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VOL.28, NO.2, SPRING 1997

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

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EDITORIAL

Early February I had an opportunity to visit Russia. This country has been suffering considerable decline of Production not only in industries but also in agriculture after PERESTROIKA. 80% of food consumption in Moscow is now imported due to the shortage of domestic production. In large part dropping of agricultural production results from shortage of machine power. One tractor manufacturer in Russia, having produced 30 000 units annually before PERESTROIKA, produced only 3 000 units last year. The steep rise in prices of tractors and other farm machines and comparatively a little growth of agricultural income lowered purchasing power for farm machines.

When I visited one of sugarcane research institutes in Puna, India last December, they told that the harvest of sugarcane had been delayed more than one month due to lack of hands, resulted in quality deterioration. Mechanization of harvesting work is urgent necessity for them.

I also had an opportunity to see farms in Brazil in March. It was surprising that large part of farm work was being done by hands in such vast farm lands. The harvesting work for coffee, sugarcane, cotton and oranges has hardly been mechanized yet. This may partly be because of low personnel expenses, but it can be said to be behind in mechanization.

In global view point, our large concern is whether food production will be able to catch up with increasing population in the future. The above mentioned circumstances in three nation teach us that mechanization is a key item in increasing food production. The most difficulty in promoting farm mechanization in developing countries is how to promote it where farmers' purchasing power is very weak. The development status is different in areas. Without finding the technology suitable for each situation and spreading its production, it will not be possible to solve the world food problem.

In 21 century, it will be more expected for agriculture to raise land productivity with increasing population and limited farm land. I hope all experts promoting mechanization in developing countries will do their share in achieving the objectives.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
April, 1997

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Electro-osmosis Irrigation

by
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Abstract

Electro-osmosis can be defined as transmission of moisture in soil, because of the difference in electric potential in a porous soil environment, where the direction of transmission is from anode to catode. In the present study, this phenomenon has been utilized to raise water in soil for providing sufficient moisture in a depth, where the plant roots develop.

For this purpose, a laboratory model was made, using plexi-glass cylinders, simulating ground water table, and istalling positive electrode in a plastic pipe at the bottom and negative electrode made of steel mesh, at the top of the cylinder. The cylinder was filled with soil sample. Then, using a direct current, transmission of moisture and salt throughout the soil was investigated.

In the next steps, the effects of different voltages (20V, 40V, 60V, and 80V) as well as soil textures, on the rate of moisture and salt transmission were investigated. The results of this study confirm the successful utilization of electrical energy for transmission of soil moisture and salts. This phenomena can be utilized for improvement of the soil chemical quality, and removing the additional salts from the soil. The voltage effect in the above phenomenon has been considered positive and the electro-osmosis phenomenon appears to be more successful in soils of fine texture.

Acknowledgements: This study was made possible through a grant from the Iranian Agricultural Engineering Research Institute. The authors wish to express their appreciation for the support and close cooperation extended for the study.

Introduction

The better and optimized use of water resources for agriculture raising of irrigation efficiencies, and modification of irrigation methods, involves more investigations on the subject, specially evolving new techniques and their application for this purpose. The present paper contains the results of a research program on the subject of electro-osmosis irrigation, which could be a potential method of irrigation in the near future.

Electro-osmosis has been used for drainage and dewatering, as well as stabilizing of soft fine-grained soils, during the last decades [1]. But the true nature of the phenomena has not been well defined and the results are not applicable for all cases.

The authors have tried to remove water in the soil porous media using electro-osmosis phenomenon, and supply enough moisture content in the root developing zone so that the plant can use this moisture for growth, without any surface irrigation. The main objectives of the research were to prove the feasibility of the idea and to investigate the effects of different factors such as soil texture, salt content and the amount of electrical energy on the phenomenon.

Principles of Electro-osmosis

When a direct current is conducted through a soil media, water molecules move in the direction of voltage gradient as shown on **Fig. 1** [4].

By application of direct current, the dipole water molecules are being attracted by cations and move toward the cathode. In the cathode, the water molecules are released and collected there, raising water content of the soil at that zone. This phenomenon is known as electro-osmosis [2].

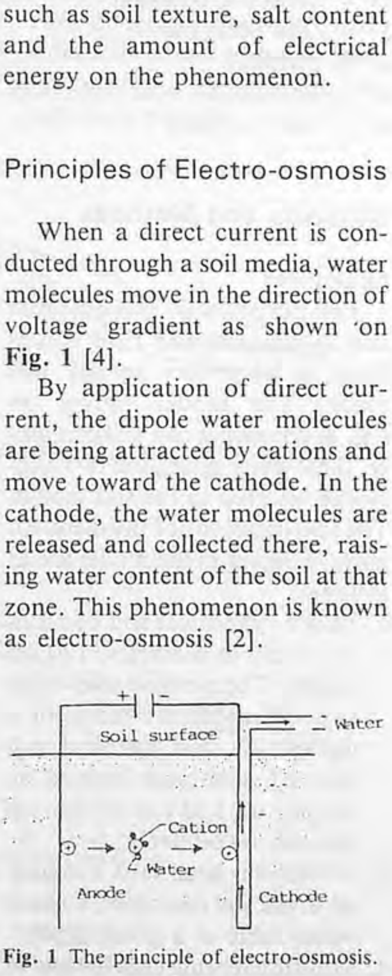

Fig. 1 The principle of electro-osmosis.

The flow of water in the direction of the voltage current is accomplished according to the following equation:

$$V_e = K_e \frac{\partial E}{\partial X}$$

Where:

V_e = Velocity of water molecules (Cm/sec)

K_e = Electro-osmosis permeability (Cm^2/sec.V.)

$\frac{\partial E}{\partial X}$ = Electrical potential gradient (V/cm)

The electro-osmosis permeability, K_e, is not a constant for the soil, and is given by the following relationship [4]:

$$K_e = \frac{n.D\xi}{4\pi\mu}$$

Where:

D = Dielectric constant

ξ = Zeta potential

μ = Viscosity

L = Distance between electrodes

n = Soils porosity

Materials and Methods

Equipment

For purposes of this research and to simulate the field condition, a laboratory model was made. The model shown on **Fig. 2**, consisting of a soil container, fixed water table, and two electrodes inserted in the soil media. The specifications of the different parts included in the model are as follows:

a. Lucite cylindrical soil container, 30 cm in diameter, 120 cm height. The positive and negative electrodes are made of a galvanized steel bar and galvanized steel mesh located on the botton and top of the soil sample, respectively;

b. A constant head tank connected to the soil container, to keep water table at a given depth;

c. Moisture sensing cells located at 10 cm. intervals along the soil profile; and

d. A D.C. source to supply the current needed for the experiments.

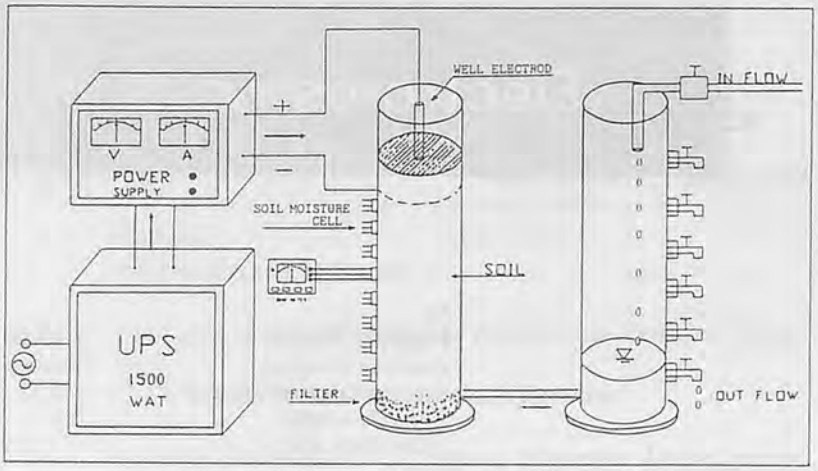

Fig. 2 Schematic model of electro-osmosis test.

Preparation of Soil Sample

The soil sample used for the experiments was obtained from the farm of the Agricultural College, Karaj. The soil was passed through sieve No. 10 and kept at above wilting point moisture content (12%). The lucite cylindrical soil containers were filled by the prepared soil under compaction equivalent to its natural condition. During the filling process, moisture sensing cells were placed at 10 cm. intervals along the soil column. Each cell was tested to obtain calibration curve, before being placed in the cylinder. The physical and chemical properties of the soil were as follows:

Apparent specific gravity	1.44 g/cm^3
Wilting point	9.4%
Field capacity	22%
Texture	Loam
Na^+	3.4 m.eq.v.g/lit
Ca^{++}	16.4 m.eq.v.g/lit
Mg^{++}	6/8 m.eq.v.g/lit
EC	2.1 m.mhos/cm
pH	7.9

Testing Procedure

After preparation of the soil sample, a constant water table was supplied at the bottom of the soil Column, and then the direct current was applied. The moisture content of the soil column was measured by reading the electrical resistance of each moisture sensor at 3-hour intervals, and continued for 5 to 14 days, to reach to a constant value. At the end of each experiment, samples were taken from the adjacent soil of each moisture cell, for chemical analysis, and tested for determination of Na^+, Ca^{++}, Mg^{++} cations, as well as EC and pH.

To consider the effect of capillary rise, a soil Column was prepared as check sample and tested for different treatments without using electrical energy to raise the water in the soil.

The factors being investigated during the experiments were soil texture, as well as different electrical voltages ranging from 20 to 80 volts.

Results

Comparison of Moisture Content for the Check and Test Soil Sample

As mentioned earlier one of the soil columns was taken as the check sample with applying no

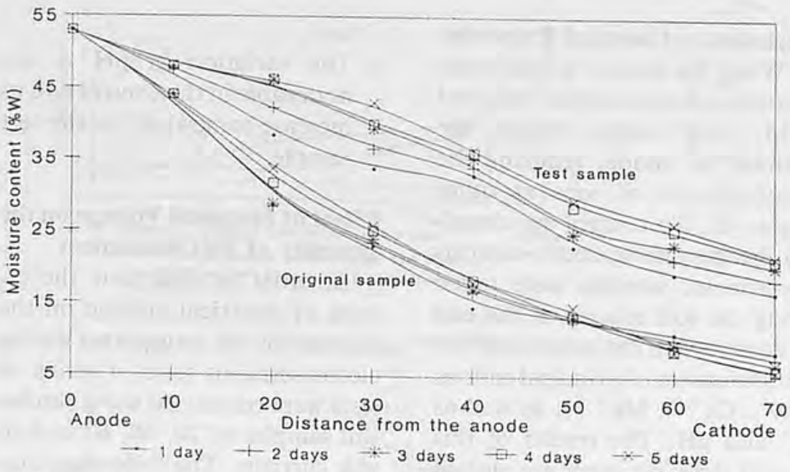

Fig. 3 Variation of moisture content vs time at different depths for test and original samples.

electrical current, and assumed that the moisture content rise was completely due to capillary effect. For the other soil columns, electrical current was applied and readings of moisture cells were taken at 3-hour intervals.

Figure 3 indicates the variation of moisture content along the soil columns after 1 to 5 days. As can be seen from the figure, the two set curves for test and check samples are very well defined, and positive effect of electro-osmosis on moisture rise is obvious, specially at the top of the soil column. The figure shows a 15-20% higher moisture content for soil sample under electro-osmosis effect. This figure proves the positive effect of electro-osmosis on moisture rise.

Effect of Voltage on Electro-osmosis

In the next stage of the experiments the effect of different electrical voltages on the moisture rise was investigated, keeping all other factors constant. The effect of electrical voltages ranging from 20 to 80 volts on the moisture rise at different time intervals is shown in **Fig. 4**. This figure proves the very well defined effect of voltage on the moisture rise.

By comparing the curves on **Fig. 4**, the following conclusions are made:

a. By increasing the electrical voltage, the volume of soil moisture at each point, increases;
b. For each voltage, the soil moisture increases, by time; and
c. The difference between the moisture content at anode and cathode is more pronounced at high time periods.

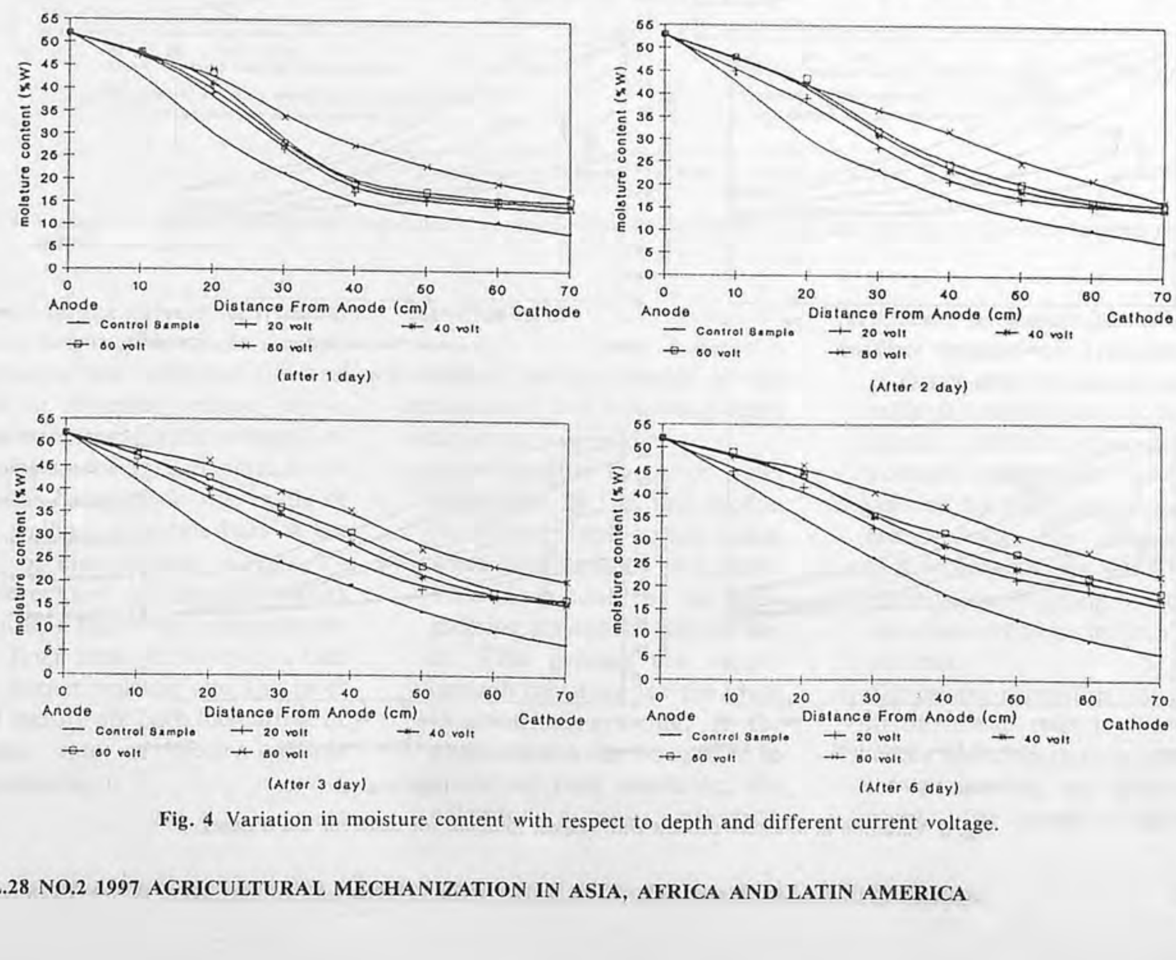

Fig. 4 Variation in moisture content with respect to depth and different current voltage.

Effect of Soil Texture on the Electro-osmosis Phenomenon

In order to determine the effects of soil texture on the speed and volume of moisture rise, five soil samples were prepared using the original soil mixed by 100, 70, 50, 30 and 10% by weight clean medium sand, 1 to 5 mm in diameter. These soil samples were numbered 1 to 5 and compared with the original soil with no sand numbered as 6 or control. All specimens were tested in the same way using a common 20 volts.

As the **Fig. 5** shows, soil texture has a very well defined effect on moisture rise. By comparing different curves on **Fig. 5**, the following conclusions can be made:

a. The soil texture has a pronounced effect on moisture rise by electro-osmosis; and
b. The finer the soil texture, the higher is the moisture rise, so that the control gave the highest moisture increase.

Variation in Chemical Properties

When the ions of a soil-water mixture are subjected to electrical field, they move toward the cathode or anode, reducing the concentration of ions at other places [6]. To control the chemical changes during electro-osmosis experiment, samples were taken along the soil column at the end of each test period, and tested for determination of principal cations (Na^+, Ca^{++}, Mg^{++}), as well as EC and pH. The results of this part of the experiment are plotted in **Fig. 6**. By comparing different curves in the figure, the following conclusions are made:

a. The nature of change in the amount of Na^+ after the electro-osmosis tests is similar for check and test samples, increasing from anode to cathode;
b. The variation in Ca^{++}, Mg^{++} and EC is in the opposite sides for the check and test soil samples — from anode to cathode; and
c. The variation in pH is not noticeable in the control and to increase somewhat for the test sample.

Effect of Electrical Voltage on the Quantity of Salt Movement

In order to determine the effects of electrical voltage on the quantity of salt transported during electro-osmosis tests, a series of tests were conducted using similar soil samples of 20, 40, 60 and 80 volt currents. The following conclusions are made about the curves in **Fig. 7**:

a. By increasing the current voltage, the speed of salt movement increased; and
b. The variation in cations, EC and pH is similar for different voltages.

Effect of Electrical Voltage on Anode Corrosion

One of the problems noticed during the experiment is the cor-

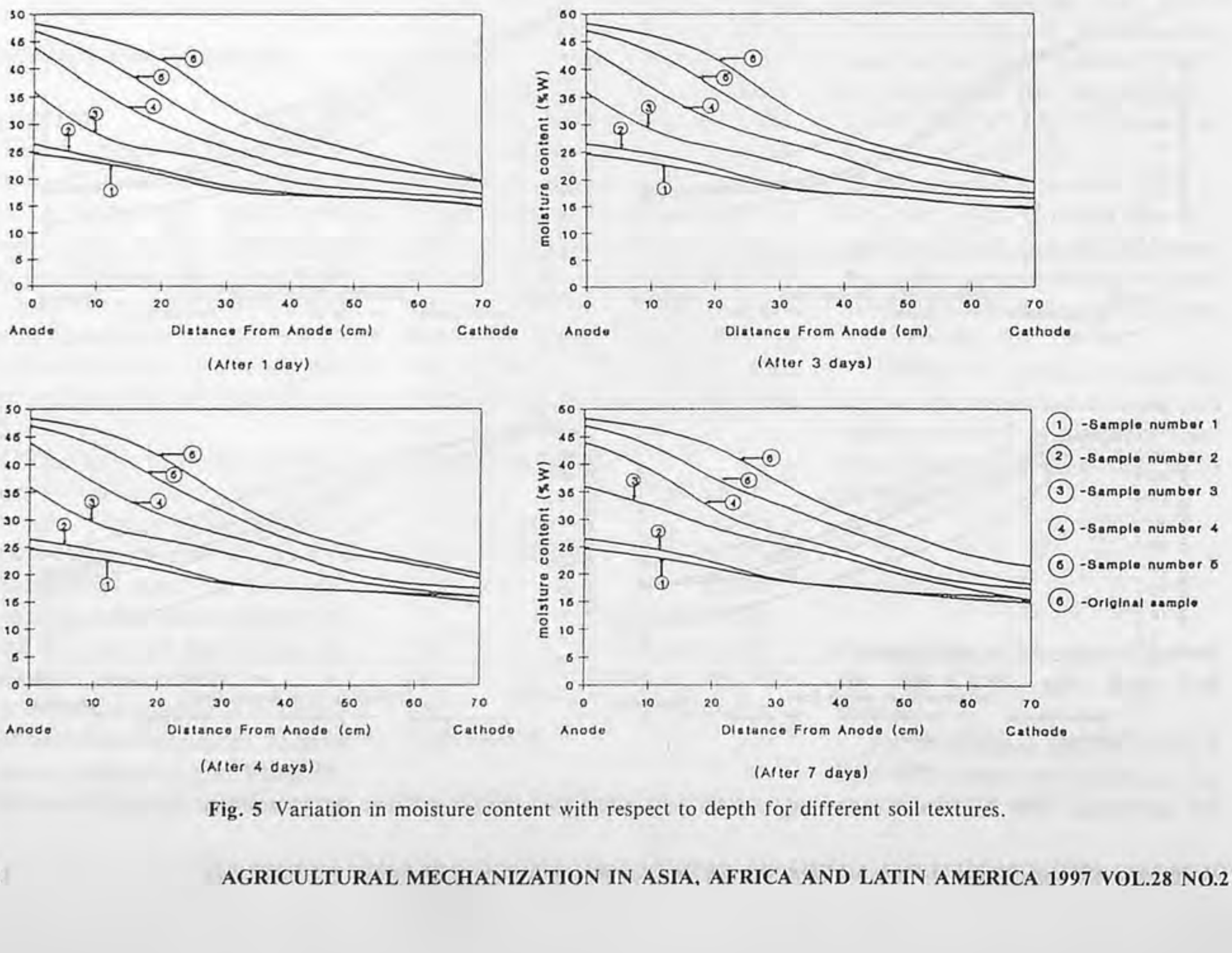

Fig. 5 Variation in moisture content with respect to depth for different soil textures.

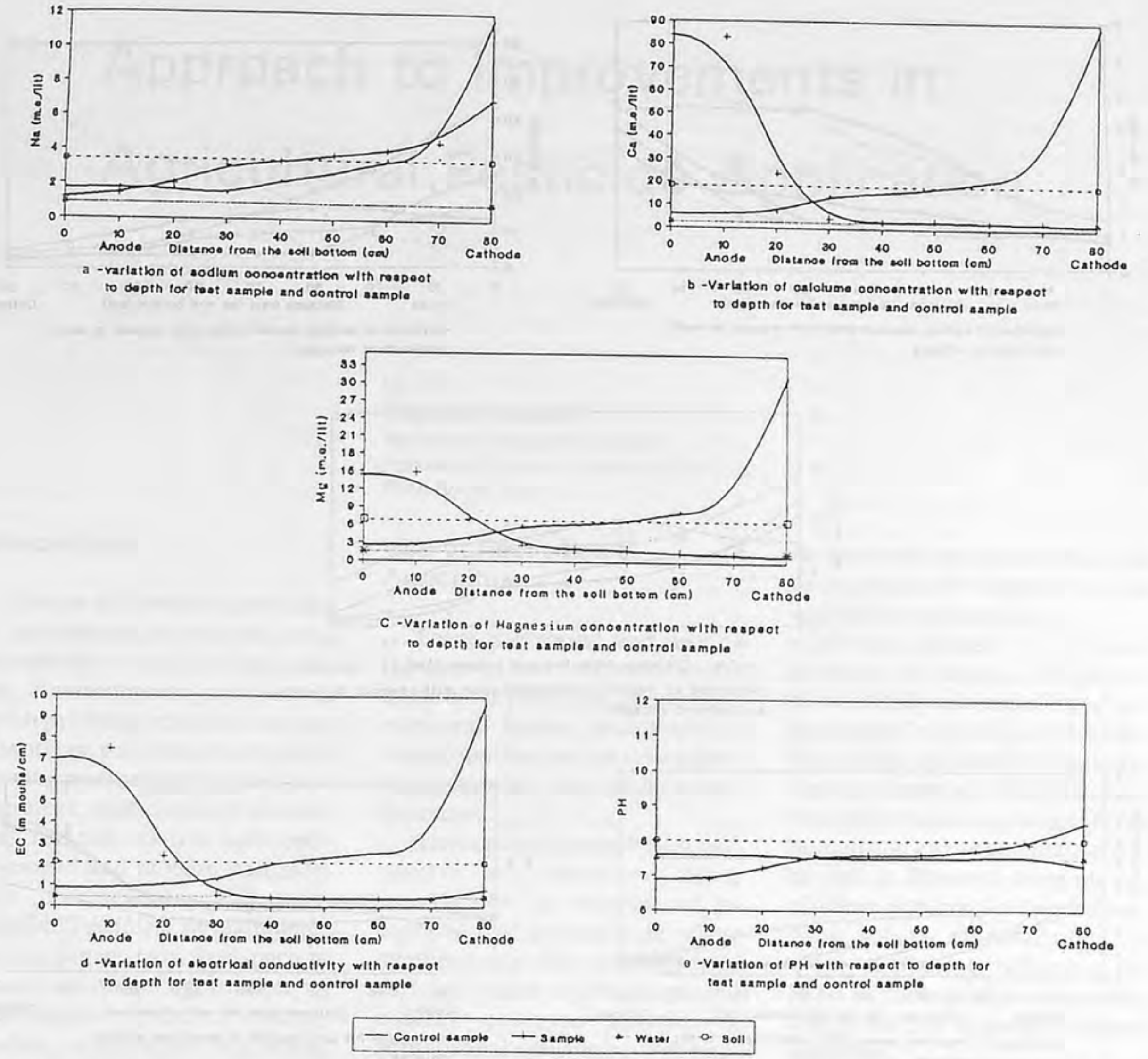

Fig. 6 Variation in sodium, calcium and magnesium concentration in electrical conductivity and pH value with respect to depth for test samples and control.

rosion on the galvanized steel bar which was used as anode. A comparison of the weights of the steel bars at different voltages shows that by increasing the voltage, the rate of corrosion also increases. A similar comparison was made of the weights of anode bars at the end of electro-osmosis tests for different soil textures. The results indicate a higher corrosion rate for the finer soils. It is obvious that the higher voltage and the finer soil texture are both indicatives of higher rate of electro-osmosis phenomenon.

