Description

Two-wheel torque and weight transducers: one for the front wheel and the other for the rear wheel of the tractor were developed to measure the torque and weight acting on the wheels. The developed transducer has to replace the standard wheel centre of the tractor under consideration and connect the wheel hub to the wheel rim. As shown in **Fig. 1**, the transducer consists of an outer ring, which is connected to the wheel rim and an inner ring, which is connected to the wheel hub. The two rings are hinged together by three pairs of equally spaced links, and hence these links are tangential to a circle between the inner and outer rings. Each pair of links has a plain clevis bolt at one end and a factory built load sensing clevis bolt at the other end. Each load sensing clevis bolt is oriented so as to measure the force being transmitted along each pair of links. The side forces are resisted by low friction pads. A position transducer is used to measure the angular position of the wheel and hence the direction of the measured forces.

The vertical and horizontal forces acting between the rim and the hub can be obtained by measuring the forces acting along the links with the three load sensing clevis bolts. **Fig. 2** shows the measured forces and their components. The total vertical and horizontal components of forces can be computed as follows:

$$F_v = F_1\sin(\theta) + F_2\sin(\theta + 120°) + F_3\sin(\theta + 240°) \quad ...(1)$$

$$F_h = F_1\cos(\theta) + F_2\cos(\theta + 120°) + F_3\cos(\theta + 240°) \quad ...(2)$$

Where:

F_1, F_2, and F_3 - the force measurements from the three load sensing clevis bolts,

θ - the angle from the vertical reference in the clockwise direction,

F_v - the total vertical components of forces, and

F_h - the total horizontal components of forces.

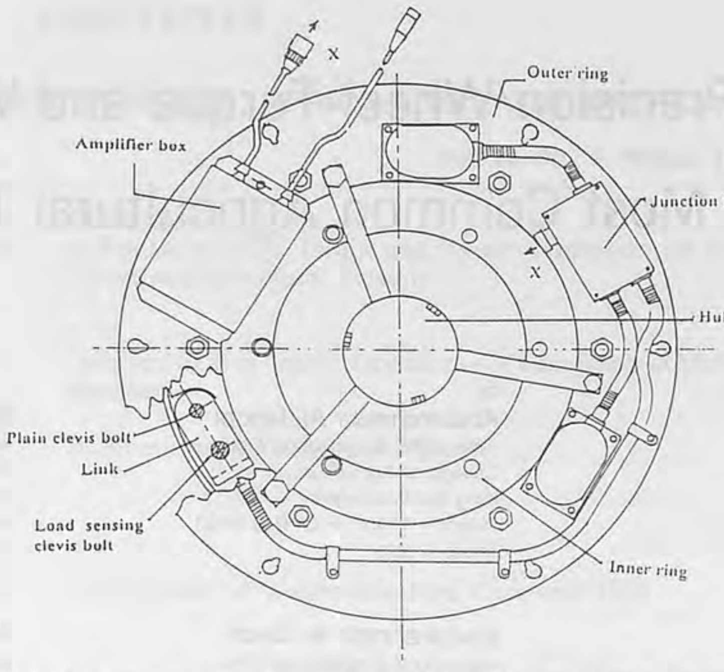

Fig. 1 Wheel torque and weight transducer replaced with the standard wheel centre of the tractor.

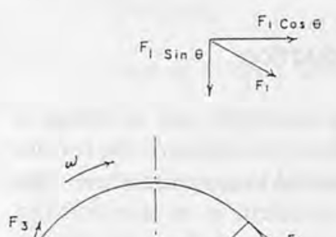

Fig. 2 Clevis pins force diagram.

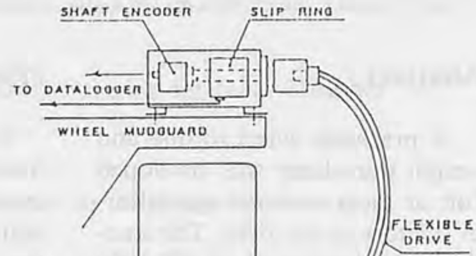

Fig. 3 Showing the connection between the wheel torque transducer and the slip ring shaft encoder assembly.

The right front and rear wheel centres of the MF 3090 tractor were replaced with the two developed wheel torque and weight transducers for testing its performance. Two shaft encoders one for each instrumented wheel are mounted on the mud guards above the wheels and the rotation of the wheel is transmitted to it via a flexible drive as shown in **Fig. 3**. The signals from the load sensing clevis bolts pass through the amplifier box bolted to the inner ring and then through the six core cable in the flexible drive to the slip rings which are mounted next to the shaft encoder. The signals from the load sensing clevis bolts and from the shaft encoder are passed to an onboard data logger where the signals can be scanned and recorded. The recorded data can be transferred to a computer and processed using a spreadsheet software package.

Calibration Procedure

Each of the load sensing clevis bolts used in the wheel torque and weight transducer were calibrated using a transducer calibration rig (Al-Suhaibani et al 1994). All the clevis bolts were tested to the maximum allowed load for both tension and compression. The maximum loads which can be carried by the clevis bolts used in both the rear and front wheel torque and weight transducers are 35 kN and 15 kN, respectively. The result of the calibration tests for the clevis bolts with static loading is reproduced in **Fig. 4**. No significant hysterisis was observed and practically identical calibrations were obtained for both tension and compression. The measured load exhibited excellent agreement with the applied load and the characteristic curves are almost linear as the coefficient of regression approached 1.0 for all the load sensing clevis bolts. The constants and coefficients from the calibration results were used in programming the data logger to read the output of the load sensing clevis bolts in kN during the performance tests.

The shaft encoder was checked for the single marker pulse for one complete resolution of the tractor wheel.

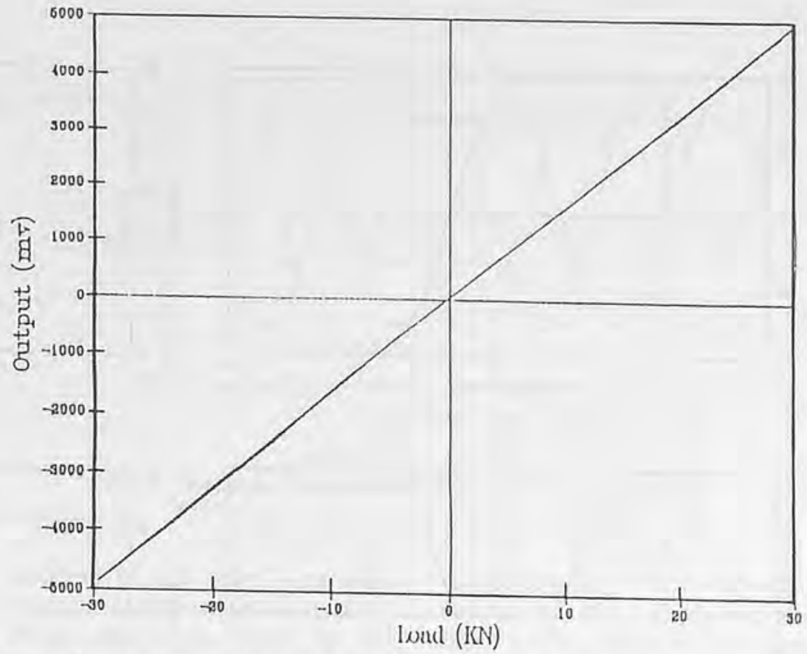

Fig. 4 Sample calibration curve for a load sensing clevis bolt used in the rear wheel transducer.

Field Performance

An MF 3090 tractor was employed as the test vehicle in evaluating the performance of the developed wheel torque and weight transducers. Before the tractor was tested in the field, the weight of each tyre and rim of the tractor were measured to determine the amount of wheel load not carried by the load sensing clevis bolts. Calculation of this load necessitated a comparison with the vertical load on each wheel of the tractor during the test run. With the tractor in normal trim and working weight (includes weight of fuel and operator), the loads on each front and rear wheel was measured using a standard load cell. At first, one of the wheels was raised and positioned on the load cell, while the other wheels were raised and kept at the same level of the wheel under measurement. This procedure was repeated for the other three wheels and the normal working weight of the tractor was calculated by summing all the loads on the four wheels. Then the tractor was kept on a level concrete surface and the signals from all the load sensing clevis bolts of both the front and rear wheels were scanned and recorded by the data logger. The total vertical and horizontal loads acting on the tractor wheels were computed. The weight of tyre and rim of the tractor was also measured. The static load on each wheel is shown in **Table 1**.

Table 1. Static Tractor Wheel Loads

Wheel	Load measured by std. load cell (kN)	Load measured by clevis pins (kN)	Weight of tyre and rim (kN)
Front right	9.378	8.04	1.38
Rear right	15.247	12.70	2.51

Upon completion of the measurement for the weight of the tyre and rim of the tractor wheels, two field tests were conducted to determine the performance of the developed wheel torque and weight transducers.

No Load Test

The instrumented tractor was driven unloaded over a hard level surface at a low speed of approximately 2 kph and the forces in the load sensing clevis bolts and the

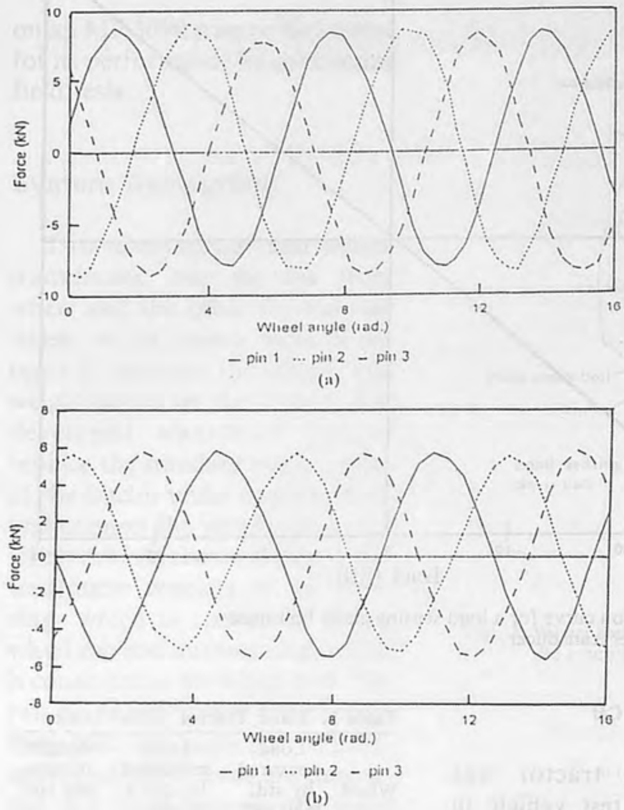

Fig. 5 Unloaded wheel pin forces, (a) Rear (b) Front.

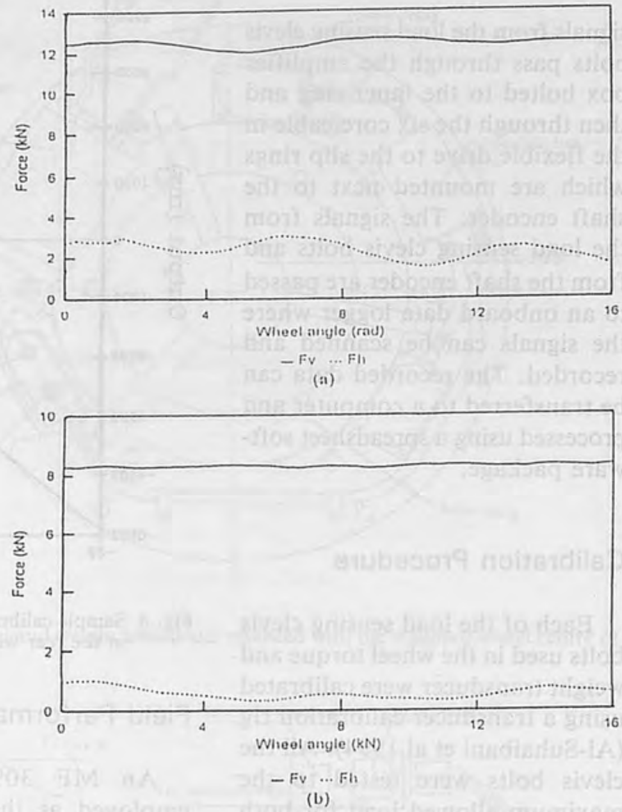

Fig. 6 Unloaded wheel forces, (a) Rear (b) Front.

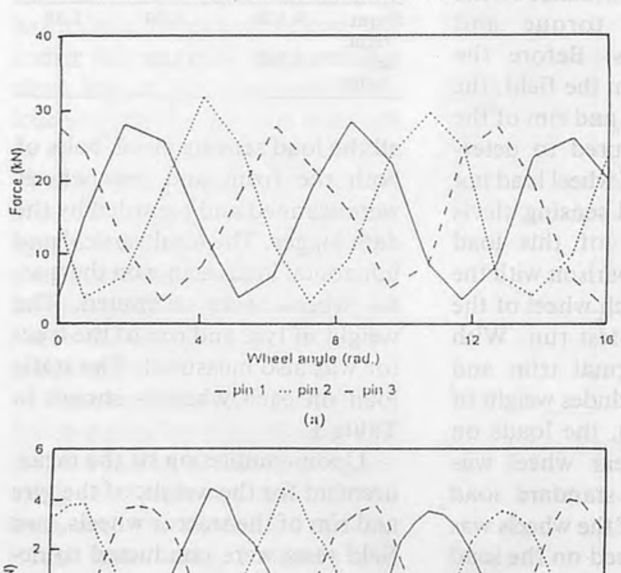

Fig. 7 Loaded wheel pin forces, (a) Rear (b) Front.

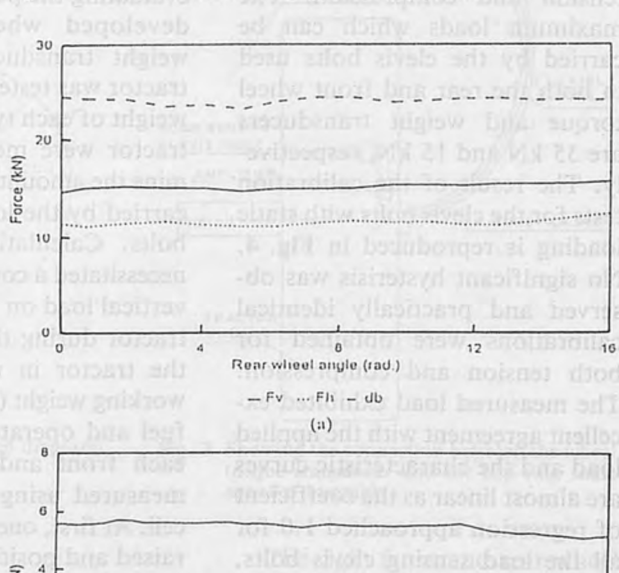

Fig. 8 Loaded wheel forces, (a) Rear (b) Front.

angular position of each wheel were recorded. Typical data for both the rear and front instrumented wheels of the unloaded tractor are shown in **Figs. 5a** and **5b**. The output wave forms are sinusoidal and symmetrical, as the load sensing clevis bolts in the wheel torque and weight transducers were kept in space by an angle of 120 degrees apart. Also, the total vertical and horizontal forces acting on both the instrumented tractor wheels were calculated and represented in **Figs. 6a** and **6b**.

Load Test

A second tractor was attached to the drawbar of the instrumented tractor to act as a brake. The drawbar was also equipped with two factory built load sensing clevis bolts to measure the horizontal draught force (Al-Suhaibani et al 1994). The instrumented tractor was again driven straight in the forward direction over the hard level surface at a low speed of approximately 2 kmph towing the second tractor which had its brake applied to give a steady draught force. The forces in the load sensing clevis bolts, the angular position of each wheel, and the draught force were recorded. Typical data for both the rear and front instrumented tractor wheels are shown in **Figs. 7a** and **7b**. The calculated total vertical and horizontal forces, and the draught force are shown in **Figs. 8a** and **8b**.

Results and Discussions

The data logger was programed to sample signals from the transducers every one second. The calibration figures for the load sensing clevis bolts were used to convert the analog signals from the transducers into the real physical parameter (kN). The angular position of the wheel was also recorded and converted to radians. These data were stored in the data logger as the test proceeded and then transferred to a computer for further processing by a spreadsheet software package. The processed data as well as the output results were presented in **Figs. 5-8**.

The total vertical forces acting on both the instrumented wheels were found to be more or less equal to the corresponding vertical load measured by the standard load cell less the weight of the tyre and rim in both the no-load and load tests. In the no-load test, the total horizontal force obtained was considerably small and approximately equal to the rolling resistance and the rolling torque. During the load test, the sum of the horizontal forces acting on both the instrumented wheels without rolling resistance was found to be half the recorded draught force. This shows that the tractor was symmetrical about its centre line and that the two uninstrumented wheels were experiencing the same forces as the two instrumented wheels. **Fig. 9** shows the sum of horizontal forces, drawbar force, and ratio of differences which is the ratio of the difference between drawbar and horizontal forces to the drawbar force. The value of the ratio ranges between 8% to −6% in an average of 2%, which is about 0.5 kN. This value is very small and it is caused by the unavoidable surface irregularities, and small errors in the readings.

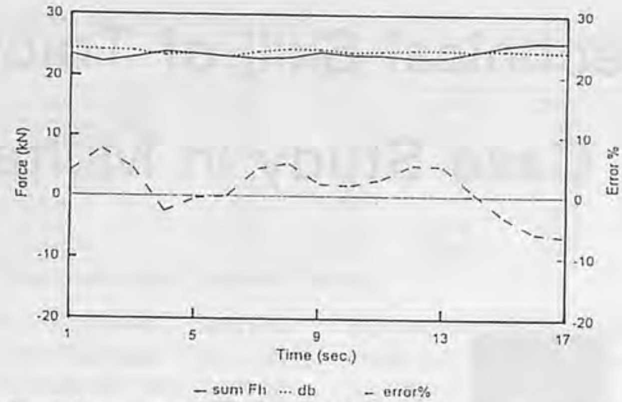

Fig. 9 Comparison between sum of horizontal forces and drawbar force.

Summary and Conclusions

Two-wheel torque and weight transducers were developed to be used in a wide range of agricultural tractors. Each wheel torque and weight transducer consisted of three factory built load sensing clevis bolts. These load sensing clevis bolts provide force measurement on the revolving wheel leading to the determination of the total horizontal and vertical components of forces acting on the driven tractor wheels. The right front and rear standard wheel centers of the MF 3090 tractor were replaced with the two developed wheel torque and weight transducers for testing its performance. The tractor instrumented with the two wheel torque and weight transducers was tested in the field. The system performed well during the field operation and the result obtained shows the transducer is highly accurate and acceptable to the most common agricultural tractors in the field.

(Continued on page 22)

Technical Skill of Tractor Operator — A Case Study in Multan, Pakistan

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Abstract

In the present study, 150 tractor owner-farmers from Multan, Pakistan were interviewed on the use of tractor. Personal profile, operational knowledge and operational training were estimated by interviewing through qualified and experienced agricultural engineers. Among the 150 tractor operators, no one went through training from any institution. Fifty-two % were coached by other sources whereas 48% were self-coached. Only 49% of these operators have license. They are not properly trained. They lacked critical information on tractor ballasting, hydraulic system adjustment and tyre pressure for working in the field. The implement handling and storage is rough. The study concludes that proper operator training is imperative. The goverenment should start special programmes for training of tractor operators. The private sector should be encouraged to participate in these special training programmes.

Introduction

Pakistan's land area is about 80 million ha of which 20.6 million ha is cultivated. Irrigated area is about 76% of the total cultivated area. Currently, agriculture contributes 26% to the national income and provides employment to 54% of the total labour force. Three-fourths of the country's exports directly or indirectly are agriculture-based (1).

Currently, there are 4.0 million Pakistani farmers. Some 33% of the total farmland area is less than 5 ha each in size. Out of 13 million people employed in agriculture, more than 8 million are farm tenants. The general income level of farm labour is approximately Rs. 5 000/year (2). The present population growth rate is 3.1% (3) which invites special attention for boosting agricultural production to feed the expected increase in population. Land area is limited for cultivation but production targets are achievable by increasing the crop yield and reducing the losses. A yield gap of 2-3 times exists between national average and progressive farms in the country. The probable solution to increasing agricultural production lies in better crop husbandry and by increasing cropping intensity through timely farming operations. A limited time span left between two crop seasons (Rabi and Kharif) has compelled the farmers to use agricultural machines so as to harvest two or more crops a year. As a result, increasing number of farmers are investing their capital in tractors and other farm machines to increase cropping intensity. This is evident from the fact the number of tractors increased from 35 000 to 187 000 in the last 12 years (4). Farm mechanization is thus, making steady progress in Pakistan.

The tractor is a very costly machine, hence it should be operated by a trained operator. Tractor operation with different machines/implements requires special knowledge, skill and training. However, so far, no comprehensive study has been conducted in Multan about the characteristics of tractor operators (5). The present study, therefore, aims to:

(1) Study the personal profile of tractor operators in Multan such as age, formal schooling, experience and monthly salary.
(2) Determine the operational knowledge and training of the tractor operators.
(3) Evaluate the technical knowledge and skill of tractor operators regarding operation and maintenance of agricultural machinery and implements.
(4) Make policy recommendation for tractor operator's training.

Methodology

The information pertaining to the objectives of the study was collected using a structured questionnaire in interviewing sample users of farm tractors and implements. A biased sample comprising 150 owners and users of farm machinery and implements having at least one farm implement made in Mian Channu was drawn amongst the 443 000 farmers operating throughout the six districts of Multan Division (**Table 1**).

The survey was conducted during August 1992 throughout Multan. The survey instrument used for the collection of data was structured to record desired information related to job objective of the study. The owners/operators of tractor were interviewed in depth by qualified and experienced agricultural engineers. The information supplied by the users was ascertained by the interview team to be the candid opinion of the respondents before entering into the questionnaire.

Results and Discussion

Description of the Project Area

Multan division comprises six districts, namely; Multan, Lodhran, Khanewal, Sahiwal, Vehari and Pakpaten. The division is strategically and economically very important. The ancient setting, rich cultural heritage, location on the main grand trunk road and canal irrigation have influenced agricultural productivity and trade. The medium textured soil and semi-arid climate characterized by two distinct seasons (summer and winter) and monsoon period which brings in a major share of the rainfall from July through August.

Table 1. Multan Division Resource Data

Particulars	Multan & Lodhran	Sahiwal & Pakpaten	Vehari	Khanewal	Total
Total population (000)	4080	3612	2331	2744	12767
Rural population (000)	2341	2510	1647	1940	8438
Total area (000)ha	659	594	438	428	2119
Croped area (000)ha	577	506	384	354	1821
No. of farms (000)	138	133	74	98	443
No. of villages	934	1089	777	679	3479
No. of tractors	12208	13153	10346	6975	42682
No. of tubewells	19275	16338	13353	9633	58599

Source: Directorate of Agri. Extension, Multan.

The abundance of labour and water also contributed to the prosperity of Multan division over the past four decades. The area was a leading producer of cotton and had well-developed cotton ginning and textile industry. The pesticide and farm machinery business was also thriving due to strong financial position of the growers. The stable price of cotton had raised the level of mechanization for cotton production. The other cash crops such as maize, potatoes and sugarcane were also gaining importance. Multan division carried significant portion of agricultural area under horticultural crops such as mangoes and citrus.

The industry in Multan is predominantly medium in size (employing labour force between 20 and 50 persons) and cotton related. The major share (70%) of the labor worked on the farm. The women labor was largely employed for cotton picking. The low literacy and skill level was widespread in the area. There was little room in the expansion of area under cultivation. The production increases were only possible through increased yields and cropping intensity.

The project area has two government-managed training schools to train tractor operators and mechanics. One of the schools was set up in 1958 with the help of Federal Republic of Germany at Chak No. 5 Faiz on Multan-Bahawalpur road. The other was set up under the establishment of the Directorate of Agricultural Engineering, Multan during the seventies. The total capacity of two schools is reported to be 500 tractor operators per annum against the replacement demand of 2 000, assuming active life of the operator to be 25 years and 5% accidents. The wide gap in the availability of trained operators is casting shadow over the efficient utilization of farm machinery.

Pattern of Use

Farm size in Multan averaged about 20 ha each. The farmers generally own a medium-sized tractor and about six different implements exhibiting higher level of mechanization compared to the national average of three (Agri. Machinery Census 1984).

The soil is loamy with adequate irrigation facilities. The draft power requirements are thus felt to be low. The cropping pattern is predominantly cotton and wheat in the southern part and maize-wheat/sugarcane/potato in the northern part of Multan (**Table 2**).

The popular makes of tractors

Table 2. Characteristics of Agriculture (Sample size 150)

Particulars	Average profile
Area Operated (ha)	Percent of Total (%)
Up to 10	40
11-20	32
21-30	9
31-40	8
<40	11
Total	100
No. of Implements Owned by Farmers	
Up to 3	18
4-6	59
7-8	18
<8	5
Total	100
Source of Irrigation	
Canal	19
Tubewell	8
Canal + Tubewell	73
Total	100
Soil Type	
Loam	55
Clay Loam	6
Sandy	8
Mixed	31
Total	100
Cropping Pattern	
Cotton-Wheat	86
Maize-Wheat	23
Potato	10
Sugarcane	13
Total	132

are Massey Ferguson and Fiat in the 50-hp range **(Table 3)**. Smaller farmers own one tractor each and large farmers own up to three tractors each **(Table 4)**.

Purchase Pattern of Tractors/ Implements

Due to a decline in institutional credit, the used tractor market has picked up. The used tractor market for Massey Ferguson is stronger than Fiat **(Table 5)**. It is hard to find a farmer not using a tractor in Multan. Some farmers rent tractors and implements. Tractor owners also exchange implements.

Profile of Tractor Operator

The profile of a tractor operator is a key indicator in assessing his management ability for tractor operation. Thus the following characteristics of the tractor operator were studied: age, educational status and work experience and salary/wages.

Table 3. Ownership of Tractors by Make and Model

Make & Model	User (%) (Based on 150)	Within Group (%)	Number of Tractors
Massey Ferguson			
MF-240	36	79	53
MF-375	3	6	4
MF-135	4	9	6
Other	2	6	4
Total	45	100	67
Fiat			
Fiat-480	32	71	48
Fiat-640	13	29	20
Total	45	100	68
Ford	7	—	10
IMT	2	—	3
Others	1	—	2
Total all Makes	100	—	150

Table 4. Tractor Ownership Pattern

No. of Tractors Owned	Area Operated (ha) Min.	Area Operated (ha) Max.	Frequency	Percent of Sample
One	2	81	141	94.0
Two	25	121	7	4.7
Three	156	162	2	1.3
Total	—	—	150	100.0

Age Profile of Tractor Operator

As shown in **Table 6**, 70% of the tractor operators are in the age of 18 to 30 years. Indeed the tractors are operated by young operators. Twenty-six percent falls between the ages of 31-40 years and 41-50 years. Only 4% are aged 50 years or older.

Educational Status

Education is one of the factors affecting the capability of the tractor operator. The literacy status of a tractor operator may influence understanding about the use of tractor/implement because he can study the operation manual and understand all the instructions. On the other hand, the less educated or illiterate are limited in their understanding of the idiosyncracies of a tractor.

The data in **Table 7** shows that 20% of the sample tractor operator are quite illiterate. Amongst the literate, 14% are above matriculation; 48 percent had 6-10 years of formal schooling and 18 percent had 1-5 years of formal schooling.

Table 5. Purchase Pattern of Tractors/ Implements

Tractors/ Implements	Sample Size	New Purchased (%)
MF-240	53	62
Fiat-480	48	70
Fiat-640	20	74
Other makes and models	29	66
Cultivators	129	90
Rotavators	35	100
Cotton drills/ planters	125	95
Cotton ridgers	84	95
Boom sprayers	60	93
Wheat threshers	87	79
Trolleys	91	82
Trolley tyres	91	24

Table 6. Age Profile of Tractor Operator

Age	Number	Percent of Total
18 to 30 years	105	70
31 to 40 years	29	19
41 to 50 years	10	7
50 years <	6	4

Table 7. Educational Status of Tractor Operator

Formal Schooling	Number	Percent of Total
Nil	30	20
1-5 years	27	18
6-10 years	72	48
10 years <	21	14

Table 8. Work Experience

Experience	Number	Percent of Total
up to 5 years	15	10
6 to 10 years	52	35
11 to 15 years	27	18
15 years <	56	37

Table 9. Operational knowledge and Training

Particulars	Number	Percent of Total
Operational Knowledge		
Ballast weights	31	21
Water filling nozzles	1	1
Record keeping	22	15
Operational Training		
Institutional	0	0
Coached	78	52
Self-coached	72	48
Licensed holder	73	49

Work Experience and Salary

The operation of tractor and implements is generally done by the owners of medium-sized farms and those that rent the farm machineries. Some operators are employed by the large farmers. The tractor operators, on the average, receive Rs. 950/month as salary and Rs. 4,443/kind annually.

Table 8 shows that the average tractor operator experience is in excess of 10 years-depicting that is about the time when tractors became popular among the large-scale farms in Multan.

Operational Knowledge and Training

Table 9 shows the operational knowledge and training of tractor operators. The tractor operational skills are invariably acquired through self efforts or coaching by experienced neighbors. The impact of the two tractor operator schools mentioned in earlier in Multan is negligible. The tractor drivers who operated trolleys on the highways are licensed.

Operation and Maintenance Skills

The lack of institutional coaching is reflected in the form of poor operation, maintenance and practices **(Table 10)**. The storage of implements in the open is common. The knowledge about appropriate tractor tyre pressure in the field is poor. The tractor hydraulic system capability is not being fully used. The soil moisture conditions when engaging tools is not given due attention and high proportion operated tillage tools in dry conditions. The operators did learn to adjust the implements which have few adjustments. The operators are, however, conscious of preparing the implements with moving parts for storage purpose.

Table 10. Percentage of Sample Operators Undertaking Operation/Maintenance

Particulars	Name of Implement						
	Cultivator	Rotavator	Cotton Drill	Cotton Ridger	Wheat Thresher	Boom Sprayer	Trolley
Preparation for storage	15	85	85	54	87	98	15
Open storage	85	54	76	84	84	68	89
Warranty availed	29	53	25	18	58	30	17
Operational manual holder	0	20	1	1	2	3	—
Field tyres pressure (Front)	3	3	3	—	—	—	—
Field tyres pressure (Rear)	16	24	22	—	—	—	—
Tractor hydraulic use (Manual)	97	94	98	100	—	80	—
Adjustments knowledge	11	97	87	93	87	83	—
Adjustments working	11	91	87	96	91	83	—
Adjustments user	9	87	87	92	89	83	—
Appropriate soil moisture	26	4	95	40	—	—	—

Conclusion

The introduction of cost effective farm machines would not be possible without the availability of trained operators. The farm machinery operations continue to be a specialized skill which combine knowledge and practices relating to the crops, soil, water, chemicals and farm equipment.

During the survey, the impact of the two tractor operators' schools could not be determined and requires investigation regarding their catchment area. The tractor operator course offered by the school of the Directorate of Agricultural Engineering is three-month duration and that of Pak-German Institute of Cooperative Agriculture in Chak 5 Faiz, Multan is a 6-month duration. The training offered by the Pak-German Institute is thus more rigorous. Syllabi uniformity and persuasion of the tractor owner to seriously attend to operation training is of paramount importance. The practice of maintaining record of farm machinery operation in "black and white" needs to be introduced since it is completely missing. The introduction of tractor/implement log book in local language with the facility of its storage close to operator seat would facilitate maintaining the record of farm machinery and tractor operation.

The number of tractor operators requiring training and retaining is very large compared to the capacity/output of the public institutions imparting such training. There are no arrangements for organizing refresher courses for training of operator in the case of new machine introduction. The scope and extent of farm machinery training need in Multan is felt to be well beyond the capacity of existing infrastructure. The opportunity exists for establishing more vocational training institutions imparting knowledge and skills to rural men and women in varoius trades and practices, including farm machinery operation, repair and maintenance.

Recommendations

1. The operator training in proper operation and maintenance of farm machinery is considered essential and is found missing in the study area. The farm machinery manufacturers must be persuaded to contribute and supervise the training institution.
2. Refresher course for all new items of machines should be organized.
3. The qualified operators should be allowed special concession on the purchase of

new machines/implements.

4. The farm machinery operators do not keep records of the operation, maintenance, repair costs and revenues. A properly designed log book printed in Urdu should be introduced.
5. The tractor manufacturers, after careful study, should work with extension workers to demonstrate to the farmers how they can improve the performance of their tractor by proper matching of farm power, weight, speed and slip in dry land conditions. These demonstrations will help to improve the efficiency of the tractors.
6. The Government should encourage tractor manufacturers to arrange demonstration of machines/implements through their dealers network at farmers' field.
7. The Government should establish agricultural engineering extension services in the public sector similar to agricultural extension where qualified agricultural engineers should be employed for extension work.
8. Tractor operator school should be established at district level and private sector should also be encouraged for participation in the farmer training. Mobile school will be more beneficial.
9. Similar study should also be conducted in other regions of the country.
10. Procedure for obtaining driving license should be simple and inexpensive.

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(Continued from page 17)

A Precision Wheel Torque and Weight Transducer for Most Common Agricultural Tractors

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A Promising Animal-drawn Plough

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Abstract

An animal-drawn moldboard plough appropriate for Bangladesh conditions has been designed, fabricated and tested at the Agricultural Engineering Division of the Bangladesh Agricultural Research Institute (BARI). The available draft animal can pull the plough comfortably. The results of the field performance test of the plough in dry land tilling as well as wet land tilling were satisfactory. Comparative studies were also conducted to evaluate the performance of moldboard plough with that of local plough. The average tilling capacity of the moldboard plough was 0.04 ha/h and the local plough was 0.035 ha/h. Time as well as cost of ploughing by moldboard plough was 50% less than that of local plough. The total energy required to prepare the land up to final land preparation by local plough was 3 times higher than that of the modlboard plough. Except the beam, all the parts of the plough are made of ferrous metal. The weight and cost of the plough without beam are 7 kg and Tk.300.00, respectively.

Introduction

Ploughing is the first and most important operation in crop production. Without proper land preparation, one cannot expect high yields even by applying all other inputs of crop production. The equipments used in land preparation by the farmers in Bangladesh are mostly traditional wooden plough. About 80% of the farmers in the country use conventional country plough (Hossain, et al. 1985). The tilling efficiency of this plough is minimal and no attempt has so far been made to improve this age-old traditional plough.

There are about 26 types of traditional ploughs used in the country (Sarker, et al. 1983). These ploughs are basically identical, with little variation in their shape, size and weight due to soil type and draft animal condition. The main parts of a traditional plough are: 1) beam; 2) handle; 3) body; and 4) share (**Fig. 1**).

The traditional plough does not cut the soil. As the plough moves forward, the share penetrates into the soil and breaks the soil by thrust which takes much energy than cutting action. The wooden plough does not turn the soil on one side but leaves it on both the sides. As a result, the ploughman sometimes leaves behind unploughed strips of land. About 5-6 ploughings and cross ploughings are required to uproot the crop residue and to get the land finally prepared for sowing/planting. The depth of ploughing with the plough goes hardly down to 10 cm, but many crops require their root system developed beyond 15 cm (Farouk and Sarker,

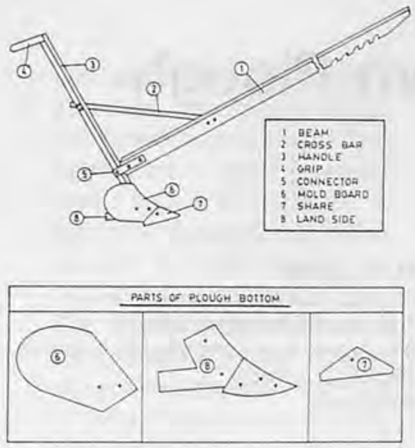

Fig. 1 BARI plough.

Fig. 2 Field Operation of BARI Plough.

1983). As the present land preparation practices by traditional plough are inadequate, farmers get low yields. The useful life of the local ploughs is short. The farmers have to change the whole plough or plough bottom every season or year.

A properly designed moldboard plough can cut and turn the soil on one side and invert it with less power (Hopfen, 1969). The moldboard plough differs from a wooden traditional plough in its moldboard, land side, share etc. The share cut the furrow slice and moldboard turns the soil completely on one side which enables the ploughman to till the field in a better way in one operation without leaving any unploughed strip of land. For better inversion and pulverization of soil up to desired depth and to prepare land within less time, a well designed animal-drawn moldboard plough is very essential for the farmers of Bangladesh.

The study was undertaken with the following objectives:

1. To develop a plough for the draft animal available in Bangladesh;
2. To test the performance of the plough under field conditions; and
3. To compare the cost of land preparation of the developed plough with that of the traditional ploughs.

Materials and Methods

The animal-drawn moldboard plough or BARI plough has been developed and fabricated in the workshop of the Agricultural Engineering Division, Bangladesh Agricultural Research Institute (BARI). The locally available materials were used to keep the construction of the plough as simple as possible. The different parts of the plough were: 1) beam; 2) handle; 3) cross bar; 4) connector; 5) moldboard; 6) share; and 7) land side/frog (**Fig. 1**). The materials used to fabricate different parts of the plough were M.S. angle bar, M.S. flat bar, M.S. sheet, M.S. plate, M.S. nut bolts, cast iron and wood. The description of different parts of the plough are as follows:

1. Beam — This part is made of wood, 210 cm long and 7 cm wide. One side is 5 cm thick and the other side is gradually reduced to 3 cm thick. The thinner end is grooved to hitch the plough with harness.

2. Handle — This part is made of 4 cm × 4 cm M.S. angle bar of 85 cm long. There is a grip in one side of the handle welded at 110° with the angle bar. The diameter and length of the grip are 3 cm and 15 cm, respectively. The other part of the handle is hollow squared with a 23 cm M.S. angle bar of same size to bear the torque during plough operation.

3. Cross bar — This part of the BARI plough is M.S. angle bar 2.5 cm wide and 60 cm long. This part is used to adjust the pull angle. One end is bolted to handle and the other end is bolted to the beam. There are some holes on the handle, cross-bar and beam for required adjustment. Pull angle adjustment is done through this cross bar.

4. Connector — Two pieces of M.S. flat 4 cm wide and 20 cm long were used to clamp together the beam and handle. Three nut bolts were used to fit the connector with the beam and handle.

5. Moldboard — M.S. sheet of 2.5 mm thickness was used to make the moldboard. The length and width of the moldboard are 26 cm and 15 cm, respectively. The size of a plough largely depends on the moldboard size. There is a special curvature shape on moldboard to turn the soil. The moldboard is bolted to the frog with two nut bolts.

6. Share — This is the soil cutting part of the plough, made of 4 mm thick M.S. plate. The size of the share also varies with the size of the plough. The cutting edge of the share is hammered to thin and then tempered to hardening. This is bolted to the frog with plough nut bolts. It is repairable and replaceable.

7. Land side/frog — This is a cast part of the plough bottom. The land side and frog are cast together.

Test Procedure

The plough was tested also at the Regional Agricultural Research Stations (RARS) of BARI (**Fig. 2**). Different sizes of draft animals were used at different soil types to test the plough thoroughly. The soil type ranged from sandy loam to clay loam. Both dry and wet land were ploughed by the experimental plough up to final land preparation. The local traditional plough was also tested in the same procedure to be compared with moldboard plough. Up to final land preparation, the moldboard plough required an average of 3 ploughings and cross ploughings both in dry land cultivation and puddling. Whereas the local plough required an average 5 ploughings and cross ploughings to do the same work. During the test, the Regional Network for Agricultural Machinery (RNAM) test code was followed to collect all data.

Table 1. Performance Results of BARI Plough and Local Plough for Dry Land Cultivation

Tilling No.	Depth (cm)		Width (cm)		Speed of operation (km/h		Field capacity (ha/h)		Draft power (kW)		Sp. energy reqd. (kW-h/ha)	
	BP	LP	BP	LP	BP	LP	BP	LP	BP	LP	BP	LP
1	8.44	6.53	18.22	12.63	2.56	2.59	0.045	0.031	0.2785	0.3586	6.16	11.56
2	8.51	6.65	19.18	13.61	2.65	2.66	0.047	0.032	0.1884	0.3568	4.00	11.15
3	9.23	7.15	20.13	15.36	2.74	2.72	0.049	0.034	0.1870	0.3507	3.82	10.96
4	—	7.58	—	16.83	—	2.84	—	0.036	—	0.3489	—	9.69
5	—	7.83	—	17.19	—	2.98	—	0.037	—	0.3468	—	9.39

BP = BARI Plough, LP = Local Plough

Table 2. Performance Results of BARI Plough and Local Plough for Puddling

Tilling No.	Depth (cm)		Width (cm)		Speed of operation (km/h		Field capacity (ha/h)		Draft power (kW)		Sp. energy reqd. (kW-h/ha)	
	BP	LP	BP	LP	BP	LP	BP	LP	BP	LP	BP	LP
1	7.92	7.50	15.50	13.00	2.00	2.25	0.036	0.030	0.2046	0.2475	5.68	8.25
2	9.33	7.17	18.17	13.17	2.25	2.26	0.039	0.031	0.1637	0.2150	4.20	6.94
3	9.52	7.43	18.85	14.00	2.28	2.32	0.042	0.032	0.1583	0.1890	3.77	5.91
4	—	8.25	—	15.50	—	2.43	—	0.033	—	0.1848	—	5.60
5	—	8.61	—	16.17	—	2.56	—	0.035	—	0.1797	—	5.14

Table 3. Comparative Performance Results of BARI Plough and Local Plough for Dry Land Cultivation and Puddling

Sl. No.	Particulars	Dryland condition		Puddling condition	
		BP	LP	BP	LP
1	Types of soil	Clay loam	Clay loam	Clay loam	Clay loam
2	Depth of cut, cm	8.73	6.98	8.92	7.59
3	Width of cut, cm	19.17	14.61	17.51	13.92
4	Speed of operation, km/h	2.65	2.68	2.19	2.32
5	Field capacity, ha/h	0.041	0.037	0.039	0.033
6	Draft power, kW	0.2180	0.3509	0.1755	0.2090
7	Total tilling operations	3	5	3	3
8	Total energy reqd. kw-h/ha	14.01	52.75	13.65	31.84
9	Time reqd.				
	Man-day/ha	9.15	16.89	9.62	18.94
	Animal-pair-day/ha	9.15	16.89	9.62	18.94
10	Total cost of ploughing, Tk/ha	732.00	1352.00	770.00	1515.00

Results and Discussion

The field performance results of the BARI plough are presented in **Tables 1**, and **2** which shows that the depth and width of cut, speed of operation and field capacity increased with an increase in the number of tilling. The pulling force, draft power and specific energy requirement decreased with an increase of tilling operations. For the moldboard plough, draft power and specific energy requirement sharply change from the first tilling to the next tilling operations. This is due to the fact that during the first ploughing using the BARI plough, there was no unploughed strip of land. For this reason, draft power as well as energy requirement suddenly decreased (28%) from first ploughing to the next. In comparison the local plough, the draft power and specific energy requirement decreased gradually from the first tilling to the next tilling operations. The BARI plough required about 30% less draft power than for the local plough.

Table 3 shows that the ploughing capacity of the BARI plough is 14% higher than that of local plough. The total energy required to prepare the land up to final tilling by local plough is about 3 times higher than that of the BARI plough. The time and cost of ploughing by moldboard plough was 50% less than that of the local plough.

Concusion

1. The BARI plough turned and inverted the furrow slice to the right, thus weeds and stubbles got buried in the soil that becomes organic matter.
2. Soil inversion and pulverization by the BARI plough is better than the performance of the local plough. This helps prepare the land for seeding/planting with less number of tilling operations.
3. The BARI plough required less time and energy for good tilth. As a result, the cost of land preparation was less than that of traditional local plough.

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Development of A Low-cost Ferti Cum-seed Drill

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Abstract

A low cost ferti cum-seed drill made from locally available materials is developed. It mainly consists of a wooden body, wooden tynes, iron shares, seed hopper, fertilizer hopper, PVC rigid pipes and beam. The drill + blade harrow is evaluated and compared with the performance of the traditional method of sowing and applying fertilizer (behind plough). The drill + blade harrow saved 46.7 man-h/ha, 53.3 bullock-h/ha and Rs 283.30 (US$9)/ha while sowing groundnut seed and applying fertilizer over traditional methods. The dryland farmers can go for this type of ferti cum-seed drill to cover more area in less time under favourable climatic conditions.

Introduction

India is the largest producer of groundnut (*Arachis hypogaea L.*) in the world with 1990 production estimated at 7.2 million t on 8 million ha harvested area. By comparison this is 31.16% of world total production (23.11 million t) and 40.06% of world production area (19.97 million ha) (Chomchalow et al., 1992).

Most of the Indian farmers sow groundnut seeds behind the plough and apply the fertilizers either behind the plough or by broadcasting. If the fertilizer is broadcast, the fertilizer use efficiency by the plant will not be that much as it will be put in the furrow below the seed. If the fertilizer is placed below the seed, the roots of the plant will absorb all the nutrients available in the fertilizer and thereby there will not be any wastage of fertilizer as it happens in broadcasting. Another thing is that the coverage by plough will be only 0.4 ha per day and it requires three labourers — to ride the plough, to sow seed and to apply fertilizer.

Sowing the seed under favourable climatic conditions is essential in increasing yields. Especially in dryland agriculture, the farmer has to complete the sowing when there is still moisture in the soil. If a farmer has 2 to 4 ha of land it will take 5 to 10 days to sow the seeds by using the plough. This means that the entire land may not be covered when there is sufficient moisture in the soil and favourable climatic conditions. Also, there will be shortage of labourers as every farmer goes on sowing the seeds at the same time i.e., when there is moisture in the soil.

To overcome the above problems, many seed cum-fertilizer drills have been introduced. But each one is having its own advantages and disadvantages and most of them (iron made ones) which are costly are not within the reach of the small, marginal and resource-poor farmers. An agricultural implement will become popular among small farmers only if it can be made and repaired by a local artisan/carpenter. This will be possible only if the material used will be of locally available wood instead of iron. Because most of the villages will not have blacksmiths and if there is any defect in the drill made

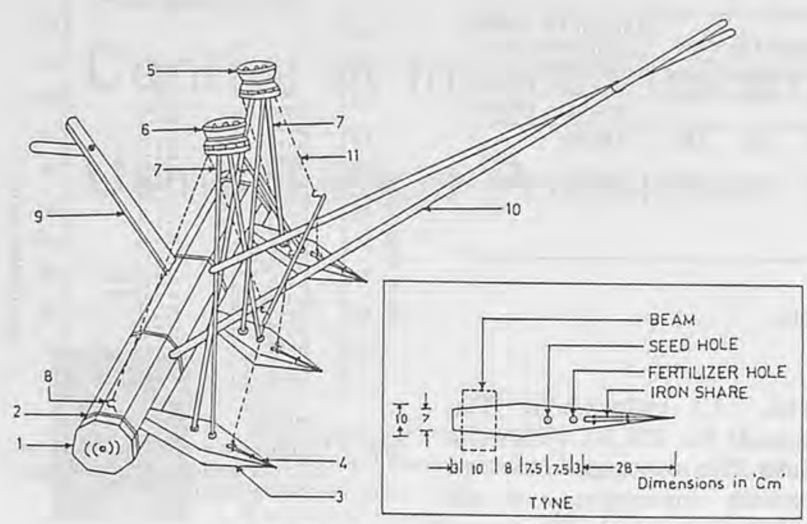

Fig. 1 Sketch of the ferti cum-seed drill.

Fig. 2 Ferti cum-seed drill.

Table 1. Specifications of Ferti Cum-seed Drill

Component	Description
Body	Wooden body, 10 cm diameter, 90 cm length
Iron ring	10 cm diameter, 1 cm width, 6 in number
Tyne	Wooden tyne, 67 cm length, 10 cm maximum width, 3 in number
Share	Iron share, 28 cm length
Seed hopper	Wooden hopper, one
Fertilizer hopper	Wooden hopper, one
Pipe	PVC rigid/Bamboo/Iron pipe, 3 cm diameter, 90-92 cm length, 6 in number
Hook	∩ type-3, ∩ type-3, ? type-7
Handle	Wooden handle, 80 cm length
Beam	Wooden Beam, 5 cm diameter, 2.7 m length, 2 in number
Rope	25 m in length

of iron, the farmer has to carry the implement all the way to the near-by town to get it repaired which is a cumbersome and time consuming process. After perusal of many existing seed drills with all their defects and operational problems a ferti cum-seed drill was developed using locally available materials and made by a local carpenter.

Materials and Methods

Construction Features

The ferti cum-seed drill consists of a 10 cm diameter and 90 cm length body fixed with 6 iron rings of 1 cm width. The iron rings protects the body from breakage whenever there is a chance to break the body. Three tynes of size 67 cm length and 10 cm maximum width at its centre with iron shares are fixed to the body separating one another at a distance of 30 cm. Two holes are made to all tynes. The fertilizer tubes are placed in the tyne holes far away from the beam and seed tubes in the tyne holes nearer the beam. Three centimeter diameter PVC rigid pipes are used for this purpose. Depending upon the availability, bamboo pipes/iron pipes can also be used as seed/fertilizer tubes. The three fertilizer tubes and three seed tubes are brought to two sides of the wooden handle and the hoppers are fixed on them with the help of the rope and iron hooks to form a ferti cum-seed drill (**Figs. 1 and 2**). The specifications of ferti cum-seed drill are given in **Table 1**. The cost of the ferti cum-seed drill was Rs 800 (US$25.40).

Treatments

Two treatments determined the performance of the ferti cum-seed drill over the traditional method (behind plough) of sowing groundnut and applying fertilizer.

In the first treatment, the seed and fertilizer were dropped behind the plough as usually done by the farmers. Three labourers were engaged to ride the bullocks, to sow the seed any apply the fertilizer. The seed and fertilizer dropped in furrows were covered by running another plough in between the two furrows. The cost of the plough was Rs 450 (US$14.30).

In the second treatment using the ferti cum-seed drill, the seed was sown and the fertilizer was applied by using the two hoppers meant for that purpose. Four labourers were engaged to run the drill successfully. One labourer handled the drill, one carried the seed and fertilizer to the other two labourers who dropped the seed and fertilizer. A blade harrow consists of straight blade was used to cover the seed and fertilizer.

In order to use the ferti cum-seed drill effectively, the land was prepared thoroughly until a fine tilth was achieved. When the drill was in operation, initially the fertilizer fell in the furrows as the fertilizer holes are 7.5 cm away from the seed holes. Due to the disturbance of the soil by the tynes, some of the soil fell back into the furrows and covered the fertilizer. Above this soil the seed fell to utilize the fertilizer effectively.

Table 2. Performance of Different Methods of Sowing Groundnut Seed and Applying Fertilizer

Treatment	Area covered (ha/day)	Requirements		Charges (Rs/day)			Amount for sowing seed and applying fertilizer (Rs/ha)	Amount Saved (Rs/ha)
		Bullock Pairs	Labourers	Bullock Pairs	Labourers	Total Cost		
1. Plough + plough	0.4	2	4	100	80	180	450.00	—
2. Fertilizer cum-seed drill + Blade harrow	1.2	2	5	100	100	200	166.70	283.30

Note: Number of working hours/day = 8.
Labour wages = Rs 20/day.
Hiring charges of bullock pair = Rs 50/day.
US$1 = Rs 31.50.

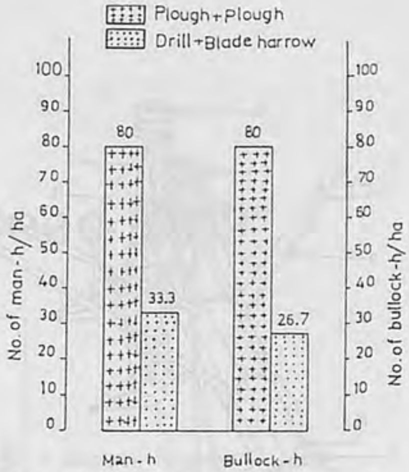

Fig. 3 Comparative performance of different methods of sowing and applying fertilizer.

Results and Discussion

The ferti cum-seed drill was compared with the performance of the traditional method (behind plough) of sowing groundnut and applying fertilizer. The plough + plough covered only 0.4 ha area in one day (8 h duration) with 2 bullock pairs and 4 labourers. But the ferti cum-seed drill + blade harrow covered 1.2 ha area in the same period of 8 hours with the same number of bullock pairs and with only one extra labourer i.e., with 5 labourers **(Table 2)**.

The ferti cum-seed drill + blade harrow saved 46.7 man-h/ha, 53.3 bullock-h/ha **(Fig. 3)** and Rs 283.30 (US$9)/ha **(Table 2)** in sowing groundnut and fertilizer application over the traditional method. The excess amount spent in making drill over plough can be covered just by sowing in 1.24 ha area. The use of drill is really advantageous for the resource-poor dryland, farmers as it saves time, money and also more area can be covered under favourable climatic conditions to get higher yields and returns. By having different size holes of hoppers, the drill can also be used for sowing different crop seeds.

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Control of Insect Pests on Rice Crop Using Tillage Practices

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Abstract

Rice fine varieties are severely attacked by insect pests such as stem borer, *Tryporyza* and *Sesamia* species in Pakistan. Stubbles of rice, if not properly destroyed after harvesting the crop, act as main host for the hibernation of stem borer larvae during winter.

The present study was conducted to assess the effect of various tillage practices on the destruction of stubbles and killing of hibernating rice stem borer larvae. The effect of zero tillage practice, although still at investigatory level for wheat production after rice, on the stem borer infestation was also evaluated. It was observed that stubble intensity and infestation was highest in zero tilled fields. Complete destruction of stubbles and no hibernating larvae was found in rotavated fields. Running of cultivator and plank with less passes was not so effective in stubble destruction and killing of winter rice stem borer larvae. However, effectiveness increased with the increase in runs of cultivator and plank.

Introduction

Rice-wheat-rice is a common cropping system in Pakistan. Stem borer, *Tryporyza* and *Sesamia* species, are the most serious insects of fine rice varieties, B-370 and B-385. Stubble of rice crop is the main host for the hibernation of stem borer larvae during winter. If destruction of stubbles is not timely and properly carried out, the spread of stem borers infests the succeeding year's rice crop severely. Also, *Sesamia* sp. attacks wheat in addition to maize and sugarcane crops in the spring.

In the rice tract, farmers give 1-3 cultivation or broadcast seed and cultivate the land twice followed by one planking to sow wheat crop in the rice harvested fields. Studies are underway to introduce wheat production with zero-tillage practices after rice. Zero-tillage leaves rice stubbles intact in the soil. The use of cultivator, a common soil tillage implement with farmers, does not completely destroy rice stubbles.

The study was undertaken to assess the effect of various tillage practices vis-a-vis zero-tillage on the destruction of stubbles and killing of hibernating rice stem borer larvae in wheat fields.

Materials and Methods

The study was carried out at adaptive research farms in Sheikhupura which lies in the rice tract of the country and three farmers' farms during 1984-85 and 1985-86. Rice fields full of stubbles of fine variety, B-370, were selected at four different locations each year. Wheat was sown in December as zero tilled and land prepared with cultivator used twice followed by plank once, cultivator thrice followed by plank twice and rotavator once followed by cultivator twice and plank once. Stubbles were collected from four randomly selected 3-square metre area during January of both years. At least one irrigation was given to the wheat crop. The rice tillers per stubble were counted. The stubbles were dissected to note infested stubbles and number of larvae per stubble. Percent destruction of stubbles with various tillage operations under study per zero tillage condition was computed. The data were analyzed statistically considering each site a replication.

Results and Discussion

The effect of various tillage practices on the destruction of rice stubbles and hibernating stem borer larvae in wheat fields under rice-wheat-rice cropping system is shown in **Table 1**.

The statistics of **Table 1** reveal very effective destruction of rice stubbles and no hibernating stem borer larvae in wheat fields which had been prepared with rotavator used once, followed by cultivator twice and plank once. In this treatment one stubble per 3 m^2 with 3 and 2 tillers per stubble was found during 1984-85 and 1985-86, respectively. The destruction of stubbles as compared with zero tillage was 99.3%. The few tillers per stubble in rotavated fields comparative to other treatments show that even the stubbles i.e; one per 3 m^2 saved from complete destruction did not go scotfree from rotavator. As a result, no infestation of stem borer larvae was found in the rotavated fields.

The use of cultivator (2) followed by plank (1) and cultivator (3) followed by plank (2) destroyed 67.9 and 81.0% stubbles during 1984-85 and 72.5 and 89.1% during 1985-86, respectively. The stubble infestation was 50.0 and 7.7% during the 1st year and 36.8 and 6.7% during 2nd year in these treatments. The average number of stem borer larvae per stubble was two in the fields prepared with cultivator (2) followed by plank (1). The use of cultivator (3) followed by plank (2) reduced the number of larvae to one per stubble during both years.

Table 1. Effect of Different Tillage Practices on the Destruction of Stubbles and Hibernation of Rice Stem Borer Larvae in Wheat Fields

Treatment	Stubbles/ 3 m^2 (No.)	Tillers/ stubble (No.)	Infested stubbles		Average larvae/ stubble (No.)	Destroyed stubbles/ zero tillage (%)
			No.	%age		
1	2	3	4	5	6	7
			1984-85			
1. Zero tillage	137^a	14^a	124^a	90.5	4^{ab}	0.0
2. Cultivator (2) + Plank (1)	44^b	11^b	22^b	50.0	2^b	67.9
3. Cultivator (3) + Plank (2)	26^c	8^c	2^d	7.7	1^{ef}	81.0
4. Rotavator (1) + Cultivator (2) + Plank (1)	1^e	3^d	0^e	0	0^f	99.3
			1985-86			
1. Zero tillage	138^a	14^a	113^a	81.9	3^{bc}	0.0
2. Cultivator (2) + Plank (1)	38^b	14^a	14^c	36.8	2^{cd}	72.5
3. Cultivator (3) + Plank (2)	15^d	14^a	1de	6.7	1^d	89.1
4. Rotavator (1) + Cultivator (2) + Plank (1)	1^e	2^d	0^e	0	0^f	99.3

Note: i. Figures followed by common letters are statistically similar at 95% level of confidence (DMRT).
ii. Figures in parenthesis show the times for which an implement was run.

Under zero tillage practices wherein stubbles remained intact in soil, 137 and 138 stubbles per 3 m^2 with 14 tillers per stubble were found during 1984-85 and 1985-86, respectively. The stubble infestation was 90.5% with 4 larvae per stubble as an average during 1984-85. In 1985-86, stubbles infestation of 81.9% with 3 larvae per stubble were observed.

Conclusions

1. Complete destruction of stubbles is essential in killing hibernating larvae. This is an effective control of stem borer attack on the succeeding year's rice crop.
2. Rotavation of the rice fields is the most effective technique for the destruction of stubbles and killing of hibernating stem borer larvae.
3. The use of cultivator and plank with less number of passes is not so effective in rice stubble destruction of winter larvae. However, the effectiveness increases with the increase in runs of cultivator and plank.
4. The zero tillage practice for wheat sowing after rice keeps stubbles intact in the soil and the highest infestation with stem borer larvae exists. There is every possibility of severe stem borer attack on the next year rice crop which would cater to the adoption of expensive chemical control measures at the cost of health hazards. ■■

Design and Development of FMI Axial Flow Groundnut Thresher

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Abstract

An axial flow groundnut thresher was developed which could be operated by tractor PTO or 12 hp diesel engine. The thresher was tested on two groundnut varieties, i.e. BANKI, bunch type and NC-334, spreading type for three crop moisture levels (just after digging, after two days sun drying and after four days sun drying). Two days sun drying when the moisture content was nearly 20% gave the best results. Pod output was high at higher drum speed varying from 264 kg/h to 357 kg/h (average) depending upon the nature of crop. Pod breakage was less than 3% and blower loss (recoverable) was 6.2%. The cleaning efficiency, excluding soil particles was above 95% and with soil particles about 75%. Both varieties have similar response but pod output was higher for the BANKI variety.

Introduction

Groundnut is a major cash crop of *barani* (rainfed) areas of Pakistan. More than 60 000 ha are being planted to groundnut annually. At present, all the production of groundnut in the country is consumed as dry fruit in the form of roasted nuts although it has good potential for oil extraction. World-wide, groundnut ranks tenth in the list of oil producing crops. It contains about 50% oil. The groundnut oil is considered one of the best for cooking because of its high smoke point (1,2). Since Pakistan is badly suffering from edible oil shortage, an increase in the production of oil seed crops is imperative. Groundnut being the second major oil seed crop in the country has a bright prospect in oil extraction. Potential acreage which has been identified by soil type and moisture availability as suited to groundnut production is in excess of 16 000 ha (2).

In order to increase the area for groundnut and to achieve optimum yield, mechanized cultivation is vital. Manual harvesting of groundnut is highly labour intensive, let alone the high losses in harvesting. The Farm Machinery Institute (FMI) of the Pakistan Agricultural Research Council (PARC) has been working on the development and introduction of suitable machines for groundnut production in Pakistan. After successful introduction of FMI groundnut digger, this study was undertaken to develop a groundnut thresher which is suitable for local conditions.

Literature Review

Dasa (4) reviewed the work done on development and introduction of stationary threshers for peanut in Malaysia. He reported that work in this field was started nearly two decades ago in Malaysia. The designs were aimed at helping farmers of small holdings with simple but cheap threshers that not only remove drudgery from the process but also save time. He quoted that with stationary threshers the total output in one hour could reach as high as 50 kg for a double cylinder thresher and 45 kg for single cylinder thresher. But this much output is too low for a power operated thresher.

Javed et al (5) tested the K.E.M. groundnut thresher (a thresher manufactured by Kincaid Equipment Manufacturing, Chicago, USA) at the National Agricultural Research Centre, Islamabad. The test results were not encouraging as the output was too low (63.3 kg/h) with poor cleaning efficiency of 24% only. The low output was mainly due to non-continuous feeding system of the machine. Therefore, the KEM thresher was not found suitable for adoption in the country.

Madan et al (6) developed an axial flow threshing system for groundnut. He made a comparison between existing groundnut (spike tooth type) threshing system and axial flow threshing system. He found that total pod losses, specific power consumption and stemmer saw load were less for the axial flow system, in addition to better straw quality.

Singh et al (7) developed an experimental groundnut thresher with a modified spike tooth cylinder and pneu-mechanical separation system. He found cylinder peripheral speed of 5.7 m/s to be optimum for threshing groundnut variety C-501. Unthreshed pods were less than one percent for all the combinations of the variables. Pod damage, trash and kernel damage were minimum at the pod moisture content of 14%. Air velocity rate of 8.3 m/s was found to be satisfactory.

Tangavelu et al (8) studied the performance of seven different types of stripping mechanisms for groundnut and established that the screw type mechanism is the best. He optimised the critical rotor speed for each mechanism that ranges between 260 to 360 rpm. However, no relationship could be derived between the moisture content and the output due to non-significant differences.

Fig. 1 FMI Axial flow groundnut thresher. A) Power drive unit, B) Tractor P.T.O. coupling.

Fig. 2 Threshing unit. A) Concave, B) Feeding table, C) Drum cover, D) Threshing drum, E) Feeding mouth.

Fig. 3 Cleaning unit. A) Guiding shield, B) Chaff blower.

Fig. 4 Pod conveying unit. A) Augar conveyor, B) Sliding tray.

To date, no suitable groundnut thresher is commercially available. It was also observed that axial flow threshing system has more potential for groundnut threshing. Therefore, this study was felt necessary, hence the following design features were established.

1. Axial flow threshing system.
2. Continuous feeding.
3. Simple, compact and low cost.
4. Easy to manufacture with local available technology level.
5. Tractor PTO driven with option for engine/motor drive.

The machine (**Fig. 1**) comprises of power drive unit, threshing unit, cleaning unit and pod conveying unit. All these units are mounted on one frame which is made of M.S. channel/angle. All frame members are welded to make a compact structure.

Tractors are commonly available throughout Pakistan and farmers prefer to use tractor as power source, although economically not justified in most of the cases for operating stationary machines. In view of this local trend a splinned shaft is provided which can be coupled to the tractor PTO through universal shaft. However, provision is also there to mount an engine/motor on the frame to use as a power source. Belts and pulleys are used to transmit power to different operating units.

Threshing Unit

The threshing unit consists of feeding table, threshing drum, drum cover and concave (**Fig. 2**).

Feeding table — The feeding table is made of M.S. sheet supported by M.S. angle at its outer edges. It covers the whole cylinder length and is divided into two portions: one horizontal and the other, inclined. The horizontal portion is for the crop.

Cleaning Unit

The major cleaning unit consists of a chaff blower and guiding shield while partly cleaning is done in pod conveying unit (**Fig. 3**).

Chaff blower — Underneath the opening portion of concave, a blower is provided which rotates at a speed three times higher than the threshing drum. The blower has four blades bolted on two crosses made of M.S. angle which have bushes in the centre. The blower shaft is passed through the bushes and supported on the main frame on bearings. The air blast is directed to an angle of 45° to strike the material falling down through concave opening, to blow out the chaff.

Guiding shield — Two guiding shields made of M.S. sheet have been provided along the sides of the concave to guide the material falling down from the openings in such a way that air blast can blow the chaff more effectively.

Pod Conveying Unit

This unit consists of sliding tray and auger conveyor (**Fig. 4**).

Sliding tray — This is made of M.S. strips (12.7 mm wide) welded on a rectangular angle frame at a spacing of 6 mm. It is pivoted on the side members of the main frame and can be adjusted at the required inclination. The spacing between the strips allow to drop down the soil particles as well as straw parts coming along with pods which have not been blown out by the air blast. The feeding table can be folded upward during transportation.

Threshig drum — The threshing drum is a hollow cylindrical drum made of 5 mm thick M.S. sheet. The diameter of the drum is 300 mm and the length is 1 220 mm. Two circular M.S. plates of the same thickness are bolted; one on each end of the drum. Plates have welded bushes at their centre through which an M.S. bar (45 mm dia) is passed and fixed through key to serve as drum axle. There are 61 pegs made of M.S. bar (16 mm dia) which are bolted at the outer surface of the drum in double start spiral form. The effective height of each peg from drum surface is 75 mm. Opposite the feeding side, four M.S. blades (3 mm thick) equal in peg height are welded at equal distance along the circumference of the drum which act as vine blower.

Concave — A semi-circular mesh type concave made of M.S. bar (10 mm dia) has been provided beneath the drum with a concave spacing of 25 mm. The concave has a rectangular (40 mm × 50 mm) openings in the middle portion while on the sides (feeding portion and thrower portion) it is covered with M.S. sheet to make it blind.

Drum cover — The lower half of the drum is covered by the concave while the upper half with drum cover. M.S. sheet is spot-welded around an angle iron structure to form the drum cover. Inside the cover louvers made of M.S. sheet are bolted at spiral angle which help in moving the material axially.

Auger conveyor — A horizontal auger is provided underneath the blower to convey the clean pods to one end. The auger cover is also made of M.S. square bars (5 mm × 5 mm) having the same spacing as in the case of tray. These spacings also serve the purpose of partial cleaning.

Machine Operation

The crop is placed on the feeding table from where it is fed to the threshing drum through the feeding mouth. The drum is rotated by power source, i.e., tractor PTO or engine. The crop moves axially by the action of pegs and louvers which are arranged spirally. The crop takes almost two and half turns to reach the throwing end. During this period the pods are detached from the vines and the vines are thrown out by the thrower provided at other end of the drum. The threshed pods and the chaff (broken pieces of vines and leaves) pass down through concave openings where they receive air blast from blower. The chaff and dust particles are blown out while the pods fall on the sliding tray and ultimately reach the auger conveyor. As inclined tray and auger housing are made of strips/square bars having longitudinal spacings, the remaining chaff and soil particles fall down through spacings and the clean pods are collected at the augar end. Two persons are required for this whole operation: one for feeding of crop and other for pod collection and allied activities.

Machine Performance

The thresher was tested during 1988 groundnut harvest for two commonly grown varieties in Pakistan, Banki (bunch type) and NC-334 (spreading type). Three crop moisture levels, i.e., just after digging, after two days sun drying and after four days sun drying were considered important from practicality point of view. On the basis of literature review three drum speeds, i.e., 300, 350 and 400 rpm were selected for the testing purpose.

The thresher was powered by tractor PTO and the speed was set by tractor engine throttle. A crop sample of measured weight (20 kg) was fed each time and the time required for threshing the sample was noted. The output was collected at the collection end while the blower and thrower losses were collected separately.