Conclusions

Based on the results of the experiment, the following main conclusions are made:

a. It is possible to move water molecules in the soil media, from water table to any place, where the cathode is located. This place could be the root-growing zone at the top soil layer. This process can supply enough moisture for the plant to continue growing. If the phenomenon can be applied to an actual field condition, developing a new irrigation method is conceivable.

b. The volume of transported moisture from the anode (water table) to cathode (root zone), is directly related to the current voltage, soil texture and time period. By increasing the current voltage, the volume of moisture rise is increased. The electro-osmosis phenomenon is more successful in the finer soil textures.

c. The electro-osmosis is also able to move the salts in the soil media and change their chemical properties at different points. The results of the ex-

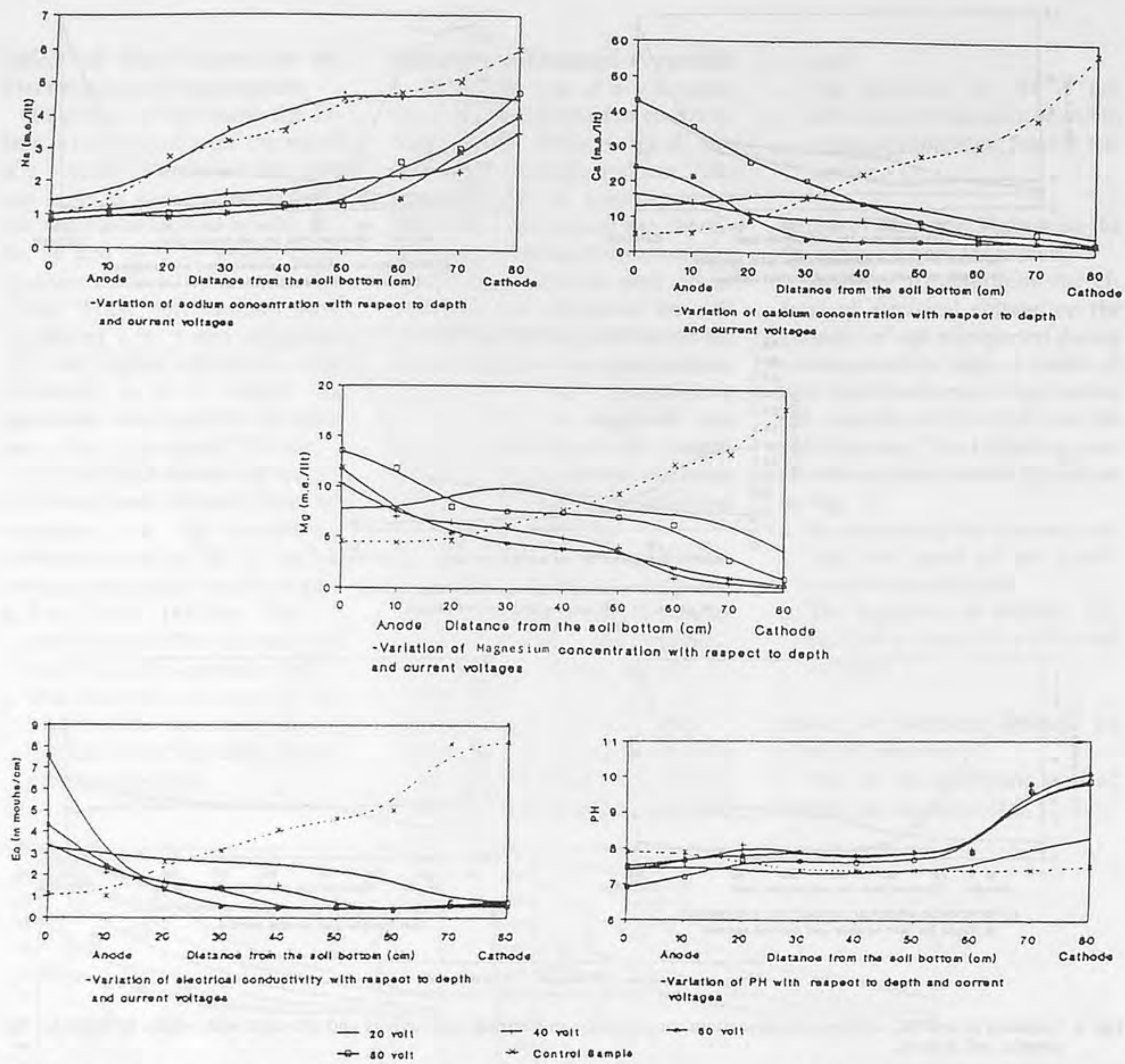

Fig. 7 Variation in sodium, calcium and magnesium concentration in electrical conductivity and pH value with respect to depth and current voltage for test samples and control.

periments show a different trend for movement of Na^{+} in comparison with Ca^{++} and Mg^{++}.

d. Considering the effects of electro-osmosis on the movement of different cations and anions in the soil media, implies that it is possible to change or modify some physical properties of soils (such as dispersitivity, swelling potential, compressibility,... etc.).

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■■

Approach to Improvements in Agricultural Pesticide Application

by
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Introduction

The use of synthetic pesticides in agriculture is still the most widespread method for pest control. Environmental and human health problems related to the use of synthetic pesticides, have stirred growing pressure against their use. Therefore, non-chemical alternatives for pest control have been developed and modern pesticides have become safer and more specific. Technical developments for equipment have kept pace to ensure adequate application of these modern products. However, modern application equipment and its professional use have not been transferred satisfactorily to field practice. In order to improve this situation, the Agricultural Engineering Service of FAO has initiated a programme to create awareness at government level to instigate adequate practical training programmes for farmers and equipment operators and to improve equipment quality through the introduction of standards and regular tests.

Use of Pesticides in Agriculture

There is growing fear around the known and unknown consequences of pesticides on environment and human health and in some countries there is strong public pressure to substantially reduce their use.

Alternative approaches to pest control are, therefore, being considered. The concept of integrated pest management where synthetic pesticides are only used as a last resort is nowadays considered common practice in professional agriculture. The non-chemical alternatives include cultural practices, the selection and development of pest-resistant varieties, the creation of an environment favourable to natural enemies of the pests, the use of biological products and agents, including beneficial insects. However, for the foreseeable future synthetic pesticides will maintain importance for pest control in agriculture worldwide.

Development of the Application Technology

The increased requirements under an IPM concept for efficient pesticide application safe for environment and humans have led to important developments in the application technology.

Design features — The characteristics of modern equipment allow a fairly safe and efficient application of pesticides of all kinds. The highest standards for application equipment are found in countries where legal requirements for human and environmental safety, as well as farmer's demands for efficient and precise application, have forced manufacturers to offer equipment reflecting the latest technological developments. This is the case in some European countries.

Monitoring and controls — The use of modern electronics has improved the accuracy of dosing and applications. Modern equipment usually features electronic flow meters, pressure gauges, speed sensors and computer unit that allow the keeping of operational parameters within a pre-set value thus providing a much higher application accuracy than with manual controls. Patch spraying with the use of Global Positioning Systems (GPS) or sensors detecting plants ahead of the spray nozzles can avoid off target spraying. For modern orchard-sprayers, a potential pesticide saving of 50% has been reported with this technology (Perry, 1995).

This paper reflects the personal views of the author and does not necessarily quote the official policy of FAO.

Atomizer technology — Modern spray nozzles are among the most important parts to ensure an environmentally safe and efficient application. As hydraulic nozzles are still the most commonly used atomizers of pesticide application equipment, their design features influence considerably the output characteristics, spray pattern and droplet size distribution and thus the creation of the appropriate type of spray, with a minimum of drift or off-target contamination. Latest developments include variable orifice and injector nozzles. Besides those, double flow nozzles and rotary atomizers receive new attention. All these developments aim at improving coverage and penetration with low volumes and reduced drift problems.

Technology for improved penetration and coverage — Insecticides and fungicides acting by direct contact need to be applied with the best possible coverage. This is best achieved with small droplets, allowing at the same time, cost-savings by reducing the application volume (Pompe et al., 1992). However, under field conditions, the application of small droplets is prone to increased drift. Air support systems, now available with boom sprayers, can reduce drift problems with small droplets increasing at the same time target coverage and penetration if set correctly (Jeffrey, 1994). Combining the air support systems with electrostatic charge of droplets could contribute to improved operator safety and a reduction of environmental pollution and application cost (Cooper, 1993).

Field Reality

Unfortunately, pesticide application practised at field level is far from reflecting the latest developments in many countries. Cases have been reported whereby simply changing the nozzles of lever operated knapsack sprayers, 70% of pesticides could be saved compared to the previous farmer's practice (Stallen and Lumkes, 1990).

The Agricultural Engineering Service of FAO has carried out studies in Central and Eastern Europe as well as in South America which showed deficiencies in the field of pesticide application technology at different levels.

Operator Knowledge

Knowledge by farmers and application equipment operators of the pesticide action principles and hence the correct way of application is usually lacking or nonexistent. Extension services normally do not have technicians with specialized knowledge in application technology. In many countries the only specialists giving some practical advice to farmers on application technology, handling and calibration of their equipment are representatives of pesticide companies. However, they normally are not interested in showing the farmer how to save large quantities of the chemicals.

There are several consequences of this lack of knowledge. A farmer, without technical criteria, will usually choose the cheapest equipment, possibly the most durable. Another common problem is the use of excessive spray volumes and pressures. Application volumes of 6 000 ℓ/ha in flowers and 10 000 ℓ/ha in orchards have been reported (Wiles, 1994) causing run-off of product and thus contaminating soil and probably groundwater resources.

Equipment Design

In a free market situation and if markets do not demand quality, manufacturers do not feel encouraged to offer equipment with any extras improving safety, comfort or efficiency let alone extras such as pressure regulators for knapsack sprayers, quality nozzles, boom suspensions, easy draining tanks etc.

In addition, often inferior materials are used. For example: tanks with rough surfaces, hoses or washers not being pesticide proof, crimped hose clips etc. In some countries, small workshops assemble spraying equipment from components without any idea of the basic principles of spraying. This sort of equipment competes on the market as it is sold at a very low price difficult to be matched by better equipment.

Service Conditions of Equipment

Usually, the greater part of the spraying equipment is in extremely poor service conditions due to lack of maintenance. As a result of this, most spray equipment leak. A study carried out in Indonesia reported 58% of manual spray equipment leaking (Hirschhorn, 1993).

Nozzles are also normally not replaced or even widened on purpose to achieve higher flow rates. The distribution patterns, under these conditions, are uneven leaving sections of the crop unsprayed mixed with others receiving overdoses. The introduction of a calibration service for aeroplanes resulted in a 15 to 20% net saving in pesticides and applications in the cotton area of Nicaragua (Friedrich, 1994).

Concepts for Improvements

Education and Training

The lack of knowledge at all levels has been identified as a major reason for faulty pesticide application practices. In the long-term, this problem needs to be addressed starting at university level.

But practical training of farmers and equipment operators also needs to be introduced. The use of government extension services for this end has proved to be efficient and sustainable only occasionally. A better approach seems to be the creation of a rather small group of paid trainers specifically for this subject. These trainers should ideally have a practical background having operated spray equipment themselves. they should be trained and kept up-to-date with refresher courses by master trainers. The established training capacity should cover the expected long-term needs. Training could begin strategically with contractors, offering service to farmers and then expand. The cost of the training could be paid by trainees, agro-chemical companies (preferably indirectly through taxes) by equipment manufacturers, and of course, by the government.

The introduction of a mandatory license for pesticide equipment operators could help increasing interest by farmers in this training. Although it would certainly be better to count on successful awareness campaigns and voluntary participation, experience in Europe has shown that at a certain stage it is necessary to introduce legal pressure to ensure the proper interest in the training (Devereux-Cooke, 1995).

Equipment Quality

While in some countries there might be a need for training of equipment manufacturers, in the majority of cases manufacturers are capable to offer good quality equipment, if demanded by the market. In these cases, incentives to improve quality on the market have to be introduced. In many developing countries, the indiscriminate demand is due to lack of knowledge. In such cases, the only solution is to limit market access, by introducing a certification system based on technical standards for application equipment.

A certification system can also be introduced on a voluntary basis by the manufacturers themselves using the certificate as a quality trade mark and sales promotion. Preconditions for any certification are that national standards be approved for application equipment available. Standards will have to be dynamic and reflect the technological development and scientific knowledge. On the other hand, the setting-up of a national "test centre" is not essential.

Equipment Testing

Apart from standards to be set up for new equipment, working conditions of application equipment in use give reason for concern. Therefore, structures have to be set up to ensure the correct operation of application equipment. The necessary checks and repairs can be carried out by the commercial sector, including agricultural equipment dealers and workshops, extension services but also government entities. Especially during an introductory phase, this approach should be preferred choice to convince parties involved of the benefits this activity presents for each of them. In any cases it should pay itself through fees.

Eventually, it might be necessary to introduce a mandatory check system. In Germany, mandatory checks were introduced in 1993, after some years' experience with voluntary checks used only by 20% of the farmers. As these checks found only 50% of the equipment in perfect conditions, the government decided to introduce mandatory checks (Wehmann, 1993). However, mandatory checks can only be introduced after the infrastructure to carry out these checks is in place.

FAO's Activities Regarding Pesticide Application

For many years now, the FAO has been undertaking promotion of rational use of pesticides. The most visible work in this respect is probably the introduction of the International Code of Conduct on the Distribution and Use of Pesticides in 1985 with the Prior Informed Consent in 1989 (FAO, 1990).

Already in 1985, a FAO panel of experts working group on pesticide application standards, highlighted the importance of equipment standards and appropriate training programmes (FAO, 1986).

The issue was more actively taken up by the FAO in 1994 with the introduction of a Programme for Safe and Efficient Application of Agro-chemicals and Bio-products. The main objective of the programme is to create awareness and basic structures in FAO member countries to introduce sustainable long-term improvements in the pesticide application practice at field level.

The programme is oriented by experiences by countries advanced in the matter of pesticide application technology. These experiences show that usually apart from awareness and knowledge, some legal pressure is required to introduce generalized good practice. The relationship between awareness and pressure, however, depends on the local realities of each country and has to be decided upon individually. The programme consists, therefore, of alternatives which can be selected and adapted according to the specific country and requirements.

The programme started with two first workshops in 1995, one for Central and Eastern Europe and one for the South Cone of Latin America.

An important activity within the programme is the formulation of FAO standards for the most common types of agricultural application equipment. These standards are limited to aspects of safety and efficiency and should be applicable world-wide.

The set of standards consists of two groups:

1. Guidelines for the Basic Requirements for Pesticide Application Equipment: Those guidelines reflect the absolute minimum requirements for application equipment, met by the majority of commercially manufactured equipment available world-wide.
2. FAO Standards for Pesticide Application Equipment: These are more comprehensive standards including test procedures that would lead to an "FAO-Approved Equipment" label. These standards will, after official adoption by FAO, be forwarded to FAO member countries attached to the Code of Conduct and as proposals for the introduction of harmonized national standards.

Conclusion

To effectively improve pesticide application practices, the introduction of standardized good quality equipment and operator-training seem to be a condition sine qua non.

Technology allowing a reasonably safe and efficient application of pesticides exists as well as concepts to introduce its use in practice. However, these concepts have to be adapted to specific situations. Their final introduction depends on the technical capacity, organization, cultural background and good will of people involved.

The role governments will have to play is tantamount to the role played by an orchestra conductor, with the orchestra being the private sector. The chellenge is not so much in the technical details but in the co-orientation of activities to guarantee that everyone is contributing at his best. As in a concert, the programme will be successful only if every player performs responsibly and in harmony with the others.

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Development of Azolla Combine Harvester

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Abstract

A walking type self-propelled azolla combine harvester powered by an 8.6 kW diesel engine of a two-wheel (steel lugged) tractor was developed and tested. The harvester consists of a V-shaped float to collect floating azolla fern which is pushed by a reel. The azolla mass is lifted by an inclined chain conveyor and delivered into an aluminum box with a slat type conveyor at the bottom to carry into the rear end of the machine. The flow of azolla at the rear is controlled by a shutter mechanism and it is distributed across the width by a set of distributing blades.

The field capacities of the machine are 853 kg/h and 396 kg/h, respectively, for stationary and mobile operations. The azolla mass is distributed by the machine at 8 Mg/ha rate with 19% coefficient of variation. Nitrogen gained from harvested azolla is 3.17 times cheaper than from urea. This machine is suitable for developing countries, where foreign exchange required to import chemical nitrogenous fertilizer can be reduced if azolla is produced and applied locally.

Introduction

Azolla is the most commonly cultivated green manure aquatic fern and can fix atmospheirc nitrogen through rhizobium bacteria. In general, azolla increases 100% in 5-7 days and at it's highest rate of propagation, needs 3 days. It can accumulate 2-4 kg or more nitrogen/ha/day and it's combination with rice growing can provide a potential nitrogen source (Khan, 1983). The cultivation of azolla is very much dependent upon phosphorus as superphosphate can significantly increase nitrogen fixation. The nitrogen fertilizer fixed by azolla becomes available to rice after the azolla mat is incorporated into the soil and its nitrogen begins to be released through decomposition. In 25 to 35 days azolla can easily fix enough nitrogen for a 3 to 8 Mg/ha crop under irrigation during dry season (Lumpkin and Plucknett, 1982). About 135 kg of nitrogen per hecare are needed to produce an optimum crop of rice (Talley and Rains, 1982).

Many efforts have been made to improve azolla use efficiencies in agricultural production. But very few efforts have been made to improve the efficiency of harvesting azolla. As azolla is an important aquatic fern for humans, livestock and fertilizer, it's production is being increased and in most cultivated areas, traditional method is still used. It is pushed into one corner by hand with bamboo pole and straw baskets are used to scoop the harvest. Hence, it was thought worthwhile to design, develop and test an azolla combine harvester suitalble for small farms. Successful small azolla harvester can increase rural income, may create interest in modern technology, increase labor productivity, decrease labor peak demands and production cost.

Design Consideration

The following points were kept in mind while designing the machine

1. The machine should match the power available form a two-wheel tractor commonly used by small farmers.
2. It may be easily attached to or detached from a two-wheel tractor to make the tractor available for other farm uses.
3. It should be within the buying capacity of farmers having small and medium-sized holdings.
4. It should be simple to operate and maintain even by farmers who do not have formal education.
5. It should be meant for farmers who cannot afford to buy costly chemical nitrogenous fertilizer.
6. It should be able to reduce the labor requirement and drudgery involved in traditional method of collecting azolla from ponds in baskets and then carry them either over the head or bullock cart in rural areas.
7. It should also be able to distrib-

ute azolla over the field surface soon after its collection from the pond so that azolla mass does not deteriorate. The azolla mass will be incorporated in the field by a power tiller.

Design Concept

Azolla would be collected from water-logged area (waste land or uncultivated land) by lifting a portion of fern mat out of the pond using a net-type conveyor harvester, which would subsequently load the inoculum into a trailer for transport and distribute to an agricultural field. A sketch of conceptual design of azolla harvester is shown in **Fig. 1**. The azolla harvester is capable of harvesting azolla efficiently over a wide range of densities of azolla mat, with high harvesting capacity and low power requirement. It is a compact walking type harvester travelling at 1 to 1.5 km/h while collecting azolla from 1.8 m width for non-clay soil. For muddy field, the harvester has to stand at the edge of the field by putting its mouth into the water to suck the azolla inoculum into the trailer. Its mouth is supported on two skids which have an aluminum sheet for gathering the azolla inoculum from the front to the back. The skids float on the mud horizontally and the operator can move them up while transporting and distributing azolla on other fields.

Description of the Machine

The azolla combine harvester (**Figs. 1** and **3**) consists of: 1. azolla harvester; 2. azolla distributor; 3. frame; 4. gauge wheels and 5. power transmission system.

1. *Azolla harvester* — The azolla harvester consists of a V-shaped sledge, a reel and a conveyor. The function of V-shaped aluminum sledge is to guide the floating mass of azolla from the pond surface towards the reel and simultaneously compressing it to increase its surface density. The purpose of the reel is to pull the azolla inoculum and water into the mouth of the conveyor. The speed of the reel is about 1.67 m/s. The bat is made of aluminum sheet and connected to spokes with the angle of 20 degrees towards the shaft.

The conveyor is made of a plastic net belt to separate the azolla and water by conveying only the azolla inoculum towards the distributors. The angle of elevation of conveyor is limited to 30 degrees.

2. *Azolla Distributor* — The azolla is broadcast as a continuous layer over the entire surface of the field and is later worked into the soil by soil working machines or it is spread on the surface as an extra nourishment at the roots of plants.

The azolla distributor (**Fig. 1**) consists of a collection box having moving conveyor slats on the front and distributing blades at the rear. The collection box (145 cm × 140 cm × 50 cm) is made of aluminum sheet. The conveyor slats are angled aluminum bars positioned cross-wise on the spreader floor. The ends of these slats are fixed to endless chain (**Fig. 1**). When the conveyor moves rearward, azolla lying on the floor is carried rearward and towards distributing blade. The distributing steel blades are fixed on a shaft, positioned cross-wise at rear and lower part of the collection box. With the help of a dog clutch, the distributing blades can be made to rotate with and stop independently of the conveyor slats. It rotates at approximately 142 rpm. The application rate of azolla can be easily varied by controlling the shutter, thereby varying the thickness of azolla layer. The blades are fixed at angle of 60° with respect to the axis of the shaft to shift and tear-off mass of azolla into pieces and to spread them on the field simultaneously.

3. *Frame* — The frame is divided into 2 parts. The first part supports conveyor and includes V-shaped frame. The second part supports collection box and driving mechanism. It is made of steel angle 38 mm × 38 mm and steel square pipe 38 mm × 38 mm × 1.6 mm.

4. *Gauge wheels* — The gauge wheels (178 mm × 356 mm) are positioned beneath and on both sides of the collection box. These are jointed to the frame of the collection box and support it. A connecting rod links the two gauge wheels to make them turn with the change in the direction of turning of two-wheel tractor.

5. *Power transmission system* — The power transmission system of the azolla combine harvester is made up of a number of units each of which has a separate and important part to play in transferring the power of the engine to mechanism, so that azolla harvester can move itself and be capable of doing work (**Fig. 2**). The main purpose of a V-belt in the transmission system of two wheel tractor is to reduce the speed of the engine crankshaft before the drive is applied to the gear box of the tractor.

The two wheel tractor (Kubota NC 131) was fitted with a dual clutch which not only provides the means of connecting the engine to the transmission of azolla harvester but also provides p.t.o. shaft to the conveyor. The original gear box of this tractor does not have the power take off shaft, therefore, a specially designed p.t.o. shaft has been made by forming splines along the shaft. A friction disc is splined onto the clutch shaft. A dog clutch is jointed to the distributor shaft so that distributor and the conveyor can

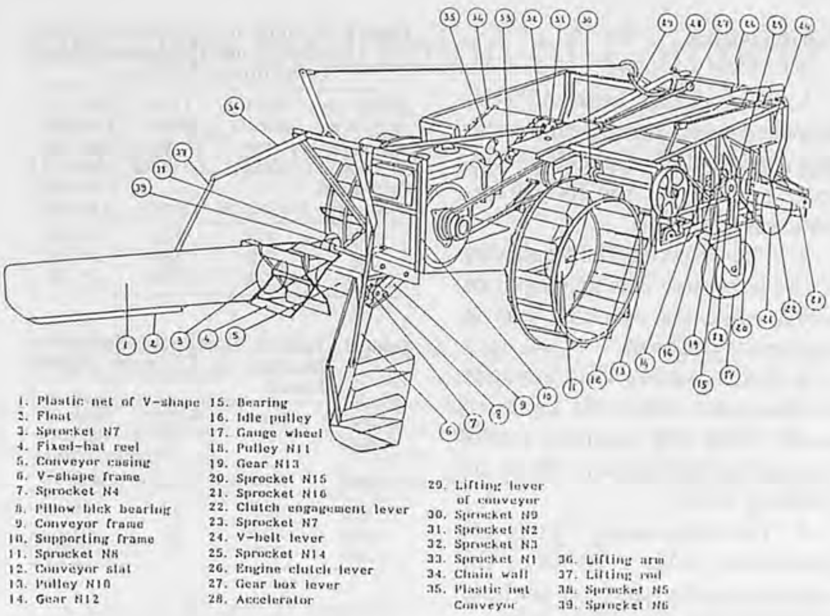

Fig. 1 Isometric view of azolla harvester.

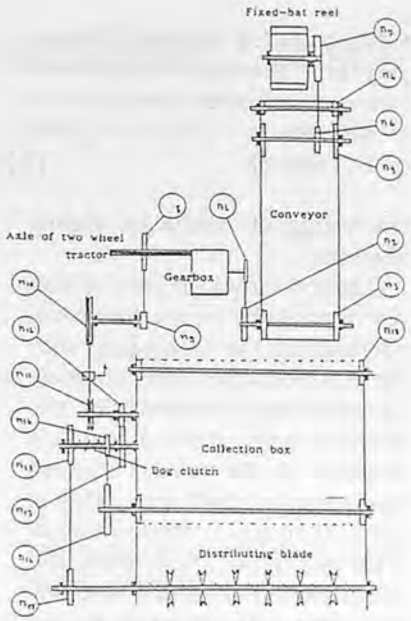

Fig. 2 Power transmission system.

work or stop together. The tractor is provided with a gear box to alter the speed ratios conveniently. There are four gears: the first, second, third and forth (reverse) gear. The gear ratios are 44:1, 23:1, 8:1 and 56:1, respectively. Lugged steel wheels are provided to improve traction and to increase available drawbar power.

There are of three types of chain drives in use on this machine: standard-pitch roller chain (12.7 mm) for ordinary drives, standard pitch roller chain (12.7 mm) with links for the conveyor and double-pitch roller chain (25.4 mm) for conveyor slat to adapt to low speed. Gears N12 and N13 (**Fig. 2**) give constant speed ratios. To make the design simple, these gears are not enclosed because they run at low speed.

Performance Tests

For testing the performance of the machine, a sloping platform was built on the bank of azolla pond. This was done with a view to dipping the front end (suck mouth) of the machine in the water of the pond. The rear end of the machine continued to rest on the firm ground. Two persons dragged the floating mass of the azolla towards the mouth of the machine with the help of a flexible plastic tube. The engine of the two wheeled tractor was started and the clutch was engaged to allow the turning of the reel and the conveyor (without engaging any gear). The mass of azolla from the mouth was sucked by the reel rotating at 80 rpm and thrown over the perforated screen of the chain conveyor. The azolla was thrown into the collection box when it reached the upper end of the conveyor. After collecting the azolla in the collection box, the machine was moved from the bank of the pond to the field, which was already ploughed, harrowed and levelled to receive the azolla. The dog clutch for the distributor was engaged and the conveyor slats below the azolla mass in the collection box was allowed to move to the rear end of the machine. When it reached the rear end, it was thrown by the blades of the distributor. The rate

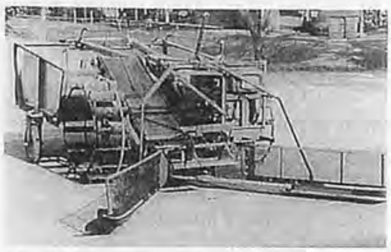

Fig. 3 Front view of azolla harvester.

of flow of azolla from the collection box to the distributor was controlled by a shutter.

Results and Discussion

Harvesting of Azolla by Stationary Machine

Table 1 shows that azolla mass is harvested approximately at about 900 kg/h. The rate of harvesting appears to be independent of surface density of azolla which varied from 2.8 to 3.4 kg/m^2. But it does depend on the distance of the floating azolla mat from the machine.

Table 2 shows that the rate of harvest of azolla is directly proportional to the speed of the engine. It increased from 590 kg/h at the engine speed of about

800 rpm to 853 kg/h at 1 200 engine rpm. The rate of fuel (diesel) consumption varied from 1.05 ℓ/h at 800 rpm to 1.29 ℓ/h at 1 200 rpm (**Table 3**).

Harvesting of Azolla by Mobile Machine

Table 4 shows the rate of harvest of azolla by the machine when operating in the azolla field with the depth of water approximately 12 cm. It may be noted that the forward speed of the machine is very slow (0.324 km/h) at the engine speed of 1600 rpm. This is due to slippage of traction wheels in the muddy soil. As a result, the rate of harvest of azolla is also low (351-396 kg/h). Thus the average rate of harvest by mobile harvester is approximately 46% of the harvest rate by the stationary machine. The operator has to walk in muddy water of azolla field which is full of drudgery. Another factor responsible for low harvest rate of azolla is the wave action created by the V-shaped mouth of the machine. As the azolla fern floats on the water, it gets displaced on the water surface due to wave action. **Table 5** shows diesel consumption of the mobile machine which varied from 1.91 to 2.16 ℓ/h.

Distribution of Azolla in the Field by Azolla Distributor

The opening of the shutter of the distributor was adjusted to 3 cm, 3 cm and 5 cm for replications 1, 2 and 3. A tarpaulin cloth was spread in field and spaces of size 20 cm × 20 cm were marked in the style of chess-board. The machine was allowed to drop the azolla mass through the shutter opening when the conveyor moved it from front to the rear end of the machine. The standard deviation of distributed mass from the mean value varied from 4.47 to 13.54 which is quite satisfactory.

Conclusions

1. A walking type of self-propelled azolla combine harvester was successfully designed, developed and tested for its performance in the field.
2. The effective field capacity of the harvester was 853 kg/h of azolla while the machine was in stationary position.
3. The effective field capacity of harvester was 394 kg/h of azolla while the machine moves through azolla field with 10-12 cm standing water.
4. The stationary mode of operations yields 2.16 times the weight of azolla harvester per hour as compared to mobile operation in the field at forward machine speed 0.324 km/h. This is due to for traction in muddy soil and wave action created due to passes of machine and its effect on floating azolla fern.
5. The effective distribution capacity of the azolla distributor was 6.6 Mg/h with coefficient of variation at 24.44% shutter opening of 3 cm and 8.65 Mg/ha with shutter opening of 5 cm (CV = 19%)
6. The cost of nitrogen from azolla using the stationary mode of harvest was 3.17 times cheaper than the cost of nitrogen from urea.

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Table 1. Pushing the Azolla by Flexible Plastic Tube Towards the Mouth of Stationary Machine

Initial surface area of azolla to be harvested (sq.m)	Surface density of azolla (kg/sq.m)	Time spent in pushing (sec)	Rate of Pushing azolla mass manually (kg/min)
25	3.2	312	15.38
25	2.8	288	14.58
25	3.4	324	15.74

Table 2. Rate of Harvest by Stationary Machine at Different Engine Speeds

Speed of engine (rpm)	Time (sec)	Weight of azolla harvested (kg)	Rate of harvest of azolla (kg/h)
800	420	69	590
1 000	362	62	615
1 200	320	76	853

Table 3. Diesel Consumption by Stationary Machine

Speed of engine (rpm)	Time (sec)	Amount of fuel consumed (mℓ)	Rate of fuel consumption (ℓ/h)
800	420	110	1.05
1 000	362	97	1.09
1 200	320	115	1.29

Table 4. Rate of Harvest by Mobile Machine

Distance travelled (m)	Time (sec)	Forward speed (km/h)	Weight of azolla harvested (kg)	Rate of harvest of azolla (kg/h)
30	309	0.324	34	396
40	420	0.324	41	351
40	382	0.376	39	367

Table 5. Diesel Consumption of the Mobile Machine

Distance travelled (m)	Amount of fuel consumed (mℓ)	Time (sec)	Rate of fuel consumption (ℓ/h)
30	164	309	1.91
40	223	420	2.15
40	230	382	2.16

On-farm Evaluation of Combine Harvester Losses in the Gezira Scheme in the Sudan

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Abstract

A total of 32 and 23 combine harvesters were tested in the seasons of 1989/90 and 1990/91 to determine on-farm wheat grain losses. Combine harvester parameters such as forward speed, cylinder speed, concave clearance, sieve opening, and fan setting were measured together with crop moisture content. Header, threshing, damage, separation, and cleaning losses were also measured for each combine. The measurements were repeated four times. A reference combine was used to investigate the effect of the different parameters on different types of wheat grain losses.

Of the total number studied, no combines were found to have the same settings. It indicated complete unawareness of the importance of proper setting. As a result, losses amounted to an average of 9% in the first season and 12.7% in the second season. Crop harvest can start at moisture content anywhere between 9% and 14%. Minimum header losses were found to occur at forward speed around 5.5 km/h. Minimum compromise threshing and damage losses may be attained around cylinder speed of 900 rpm.

Introduction

Many researchers studied harvest settings for different combines, the effect of environmental conditions, and crop factors on wheat losses. This study puts more emphasis on the problem of wheat losses through an on-farm evaluation of combines in the Gezira scheme in Sudan. For the purpose of evaluating wheat harvest losses, a comprehensive data collection program was designed to cover the operations of different commercial combine harvesters in the Gezira scheme. In the first season (1989/90) 32 combines and 23 combines in the second season (1990/91) were chosen at random for evaluation. The types of losses evaluated were preharvest, header, cylinder, separation, and cleaning losses. Combine forward speed (km/h), reel speed (rpm), cylinder speed (rpm), sieve opening (cm), fan speed (rpm), and concave clearance (cm) were measured before each combine harvester was evaluated for wheat losses. The combine harvester parameters and the combine losses were repeated four times in the field. The work was then completed in the laboratory by weighing the crop samples, threshing the crop heads collected, drying and measuring the moisture content and inspection of seed damage and foreign objects.

Materials and Methods

Different makes and models of combines were tested. To further validate the results obtained from commercial combines, a reference combine (John Deere 1157)* was used to test all experimental parameters as with the other combines. The effect of moisture content on crop losses was also evaluated. A stop watch, a measuring tape, wooden pegs, a clearance gauge, a tachometer were used in the experiments. Together with these, locally made steel frames were used to mark the boundaries of sample areas where crop losses were picked from. Also, a steel frame (1.5 m × 1 m) covered with a cloth was also used to recover the header, threshing and separation losses. Cloth bags were used for collecting the grain samples. A 20-cm long and 2-cm diameter grain sampler was made locally from sheet metal to collect samples from grain sacks to evaluate grain damage and cleaning losses.

An oven with a temperature range from 0-300°C was used to dry the grain samples for moisture content determination. A digital scale with four decimal reading places was used to weigh grain samples. Sieves 1.0 mm and 2.0 mm mesh were used to clean grain samples for evaluating damage and cleaning losses. A 90-mm diameter magnifying glass of up to × 5 was used for visual inspection and sorting out damaged grain and foreign objects.

Measurement for Combine Harvester Parameters

a) *Forward speed* — A distance of 40 m was measured and marked by two wooden pegs close to the line of combine operation. The combine was allowed to travel approximately 60 m before any readings were taken to ensure that it travelled at its full speed. A stop watch was used to measure time taken in travelling the marked distance. The readings were repeated four times and an average value was taken.

b) *Reel speed* — The reel was marked at one of its ends by a piece of cloth or a string. The time required by the reel to complete 25 revolutions was recorded. The procedure was repeated four times and the average was taken. The diameter of the reel was measured and the speed was converted to km/h. The reel speed ratio was determined by dividing the reel speed by the combine forward speed.

c) *Cylinder speed* — The tip of the tachometer rotating rod was centered at one side of the cylinder. The combine was operated while stationary at full throttle as that used in the normal working conditions and the speed in rpm was read directly from the tachometer.

d) *Concave clearance* — A ruler was used to measure front and rear cylinder concave clearance. The gauge was used in cases when the clearance was too small.

e) *Fan speed* — Determined in the same manner as the cylinder speed.

f) *Sieve opening* — Different gauge steps were tried until the one that fits was found and gauge size was recorded.

Determination of Grain Losses

i) *Preharvest losses* — The steel frame was carefully placed on the ground through the standing crop. The free seeds and the fallen heads were collected and put in the sample bags and clearly labelled to indicate the combine number and source of crop loss. The heads were then placed in a can, threshed and cleaned by a sieve and weighed.

ii) *Header losses* — This includes grains laying on the ground due to shattering when struck by the reel, heads out of reach of cutter-bar, grain loss due to rough handling by cutter-bar, and complete heads thrown out of combine platform by the reel. To measure the header losses, the grain trap was thrown carefully under the combine between the front and rear wheels during operation. An area of length equal to the width of the combine and 0.5 m wide, including the area under the grain trap, was marked by small wooden pegs and fenced with a string. All free seeds and complete heads in the prescribed area were collected, tied in the sample bags and labelled as header plus preharvest losses. The heads were then threshed and weighed. The header losses were then determined by subtracting preharvest losses from result obtained above.

iii) *Cylinder losses* — This is composed of threshing and damage losses. The unthreshed and partially threshed heads on the grain trap thrown under the combine were collected and tied from an area of 1 m × combine width. The heads were threshed and cleaned from chaffs and trash and weighed. The damage losses were determined by taking a sample of 150 g and visually inspecting for any damage using the magnifying lens. The damaged seeds were separated and weighed to determine the percent damage.

iv) *Separation losses* — The free seeds were collected from the same grain trap that was thrown under the combine and tied and labelled.

v) *Cleaning losses* — The procedure used is similar to that followed in determining the damage losses. Small chaff pieces, soil particles, other crop seeds, and any materials other than wheat grain were separated out of four samples of 150 g each, weighed and expressed as a percentage of the total weight.

Results and Discussion

Test results showed that reduction in moisture content below a certain limit enhances the crop preharvest losses. Crop preharvest losses were minimum in the range of moisture content between 6% and 9% in the first season, and 4% and 14% in the second season.

The header losses ranged from 0.3% to 12.48% in the first season and from 0.96% to 31.64% in the second season. The high header losses might be due to lodging of the crop in the specific fields where these combines worked. The mean combine header losses was 3.95% and 6.39% for the first and second seasons, respectively. It was the highest among all sources of losses due to the fact that header losses is the sum of crop losses caused by the reel, auger and cutterbar combined. The high header losses in the second season was attributed to the delay in crop harvest which resulted in crop shattering while being harvested. As expected, the header losses decreased as the reel speed ratio increased for both the first and second season data.

Analysis of the reference combine data showed that header losses decreased sharply between combine speed of 3.0 and 5.5 km/h (high reel-speed ratio) and increased in the range between 5.5 and 20 km/h (low reel-speed ratio). That was due to the reel speed being too slow in relation to the combine forward speed to capture all crop heads on the combine platform. Also, the cutter-bar speed was too low to cut the standing crop efficiently resulting in pushing the crop down uncut adding to the header losses. High header losses at low forward speeds results mainly from the heads being stricken by relatively fast moving reel and shattering the crop in front of the combine header. Analysis of variance of the reference combine data showed that the forward speed has significant effect on header losses.

Threshing and Damage Losses

The threshing losses ranged between 0.3% and 4.8% in the first season and between 0.04% and 5.65% in the second season with means of 0.78% and 1.2%, respectively. Grain damage losses ranged from 0.08% to 3.36% in the first and second seasons combined. The variation in losses was mainly due to variations in cylinder speed, concave clearance, and grain moisture content at which the crop was harvested. The data showed a positive correlation between grain damage and cylinder peripheral speed which indicates that damage losses increase with the increase of cylinder peripheral speed. The data from the reference combine indicated that cylinder speed change produces a significant effect on threshing losses at the 5% level of significance. The threshing losses decreased from 0.83% to 0.23% when the cylinder speed was increased from 550 to 1 150 rpm. However, the damage losses increased from 2.25% to 10.49%. At low cylinder speeds threshing losses increased while at high speeds significant grain damage occurred. The best cylinder speed that produced minimum crop losses was around 900 rpm.

The concave clearance has shown to have positive correlation of 0.56 with htreshing losses in the first season while the correlation was negative (−0.12) in the second season. That could partly be attributed to the variation in cylinder speed which has more profound effect on crop threshing losses than concave clearance. Increasing the concave clearance in the reference combine from 24 mm to 36 mm have produced a significant effect on threshing and damage losses at 1% level of significance. In the 24 mm to 28 mm concave clearance range, the threshing losses were insignificant at $p = 0.01$. However, the same range of concave clearance gave significant damage losses at $p = 0.01$. According to the mentioned results the mid range of clearances between 28 mm and 32 mm could produce the minimum possible combination of threshing and damage losses.

The reference combine threshing losses have significantly increased as the forward speed increased from 3.0 km/h to 20 km/h. Increase in feed rate at high speed resulted in a cushioning effect that reduced the effectiveness of the cylinder and concave in threshing the heads thoroughly. The cylinder speed and concave clearance are considered to be the major sources of threshing losses and not the combine forward speed.

Separation Losses

Separation mean losses were found to be 0.79% and 1.40% for the first and second seasons, respectively. The higher losses in the second season (almost twice as much as that in the first season) was attributed to the dryness of the crop as it was harvested over a wider time period. The separation losses, however, do not have a significant contribution to the total crop losses but can further be reduced by decreasing the forward speed of the combine. Moreover, all chaffer sieve openings greater than 1.1 cm produced less separation losses. That might be because wide sieve openings provide more chance for the grain to pass down through the chaffer.

Separation losses have shown to increase as the forward speed increased. Increase in forward speed results in increase of the stream of straw over the straw walker and chaffer sieves, which reduces the ability of the straw to walk their way down through the matted material. Separation losses increased from 0.1% to 0.4% as speed increased from 3.0 km/h to 20 km/h. However, the increase in separation losses was in a decreasing rate as the speed was increased.

Cleaning Losses

Cleaning losses ranged between 0.22% and 7.34% in the first season and between 0.14% and 9.15% in the second season with an average of 1.56% and 1.50% which can be considered minor when compared with the header losses. The fan speed and cleaning losses gave a positive correlation of 0.32 and 0.30 for the first and second seasons, respectively. Too much air will blow away and keep the grains suspended which will exit the combine with the chaffer. With the reference combine, change in fan setting from level 5 to level 8 produced a significant effect in the amount of cleaning losses at $p = 0.01$. The best results were obtained when the fan was set between levels 7 and 8.

Total Losses

The average total grain losses in the first and second seasons were 9% and 12.70%, respectively, of the total grain yield. The losses were substantial and measures should be taken to reduce such losses to an acceptable level. The total wheat yield in the Gezira scheme in the season was approximately 2 700 916 sacks from an area of approximately 615 000 acres. The grain loss based on the season average amounted to 242 452 sacks, and was nearly double in the second season which showed an average crop loss of 12.7%. The price of one sack of wheat at the beginning of the harvest season was Ls 1 250 (sudanese pounds) and the total cash loss amounted to over Ls 300 million sudanese pounds (US$24 million at an exchange rate of Ls 12.5 per dollar). The loss was almost twice as much in the second season.

Conclusion

The results of the wheat harvest losses obtained in this study show that forward speed, cylinder speed, fan setting (amount of air blown), and sieve opening have an effect on the different types of grain losses (header losses, threshing losses, separation losses, damage losses, and cleaning losses).

As the moisture content of the wheat grain is reduced, there was a general trend of increasing preharvest losses in the first and second seasons, and that the least amount of grain losses occur at moisture content ranging from 9% to 14%.

The combine forward speed that resulted in the minimum header losses was slightly greater than 5.5 km/h, and that the header losses were the highest among all other types of losses examined.

A compromise minimum threshing and damage losses were found to occur at approximately 900 rpm. However, minimum threshing losses were obtained at speeds slightly greater than 5.5 km/h.

Increasing concave clearance from 24 mm to 36 mm resulted in a significant increase in threshing losses and a significant decrease in grain damage. The range of concave clearance opening between 28 mm and 32 mm was found to give a minimum combined threshing and damage losses. The results also showed that increasing concave clearance generally produces less effect on the damage losses than that produced by changes in cylinder speed.

Sieve openings between 1.1 cm and 1.3 cm resulted the least separation losses in both seasons. Also, forward speed slightly greater that 5.5 km/h resulted in minimum separation losses.

Minimum cleaning losses could be obtained at fan setting between levels 7 and 8.

Finally, it was clear that the total losses from harvesting wheat in the Gezira scheme were substantial and they cost the farmer dearly in lost income.

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Cab for Indian Tractors: A Case Study

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Abstract

A questionnaire survey regarding a tractor cab was conducted with six leading tractor manufacturers in India. The views of the manufacturers indicate that, the comfort and efficiency of the operator will be increased with cab fitted tractor except small increment in total cost of the tractor. Export level will also be increased by the introduction of the cab.

Introduction

Agricultural machinery enabling comfortable and safe operations of various farm needs to be developed. With a high degree of mechanization on farms, along with the increasing size and complexity of farm machinery, a safe, efficient and comfortable working environment for the operator becomes an important consideration for enhancement of productivity and customer satisfaction. The tractor is an important source of power on the farm. In India, there are more than 0.8 million tractors used in agriculture for various operations. Tractor drivers comfort needs serious through so far as his overall performance is concerned. During the past few decades, the interaction between human health and the ride vibration related to its amount and duration has been investigated. The results reveal that it is necessary to reduce the vibration level for the tractor operator under a certain maximum level to ensure the operator's health and safety. The available literature reveals that either suspended seats or cabs have been equipped on the tractor to improve the operator's comfort. Tractor cab appears to provide increased comfort and higher work output (Egging, 1966). In European countries almost all the tractors are provided with a cab, even they are also using air conditioned cabs (Persson, 1967). The human being in many modern man-machine systems has to endure various environments and stresses. As a result of process in the development of agricultural vehicles, more and more has been demanded of human operator, yet relatively little attention has been given in design to his performance and endurance capabilities. This often results in poor operating efficiency of the man-machine system.