The crop moisture contents just after digging were about 50%. During threshing at this high moisture level the crop was wrapping around the drum, resisting axial movement and resulting in drum clogging. The same crop behaviour was observed for both varieties and test could not be conducted at this moisture level, i.e., freshly dug crop. However, the test data was recorded for two days sun dried and four days sun dried crops which was further analyzed. The pod breakage, straw

Table 1. Effect of Drum Speed and Moisture Content (wb) on Thresher Performance for Threshing BANKI and No. 344 Groundnut Varieties

Moisture Content (wb) (%)	Drum Speed (rpm)	Clean Pod Output (kg/h) R1	R2	R3	Avg.	Pod Breakage (%) R1	R2	R3	Avg.	Blower Losses (%) R1	R2	R3	Avg.	Cleaning Efficiency (%) (with soil particles) R1	R2	R3	Avg.	Cleaning Efficiency (%) (without soil particles) R1	R2	R3	Avg.
Variety: BANKI																					
	300	317.14	310.00	325.67	317.27	0.9	1.2	2.2	1.4	4.2	3.4	5.0	4.2	72.7	76.6	71.4	73.6	98.4	97.4	95.5	97.1
23	350	333.82	352.00	346.42	343.33	2.9	1.4	2.5	2.3	5.2	5.1	6.0	5.4	76.5	79.5	74.5	76.8	95.8	97.7	96.8	96.8
	400	367.06	353.48	352.50	357.38	2.2	3.0	2.5	2.6	6.6	6.4	5.7	6.2	75.0	76.4	73.5	75.0	97.4	96.4	96.7	96.8
	300	198.75	214.39	248.82	217.80	2.6	3.9	2.3	2.9	6.9	5.1	6.1	6.0	78.6	66.7	76.0	73.7	94.5	93.5	95.6	94.5
3	350	261.60	235.64	260.00	252.00	3.5	2.7	2.4	2.9	9.7	10.3	8.0	9.4	73.8	76.4	69.8	73.3	94.2	95.2	96.0	95.1
	400	292.62	309.38	276.43	292.43	4.4	3.6	3.9	4.0	8.6	19.2	4.9	10.9	71.7	71.4	74.5	72.5	94.0	94.5	94.7	94.4
Variety: No. 344																					
	300	245.45	240.00	244.00	243.16	1.4	2.2	3.3	2.3	5.7	5.3	1.8	4.3	71.1	78.0	82.9	77.3	98.4	98.5	95.6	97.5
19	350	243.12	271.50	262.96	259.13	2.0	2.4	2.7	2.4	4.9	6.1	4.6	5.2	78.5	76.7	80.7	78.6	98.0	97.1	95.9	97.0
	400	282.29	273.60	286.00	280.00	2.7	2.8	2.7	2.7	5.3	6.7	6.6	6.2	82.5	71.1	75.0	76.1	97.4	95.7	95.3	96.1
	300	234.00	182.77	203.08	208.25	1.8	2.1	1.7	1.8	1.9	5.8	2.3	3.3	76.9	63.6	77.3	72.6	96.3	91.0	96.5	94.6
2	350	232.41	244.66	237.45	238.70	3.0	2.2	1.2	2.1	2.6	4.2	5.5	4.1	76.5	75.7	75.8	76.0	96.0	95.2	94.7	95.3
	400	264.00	268.47	259.20	264.16	2.7	3.6	2.1	2.8	6.9	6.9	6.7	6.8	78.8	77.3	77.8	77.9	96.2	97.1	95.9	94.4

particle and soil particles were separated from the clean pods for each output sample and their weights were recorded on the data sheet.

The calculations were made as shown below for pod breakage, blower loss and cleaning efficiency. The cleaning efficiency, excluding the soil particles was also calculated keeping in view the assumption that in sandy loam soil which is generally recommended for groundnut cultivation, crop will be free of soil particles.

$P_i = P_b + P_c + P_l$
$SP = T_p - (P_c + P_b)$
Pod Breakage, % = $(P_b/P_i) \times 100$
Blower Loss, % = $(T_l/P_i) \times 100$
Cleaning Efficiency (%):
a) With Soil Particles
   = $(P_c/T_p) \times 100$
b) Without Soil Particles
   = $(P_c/(T_p - SP)) \times 100$

Where
T_p = Total output, kg
P_i = Actual Pod Input, kg
P_c = Clean Pod, kg
P_b = Pod Broken, kg
P_l = Pod Loss (Blower & Thrower), kg
SP = Soil Particles in Output Sample, kg

The results (**Table 1**) show that pod output per hour increased with an increase in drum speed while it decreased with decreasing moisture content. It was observed that when the crop was more dried feeding was difficult, therefore, the feeding rate became slow which resulted in low output. Pod breakage and blower loss (recoverable) showed an increasing trend with speed increase but these were within acceptable limits even at higher speed. The cleaning efficiency was not much affected by the cylinder speed as there was very little difference between the specific weights of pods and straw. However, the cleaning efficiency was slightly higher at higher moisture level. Both crop varieties showed the same behaviour.

Conclusions

1. The thresher gave the best performance on two-day sun dried crop for both varieties, when the moisture contents were nearly 20%.
2. Drum speed can be selected as 400 rpm for higher pod output. Although pod breakage and blower loss at this speed were higher these were within acceptable limit. Pod breakage for both varieties was less than 3% while blower loss was 6.2% but it was recoverable.
3. Cleaning efficiency was not affected by drum speed. It was above 95% when soil particles were excluded and about 75% with soil particles for both varieties.
4. Pod output for the BANKI was 377 kg/h while 280 kg/h for NC-334. Pod output varied with the nature of crop (yield index).

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Low-cost High Efficiency Portable Egyptian Thresher

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Abstract

This research was intended to improve the multi-crop El-Shames stationary thresher for wheat and paddy under Egyptian conditions. The new thresher provides an iptimal performance for small farmers. The techniques used included developing a new cylinder that can thresh wheat and paddy without major adjustment and also a modified and improved shape of the louver fins. A study of operating ranges determined the thresher capacity and results showed it had been increased for wheat and paddy crops without affecting seed quality (i.e., damage and losses). This research contains results on feedrate, cylinder speed, moisture content, separation efficiency and material flow rate along the rotor cylinder.

Introduction

Annually, Egypt cultivates around 1.8 feddan of wheat and one million feddan of paddy. The harvesting system for both crops primarily consists of manual cutting, mowing, gathering and transporting the crop to one location, which causes losses of up to 25% in the field. Improving this harvesting system has been a main national objective. To assist with this task various combines, mowers, reapers, and threshers have been introduced throughout the last decade. This introduction program supervised by Agricultural Engineering Research Institute (AERI), includes field testing and economic evaluation and determines potential manufacturing capabilities of local manufactures. As a result of the program, 15% of the Egyptian rice area is harvested using Japanese combines. A Turkish thresher was accepted and used mainly for wheat. Currently this machine is locally manufactured in small and medium size farm machinery companies. The total sales of this machine have been 10 000 units. AERI has started to adapt the same thresher to handle rice. AERI indicated that wheat grain output by the Turkish thresher is around 450 kg/h, with a 1:1.4 grain to straw ratio at 12% moisture content (MC). The mean feed rate was around one t/h for wheat. For rice the machine performance could reach 700 (kg/h) and was driven by a 65 hp tractor. In comparison, a 30-hp Japanese combine which harvested one feddan in one hour had a 3 000 kg output. The 2-meter-cutter-bar universal combine has a capacity of one feddan per hour, for crops averaging 2 t/h. This information indicated that the performance of this Turkish thresher can be further improved.

One of the limitations with the current thresher design is that it requires an auxiliary power supply, usually a P.T.O. on a tractor. Therefore, during threshing one farm tractor owned per person is not available for rice and corn seedbed preparation. When both of these crops are planted later than their calendar dates, their yields are significantly reduced. In order to free the tractor the thresher could be equipped with its own power supply. Prior to selection of the appropriate power supply, the thresher power requirements need to be assessed. The main purpose of this work was to:

a. Define the thresher component

which hinders capacity.

b. Redesign components to increase capacity.

c. Estimate the power required for operation.

d. Test and report machine performance.

This research work was conducted as a USAID/NARP project and carried out at the Agricultural Engineering Department of Purdue University, West Lafayette, Indiana in the U.S.A.

Literature Review

Majumdar, K.L. (1985) developed a multi-crop thresher by incorporating an axial flow arrangement on a traditional spike tooth thresher for threshing major crops. The machine was operated by a 5 hp electric motor and the output capacities at maximum feed rates were 348, 276, 200, 540, 1 635, and 392 kg/h for wheat, soybeans, sorghum, maize and paddy, respectively. The threshing efficiency was approximately 99% in most cases. Total grain losses were 2% for wheat, sorghum and paddy, 2.3% for maize, and 4% for soybeans.

Khan, A.U. (1990) described a dual model thresher, developed in Egypt, which could be operated as a beater or axial-flow type thresher. This threshing machine can thresh all the popular cereal crops that are grown in developing countries and produce fodder from straw. It has generated significant interest among farmers, and three manufacturers have now started commercial production in Egypt.

He also described a wheat thresher with a beater threshing drum and a built-in-screen that was modified to serve as a whole crop thresher. It could be quickly converted from a beater to an axial-flow model. In field tests, threshing outputs of 390 kg/h of wheat and 634 kg/h of paddy were achieved with maximum grain losses of 1.5 and 1.2%, respectively. Cleaning efficiencies ranged from 97.6% to 99.9%.

Sharma, V.K. et al (1986) stated that, studies were conducted on wheat crop with grain moisture of 8.5%. Power requirements of the components increased with an increase in component speed, and with an increase in feed rate. Power requirements of the blower and sieves remained constant whereas power requirements of the threshing cylinder increased. The threshing cylinder consumed the most power (55-82%), followed by the blower (17-43%) and the sieves (0.4-1.7%).

H.P. Harrison, (1991) stated that the power required for the axial-flow rotor was extremely sensitive to change in the feed rate. A 50% increase in feed rate doubled the power required. Power was also affected, to a lesser degree, by changes in the crop moisture content and the helix angle of the transport vanes. The power reduction associated with an increase in the helix angle is due to the fewer number of passes a crop takes to go around the rotor axis, or a portion of it. He concluded that the effects of the rotor speed and concave clearance on the power requirement were minor.

Procedure and Methods

This study gives a detailed account of the modifications done to the El-Shames thresher in order to attain both the primary and secondary objectives. In this study, unless otherwise stated, left and right refer to looking forward toward the front hitch.

This study began with sketches of all parts that were planned to be changed. These included the thresher cylinder, rice head, P.T.O. shaft, and concave. Drawings of other parts were done as needed throughout the redesign process. These included the belt shields, spacer plates, and rasp bar assemblies. Several of these drawings are included in reference El-Behery to help illustrate the modifications made during the project. These drawings were made using AutoCAD 11.

A major decision was to change the flow direction of material through the thresher section. This decision was based on the fact that the Case IH rasp bars selected for use on the El-Shames were designed only for material flow from left to right. Originally, flow direction was from the right to left. The selected rasp bars had the three angles recommended by Phan Hieu Hien, 1991, for an axial flow thresher. In changing the flow direction, from left to right, several alterations were necessary.

A hydraulically-operated conveyor was mounted to the back of the thresher to allow easier and smoother feeding into the threshing cylinder. The conveyor itself is 99 inches (2 515 mm) long, and 12 inches (305 mm) tall. The belt dimensions are as follows: 1/8 inch (3 mm) thick, 14 inches (356 mm) wide, and 200 inches (5 080 mm) long. The conveyor is mounted on the machine using five 9/16 inch (14 mm) bolts. The back end of the conveyor is supported by two angle-iron bars and the conveyor is mounted at a 24 degree angle.

A no-load lab test was conducted in the Agricultural Engineering shop. This was done to acquire various specifications on the thresher. Thresher speeds of 500 to 800 rpm were used. Airflow and torque were found using a data collection system which consisted of the following: torque sensor, Fluke Hydra data logger, Daytronic strain gage amplifier, Delco Freedom twelve-volt DC battery (to power the strain sensor), electrical cable from the torque sensor to the strain gage, Texas Instrument Travel-mate 4000 Win SX computer, and a stopwatch.

Sensors available for the project included a LEBOW torque/rpm sensor. Sensors were selected for the type and range of information to be measured. From the available sensors it was determined which features would be required for the data acquisition.

The data acquisition tool selected was a FLUKE data logger which can be powered using a 12-volt battery, thus providing portability. Connections to this data logger were through the connection adapter. Connection to the torque sensor was accomplished with a 5 pin military connector. A twisted pair of wires was used to connect between the sensor and data acquisition. Also, a strain gauge conditioner was needed between the torque sensor and the data logger.

A test with wheat was made to determine the separation efficiency of the thresher. This was done with the use of a grain pan collector which was designed and made specifically for this purpose. The grain pan collector was held in place under the screens to catch the grain as it fell from the threshing cylinder.

Grain damage was measured from samples of wheat taken at the outlet. This method used a series of sieves with different hole sizes which allowed cracked and broken kernels to fall through. A sample size of one hundred kernels was used. The number of kernels remaining after running the samples through the sieves were then counted.

One test on soybeans was conducted at the Purdue Throckmorton Farm. The maximum crop feed rate was 40 kg/min. for 300 and 400 cylinder rpm speed. Samples of soybean seed were collected and examined for damage. Also, seed loss samples were taken at the same time that samples were collected for moisture content tests.

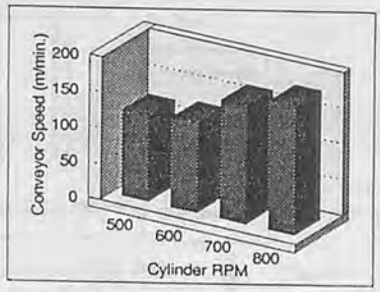

Fig. 1 Conveyor belt speed used in tests (m/min.).

The thresher was tested for its corn shelling ability. The maximum crop feed rate was 100 kg/min at both 300 and 345 cylinder rpm. Samples of shelled corn were collected and examined for kernel damage. At the same time, samples were taken for both grain loss and moisture content.

Results and Discussion

Belt Conveyor Evaluation

Fig. 1 shows the time required for the material to move on the conveyor. It is calculated as material velocity divided by the length to be transverse. Thus for the feeder conveyor:

$$\text{crop dwell time} = \frac{\text{crop velocity}}{\text{feeder length}}$$

The feeder unit was 2.55 m long and hydraulically operated at speeds of 120, 125, 165 and 180 m/min (2, 2.08, 2.66 and 3 m/s, respectively). Thus the value for crop velocity in m/s for the conveyor belt was 2, 2.08, 2.66 and 3 m/s, respectively. Therefore, crop time on the conveyor belt was calculated using the above equation at: 0.7, 0.8, 1.05 and 1.15 seconds, at 2, 2.08, 2.66 and 3 m/s belt speed, respectively. Therefore, the mechanical feeder was designed and established improved thresher capacity, besides improving evenness and controlled feed rates. During wheat field tests under normal working conditions three different feed rates (2 400, 3 000 and 3 600 kg/h) were achived by three different human operators.

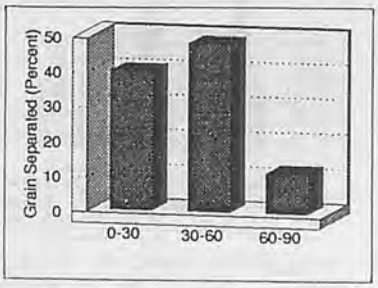

Fig. 2 Grain separation analysis along thresher cylinder.

Fig. 2 indicates grain separation at different distances along the threshing cylinder for the 800 cylinder rpm test and at a crop flow rate of 3 600 kg/h, for 14.3% moisture wheat. Three hundred and fifty-one grams were collected on the collection pan placed under the thresher concave. The first section (0-30 cm) had a separated grain percentage of 39.88%. On the second section (30-60 cm) of pan, 426 grams of grain were collected for a separated grain percentage of 48.40%. The quantity of grain collected on the third section (60-90 cm) was 103 grams and grain separated percentage was 11.70%.

The mass flow analysis diagram for the thresher is shown in **Fig. 3**. The numbers are assigned to the different working units, and the letters show the different flow of materials during processing in the machine. First unthreshed wheat is fed by conveyor belt to the crop hoppers, into the threshing unit (1). Then wheat kernels and chopped straw (b,c) drop onto the sieve separator (2). Eccentric action separates materials into three directions, dirt (i) moves toward to dirt collection pan, straw (d) is drawn by the suction fan (3) and blown onto the field (e) while wheat kernels (f) drop onto the grain pan underneath the sieve separator pan. Then wheat kernels (g) move up to the cyclone sepa-

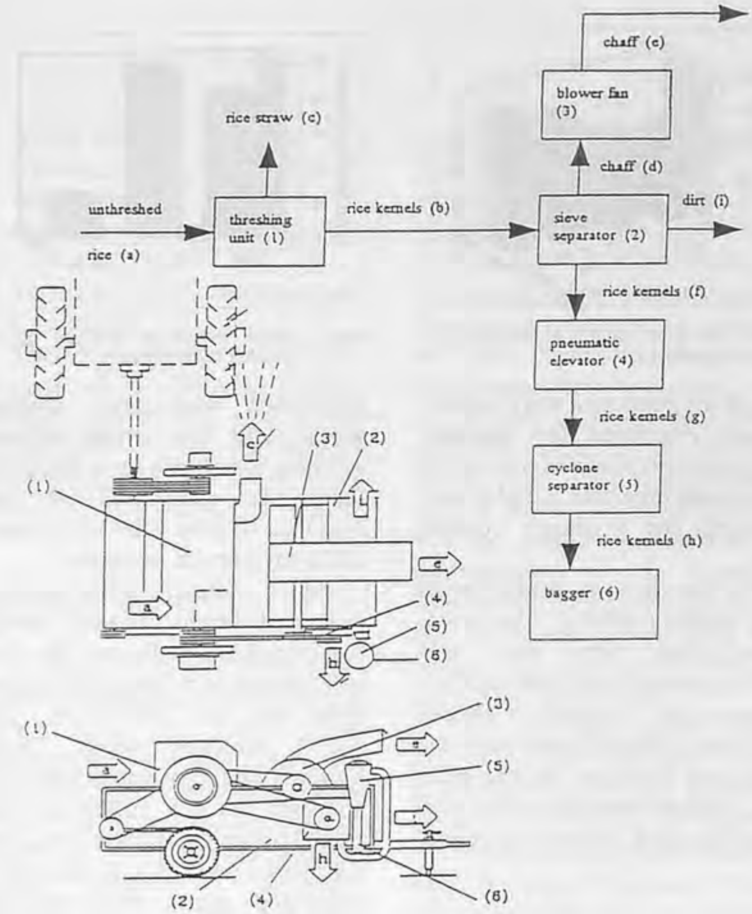

Fig. 3 Mass flow analysis-rice threshing.

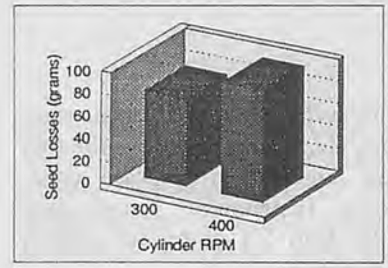

Fig. 4a Soybean seed losses at 40 kg/min feedrate and m.c. 13.8%.

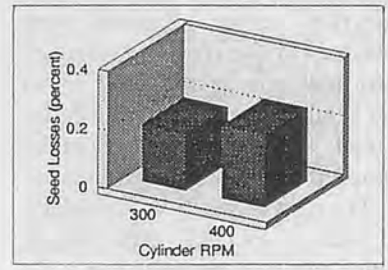

Fig. 4b Soybean seed losses at 40 kg/min feedrate and m.c. 13.8%.

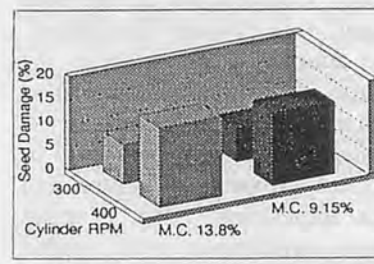

Fig. 5 Soybean seed damage in percent.

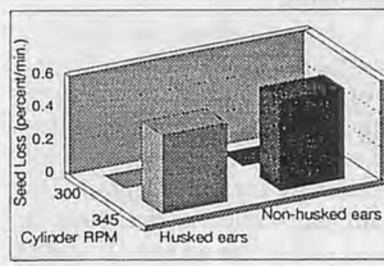

Fig. 6 Corn seed loss at 100 kg/min feedrate and m.c. 15.8%.

rator (4,5), and finally they are transported (h) to a bagger (6) and stored in bags.

Soybean Throughput, Seed Loss and Seed Damage

Figs. 4 and **5** provide thresher machine efficiency for threshing soybeans. Two thresher cylinder rpm's were used (300 and 400), for a crop moisture content 13.8% at 40 kg/min (2 400 kg/h) crop feed rate. Results indicated that, seed losses were 0.19% at 300 rpm, and increased to 0.25% at 400 cylinder rpm. Also, seed damage was 7.315% for 9.15% moisture content at 300 cylinder rpm and increased to 8.42% for 13.8% moisture content soybeans, at 400 cylinder rpm. Also, soybean seed damage was 15.458% for 9.15% moisture content and 300 cylinder rpm and increased to 16.915% for 13.8% moisture content and 400 cylinder rpm at a flow rate of 40 kg/min. This figure indicated that cylinder rpm and seed moisture content had a major effect on seed damage.

Fig. 6 shows results of the corn shelling test at two different cylinder speeds (300 and 345 rpm) and two different ear shelling conditions of non-husked ears and husked ears. Seed losses were measured at 300 and 345 cylinder rpm for a feed rate of 100 kg/m/min. and a moisture content of 15.8%. During corn shelling at 300 cylinder rpm the tractor engine stopped because the tractor fuel pump governor setting was at the maximum rating and available power was exceeded. Therefore, the corn shelling test was conducted at a 345 cylinder rpm at the same feed rate and crop moisture content. Kernel losses of non-husked ears was 0.55% and kernel losses for husked ears was 0.475%. Corn losses were higher when the thresher was fed with non-husked ears. It was observed that ear husks held some kernels at the thresher outlet but kernel losses were less when husked ears were shelled.

Laboratory Test

Fig. 7 shows the result of power required (kW) at the different tractor P.T.O. rpm's of 280, 300, 350, 280 and 410 for each component of the system. The power required to operate a no-load bagging fan at 280 P.T.O. rpm was 0.637 kW and 0.329 kW at 410 P.T.O. rpm. Also, the power needed to operate a no-load separating fan (Chaff fan) was 0.671 kW at 280 P.T.O. rpm and 3.570 kW at 410 P.T.O.

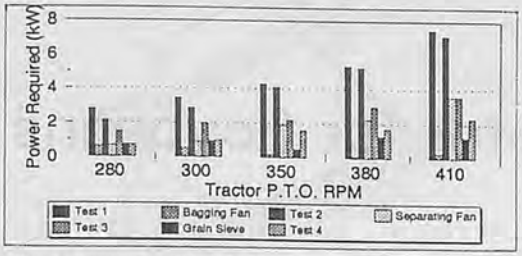

Fig. 7 Power required from lab test of each component at no-load.

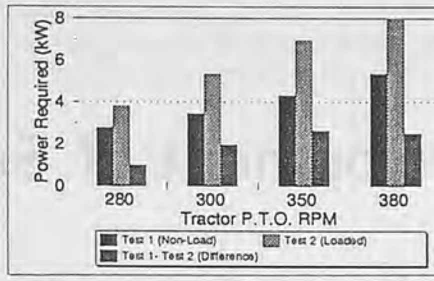

Fig. 8 Power required for wheat threshing at 3 600 kg/h feedrate.

rpm. The grain sieve power at no-load at 280 P.T.O. rpm was measured as 0.757 kW and 1.266 kW at 410 P.T.O. rpm. Finally, the power needed to operate a no-load threshing cylinder was 0.732 kW at 280 P.T.O. rpm and increased to 2.338 kW at 410 P.T.O. rpm. The power required per cm to operate a no-load thresher cylinder was 0.00006 kW at 280 P.T.O. rpm and 0.019 kW for the thresher at 410 P.T.O. rpm.

Field Test

Fig. 8 shows that power was required (kW) to operate the thresher in wheat at different tractor P.T.O. rpm's (280, 300, 350, 380) and at a 3 600 kg/h crop feed rate for a crop moisture content of 15.5%. The power required to operate the loaded thresher was 3.8 kW at 280 P.T.O. rpm and it increased incrementally up to 5.33, 6.96, and 7.9 kW at 300, 350 and 380 P.T.O. rpm, respectively. This figure also indicated that the power required to operate the thresher at no-load at the same P.T.O. rpm of 280 rpm was 2.798 kW and increased gradually to 3.454, 4.304 and 5.369 kW at 380 P.T.O. rpm. Therefore, power required for threshing only (no friction) at 280 P.T.O. rpm was 1.002 kW and increased to 1.876, 2.656 and 2.531 kW at 300, 350 and 380 rpm. Several wheat threshing tests were carried out at different P.T.O. rpms.

Regression Analysis

Regression analysis was used to investigate the effects of three parameters, crop feed rate, cylinder radius and P.T.O. rpm on power required. Twelve sets of input data were used for model development. Regression analysis was calculated for the equation:

$$P = C (F * R * RPM)$$

Linear regression through the origin was chosen and C is the slope which was obtained from the data set for a 95% confidence level. The R2 of this regression model was 0.97. Therefore, power required (kW) for this type of thresher would be computed as:

$P (kW) = C (F * R * RPM)$

P (kW)	is power kW
C	is constant = 0.001
F	is crop feed rate (kg/min.)
RPM	is tractor PTO shaft rpm

During this test the drum radius did not vary, but is within the range of most axial threshing systems.

Conclusions

1. By attaching a conveyor belt to the thresher, the crop throughput increased to 3 600 kg/h for wheat, 2 400 kg/h for soybeans, and 6 000 kg/h for corn.
2. The newly designed thresher cylinder improved the threshing performance for wheat, soybeans and corn. Grain loss and grain damage are within ASAE Standards. Also, grain purity was 99%.
3. The optimum cylinder rpm for threshing wheat was determined to be 800 rpm, 300 to 400 rpm for soybeans, and 350 rpm for shelling corn.
4. The clearance between the cylinder and concave used was 18 mm.
5. The slotted concave was observed to perform better while threshing high moisture content crops than the concave with 18 mm round holes.
6. Determination of power required for each component at different feed rates and cylinder rpm was accomplished to aid design engineers in further modifying and optimizing this unit.
7. This project was deemed successful in developing intermediate mechanization technology.

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Development of Separator for Soybeans

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Abstract

A simple and effective separator for soybeans was developed for small-scale farmers in Uganda, to clean the seeds from foreign material, chaff, broken beans etc. as demanded by local and world markets. It will help to avoid losses during post-harvest time and to reduce human drudgery of cleaning the seeds manually. The principle is a jute belt conveyor of a simple construction that can be fabricated locally. For soybeans the capacity is up to 360 kg/h and separation is very good if the angle of the conveyor is about 20 degrees and the conveyor speed is about 0.5 m/s. The separator could be used for other seeds.

Introduction

Soybean is a relatively new crop in Uganda. Production of the crop was very low until 1944 when an estimated total of 16 180 ha were planted to soybean. Between 1971 and 1980 the average annual production was estimated at 4 900 t from 5 600 ha. In 1990 a planted area of 38 500 ha produced 35 000 t. Soybean used for human food must be of high quality. Foreign materials such as stems, pods, sticks and stones must be removed. Crushed and damaged beans should be removed also as they are of no value and may contain toxin.

The government and non-government institutions have set a quality control for the soybean buyers and exporters in order to compete in the international marketing of soybeans. The quality control for export is indicated in **Table 1**.

This doesn't seem very difficult to realize, but is a problem when harvesting, threshing and cleaning of the crop are done manually. In that case, under dry conditions, the mature plants are uprooted by hand or cut at ground level using a sickle or knife. The harvested plants are transported to the drying place on head, by ox-chart or by tractor with a trailer. They may be spread on a platform and sun-dried. Threshing is normally done at home or near farm stores. Hand threshing using wooden sticks is done when quantities are small.

Winnowing

In Uganda winnowing is mostly done by women using a tray.

Table 1. Quality Control for Soybean Exports

	max. (weight %)
Foreign material (FM)	2.0
Moisture content (MC)	12.0
Insect damage (ID)	2.0
Disease discoloured (DC)	6.0
Broken/split/shrivelled (BSS)	9.0
Total damage max.: ID+DC+BSS	17.0
Aflatoxin: 8 PPB (parts per billion)	

The tray is circular or rectangular in shape, made of closely interwoven sisal and straw material. The threshed soybeans of which most of the bigger foreign material has been removed are scooped into the tray. The tray is held in upright position and shaken a little to let the beans fall on a clean floor. The result of cleaning depends on the natural wind speed at that moment, because the foreign material has to fall apart from the beans. Further separation, using the same tray, is carried out by vibrating and tossing the beans. The capacity of winnowing is about 25 kg/h. If an average farmer owns about 1.5 ha of land and the estimated yield is 2 000 kg/ha, 15 work days per farm are needed. In spite of the many hours spent on winnowing, the quality of the work mostly does not meet the specified quality control.

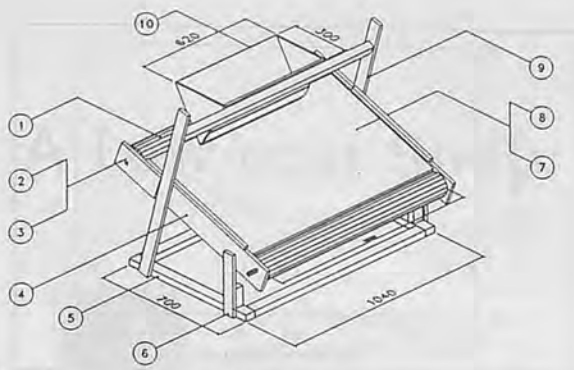

Fig. 1 Construction of the soybean separator.

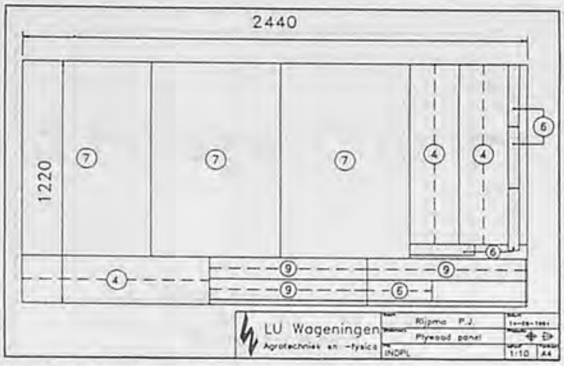

Fig. 2 Main plywood parts for 3 separators made from one panel.

Design of Separator

One can see the need for cleaner beans on the small farms, based on the above estimated calculations. Existing systems cannot be used because there is lack of capital, lack of electricity in some areas and lack of technological skills. The major function is to separate the soybean seeds from foreign material and secondary functions are to clean the seeds from broken seeds and hulls.

After analyzing the problem, the method chosen for cleaning is the separation by rolling on a jute belt conveyor. This principle is inexpensive compared to other methods regarding labour cost, material cost and energy consumption and has a good capacity. The technology and skills used are simple and appropriate for an average farmer to maintain and repair the separator. It can be driven by an electric motor, engine, a bicycle or even by hand. Locally available materials are used for the simple construction and the weight of the separator is low.

The construction (**Fig. 1**) used materials that are listed in **Table 2**. From one plywood panel of 1 220 * 2 440 mm^2 the main parts for three separators can be made, as explained in **Fig. 2**. In the prototype, ball bearings were mounted but in practice much cheaper journal bearings can be used.

The angle of the conveyor has to be adjustable and the height of the lowest part has to be high enough to collect the soybeans in a bin or sack. Besides it must be easy to fill the hopper that has to be big and strong enough to contain about 25 kg of seeds. The feeding opening has to be adjustable and will be about 10 mm wide. The jute belt has to be driven, so the foreign material that is sticking to the belt is transported to the top of the machine and will fall behind the machine and the beans are rolling downwards and can be collected at the lower part of the machine. One of the rollers has to be adjustable to span the jute belt. If the belt is moving to one side of the rollers, the distance between the rollers at the opposite side has to be increased a little bit. It must be prevented that soybeans fall on the lower part of the belt that is going downwards, because otherwise those beans will come between the lowest roller and the belt every time. For soybeans it turned out that the angle of the conveyor has to be about 20 degrees and the speed of the belt has to be about 0.5 m/s to give good results.

Table 2. Parts List of Soybean Cleaner

No.	Qtty	Name	Mat. / dimension in mm
10	2	Hopper	Plywood 620 * 300 * 19
9	2	Long stand	Plywood 780 * 55 * 19
8	1	Conveyor belt	Jute 1920 * 850
7	1	Plate	Plywood 975 * 630 * 19
6	2	Short stand	Plywood 320 * 55 * 19
5	1	Base frame	Wood 1040 * 700
4	2	Side frame	Plywood 930 * 120 * 19
3	4	Bearing	INA 01LCTE04
2	2	Shaft	Steel ø = 20, L = 1100
1	2	Roller	Plastic ø = 110, L = 970

Experiments

Several experiments were carried out with samples of only soybeans, a mixture of round and broken soybeans, a mixture of round and broken soybeans and chaff, a mixture of broken soybeans, chaff and husk.

Fig. 3 gives the results when the conveyor angle is 20 degrees and when only soybeans are used. The percentage failure, that means the quantity of soybeans moving to the top side of the machine and falling on the ground, is dependent on the speed of the belt. Good separation is at belt speeds between 0.2-0.7 m/s whereby nearly all the beans are rolling down to the right side. If the angle of the conveyor is increased, the result at high speeds will be better in this case, but far less if foreign material, broken beans, chaff etc. have to be removed.

The separation of 5% broken soybeans from whole soybeans is shown in **Fig. 4**. At very low speeds part of the broken beans are rolling downwards to the wrong side and at high speeds part of the round beans go up to the wrong side. To remove nearly all broken beans and to collect nearly all whole beans the speed of the belt has to be about 0.5 m/s.