The environment in which a man operates a machine, should be considered in the design of man-machine system as the environmental conditions like temperature, relative humidity and dust, seriously affect the performance of operators (Hornick, 1961). Operators of farm tractors and other off-road vehicles are subjected to vibrational levels which are known to be injurious to health and deleterious to performance. Rosegger and Rosegger (1960) showed that tractor driving, which induces unnoticed discomfort, including mental and physical stress, has a deletorious effect on the operator's health over a long period, particularly, in con-

Acknowledgement: The cooperation of tractor manufacturers are acknowledged for providing the informations and views regarding the cab for Indian tractors. The cooperation of C.S.I.R. New Delhi is also acknowledged for providing the financial support to carry out this work.

Table 1. Views of Tractor Manufacturers Regarding the Tractor Cab

Questions	Escort	TAFE	Mahindra	HMT	Pratap	Eicher
1	2	3	4	5	6	7
Model produced (bhp)	27, 35, 47 & 50	26, 33, 34 & 45	25, 30, 35, 45 & 50	25, 35, 45 & 58	28	24
Present production	38700	24463	32000	17656	nil	24000
Country sale	38600	148342	32000	149829	—	24000
Export level	100	Just started	300	100	5 (earlier)	100
Cab fitted tractor introduced earlier?	no demand	no	not cost effective	Yes (3 to 4)	no	no customer demand
Reason for not using cab?						
a) Higher cost	—	yes	yes	yes	yes	yes
b) Suffocation	—	—	—	yes	—	yes
c) Not familiar	—	—	—	yes	—	yes
d) Other reason	no requirement from party	air cooling / air conditioning	not primary need	tractor needs major changes	no demand	—
Increment in operator's efficiency, safety and comfort?						
a) Efficiency	yes	yes	not known	yes	yes	yes
b) Safety	yes	yes	not known	yes	yes	yes
c) Comfort	yes	yes	yes	yes	yes	yes
Marketability						
a) Increase	—	—	if cost effective	—	yes	—
b) Decrease	—	—	—	—	—	—
c) Not known	—	yes	—	yes	—	yes
Effect of cab introduction on export level?						
a) Increase	yes	yes	—	yes	yes	yes
b) Decrease	—	—	—	—	—	—
c) Not known	—	—	not known	—	—	—
Cab will lead to?						
a) Vibration	—	—	—	—	—	no
b) Noise	—	—	—	—	—	no
c) Accident	—	—	—	—	—	no
d) Problem in field operation	yes	yes	yes	yes	yes	no
e) Visibility problem	yes	—	yes	yes	yes	no
f) Problem getting in and out to cab	—	—	—	—	—	yes
g) Other problems	—	—	—	difficult servicing	having small holding	restriction to carry persons on
Need of AC cab?	yes	yes	no	no	no	yes (for export)

nection with spinal and stomach disorders. Tractor cabs of various designs have been offered for many years as a means of protecting the operator from different atmospheric conditions and inceasing operator working efficiency (Egging, 1966).

In many cabs vibration absorbing seat suspension is provided in an effort to reduce the vibrational inputs. As per the research findings, the significant levels of high frequency vibration from the engine and gear train present in the platform, steering wheel and other controls could be effectively isolated by means of suspended cab. Suspended cab was also introduced to reduce the tractor vibration and improve operator performance (Suggs and Huang, 1969 and Roley, 1975). Hilton and Morgan (1975) reported an improvement in tractor operator ride by conducting experiments on a cab suspension. They stated that the suspended cab has two advantages compared to suspended seats. First, the relative motion between the driver and his control is removed. This allows the possibility of greater suspension travel and isolation from other components of vibration as well the vertical. Second, the mass of the suspended unit is greater by a factor of 5 or more, together with the greater isolation from the vibration of the basic tractor. Another result of increasing the mass of the suspended unit is that the energy dissipation of the suspension system is increased, which can reduce the vibration of the tractor.

The noise and dust also causes discomfort to the operator with respect to nervous tension, irritation and fatigue. Huang and Suggs (1968) analyzed the physical characteristics of tractor noise under operating conditions and its effect on human performance. Simpson and Deshayes (1969) conducted a survey to estimate the noise levels of tractors and recommended the elimination of noise level and use of protective devices to safeguard against hearing damage. Hakimi (1971) measured tractor noise and suggested that most of the mounts isolate from the vibration sufficiently to reduce noise near the level of the free standing cab. He concluded that most effective mounts reduced the total noise by 5 db. He also reported that some apparent correlation exists between the vibration and noise performance in that the mounts with lower reference numbers performed more effectively with vibration and noise reduction.

Cab is not a primary need of Indian customer but if we can increase the comfort and safety, the output of the operator will be greater and he can work for a long period with less exertion.

Scope of Cab for Indian Tractors

The development of good cab with sufficient structural strength to resist crusing would make a significant contribution to the health, safety, comfort and efficiency of tractor operator. The cab would also provide isolation from machine vibration, noise, adverse environmental temperature, dust, rain and chemical contaminants.

A survey was conducted from various leading tractor manufacturers like Escort Ltd, TAFE Ltd, Mahindra & Mahindra Ltd, HMT Ltd, Auto Tractors Ltd and Eicher Tractors Ltd regarding the tractor cab and view are presented in **Table 1**.

Most of these are in favour of tractor cab. Along with the increase in efficiency and comfort, the export level will also be increased. Manufacturers quoted reasons that Indian people are not very much familiar with the advantages of tractor cab and because of this there is no demand from the market. The cost of tractor will be increased slightly due to introduction of cab but overall operator's safety, comfort and performance could improve. Therefore, scope of tractor cab can be enhanced by bringing its advantages to owners knowledge.

Conclusions

Cab-fitted tractors have a scope in India to increase the overall performance of tractor operators in varying atmospheric conditions. Suspended cab would also reduce vibration, noise and dust level, leading to better comfort. However, suspended cab will increase cost also.

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Rice Post-harvest Practices in Orissa, India

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Abstract

Rice milling is the biggest agro-based industry in Orissa as it employs the largest number of persons and handles large quantities of rice. The present study was conducted to determine the status of the various post-harvest operations in rice milling industry. It was observed that of the total rice production, 76% was parboiled and 53% was milled using traditional hullers. The milling capacity and energy utilization of rice mills were compared with the actual paddy production.

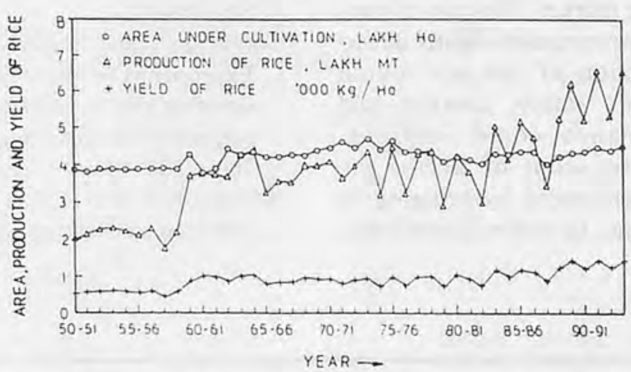

Fig. 1 Growth of rice production in Orissa.

Introduction

Orissa is the 7th largest rice producing state in India contributing about 8.5% of the total national production. **Fig. 1** shows the growth rate of rice production in the state, which has increased substantially in the past decade with the introduction of high yield varieties, better irrigation facilities and adoption of scientific farming methods (DAFP, 1951 to 94). The per capita availability of rice, total cereals and total food grains in Orissa during 1990-91 was 465, 510 and 614 g/day (DES, 1992). There were more than 7 000 rice mills in the state and the number grew steadily every year (Dash et al. 1993).

Dash et al. (1993) studied the status of rice hullers in Orissa and reported that the hullers in most parts of the state operated for 2-16 h/day depending upon the season. The average was only 6 h/day; the reasons of which were mainly attributed to unavailability of sufficient paddy due to the large huller population, erratic power supply and competition from unlicensed hullers. However, the rice milling industry, not only mills rice, but also procures paddy and performs other operations like cleaning, parboiling, drying, storage and by-products utilization. The present trend and practices of performing these operations, loss of rice at different stages of rice processing chain and efficient use of by-products have a definite impact on the health of the industry and state's economy. Therefore the present study was conducted to gather information on existing post harvest practices of rice with emphasis on milling and to sort out areas for development/improvement.

Methodology

Twenty-five villages in five rice growing districts of the state, namely; Cuttack, Puri, Ganjam, Sambalpur and Balasore were covered under the study. The losses were calculated as per the methods proposed by Anwarul Haqùe et al. (1989).

Statistical information on the rice milling industry in all the 30 districts of Orissa was collected and recorded in a specified format. The information included the total power of installed motor, actual milling capacity, licensed milling capacity, type of parboiling and drying equipment and the type of fuel and furnace used for generation of heat. Sample surveys were conducted in 200 rice mills in different districts: 50 in each category of huller, sheller-cum-huller, sheller and modernized mills in an effort to ascertain the actual quantity of rice milled per year, daily working hours, nature of milling, utilization of by-products, type of fuel or energy and manual labour engaged for different kinds of operation.

Harvesting and Transportation

The farmers use mostly traditional methods for harvesting paddy with sickles, which vary in their size and curvature depending upon the locality. The process consumes a lot of labour and often creates problem for availability of labour during peak season. In parboiled rice consuming areas, paddy is harvested when the grain becomes fully meatured, i.e., at about 18-20% (w.b.) moisture content or less. The farmers claim that this method avoid subsequent long drying hours and labour problem. But grain shattering and losses due to birds etc. were estimated to range between 0.5 and 1.8% (RESC, 1994 b). However, the varieties of rice which are consumed in raw form are harvested at a comparatively higher moisture content of 21-24% (w.b.) i.e., when there are about 2-3% green grains on the stalk.

After cutting, paddy stalks are left on the ground for 2-3 days, then tied to form bundles and transported by bullock carts and tractor trolleys to threshing yards and primary storage points. Trucks or tractor trolleys are used to convery the grain from primary storages to mill sites or onward locations. The grain is shortly dried after threshing either on country yard or "pucca" floor for temporary storage. Gunny bags, each having a capacity of 75 kg are used for convenience in movement of paddy. The loss in paddy during stalking and transportation from field to milling installations was estimated to range between 0.1 to 0.3% and 0.05 to 0.25%, respectively, (RESC, 1994 b).

Storage

Storage of grain is done at farmers' level, traders' level, mill sites and Government storage depots either in the form of paddy or rice. The farmers commonly use the following types of traditional storage structures with 0.1 to 1.5 mt capacity (**Figs. 2-5**).

1. Straw storage structures (Puri, Malei, Olia etc.)
2. Bamboo or reed storage structures (Doli)
3. Wooden storage structures
4. Mud storage structures (Ghuma, Handi etc.)
5. Underground storage structure (Khani)
6. Bag storages
7. Masonry storage structures

Though grain loss in these types of storage due to moisture, insects and rodents have been estimated to range between 3.5 and 8.2% (RESC, 1994 b), it is claimed that some of them offer special advantages like partial drying of high moisture grain in straw or bamboo storages and curing in underground storage. Therefore, to prevent grain loss due to insects and rodents and simultaneously to

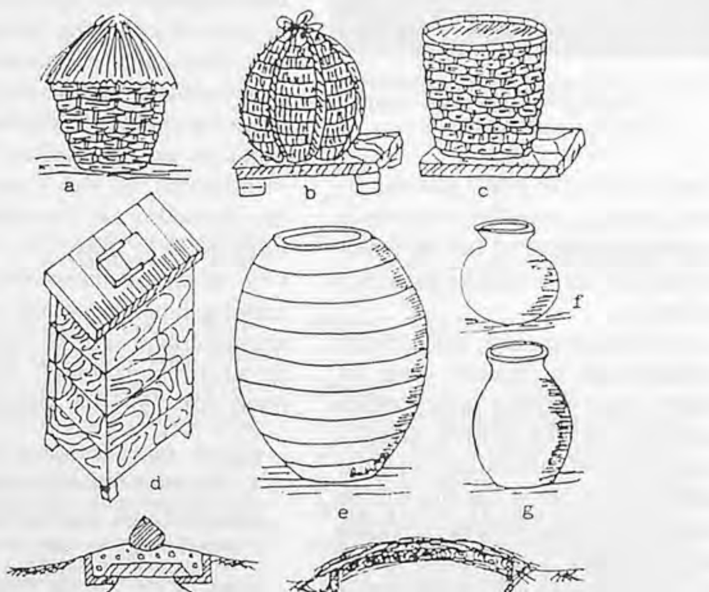

Fig. 2 Traditional storage structures commponly used in Orissa. (a) and (b) Straw storage structures, (c) Bamboo/reed storage structure, (d) Wooden storage structure (e), (f) and (g) Earthen storage structures, (h) and (i) Under-ground storage structures.

Fig. 3 Straw storage strucutre (Puri).

Fig. 4 Straw storage structure for seed (Olia).

Fig. 5 Under-ground storage structures in village yard (In the above figured chill is dried over them).

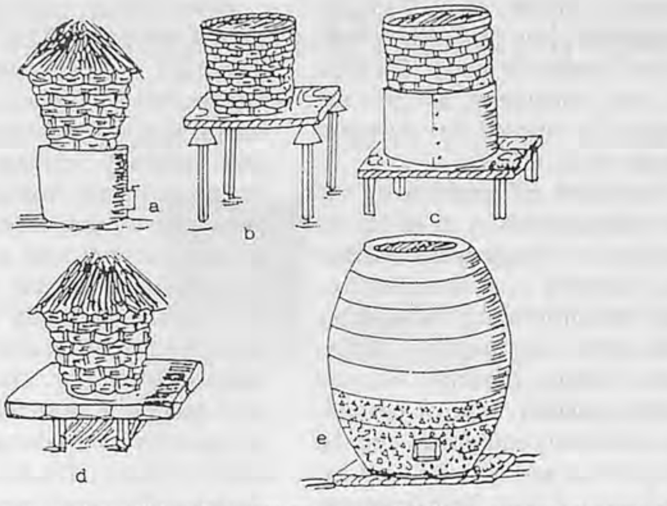

Fig. 6 Improvements in traditional storage structures. (a) Straw storage structure on rcc rings and provided with an outlet, (b) Providing a platform ona metallic inverted cones stand, (c) metallic sheet nailed to bamboo structure, (d) Providing a stone/masonry platform, (e) Skirting of earthen structures by baby chips up to 300 mm height.

meet the need of small and marginal farmers, some improvements have been suggested for the traditional storage structures as shown in **Fig. 6**.

Storage of grain in commercial installations is mainly done in gunny bags without taking much care for quality control, cleanliness or insect infestation. In most cases a portion of the rice mill is used for storage without providing any dunnage. The grain is stored at an average moisture content of 13-14%. The Food Corporation of India (FCI) is the main organization which procures, stores and distributes rice under public distribution system. Though FCI godowns in most of the districts are structurally and functunally sound, still proper care for moisture and insect control is often a problem (RESC, 1993).

Procurement

Procurement of paddy from farmers is done by either Government agencies or by private traders at prices fixed by the Government. The Government announces the procurement / minimum support price for major agricultural commodities on the basis of recommendations by the Commission for Agricultural Costs and Prices (CACP). The objective is to provide adequate incentives for increasing investment and supplying agricultural products at reasonable prices to consumers. The price fixed for 1993-94 was Rs. 310 (US$9.83), Rs. 330 (US$10.46) and Rs. 350 (US$11.09) per quintal for Fair Average Quality (FAQ) of common, fine and superfine varieites of paddy. The different specifications recommended for FAQ paddy are given in **Table 1**. However, strict quality assessment is not done at procurement points in most areas. Procurement at a lower price than that specified by the Government is also reported sometimes. The small millers often face difficulty in procuring adequate amount of paddy for commercial milling.

There is a system of imposing levy on rice with a view to forcing millers to contribute a statutory minimal quantity to the national

Table 1. Uniform Specifications for All Varieties of Paddy

The paddy shall be in sound merchantable condition, sweet, dry, clean, wholesome of good food value, uniform in colour and size of grains and free from moulds, weevils, obnoxious smell, argemone mexicana and kesari, admixture of deleterious substances or colouring agents and also conforming to PFA standards.

Paddy shall be classified in to Superfine (L.B. ratio more than 3.0), Fine (L.B. ratio between 2.5 to 3.0) and Common (L.B. ratio less than 2.5) groups. The varieties with natural aroma will be taken under Scented group. The other schedule of specifications are as follows.

Constituents	Maximum limits (%)
Foreign matter	
(a) Inorganic	1.0
(b) Organic	1.0
Damaged, discoloured, sprouted and weevilled grain	3.0
Immature, shrunken and shrivelled grain	3.0
Admixture of lower varieties	10.0
Moisture	18.0

Source: Food Supplies and Consumer Welfare Deptt., Govt. of Orissa, Bhubaneswar.

food stocks. The balance is bought and sold in the free market. To assure adequate supplies of reasonably priced food grains for the huge population, the mechanism of Public Distribution System (PDS) has been brought in to force. Through PDS, the Government procures grain from farmers/millers at subsidized prices and sells to consumer at subsidized prices. The issue price of PDS rice available through a network of Fair price shops during 1993-94 was Rs. 537 (US$17.02), Rs. 617 (US$19.56) and Rs. 648 (US$ 20.54) per quintal of common, fine and superfine varieties, respectively. The prices for tribal areas and revamped PDS was Rs. 50 (US$1.58) less per quintal than the above prices (AIREA, 1994).

Parboiling

In Orissa about 76% of the total milled rice is parboiled (RESC, 1993). Most of the household processors use traditional, single boiling and double boiling methods for parboiling, which often impart dark colour and bad odour to rice. The commercial installations mostly employ the double steaming method, where paddy is first steamed for 25-30 min and then soaked in large masonry tanks for 4-8 h. The soaked grain is again steamed for 25-30 min before drying. The steaming tanks are made of concrete or steel sheet. The concrete tanks (**Fig. 7**) generally hold up to 0.5-1 mt paddy whereas metallic tanks are used for higher capacities up to 4 mt (**Fig. 8**). In some rice mills these tanks are also used for curing of raw paddy. Husk, wood or coal are used as fuel for production of steam (RESC, 1993).

A few rice mills have adopted the improved CFTRI method whereby paddy is first soaked in hot water at 60-70°C for 4-6 h inside a metallic tank and then steamed for 25-30 min in the same tank, which is provided with radially distributed steam pipes (**Fig. 9**). The steam pipes are also used to heat soak water inside metallic tanks. The process offers a better control of temperature and pressure thus giving excellent product. However, the method is yet to be popularized with small millers and household processors. Small improved parboiling tanks (75 kg/batch) designed by the Central Rice Research Institute, Cuttack (**Fig. 10**) are also being marketed in the state since 1992 which costs Rs. 1 580 (US$50.08) (RESC, 1993).

Fig. 7a Concrete soaking and steaming tanks for parboiling with husk fired furnace (Front view).

Fig. 7b Concrete soaking and steaming tanks (Side view).

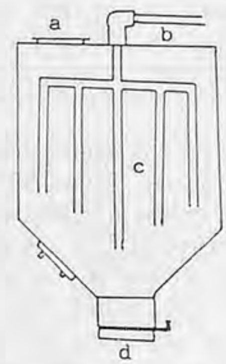

Fig. 9 CFTRI parboiling tank. (a) paddy inlet, (b) steam inlet, (c) steam pipes, (d) paddy outlet.

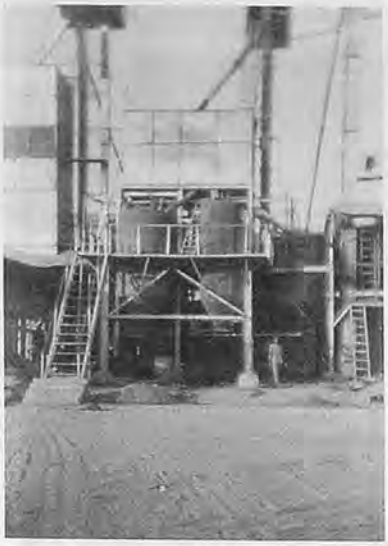

Fig. 8 Metallic steaming tank used for parboiling.

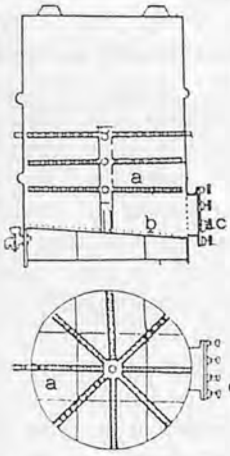

Fig. 10 Small improved parboiling tank. (a) steam pipes, (b) wire mesh, (c) paddy outlet.

Drying

Drying of grain after threshing or parboiling is done mainly under the sun with casual stirring (**Figs. 11** and **12**). So uneven heating of grain causes development of stress cracks and ultimately more breakage of rice during milling. Besides, open sun drying has its own disadvantages like losses due to wind, birds and scattering etc. In rainy days drying is often delayed causing degradation of grain.

Only 41 sheller type / modern

Fig. 11 Drying of paddy under sun on a cement yard.

Fig. 12 Stirring of grain during sun drying.

Table 2. Rice mills in Orissa

Name of the District	Type of rice mill				
	Huller	Sheller-cum huller	Sheller	Modern rice mill	Total
Angul	276	10	—	—	286
Balangir	267	51	3	17	338
Balasore	584	2	—	1	587
Baragarh	243	33	25	56	357
Bhadrak	372	10	6	—	388
Boudh	75	1	—	1	77
Cuttack	329	—	3	1	333
Deogarh	105	3	4	—	112
Dhenkanal	279	6	2	—	287
Gajapati	81	32	16	8	137
Ganjam	450	96	64	10	620
Jagatsinghpur	235	18	—	—	253
Jajpur	191	—	—	1	192
Jharsuguda	70	4	3	2	79
Kalahandi	182	8	23	42	255
Kendrapara	391	—	—	—	391
Keonjhar	222	19	2	10	253
Khurda	219	—	—	—	219
Koraput	49	2	—	5	56
Malkangiri	24	—	—	9	33
Mayurbhanj	334	6	—	3	343
Nawapara	54	42	—	3	99
Nowrangpur	47	33	3	1	84
Nayagarh	114	2	—	1	117
Phulbani	22	46	—	1	69
Puri	658	1	—	9	668
Rayagada	30	33	10	—	73
Sambalpur	128	37	23	4	192
Sonepur	70	—	—	—	70
Sundergarh	123	1	—	3	127
Total	6224	496	187	188	7095

rice mills of the state are equipped with LSU dryers for drying parboiled paddy, which allow uniform mixing of grain during drying. But tempering, the most important aspect of drying to reduce milling breakage, is not done properly in most cases. In some mills though paddy is tempered under shade, but it is done at a fairly high moisture content of 20-24% (w.b.), thus not serving for the actual purpose. Small mechanical dryers are yet to be popularized in the state. Mostly grate type husk fired furnaces are used to generate heat for boilers and mechanical dryers. The rural and household processors still use wood or coal as fuel (RESC, 1993).

Milling

The distribution of licensed rice mills operating in different districts of Orissa during 1993-94 are shown in **Table 2** (RESC, 1994 a). Besides, there were more than 5 000 unlicensed hullers. These hullers, in addition to giving lower rice yield, also give the main by-products viz. husk and bran in the form of a powdered mixture, commonly called 'kunda'. Also, the degree of milling cannot be controlled properly. About 90% of the paddy milled in hullers are on custom basis and 85% customers take away 'kunda' for use as cattle feed. The milling charge is waived for customers who leave this by-product at mill points, which is then sold to local traders.

The government has been trying to modernize hullers into sheller type mills to increase the yield of rice and obtain pure by-products. But eradication of hullers has not been possible due to their large numbers, contribution to rural economy and other socio-economic-political factors. Therefore, a Regional Extension Service Centre (Rice Milling) has been established in the state to educate people about modern methods of rice milling and allied post-harvest operations. The Government is also operating a 'huller modernization scheme', in which an amount of Rs. 15 000/- (US$475.44) is given as subsidy to each beneficiary interested to modernize. Under this programme, a paddy cleaner, a rubber roll sheller and a paddy separator of matching capacity are added in series above the existing huller, which cost around Rs. 30 000/- to 40 000/- (US$950 to 1 250).

However, modernization of hullers has not picked up in the state due to several factors like competition from unlicensed hullers, custom milling nature of about 90% paddy coming to hullers, unavailability of any low cost substitute for 'kunda' as cattle feed and problems in disposal of husk and bran at a suitable price. Of the total rice production of the state, about 76% is parboiled and the yield of parboiled rice in hullers is not so low as that of raw rice. Further, it is a common practice among huller owners to mill paddy at a moisture content of more than 15% (w.b.) to gain in weight, which would reduce the life of rubber rolls in a modernized mill.

Paddy Production vs Milling Capacity and Energy Utilization

The capacity utilization and energy consumption of the rice milling industry of Orissa during 1993-94 were studied as these two factors play vital roles in the health of the industry. The actual quantity of rice milled in the state and machine utilization time were calculated assuming that there was no interstate transport of paddy. The sample studies reveal that of the total paddy production, 5% was stored as seed and 5% for preparing rice products like flakes and popped rice (RESC, 1994 a). The balance 90% of the paddy production in the corresponding year i.e., 90.22 lakh mt was milled by different categories of rice mills in the state.

The milling capacities of different types of rice mills of Orissa are shown in **Table 3** which indicates that if all rice mills were operated for 8 h/day and 320 days/year, they could mill about 145.74 lakh mt paddy, which was 1.45 times the total production. The situation is further aggravated if milling capacity of unlicensed hullers were added. However, most of the shellers, sheller-cum-hullers and modern rice mills operated for 10-16 h (average 12 h)/day. But due to improper operation and maintenance, the machines were capable to run only at 50-80% of their rated capacity and thus their average milling capacity for 12-hour operation was almost equal to that obtained from a perfect machine in 8 h. Similarly, most of the hullers used double pass method, thus milling only 50% or less paddy of their rated capacity. Hence, all rice mills consumed about 25-100% more energy than that required for milling a specified quantity of paddy.

Table 3. Milling Capacity of Different Types of Rice Mills in Orissa

Type of rice mill	Number	Milling capacity mt/h	Milling capacity per day (8 hours operation) mt/day	Theoretical capacity per year (320 days operation) '000 mt/year	Actual amount of rough rice milled during 1993-94 '000 mt
Huller	6224	4022	32176 (16088)*	10296.32	4743.84**
Sheller-cum-huller	496	721	5768 (2884)	1845.76	1845.76
Sheller	187	544	4352 (2176)	1392.64	1392.64
Modernized/ modern mills	188	406	3248 (1624)	1039.36	1039.36
Total	7095	5693	45544 (22772)	14574.08	9021.60

*The figures within brackets indicate the licensed milling capacity.
**This includes the paddy milled by unlicensed hullers.

Table 4. Energy Consumption in Milling Sections of Different Types of Rice Mills in Orissa, 1993-94

Type of rice mill	Total power of installed motors kW	Period of operation (h/day)	Elect. energy consumption MJ	Manual energy consumption MJ	Total energy consumption MJ
Huller	55711.28	295 (8h/day)	4.733×10^8	7.889×10^6	4.812×10^8
Sheller-cum-huller	10135.16	320 (12h/day)	1.401×10^8	5.115×10^6	1.452×10^8
Sheller	8593.92	320 (12h/day)	1.188×10^8	1.928×10^6	1.207×10^8
Modernized/ modern mills	5908.32	320 (12h/day)	8.168×10^7	1.938×10^6	8.362×10^7
Total	80348.68		8.139×10^8	1.687×10^7	8.307×10^8

All types of mills, except hullers, were reported to be running for 280-350 days (average 320 days) in a year. Therefore, they milled about 42.78 lakh mt paddy thus leaving 47.44 lakh mt to be milled by hullers, which was 52.6% of the total production (**Table 3**). Thus all licensed hullers could be operated healthily for 295 days/year. But this does not happen actually field and most of them operated for less than 6 h/day and 200 days/year as a substantial quantity of paddy was diverted to unlicensed hullers. The erratic power supply and irregularity of paddy incoming for custom milling worsened the situation. However, for energy calculations, whether rice was milled by licensed or unlicensed hullers had no significance and it was assumed that all licensed hullers operated for 8 h/day and 295 days/year.

The energy utilization by rice mills was calculated separately for milling and parboiling sections. The actual power of installed motors and working hours were considered for evaluation of electrical energy consumption in milling operations starting from precleaning till the end of grading. Manual labour is employed in rice mills for operating the machinery, weighing and bagging, internal conveyance and similar other operations. The sample studies reveal that, hullers on an average employed 2 labours in milling sections, whereas the sheller-cum-hullers, shellers and modernized / modern rice mills employed 8-16 persons (average 10) / shift. On that basis, the electrical and manual energy consumption in milling sections were computed to be 8.139×10^8 and 1.687×10^7 MJ, respectively (**Table 4**). The total energy utilization in milling sections was thus 8.307×10^8 MJ.

Of the total rice production in Orissa, 76% is parboiled. The parboiling methods and equipment vary from small household processors for custom milling to large-scale commercial processors. As it was not possible to study the actual energy consumption for parboiling in each individual rice mill/household processor, the average energy consumption in parboiling, including manual ener-

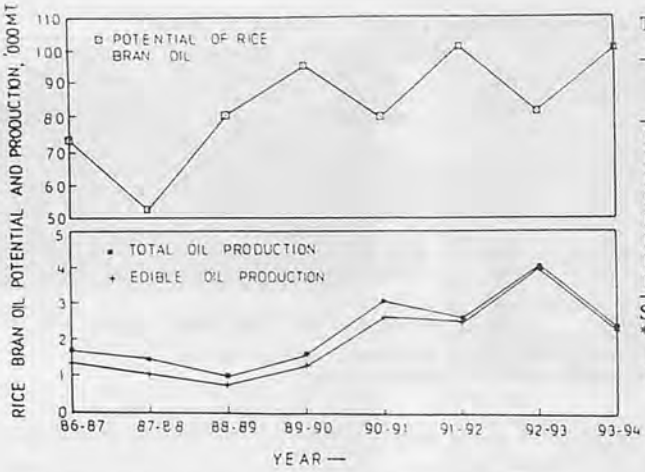

Fig. 13 Rice bran oil potential and production in Orissa since 1986-87.

Table 5. Rice Bran Oil Potential and Production in the State of Orissa since 1986-87 (Unit: mt)

Year	Rice bran oil potential	Production of Rice Bran Oil in Orissa		
		Edible oil	Industrial oil	Total
1986-87	73 242.5*	1 325	350	1 675
1987-88	52 590.9	1 037	409	1 446
1988-89	80 257.57	734	272	1 006
1989-90	95 212.12	1 302	314	1 616
1990-91	79 924.24	2 658	440	3 098
1991-92	100 909.0	2 491	125	2 616
1992-93	81 636.36	3 999	58	4 057
1993-94	100 242.4	2 283	115	2 398

Source: Solvent Extractors Association of India.
*The potential of rice bran has been taken as 5% of the paddy production, and potential of rice bran oil as 20% of the bran production.

gy input was assumed to be 2 529 MJ/t of paddy, as proposed by Sehgal et al. (1987). The value was also found to be applicable under Orissa conditions. So no differentiation was made between small and large processors and total energy utilization for parboiling 76% of total paddy milled in the state i.e., 68.56 lakh mt was 1.734×10^{10} MJ.

Thus total energy consumption by the rice milling industry of the state during 1993-94 was estimated to be 1.817×10^{10} MJ. However, the energy consumption and amount of rice milled by the industry in any particular year was liable to vary according to the paddy production in the corresponding year (RESC, 1994 a).

By-products Utilization

The cost effective disposal of husk and bran is a major problem for rice mills of the state. The bran from big mills is purchased by solvent extraction (SE) plants for oil extraction. There are 8 solvent extraction plants in the state, of which 5 have stopped functioning due to un-availabilityof adequate bran and other management problems. All the 3 running plants are located in southern and western districts. So the millers from other districts get low return due to high transportation cost and degradation of bran by increase of free fatty acid (FFA) content during freight. The rate of FFA rise is accelerated because of the high humidity and temperature prevalent in most parts of the state throughout the year, which further aggravates the situation. A few rice mills have bran stabilizers mostly working on the principle of application of heat (RESC, 1993).

A huge quantity of bran is sold every year to the SE plants of neighbouring states because of the absence of any suitable bran collection network in the state. The selling price of bran during 1993-94 ranged between Rs. 2 500 and 4 500 (US$79.24 to 142.6) per mt depending upon its grade. **Fig. 13** and **Table 5** presents the actual production of rice bran oil in Orissa since 1986-87 against the potential of production (SEA, 1987-94), which indicates that more than 95% of this great source of edible oil still remains untapped. The deoiled bran is used for cattle feed formulation.

The sample study in selected rice mills show that about 70% of the husk production is used as fuel for parboiling and drying. But husk ash is thrown away as such due to the unavailability of any husk utilization plant. A small portion of the husk is used for agricultural purposes such as seeding aid, compost, mulch, bedding and litter in poultry houses and as domestic fuel. The powdered mixture of husk and bran obtained from hullers are used directly as cattle feed.

Conclusion and Recommendation

1. Improved techniques and equipment should be introduced for harvesting, parboiling, drying and milling of rice for minimizing losses. Care should be given for proper operation and maintenance of rice mills by imparting training to the mill operators.
2. Improved storage techniques and structures should be popularized and introduced at farm and commercial levels. Strict quality control should be observed at the time of procurement for both paddy and rice.
3. The Government should give more emphasis on modernization of hullers by providing incentives like waiving of levy, concession in power tariff etc. which will attract more huller owners.
4. Suitable bran collection network should be developed at district level with provision for stabilization of bran on a cooperative basis to help in increasing the output of edible rice bran oil. Entrepreneurs should be encouraged to set up plants for utilization of husk.

(Continued on page 40)

Grain Post-production Practices and Loss Estimates in South China

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Abstract

The study was conducted in Zhejiang province in China. Information on existing post-production operations, including harvesting threshing, cleaning, drying and storage was gathered and analyzed. Grain losses, both quantitative and qualitative were compared with losses incurred when using different operating methods and suggestion of reducing the losses were put forward.

Introduction

China is an agricultural country with rice as the staple food. The situation of grain demand-supply has been serious, but grain loss reduction in grain post-production has long been ignored. In fact, great losses in grain post-produciton systems have occurred in vast rural areas. People always pay great attention to pre-production and production system, otherwise, grain post-production system was neglected by farmers as well as by government officials. Since the reformation of the agricultural economy, the structure of agricultural production has been changed greatly. Rural enterprises, commercial business and services have been developed. As a result, farm labor transfer has been promoted. In economically developed areas, therefore, the land was merged into the hands of skillful farmers and a number of specialized farm households have emerged. The land areas that the farmers managed, therefore, became larger. The labor shortage has become obvious in farming operations and mechanization of farming, especially in grain post-production operation. In developing areas of the country, the traditional methods are still used in grain post-production system. The objective of the study was to observe grain post-production practices and estimate losses occurring in South China from harvesting to storage operations.

Table 1. Main Grain Post-production Patterns in Survey Sites

Site	Harvesting	Threshing	Cleaning and drying	Storage
Jinghua	Sickle	Pedal thresher	Dried on bamboo mat Cleaned by cabinet	Wooden cabinet
Jiaxing	Sickle	Motor thresher	Dried on cement yard Cleaned by electric blower	Stored in bamboo mat
Ningbo	Combine	Combine	Dried on cement yard Cleaned by simplified vibrating screen with electric blower	Stack on the ground

Materials and Methods

Loss Assessment Methodology

The field trials were conducted in three localities (Jinghua, Jiaxing and Ningbo) representing different levels of economic and technical developments in Zhejiang province. Three villages with three farm households in each of the localities were selected to represent the village level. The field trials in three crop seasons consisted of winter crops (barley and wheat), two crops of rice have been grown per year from 1987 to 1989. The main grain post-production patterns in survey sites are listed in **Table 1**.

Table 2. The Drying Means and Their Proportions at the Survey Areas (Unit: %)

Survey site	Cemented drying yard	On roof of house	Bamboo mat	Roadside	Others
Ningbo	93	0	0	3.3	3.7
Jiaxing	95	0	0	2.4	2.6
Jinghua	58.3	11	30.7	0	0

Table 3. The Proportion of Transportation Means in the Survey Sites

Means	Boat	Wheel barrow	Shoulder	Tractor	Others
Proportion (%)	51.5	27.5	13.4	7.2	0.8

Quantitative Losses

Physical losses were measured in each post-production operation from harvesting through storage. All yield and weight measurements were corrected for moisture content and purity.

In Zhejiang province, more than 95% of the rice fields was harvested manually, but in some areas, combines are used. As the rural enterprises develop more combines are used in economically developed areas. The losses in harvesting using sickles and mechanical harvesters were determined. For harvesting with sickles, the samples from 5 points with 1 square meter each in a plot using X-shaped pattern were taken. The loss due to natural shattering before harvest and grains shattered in cutting on the ground was examined by picking up carefully the fallen grains in sampling areas before and after harvest. These harvested crop was laid on a plastic sheet and the grains falling on it were gathered to be measured as the crop was removed for threshing. The standing plants left in sampling areas were reharvested. Threshing in most areas was done by mechanical threshers with about 98% of the areas in the developed regions where electric power is available. Otherwise, in less developed areas the pedal threshers were most popular accounting for more than 80% of the farms. In the remote mountainous areas, the traditional methods of threshing by hand were still practised. The proportions of threshing methods are: electric powered thresher 54.5%, pedal thresher 33.3%, diesel engine powered thresher 9%, and threshing by hand 3.3%. The losses due to threshing were determined by gathering the grains splitting out in threshing operation on the previous prepared plastic sheets around the thresher and those that were mixed in the straws and chaffs were recovered by hand. Grains on unthreshed panicles and unseparated grains on the plants were rethreshed by stripping. For the combine harvester, the losses included those in harvesting and threshing. Natural shattering loss was also assessed by picking up the fallen grains in the sampling areas before harvest and scattered grains in the operation wre recovered by picking up in one square meter areas randomly with four replicates. The shattering loss was determined by subtracting the total shattered grains recovered. Grains disposed by the blower as mixed with straw were also collected. Standing plants and unseparated grains were gathered and rethreshed also by hand stripping in the sampling areas. Drying in most cases relied on the natural solar energy. Almost all of the farm households used only the drying yards around their houses. Occasionally a few farmers hired machines from the state farms or research institutions. The drying yards were cemented or soil spread with bamboo met, or the roadsides, even on roofs of their houses (**Table 2**). Drying loss that could not be accounted for referred to spilling, improper or careless handling, consumption by birds, rodents or chickens etc. The samples of grains dried separately under controlled condition were used to determine the drying loss, as compared with the normal drying methods adopted by the farmers. The ways of grains cleaning are different in different areas. In the northern part of the provicne 53% of the farmers used the mechanical blowers to clean the grains, 18.7% used the traditional wooden blowers and 28.6% used electric fans. The majority of the areas in the province, however, was still using the traditional wooden blowers that were shared among the farmers. The cleaning and winnowing losses consisting of the grains and panicles mixed with the chaff or straw that were normally not recovered by farmers, were assessed using the standard check that was sampled and dried separately under controlled condition and recovering the grains from the discarded portions in cleaning and winnowing operations. Transportation was done by shoulder to carry and by wheel barrows. In Jiaxing boats were popular because the area was inundated. The proportion of the transportation means is indicated in **Table 3** in survey areas. Because of difference in examination of transportation loss which incidentally occurred, the loss was determined by interviewing 10 farmers for estimation of the transport loss in each survey site. Storage of grains at farmers' homes was done in several ways. The duration of the grain storage depends on the crops. In most cases the grains of first crop of rice were stored only for 4 to 5 months while the rice of the second crop was stored for 8 to 12 months with maximum of about two years in a few cases. Wheat and barley were usually sold. The major causes of grain losses in the storage were rats, insect pests and molds. The processing of the grains was done by farmers themselves. Normally every village has one or two processing houses (millers) which are operated by the farmers in contract or rented to them.

Qualitative Loss

In order to evaluate the impact of post-production technologies on the quality of paddy and milled

Table 4. Percent Loss Estimated in Harvesting to Storage Operations by Method

Operation method	Range of loss	Weighted average of loss
Harvesting	0.29-2.34	0.86
-sickle	0.29-0.53	0.43
-combine (including threshing)	1.54-2.34	1.82
Threshing	0.62-2.68	1.31
-pedal thresher	0.62-1.03	0.80
-motor thresher	0.90-2.68	1.52
Cleaning and drying	1.72-7.36	3.47
-dried on bamboo mat and cleaned by wooden winnower	2.59-4.32	3.35
-dried on cement yard and cleaned by electric blower	2.61-5.16	4.10
-dried on cement yard and cleaned by simplified vibrating screen with electric blower	2.58-3.05	2.90
Storing	1.9-10.24	5.23
-wooden cabinet	1.9-3.88	2.89
-stored in bamboo mat	3.17-5.17	4.67
-Stack on the ground	6.04-10.24	8.14

rice, samples were randomly taken to measure the losses in every on-farm grain post-production activity with working sample of 1 500 grains each. For every item, three sub-samples were used with 50 grams for each. All work was done in the laboratories. The major items to be measured were: head rice recovery; milling recovery; germination rate; percentage of mouldy grains; and percentage of discolored kernels.

Limitations

Timeliness must be considered in assessing losses because delays greatly affect the results. The so-called "optimum harvesting time" was that the most of the crops in the field started to be harvested regardless the physiological maturity of the crops. The crops harvested three days before were "immature harvest" while that done three days after the most of the field crops were harvested was "delayed harvest." The quality changes from the delayed drying were observed by taking the samples from the piles that were internationally kept in farmers' house for 5 days. The samples served as the standard checks were taken immediately after harvest and dried under the sunlight up to the moisture content of 14%.

Results and Discussions

Quantitative Losses Assessment

The grain losses in each operation are listed in **Table 4**. Harvesting losses ranged from 0.29-2.34% in harvesting operation. Weighted average loss is 0.86%. Threshing losses were 0.62-1.03% and 0.9-2.68% as done with pedal thresher and motor thresher, respectively. Losses in the processes of drying and cleaning varied with the ways of drying and the methods of cleaning. Drying on cemented yard and cleaning with the electric blower had 2.61-5.16% of grain's losses, while with the same drying method but using simplified mechanical vibrating screen combined with electric blower, the losses ranged from 2.58-3.05%. The results of field trials in three crop seasons from different locations indicated that the losses from harvesting to storage in Jinghua, Jiaxing and Ningbo were 7.47%, 10.72% and 12.86%, respectively. The losses in different crops using the same operating method in harvesting, threshing, cleaning and drying operations are shown in **Fig. 1** indicating that the loss in barley is largest due to the fact that the motor thresher is not suitable for threshing barley. The first crop of

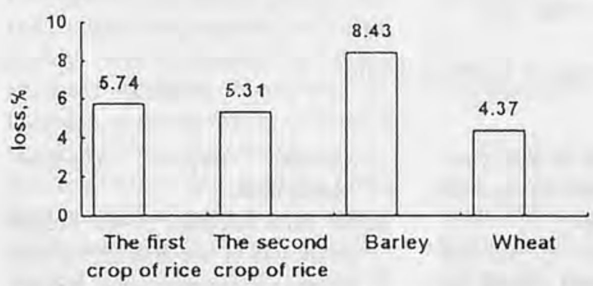

Fig. 1 Loss varied with different kinds of crops.

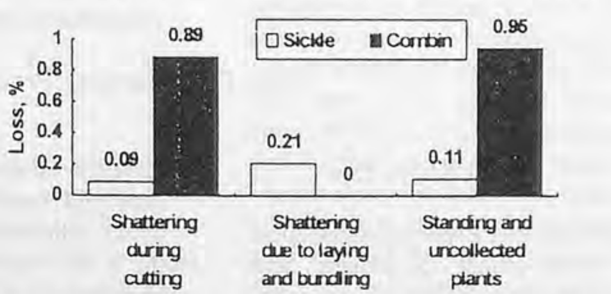

Fig. 2 Composition of losses in harvesting operation by methods.

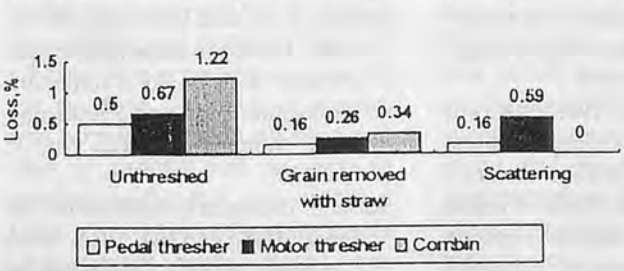

Fig. 3 Composition of losses in threshing operation by methods.

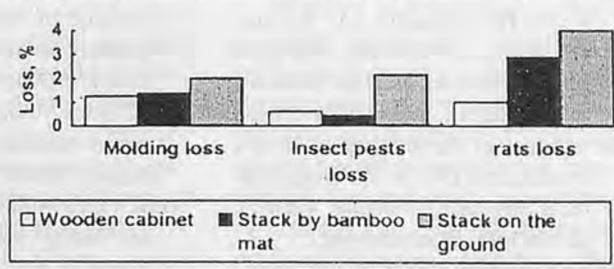

Fig. 4 Composition of losses in storage operation by methods.

Table 5. Qualitative Lossses of Grain Dried by 5 Days Delay (1987-89)

Type of crop	Decrease in weight in 1 000 grains, g	Decrease in germination rate, %	Increase in broken kernels, %
First rice crop	0.19	7.45	7.37
Second rice crop	0.45	4.27	4.54
Average	0.32	5.86	5.96

rice loss is larger than that for the second crops of rice. As to component losses in the processes from harvesting to threshing, the results were shown in **Figs. 2** and **3**. Compositions of losses using different storage method are showed in **Fig. 4**.

Qualitative Loss Assessment

Quality deterioration analysis shows that timely harvest can increase the head rice recovery, milling recovery and germination rate **(Table 5)**. The causes of timeless harvesting were due to the tightly growing season that required timely transplanting of the following crop, shortage of laborers, the weather and the defective farm equipment. The main factor causing delay drying was unfavorable weather condition.

Conclusion and Recommendation

1. Grain post-production system in South China depends mainly on manual power and natural force. The technologies were still behind and the equipment were obsolete with low efficiency. Total loss estimates from harvesting to storage, in Jinghua, Jiaxing and Ningbo were 7.47%, 10.72% and 12.86%, respectively.

2. New advanced equipment for cleaning is important since the loss in this process was large. The preselling cleaning equipments are very obsolete and inefficient.

3. Storage method should be changed with new storage methods such as wooden cabinet or concrete cabinet should be adopted to reduce storage losses and improve grain quality.