Fig. 5 gives the effect of the

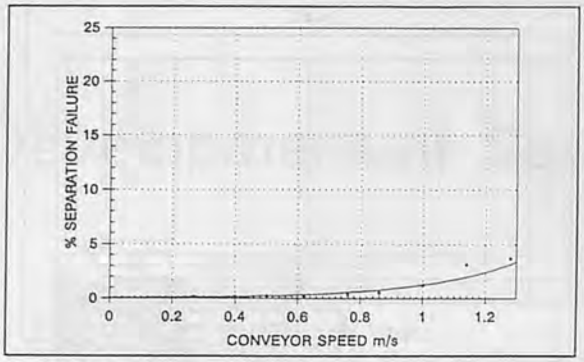

Fig. 3 Effect of conveyor speed on the separation of soybeans (angle of conveyor 20 degrees and feed rate of 150 kg/h).

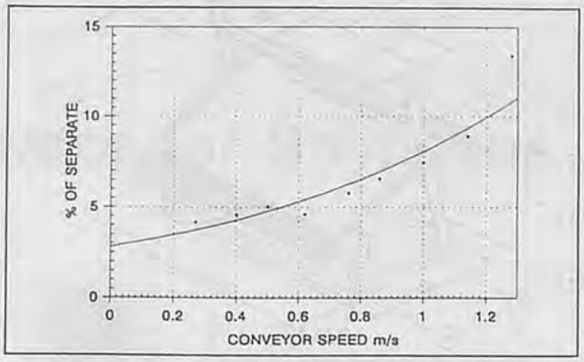

Fig. 4 Separation of 5% broken soybeans from whole soybeans (angle of conveyor 20 degrees and feed rate of 150 kg/h).

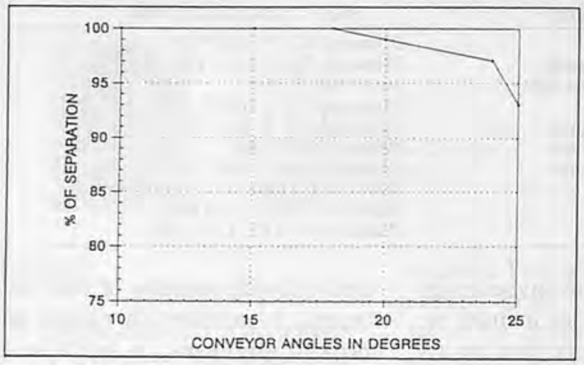

Fig. 5 Effect of conveyor angle on separation of broken soybeans and chaff (belt speed 0.5 m/s and feed rate 360 kg/h).

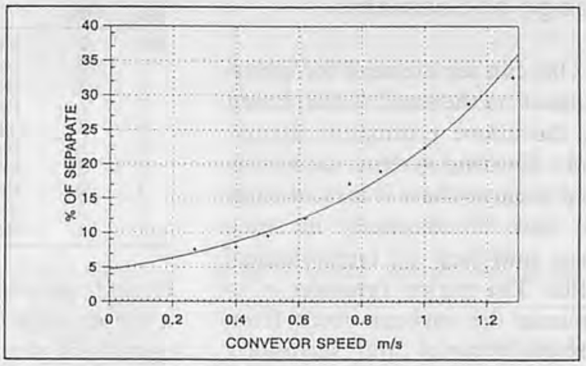

Fig. 6 Separation of a mixture of round, broken soybeans and chaff (angle of conveyor 20 degrees; 10% broken soybeans and chaff; and feed rate 360 kg/h).

conveyor angle on the removal of broken soybeans and chaff at a conveyor speed of 0.5 m/s and a feed rate of 360 kg/h. If the conveyor angle is less than 18 degrees, the separation performance is 100% and at increasing belt angle the separation result drops till 93% at an angle of 25 degrees. This is due to gravity and jumping action of the broken beans as they fall on the conveyor.

The result of the separation of a mixture of whole soybeans with 10% of broken beans and chaff at a feed rate of 360 kg/h is as shown in **Fig. 6**. At low speeds (0.2-0.4 m/s) the separation of the broken soybeans and chaff is less due to the big stream of whole soybeans falling on the conveyor, forcing part of the broken beans downwards. Good separation is at a speed of about 0.5 m/s. At increasing speeds more and more round soybeans are moving upwards to the wrong side.

A sample of stones of reasonable sizes that are expected to mix during the hand threshing were tested using the speeds and angles that were found earlier to be good for the separation of soybeans from foreign material. Round stones, irrespective of their size, fell on the side of round soybeans and the irregularly shaped, flat stones fell on the separate side of the conveyor.

It is free to use the ideas and the design. If there are any questions concerning production or use of the separator, please contact ir. H.C.P. de Vries. He likes to hear if the separator is successfully used.

Conclusions

It is possible to separate soybeans from foreign materials, chaff, split, broken and shrivelled beans very well with a simple jute belt conveyor. Important is the angle of the conveyor and the speed of the belt. For soybeans the angle has to be about 20 degrees and the speed of the belt about 0.5 m/s. The system could be used for other seeds. For smaller seeds other belt material has to be used. The power consumption and the speed of the belt are low, so even human energy can be used to drive the belt by hand or bicycle.

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A Low-cost Straw and Forage Chopper

by

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Abstract

A flywheel-type, inclined axis chopper (acronymed FLIPPER) for small-scale rice and livestock farmers, was developed at the International Rice Research Institute (IRRI). The prototype is belt-driven by a 3.7 kW (5 hp) engine and uses four angled blades rotating below a fixed counter-edge. Throw-in manual feeding is facilitated by a convenient hopper presenting the crop perpendicularly to the inclined blade housing and also by the suction effect of the rotating blades. The distance between the counter-edge for the rotating blades (the cutting plane) and the floor of the blade housing determines the length of chop, set here for 25 mm. The unit would cost about $200 without the engine.

Tests with napier grass, corn stalks, and rice straw showed satisfactory performance within the acceptable clearance, speed and moisture content ranges of the materials presented. Highest capacities were 1 186, 1 148 and 744 kg/h for napier grass, corn stalks and rice straw, respectively. Corn stalks required the highest power demand at 2.3 kW. These results showed that a 2.6 kW (3.5 hp) motor, or a 3.7 kW (5 hp) engine would be adequate as power source. The chopper performance was comparable to higher cost commercial choppers in terms of capacity and specific energy.

Introduction

The forage chopper is a regularly used piece of equipment in livestock farms. Feeding ruminants with chopped forage is more economical than free self-grazing, since grass can grow faster for the next cutting and animals are more easily managed. This is especially true for small-scale livestock farmers or those who practice integrated rice-livestock farming. Choppers can also be used for size reduction of farm residues for mulch, compost, green manure, or raw material for handmade paper.

Imported choppers of medium to high capacity, for example, 1 to 5 t/h are usually equipped with speed change gears and feeding units for adjustable chop length. These are appropriate for large livestock farms. Locally designed choppers in the Philippines and in other developing countries in Asia are either manually cranked or power driven. They may be unsafe, inconvenient to use, or excessively priced.

The objectives of this study were: (1) to develop a low-cost (about $200 without prime mover), medium capacity (0.5 to 1 t/h), versatile, safe and ergonomic chopper for small-scale rice-livestock farmers; and (2) to evaluate the principle of the machine in terms of capacity, power requirement, specific energy and chopping performance with rice straw, napier grass and corn stalks.

Chopper Design and Operation

In the design of a low-cost chopper for use with rice straw, forage grass and corn stalks, the important criteria are simplicity, ease of fabrication, operation, adjustment and repair. Based on these criteria, a flywheel type chopping principle was selected (**Fig. 1**). To keep costs down, a feeding device was excluded. For convenient and effective feeding, the chopper blade housing was inclined 45°, and the suction produced by the blade rotation was designed to assist feeding. The

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Fig. 1a The flywheel-type, inclined-axis, straw and forage chopper.

Fig. 1b The chopper blades: four rotating blades angled 10° upwards with respect to the counter-edge. The distance from the cutting plane to the floor of the housing is 25 mm, the theoretical length of chop.

blades were made from discarded leaf springs available from vehicle repair workshops and metal junkshops. The four rotating blades were angled 10° upwards with respect to the counter-edge, for effective and low-power cutting. The angled blades also function as a centrifugal fan to suck presented materials and throw them effectively in chopped form. Both the rotating blades and the counter-edge are reversible. The floor of the blade housing restricts feeding length to 25 mm, theoretically, thus allowing accurate cutting with still-stemmed materials.

The whole unit,less the engine, weighs 40 kg, thus making it easily transportable. The unit was designed to be powered by an off-the-shelf 3.7 kW (5 hp) engine. The chopper is driven via a quarter turn V-belt. The objective of developing a $200 chopper (without the prime mover) was reached. The chopper is identified by its acronym FLIPPER, for *Fl*ywheel-type, *I*nclined Cho*pper*.

Materials and Methods

Materials

The chopper was tested with napier grass, corn stalks and rice straw. Napier grass is a high moisture, stiff grass having cross-section of 10 to 20 mm at the stems and leaf thickness of 0.5 to 1 mm. Initial tests showed that feed rate of 400 g/s gave a reasonable capacity and power requirement without overloading the motor. Two moisture levels (70.9 and 80.9% wet basis (wb)) and two clearances between rotating blades and counter-edge (1.5 and 2 mm) were used.

Tests used freshly harvested corn stalks with the cobs removed and with moisture content of 62.7%, wb. Initial trials showed that at 2 mm clearance between the rotating blades and the counter-edge, only two stalks could be fed at a time to prevent overload of the motor.

Fresh rice straw at two moisture levels were used (47.9 and 65.9%, wb). Preliminary tests showed that they should be bundled to compensate for low stiffness. Bundles of 150 to 200 g gave reasonable capacities and power requirement. Bundles of 150 g were used. Previous tests with rice straw showed the ideal clearance of 0.1 mm between rotating blades and counter-edge (Pasikatan and Quick, 1992) but manufacturing tolerance prevented this from being achieved. A more practicable clearance of 0.5 mm was used.

Test Set-up and Instrumentation

Power requirement was measured through an AC power meter and a 2.2 kW (3 hp) calibrated electric motor. The analog output of the power meter was recorded by a POLYCORDER - a portable data logger. Speed was varied through four sizes of driving pulley. Clearance between the blades and the counter-edge was measured by a feeler gauge and set by inserting or removing steel plates on the counter-edge mounting. Capacity was measured by weighing the chopped material output over time. Size analysis of chopped material was carried out through the frequency distribution of 100 randomly selected straw pieces, for each replication (Persson 1987, Tremblay, et al. 1991).

Test Procedure

The blades were sharpened before each series of runs. Blade clearance and speed were carefully checked. Feed rate was set by bundling the materials to a set weight and feeding them in nearly continuous manner. A collecting container was placed on the chopper discharge. The polycorder was switched on at the start of each run. Feeding time was 30 seconds, after which materials were collected, sacked, labelled and weighed.

The experimental design was completely randomized with treatments consisting of four speeds: 900, 1 050, 1 200 and 1 500 rpm, three materials with a set clearance and feed rate for each.

Results and Discussion

The average power, capacity, specific energy and percent chopped materials of 25 and 50 mm length or less, at four speeds and for three different materials are shown in **Table 1**.

Tests with Napier Grass

At 1.5 and 2 mm clearance between rotating blades and counter-edge, power and capacity increased with speed. At 2 mm clearance, the highest capacity was 1 113.8 kg/h at 1 500 rpm. This did not vary significantly from the capacity at 1 200 rpm. However, power at 1 200 rpm was 16% less. Hence, at 2-mm clearance, the best speed setting was 1 200 rpm. In terms of length of chop, speed had no significant effect **(Fig. 2)**.

At 1.5 mm clearance, the highest capacity was 1 186 kg/h at 1 500 rpm, 12% higher than at

Table 1. Average Power Requirement, Capacity, Specific Energy and Percent Chopped Materials of 25 and 50 mm Length or Less, at 2 Clearances between Blades and Counter-edge, and 4 Speeds of Blade Rotation

Speed (rpm)	Power (kW)	Capacity (kg/h)	Specific energy (kW-h/tonne)	Materials with length <25mm (%)	Materials with length <50mm (%)
(1) Napier grass, 70.9% MC wb. 2 mm clearance between blades and counter-edge.					
900	0.357a	865a	0.414a	20	84
1 050	0.448b	922.5ab	0.483ab	29	91
1 200	0.517c	1 012.8bc	0.513b	24	87
1 500	0.613d	1 113.8c	0.552b	30	94
F test	*	*	*	—	—
(CV)	(9.26)	(8.25)	(11.17)	—	—
(2) Napier grass, 80.9% MC wb, 1.5 mm clearance between blades and counter-edge.					
900	0.740a	900a	0.820a	29	85
1 050	0.789ab	930ab	0.848a	26	87
1 200	0.827abc	1 060c	0.781a	27	83
1 500	0.937c	1 186d	0.790a	29	84
F test	*	*	ns	—	—
(CV)	(7.68)	(4.54)	(7.81)	—	—
(3) Corn stalks, 62.7% MC wb, 2 mm clearance between blades and counter-edge.					
900	1.574a	890a	1.770a	31	87
1 050	1.799a	1 062b	1.697a	35	89
1 200	2.302b	1 148b	2.016a	23	93
F test	ns	*	ns	—	—
(CV)	(13.16)	(6.134)	(14.63)	—	—
(4) Rice straw, 47.8% MC wb, 0.5 mm clearance between blades and counter-edge.					
900	0.996a	394a	2.535a	29	64
1 050	1.023ab	466b	2.196ab	25	59
1 200	1.055ab	498bc	2.124ab	28	61
1 500	1.131b	584d	1.946b	17	62
F test	ns	*	ns	—	—
(CV)	(6.02)	(5.95)	(10.16)	—	—
(5) Rice straw, 65.9% MC wb. 0.5 mm clearance between blades and counter-edge.					
900	1.043ab	432a	2.417a	28	65
1 050	0.930b	488ab	1.910a	27	60
1 200	1.171ab	518abc	2.263ab	22	62
1 500	1.026ab	744d	1.475b	26	62
F test	*	*	*	—	—
(CV)	(7.43)	(15.22)	(14.38)	—	—

For each material and moisture content, in a column means followed by a common lettter are not significantly different at the 5% level by LSD.
F test: * = significant at the 5% level.
ns = not significant.
CV = coefficient of variance.

1 200 rpm. Power at 1 200 and 1 500 rpm were not significantly different, hence, the best setting for 1.5 mm clearance was 1 500 rpm. There was an average 74% increase in power required at 1.5 mm compared to 2 mm clearance, but there was no improvement in terms of quality of chop. Hence, for napier grass, 2 mm clearance was the better setting.

Tests with Corn Stalks

Tests were carried out with corn stalks at three speeds: 900, 1 050 and 1 200 rpm, at 2 mm clearance between blades and counter-edge. The capacity at 1 200 and 1 050 rpm did not vary significantly. However, power at 1 050 rpm was 28% less. Hence, the best speed setting for corn at 2 mm clearance was 1 050 rpm. Chopping corn stalks required almost 4 times as much power compared to napier grass at the same clearance because of larger cross-section and higher stiffness. **Fig. 3** indicates that although power could be reduced by using a larger clearance, the quality of cut would be sacrificed. The driving motor could only cope with 2 stalks at a time with these settings. The highest power measured was 2.3 kW (3.1 hp) at that feed rate.

Tests with Rice Straw

Chopping rice straw at 65.9% moisture content yielded significantly higher capacity than at 47.8% moisture. There was no significant difference in power required to chop rice straw at these moisture levels. This could be attributed to moisture variations for a sample of rice straw. Rice straw then should be chopped as fresh as possible to ensure high capacity. This will also eliminate the dust problem characteristic of dry straw chopping.

At 65.9% moisture content, the highest capacity obtained was 744 kg/h at 1 500 rpm. This was 44% higher than at 1 200 rpm. The amounts of power required at these two speed settings were not significantly different; therefore, the recommended speed for rice straw chopping was 1 500 rpm. This was also supported by the results of chopping rice straw at 47.8% moisture.

Due to its low stiffness and the 0.5 mm clearance used, rice straw yielded the lowest percentage of chopped materials of 25 and 50 mm length or less **(Fig. 3)**. With a second pass, the frequency of chopped materials of 25 and 50 mm length or less, increased

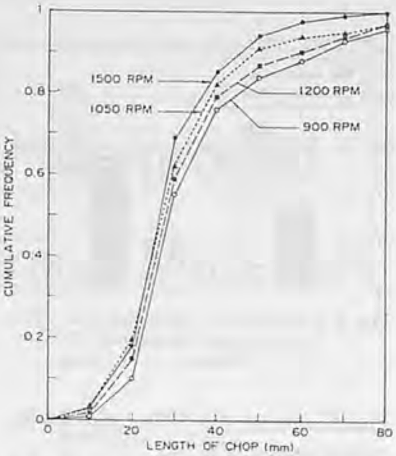

Fig. 2 Frequency distribution for each length of chop for napier grass (2 mm clearance) at four varying speeds.

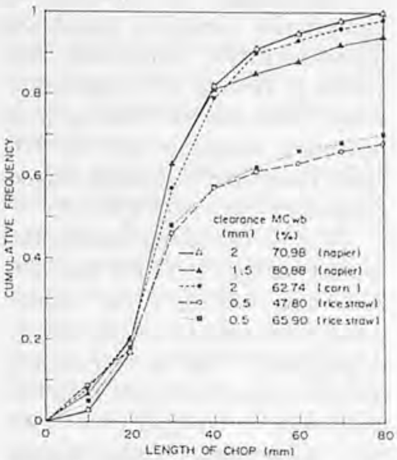

Fig. 3 Frequency distribution for each length of chop for different materials at 1 500 rpm.

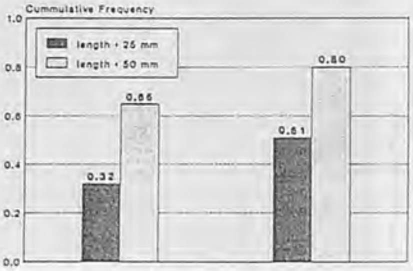

Fig. 4 Frequency of chopped straw for first pass and second pass (MC = 3.7%, Clearance = 0.5 mm).

significantly by 59% and 23%, respectively (Fig. 4).

Comparison with Commercial Choppers

Performance parameters of commercial choppers based on manufacturers' brochures are shown in Table 2. Their capacities range from 400 to 5 000 kg/h at operating speeds of 650 to 970 rpm. Their specific energy ranged from 0.491 to 1.875 kW-h/t.

At these operating speeds, the capacity of the FLIPPER was 900, 890, and 432 kg/h for napier grass, corn stalks and rice straw, respectively. The corresponding specific energy for each material was 0.414, 1.770 and 2.417 kW-h/t, respectively. These values show that the FLIPPER was comparable to the commercial machines. A big advantage for small-scale livestock or rice-livestock farmers is that the FLIPPER can be made for 20 to 33% the cost of commercial machines in its class.

Table 2. Specification and Performance Parameters of Some Commercial Choppers

Chopper Brands	PC-603[a]	PC-700[b]	YDC-125[c]	SS-77[d]	Iseki CH101MB[e]	Iseki CS131[f]	Chiyoda[g]	Mitsubishi F-15[h]
No. of rotating blades	2	2	—	—	—	—	—	—
Blade rpm	—	—	650-800	750-970	900	650-850		
Length of cut (mm)	—	—	11, 15 28, 30, 37, 62	20-150	9, 17, 32, 60	10, 15, 24, 30, 48, 110, 140	6-60	16-150
Power (kW)	1.111	0.927	0.736-1.472	1.104	1.104-2.576	0.184-2.208	0.4-0.75	0.368-2.208
Capacity (kg/h, fresh weight)	1 737	1 144	1 350	1 000-1 500	1 800	3 000	400	3 000
Specific energy (kW-h/t)	0.639	0.811	0.545-1.090	0.736-1.104	0.613-1.431	0.061-0.736	1-1.875	0.123-0.736
Type*	F	F	F	F	C	C	C	C
With feeding device	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Over all weight	60	61	58	65	59	43	37	45

*F = Flywheel type, C = Cylinder type.
a,b,c,d - Korean made (Source: RNAM, 1991); e,f,g,h - Japanese made (Source: Iseki, Chiyoda and Mitsubishi leaflets).
Note: Power, specific energy were calculated from manufacturer's leaflet.

Conclusions

1. The chopper performance with three materials: napier grass, corn stalks and rice straw was satisfactory, provided the materials were fresh or had high moisture, and the right clearance between blades and counter-edge and the appropriate chopping speed were used.
2. Capacity was directly influenced by blade speed. Highest capacities were obtained at 1 500 rpm.
3. The effect of speed on power requirement varied with crop material. For stiff, high-moisture materials, like napier grass and corn stalks, power increased with speed. For low stiffness materials, like low-moisture rice straw, power was not significantly influenced by speed.
4. Power requirement increased with decreasing clearance. The smallest practicable clearance was important for effective cutting of stemmy and leafy materials.
5. For napier grass, the best setting was 2 mm clearance at 1 200 rpm. At this setting, capacity and specific energy were 1 012.8 kg/h and 0.513 kW-h/t, respectively.
6. For corn stalks, limited tests indicated the best setting was 1 050 rpm at 2 mm clearance. This setting gave 1 062 kg/h capacity and specific energy of 1.697 kW-h/t.
7. Rice straw should be chopped as fresh as possible. For rice straw at 65.9% moisture, the best setting was 1 500 rpm and clearance of 0.5 mm or less, if possible. Capacities of 744 kg/h and specific energy of 1.475 kW-h/t were obtained. Subjecting rice straw to a second pass increased the frequency of 25 and 50 mm choppped length or less, to 59 and 23%, respectively.
8. For the materials used, the highest power requirement was with corn, at 2.3 kW (3.1 hp). This power can be provided by a 2.6 kW (3.5 hp) motor or a 3.7 kW (5 hp) engine.

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Improving the Micro-climate of Underground Grain Stores Using Indigenous Lining Materials

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Abstract

Reducing grain losses in underground storage by proper selection of lining (insulation) materials is one way of increasing food supply.

A study was carried out to investigate the effect of different indigenous lining materials on the micro-climate (temperature and relative humidity) of underground grain stores. Underground storage is the most commonly used technique for minimizing post-harvest losses in Ethiopia, hence it was paramount to consider this study which employed four locally available lining materials. The liners used were straw of Tef (*Eragrostis* tef Zucc.), wood shaving, plastic and sack. Pits resemble the type used by the farmers were dug and maize was the grain used.

The change in the internal environment (temperature and relative humidity) was measured using digital hygrometer. Moisture content of the grain was also measured at the end of the experiment using a moisture meter.

From the result we concluded that, the resulting micro-climate in pits lined by plastic and wood shaving seem to be desirable from the point view of inhibiting fungi development. Desirable moisture contents were also measured for the grain in pits lined by plastic and wood shaving.

Introduction

Storage is an important controllable factor in programs designed to increase world food supplies. Grain supplies to requirements and reserve stock of grain held as a safeguard against years of storage requires storage periods. The rate of loss of grain quality can be reduced if adequate grain storage facilities are provided. At present, many tropical grain stores are of the underground type and may have unsuitable design features. Some features are more likely to promote deterioration of the stored grain, particularly when the grain in store is of a high moisture content.

Underground storage is probably the oldest form of storage of grain. It is widely used because of the ease of construction and the fact that grain is stored safe from insect attack for long periods of time. This is due to the fact that pits are relatively airtight structures and respiration of insects and fungi deplete the oxygen available to such a level that further respiration is extremely limited or stopped.

The adverse ambient temperature and relative humidity in some areas can dictate the use of vapor proof materials or some form of temperature control for effective underground storage. Grains are hygroscopic and their moisture content approaches equilibrium value depending on the ambient relative humidity. In underground stores there is a fluctuation of stores microclimate which directly influences the temperature and moisture content of stored grain.

Several studies have been done on pit stores by researchers. Gilman and Boxall (1974) summarized information from different countries about grain storage in pits.

Gilman (1968) in his findings, concluded that a greater effort should be made on a lining which would harden the walls and reduce the rate of moisture infiltration from the soil.

Boxall (1972) in a research on the use of straw lining showed that it is good for short term storage in reducing mold damage.

Hall and Hyde (1954) recommended that underground pits can never be made sufficiently air tight even with the use of cement and vapor barriers and that only dry

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grain (less then 13% M.C) should be stored in them.

Hindrmarsh et al. (1978) recommended also that the improvement of traditional types of stores should be given preference in introducting completely new storage methods.

Also other works on the same problem include Donahaye et al (1967), Shellenberger et al (1952), Oxley et al (1957) and Swaine (1954). All these works have been focusing on the improvement of conditions of underground pits in different regions of the world and these findings apply to that particular conditions prevailed.

The underground storage technique is popular and maintained by the majority of the farmers for storing sorghum and maize in the Eastern part of Ethiopia.

A survey by Boxall (1972) indicated that in Hararghe province 70% of the farmers use underground stores exclusively and 8% use it in conjunction with other methods of storage. This situation has no change so far and also he has estimated the loss due to fungi and insects from this storage which ranges from 5 to 90%.

Regardless of this estimated loss the continued use of underground pits is substantiated by the following reasons:

- The husband can maintain control over the family's grain:
- Grain is secure from fire and theft:
- Rodents damage seems to be non-existent:
- The farmers wealth is hidden from government officials:
- Under correct conditions control of insect numbers may be achieved without the use of chemicals: and
- Farmers are already accustomed to this storage and reluctant to change to other structures.

In addition to the above reasons the continuing crop failures in Ethiopia and the need for grain reserve can only be effective with proper and improved grain storage facilities. This experiment was initiated by the Department of Agricultural Engineering taking into consideration the above arguments and has employed four locally available lining materials to improve the micro-climate in the pit.

The research reported in this paper had the objective of assessing the possibility of using locally available lining materials in underground pits and evaluating the resulting micro-climate in the store.

Materials and Methods

As the main objective is to identify better insulation material for the underground pit and evaluate the performance of the same through the resulting environment, pits that resemble the type used by the farmers were dug on sand soil at a relatively elevated place in Alemaya University campus. **Fig. 1** shows the cross section of the undeground pit used. The depth of the pit is 0.9 m and 0.8 m wide at the bottom with opening width of 0.6 m.

The lining materials used were straw of Tef, wood shaving, plastic sheet and sack. A 5-7 cm layer of straw and wood shaving were spread around the wall and floor of the pits. The plastic sheet of 0.08 mm thick was also used as an alternative liner. By the same procedure a double layer of sack sewed together was also placed for the other pit considered. There was also a control pit with no lining material except that the surfaces of wall was made smooth.

The grain used was maize and each pit was provided with about 90 kg of maize at 10% M.C. Before filling the pits the grain was inspected for visible insects and all the grain were taken after

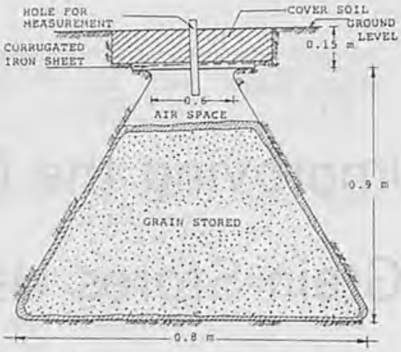

Fig. 1 Cross section of underground storage.

thoroughly mixing and proper sampling technique. In all cases the pits were covered with sheet metal below the 15 cm soil cover to avoid the entry of water or rain storm.

Change in grain pit temperature and relative humidity were measured over the storage period of each pit. Temperature and relative humidity are measured using digital hygrometer by inserting it through a hole constructed for this purpose.

Moisture content of the grain were also measured at the end of the experiment for the samples taken at three different layers.

The experiment was carried over the month of April 1994 as it was the hottest month in the area. The experiment lasted for 4 weeks and measurements were recorded around noon time repeatedly and only average readings were taken for analysis.

Result and Discussion

After recording the resulting environment for each pit, graphs were drawn showing temperature and relative humidity time. **Figs. 2** and **3** show this result.

From the experiment carried out, pits lined with plastic sheet and wood shaving show good control over an internal environment than the other two alternatives and the control experiment.

For the plastic lined pit the temperature rose from an initial value of between 23.3 and 28.7°C. The RH of this pit was very low compared to the other pits as shown

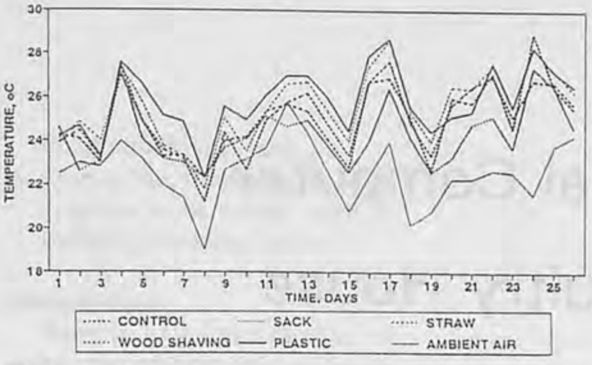

Fig. 2 Graph showing temperature vs time in days for the pits.

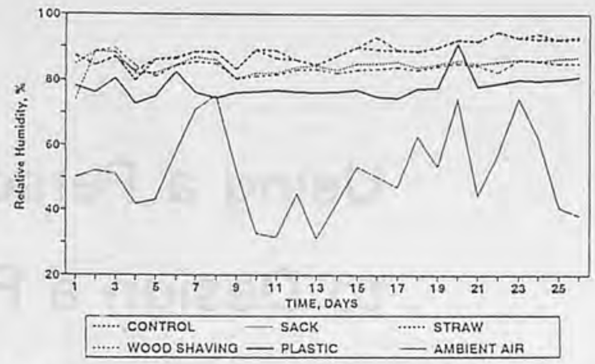

Fig. 3 Graph showing relative humidity vs time in days for the pits.

on **Fig. 3**. This implies that moisture migration was controlled by the plastic lining. The use of plastic sheet lining proved to be a very effective technique for preventing a rapid rise in moisture content and subsequent fungal damage. **Table 1** shows that the moisture content of the bulk sample for this pit has remained below 15%. The moisture content of the surface layer of grain was never more than 4% higher than the bulk sample and the surface was also free from fungal damage and was visible to be in a very good condition.

The wood shaving has absorbed moisture from the wall of the pit and its outer part which is on the pit wall side was humid, but the inside part of the lining was dry. The maize in this pit was also free from fungal damage. Though the RH seems to be higher than the plastic lined pit, the temperature readings were low.

The RH of the straw-lined pit was higher than that of plastic and wood shaving lined pits but lower than that of the control pit. From the periphery of this pit traces of mold development were noticed.

The sack lined pit showed little difference from the control pit. In this pit the moisture migration was insignificantly controlled. Fungal damage was also a problem seen in this pit.

Generally, this pit showed little difference from that of the control pit in the resulting environment.

Conclusion

From the experiment carried out, the following conclusions are made:

1. Plastic and wood shaving lined pits showed a better performance in maintaining the pit environment to a relatively desirable level.
2. The other two lining materials fail to achieve conducive environment for the grain as they allow higher values of temperature and RH with subsequent mold development.
3. Fungal damage was noticed to decrease from the periphery to the center of the pit.

Recommendations for Further Work

1. The use of other lining materials as alternative should be considered.
2. Plastic and wood shaving lining could have a better performance if used in conjunction with other materials.
3. Further work should be done on the use of some insect repelant herbs to improve grain condition in the pit. Farmers traditionally use leaves of some plants and ashes of wood as an insect repelant and desiccant.

Table 1. Percent Moisture Content of Grains at Different Depths of Pits at End of Experiment

Depth of Sample taken	Straw	Sack	Wood shaving	Plastic	Control
Top	20.0	20.3	16.0	14.0	21.2
Middle	14.0	17.0	12.2	11.1	18.1
Bottom	14.1	17.0	12.5	12.0	18.3

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Using a Personal Computer to Design a Poultry House

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Introduction

The economical growing of chickens starts from a correct and adequate design of the building for the appropriate breed and the environment of the place. The design of the poultry building for hens and broilers in the developing countries is not always based on engineering and scientific considerations but on some incorrect information and practices. For these and other reasons, there is a high mortality rate.

In the absence of scientific and engineering aspects and rules in poultry housing design different sizes and many substandard types of houses are constructed. Selecting the correct dimensions for the poultry house helps in the use of standard mechanization and special mechanization. At the same time the number of feeders, waterers, heaters and ventilation system could be determined easily.

The use of non-scientific principles in building poultry houses could create production problems, high production cost, and lower returns.

Because of the large number of variables used in determining an adequate design and the difficulties in use of regular calculations, the use of a computer is very useful in making correct calculations and the adequate design for certain environmental conditions.

Literature Review

Alchalabi (1990) built a simulation model to evaluate and select the wall insulation for poultry buildings based on heat loss analysis and environmental conditions inside and outside the building. He recommended using U value of 0.8 $W/m^2 \cdot C$ in the walls for Iraq and the Middle East. Using this value will prevent the water condensation on the walls in winter. The model includes 27 types of walls.

The same author in 1992 presented a simulation model for poultry environmental control, in order to estimate several ventilation rates and the amount of supplemental heat needed for that condition. The ventilation rates were minimum ventilation rate for pollution control, ventilation rate for moisture, ventilation rate for temperature, and the ideal ventilation rate for the poultry house for the entire year. An estimate of the quantity of fuel used in supplemental heat was likewise made.

Stanly E. Curtis (1983) suggested in his book "Environmental Management in Animal Agriculture" a simple rule to calculate the ventilation rate for summer and suggested the use of an evaporative cooling system should temperature rise in animal housing.

The same reference presented a way to calculate the lighting system based on light requirement for the chickens and the size of the building required and management. Alchalabi (1991) presented a mathematical model to calculate all requirements of an evaporative system for poultry house. He found that the best air velocity through the pad was 1.5 m/s.

Objectives

The objectives of building a simulation model in designing a poultry house for layers or broilers aim to:

1. Determine the appropriate size of the building;
2. Select the adequate amount or wall insulation for the above building based on environmental conditions and number of birds;
3. Calculate the number of fans, evaporative coolers and heaters for winter and summer ventilation rates;
4. Calculate all requirements for the evaporative cooling pad system;
5. Determine the elements of the lighting system adequate for the environmental and manage-

ment conditions; and
6. Display the results as text and graphics to be further used in building a poultry house.