4. Attention should be drawn by the decision makers to the reduction of losses in the processes of post-production system. Programs, seminar and training for farmers should be held nationwide to create awareness on their part of the serious economic implications of post-production losses on the income of small farmers and the rice industry, in general.

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A Comparative Study of the Quality of Rough Rice Stored in Bamboo, Wooden and Metal Bins

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Abstract

An experiment was conducted to compare the quality of rough rice stored in three different types of cylindrical storage bins (bamboo, wooden and metal) of similar dimensions. Temperature, moisture content, germination capacity, insect infestation and 1 000 grain weight were recorded throughout the storage period and the changes in the quality of stored paddy were evaluated in terms of these variable. There was an increase in temperature of stored rough rice from bottom to top layers in bamboo and wooden bins. Minimum fluctuation of temperature between the layers and the highest temperature was observed in metal bin. The moisture content in the top layer was lower than in the middle and bottom layers of all bins. The germination capacity for the first 220 days of storage was almost equal in all bins and then it rapidly fell to zero in wooden and metal bins within a short time. Stored grain insect (*Angoumois* grain moth) was present mainly in the top layers of bamboo and wooden bins and in bottom layer of metal bin and more spoilage was observed. There was no significant difference in 1 000 grain weight between the layers within the bin. Rough rice stored in bamboo bin was found to be good in terms of temperature, moisture content and germination capacity in comparison with those in wooden and metal bins.

Introduction

Rough rice is essentially paddy that is harvested, threshed and dried but not husked. There are different types of storage systems for paddy at farm level commonly use in Bangladesh and in other non-industrialized countries. Among these, bamboo, wooden and metal bins of medium-sized capacities (300 kg) are common types of storage systems. Temperature and moisture content are two important factors influencing the distribution and abundance of insects and fungi. When conditions are favorable for these pests, severe deterioration may result.

Bhatnagar (1969) reported a replicated study on the Punjab Agricultural University (PAU) steel bins, indigenous mud bins and polythene lined mud bins for storage of wheat grain for a year. Moisture content, germination, insect infestation and temperature were studied. The grain stored in mud bins displayed higher moisture level, higher incidence of infestation and lower germination values. Polythene-lined mud bins and steel bins showed lower moisture level, lower infestation and higher germination values. The air tight steel bins were slightly better than the polythene-lined mud bins in having lower incidence of infestation and higher germination value.

Basnet and Jindal (1982) reported the changes of quality in terms of moisture content, bulk density, percent germination, milling yield and breakage strength of stored paddy in traditional bamboo bin and two ferro cement bins of conical and cylindrical shape, each of 0.5 ton capacity. The bamboo bin maintained an overall better quality of paddy during the four-month storage period than did the ferro cement bins.

Ahmed (1990) reported storage of wheat in *doles* (bamboo basket), *doles* with seeds dried at monthly interval, *doles* lined with 0.12 mm polythene bags, *doles* with seeds mixed with *biskathali* leaves, *doles* with coaltar coating, hessian bags, kerosene tins with air tight lids, polythene bags, and 0.12 mm thick polythene bags. Based on the viability retention capacity of seeds, the *doles* lined with 0.12 mm polythene, kerosene tins with air tight lids and 0.12 mm polythene bags were found to be efficient, maintaing a rate over 80% germination at the end of storage.

Bala et al. (1993) reported a replicated study on storage of paddy in three types of traditional bamboo storage bins of different sizes. The storage capacity of each of the storage bins was 370, 930 and 1 300 kg, respectively. They concluded that all these bins can be used for storage of paddy seeds from harvesting to sowing season and the smallest capacity bin (370 kg) is the best.

Basunia, M.A. and Takemi Abe (1996) reported the changes of quality of rough rice in terms of temperature, moisture content, percent germination, insect infestation and 1 000 grains weight of stored rough rice in a traditional bamboo bin (doles), commonly used in Bangladesh, and a modern thick paper bag, commonly used by the Japanese farmers. The paper bag maintained far better quality of rough rice during one year storage period than did the traditional bamboo bin.

Few scientific data are available to demonstrate the success or otherwise of these bamboo, wooden and metal bin storage systems, and information on temperature, moisture content, insect infestation, germination capacity and mold growth and extent of spoilage is also lacking. No comparative study has been reported on the temperature and moisture changes during storage of rough rice in similar sized bamboo, wooden and metal bins. The objective of this study is to present experimental studies on the changes of temperature, moisture content, germination capacity, insect infestation and 1 000 grain weight during storage of rough rice.

Materials and Methods

Three different types of cylindrical storage systems (bamboo, wooden and metal) were constructed for experimental studies. Dimensions of three storage systems were identical, having 1.0 m height and 0.8 m in diameter, respectively. The bamboo bin has a bottom as an integral part of it, and the metal and wooden bin do not. The metal bin wall was constructed by using hard polyurethane foam, called adiabatic material, between steel plates. The lower part of the metal bin was covered with wooden plate. The upper part of all bins were covered with wooden plates for removal with bamboo bin but not for wooden and metal bins. So the wooden and metal bins were almost air tight. All the bins were completely filled with rough rice with a constant capacity of 295 kg. All these three bins were placed on raised platforms inside a room ventilated to the atmosphere. A sampling spear was constructed to collect the grain samples from the storage bins.

In order to monitor the temperature of the grains, copper constantan thermocouples probes were inserted at three positions in each of the storage bin as shown in **Fig. 1**. Dimensions and positions of thermocouples for each storage bin are shown in **Fig. 1**

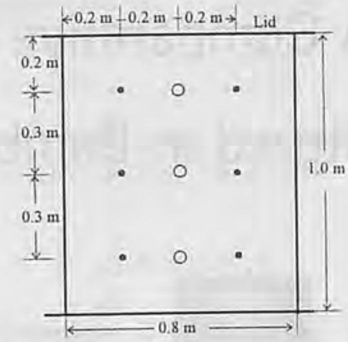

Fig. 1 The vertical section of an experimental cylindrical storage bin with the positions of thermocouples and grain sampling holes, ●, Grain sampling holes; ○, Thermocouple positions.

also. They were set at depths of 0.2 m, 0.5 m and 0.8 m from the surface of the grain bulk along the center of each bin. Thermocouple probes were connected through an interface of an AD converter (green kit 77a model) then to a personal computer for data collection. The temperature readings from the thermocouple probes were recorded every hour. Data was collected from November 22, 1994 to November 17, 1995 (360 days).

Grain samples were collected from three levels (0.2 m, 0.5 m and 0.8 m from the surface of the grain bulk) of each storage bin as shown in **Fig. 1**, by using sampling spear to measure the moisture content at an interval of 15 days. At each level, samples were collected from 2 locations at equal radius from the center of the bins. Moisture content measured at equal radii averaged and reported as one value, thus giving 3 locations. Sampling of the grain was carried out with a manual probe which have to be pushed into the grain mass. The sampling spear was pushed vertically in banboo and metal bins through the holes made earlier but horizontally in wooden bin to collect the grain sample from the desired locations. The probe has inner and outer tubes both with slotted holes along one side. The inner tube can be rotated such that, after the spare has been pushed in the grain mass, the slots can be brought into alignment allowing grain to follow into the inner tube. A reasonable representative sample is thus obtained from the depth penetrated by the spear. The samples thus obtained were used to determine the grain moisture content (w.b.) by oven drying at 135°C for 24 h. Each reading was replicated three times for each location and at each interval to get the average value.

The samples of grain collected from surface, middle and bottom layers of each of the bin were also used for measurement of germination capacity, insect infestation and 1 000 grain weight. A hundred grains were randomly selected for measurement of 1 000 grain weight, germination and insect infestation, respectively. Each reading was replicated three times to get the average value at each interval at each locations of the bins.

A hundred randomly selected grains were sterilized, soaked with distilled water for 24 hours, then placed on petridish lined with filter paper and placed into a germination chamber for 7 days maintained at a constant temperature of 25°C. The filter paper was moistened every day with fresh water to facilitate germination. The number of germinated seeds after 7 days was recorded as the germination percentage.

For measurement of 1 000 grains weight, a 100 randomly selected grains were weighed in a digital precision balance at an interval of 15 days and this weight was multiplied by 10. A hundred randomly selected grains were checked for insect damage and damaged grains were counted at an interval of 15 days.

The rough rice used was Japonica type and was collected from the Maki Agricultural Farm near the Agricultural faculty of Ehime University, Japan.

Statistical analysis was performed using the MICROSOFT software package. The normal test was selected for temperature data analysis as the number of observations was more than 30 and the t-test was used for other data analysis (Rabindra, 1992). The t-test was performed for moisture content, germination capacity, insect infestation and 1 000 grain weight and normal test was performed for temperature data analyysis. The difference in each of these parameters between any two layers for a given bin and between any two types of bins for a given layer was tested. The completely randomized design was considered in the above test.

Results and Discussions

The temperature and moisture content of the stored grain in the bins varied with time and position because of changing weather conditions. Ambient temperature and relative humidity for the storage period starting from November 22, 1994 to November 17, 1995 are shown in **Fig. 2**. The ambient temperature and relative humidity decreased gradually at the beginning of storage and then increased gradually for a considerable period. The temperature remained over 30°C for more than one month in the summer and then gradually fell. The average relative humidity remained around 71% throughout the storage period.

Temperature Changes During Storage

Temperature changes in stored rough rice in three different types of bins are shown in **Fig. 3**. The temperature was highest in the top layer and lowest in the bottom layer for the first 280 days in bamboo and wooden bins. Statistical analysis shows that there was no significant difference in temperature changes between any two layers with in a bin **(Table 1)**. There was also no significant difference of temperatures changes between the bin types except between the bottom layers of metal and bamboo bins **(Table 2)**. The minimum fluctuation of temperatures among the layers of metal bin, as shown in **Fig. 3(c)**, was due to low thermal conductivity of the adiabatic material used in the wall of the metal bin. Heat developed in the metal bin mainly due to the respiration of grain. The highest temperature was 35°C in the metal bin. The high temperature in the top layer, of up to 34.5°C in the bamboo bin, was mainly due to the highest infestation of insects (*Angoumois* grain moth) at the

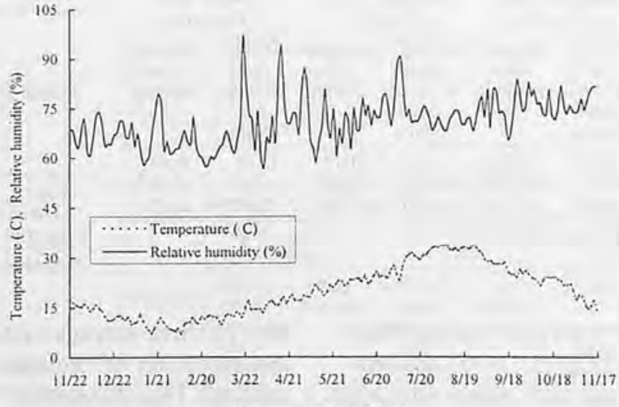

Fig. 2 Ambient temperature and relative humidity changes during storage of rough rice.

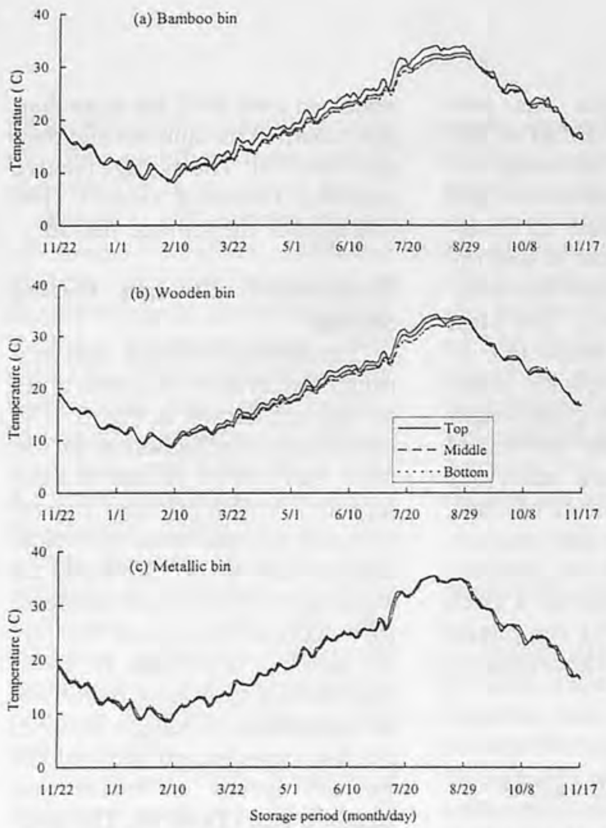

Fig. 3 Temperature changes during storage of rough rice in three different layers of bamboo, wooden and metal bins.

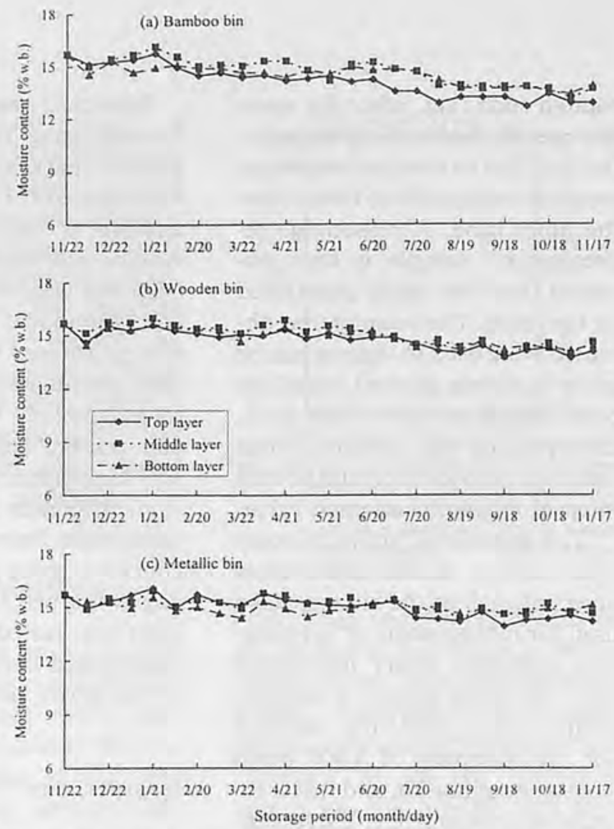

Fig. 4 Moisture content changes during storage of rough rice in three different layers of bamboo, wooden and metal bins.

Table 1. Statistical Analysis of Temperature Data in Different Layers of Each Bin During Storage by the Normal Test Method

Type of bin	Top and Middle		Middle and Bottom		Top and Bottom	
	Difference between two means	Normal test statistic	Difference between two means	Normal test statistic	Difference between two means	Normal test statistic
Bamboo	0.86	0.102	0.43	0.559	1.29	1.670
Wooden	0.56	0.725	0.30	0.391	0.86	1.128
Metal	0.07	0.087	0.12	0.149	0.20	0.236

Table 2. Statistical Analysis of Temperature Data During Storage by the Normal Test Method

Position	Bamboo and Wooden		Wooden and Metal		Metal and Bamboo	
	Difference between two means	Normal test statistic	Difference between two means	Normal test statistic	Difference between two means	Normal test statistic
Top	0.03	0.042	0.15	0.187	0.12	0.145
Middle	0.27	0.816	0.79	1.867	1.05	1.317
Bottom	0.40	0.532	1.20	1.550	1.60*	2.051

*Significant ($P<0.05$).

Table 3. Statistical Analysis of Moisture Content Data in Different Layers of Each Bin During Storage by the T-test Method

Type of bin	Top and Middle		Middle and Bottom		Top and Bottom	
	Difference between two means	t-test statistic	Difference between two means	t-test statistic	Difference between two means	t-test statistic
Bamboo	0.32*	2.414	0.22	1.104	0.37	1.693
Wooden	0.32	1.908	0.19	1.777	0.13	0.865
Metal	0.32	1.191	0.21	1.953	0.04	0.259

*Significant ($P<0.05$).

Table 4. Statistical Analysis of Moisture Content Data During Storage by the T-test Method

Position	Bamboo and Wooden		Wooden and Metal		Metal and Bamboo	
	Difference between two means	t-test statistic	Difference between two means	t-test statistic	Difference between two means	t-test statistic
Top	0.32*	3.031	0.24	1.438	0.92*	4.065
Middle	0.44	1.993	0.08	0.542	0.52*	2.602
Bottom	0.43*	2.687	0.07	0.570	0.50*	3.571

*Significant ($P<0.05$).

top layer.

After 205 days of storage starting from July 15, 1995, the temperature in all three storage systems were in the optimum range for insect infestation, and resulting a rapid fall in germination in three storage system with the exception of the top layer of bamboo bin. Maximum fluctuation of temperatures was observed in bamboo bin because of comparatively free air movement through the porous wall of the split bamboo. However, there was a continuous persistence of high temperature both in wooden and metal bin because of comparatively low thermal conductivity of the bin wall material. There was the risk of a significant amount of damage of the stored paddy due to insect heating and, therefore, germination become zero in wooden and metal bin within a short time. Grains lost their viability with the increase of temperature because of almost no air movement through the storage systems, particularly in wooden and metal bins.

Moisture Changes During Storage

The grains had uniform moisture content of 15.7% (w.b.) before entering the storage. Moisture changes during storage followed similar patterns in all three storage systems (**Fig. 4**). Moisture content almost gradually decreased in three types of bins throughout the storage period. Changes in moisture content in bamboo bin was mainly due to desorption of moisture to the ambient air. Moisture changes in wooden and metal bins were mainly due to moisture migration within the bin. The moisture content of the top layers decreased considerably because of low humidity of the ambient air. Moisture content changes were significant between the top and middle layers of the bamboo bin only (**Table 3**).

There was a significant difference of moisture content changes between the layers of bamboo and metal bins (**Table 4**). There was no significant difference in moisture content changes between the layers of the wooden and metal bins. Moisture content changes were also significant between the top layers as well as bottom layers of bamboo and metal bins, but not between the middle layers (**Table 4**).

Germination Capacity

The percentage germination of rough rice stored in three storage systems is shown in **Fig. 5**. Almost equal percent germination was observed in three storage systems for the first 210 days of storage, when the storage temperature was within 25°C. The germination capacity of the grain in wooden and metal bins rapidly fell to zero within a short period, as indicated in **Figs. 5(b)** and **(c)** with the increase of ambient temperature. This was possibly due to almost no ambient air movement through the wooden and metal bins. This causes the loss of viability of rough rice grain with the increase of ambient temperature. The germination capacity of grain in bamboo bin also fell rapidly but not to zero, as shown in **Fig. 5(a)**. Due to comparatively low ambient air movement in the middle and bottom layers of bamboo bin, germination capacity of the grain of these layers fell more rapidly than the top layer. The main reason of falling germination capacity of the top layer grain of the bamboo bin was due to high insect infestation

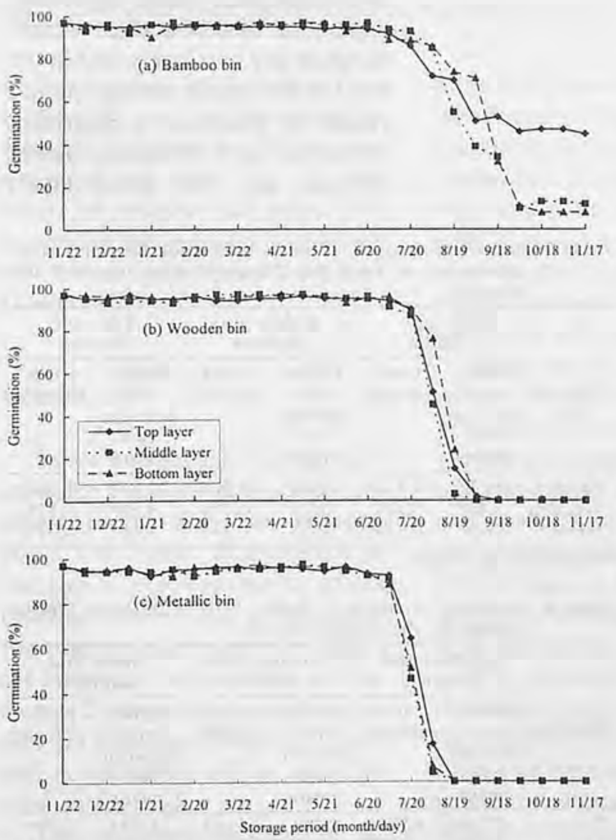

Fig. 5 Percentage of germination during storage in three different layers of bamboo, wooden and metal bins.

Table 5. Statistical Analysis of Germination Capacity Data in Different Layers of Each Bin for the Rest of the Period after 210 Days of Storage by the T-test Method

Type of bin	Top and Middle		Middle and Bottom		Top and Bottom	
	Difference between two means	t-test statistic	Difference between two means	t-test statistic	Difference between two means	t-test statistic
Bamboo	6.16	0.791	1.00	0.106	5.16	0.665
Wooden	0.95	0.103	3.20	0.361	2.25	0.266
Metal	2.28	0.315	0.72	0.093	1.56	0.220

Table 6. Statistical Analysis of Germination Capacity Data During Storage by the T-test Method

Position	Bamboo and Wooden		Wooden and Metal		Metal and Bamboo	
	Difference between two means	t-test statistic	Difference between two means	t-test statistic	Difference between two means	t-test statistic
Top	33.70*	2.492	7.90	0.491	41.60*	3.475
Middle	30.40	2.074	8.50	0.553	38.90*	3.015
Bottom	18.80	1.069	14.20	0.876	33.00	2.176

*Significant ($P<0.05$).

and rat attack in this layer. This indicates that the viability of the grain in top layer of the bamboo bin remained unchanged throughout the storage period. There was no significant difference in germination capacity of grain between the layers within the bin (**Table 5**). A significant difference in germination capacity of grain was observed between the top layers of the bamboo and wooden bins. There was also a significant difference in germination capacity changes between the top layers as well as middle layers of metal and bamboo bins (**Table 6**).

Insect Infestation During Storage

There was an infestation of *argoumois* grain moth (*Sitroga cerealellaa* Olivier) in all three types of storage systems (**Fig. 6**). Heat developed during respiration was mainly from the respiration of insects. A rapid and significant changes in temperature occurred in stored grain due to the metabolic activity of the insect population. The insect infestation was high in the top layers and very low in the middle and bottom layers of bamboo and wooden bins. Rats also attacked the top layer grain of bamboo bin. But in the metal bin insect infestation was high in the bottom layer as compared to top and middle layers.

There was a significant difference in insect infestation between the top and middle layers as well as top and bottom layers in all bins (**Table 7**). But there was no significant difference between the middle and bottom layers within the bin. There was a significant difference in insect infestation between the layers of the bamboo and the wooden bins. There was also a significant difference in insect infestation between the top layers and bottom layers of metal and bamboo bins (**Table 8**). Statistical analysis shows that there is no significant difference in insect infestation between the layers of wooden and metal bins (**Table 8**).

Weight of 1 000 Grain

The 1 000 grain weight is an indicator of the quality of soundness of the grain. **Fig. 7** shows that 1 000 grain weight of rough rice during storage in the bamboo, wooden and metal bins. In almost all cases, 1 000 grain weight was the lowest in the top layers of all the storage bins. The lowest 1 000 grain weight was observed in the top layer of bamboo bin due to high rat and insect infestation. Statistical analysis shows that there was no significant difference of 1 000 grain weight between any two layers within the bin for the whole storage period (**Table 9**). There was a significant difference in 1 000 grain weight between any two given layers

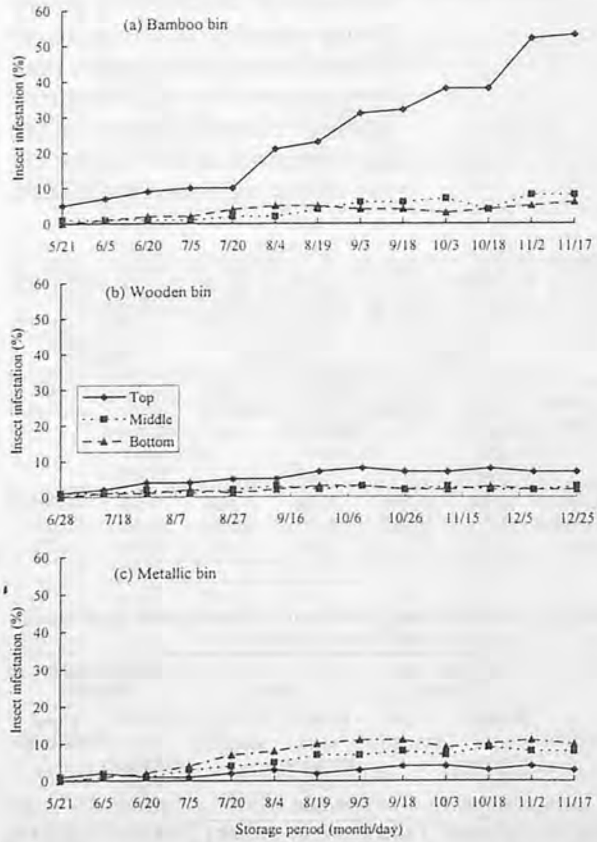

Fig. 6 Percentage of insect infestation during storage of rough rice in three different layers of bamboo, wooden and metal bins from the 180th day of storage.

Table 7. Statistical Analysis of Insect Infestation Data in Different Layers of Each Bin During Storage by the T-test Method

Type of bin	Top and Middle		Middle and Bottom		Top and Bottom	
	Difference between two means	t-test statistic	Difference between two means	t-test statistic	Difference between two means	t-test statistic
Bamboo	21.38*	4.529	0.46	0.505	21.85*	4.664
Wooden	3.46*	5.237	0.23	0.707	3.69*	5.476
Metal	2.85*	3.324	1.85	1.337	4.69*	4.010

*Significant ($P<0.05$).

Table 8. Statistical Analysis of Insect Infestation Data During Storage by the T-test Method

Position	Bamboo and Wooden		Wooden and Metal		Metal and Bamboo	
	Difference between two means	t-test statistic	Difference between two means	t-test statistic	Difference between two means	t-test statistic
Top	19.77*	4.206	3.00	4.285	22.77*	4.877
Middle	1.85*	2.207	3.31	4.012	1.46	1.286
Bottom	1.62*	2.945	3.85	3.816	2.23*	2.043

*Significant ($P<0.05$).

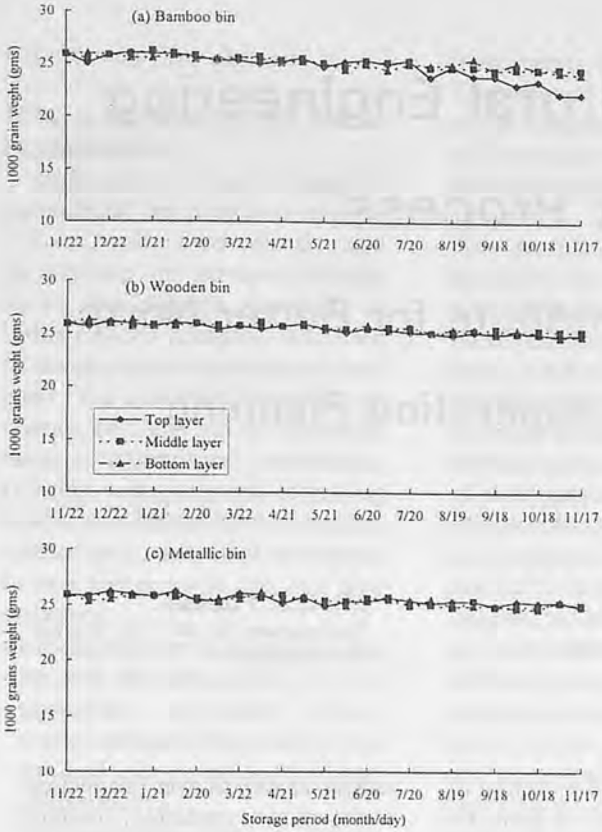

Fig. 7 1 000 grain weight during storage in three different layers of bamboo, wooden and metal bins.

Table 9. Statistical Analysis of 1 000 Grain Weight Data in Different Layers of Each Bin During Storage by the T-test Method

Type of bin	Top and Middle		Middle and Bottom		Top and Bottom	
	Difference between two means	t-test statistic	Difference between two means	t-test statistic	Difference between two means	t-test statistic
Bamboo	0.41	1.807	0.10	0.660	0.31	1.363
Wooden	0.15	1.630	0.04	0.410	0.11	0.988
Metal	0.06	0.588	0.05	0.491	0.12	1.060

Table 10. Statistical Analysis of 1 000 Grain Weight Data During Storage by the T-test Method

Position	Bamboo and Wooden		Wooden and Metal		Metal and Bamboo	
	Difference between two means	t-test statistic	Difference between two means	t-test statistic	Difference between two means	t-test statistic
Top	0.68*	2.927	0.04	0.322	0.72*	3.085
Middle	0.37*	3.129	0.19	1.9274	0.18	1.342
Bottom	0.39*	3.426	0.31*	2.772	0.08	0.633

*Significant ($P < 0.05$).

of the bamboo and wooden bins (**Table 10**). A significant difference in 1 000 grain weight was also observed between the bottom layers of wooden and metal bins as well as between the top layers of metal and bamboo bins (**Table 10**).

Conclusion

There was an increase in temperature from the bottom to top layers in bamboo and wooden bins. The higher temperature in the top layers was due to insect heating. There was a minimum fluctuation of temperature within the layers of the metal bin and an elevated temperature persisted in this bin because of very low thermal conductivity of the material used in the wall.

The moisture content in all three types of bins fell gradually with the storage period. A comparatively low moisture content was found in the top layers of all storage bins due to desorption of moisture to the ambient air. There was almost no significant difference in moisture content changes between the layers within the bin except between the top and middle layers of the bamboo bin.

There was a significant difference in moisture content changes between the bin types with the exception of wooden and metal bins and the middle layers of bamboo and wooden bins. Brightness of the grains seemed to have slightly deteriorated in the metal bin and the grain became packed, specially in the bottom layer.

The germinatioin capacity of the stored grain fell greatly with the increase in ambient temperature in all bins and the grain in the wooden and metal bins totally lost their viability within a short time. The germination capacity of the grain, was highest in the bamboo bin, specially in the top layers because of comparatively free ambient air movement in this layer.

There was no significant difference in 1 000 grain weight between the layers within the bin but there was a significant difference between the bin types, mainly between the bamboo and the wooden bins. The lowest 1 000 grain weight was found in the top layer of the bamboo bin because of high insect and rat infestation.

Insect infestation was highest in the top layers of the bamboo and wooden bins and the bottom layer of the metal bin. There was a significant difference in insect infestation between the top and middle layers as well as the top and bottom layers in each bin.

All of these bins can be used for storage of rough rice for eating purposes only, but not for seed purposes. The bamboo bin was the best of the three bins. The metal bin was the worst.

The small capacity bamboo bin (capacity < 100 kg) seems to be an alternative for storing seed rice if it is protected from rats and insects.

(Continued on page 52)

The Role of Agricultural Engineering in the Development Process

Some Basic Aspects to Contribute for Better North-South Understanding and Cooperation Planning

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Foreword

The intention of this paper is to continue discussions started during the meeting of the respective special interest group at AG ENG 92 Conference in Uppsala and to initiate the formation of an EUR AGENG or even CIGR and hoc working group or a competent forum of Agricultural Engineering in the Tropics and Subtropics.

Agricultural Engineering and Mechanization of Agriculture

What does it mean?

Agricultural engineering is the discipline that deals with design, production, utilization and management of technical means and processes for production, storage, treatment and processing of agricultural goods (plant and animal production, post-harvest technology).

Included is the utilization of agricultural products as food-and fodder as well as as energy source or industrial raw material. Included is also the technology of treatment, upgrading and recycling of rest-and by-products to generate and use renewable energy in integrated energy systems or to serve as fodder or soil-improving/fertilizing material.

Agricultural engineering may also include responsibility for planning, implementation and maintenance of rural infrastructure (transport, irrigation, energy). And last but not least agricultural engineering extends to landscape maintenance and public services like cleaning of ditches, cutting of hedges.

Agricultural engineering covers all levels of mechanization from physical, chemical and biochemical basic processes, from simple hand-tools over draught-animal-power-systems to simple and more complicated small and big tractors and self-propelled harvest machines and automatic, computer-aided control systems and robotics in field and post-harvest operations as well as in animal production.

Agricultural engineering extends over the branches of research, education, training, extension as well as over production, maintenance, repairing, managing, testing and evaluation of farm machinery.

Agricultural engineering is an integrating discipline that tries to realize and implement ideas, identified as useful and necessary by other disciplines and to strengthen interdisciplinary cooperation.

Agricultural engineering and mechanization aims at:

- increasing land and labour efficiency;
- serving to extend agricultural area;
- saving resources (seed, fertilizer, water) and energy;
- improving products quality;
- protecting the environment (f.i. manure treatment);
- saving sustainability of agricultural production;
- reducing hard work and drudgery;
- improving operator's safety;
- creating attractive jobs for men and women to prevent rural exodus;
- improving farm machinery management and multi-farm-use; and

• increasing farm income.

What is the Role of Agricultural Mechanization

Can society afford to neglect agricultural engineering or even to prevent further mechanization and to develop an adverse attitude as we can observe, especially in industrialized countries and even in development-cooperation agencies? We are sure, there is no chance for survival of mankind without agricultural mechanization but suitability and effects as well as side effects have to be considered and controlled thoroughly and better as in the past few decades:

- Mechanization has a substantial on-and off-farm effect. It is a powerful instrument which can be utilized efficient and fruitful and can be misused as any technology;
- Mechanization has a strong impact on the socio-economic situation. Over-mechanization can set labour free and create unemployment but mechanization also can create more and better new jobs in the ante-and post-production area and generate spare time for education, social, cultural and political activities and human development;
- Mechanization so can contribute to stop the rural exodus;
- The distribution of labour between men and women can be effected substantially by advanced mechanization. Special attention therefore has to be given, especially to food production and on-farm post-harvest technology which mainly is womens' field;
- Government policy plays an important role in the mechanization process (prices of agricultural products and farm machinery, level of wages, foreign exchange and import regulation and taxes, research, training, testing, extension and investment credit);
- Therefore, for countries in mechanization progress it seems to be obligatory to develop their mechanization policy and strategy;
- The farmer and his family have to make their independent decision on each step into advanced mechanization based on know-how, technical infrastructure, market price and availability of technical products to really identify themselves with their choice of mechanization;
- Mechanization affects energy consumption. Mainly fuels are needed which can cause dependencies, but there are alternatives of renewable energy or draught animal power.
- Mechanization makes operations more precise and so can contribute to protect the environment (application of agro-chemicals) and save resources; and
- Mechanization of agriculture over local production of farm machinery very often is the first step into and incentive for advanced general industrialization.

So mechanization has a strong impact on social and economical as well as ecological development. Because there is no way without mechanization we have to look for a situation conform mechanization with positive turn-out.

Agricultural Engineering and Mechanization in West Europe and its Role in North-South-Cooperation

Dividing mechanization from handhoe over animal traction, simple tractors and machines to automated machinery into four groups West Europe arrived in groups III and IV with few exceptions only, while in Southeast Asia and South America only a few countries and farm holdings exceed I to III and Africa south of the Sahara is primarily in groups I and II.

This is necessary to remember because jumping over too wide a gap may be — and often was — fatal.

In West Europe less than 10% of the active population are working in agriculture and many countries are suffering from agricultural overproduction. In developing countries 50% or more of the active population are working in agriculture and many of them are obliged to import food. Prevailing subsistency farming based on animative power (that means hand tools and draught animal power) is not in the position to produce food for the growing urban population. Export of agricultural products, often the only source of foreign exchange, on the contrary is generally based on at least partly mechanized production.

Category	Level of Mechanization
I	hand tools
II	draught animal power
III	simple motor mechanization
IV	sophisticated technology

	I	II	III	IV
AFRICA	x	x		
S. AMERICA	x	x	x	
S.E. ASIA	x	x	x	
E. and M.E. EUROPE			x	
W. EUROPE and N. AMERICA			x	x

Fig. 1 Level of mechanization, worldwide.

In the first decade of development cooperation the donor countries tried to export their technology with little modification and adaptation into many developing countries, jumping from Phase I to Phase III. The results were disappointing and frustrating due to lack of training of operators, absence of necessary infrastructure, lack of spare-parts, fuel and other problems. Many remainders of farm machinery out of operation demonstrate this failure.

The success of the "green revolution" in the seventies is based on increased use of farm inputs, including farm machinery. The social consequences of this development are well known and hard to be compensated so that acceptance still is lacking in many countries, especially in Africa.

The following "appropriate technology" approach was of limited success only, mainly because many people believed small, simple and cheap technology means appropriate and a lot of unprofessional design and manufacturing lead to disappointing results and early failure.

So many projects of technical cooperation failed or at least were lacking sustainability because of many reasons, six of them being symptomatic:

- missing or inadequate infrastructure;
- target group not involved and adequately prepared in the planning phase;
- targets and goals too high and not to be reached;
- time of cooperation too short to stabilize the project;
- too much personal fluctuation; and
- income not increased.

The projects also often failed because the necessity of technical know-how and the participation of agricultural engineering — as the responsible discipline — was underestimated or not at all involved.

Today, therefore, the majority of German North-South bilateral projects in the field of agricultural engineering are devoted to technical training, demonstration, testing and extension and go far beyond the pure technical approach to rural development.

Coordination of activities and integration into a general development plan is another problem. Agricultural engineers in the European countries are organized in many regional and national groups according to their activities and specific interests such as farm machinery and tractor manufacturers associations — as a branch in the greater associations of machinery and vehicle production industries —, import- and dealers organizations or agricultural engineering research organizations (**Fig. 2**). There is an intensive flow of information.

Examples in Germany are the Association of Engineers (VDI) with a special branch of agricultural engineers, the "Max-Eyth-Gesellschaft" (MEG) or the association of farm machinery and tractor producers (LAV). Respective examples are UNACOMA in Italy or the Vimpoltu and the Nederlandse Vereiniging Techniek in de Landbouw (NVTL) in the Netherlands.

These national groups are linked internationally. So LAV, the German Association of farm machinery and tractors manufacturers, is a member of the "Comité Européen des Groupements de constructeurs du Mechanisme Agricole" (CEMA). From the next year VDI/MEG will be knots in the network of European associations controlled by EUR AG ENG and member of the world-wide operating "Comission International de Genie Rural" (CIGR).

According to CIGR there exist

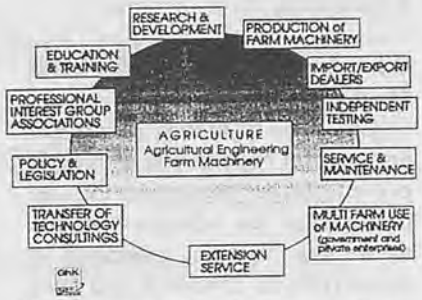

Fig. 2 Network of institutions contributing to progress in agricultural engineering.

about 60 other national or subregional agricultural engineering societies worldwide, 80% of which are found in the developing countries.

In Southeast Asia the Regional Network for Agricultural Machinery (RNAM) is doing efficient coordination work in design, testing and manufacturing of farm machinery since 1978 (but seems to run out of support), and similar networks are in the preparatory phase in Africa and South America.

There is a necessity of concentration, cooperation and networking instead of fragmentation to be able to clearly represent agricultural engineering demands and to compete with demands of other groups in the society and in the political process. So it should be recommended to establish similar structures in all the countries of the world to live and cooperate under the same roof.

How can West European Industrialized Countries Contribute to Worldwide Agricultural Mechanization Development?

World politics are changing. New developments in East Europe and economic stagnation and/or regression make not only money more rare than before but necessarily direct many activities towards new focuses. Thus, we have to look more intensive for an effective, fruitful North-South cooperation, for stable and permanent links on one side and growing independence on the other side.

For the fruitful development of agricultural mechanization all involved groups from donor countries as well as from the so-called developing countries and last not least the target group together should aim at the production of a demand-oriented quantity and quality of food, fodder and commercial / industrial agricultural products and energy plants regarding:

- saving of resources and energy;
- protection of the environment;
- maintaining the productivity of soils; and
- respecting social-cultural, economic and political aspects.

Special engagement, cooperation and support from the West European countries in the field of agricultural engineering and mechanization of developing countries (including mainly the increasing number of privatized advanced — and that means motor-mechanized — enterprises) shifting more and more from bilateral to internationally coordinated North-South and South-South cooperation and joint ventures could be expected in the following direction.

- elaborating regional and national policies / strategies for agricultural engineering and mechanization;
- coordinating and integrating individual and bilateral projects into a general development plan;
- standardize monitoring and evaluation of cooperation projects to adapt them to changing conditions and to add a long-lasting active follow-up;
- strengthening of local applied research, education, training and extension as most efficient long-term investments;
- cooperating in the development of suitable curriculae of schools, colleges and universities in the field of Agricultural Engineering in the tropics;
- to promote North-South cooperation in training more on post-graduate than on B.Sc./M.Sc. programmes;
- stopping brain drain from DCs, that means mainly to motivate top scientists and managers to return to their home countries giving them suitable conditions to work;
- improving flow of information / documentation;
- sharing the job of agricultural engineering research and development and cooperation instead of duplication and waste of resources;
- establishing long-term North-South partnerships to improve sustainability of projects not only in the manner of after-sales service but as long-lasting mutual fruitification, follow-up, feedback and adaptation;
- strengthening of networking and South-South-cooperation;
- promoting local close-to-the-consumer design and manufacturing in independent private enterprises;
- promoting independent practical testing and evaluating of tools, implements and farm machinery (also f.i. by joint ventures) under local conditions;
- promoting decentralized local post-harvest technology units to close production, consumption and recycling circuits with little transport;
- improving farm machinery management and promoting privatized multi-farm use;
- improving the necessary infrastructure and standardization of agricultural production process for efficient utilization of mechanization;
- looking not for individual technical solutions only, but for the optimization of integrated mechanization systems in an interdisciplinary approach for rural development; and
- introducing Agricultural Engineering research in the mandate of the CGIAR-instituts.

A well balanced level of competition and cooperation between European Agricultural Engineering in this field seems to be optimal. The cooperation and integration of the majority of European Agricultural Engineers of all professional sectors can form the basis for a stronger and more efficient European policy on North-South technical and scientific cooperation. EC-research programmes like Life Sciences and Technology for Developing Countries (STD) as well as many national programmes contribute substantially to both, cooperation between European countries and between partners from EC- and so-called developing countries. The future role of agricultural engineering and mechanization depends on situation-conform solutions, acceptable not only for the farmer but for the society as a whole. The necessity to identify and implement technical and management solutions only that — beside others targets — contribute to increase the income of those depending on agriculture as vital incentive and motivation for increased production cannot be overemphasized.

Conclusion

It seems necessary to standardize the definition of "Agricultural Engineering" as a far extended innovative scientific application orientated discipline that serves and integrates agronomic disciplines in developing basics as well as situation-conform technical solutions on all levels of mechanization, regarding socio-economic as well as ecologic aspects. The role of agricultural mechanization is an integrated and not to be missed part of rural development not only to feed increasing population and to produce raw materials but to save energy and resources, to improve the level of rural life and to stop the rural exodus. At least in the early stages of industrialization agricultural mechanization is the prime mover of technological progress.

There is an enormous potential of know-how and worldwide — not always positive — experience in agricultural mechanization in west European industrialized countries, which can contribute substantially to solve the most urgent problems of the future of developing countries, but which also, if not adequately utilized, is threatened to get lost.

Only 6 years before the beginning of the next thousand years phase and with still growing demand for food and agricultural products based on a sustainable production and at decreasing inputs the challenge of AG ENG is to learn from mistakes of the last decades and to strengthen worldwide cooperation and know-how exchange. Situation conform solutions are available and have to be implemented.

Networking proved to be an efficient instrument. So existing regional knots and fragmentary networks should be knit and strengthened to serve as mundial agricultural engineering and mechanization network. So governments, donors and agencies of technical cooperation should devote adequate attention and support to Agricultural Engineering institutions, organizations and activities instead of reducing budgets and projects.

It is our challenge to convince politicians, decision makers, target groups and the society as a whole, that to continue and strengthen efforts and national as well as international programmes aiming to solve or improve items of the list, mentioned above to promote Agricultural Engineering and situation conform mechanization as a whole is vital to guarantee sustainable food production for the still growing world population.

Agricultural Engineers have to be represented in decision making in national and international positions as well as in the CGIAR centres. After a period of failure, discredit and lack of orientation new activities and projects of agricultural engineering and mechanization have to be started to prevent an increasing gap in the so-called developing countries and to promote the necessary increase of sustainable agricultural production. ■■

(Continued from page 47)

A Comparative Study of the Quality of Rough Rice Stored in Bamboo, Wooden and Metal Bins

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Design and Development of Small Container for Controlled Atmosphere Storage

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Abstract

A low-cost controlled atmosphere storage system was designed and constructed based on the principle of steady state diffusion. The system was developed from a 100 × 75 × 60 cm PVC container. By using Fick's law of diffusion, it was provided with two diffusion channels: one for oxygen equilibrium and the other, for carbon dioxide. The relative humidity was controlled by means of a saturated solution contained in a channel especially designed for that purpose as well as to provide a good airtight operation.

The main objective was to establish a dynamic equilibrium between the rate of respiration of the produce and the rate of diffusion of gases in and out of the system, thus permitting the control of these gases throughout the storage period.

Cos lettuce was used for testing the CA container under a pre-established atmosphere of 3.5% O_2 and 0.5% Co_2. Results showed that the container can be used to provide controlled atmospheres low-cost conditions for perishable products.

Introduction

Losses in quantity and quality occur in fruits and horticultural products between harvest and consumption. Kader (1985) estimated the magnitude of postharvest losses in fresh fruits and vegetables to be between 5 to 25% in developed countries, and 20 to 50% in developing countries. The losses are highly dependent on the availability of proper storage facilities.

The storage period for fruits and vegetables varies widely. Some such as apricots, green peas and tomatoes may be stored for a few days to two weeks, while others may be stored for longer periods, up to 8 months for apples and potatoes. (Kader, 1985).

Even though biological or physiological changes in fresh produce cannot be completely stopped by certain techniques, it is possible to slow them down within certain limits.

One of these techniques is known as Controlled Atmosphere (CA) which means the precise control of atmospheric gases in a storage environment where the concentration of carbon dioxide is high and that of oxygen low. The effect is to reduce the rate of respiration of the crop, with the result that it may be stored for a longer period at a higher temperature than the usual time.

Controlled Atmosphere systems can be used during transport or temporary or long-term storage of perishable commodities destined for fresh market or processing. Occasionally, other gases such as carbon monoxide are added in low concentrations to keep cut surfaces from darkening, but this practice is not considered part of CA storage (Kader, 1985).

The effects of CA depend on the nature of the product stored, environmental variables, building and duration of storage. However, the produce to be stored must be first-class quality. Controlled atmosphere storage can only maintain quality not improve initially inferior products. This is very important because CA stores are expensive to build and equip, and may not be an economic proposition in some cases (Zahradnik and Southwick, 1958).