Methodology

Because of a large number of equations used in this model, it will give emphasis on the main and important ones. In order to have a steady state condition inside the building there should be a heat balance between the quantities entering the system and the quantities leaving it. The important task in the cold regions or the cold seasons is the heat loss by conduction. This could be the opposite in the hot season which means heat gain and temperature rise inside the building.

Heat loss by conduction could be controlled in some cases by understanding the ideal design requirement of the poultry house.

The surface temperature in interface of any material or wall in any point may be calculated if certain information is available and could be calculated by the following equation:

$$t_x = t_{id} - (R_x/R)*(t_{id} - t_{od})$$

where,

t_x = wall surface temperature °C

R_x = overall heat resistance for the inside wall surface $m^2.k/W$

R = overall heat resistance flow for the wall $m^2.k/W$

t_{id} = inside design temperature °C

t_{od} = outside design temperature °C

The rule which is used in deciding the kind of wall insulation (type of wall) is a function of water condensation on wall surfaces. If the wall surface temperature is less than dew temperature a higher value (another type of wall) need to be selected. All calculation should be reviewed to test the new wall.

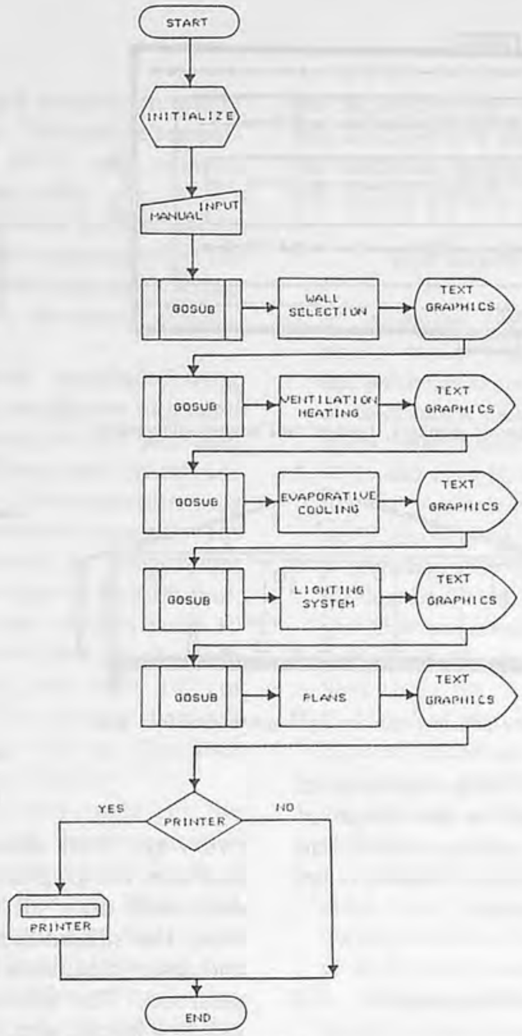

Fig. 1 Flow chart of the model.

To calculate the ventilation rate for temperature control inside the poultry house without using supplemental heat could use the following equation:

$$Q_s = [v/c_p*(t_i - t_o)]*(q_s - q_b)$$

where

Q_s = ventilation rate for temperature m^3/s

v = specific volume $m^3/kg_{d.a}$

c_p = specific heat of air 1.0035 $kJ/Kg_{d.a.}$°C

t_i = inside temperature °C

t_o = outside temperature °C

q_s = heat generated by birds kJ/s

q_b = heat loss through the building kJ/s

The ventilation rate for moisture control may be calculated based on the following equation:

$$Q_l = (v*M_w)/(W_i - W_o)$$

where

Q_l = ventilation rate for moisture m^3/s

M_w = amount of moisture produced inside the building kg_{H2O}/s

W_i = inside humidity ratio $kg_{H2O}/kg_{d.a}$

W_o = outside humidity ratio $kg_{H20}/kg_{d.a}$

The ideal ventilation rate is determined from the previous ventilation rates. In any point (outside temperature) the higher ventilation rate should be chosen as the ideal ventilation rate.

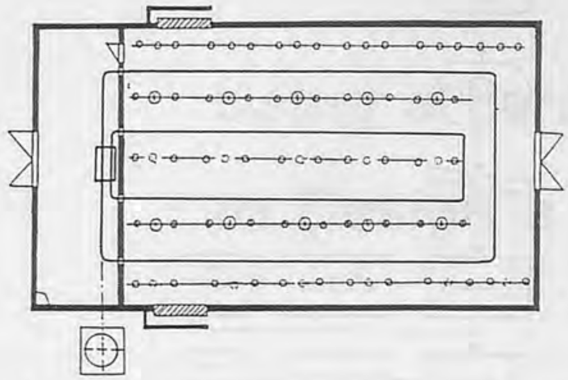

Fig. 2 Top view of drinkers, feeders and heaters placement.

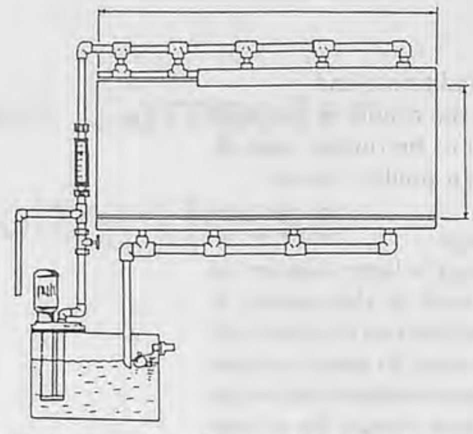

Fig. 3 Front view of evaporative cooling system.

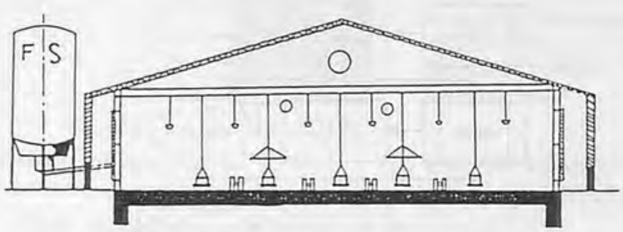

Fig. 4 Side view includes, drinkers light system and feed silo.

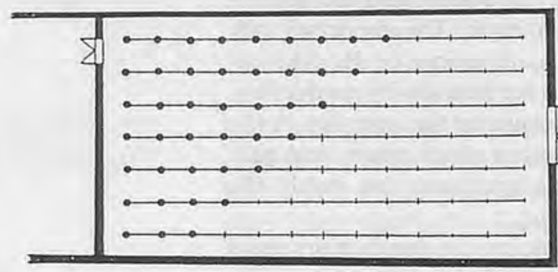

Fig. 5 Top view of light system lay out.

Because of large humbers of equations used in the design of evaporative cooling system and lighting system any reliable reference may be used.

Program Development

All equations and rules are put in a computer program. The program has specialized subroutines in sequence. The first program is the wall selection (insulation) and buliding dimension (size). The second program is to determine the ventilation rate, supplemental heat, number, type and size of fans, and heaters. Also, the amount of the different fuel used in heating based on first program and the input information are considered. The third program is executed to design an evaporative cooling system for summer conditions based on the number of birds, and water quality. This program gives all information needed to construct the system. The fourth program is to calculate and design the lighting system for the proposed poultry house.

The results are displayed into two ways. First display the text and then the graphics. The computer will draw all information from the subroutines in graphs and design pictures to be easily understood. The pictures include building layout, size, light places, location of the waterers, feeders and heaters. These pictures (plans) could be printed on a dot matrix printers (**Figs. 2-5**).

Results

The output of the model incorporated more than 90 different items for poultry house design. These items are categorized to be easily understood. Every category includes several related elements. The categories are 10 and they are as follows:

1. Specification of the building, includes dimensions, type and orientation of the roof and building;
2. Component of the wall selected for the building and the insulation value;
3. Component of the roof selected for the building and the insulation value;
4. Winter environmental conditions used in designing the building;
5. Summer environmental conditions used in designing the building and expected environmental conditions;
6. Specification of the ventilation system and the ventilation rates, number and type of fans required;
7. Specification of the evaporative coolign system and the information needed to assemble this system as well as the number of the evaporative air coolers if the previous system is not desired;
8. Specification of lighting system and its component, number, type, and distance between bulbs;
9. Management information for the poultry house designed; and
10. Expected quantity of fuel used in heating.

The model used for the design of a poultry house for broilers with 10 000 birds, average body weight of 1.5 kg, in a location at latitude 33 degrees. After entering the input necessary information for the model, the results were as follows:

The building length was 90.91 m with a 4 m service room. Taking into account the walls, the final length of the poultry house will be 95.66 m. The width of the building was 11.5 m. Orientation of the building was east-west and the roof angle 10 degrees. The wall width was 25 cm. The height of the building was 3 m and the number of doors was 2 (size 2 × 2 m) with insulation value of 1 W/m^2.C. The type of the roof was shed.

The selected wall for the proposed building was 20 mm gypsum plaster, 240 mm regular bricks, 100 mm lime stone with a total insulation value of 1.73 W/m^2.C. The roof includes asbestos board, 50 mm styropour, with metal structure, the total insulation value was 0.65 W/m^2.C.

The inside and outside design conditions for the winter and summer were as follows:

Winter conditions

The inside temperature was 20°C and the outside design temperature was −5°C, relative humidity for the inside and outside were 70% and 60%, respectively. The dew point temperature inside was 14.3°C. The wall surface temperature was 14.3°C. This means that the wall will prevent water condensation inside the building if above information is not changed, but since it is a critical balance, a large difference of dew point temperature is desirable.

Summer conditions

The inside design temperature was 26°C, and maximum design temperature was 29°C. Expected inside temperature with the use of evaporative cooling system was 27.36°C, (this could be changed if different pad depth used (20 mm), and relative humidity was 57.65%. The outside temperature was 45°C and relative humidity was 10%.

The ventilation system has an important task in getting rid of the excess heat and moisture in winter and improve the environmental conditions

The model calculated four types of the ventilation units and also the amount of fuel used with every ventilation unit for outside temperature. The ventilation units are: for pollution control, for moisture control, for temperature control and ideal ventilation rate.

The number of fans were 10 small ones with 35.5 cm diameter and 5 large fans with 102 cm diameter. The distance between the fans was 6.16 m. The total inlet area was 9.52 m^2.

For the summer conditions, the component of the evaporative cooling pad system were: The total length of the pad was 24 m, pad width was 60 cm, pad height was 1 m and the depth of the pad was 10 cm. The number of pads were 40 and the air velocity through the pads was 1.5 m/s.

The minimum ventilation rate for summer conditions was 2 189 m^3/min, number of evaporative air coolers size 4 500 cfm was 17 (the list of the output includes more information).

The proposed lighting system includes 6 lines, every line has 38 bulbs (15 watt), and total number of bulbs was 228 bulbs. The height of the bulb off the floor was 1.7 m, the distance between the wall and the first line was 0.85, the distance between bulbs in the line was 1.96 m. This system will give light intensity of 10 lox (1 ft/cd).

The model will estimate the number of heaters appropriate for this building. The number of heaters were 14, round drinkers with 38 cm diameter were 50. The expected fuel amount used in heating the building was for the L.P. gas 32.30 ℓ/h, for the kerosene was 23.23.45 ℓ/h and in case of use electrical heaters the energy was 187.41 kWh/h.

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Poultry Housing Design

Building Specification

Inner length	90.91 m
Service room length	4.00 m
Total length	95.66 m
Total width	11.50 m
Long height	3.00 m
Short height	0.75 m
Wall thickness	0.25 m
Roof angle	10.00 deg.
Latitude	33.00 deg.
Orientation	East-West
No. of end doors	2.00
Width of end doors	2.00 m
Height of end doors	2.00 m
End door insulation	1.00 W/m^2.C
Select building	Shed

Selected Wall

1- 20 mm gypsum PLS	
2- 240 mm brick REG	
3- 100 mm lime stone	
Wall insulation	1.73 W/m^2.C

Selected Ceiling

1- Asbestos board	
2- 50 mm styropour	
3- Metal structure	
Ceiling insulation	0.65 W/m^2.C

Environmental Conditions

1- Winter Conditions	
Inside design temperature	20.00°C
Outside design temperature	−5.00°C
Inside relative humidity	70.00%
Outside relative humidity	60.00%
Wall surface temperature	14.30°C
Inside dew point temperature	14.30°C
2- Summer Conditions	
Inside design temperature	26.00°C
Maximum design temperature	29.00°C
Expected inside temperature	27.36°C
Expected inside R. humidity	57.65%
Outside temperature	45.00°C
Outside relative humidity	10.00°C
Incident solar radiation	700.0 W/m^2

Ventilation System Specification

1- Winter Conditions

Ventilation Rates for Moisture, Temperature, Ideal and Supplemental Heat Requirements

C	m^3/S	m^3/S	m^3/S	kJ/S
−10	0.93	0.00	2.40	85.73
−5	0.99	0.51	2.40	56.24
0	1.08	1.27	2.40	26.75
5	1.24	2.55	2.55	0.00
10	1.53	5.11	5.11	0.00
15	2.23	12.78	12.78	0.00

Minimum Ventilation Rate 2.40 m^3/S

Summer Conditions

Evaporative Cooling System Specification Design

Pad length (total) (L)	24.00 m
Pad width (W)	0.60 m
Pad height (H)	1.00 m
Pad depth	0.10 m
Pad efficiency	73.88%
Number of pads	40.00
Air velocity	1.50 m/s
No. of gutter supports	9.00
Bleed-off ratio (B/E)	1.26
Bleed-off flow	23.97 L/min
Wetting flow rate	145.96 L/min
Pump capacity-total flow	169.93 L/min
Pump power	218.12 W
Water calcium concen.	150.00 ppm
Water carbonate concen.	200.00 ppm
Water pH value	7.30
Total suction head	0.91 m
Total discharge head	4.75 m
Total head	5.66 m
No. of elbow 90 degree	4.00
No. of tee 90 degree	2.00
No. of coupling used	2.00
No. of gate valves	1.00
Minimum tank volume	0.61 m^3
Pipe size	38.10 mm
System pressure	55.45 kPa
Air exchange rate	39.00 ℓ/h
Summer ventilation rate	2 189.4 m^3/min
4 500 cfm air cooler	17.00
8 000 cfm air cooler	9.00
10 000 cfm air cooler	7.00

Lighting System Specification

Bulb height off floor	1.70 m
Spacing of wall & cent. points	0.85 m
Spacing of lights in line	2.54 m
Spacing between lines	1.96 m
No. of bulbs in the line	38.00
No. of lines in the house	6.00
Total number of bulbs	228.00
Wattage of bulbs	15.00 W
Selected illuminace	10.00 Lox

Management Information

No. of pan drinkers D = 38 cm	50.00
No. of gas burners	14.00
Feed chain with tow lines	1.00
No. of small fans D = 35.5 cm	10.00
No. of large fans D = 102 cm	5.00
Spacing of large fans	6.16 m
Total inlets area	9.52 m^2

Estimated Amount of Fuel Used

L.P. gas, heater eff. 70%	32.30 L/h
Kerosene, heater eff. 70%	23.45 L/h
Electrical, heater eff. 90%	187.41 kWh/h
Kind of birds to grow	Broiles
No. of birds used	10 000
Birds dencity	10.00 bird/m^2

■■

Design and Testing of a Household-size Batch-type Digester

by
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Abstract

Three small batch-type digesters were tested, and gas production started 12 days from feeding date. Many problems, among which scum formation, were encountered during the process of development of a suitable household-size digester. A digester with a maximum burning time of 58 min (single cooker), enough for a single household consumption, was developed.

Introduction

Energy for household consumption has become so difficult to obtain. Wood fuel has also fallen short of meeting the demand. In many cases random wood cutting has lead to environmental disasters. In Sudan, the dependence on firewood has caused a steady reduction in the country's forest reserves. At the current depletion rate, the country's forests may be eliminated in 20 years (Energy Research Council, 1985). In order to reduce the dependence on wood energy for houosehold energy needs, new technologies may be required, among which the utilization of animal waste in producing gas for burning. An attempt was made to design, develop, and evaluate a suitable batch-type digester for household use.

Materials and Methods

Three different small digesters were designed and constructed as follows:

1) Batch-type I Digester

A barrel of standard volume of 0.17 m^3 was used as a fermentation chamber and as gas holder. A galvanized 1/2 inch pipe was used as a connection between gas holder and the control valve. A 1/2 inch alkatheine pipe was used as a gas supply hose. A manometer and gas pressure regulator valve were also used in the system. **Figure 1** shows the different parts of the batch-type I digester.

2) Batch-type II Digester

Two barrels of 0.17 m^3 capacity were connected in series to serve as a fermentation tank, and gas holder as shown in **Fig. 2**. Thus the capacity was doubled. The same measuring and control devices were used.

3) Batch-type III Digester

Two 44-gallon barrels were used in this digester to act as fermentation tank. A steel stand was used to assist in controlling the digester orientation. A substrate mixer shaft was fabricated from 1 inch diameter galvanized pipe and 9 steel plates of 15 cm × 17 cm were fixed on the shaft to form a mixer shaft which was driven by a gear and cranking mechanism consisting of two gears fabricated from steel plates. Thirteen spikes made from 1.0 cm diameter iron rods and 4 cm long were welded to the circular plates, the crank was made in a tee (T) shape from iron rods of 1 inch diameter and 0.5 m long. Another 44-gallon barrel was filled with water and used for gas displacement. Two more barrels of 5-gallon capacity each were used to serve as gas holder. A 1/2 inch galvanized pipe, an elbow, a gas control valve, a 1/2 inch alkatheine pipe, and gas pressure regulator were also used as before.

Methods

The design and fabrication of the batch-type digesters progressed from type I to type III as need for improvement arose. For batch-type I design, the small opening of the 44-gallon capacity barrel was used as the gas outlet to which the 1/2 inch galvanized pipe, the manometer, and the pressure regu-

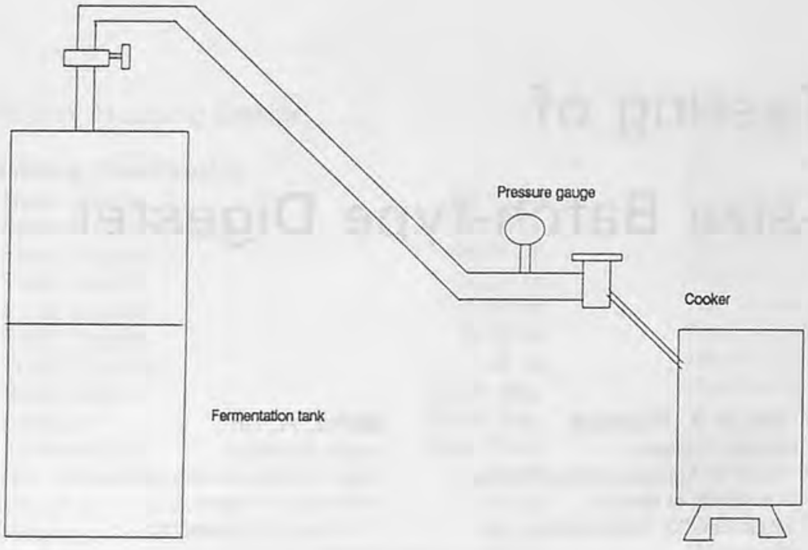

Fig. 1 Batch-type I digester.

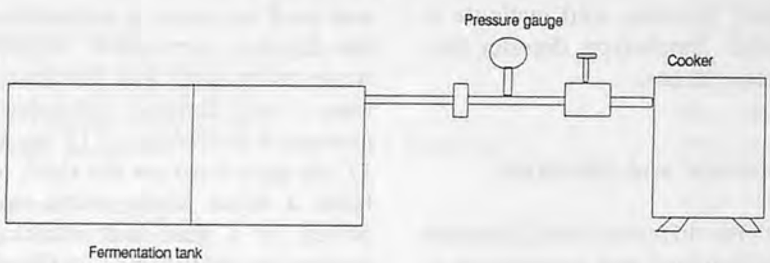

Fig. 2 Batch-type II digester.

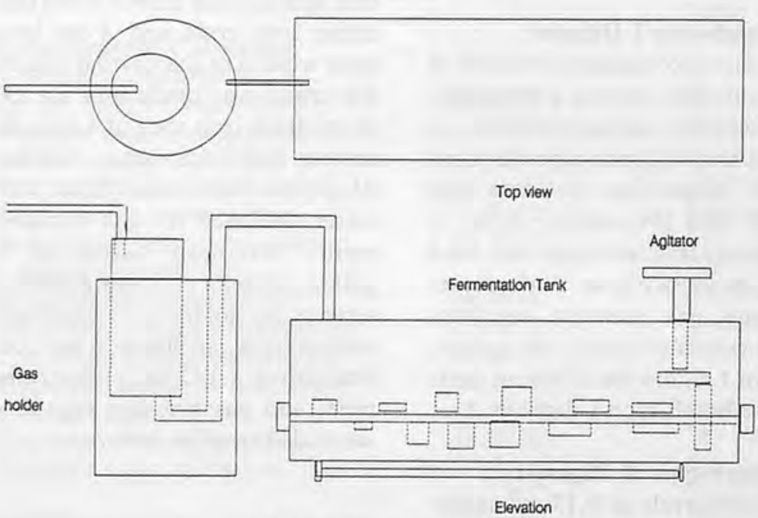

Fig. 3 Batch-type III digester.

lator valve wre connected (**Fig. 1**). A rubber hose connects the pressure regulator valve to a locally designed gas cooker. The large opening of the barrel was used as the feed inlet.

The barrel was painted black to maintain a thermophylic environment inside the digester. Since the digester was fed once with the substrate, the substrate was prepared outside the digester as a fluid mixture of 72 kg cow dung and 72 kg of water, the barrel was then completely closed and left in the open in an upright position under the sun to ferment. After two days the digester was tested for gas production every other day until the 12th day when gas was produced.

The batch-type II digester consisted mainly of the two 0.17 m^3 capacity barrels both being cut at one end and welded along the cut ends to form one long barrel as shown in **Fig. 2**, and thus the capacity of the digester was doubled. Again the barrels were painted black to maintain the thermophylic environment inside the digester. The small opening of the top barrel was used as the gas outlet, and gas connections were similar to the connections in the first digester. The other larger opening was kept closed and sealed. A rectangular opening of size 30 cm × 45 cm was made at the middle of the assembled digester to act as a feed inlet.

The digester was fed once with the substrate 144 kg cow dung and 144 kg of water mixed outside then fed into the digester. The digester was then left under the sun in a horizontal position for the fermentation process to take place. Gas production was tested every two days until the 12th day. Due to formation of scum gas production was slow. The digester was opened and the scum was broken. After 8 more days gas production took place and measurement of gas burning time was recorded every day.

The batch-type III digester was similar to the batch-type II design except for the location of the feed inlet and gas connections. However, two major modifications were made in the form of addition of an agitation system and an adjustable stand as shown in **Fig. 3**. The agitation system consisted mainly of a 1.78 m long shaft with 9 plates (15 cm × 17 cm) welded in an alternating pattern around it. The shaft was attached to the inside of the barrels through two short pipes of 3 inch diameter welded to the inside of both the front and the rear ends. Two thick, round steel plates of 19 cm diameter, and with thirteen steel spikes of 4 cm length welded to each of them, were used to drive the agitator shaft manually as shown in **Fig. 3**. **Figure 4** shows the overall view of the digester together with the gas chamber.

At first the space provided for anchoring the crank of the agitation mechanism was dually used for feeding the slurry into the digester. The slurry outlet was a circular opening cut out from the front end of the digester and was covered by a 1 cm × 15 cm steel plate as shown in **Fig. 4**. The gas outlet from the fermentation tank to the gas holder was located at the top front of the fermentation tank and consisted of an opening to which a 1/2 inch galvanized U-shaped pipe was welded. Due to problems encountered in the feeding system it was modified and separated from the cranking mechanism and the later was also reduced in size to prevent gas leakage. The 1/2 inch U-shaped galvanized pipe was used to deliver the gas from the fermentation tank to the 0.17 m^3 barrel filled with water. The small opening of the top barrel was used as the gas outlet through a 1/2 inch galvanized pipe, to which a pressure control valve, a 1/2 inch alkatheine pipe, the manometer, and the gas pressure regulator were connected.

The substrate was prepared outside the digester as a fluid mixture of 120 kg of cow dung and 240 kg of water. The large amount of water was due to the hot summer conditions which increased the evaporation rate. The digester was left in the sun and tested for gas production every 2 days. Gas production started on the 12th day as the case with previous digesters. The burning time was recorded every 3 days, then every 2 days and lastly, the burning time was recorded every day for a week.

Results and Discussion

Batch-type I Digester

Fig. 4 shows the daily total burning time of the gas produced by digester I. It was observed that the maximum gas pressure occurred just before conducting the burning test was 289.6 Pa. and was clear that the process of fermentation that led to gas production culminated on the 11th day so that gas production tested positive on the 12th day. During the test period of 40 days gas was produced every day for 27 days. Gas production started slowly in the first 13 days then increased slightly during the next 4 days and peaked during the last 10 days. Three gas production stages were observed and could be explained according to the dynamic nature of the anaerobic process itself (NAS, 1977). The first stage which started on the 12th day and continued through the 20th day may be considered as the bacteria-reproduction state where the methanogenic bacteria started to reproduce, and conversion of the substrate into gas was very low. The second stage which started on the 21st day and continued to about the 29th day may be explained by the fact that the numbers of bacteria involved in the digestion process became greater while the nutrients available to them were quite enough and in excess. Such a condition is conducive for gas production, and in fact, the gas production started to increase during this period. The third and last stage from about the 30th to the 38th day was characterized by maximum gas production at almost constant rate. It was clear that this stage constitutes the steady-state of operation of this digester. It is reasonable to assume that during this stage the amount of available nutrients was in enough to satisfy the needs of the larger numbers of bacteria within the digester. This was not the case in the last days during which the digester experienced deficiency of nutrients which led to the decline and eventually stopping gas production.

The performance of this digester was typical of the ideal batch-type digester as reported by (Ottmar, et al 1983). It was balanced and caused no problems in operation. However, one major drawback was the size of the digester itself which, even at peak production rates, could not produce enough gas to support a household for any practical use. Therefore, the batch-type I was modified to give batch-type II digester.

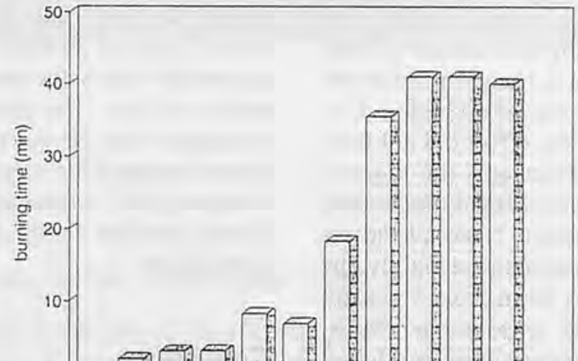

Fig. 4 Daily burning time (min) for batch-type I digester.

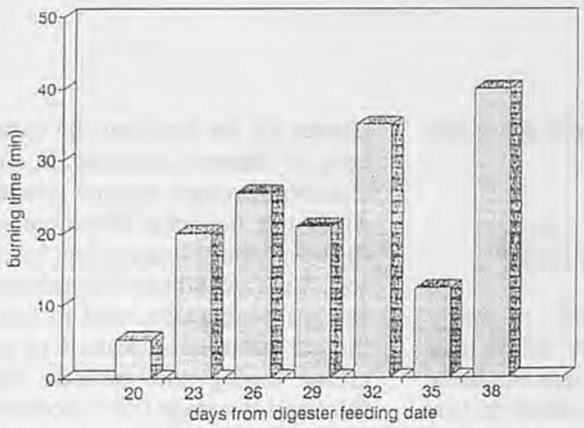

Fig. 5 Daily burning time (min) for batch-type II digester.

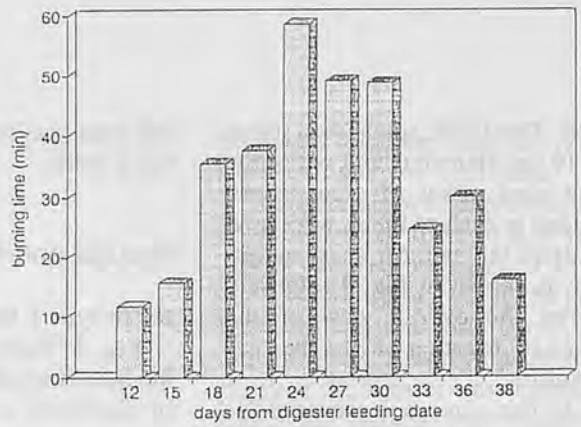

Fig. 6 Daily burning time (min) for batch-type III digester.

Batch-type II Digester

The main objective of this digester design was to provide more gas holding capacity over the previous one by doubling its capacity. The performance of this digester is shown in **Fig. 5**. Gas production started after 20 days from the initial feeding date. The main reason for the delay was scum formation which was noticed when production of gas did not start on the 12th day and the digester had to be opened for investigation on the 13th day. The scum was broken and the digester was resealed and gas production started 7 days later and continued for 19 days then it stopped completely. Gas production was low during the first five days (but slightly more than that produced by digester type I). Then production increased slightly during the next seven days, after which gas production became very erratic due to scum formation. An attempt was made to break the scum by vigorously shaking and rolling the digester and a big jump was noticed in the gas production on the 28th day of operation. Unfortunately the effort did not have a lasting effect and the digester stopped producing gas afterwards.

This digester, from all indications, was unbalanced mainly due to the scum formation which inhibited gas production (NAS, 1977). Moreover, gas production was less than expected even at its maximum production rate. It was very clear some sort of an agitation device needed to be incorporated in the design to effectively and more conveniently break the scum.

Batch-type III Digester

The total burning time of the gas produced by this digester is shown in **Fig. 6**. It was observed that the pressure developed within the gas holder just before burning the gas was constant at about 289.6 Pa. As expected gas production tested positive on the 12th day from feeding date, and was gradual in the first eight to 10 days then became substantial in the next ten days till the 32nd day from feeding date then started to decline steadily. During the test period of 40 days gas was produced for 28 days, and the digester was still working when the tests were terminated. Although the scum formation problem was not completely solved, the daily gas production of this digester was capable of producing gas with enough burning time for 16 days out of a total of 39 days, to satisfy household needs for that limited period of time. The performance of digester type III was satisfactory and its operation was balanced. However, with more modification it can perform better and more dependably.

Conclusion

The results obtained from testing small batch-type digesters, gas production started on the 12th day from feeding date. Minimum burning time characterized the first seven days of gas production in all three batch-type digesters. Gas production increased steadily then become constant in the last eight to 10 days of performance. The batch-type III digester has shown to posses the potential to produce enough gas to support a household. Further modification of the agitation system will add more reliability to the digester.

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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 1993 agricultural total products was ¥7 135 billion, it occupied 1.5% of GNP. The imports agricultural products are on the increase. In 1994 the imports reached $36.2 billion. The exports agricultural products are $1.6 billion (an increase of 7.2% of the preceding year). In Japan, feed cereals, soybean, wheat and so on depend on the imports from foreign countries. Self-sufficiency ratio of agricultural products for food is 62%, cereals is 33%.

Population mainly engaged in farming has been decreasing yet, in 1994 it was 3 350 000 persons. It was 5.2% of total working population. Farm house has decreased, in 1994 are 3 640 000 farm houses. And, commercial household was 76%.

Arable land was 5 080 000 ha in 1994. Arable land per one farm family was about 1.4 ha very small.

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 1995, almost planting and harvesting have been mechanized. As to rice, working hours per 10 a decrease to 39.6 hours, they were 117.8 hours in 1970.

In recent years farm machinery for rice crop is developed to be largersized, higher-efficiency and more commonly used. In addition, farm machinery for field crops and live stock farming is being developed and improved, which had been lagged behind so far. From 1993 Japanese government started the program developing the new high-tech machine to make farm working efficient and to reduce farm burden.

By 1995 those have been on the market such as bigsize multipurpose combine and vegetable grafting robot so on 13 types. And we decided eight types of unification for growing vegetables. Local governments have been developing the machine to vitalize special local products.

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

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

Shipments of major farm machinery in the domestic market in 1995 are as follows: riding tractor reached 90 000 units (those under 20PS were 30 000; those 20-30PS 380 000; 30-50PS 15 000; over 50PS were 7 300); walking tractor 163 000; rice transplanter 82 000; power reaper 23 000; combine 65 000 (standard types were 305); grain dryer 60 000; huller 40 000. A safety cabin and a safety frame for tractor which are devoted to guarding operator increased sharply. This shipment was 64 000 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.

Table 1. Major Farm Machinery on Farm

Unit: Thousand

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

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

Table 2. Shipment of Major Farm Machinery

Unit: Number

Year	Walking type tractor	Riding type tractor	Rice trans-planter	Power sprayer	Power duster	Binder	Combine	Rice dryer
1990	205,944	95,691	89,139	183,820	107,227	37,117	65,247	51,954
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
1995	163,323	90,623	81,729	162,352	96,499	23,293	64,572	60,564

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

The rate of used farm machinery in the total sales amount is as follows: riding tractors forms 38%; walking tractor 19%; rice transplanter 30%; combine 33%.

Movement of Farm Machinery Industry

In 1995, a shipment of farm machinery was ¥613.5 billion (an increase of 0.3% over the preceding year). Farm machinery makers had good figures in 1993, 1994. Almost of machine demands are machines which related to rice production. So, machine demand depends on rice production and rice price. In this field we had great change in November 1995. It was a new staple food law became effective.

Before this law, Japanese farmers cannot produce rice freely. Because of set aside policy, recently Japanese don't eat rice as much as 30 years ago.

Of course, we must to reduce a production of rice. But it was very hard to do it. This new staple food law should guarantee farmers to produce rice freely. In spite of this law, set aside was enforced. Farmers got angry, it was indispensable to keep rice price. Someone explained it like that. But farmers could not consent this. This situation decrease the demand of rice transplanter in 1995 spring.

Farm machinery industry had to introduce computer. A part of this industry had introduced already. But, Almost makers, distributors and government offices had not introduced yet.

U.S.A. is most advanced coutry in this field. I wonder difference between U.S.A. and Japan is 10 years.

Reducing rice producing cost, a size of paddy field was enlarged. We have 1 ha paddy field recently. When paddy field was enlarged, farm machinery system had to change. Farmers prefer to riding type machine to cut weed, applicate herbicide and fertilizer. Machinery makers are developing theose machines.

Trend of Farm Machinery Production

Farm mchine production of 1995 amount to ¥649.9 billion (7.2% an increase of over the preceding year). It was rose by harvester, combine, grain drier, huller, rice miller. Those machines related rice production have risen again.

Production of the major farm machinery is as follows:

Riding tractor 153 890 units decreased by 1.4% over the preceding year. Seeing by h.p., those under 20PS amounts to 54 004 units, 20-30PS 61 547 units, over 30PS 38 339 units. Tendency of demand is enlarging engine power.

The production of walking tractor amounted to 205 758 units, which showed a decrease of 3.2% over the preceding year. Under 5PS was 124 409 units, over 5PS 82 349 units.

The production of combine, which is next to the riding tractor is 66 767 units (an increase of 9.0% over the preceding year). Main type is its harvesting wide is about 1 meter head feed type.

Following are the production of other types of farm machinery : rice transplanter amounted to 86 713 units (an increase of 1.0% over the preceding year), binder (walking type harvesting machine for rice and corn) 27 562 units (an increase of 31.0%), thresher 12 422 units (an increase of 8.8%), grain dryer 67 700 units (an increase of 9.1%), huller 56 792 units (an increase of 34.8%), bush cleaner 1 471 192 units (a decrease of 5.4%), pest-controller 298 373 units (an increase of 10.1%) so on. **(Table 3)**.

Trend of Farm Machinery Market

In Japan distribution systems

Table 3. Yearly Production of Farm Machinery

Unit: Number, Million Yen

Year	Farm machinery total		Riding type tractor		Walking type tractor		Rice transplanter		Power sprayer		Power duster		Blower sprayer	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1990	—	585,561	115,939	198,557	269,027	38,248	91,141	52,462	220,528	12,339	149,789	5,575	9,565	9,514
1991	—	615,131	148,437	203,260	270,714	40,102	87,019	54,265	198,887	10,607	163,306	6,155	9,318	12,766
1992	—	575,986	145,948	195,189	245,675	35,917	80,540	50,760	181,475	7,826	162,040	6,548	9,923	14,884
1993	—	588,627	146,115	186,983	225,564	33,738	84,980	58,344	165,909	6,899	134,901	5,985	8,559	12,155
1994	—	606,279	156,039	198,278	212,539	30,921	85,837	66,726	141,556	6,569	123,268	5,670	6,260	8,261
1995	—	649,874	153,890	205,489	205,758	28,271	86,713	69,218	161,360	7,370	129,995	6,293	7,018	11,622
(1996)	—	623,500	151,000	199,800	206,900	30,100	71,900	58,400	153,500	6,800	125,700	6,000	7,900	12,500
Year	**Grain reaper**		**Brush cutter**		**Power thresher**		**Grain combine**		**Rice husker**		**Dryer**		**Grain polisher**	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1990	42,502	11,110	1,601,652	25,798	22,634	9,118	68,993	138,396	60,004	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	27,562	7,484	1,471,192	27,731	12,422	4,751	66,767	162,329	56,792	21,178	67,700	56,215	56,590	6,755
(1996)	22,000	6,500	1,300,000	26,000	11,500	4,500	64,500	167,200	59,900	22,300	66,800	55,200	51,000	6,500

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

Source: Ministry of International Trade and Industry

Table 5. Handling of Farm Equipment by Agricultural Cooperative Association (1994 Business Year)

Unit: Million yen

Business year	Total number of coops. surveyed	Purchase in this term	Of which purchased through affiliated organs	Amount of supply and handling
1990	3,591	349,521	268,763	375,660
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
1994	2,669	378,660	281,625	417,474

Source: "Statistics on Agricultural Cooperatives—1994 business

for farm machinery is roughly divided into two major channels: the traders concerned and Agricultural Cooperatives 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 mchinery by Agricultural Cooperative Association reached ¥417.5 billion in 1994 (¥388.3 billion in 1993) **(Table 5)**. In 1994 numbers of Agricultural Cooperative was about 2 700. amount of dealing machines per Cooperatives was about ¥150 million.

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

Export and Import of Farm Machinery

Export

In 1995 the exports of farm mchinery amounted to ¥104.6 billion, which showed an decrease of 12.9% over the preceding year. The ratio of exports to the total production amounts to ¥649.9 billion ended 16.1%.

Seeing by the shipments, ¥51.1 billion for North America (a decrease of 15.7%), ¥22.9 billion for Asia (a decrease of 9.1%), ¥20.9 billion for Europe (a decrease of 11.4%).

For North America, ¥48.6 billion was U.S.A., tractor 54 778 units,38.7 billion, which is a major part.

As for the types of farm machinery, tractor was chiefly exported : 81 463 units were exporeted in 1995 (the total production was 153 890 units). It amounts to ¥53.9 billion. Seeing by horse power, those under 30PS amounted to 61 790 units, those from 30 to 50PS 16 628 units, those over 50PS 3 645 units.

Major farm machinery, next to tractor, is bush cleaner. The total exports were 927 706 units, ¥19.5 billion.

The exports of other farm machinery are as follows: walking tractor 54 288 units; lawn mower 34 472 units; grass mower 52 644 units; chain saw 149 444 units,

Table 6. Export of Farm Equipment 1995

Unit: FOB Million Yen

Year	Unit	Value	Ratio	Major destinations
1990		132,757		
1991		129,943		
1992		143,891		
1993		124,505		
1994		120,079		
1995		104,597	100.0	U.S.A., Taiwan, Korea, France
Power tiller	54,288	3,167	3.0	Germany, France, Viet Nam
Wheel tractor	81,463	53,915	51.6	U.S.A.
Seeder, Planter	3,185	1,106	1.1	Taiwan, Korea
Power sprayer	36,084	1,217	1.2	Taiwan, Korea, Ethiopia
Duster	7,509	240	0.2	Taiwan, Korea, Malaysia
Lawn mower	34,472	3,446	3.3	France, U.S.A., Belgium
Brush cutter	927,706	19,501	18.6	U.S.A., France, Germany
Mower	52,644	2,031	1.9	U.S.A., Korea, Singapore
Combine	1,428	3,967	3.8	Taiwan
Chain saw	149,444	2,755	2.6	U.S.A., France
Other	—	13,252	12.7	

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

Table 7. Import of Farm Equipment 1995

Unit: CIF Million Yen

Year	Unit	Value	Ratio	Exporters
1990		33,205		
1991		26,598		
1992		25,778		
1993		25,578		
1994		27,779		
1995		27,015	100.0	U.K., Germany, France
Wheel tractor	3,861	11,948	44.2	U.K., France, Germany
Pest control machine	2,120,880	968	3.6	U.S.A., Taiwan, Israel
Lawn mower	30,887	2,344	8.7	U.S.A., Sweden, Germany
Mower	1,958	973	3.6	Netherlands, Denmark, France
Hay making machine	1,828	882	3.3	France, Germany, U.S.A.
Bayler	748	1,004	3.7	U.S.A., France, Germany
Combine	78	908	3.4	Belgium, Germany
Chain saw	66,841	1,630	6.0	Germany, Sweden, U.S.A.
Other	—	6,358	23.5	

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

etc.(**Table 6**).

Import

In 1995 the imports of farm machinery amounted to ¥27 billion, which means a decrease of 2.7% over the preceding year. Followings are the major imported farm machinery: tractors 3 861 units (those more than 70PS were 3 190 units of all the tractors); chain saw 66 841 units, lawn mower 30 887 units, mower 1 958 units, fertilizer distributor 2 806 units. 53% of the tractors 2 035 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 structual and technical reforms in Japanese agriculture are requested urgently.

Researchers are chiefly made for high performance, automatic and popularized farm machinery in order to reduce cost in the production of agricultural products. Electronics and mechatronics are positively adopted for their technology.

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

In 1995, in the field of farm machinery, there were movement as follows; Tractor has developed auto-running systems, and that study has been continuing. Regarding tillage, high-speed rotary, saving-energy rotary has been developed. And paddy field leveling machine which has built in razor and personal computer has been developing.

In rice production, direct sowing methods are vigorous. A lot of kind method are studying. Studies concerned with saving work power keeping levee of paddy field and pest controlling, weeding in largesized paddy field, are very active.

In vegetable production, grafting robot and many harvesting machines has been developing.

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

In stock rising, improvement of silage adjusting technology, management of each livestock, slurry disposal technology for environmental problem have been developing. ■■

Activities at the Laboratory of Farm Mechanization, National Research Institute of Vegetables, Ornamental Plants and Tea (NIVOT)

by

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Historical Background

The national horticultural research organization in Japan was founded in 1902 and the Horticultural Research Station was established in 1921. After several reorganizations, the Vegetable and Ornamental Crops Research Station (VOCRS) was established in 1973 for specific fields of research on vegetables and ornamental crops. On the other hand, the national research organization for tea was founded in 1896 and the Tea Experiment Station (TES) was established in 1919. VOCRS and TES were fused in 1986 into the present research institute: National Research Institute of Vegetables, Ornamental Plants and Tea (NIVOT). At the time of the reorganization, the Department of Floriculture was created to strengthen the research on ornamental plants. The research fields on post-harvest physiology and processing were also expanded, and the basic research on biotechnology was intensified to meet demands of the new era.

Main Research Subjects

1. Evaluation and utilization of genetic resources and development of techniques for breeding.
2. Development of advanced breeding methods utilizing of biotechnology and technology for mass production of seedlings.
3. Analysis of physiological processes; development of techniques for seedling nursery; and streamlining of techniques for highly efficient production.
4. Development of techniques for peat and disease control and for the preservation of farm soil and prevention of meteorological hazards.
5. Development of shipping, storage and processing techniques for the maintenance of post-harvest quality.
6. Development of new varieties and products, and techniques for the utilization of useful, components of tea.
7. Streamlining of research and technical information.

Publications

1. Bulletin of the National Research Institute of Vegetables, Ornamental Plants and Tea, Ser. A (Vegetables and Ornamental Plants), Ser. B (Tea)
2. Technical Information of NIVOT
3. Newsletter of NIVOT
4. Annual Reports of Departments and Branches of NIVOT
5. Main Research Reports on Vegetables, Ornamental Plants and Tea

Protected Cultivation in Japan and Role of the Department of Protected Cultivation

The vegetable planted areas in Japan cover nearly 580 000 ha, which is about 11% of the total cultivated land. Vegetables production accounts for 23% of the total agricultural production.

Vegetable consumption per capita is 106 kg a year and the domestic production provide

Table 1. Distribution of Staff and Personel, 1995

	Ano	Taketoyo	Kanaya	Morioka	Kurume	Makurazaki	Total
Director-General	1						1
Administration officers	32	9	12	4	7	4	68
Field workers	21	9	7	5	8	4	54
Researchers	74	15	33	11	18	7	158
Total	128	33	52	20	33	15	281

Table 2. 1993 Annual Budget (Unit: million yen, 1993)

	Expenses
Personnel expense	1 869
Research funds	1 153
Management expenses	103
Total	3 095

Table 3. Physical Facilities*

	Ano	Taketoyo	Kanaya	Morioka	Kurume	Makurazaki	Total
Buildings & facilities	696	300	361	282	225	225	2 089
Experimental fields	1 404	524	501	697	853	898	4 877
Others	537	155	83	101	62	136	1 074
Total	2 637	979	945	1 080	1 140	1 259	8 040

*Land area (in ar) of each facility.

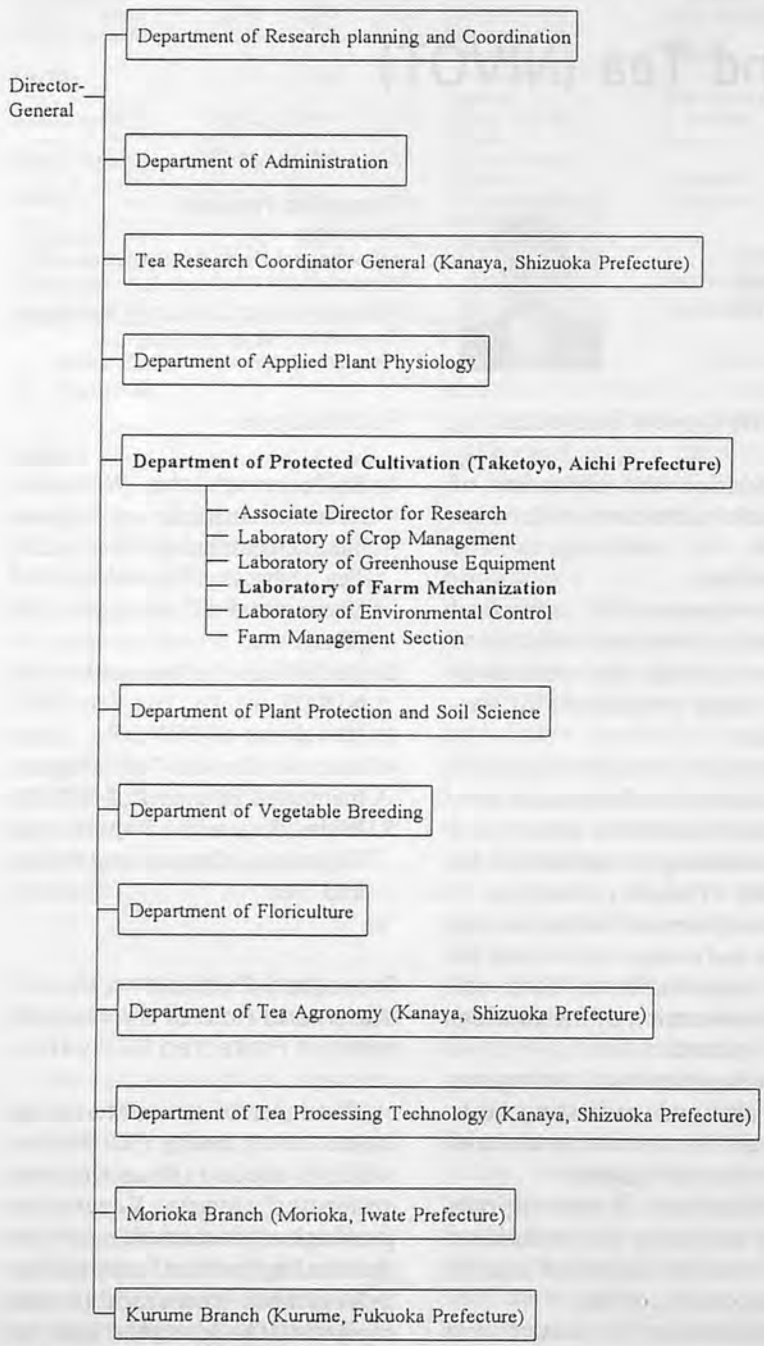

Fig. 1 NIVOT organizational fellow chart.

approximately 90% of the total. The area planted to flower is estimated at about 46 000 ha. The flower accounts for 6% of the total agricultural production. The average yearly purchase of flowers per household is ¥12 000.

An area of 35 000 ha is used for protected cultivation of vegetables. The types of protection are various, from open-sided high tunnels for rain-shelter to glass houses with automated air-conditioning and watering equipment. Soil culture is prevailing, while hydroponics has been on the rise recently.

The contributions of protected cultivation are very high with fruits and vegetables, namely; 92% strawberry; 65% of tomato; 56% of sweet pepper; 59% of cucumber and 30% eggplant which are produced under protected cultivation. In flower growing, especially of cut and potted flowers, the protected cultivation has significant shares of 44% in area and 77% in value.

Department of Protected Cultivation consists of an associate director for research, four laboratories and a farm management section to promote research on the development of techniques for enhanced and sustainable crop production.

The main subjects of research are as follows: (1) Control of environmental factors and plant growth; (2) Analysis and processing of environmental and biological information; (3) Improvement of rhizosphere environment and water-management; (4) Improvement of farm work through analysis of work processes; (5) Technology for mechanization and new production systems; (6) Evaluation and utilization of new materials and equipments; and

(7) Protection of crops against meteorological hazards.

Activities of Laboratory of Farm Mechanization

For making a great stride in the work productivity and innovating the farming system in protected cultivation, studies of mechanized production system by use of advanced technologies are being carried out in Laboratory of Farm Mechanization which belongs to Department of Protected Cultivation.

Some of current studies and activities at the Laboratory of Farm Mechanization are presented shown below.

Robotics Tomato Harvester

Tomato plants bear fruits at varying stages and farmers have to select only the ripe fruits. Since harvesting work is done by hand, it occupies more than one-fourth of the total work time. Hence, a Robotics Tomato Harvester was developed and tested. It has the funcitons of recognizing the fruits, picking them and putting them in a basket.

Fig. 2 is a general view of the tomato harvester. It consists of machine vision, control unit, manipulator and running unit. Its operation is done by an operator. The specifications of the tomato harvester is shown in **Table 4**.

The basic operation of the tomato harvester is as follows. Firstly, the machine vision develops images of tomato plants through two cameras as RGB signals. Red parts are detected by calculating R image and G image. Secondly, the computer examines the corresponding part of the fruit using the left and right cameras. The fruit position in three-dimensional area is measured by triangular method. The data calculated is sent to the manipulator controller. Thirdly, the manipulator hand approaches the desired fruit and the absorption pad pulls the fruit into the hand which picks it up and puts it in the basket.

This Robotics Tomato Harvester takes about 64 seconds to harvest a tomato fruit. It is impossible to detect a fruit when hidden by leaves or covered by an adjacent ones. Considering the above limitations, the possible space for harvesting is restricted to size 70 cm in height, 50 cm in width and 30 cm in depth.

Research of the Tomato Harvester show recognition of tomato fruit, measurement and picking-up are technically feasible. Further study on speeding and soft-hand will facilitate development of the harvester for practical use.

Fig. 2 General view of the tomato harvester.

Robotics Selective Thinner

Not only automated system but also improvement of work posture are vital factors for a stable supply of root vegetables. Root crops such as radish and carrot need thinning operation. Thinning by hand is a back-breaking operation as it is done in a half-sitting position for a long periods of time. Hence, a Robotics Selective Thinner was developed and tested.

The general view of the Selective Thinner is shown in **Fig. 3**. It consists of control, sensing and actuator unit. **Table 5** shows the specifications of the Selective Thinner.

Basic movement of the thinner are as follows: The main body runs on sprouts sowed in clumps. The laser sensor mounted at the top of the body measures the individual diameter of three stems. Then the controller selects the thickest sprout and commands the actuator to cut all the others. All operations are done while the thinner is running.

The overall thinning accuracy of the machine was 95% of the

Fig. 3 General view of the selective thinner.

Table 4. Specifications of Tomato Harvester

Dimension (size)	L; 2900 mm W; 1400 mm H; 1700 mm
Mass	750 kg (gross)
Control unit	Personal computer; PC-9801GS (CPU; 386SX, 20MHz)
Control method	Bath system programmed by C
Vision unit	Color camera; Victor TK-1070*2 Lens; Victor HZ-E9120 Resolution; 768(H)*493(V)
Manipulator unit	Manipulator; Melfa RV-P2S, DC servo motor drive Degree of freedom; 5 Hand, 85 mm stroke, parallel aluminum plates with a 10 N absorption pad

Table 5. Specifications of Selective Thinner

Dimension (size)	L; 450 mm W; 820 mm H; 750 mm
Mass	25 kg (gross)
Control unit	Programmable controller
Control method	Stored program method
No. of IO pins	Input; 24 (data 8) Output; 16
Sensing unit	3 mW Semi-conductor laser sensor Valid Length; 5 mm, Accuracy; 1/20 mm Weave Length; 870 mm, Clearance; 300 mm
A/D converter	BCD output 0-9999, Conversion speed; 30 ms
Actuator	Triple cut blades by solenoids
Travel velocity	2000 mm/sec

sprouts; 80% of radish; and 60% of carrot. Travel velocity achieve was 200 mm/sec. It is in no way inferior to manual speed. Image data would be likely to increase the accuracy.

Robotics Seedling Transport Gantry

Mass production of vegetable and flower seedlings has been feasible for reasons of expansion of plug seedling. Work of filling soil, sowing and watering have been automated, but transporting of seedling tray still uses the conventional manual method. A Seedling Transport Gantry, which moves between workshop and greenhouse, was developed as basic component of seedling production system.

Fig. 4 presents the general view of the Seedling Transport Gantry. The objective of the Gantry is to transport pallets which contain six trays of seedlings. It consists of control, sensing, loading and driving unit. The gantry runs on rails. Specifications of the gantry are shown in **Table 6**.

The loading, unloading and transporting procedures are described as follows. Firstly, the gantry runs on the rails at high speed mode (0.33 mm/sec) and changes to low speed mode (0.12 mm/sec) at the moment when the photo sensor detects clearance between pallets. The main body stops accurately upon the pallet by the reflection type photo-sensor detecting the clearance. Secondly, the folk lifters raise the pallet to a vacant shelf. The lifters go down and the body moves to the next pallet. Five pallets are set in one after another in the same movement repeatedly. Thirdly, it moves at high speed mode again. The unloading is done in the reverse way of loading. At this time, the shelves below the object pallet are retracted by the solenoid operation to avoid collision.

This gantry has the capability of transfering five pallets (30 trays) simultaneously and to run at 0-0.5 m/sec. It provides access between greenhouse and workshop. Further study on remote control is needed to achieve seedling production system.

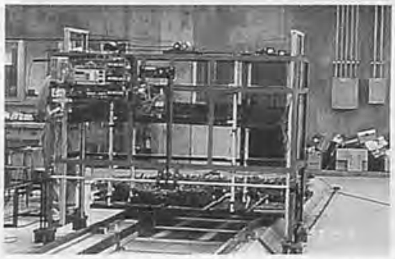

Fig. 4 General view of the seedling transport gantry.

Fig. 5 General view of intelligent battery vehicle.

Robotics Intelligent Battery Vehicle

With the development of high technical machine, the improvement of farm work system has been required in recent years. The harvesting, transporting of material and pest control are hard work in protected cultivation. The problem of exposure to pesticides is a live issue. It is indispensable to lighten this work. Therefore, an automated work system with an Intelligent Battery Vehicle was designed. It has the performance of non-exposure to pest control chemicals and speed of operation.

Fig. 5 presents the general view of the Intelligent Battery Vehicle. It consists of control, sensing and driving units. A strong point is worker follow-up by photo-switch detecting rows and worker. **Table 7** shows the specifications of the Intelligent Battery Vehicle.

The Intelligent Battery Vehicle has two operation modes, namely; pest control mode and harvesting mode.

In the pest control mode, the worker selects the speed and spray in a number of rows and connects a hose mounted on the vehicle to a pesticide tank. Then it starts spraying and runs along the rows. It is capable of detecting the row, hence it follows the row while spraying. After reaching the edge, it comes back and goes into the next row. After spraying the final row, it goes back to the original station.

In the harvesting mode, the worker selects the turning direction, move direction, speed, wait-

Table 6. Specifications of Seedling Transfer Gantry

Dimension (size)	L; 1060 mm W; 2120 mm H; 1900 mm
Mass	150 kg
Control unit	Programmable controller
Control method	Stored program method
No. of IO pins	Input; 32 Output; 24
Sensing unit	μ-photo switch*5, Limited switch*1 Photosensor*2, Reflection type photosensor*2
Driving unit	Power; AC40W motor (speed controller) Final Drive; 2 Rubber wheel drive
Loading unit	Pallet up and down; 2 fork lifers No. of loading pallets; 5 (30 trays) Pallet hanging; retractable shelves
Travel velocity	0-0.5 m/sec

Table 7. Specifications of Intelligent Battery Vehicle

Dimension (size)	L; 1120 mm W; 500 mm H; 940 mm
Mass	100 kg (gross)
Control unit	8 bit microprocessor
Control method	Stored program method
No. of IO pins	Input; 32, Output; 24
Sensing unit	Photoswith*12, Limit swith*2
Driving unit	Power; DC80W motor*2 Final drive; 4 rubber wheel drive
Driving mode	Pest control; worker-free Cultivation; follow-up or proceed Out of greenhouse; manual
Travel velocity	0.5 or 0.7 m/s

ing time, and moving distance. It moves backward or forward automatically in response to the worker's movement because it senses the distance to the worker. At the edge of the row, it turns and goes into the next row.

The Intelligent Battery Vehicle requires some conditions inside the greenhouse. These are distance between rows of 50-60 cm, row height of more than 20 cm, arranging the tentative rows on both sides of the greenhouse, turning space of more than 1.5 m and mirrors to detect the size of field. The movement of harvesting mode can be used for transplanting, pinching or fruit thinning.

With this battery vehicle, the worker can avoid the risk of pesticide and increase his efficiency.

Image Processing Technique for Cabbage Head Detection

The growth and maturity judgement for leafy head vegetables such as cabbage and lettuce are determined through vision by estimating the head size. This might be a basic technique of the selective harvester as well. Image processing can be a vital tool for measuring parameters in agricultural production. The algorithm for detection of cabbage head was developed.

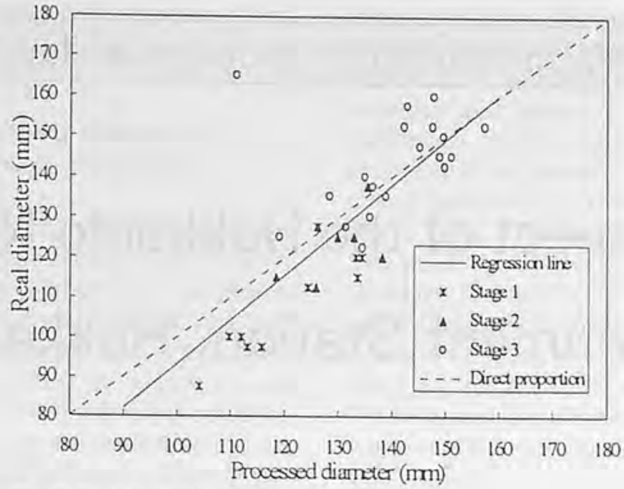

Fig. 7 Precision of head detection.

The image processing system shown in **Fig. 6** is mounted on a cart. The cart can be covered with a blackout curtain in order to block off direct light. The image processing method was developed on a personal microcomputer (Intel pentium processor with a clock rate of 60 MHz) using C language. The image is captured using a commercial image processing board, 12-frame memories with 256 gray levels. The image sensor is a 3 CCD color camera with a zoom lens of 7.5-90 mm focus distance. The image captured by the board could be saved in an opt-magnetic diskette.


Fig. 6 Image processing system.

The head of cabbage is detected by extracting a shadow between the head and outer leaves. Firstly, a cabbage color image is loaded. Then, a gray image is acquired by adding 3 images (R, G and B) and shadow parts are binarized. All objects are swelled until they becomes a ring shape. Then a circular object is driven by thinning. The part inside the circular object is detected as a head. Finally, the geometric features are calculated.

Image processing took 2.2 seconds. This performance should be adequate compared with manual selection. Thirty-seven samples out of 40 could be detected successfully. All cabbage heads in matured stage were detected, because the space between a head and outer leaves beocme wide. The relation between a processing diameter (diameter calculated from projective area) and a real diameter is shown in **Fig. 7**. The processed diameter showed direct proportion to the real diameter. Therefore, the processed diameter could be selected as index for head size. The result also indicated that 10 samples out of 19 in the matured stage could be adjudged mature with the threshold of 140 mm on this experiment.

International Cooperation in Technology

The Farm Mechanization Laboratory has been active in sharing experience in the development of farm mechanization for vegetable and ornamental plants, whenever there have been requests for technological cooperation from developing countries — for example China, Rep. of Korea and Turkey — mainly through JICA projects. ■■

Prospect of the Hokkaido National Agricultural Experiment Station, Hokkaido NAES

by
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Introduction

Hokkaido agriculture is managed under climatic conditions of cool summers and cold winters. In summer, Hokkaido has favorable agricultural conditions, with long day-length, plenty of sunshine and large day-night temperature differences. Large-scale farming of dairy, paddy rice and upland crops is developed utilizing vast land resources, and Hokkaido has become the most important food-supply base in Japan. However, problem soils, such as volcanic ash soil, peat soil and heavy clay soil are distributed widely, and crops sometimes suffer from unexpected low-temperature damage.

The cultivated area in Hokkaido is 23.5% of the total Japanese cultivated area. The average cultivated area per farm is about 10 times that of the districts. Production of milk and beef ranks at the top among domestic production, as do production and planted areas of wheat, beans, potato, sugar beet, onion, corn and forages.

Main Feature of Hokkaido Agriculture in Relation to Research Work

(1) Climate in Hokkaido is characterized as humid-sub-arctic. Sum of air temperature during crop growing season is rather low, and climatic condition varies widely year to year. So, crops are threatened to be suffered from cold injury frequently.

Hokkaido has wide area of "problem soils"; volcanic ash soil, peat soil, heavy clay soil etc., covering more than two thirds of arable land. On those soils, if not improved, crop grows quite poorly due to soil acidity, ill-drainage, drought, nutrient deficiency and others.

Overcoming those difficulties, to raise utility of land resource and to stabilize crop yield are fundamental problems in Hokkaido agriculture.

(2) Markedly larger holdings and higher ratio of full-time farmer as compared with Main land Japan are the outstanding features of Hokkaido agricultue. Furthermore, highly mechanized and specialized farming of paddy rice, upland crops, vegetables and dairy is increasing in recent years. So, the development of advanced technology is urgently needed to establish large-scale agriculture of high productivity. On the other hand, quick extension of grassland and introduction of upland crops in set-aside paddy field in this decade necessitate new technology development responsible to the changing land use.

(3) Since Hokkaido is expected to be food production base of Japan, it becomes more important to produce agricultural and dairy products in response to the demands of consumers. For the purpose of this, efforts should be paid to reduce production costs, to improve quality and to raise marketability of farm products. Technology development would be helpful to solve those problems.

A Brief History of Hokkaido NAES

1901 The Hokkaido Agricultural Experiment Station was established in Sapporo by national fund. At the same time, the Hokkaido District Agricultural Experiment Station was founded in Kamikawa by prefectural fund.

1910 At the start of Hokkaido Colonization program, the stations were united into one. The new Hokkaido Agricultural Experiment Station had its headquarters in Sapporo, and branch stations in Kamikawa, Tokachi, Kitami and Oshima.

1925 The headquarters moved to Kotoni, on the west of Sapporo.

1936 The livestock Division was founded at Makomanai, on the south of Sapporo.

1942 The Station affiliated the Hokkaido Prefectural Livestock Breeding Station and the Sheep Breeding Station.

1950 By the policy on reorganization of national research system in agriculture, the Station was divided into the Hokkaido National Agricultural Experiment Station and the Hokkaido Prefectural Agricultural Experiment Station.

1959 The Department of Upland Farming was founded in Memuro.

1964 The Department of Grassland Development was established.

1966 Main body of the Station moved from Kotoni to Hitsujigaoka and a main building, laboratories and facilities were newly constructed. The Department of Horticulture and Industrial Crops was separated from the Department of Agronomy.

1970 The Department of Grassland Development was reorganized into the Department of Grassland Improvement and the Department of Forage Crop Breeding.

1973 The Japan Sugar Beet Improvement Foundation was dissolved and affiliated in the Station as Department of Sugar Beet.

1988 After the reorganization, the Station had nine research departments, with the newly established Research Project Teams and Research Information Coordinator.

Agricultural Research System of Hokkaido

As a national organization, Hokkaido NAES, one of seven regional agricultural experiment stations, executes basic and leading studies for the development of agriculture in regions of cold climate. As prefectural organizations under the leadership of Central Agricultural Experiment Stations, 10 Hokkaido Prefectural Experiment Stations - each suited to it's own region of Hokkaido - develop and establish practical techniques.

Hokkaido NAES contributes to development of Hokkaido agriculture by executing research, and maintaining close cooperation with Prefectural Experiment Stations.

The Role of NAES

Japan extend in an elongated shape from north to south and has complicated geographical features. Specialized and diverse agriculture are developed, depending on natural conditions. The Ministry of Agriculture, Forestry and Fisheries established seven regional national agricultural experiment stations for promoting regional agriculture in Japan. Hokkaido NAES is one of these experiment stations and is responsible for the Hokkaido district. Hokkaido NAES executes leading investigation for development of agriculture techniques suited to Hokkaido large-scale and high profit farm management, utilization of large-scale machinery and vast land resources in order to improve productivity, safety and quality of agricultural products; and the boosting of international competitiveness. Through basic studies under a policy of "utilization and/or conquest of low temperature and heavy snowfall," Hokkaido NAES contributes to the stable development of international agriculture. To fulfill the above role, Hokkaido NAES consists of the Upland Agriculture Research Center, Northern Agriculture Research Coordinator and 6 research departments. All of these are supported by Research Planning and Coordination Dept. and General Administration Dept.

Principal Research Subjects

1. Investigation of low-temperature physiology and ecological mechanisms, and development of the abilities to utilize methods of biological resources in (sub-)arctic regions
2. Evaluation of natural resources in cold environments, and investigation and management of (sub-)arctic ecosystems
3. Development of crop breeding methods and breeding of good cultivars suited to cold environments
4. Establishment of sustainable high-production systems for large-scale rice paddies and upland farming
5. Establishment of animal production based on a grass and forage system that takes into account environmental conservation
6. Integrated research for agriculture

Organization of NAES

Fig. 1 shows the overall organization chart of the present NAES. In **Fig. 1**, Upland Agriculture Research Center is in Memuro. The Number of total personnel of NAES is 349. And among them, researcher is 171.

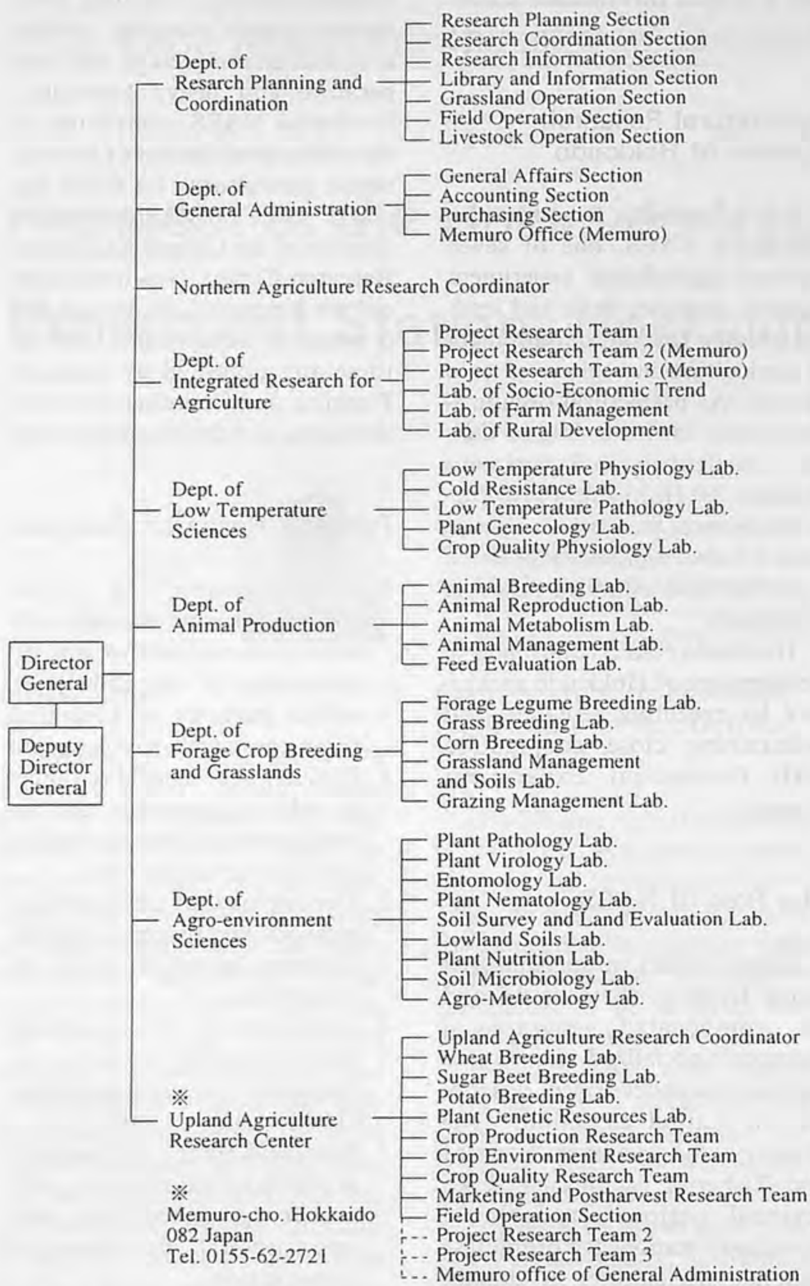

Fig. 1 Organization.

Fig. 2 Test for the cold tolerance of wheat.

Fig. 3 New caltivar of red clover "TAISETSU."

Fig. 4 Large-scale paddy field.

Research Activities

Low-temperature Sciences and Agriculture

Cold climates often limit not only which crop cultivars can be grown but also their productivity. Interdisciplinary research in Hokkaido on agriculture at low temperatures has made it possible to cultivate temperate crops in cold regions and also to improve the cold tolerance of winter-hardy crops. In order to develop agriculture that turns the cold climate to an asset, basic and fundamental research is conducted on the physiology and ecology of major crops and biological resources at low temperatures.

Crop Breeding

Breeding for various kinds of crops important to Hokkaido agriculture (such as rice, sugar beet, potato, corn, buck wheat, sunflower, forages, flowers, vegetables, and fruits) is carried out to develop new cultivars and parent lines adapted to cold regions. Collection and evaluation of genetic resources for the breeding of new cultivars and development of new breeding methods utilizing the latest results of biotechnology are conducted.

Research on Large-scale Rice Farming

For labor-saving, low-cost production of rice, which is a major lowland crops, Hokkaido NAES conducts leading studies to establish new technology of paddy field management and rice

Fig. 5 Fruition of apple.

Fig. 6 Harvesting work by using a big machine.

Fig. 7 Grazing trial.

Fig. 8 Test for peat soil.

direct sowing in cold regions, and also executes studies to develop labor-saving, low-cost farming systems that combine rice and upland crops for converted paddies for large-scale, lowland agriculture.

Research on Horticulture

In order account for the recent remarkable increase of the production of vegetables and flowers as high-profit crops, Hokkaido NAES executes breeding and studies on cultivation techniques for high quality.

Research on Large-scale and High-profit Upland Farming

Hokkaido NAES concentrates its efforts on establishing new technology of upland field management that yield high profit in large-scale field farming in hand with sustainable land utilization. Hokkaido NAES conducts leading studies on field improvement, cultivation, quality regulation, pre- and post-harvest technology, marketing and management.

Animal Production in Cold Region, Based on Grass and Forage

Hokkaido NAES works toward the development of highly productive animal management in harmony with ecosystem conservation, a management that is based mainly on grass and forage (which land accounts for about half of all of Hokkaido's cultivated land). The organization executes studies on stable production of and self-sufficiency in feed, on the characteristics of dairy and beef cattle and on systems of rational management and environmentally friendly animal production. Also researches are ways to ensure a stable supply of fresh and healthy milk and beef products.

Agriculture in Harmony with Ecosystem Conservation

For the establishment of sustainable agriculture through the harmonization of the natural and rural environments in Hokkaido, studies on the characteristics of natural factors, such as climate, soil types locally specifics, are being carried out to minimize the use of chemical fertilizers and pesticides/insecticides by means of new methods of soil and pest/insect management.

Rural Vitalization

Rural development research seeks to improve productivity in agriculture by integrated research for agriculture and by utilizing features of rural areas in cold regions. Developing new technol-

Fig. 9 Large-scale upland farming.

ogy related to agricultural machinery, buildings and land improvement is main factor.

To support rural vitalization, special interest is taken in environmental conservation, rural landscape and producer-consumer communication.

Research Collaboration with Other Northern Regions

In order to contribute to development of agriculture in Hokkaido, collaborative programs are being carried out, including exchange of information and researchers with other northern regions, that are similar to Hokkaido in climate, soils and plant ecology, in particular with Russia, Eastern Europe, Canada, the northern US and central Asian regions.

The Society of Agricultural Cryo-Sciences (SACryS)

The Society of Agricultural Cryo-Science (SACryS) was founded on February 21, 1994. Hokkaido NAES is supporting the management. Keeping in mind the special circumstance of low temperatures, it aims at the development of a Hokkaido agriculture of the 21st century by promoting active interchange of information on agricultural sciences and technology, from production to processing and marketing. Such development seeks to improve low-temperature science in agriculture and develop agri-business in Hokkaido. It is open to everyone who is interested in the field. The membership consists of staff of agricultural organizations, agri-business and administrative organs as well as researchers at research institute. "The Journal of Agricultural Cryo-Science (J.ACryS)" is issued quarterly. ■■

FINDER SYSTEM FOR AMA ARTICLES AVAILABLE

A computerized finder system consisting of a database listing of all technical articles in Agricultural Mechanization in Asia, Africa and Latin America since it began publication in 1971, along with searching software, is available without charge. The system is on a 3 1/2 inch diskette for use with IBM-compatible computers. Requests for this diskette should be sent to:

William Chancellor
Bio/Agric. Engineering Dept.
University of California
Davis, CA 95616, USA
(e-mail: wjchancellor@ucdavis.edu)
(fax: 916-752-2640)

The diskette will be sent by air-mail. Those with access to the INTERNET may download AMA-96.EXE (or a larger agricultural engineering database, AE-NDX95.EXE) by using File Transfer Protocol (FTP) from POPPY.ENGR.UCDAVIS.EDU (or 128.120.65.75 for those wishing to use numeric characters), User = anonymous, Password = guest. Before "getting" either file by FTP, first type: binary <enter>. Either of the above files should then be placed by itself in a hard-disk subdirectory. Typing the file name (without extension) <enter> will result in a ready-to-run system activated by typing: HI <enter>.

Introduction to the Laboratory of Agricultural Engineering, Kagoshima University

by
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General Description of Kagoshima University

Kagoshima Prefecture is at the southern end of the Kyushu Island which locates on the southeast of Japan and constituted by the Satsuma and Ohsumi major peninsula, and more than 200 islands such as Tanegashima island, Yakushima island and Amami islands. These islands extend around 270 km east and west, 590 km north and south and the total area is about 9 100 km^2.

Kagoshima city is the capital of Kagoshima Prefecture and locates 1 150 km from Tokyo and it takes 2.5 hrs by air and shuttle bus.

Kagoshima University locates around the center of the Kagoshima city and one of the major universities in Japan. Kagoshima University was established in 1949 with the faculty of Letters and Science, Education, Agriculture and Fisheries with the fusion of five pre-war educational institutions such as Seven higher school, Kagoshima normal school, Kagoshima normal school for youth education, Kagoshima College of Agriculture and Forestry and Kagoshima College of Fisheries. The faculty of Medicine and Engineering were added in 1955 and the faculty of Law, Economics and the Humanities and the faculty of Science and college of Liberal Arts were established in 1965. The faculty of Dentistry was established in 1977 and school of Allied medical science in 1985.

Kagoshima University have eight faculties and the school of Liberal Arts and seven graduate schools for master course and five graduate schools for doctoral course. Other facilities are used for education and research such as University Libraries, Health service center, Research center for South pacific, Research and development Center, Information processing center, Gene Research center, 3 training and research ships in the faculty of Fisheries.

Total number of university faculties and stuff is 2 347 and that of faculties is 1 159 and that of stuff is 1 188. Number of students is 10 642 which includes under graduate courses 9 472, graduate courses for master course 698 and for doctoral course 1 170. The number of foreign students are 221 mostly from Asian and Pacific 29 countries and the international academic exchange of the universities and the faculties has been activated.

Innovation of the organization of the university is expected from 1997 for more development toward 21st century.

Agriculture in Kagoshima Prefecture

The climate at Kagoshima Prefecture varies from temperate to subtropical and the yearly average temperature varies from 15°C to 23°C. The amount of rainfall varies according to the area and it is not the rare case that the yearly rainfall exceed 10 000 mm in the mountainous area of Yakushima island which is designated as the world property. But we have from 2 000 to 3 000 mm rainfall and about the half is on from rainy season to summer. In summer or autumn, Kagoshima suffers from typhoon with heavy rain or drought.

The agricultural production is increasing in the livestock and horticulture using wide upland field under warm climate and much rain in Kagoshima Prefecture. While Kagoshima suffers from climate disaster such as typhoon and disadvantage of the location to be far from the large consuming area.

The number of farmers in Kagoshima Prefecture is 111 000 which is 20% of the total families and agricultural population is 337 000 which is 19% of the whole population stands 15th and 21st place, respectively, in Japan. The arable land area per farmer under 0.5 ha is 48% and that of more than 2.0 ha is only 8% but the farmers cultivating more than 2 ha are increasing.

The top four ranked agricultural products are upland rice, sweet potato, rape seed, tobacco, green pepper, pod pea, pod kidney bean, pumpkin, taro, loquat, beef, poke, chicken and broiler. Agricultural gross production is 440 billion and ranked 4th place in Japan which brakes down broiler 26%, beef 20%, poke 15%, vegetables 21%, flowers 9% and fruits 6%.

Education in Kagoshima University

The special feature of the research activities in Kagoshima University is to contribute finding and solving problems from local to world wide. Students are educated to be an advanced engineer or an academic / industrial leader correspond to the international current. In 1990, university organization was innovated to promote totalized, interdisciplinary and international education and research. In Kagoshima University, students are educated consistently for four (six) years systematically making the best use of the features in common and special education. After graduation, students can go on the master and doctoral course to learn advanced theories and applications.

The academic schedule in Kagoshima University is as follows:

Academic year: April 1st ~ March 21st
First semester: April 1st ~ October 31st
Second semester: November 1st ~ March 31st
Holidays: Saturday, Sunday, National holidays
Anniversary of the founding of the University: November 15th
Spring holidays: April 1st ~ April 10th
Summer holidays: July 11th ~ September 10th
Winter holidays: December 25th ~ January 8th

General Description of Faculty of Agriculture

The faculty of agriculture originates in Kagoshima College of Agriculture and Forestry established in 1908. The first president was Dr. Kizou Tamari who is the first doctorated professor in Japan and showed leadership in agricultural education. In 1949, this college became the faculty of agriculture, Kagoshima University and graduate school for master

Table 1. The Organization of the Faculty of Agriculture

Departments (4)	Chairs (21)	Laboratories
Agricultural Sciences and Natural Resources	Crop Science	Crop Science, Tropical Crop Science, Plant Breeding
	Horticultural Science	Fruit Science, Vegetable Crops, Ornamental Horticulture
	Forest Resources	Silviculture, Forest Management, Forest Policy, Forest Genetics and Protection
	Animal Sciences	Animal Reproduction, Animal Breeding, Animal Management
	Agricultural Systems Engineering	Farm Power and Machinery, Food and Agricultural Process Engineering, Agricultural Physics
	Agricultural Economics and Management	Agricultural Economics and Policy, Agricultural Marketing, Farm Management
Biochemical Science and Technology	Biochemistry and Biotechnology	Biochemistry and Nutritional Chemistry, Applied Microbiology, Applied Starch Chemistry, Chemistry and Technology of Agricultural Products
	Animal Biochemistry and Food Science	Animal Biochemistry, Animal Nutrition, Animal Products Processing Research
Environmental Sciences and Technology	Agronomical and Food Chemistry	Environmental Chemistry, Soil Science, Plant Nutrition and Fertilizers, Postharvest Physiology and Preservation of Fruits and Vegetables
	Plant Pathology and Entomology	Plant Pathology, Entomology
	Water Control and Reclamation Engineering	Irrigation and Drainage Engineering, Farm Land Engineering
	Water Management and Forest Products Technology	Wood Technology and Forest Products Chemistry, Forest Civil Engineering and Erosion Control
Veterinary Medicine	Veterinary Anatomy, Veterinary Physiology, Veterinary Pharmacology, Veterinary Pathology, Veterinary Microbiology, Veterinary Public Health, Veterinary Internal Medicine, Veterinary Surgery, Veterinary Reproduction	

course was established in 1966.

The seven departments were restructeured to the four department such as agricultural sciences and natural resources, biochemical and science technology, environmental sciences and technology and veterianry medicine. The organization is shown in **Table 1**. The united graduate school of agricultural sciences was established in 1988 and the united graduate shcool of veterinary science was also established in 1990. Experimental farms, university forest and veterinary hospital are attached making good use of the characteristics of the southern natural environment and this is the feature of the faculty of agriculture. The total number of graduates exceed 50 000 since the establishment in 1949. The number of students is 1 385 now which includes under graduate courses 1 121, master course is 168. The number of foreign students are 103 which includes 92 students for doctoral course from Asian and African countries. Bachelor's degree is given to the students who earned enough credits for graduate in four years. Master's degree is given to the students who has finished two years master course and doctor's degree is given to the students who has finished three years doctoral course and passed the judgment. The doctoral degree is given to 134 students until now. For the promotion of international exchange, the faculty of agriculture has made the academic exchange agreements with the University of Georgia (USA), Yunnan Agricultural University (China), Hunnan Agricultural University (China).

The research activity in our faculty is quite lively under such circumstances mentioned above and many professors are given domestic and international academic awards every year.

Agricultural Machinery Course

The department of agricultural engineering is established in 1963 based on the chairs of agricultural machinery, agricultural electricity and agricultural engineering work 1 and 2 which belonged to the department of general agriculture. At that time, the department was composed with the chairs of agricultural land maintenance, agricultural machinery 1, agricultural machinery 2 and agricultural physics. Later on the chair of land reclamation was added and the chair of agricultural land maintenance was renamed as agricultural water control in 1972. The latter two chairs are called rural engineering course and others agricultural machinery course.

By the restructure in 1990, the rural engineering course moved to the department of environmental sciences and technology and agricultural machinery course moved to the department of agricultural sciences and natural resources. In 1997, agricultural machinery course is planned to move to the department of environmental sciences and technology. The name and the organization has changed but the essence has not changed. Now the agricultural machinery course is composed with three laboratories of farm power and machinery, food and agricultural process engineering and agricultural physics.

The graduate school for master course is founded as a higher course of the agricultural machinery course and the graduate school for doctoral course has the science of life environmental and conservation curse and united chair of agricultural engineering. The united chair of agricultural engineering belongs to the united graduate school of agricultural sciences organized by Kagoshima University, Saga University, Miyazaki University, and University of the Ryukyus.

Recent Education, Research Interest and Academic Papers

Farm Power and Machinery

Miyabe Yoshiteru,
Professor, Ph.D. (Agri.)
Iwasaki Koichi,
Associate Professor, Ph.D. (Agri.)

The education and research is focused on mechanization, performance improvement, automization, robot usage in series of farm operation such as tillage, seedling, nursering and harvesting as the fundamental part in agricultural produciton. Following subjects are taught in lectures, practical lessons and experiments, the structure and the function of the farm machinery such as tractors, energy usage in farm production and engines,subjects related to mechanical engineering which are the basis for the design and development of farm machinery.

Aiming systematic mechanization from planting through harvesting of sugar cane which is one of the special products in Kagoshima, machines are manufactured by trial and investigated for the practical use. The automatic planters for root vegetables such as taro are developed and tested with the cooperation of the prefectural agricultural experiment station. For the improvement of the farm machinery, human engineering is applied and designing guideline is investigated for the development of machines which enables easy operation for farmers. Planting system is developed in which crops and seed bed moves to the operator aiming automated agriculture. Operatorless drive system of the tractor is studied using high technologies such as GPS. For the improvement of the rotary tilling equipment which is the main machinery used for paddy field in Japan, tillage resistance acting on rotary blade and power transmitted systems are investigated.

List of Publication

1. Y. Miyabe, K. Iwasaki, S. Kashiwagi: Fundamental Studies on the Leaf Stripping Operations for Sugar Cane (I), Japanese J. Farm Work Research, 28(1), 48-55 (1993).
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5. K. Iwasaki, Y. Miyabe and S. Kashiwagi: Dynamical Analysis of Rotary Tiller. Stress on Chain Tightener. Mem. Fac. Agr. Kagoshima Univ., 29, 93-99 (1993).
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Food and Agricultural Process Engineering Laboratory

Tanaka Shun-ichiro,
Professor, Ph.D. (Agri., Engg.)
Morita Kazuo,
Associate Professor, Ph.D. (Agri.)
Tanaka Fumihiko,
Assistant Professor, Ph.D. (Agri.)

The Laboratory deals with Education and research related to postharvest technology and agricultural structures. The postharvest technology mainly deals with drying, sorting, processing, storage and transportation of agricultural products and food engineering field. The agricultural structures mainly deals with environmental control in greenhouses, automatic or robotic production system in greenhouses and bio-engineering field.

Therefore, in this educational program, there are several lectures, experiments and exercises related to basic engineering subjects in cooling, refrigerating, air-conditioning, thermal properties, fluid mechanics etc., also fundamental professional subjects like physical and rheological properties of food and agricultural products and professional subjects in agricultural process engineering, agricultural structures, food engineering etc.

In the research fields, many studies at international level with high techniques and analysis to the local level solving local agricultural problems influenced by warm weather and volcanic activity are widely undertaken. The plant growing technology in a greenhouse with cooling system in the warm night time, analysis of thermal properties of agricultural products using finite element method, development of dehumidified drying system for agricultural products and other useful technologies have been established. Recently, these studies were undertaken as follows: ① Development of long period storage technology for local products like sweet potato and strawberry, ② Development of cooling, drying and storage system of agricultural products using absorption type refrigerator driven by application of geothermal energy, ③ Development of cooling tempering drying using heat-pump system, ④ Development of quality evaluation methods for agricultural products using ultrasonic secondary wave and near infrared, ⑤ Detection of non-metallic foreign materials in food and agricultural products using soft X-ray and X-ray CT system, ⑥ Development of anaerobic fermentation system for food and agricultural wastes using a two-phase methane fermenter, ⑦ Development of new food materials using twin-screw extruder, ⑧ Pasteurization of food using High oxidation potential water, ⑨ Analysis of visco-mechanical properties of a conjac and yam, ⑩ Analysis of thermal property of food and agricultural products, ⑪ Development of robot harvester for stawberry, ⑫ Development of solar collection system for plant greenhouse in the underground.

There are several studies undertaken from basic level to applied level. Several foreign students from China, Malaysia, Tanzania and Argentine have studied/are studying at the laboratory and International collaborative researches with University of Georgia and University of Hawaii are actively undergoing in the laboratory.

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Agricultural Physics

Mochizuki Hiroaki,
Associate Professor, Ph.D. (Engng.)
Ishiguro Etsuji,
Associate Professor, Ph.D. (Agri.)

Laboratory of Agricultural Physics has been focused on the agricultural problems by means of physical and informational analysis. The lectures are mainly divided into following three parts. One is the fundamental in agricultural engineering, such as Applied Mathematics and Information Process Engineering. Second is the Electric Circuit, Introduction of Electronics and Automatic Control. Final is Applied Measurement and Agricultural Meteorology. Furthermore, practical lessons and experiment, such as Seminar in Agricultural Systems Engineering and Laboratory Course of Agricultural Physics, are opened.

The details of our studies are shown as follows. Biomechanics is a rapidly developing study in which functions of animate beings such as an insect, bird, animal, human being, plant etc. are regarded as parts of biomachine. When an insect is regarded as a biomachine, its function gives important information of new unknown design method for machine different from one until now. In application, it is expected that "a flight insect based robot" can inspect noxious insects or growth of crop in a field. In the laboratory, an investigation to clarify flight performance of a dragonfly has been studied for the past three years, since the dragonfly performs the best excellent flight performance in all insects, at a relation between its flight mechanism and flow has been studied a few so far. The second is a quality evaluation of agricultural products. This study is performed with two methods, infrared imaging method and vibration of impact force method. These methods are based on that distribution of the surface temperature of agricultural products are depended on those quality, surface bruise and maturity. And the latter is basesd on the frequency analyses method of vibrating wave passing through agricultural products, watermelon and pumpkins. The third is the effective utilization of radio-magnetic radiation, gamma ray and ultraviolet ray for agriculture. This is a plant breeding and fundamental analysis of sterilization mechanisms for microorganisms, fungi and bacteria. And final study is remote sensing. Using satellite data, Landsat-5, SPOT, MOS-1 and NOAA, estimation of the rice yield, estimation the volcanic deposits from Mt. Sakurajima (active volcano), identifying the damaged area by typhoon, and the estimation of standing tree volume, are studied.

List of Publications

1. K. Matsuo, H. Mochizuki, Y. Miyasato, M. Yaga: An application of Passive Boundary Layer Control to Pseudo-Shock Waves, Pro. of the Second KSME-JSME Fluids Engineering Conference, 2, 64 ~ 69 (1990).
2. E. Ishiguro, K.K. Mishra, Y. Hidaka, M. Miyazato: A Study on the Effects of Mt. Sakurajima's Falling Ash over Crop and Forest Area Using Image Processing for Landsat-5, MOS-1 and JAFSA Digital Data, Proc. 5th International Colloquium-Physical Measurements and Sngnature in Remote Sensing, France, 509-512 (1991).
3. K. Matsuo, H. Mochizuki, Y. Miyasato, M. Gouya: Oscillatory Characteristics of a Pseudo-Shock Wave in a Rectangular Straight Duct, JSME International J(B), 36(335), (1993).
4. E. Ishiguro, K.K. Mishra, Y. Hidaka, S. Yoshida, M. Sato, M. Miyazato and J.Y. Chen: Use of Rice Response Characteristics in Area Estimation by Landsat/TM and MOS-1 Satellite Data. ISPRS Journal of Photogrammetry and Remote Sensing, 48(1), 26-32 (1993).
5. K. Matsuo, Y. Miyasato, H. Mochizuki: Flow Visualization of Passive Shock Wave/Boundary Layer Interaction Control, Proc. of the Third Asian Symposium on Visualization, 301 (1994).
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7. H. Mochizuki, Y. Miyazato, H. Komaki: Visualization of Flow Generated by Flapping of Dragonfly, J. of the Visualization Society of Japan, 15(2), 205 ~ 207 (1995).
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(S. Tanaka and K. Iwasaki take responsibility for the content and wording of this article.)

Introduction of the Department of Environmental Engineering Utsunomiya University

by
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Introduction

National Utsunomiya University is located at Utsunomiya city in Tochigi prefecture. Tochigi prefecture is situated in northan Kanto plain with an area of about 6 400 square kilometers and population of 1 960 thousand. Utsunomiya city is prefectural seat of Tochigi prefecture with a population of 450 thousand, and major production area both of industry and agriculture. Utsunomiya is at approxiately 100 km distance from Tokyo, capital of Japan, and we can reach to Tokyo about 45 minutes from Utsunomiya station by Tohoku super express lines. Therefore Utsunomiya actually belongs to same economic area with Tokyo, and so is called metropolitan area.

The various kind of plants are produced in Tochigi prefecture by utilyzing the favorite geographical and climate features. In fact, paddy are mainly planted in northern part and vegetables and fruits are produced in southern part in Tochigi district. In the vegetables and fruits, strawberry, leek, mushroom, turnip, garland, egg plant, tomato, taro, edible burdock, spinach, broccoli, Japanese radish, lettuce, pears, melon, chestnuts and grapes are known as the staple products in Tochigi, and these rank high at yield in Japan. In these products, Tochigi has largest production area of strawberry and keeps top rank at the yield and quality over these 10 years. Also livestock and dairy farming are flourishing in the northern highlend area. Tochigi is the advanced agricultural area keeping the balance between the paddy, horticulture and livestock productions. Because Tochigi district is near the Tokyo having the largest consuming population, we have advantage at rapid information and distribution for agricultural products. Therefore Agriculture in Tochigi is called "metropolitan agriculture", and is developing now.

With the enforcement of the National Schools Establishment Act on 31 May 1949, Utsunomiya University was established as a new-system university with two faculties, the Faculties of Liberal Arts and of Agriculture. On 1 April 1964, the Faculty of Engineering was set up in the University, as the result of the incorporation of Utsunomiya Technical Junior College. The faculty of Liberal Arts changed its name to the Faculty of Education on 1 April 1966, and the Faculty of General Education existed for the period April 1968 to September 1994. The Faculty of International Studies was founded on 1 October 1994, as the forth faculty of the Utsunomiya University.

The first graduate school of Utsunomiya University, the Graduate School of Agriculture (Master's Courses), was established on 1 April 1966, then that of Engineering (Master's Courses) on 1 April 1973, and that of Education (Master's Courses) on 1

April 1984.

The United Graduate School of Agricultural Science (Doctor's Courses), Tokyo University of Agriculture and Technology, which was established on 1 April 1985, is managed in cooperation with Utsunomiya University and Ibaraki University. On 1 April 1992, Doctor's Courses were established in the graduate School of Engineering.

Now, Utsunomiya University is organized into 4 faculties, 3 graduate schools and 3 university institutes, as shown in **Table 1**.

Table 1. Organization of Utsunomiya University

Faculty, Graduate School or Institute	Department or Course	Academic Staff	Legally Number of Students per year
Faculty of International Studies	International Social Studies	39	50
	International Cultural Studies		50
Faculty of Education	Elementary School Teachers' Training Course	105	160
	Junior High School Teachers' Training Course		70
	Mentally Retarded Children's School Teachers' Training Course		20
Faculty of Engineering	Mechanical Systems Engineering	149	100
	Electrical and Electronic Engineering		95
	Applied Chemistry		105
	Architecture and Civil Engineering		90
	Information Science		85
Faculty of Agriculture	Bioproductive Science	94	123
	Environmental Engineering		42
	Agricultural Economics		46
	Forest Science		42
Graduate School	Education (Master's Course)		38
	Engineering (Doctor's Course)		111
	Agriculture (Master's Course)		70
United Graduate School	Agriculture (Doctor's Course)		
Center for Education and Research of Lifelong Learning		2	
Weed Science Center		7	
Cooperative Research Center		2	

Faculty of Agriculture

The Faculty of Agriculture started at 3 Departments of Agriculture, Forestry and Agricultural Economics as the Utsunomiya Higher Agricultural and Forestry School on October 1922. In 1949 the Faculty of Agriculture, Utsunomiya University was newly established at 6 Departments added 3 Departments of Animal Science, Agricultural Engineering and Agricultural Chemistry. Then in response to rapid changes in social situations and agricultural and rural structures, education and research activities were developed and deepened. Especially in order to develop the high technology as related to the biotechnology and information science, new educational and research fields were opened and expanded.

As the graduate course, the Graduate School of Agriculture (Master's Course) was established in 1966, and the United Graduate School of Agricultural Science (Doctor's Course) was established in 1985 at Tokyo University of Agriculture and Technology cooperating with Utsunomiya University and Ibaraki University. From this, the higher educational and research activities were fully arranged and 31 students took a doctor's degree in our University before 1995.

Furthermore, the new educational and research system on the borderline and compound research fields were required in response to the expansion of the technology and industry concerning to agriculture and foods, the development of high scientific technology and needs of worldwide environmental preservation by the recent growth and glovalization of the economical and political society. So the Faculty of Agriculture was reorganized from 6 Departments to 4 Departments of Bioproductive Science, Environmental Engineering, Agricultural Economics and Forestry Science including 10 large majors. That is shown in **Fig. 1**. We, staff on agricultural machinery, facilities and process engineering, belong to the Department of Environmental Engineering.

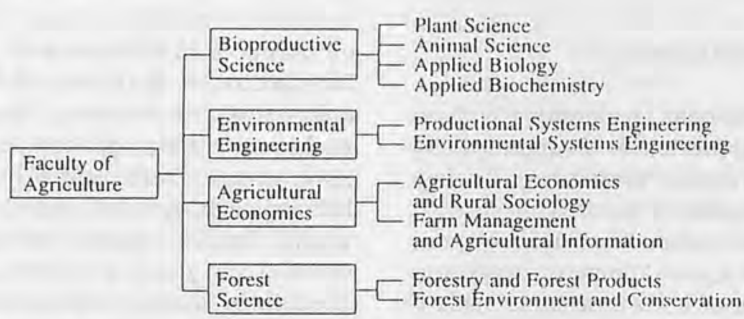


Fig. 1 Departments and laboratories in Faculty of Agriculture.

Department of Environmental Engineering

In the Department of Environmental Engineering of the Utsunomiya University, we offer the special education and researches on the planning and designing of agricultural infrastructure, productional facilities and machinery, and those manufacturing and utilization to the natural and biological resources, in order to create and renovate the stabilized productional systems and the healthy rural community harmonized with environment. That is, we approach to the physical and engineering fields concerned with environment and biological production systems. The education and research fields are concretely described as follows.

- Construction and Management of foundation of plant and food production such as the soil and farm.
- Environmental Control Engineering of food productional spaces.
- System Engineering and Postharvest Technology dealing with the machinery and facilities on food production, processing, distribution and storage.
- Regional Resources Engineering on biomass and solor energy.
- Regional Water and Energy Circulation Engineering on the water resources development.
- Rural Planning and Management on farm and community through international development.

This department is composed of two Majors; Productional Systems Engineering and Environmental Systems Engineering. But we all do not only educate and research in individual Majors, but also incorporated this Majors in one unit, because environment of plant production and rural life must be observed as the synthesized system. Also in our Department, we conduct two educational courses of the Productional Ecorogical Environmental Engineering and Synthesized Environmental Management. We mainly put emphasis on the education of the engineering and technology on the plant production in the Productional Ecological Environmental Engineering Course, and the management and operation of productional environment in the Synthesized Environmental Management Course, respectively.

Three Laboratories deal with the reaches on the Agricultural Machinery and Process Engineering. Laboratory of Farm Machinery makes researches in the design and development of farm machines and devices concerned with processes from planting to harvesting, and the development of renewable resources and energy in the rural area. Laboratory of Food process Engineering deals with the processing, distribution and storage technology of fresh foods, and the recycling of processing and packaging waste. Laboratory of Environmental Control Engineering deals with the environmental control in plant production by hydroponic culture and plant factory, and the preservation of fresh products and foods. The main recent research activities and research staff of three laboratories are summarized as follows.

Laboratory of Farm Machinery

- Development of harvest machine for strawberry.
- Automatic steering system of the herbicide spraying machine in the paddy field.
- Automatic remote control of steering for agricultural vehicles.
- Development of multipurpose hyblid vehicles.
- Detection of internal color of fruits and its sensing device for automation of harvesting.

Professor Takenaga, Hiroshi D. Agr.
Associate Professor Imou, Kenji D. Agr.

Laboratory of Food Process Engineering

- Nondestructive quality evaluation for peaches and apples.
- Temperature changes of fruits during transportation process after precooling.
- Changes in gas composition and concentration around the film-packaged fruits.
- Comparison of prototype machines for evaluating the internal cracking in the watermelons.
- Re-utilization and recycling system of syrofoam waste in the whole market.
- Effective utilization of barcode system through the distribution process of fresh products.
- Improvement of vaccum cooling unit and its effective utilization to fresh vegetables.
- Nondestructive temperature measurement of precooled fruits by thermography.
- Top-icing method of fresh products and preservation of freshness.

Professor Iba, Yoshiaki D. Agr.
Associate Professor Nakajima, Yoshihiro D. Agr.

Laboratory of Environmental Control Engineering

- High quality plant production system by hydroponic culture.
- Growth and internal quality control of plant by controlled light.
- Respiration characteristics and controlled atmosphere storage of fresh products.
- Design and management of effective distribution system and facilities of fresh products.
- Quality preservation of rice under the controlled atmosphere conditions.
- Night cooling system of greenhouse by spraying the underground water.
- Plant production and material recycling in the closed ecological life support system (CELSS)

Professor Shiga, Tohru D. Agr.
Associate Professor Saito, Takahiro D. Agr.

Graduate School

The Graduate School of Agriculture consists of 4 Master's departments; Bioproductive Science, Environmental Engineering, Agricultural Economics and Forest Science. These Master's Course has same educational and research fields as the undergraduate course, and almost the same academic calendars in 2 years. And the academic advisers also same in the undergraduate course. The students of Master's Course must complete two years of residence and more than 30 credits required for the Course. Master's degree is awarded after Master's dissertation approved and final examination.

The United Graduate School of Agricultural Science, managed in cooperation with Tokyo University of Agriculture and Technology, Ibaraki University and Utsunomiya University, Consists of 3 Doctor's Courses; Science of Plant and Animal Production, Biochemistry and Biotechnology and Science of Researces and Environment. The Purpose of this Doctor's Courses is to educate excellent researchers and engineers with highly specialized knowledge and abilities as well as wide and fundamental knowledge about agricultural science. The United Graduate School is three years Doctor's Course independent from the Master's Courses in respective Universities. So applicants for this Doctor's Courses is required to pass the entrance examination on written tests and oral test for judging their academic abilities. By the written tests, mainly the ability of foreign language is evaluated, and by the oral test, the content of the Master's theses of applicants and research plan expected in the Doctor's Courses are questioned.

International Exchange

Utsunomiya University has been promoting the international cooperative exchange in education and research activities by accepting foreign students and researchers, and carrying out the joint researches and information exchange. We have completely provided the programs and welcome the foreign students to our University. Applicants for the Graduate School are recommended to contact in advance to our Department of Environmental Engineering, given the adress and Fax below.

Fax: +81-28-649-5508
e-mail: shiga@cc.utsunomiya-u.ac.jp

The World Food Prize

The World Food Prize Foundation requests nominations for the 1997 World Food Prize, which recognizes outstanding individual achievement in improving the quality, quantity, or availability of food in the world. The Prize emphasizes the importance of a nutritious and sustainable food supply for all people and recognizes that improving the world's food supply for the long term depends on nurturing the quality of land, water, forests, and other natural resources.

Nominees should be individuals who have worked successfully toward this goal in any field involved in the world food supply, including food and agricultural science and technology, manufacturing, marketing, nutrition, economics, political leadership, social sciences, and other related fields that have brought food to tables of a significant number of people across the world.

The laureate will receive $200 000 and a sculpture created by world-renowned designer Saul Bass. The award is based solely on individual achievement with no consideration of nationality, ethnicity, political persuasion, religion, sex, or age.

For a brochure detailing nomination procedures, contact: The World Food Prize Office of the Secretariat, David Acker, College of Agriculture, Iowa State University, Ames, IA 50011-1050; tel. (515) 294-8454; fax. (515) 294-9477; e-mail: bjelland@iastate.edu; or http://www.netins.net/showcase/wfp.

Main Products of Agricultural Machinery Manufacturers in Japan

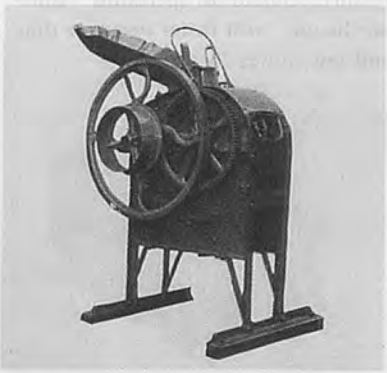
by
Shin-Norinsha Co., Ltd.
No. 7, 2-chome, Kanda Nishikicho
Chiyoda-ku, Tokyo 101, Japan

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.

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

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



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.

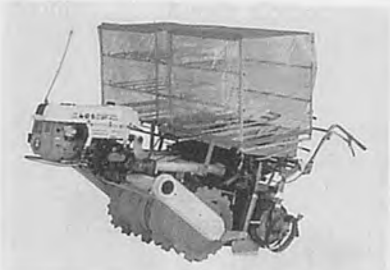
KUBOTA Combine Harvester SKY ROAD PRO 481-M. Easy-to operate, micro-computerized 4-line combine harvester that cuts down on time as well as crop. Equipped with many helpful mechanisms and a reliable water-cooled diesel engine. Max. output: 48PS/2700 rpm.

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.

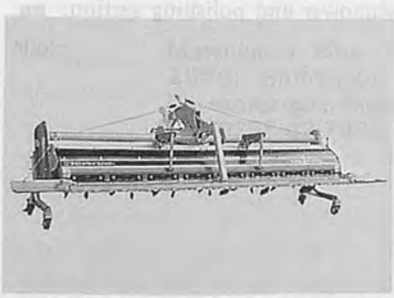
MAMETORA Vegetable Transplanter TP-4. This machine is available in both pot and soil block in seedling transplanting. Application: all vegetable nursery.

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

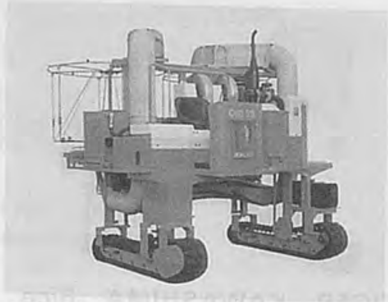
MARUYAMA Portable Power Sprayers MSO55D. Engine: Air-cooled, 2-cycle, output 22.6cc, Pump: Suction capacity 5.1ℓ/mm, max pressure 25kg/cm^2, Weight: 8.5kg.



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.

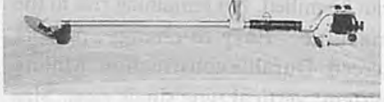


NIPLO Drive Harrow HR-2408B-3S for paddy field. Working width: 244 cm; Required tractor horsepower: 24 ~ 40 HP.



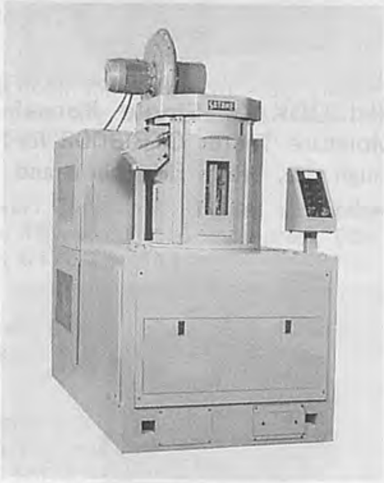
OCHIAI Riding Type Tea Picking Machine OM-25. Full working width cutter bar. Stepless speed control. Water-cooled Diesel engine 28.5PS.

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.

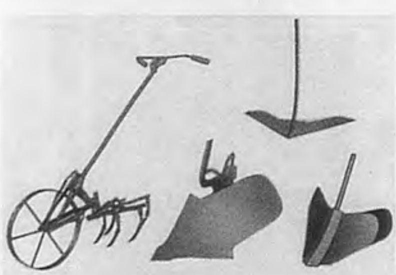


SATAKE New Rice Whiteness, Abrasive and Friction types, have high recovery, uniform & gentle milling, less installation space and high capacity. Model: VRM8A (Abrasive type) & VMA8A (Friction type) Capacity: 8 to 10 mt/h brown rice.

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.

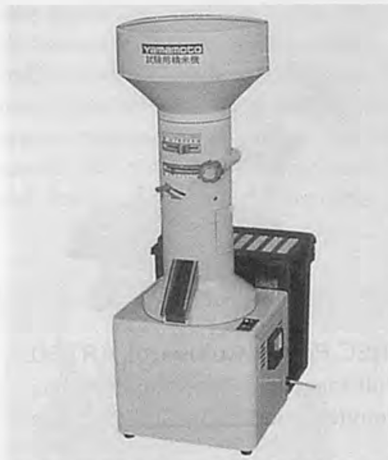
SHIZUOKA's Single Kernel Moisture Tester CTR-800E for rough rice, brown rice, wheat and barley.

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.



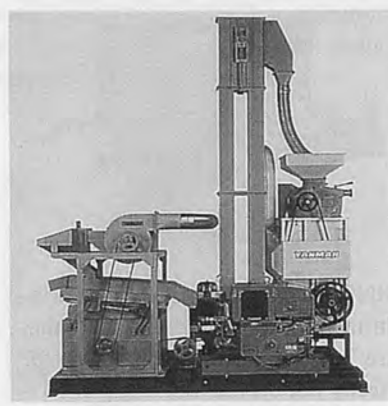
SUKIGARA Hand Cultivator. Here ia a new HAND CULTIVATOR to replace conventional hand agricultural implements! With this model, you can work more easily and efficiently from an upright position no longer will you have to bend over to guide your cultivator.

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



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. 06-648-2111
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. 03-3252-2271
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. 0268-42-7500
Ochiai	Ochiai-Shoji Co., Ltd.—58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-pref., 439. Tel. 0537-36-2161
Orec	Orec Co., Ltd.—548-22, Hirokawa-machi, Yame-gun, Fukuoka-pref., 834-01. Tel. 0943-32-5055
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. 03-3253-3111
Shizuoka	Shizuoka Seiki Co., Ltd.—4-1, Yamana-cho, Fukuroi-city, Shizuoka-pref., 437. Tel. 0538-42-3111
Star	Star Farm Machinery Mfg. Co., Ltd.—1061-2, Kamiosatsu, Chitose-city, Hokkaido, 066. Tel. 0123-26-1122
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
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 ■■

NEWS

ATNESA Workshop on Improving Donkey Utilization and Management

May 5-9, 1997
Debre Zeit, Ethiopia

ATNESA (Animal Traction Network for Eastern and Southern Africa) was formed in 1990 to improve information exchange and regional cooperation relating to animal draft power. The network aims to unite researchers, manufacturers, development workers, institutions and the users of animal traction in the region. Membership of the network is open to all individuals and organizations interested in its objectives. ATNESA is coordinated by a regional steering committee. ATNESA has arranged several important workshops on improving animal traction, meeting the challenges of animal traction technology, gender issues in animal traction, animal-drawn carts and weeding using animal power.

Workshop objectives

The objective of the workshop is to bring together national and regional specialists involved in research, development and extension relating to utilization of donkeys in order to:

- Review existing knowledge (indigenous and international) concerning donkeys.
- Exchange experiences relating to donkeys, including traditional and farmer-led systems and national and project initiatives.
- Review traditional and recent donkey technologies, management systems, socio-economic issues and environmental implications.
- Identify existing farm-level constraints and opportunities for improving the use and management of donkeys in the region.
- Identify opportunities for future programme initiatives and make plans for addressing needs at country and regional level.
- Critically review the research, development and extension messages relating to donkeys.
- Identify specific needs for training manuals, guidelines or other donkey resource publications. Initiate the preparation of these.

Workshop themes

The main workshop theme will be *Donkey management and utilization*. This theme will initially be reviewed from three main perspectives: the animals, the users and the technologies.

Further information contact: Donkey workshop secretariat (Dr ALEMU Gebre Wold). Institute of Agricultural Research (IAR). PO Box 2003, Addis Abeba, Ethiopia. Fax: +251-611222 (or c/o +251-1-611892), Computer E-mail: Dr ALEMUc/o cfgb@padis.gn.apc.org)

Agro Mart '97 — Fifth Annual International Exhibition

June 18-21, 1997
Ho Chi Minh City, Vietnam

Agro Mart '97 will take place from June 18-21, 1997 in Ho Chi Minh at the Ho Chi Minh International Exhibition and Convention Centre.

Agro Mart '97 will be the best exhibition for agriculture, animal breeding, fishery, food processing and packaging equipment.

Agro Mart '97 is a joint effort between B.O.I. from France and Royal Dutch Jaarbeurs of the Netherlands. B.O.I. has a six years experience in organizing exhibitions in Vietnam, particularly in the field of agriculture and food industry. Royal Dutch Jaarbeurs is one of the most experienced exhibition organizers in Europe. They have organized several exhibitions in related industries including VIV Europe, one of the worlds' largest exhibitions for hte animal protein market.

Contact: Royal Dutch Jaarbeurs, Press & Public Relations Department, tel.: +31 30 2955 504, fax: +31 30 2955 890 (Mr Ben de Jongh).

ASAE Annual Internaitonal Meeting

August 10-14, 1997
Minneapolis, Minnesota, USA

Presentation Topics

The technical sessions at the meeting are divided into the following topic areas:

100s = Power and Machinery
200s = Soil and Water
300s = Information and Electrical Technologies
400s = Structures and Environments
500s = Forest Engineering
600s = Food and Process Engineering
700s = Other areas (business development, safety, sustainable agriculture, education, etc.)

For quesitons or additional information: Contact ASAE Meetings Department at Voice (616) 429-0300, Fax: (616) 429-3852 or e-mail buntjer@asae.org.

AIFME '97 — Australian International Farm Machinery Exhibition

August 13-16, 1997
Brisbane, Queensland, Australia

The new Brisbane Convention and Exhibition Centre will be host to AIFME '97, Wednesday to Saturday, August 13th-16th, 1997. This exceptional exhibition centre, having opened in 1995, has already drawn record visitor attendance to its major exhibitions. Built on the old World Expo Site in the heart of Brisbane and a 45 minute drive to the famous 'Surfers Paradise' Gold Coast, this exhibition centre is ideally located to many visitor attractions.

The Australian International Farm Machinery Exhibition will be the first public exhibition for agricultural machinery to be held in this new venue and will run simultaneously with the long running Royal Brisbane Exhibition, known by the locals as the EKKA. The EKKA caters for livestock, breeders, produce and a large sector of the agricultural community (excluding agricultural machinery).

AIFME '97 will be launching, what we believe to be a first for the industry by providing an all new service to exhibitions to dispose of their products exhibited at this event. Running for two days Saturday 16th and Sunday 17th, 1997, AIFME '97 will stage a massive public auction sale of this equipment, on site at the exhibition. Apart from being an obvious retail attraction which will be heavily promoted, more importantly, it provides an opportunity for AIFME '97 to subsidise or negate floor space costs to exhibitors agreeing prior to the event on a fixed sale price for their goods.

5th International Symposium on Fruit, Nut, and Vegetable Production Engineering

September 3-10, 1997
Davis, California, USA

The Fifth International Symposium on Fruit, Nut, and Vegetable Production Engineering willl take place in the U.S.A. (California). Prior Symposiums were held in Israel (Bet Dagan) in 1983; France (Paris) in 1988; Denmark, Sweden, and Norway in 1991; and Spain (Valencia-Zaragoza) in 1993.

Objectives and Topics

The objective of the symposium is to bring together researchers involved in all aspects of engineering for the production of fruit, nut, and vegetable crops.

Abstracts will be accepted for oral or poster presentations in the following areas:

- Cultural systems
- Harvesting methods and systems
- Post harvest operations
- Human and environment factors

Structure of the symposium

Tuesday, September 2:
Arrival in Davis, California
Wednesday, Sept. 3 to Friday, Sept. 5:
Technical sessions, poster sessions, and short field trips
Saturday and Sunday, September 6-7:
Free days for leisure sightseeing
Monday, Sept. 8 to Wednesday, Sept. 10:
Post-Symposium technical tour

Fees

Registration fee: Approximately US$250 to $300 (including banquet) depending on the total number of participants.

Accompanying persons: US$100. Post-Symposium technical tour: About US$250. This fee includes transportation and lodging, but not meals.

Anuga

October 11-16, 1997
Cologne, Germany

Anuga offers unique synergy effects: it presents innovative food and beverage products as well as production techniques geared to them. The new concept, implemented for the first time at the '95 event, is directed at large-scale and system catering, communal catering and resourceful individual caterers. At the next **Anuga** from 11th to 16th October 1997, a top-class range will be presented with an even clearer and more transparent structure. The sector will concentrate on three main themes: innovative kitchen technology, vending and service providers as special problem solvers.

In total exhibition space of 260 000 m^2, **Anuga** offers a unique overview of the worldwide ranges for the food industry. The product sectors offer a spatial concentration in specific halls and, at the same time, guarantees a broad product diversity.

Contact: Messe- und Ausstellungs-Ges.m.b.H. Köln. Messeplatz 1, D-50679 Köln, Postfach 210760, D-50532 Köln. Tel: 02 21/8 21-0, Telex: 8 873 426 mua d, Fax: (02 21) 821-2574, Telegramm-Adresse: Intermess Köln.

Agro Machinery China '97

November 11-14, 1997
Beijing Agriculture Exhibition Centre, Beijing, P.R.China

Agro Machinery China 1997 is to be held from November 11-14, 1997. The Show is expected to be the biggest of its kind since the 12 states' Agricultural Machinery Show in Beijing in 1978.

Agro Machinery China 1997 will be the best possible forum for international Companies involved in the manufacture and supply of advanced agricultural machinery to display their products in this enormous market. The China Agricultural Machinery Circulation Association and China National Agricultural Machinery Corporation which operate under the control of the Ministry of Internal Trade and the Ministry of Building Industry are the only organizations that provide the link between suppliers and buyers of agricultural machinery. Their 18 000 outlets situated all over the country guarantee the success of Agro Machinery China 1997.

Exhibit Categories

- Tractors
- Earth Working Machinery
- Machinery for Tillage & Distributing Fertilizer
- Equipment for Culti-Crop Protection
- Harvesting Machinery
- Farm Working Products & Drying Machinery
- Equipment for Irrigation & Drainage
- Agricultural By-Product Processing Machinery
- Farm Transport & Materials
- Equipment for Animal Husbandry
- Seed Processing Technology & Equipment
- Grain Processing & Storage Equipment
- Forestry, Garden & Orchard Equipment
- Agricultural Machinery Implements & Attachments
- Accessories for Tractors & Internal Combustion Engines
- Other Machines & services

Contact: Agro Machinery China '97—Show Management Office. China National Agricultural Machinery Corp., 26 South Yuetan St. Beijing, China 100825

Fourth International Dairy Housing Conference

January 28-30, 1998
St. Louis, Missouri, USA

The 1998 Dairy Housing conference will immediately follow the National Mastitis Council (NMC) 37th Annual Meeting which will be held January 26-28, 1998 in St. Louis, Missouri at the Adam's Mark Hotel. The NMC and the Dairy Housing conference participants will be meeting together for the entire day on Wednesday, January 28 in a joint session.

Purpose

This conference will bring together engineers, dairy scientists, veterinarians, economists, researchers and practitioners from the public and private sectors with the common interest of planning, development and management of humane and economical facilities and systems for dairy animals and milk production.

The conference goals are to compile a body of knowledge on the "state-of-the-art" in dairy housing, equipment and facilities, and to provide for an exchange of information between professionals from around the world.

Sponsored by

ASAE — the Society for engineering in agricultural, food, and biological systems

For conference information contact: Robert E. Graves. The Pennsylvania State University, Agricultural & Biological Engineering Dept, 201 Agricultural Engineering Building, University Park, Pennsylvania 16802-1909, Voice: 814.865.7155, Fax: 814.863.1031, E-mail: reg2@psu.edu

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The FAO Agricultural Engineering Branch (AGSE)

Focus, Priorities and Strategy

Emphasis will be placed on agricultural engineering activities which support efforts to increase food production, food security and farm incomes, reduction of food losses, as well as activities which address environmental and social issues. At the same time, engineering investments which contribute to overall agricultural and economic development though increased operational efficiency, will form an important part of AGSE's approach. AGSE will therefore, address activities relating to sub-sector analyses and policy and strategy advice and generally addresses factors which cause distortions in the agricultural engineering sub-sector. Of particular significance in this respect will be analyses and advice on the restructuring of mechanization systems in countries with formally centrally planned economies. Additionally, emphasis will be placed on the need for governments to formulate a basic national agricultural engineering policy and strategy, which is an essential step in the development cycle, prior to the formulation of programmes and projects. The activities envisaged require a broad multi-disciplinary expertise, and in this instance, AGSE has the definite comparative advantage because of its access to FAO's enormous multi-disciplinary knowledge and expertise.

Activities have been initiated on the application technology for biochemical crop protection which address environmental and health concerns of *UNCED agenda 21*, these activities will be subsequently developed and expanded. Similarly, AGSE has also initiated activities concerning engineering aspects of Women in Development (WID). Depending on the future availability of qualified staff, WID activities will be continued and expanded.

A current and future major problem to be addressed is the shortage of seasonal rural labour, to increase productivity and reduce costs of production, by making available better selections and utilization of engineering inputs. Emphasis will continue to be placed on handtool and animal draught technology, which are main sources of farm power in low-income countries. The importance of this problem has been amplified in several countries by the tragic effects of aids on farm labour. Human resource development will continue to feature prominently in the sub-programme and this subject will also the facilitate the Organization in remaining a global focal point and leading institution for developing countries on issues relating to farm power, tools, machinery and equipment.

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Club of Bologna — Conclusions and Recommendations of the 7th Full Members Meeting

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The 7th Full Members Meeting has held in Bologna from 11 to 13 November 1996. The meeting reached the following conclusions and recommendations.

Subject 1: Cooperation between Industry and Research Institutions

This question was considered both from the standpoint of research institutions and from the point of view of industry, with contributions from the following keynote speakers: K. Th. Renius (D), B. Legg (UK), P. Celli (I), H. Cetrangolo (Arg.), T. Yotsumoto (Jap.) and D. Wilkens (D).

The papers dealt with the general issues of future needs and the advantages to be gained from better cooperation, but also went into specific examples of successfully-implemented collaborative projects.

These studies, undertaken in various countries - Argentina, Germany, Japan, Italy and the United Kingdom - confirm the effectiveness of cooperation between industry and research institutions. The ingredients for this success are various but they include:

- the creation of an innovation in a research institute, perceived by the industry to be a potential winner as a product;
- the need for a product to meet requirements of farmers and/or restrictions placed on agriculture by Government policies or interventions;
- a need felt by industry to improve their product coupled with the recognition that their own expertise needed to be supplemented.

It should be emphasized that University and Institute researchers welcome the opportunity of working cooperatively with industry in such researh.

Following extensive in-depth discussion, the participants agree taht this type of cooperation is, at present, insufficiently developed because industry tends to view contacts with the research sector as a time and money consuming activity. In addition, the pursuit of long-term ideas may be secondary to existing problems within companies and the actual production and marketing problems they are facing. This attitude is reflected in poor attendance by industry employees at scientific conferences. It has however to be noted that a similar lack of interest in cooperation can be found among some members of the scientific community also who prefer to pursue their own interests.

However, it is universally acknowledged that closer collaboration between the two sectors - whose activities are of reciprocal interest, given the diversity of experience, subject matter and timescale constraints - can be one of the keys to successful business. It can allow new products to be developed faster, more effectively and at a lower cost. Such advantages are all the more important in the current context of rapidly-changing globalized markets, where the trend is towards "total quality" methods, with a consequent strong demand for radical innovations in products and agricultural systems.

The participants are unanimous in confirming that, in any case, a modern and effective form of cooperation must necessarily begin with the joint "generation" of new ideas before moving on to the delineation of concepts and, finally, to the development of a product and the evaluation of its viability in the agricultural context. This approach offers many interesting opportunities, especially to small and medium-sized companies, and should also prove to be of interest to the technical training sector at various levels.

From the research standpoint, the hatching of new ideas in preliminary brainstorming sessions with experts from both sides is an opportunity to compare notes and evaluate within the various agricultural systems radical innovations-machines, components and systems-that may become industrially viable in the medium term. On the industrial development side, the short-term benefits of collaboration should essentially be sought within the domain of solving practical technical probelms, including the analysis of how to most effectively employ machinery in an agricultural context. A parallel consideration is the problem of technical training, to which research institutions can make a fundamental contribution, also in terms of promoting dissemination of information relating to innovative machinery.

The participants are therefore unanimous in recommending that every possible effort be made to develop effective forms of collaboration between industry and public research bodies. This involves laying the institutional framework for cooperative ventures applicable at product (electronics, safety systems, new materials, etc.) and process level, to define mechanization systems suitable for implementing new cropping methods geared towards improved quality and reduced environmental impact and for promoting and assisting transfer of technologies.

Due recognition is given to the fact that cooperative efforts involving several companies are not always successful because it is difficult to establish who or which of the participating enterprises owns (and can therefore market) the resulting innovations. This becomes more complex when patents are involved. Nevertheless, the participants believe that the following initiatives would lead to improved understanding and collaboration between industry and research organizations.

Training

- Universtities should require students to spend time in industry.
- Universities should offer continuing technical education opportunities for industry staff.

Communication

- Professional societies should adapt their activities to be of greater value to industry.
- Industry should consider organizing technical exchange meetings at which they choose the agenda.
- More brainstorming sessions should be organized between individual research organizations and industries (including small companies).

Partnerships

- Partnerships with several complementary industries as well as with several complementary research organizations should be encouraged. They have to be as permanent as possible.
- Industry/research collaboration must be professionally structured and managed.

Specific actions for research organizations

- Research organizations must continue to generate new ideas. This can be guided by technology foresight.
- Working with industry must be valued and rewarded and taken into account in decisions on promotion and tenure.
- Research organization must understand and respect industries' priorities and time pressures.
- Staff with industrial experience must be employed; or experience gained through industry/research exchanges (both ways).
- Research organizations should have a panel of advisers from industry and end-users to check whether their research is relevant to industry and users.

Specific actions for industry

- Industry must participate in national and regional discussions of research priorities.
- Many companies have special problems that can best be overcome through collaboration with complementary companies.

Subject 2: Mechanization requirements for Low-Input Sustainable Agriculture (LISA)

This topic was first dealt with in 1991, at the 3d Full Member's Meeting, with introductory talks by *R. Hegg* and *J. Matthews*. The Club decided to return to this issue, with a keynote paper by **A.A. Jongebreur**. The goal was to review the progress made during the past 5 years, and to determine the extent which machinery meets the criteria for LISA, defined as an activity that is ecologically sound, economically viable, socially justified and humane.

Following extensive in-depth discussion, the participants agree that the attainment of LISA depends primarily on reducing soil erosion, agrochemical and nutrient consumption, and on rationalizing energy usage.

In this connection, they acknowledge the progress made by certain countries, and the promising potential of new electronically-controlled machines and the use of special models, which can reduce chemical application by up to 50% by optimizing the boom position and taking air velocity into account.

The participants consider it essential that these innovations be developed and marketed, in order to achieve those general advantages that will help to promote LISA. The emphasis should change from "low input" to "sustainable". The Club recognizes that "low input" is a relative term that will have different values in developed and developing countries. For example, FAO 1995 reports that 70 countries of the world would be unable to feed their populations by the year 2000 unless they adopt more intensive farming systems. Efficient use of inputs taking into account the environmental impact, should be the goal, not necessarily "low" inputs. The Club also recognizes that soil, water and air resources are most crucial to the long term sustainability of agriculture. Soil is probably the most critical of these resources because of the long time frame required for recovery. Mechanization and irrigation practices must be designed to minimize soil erosion, salinity and other soil degradation problems.

Organic farming practices may be useful as a research tool, to indicate ways in which conventional agriculture can be changed to decrease dependence on agricultural chemicals.

The Club recommends that every possible effort be made by agricultural policy-makers and equipment manufacturers to create favourable conditions for farmers to implement sustainable agricultural practices on the entire cultivated territory. This will involve:

- the development of improved

methods for evaluation of the environmental impact of farming activities;

- measurement of progress in a holistic manner applying engineering and economic criteria i.e. the cost/benefit of sustainable practices with due consideration for the environmental impact;
- site specific (spatially selective, precision agriculture, etc.) practices and technologies designed to improve the efficiency of use of fertilizers and pesticide inputs and thus to reduce the potential for environmental degradation;
- decision support systems that may employ advanced satellite communications to achieve optimal yields with minimum environmental impact;
- continued efforts to use energy efficiently in agriculture as a key element of sustainable agriculture and use of renewable forms of energy such as biomass energy where appropriate;
- high priority for health and safety concerns of farmers and the public;
- an additional innovative push, geared towards developing tractors and implements that incorporate the latest advanced in engineering technology;
- a comprehensive information and training campaign, to instruct farmers on the necessary actions for achieving the basic objectives; and
- the wholesale participation of research institutions, collaborating with industry to identify innovations, and to promote the rational application of new processes and techniques.

Report from IAMFE/FRANCE '96

Conference and Exhibition

The 10th International Conference and Exhibition on Mechanization of Field Experiments, IAMFE/FRANCE '96, was organized by Institut National de la Recherche Agronomique (INRA) in cooperation with Association Française pour la Mécanisation en Expérimentation agricole (AFMEX, The French branch of IAMFE) and IAMFE. It took place at the INRA research center Versailles, Paris on July 8-12, 1996.

The **conference**, with the main theme Agricultural experimentation and methodological constraints relative to equipment, attracted 230 participants from 35 countries. The discussions dealt with how one can assure a high level of accuracy in the field research in industrialized as well as in developing countries. There are many limitations in the technology and methods used and IAMFE's work in developing countries is very important in order to spread information about simple but reliable methods and equipment for field research as well as for arranging conferences, exhibitions and training courses in these countries.

Topics discussed at the conference were, among others: Strategies for mechanization of field experiments; Good experimental practice in field trials; Metrology and the evaluation of measured data; Methods and equipment for soil tillage, seedbed preparation, fertilizing, spraying, planting and harvesting; Experimentation in fruit and vegetable production; Laboratory equipment and seed processing equipment, Agricultural pollution, Safety risks etc.

At the exhibition and field demonstrations, 43 companies displayed and demonstrated a wide range of machines and instruments for agricultural research. The exhibition had about 400 visitors (besides the conference participants). AFMEX has printed a list of the exhibitors. It is in the French language.

The Proceedings of IAMFE/FRANCE '96 consists of 435 pages with 61 papers of authors from 19 countries. It is distributed to all IAMFE members. It can also be ordered from the International IAMFE Centre. The price per copy is US$ 45, for extra copies to IAMFE members - US$ 25.

Final discussions and conclusions

This session was held on July, 12, 1996 - the last day of our Tenth International Conference and Exhibition on Mechanization of Field Experiments, IAMFE/FRANCE '96.

About 60 persons took part in these discussions. They were first divided into three groups and the topics to discuss were: 1) What expectations did you have of IAMFE?, 2) What did you get out of IAMFE/FRANCE '96?, 3) What was the balance - suggestions for improvements?

General conclusions:

- Conference papers must be concentrated on field experimentation. This is the job of the Scientific Committee appointed for each conference.
- The conferences must have strong themes and rejected papers should be presented as posters instead
- Better (simpler) solutions is often needed for local engineers as well as training
- IAMFE should have a strong, well informed and active board (or executive committee)
- IAMFE needs more members from new countries, especially from the developing countries
- IAMFE's work for improving field experimentation in developing countries should be strengthened and some conferences (mainly regional ones) must soon take place in these countries (like India) ■■

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B A Snobar


C J Chung


C C Lee


I Haffar


M Z Bardaie


M P Pariyar


E S Eldin


A D Chaudhry


A Q Mughal


R ur Rehman


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BACK ISSUES

(Vol. 27 No. 1, Winter 1996 ~)

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 28, No. 1, Winter, 1997)

NEW TECHNOLOGY IN GRAIN POSTHARVESTING

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

This book contains the last lecture of professor Ritsuya Yamashita at his retirement by the age limit, which were summarized from his enormous researches for a long time, and supplementarily recent new technologies of postharvesting. Therefore, topics in this book are extended to all techniques of postharvest processing and a lot of new findings and techniques are described from fundamental studies for their actual applications.

Details are explained especially on property of rice, low cost drying system of rice from the taste point of view, husking, whitening and polishing techniques and dynamic storage. This book is consisted of 9 chapters and 4 appendixes: Chapter 1 Introduction, Chapter 2 Harvesting, Chapter 3 Drying, Chapter 4 Husking, Chapter 5 Whitening and polishing, Chapter 6 Separation and rice mixing, Chapter 7 Storage, Chapter 8 Quality adjusting by moisture control, packing and distribution, Chapter 9 Conclusion (future technique), Appendix-1 Evaluation of rice taste by taste meter, Appendix-2 Numeric color expression by color difference meter, Appendix-3 Example of calculation of drying speed with temperature control and Appendix-4 Equations for respiratory type gas replacement method.

This book covers from processing just after harvesting through adjusting, packing and distribution to possible and necessary future techniques from quality, taste and low cost production of rice points of view.

The author is convinced that this book is surely useful as a guide for technicians, administrators and researchers concerning to the postharvest.

Price: Japanese ¥6,000 (US $65.00). including air mail postage.
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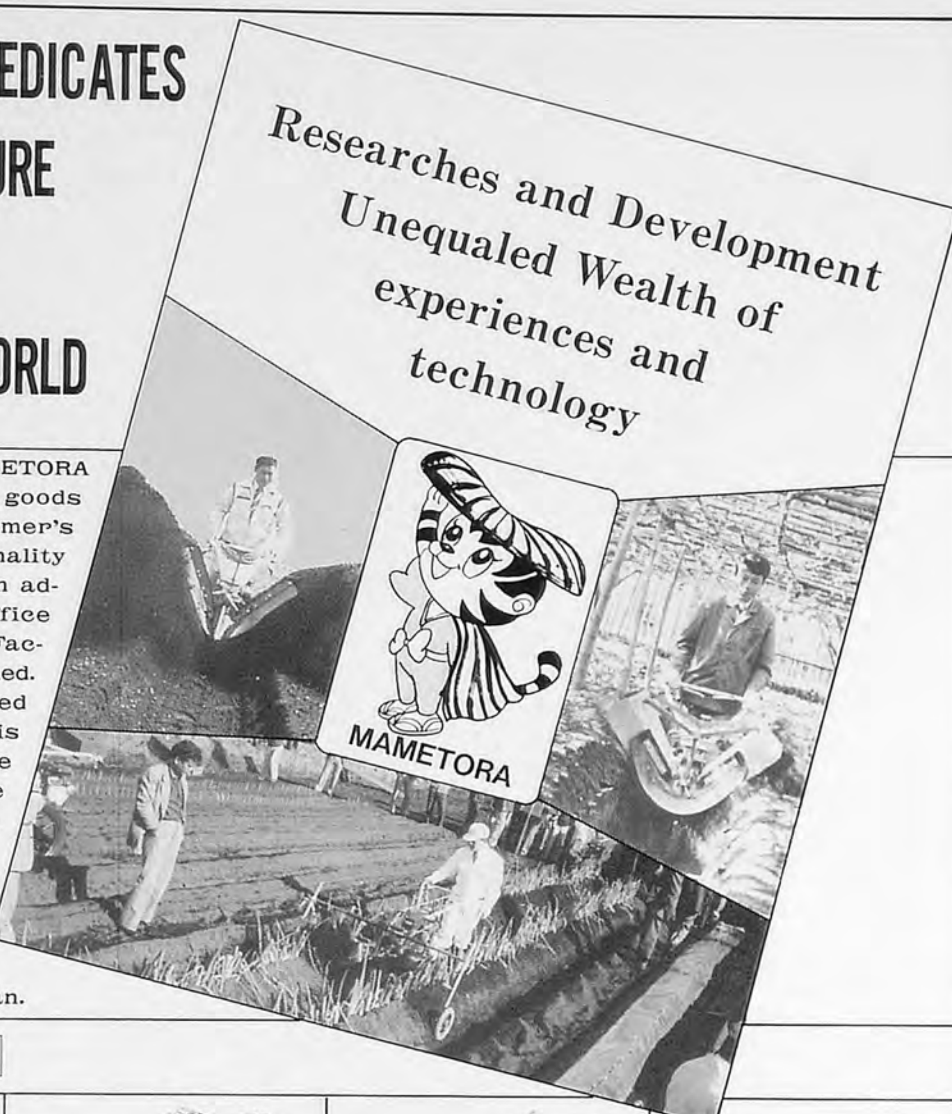

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