Among the environmental factors investigated by postharvest researchers, temperature, relative humidity, carbon dioxide and oxygen seem to be the most important variables related to deterioration of perishable in store (Lau, 1983; Lougheed, 1987; Smith and Reyes, 1988). Previous research has been carried out to develop low cost CA stores, but not many of them have also considered the control of relative humidity (Ayenew, 1990).

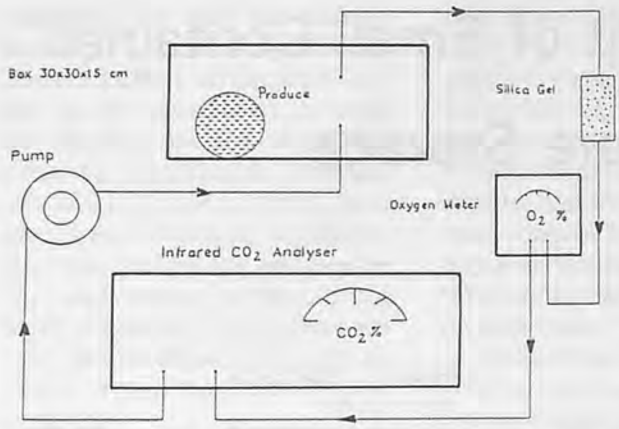

Fig. 1 Measurement of O_2 and Co_2 concentrations in a closed system.

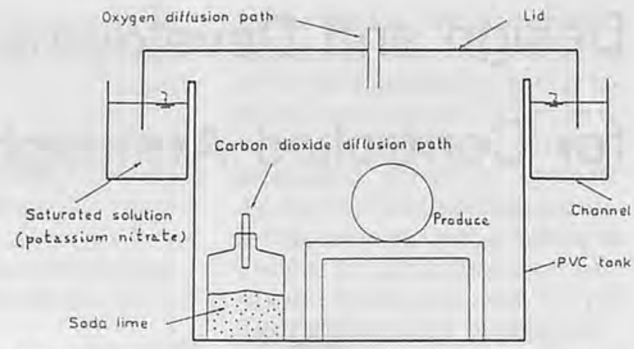

Fig. 2 Schematic diagram of the prototype CA storage container.

The development of CA storage conditions easy to construct with the minimum cost is a very good alternative can be applied in developing countries. For those reasons, the objectives of this project were:

1. To design a low-cost controlled atmosphere storage system, which included the control of relative humidity.
2. To perform a preliminary test for the short-term storage.

Materials and Methods

Definition of Variables

A 100 × 75 × 60 cm low-cost controlled atmosphere container was designed and constructed. The size was used for experimental purposes to permit the control of temperature, carbon dioxide and relative humidity.

A common and applicable gas exchange equation is a modified form of the Fick' law equation,

$$E = -D * (Ci - Co) * A/X$$

where E is the mass transfer of the gas, Ci and Co are the concentrations of the gas within and external to the commodity, respectively. A is the portion of the commodity's surface area perforated by air-filled spaces, and X is the thickness of the barrier limiting gas exchange.

The diffusion coefficient D is related to air pressure and the absolute temperature as follows:

$$D = Do * (T/To)^m * (P/Po)$$

with Do as the diffusivity of the gas at 273°K and 760 mm Hg, and m, a constant, between 1.75 and 2 depending upon the nature of the gas mixture.

Assuming m = 2 and that there is no difference between the pressure P in the commodity and the atmospheric pressure Po, then, the value of D may be calculated such that:

$$D = Do * (T/To)^2$$

The basic design variables to achieve CA conditions were: the respiration rate of the product, the desired levels of carbon dioxide, oxygen and relative humidity, the diffusion coefficients of the gases, the mass of the product, and the temperature.

Respiration Rate

This is one of the most important factors to be considered in the design of a CA container. In the present study respiration rates of the produce were assessed in the laboratory at 10°C and two atmospheric conditions: in normal air, and at 3.5% O_2 and 0.5% Co_2.

Cos lettuces were used in this experiment, which were placed in a sealed 30 × 30 × 15 cm plastic chamber (**Fig. 1**). The atmosphere of the closed system circulated through an infrared CO_2 analyzer and an oxygen meter. To avoid side effects on respiration rate, the duration of the test was limited to a period of 4 h. An increase in CO_2 from 0.03 to 0.5% was achieved by extracting around 2 ℓ of air from the container and injecting the quantity of pure carbon dioxide.

Maintaining CA Conditions

In order to maintain oxygen and carbon dioxide as desired, it was necessary to design the diffusion channel for these gases. Carbon dioxide removal was achieved by means of a bottle containing 500 g of soda lime, which was connected to the container's atmosphere through a tube having the area to the length ratio (A/X) equal to 1.416 cm. The O_2 consumed by respiration of the crop was replaced by via a diffusion path of 0.223 cm diameter and 0.25 cm length. Cos lettuces (3 kg) were placed inside the PVC tank supported by a plastic tray (**Fig. 2**).

In order to keep the desired CA conditions, the tank was sealed by means of a water channel, which was used both to seal the container and to control relative humidity. A saturated solution of potassium nitrate (11 500 cm^3) was placed in

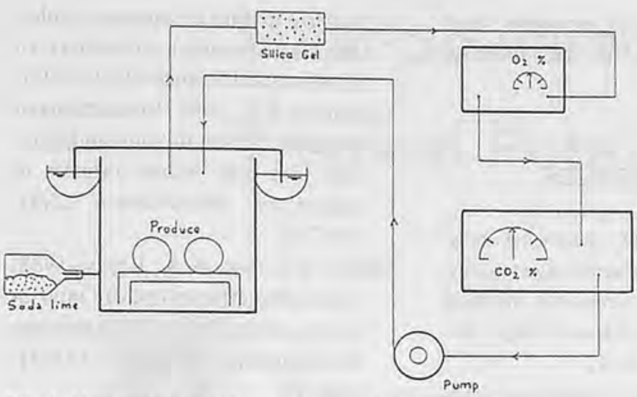

Fig. 3 Monitoring of CA environment in the container.

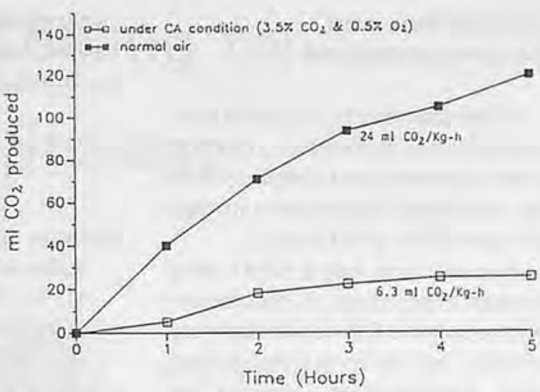

Fig. 4 Respiration rate of Cos lettuce in normal air and under CA conditions.

the channel to provide a relative humidity at 95% level in the container (**Fig. 3**).

The CO_2 concentration was monitored with an infrared CO_2 analyzer, whereas the O_2 was measured by using a Taylor Servomex type OA 250 oxygen analyzer. Relative humidity was measured with a Michell Series 3000 dew-point thermometer.

Table 1. Concentrations of CO_2 and O_2 within a Storage Container at 10°C. Nominal atmospheric composition (3.5% O_2 and 0.5% CO_2)

Days		Time of Measurement			
		0800	1200	1600	2000
1.	$\%CO_2$	0.50	0.50	0.48	0.45
	$\%O_2$	3.50	3.53	3.55	3.62
2.	$\%CO_2$	0.50	0.50	0.52	0.60
	$\%O_2$	3.40	3.45	3.52	3.65
3.	$\%CO_2$	0.58	0.67	0.60	0.61
	$\%O_2$	3.65	3.64	3.65	3.55
4.	$\%CO_2$	0.60	0.63	0.62	0.65
	$\%O_2$	3.52	3.63	3.75	3.52
5.	$\%CO_2$	0.55	0.65	0.65	0.65
	$\%O_2$	3.72	3.52	3.55	3.45

Results and Discussion

Respiration measurements of the Cos lettuce studied in this experiment are presented in **Fig. 4**. It was found that Cos lettuce respires much more slowly under CA and high humidity conditions at 3.5% O_2 and 0.5% CO_2 than in normal air. As shown, the respiration rate of the commodity was slowed by about 4 times under CA conditions.

In a previous experiment, Ayenew (1990) working with Iceberg lettuce found a similar trend. The respiration rate of the produce under normal air was 14.95 mℓ CO_2/kg-h, whereas under CA conditions at 3% O_2 and 1% CO_2 it was 1.34 mℓ CO_2/kg-h (about 10 times faster in normal air).

Even though the atmospheric conditions were different, the higher respiration rate of the Cos lettuce can be explained by a higher surface area of leaves as compared to the Iceberg lettuce. According to Fick's law of diffusion, the higher the surface area of the produce the higher the mass transfer (Kader, 1985).

Observations of the conditions inside the CA container are shown in **Table 1**. Data from this experiment suggest that the CA tank could maintain the gas concentrations as desired. Atmospheric analysis showed that the oxygen concentration fluctuated between 3.4% and 3.75% during the storage period. This suggests that the gas exchange process was in dynamic equilibrium, with the same amount of oxygen diffusing into the system as compared to the amount of oxygen utilized by the lettuce.

Regarding carbon dioxide, the scrubbing of this gas proved to be satisfactory in maintaining the concentration as desired. It rose 30% from the target value of 0.5% and reaching 0.65% at the end of the storage period.

The extraction of samples from the storage chamber for oxygen analysis was avoided in this experiment. Previously, Ayenew (1990) found that the removal of samples would adversely influence the gas equilibrium in the storage environment. By using an oxygen analyzer on this occasion it was not necessary to remove samples from the CA container, thus avoiding such problems. Carbon dioxide as well as oxygen concentration was measured by the constant circulation of air in the system. It proved the system to be satisfactory since no atmosphere was lost during the analyses.

Relative humidity fluctuated in the range 93% to 97%; it was not necessary to replace water in the channel because of the minimal water loss during the storage period.

Conclusions and Recommendations

From the results, it can be concluded that it is possible to develop a less expensive and simple system for controlled atmosphere storage of vegetables and fruits.

Because this was a short term storage experiment, it was necessary to achieve CA conditions very quickly, but for long term storage such modifications should be achieved by the produce itself.

Further work on the subject with different building materials and room sizes during long term observations is desirable. Also, it could be possible to achieve through the use of different concentrations of oxygen and carbon dioxide in the storage environment.

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Solar-powered Cooling for Tropical Potato Storage

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Abstract

A summary of the principles of tropical potato storage is given. A method of utilizing solar energy to heat rocks which then provide additional thermal bouyancy and hence can give a higher ventilation rate with cooler night air is described. Trials with the solar cooling system which compare it with conventional night cooled stores in Kenya are reported and suggestions are given for future improvements.

Introduction

Potatoes (*Solanum tuberosum*) are being increasingly grown in tropical climates owing to successful plant breeding and the development of new varieties such as Kufai, Yzoti and Atzimba by the International Potato Centre (CIP) and other organizations. However, if potatoes are to become an important dietary constituent in many of these areas it is important that the crop can be stored at family level without reliance on electrical or mechanical power.

Various designs of store have been used in tropical areas, all with the intention of (1) protecting the potatoes from undesirably high air temperatures and corresponding low relative humidities; and (2) reducing the opportunities for predators and pests to aggravate losses.

For example, a traditional woven basket, covered with straw may be used as a store in a residential house. The structure of the house, intended to provide a stabilized environment for the residents and sometimes animals against the extremes of the outdoor weather conditions, is also of benefit in the storage of a number of crops, including potato tubers. Some air movement is also desirable in the crop; the weave of the basket allows some natural ventilation of the contents, thus reducing the likelihood of hot spots or localized deterioration.

Another important objective of a store design would be, wherever

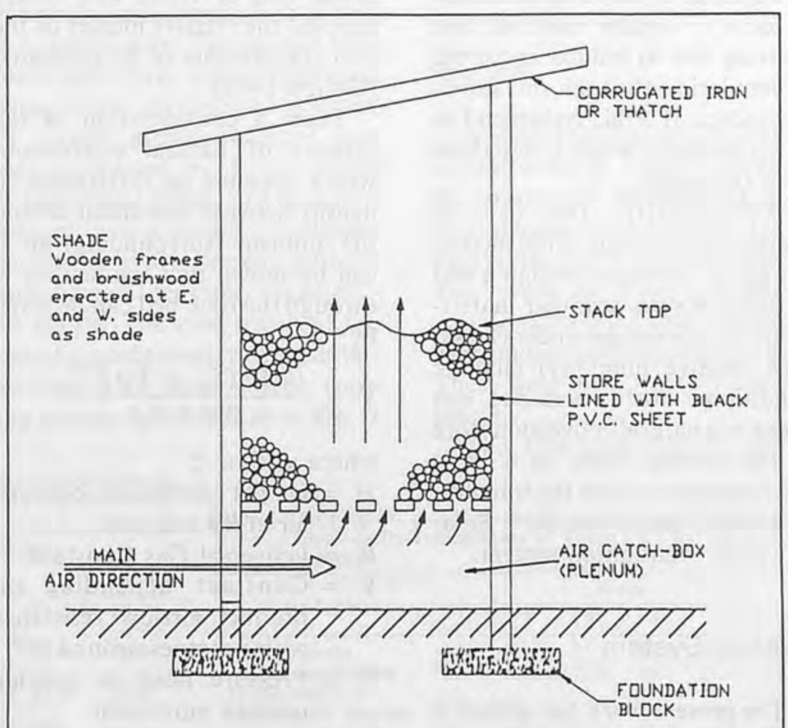

Fig. 1 Naturally ventilated store.

possible, to use beneficial aspects of the climate. In addition to some form of insulation and shading to minimize daytime heating, a facility which allows exploitation of nocturnal periods, when the ambient air is at its coolest and most humid, can be advantageous in bringing the stored crop temperature as low as possible with minimum moisture loss. This necessitates a means by which the nocturnal air can be directed through the store for sufficient time to bring about the required temperature changes. The possibilities which present themselves are:

1. Natural convection, brought about by differences in density of interstitial and of ambient air (**Fig. 1**);
2. Forces convection, either using night wind directly via a suitably designed inlet or by introducing a form of wind driven turbine to draw air into the store. (Redulla 1984, More 1992); and
3. Solar energy storage during daytime, in the form of heated rocks or similar material, and using this to induce nocturnal ventilation through the stored product. It is this system and its performance which is described in this paper.

Additionally, the use of evaporative cooling of the incoming air, by passage through a bed of moist porous granular material, offers advantages under certain (low relative humidity) climatic conditions. Such a wet pad was fitted to a natural convection store in the present work as a basis for comparison with the unmodified store and with the "Solar powered" ventilation system.

Cooling System

The present work has utilized a combination of possibilities, but first investigations were limited to the use of a hot-rock thermal store which induced natural ventilation of the stored material. **Fig. 2** shows the underlying principle of the equipment used in the preliminary trials conducted in Britain during the summer months of 1988 in a glasshouse at Silsoe College, UK. This provided a realistic simulation of a tropical environment.

A solar collector (thermal store) which is heated by the sun during the day, is connected to the ventilation outlet of the potato store via a flap valve which is closed during the day in order to prevent the passage of air through the system. At night the flap between the solar collector and the store is opened and the interstitial warm air of the thermal store rises drawing in air from the potato store which in turn draws in air from outside.

The design was based on the original idea of Wilmot (Wilmot 1985). A computer model was developed of the natural convection process occurring in a combined bed of rocks and tubers enabled the relative masses of the two components to be estimated (Bishop 1992).

From a consideration of the process of natural convection, which depends on differences in density between interstitial air and the ambient (surrounding) air it can be shown that the airflow V through the rock bed can be given by:

$$V = \frac{(gHP\,(T_2 - T_1))^{0.55}}{(kR\,T_1T_2)}$$

where at time t;

H = Height difference between air entry and exit
R = Universal Gas Constant
k = Constant depending on product airflow resistance with potatoes around 10^4
P = Pressure head to provide upward movement
T_1 = Ambient temperature
T_2 = Solar Collector temperature

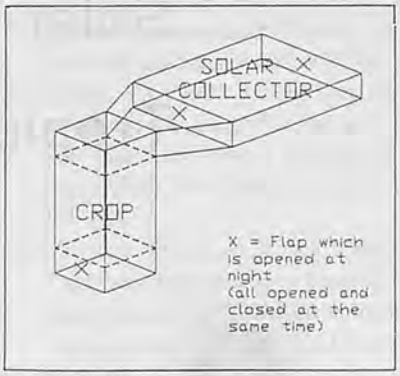

Fig. 2 Solar cooled store (High level solar collector).

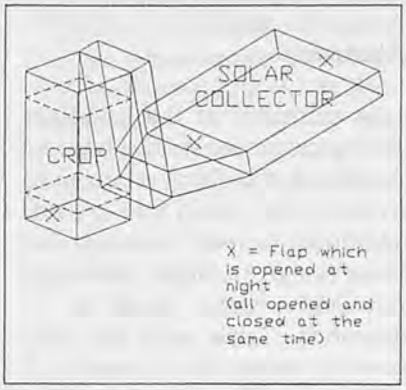

Fig. 3 Solar cooled store (Low level solar collector).

if there are no potatoes present.

When tubers are present, however, they influence the temperature of the air entering the rock store. Additionally, as the air convects through the combination of tubers and rocks, the temperature of the rocks is also reduced.

As guide figures to store design 1 300 kg of rocks or pebbles are required per tonne of stored potatoes which with a solar collector thickness of 0.25 m gives an area of solar collector per tonne of 2.5 m^2.

In the Silsoe trial the masses of tubers and tuber-sized pebbles/rocks were 120 kg and 150 kg, respectively. A major disadvantage of the arrangement as shown in **Fig. 2** was that the pebbles/rocks were supported in a transparent topped box above the bed of tubers, on a scaffolding frame-

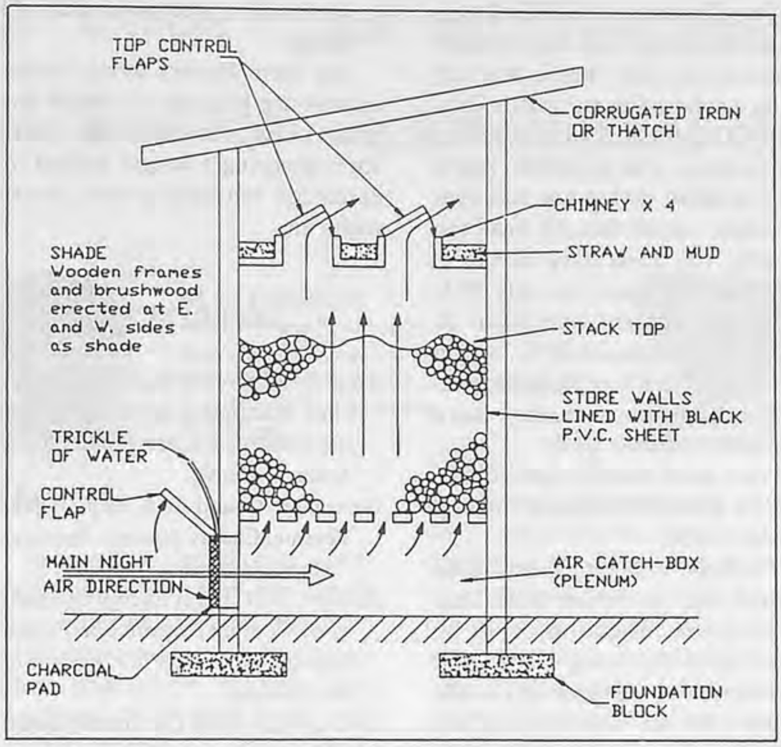

Fig. 4 Naturally ventilated store with night ventilation system and evaporative cooling.

work designed to support the weight of the unit. Clearly, where considerably greater masses of rocks or pebbles are to be supported, this arrangement is unsatisfactory. Although results provided by the Silsoe trial indicated that it was beneficial to have the collector at a high level it was decided to hold the first trial at Mtwapa, near Mombasa, Kenya with the collector at ground level as in **Fig. 3**. However, as suspected, this was not satisfactory. The second trial used high level solar collectors. This work investigated storage of locally grown potatoes and was conducted by Taylor Hunt (Taylor Hunt 1992). The design of the unit was a matter of collaboration with the present authors and some of the results are reported below. The trial involved the use of a traditional night ventilated store with either a solar cooling system connected as in **Fig. 2** or by having a charcoal pad of 25 mm thickness at the entrance over which water is trickled to provide fully saturated air as in **Fig. 4**.

In the Kenya trial the material used as the thermal storage medium was a fossilized form of coral which was purchased from a local (Mombasa) cement works. Coral is not the ideal medium in that its density was low (1 000 kg/m^3) as opposed to the bulk density of river pebbles of 2 250 kg/m^3 and it was only available in limited quantities. Instead of a mass of 600 kg estimated by Bishop (Bishop 1992) as necessary to induce ventilation of night air in this trial only 220 kg could be obtained for each thermal store. As a result the temperature of the coral fell rapidly providing insufficient ventilation to cool the stored tubers. However, the principle of the device was established and is seen to be applicable in situations where suitable nocturnal temperatures prevail and appropriate thermal storage materials are available.

Table 1. Potato Storage in a UK Glasshouse, Summer 1988 (mean daily temperature of tuber (°C) during August 1988)

Item	Week 1	Week 2	Week 3
Tuber storage using a solar collector	19	18	15
Mean ambient	22	24	20
Mean minimum	15	17	13

Results

A short trial was undertaken in a glasshouse at Silsoe College in the summer of 1988 with 125 kg of potatoes in a column 1.5 m high to the same design as **Fig. 2**. The results are given in **Table 1**.

Two trials using solar collectors were undertaken in Kenya in 1989. These were after the two harvest seasons.

The first trial was in March

Table 2. Tropical Potato Storage; Storage System Comparison of Mean Daily Temperature of Tuber (°C) during March 1989

Store type	Week 1	Week 2	Week 3	Week 4
Solar collector on ground no evaporative cooling	26.2	26.9	27.1	28.7
Solar collector on ground evaporative cooling	31.2	37.4	34.8	32.8
Natural ventilation (night only) + evaporative cooling	24.9	26.3	27.0	27.0
Mean ambient	31.0	30.3	31.7	30.6
Mean minimum	23.1	23.9	23.4	24.2

Table 3. Tropical Potatoe Storage; Storage System Comparison of Mean Daily Temperature of Tuber (°C) during September 1989

Store type	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Solar collector	25.1	25.5	25.5	26.1	26.9	26.7
Natural ventilation (night only) + evaporative cooling	25.4	25.6	25.8	26.1	27.0	27.0
Mean ambient	26.1	26.6	27.0	28.0	27.7	27.2
Mean minimum	23.1	23.1	23.3	23.6	24.4	24.0

1989 and involved a comparison between a naturally ventilated (night only) store with evaporative cooling and two stores with solar collectors at ground level, with and without evaporative cooling, respectively. The stores were of the design shown in **Fig. 3**. The results are given in **Table 2**.

The second trial was in the autumn of 1989 using a solar collector above the tubers as described in **Fig. 2** and the results are given in **Table 3**.

Conclusions and Discussion

The first trial, in a glasshouse, was undertaken to evaluate the principles of using a solar collector. The solar collector produced an airflow through the tubers as expected. The night temperatures in the glasshouse were low and there was rapid cooling, confirming the usefulness of the principle of enhanced nocturnal ventilation.

However, during the Mombasa trials, it was found, as suspected, that having the solar collector at ground level gave worse results than a ventilated store. This was thought to be because the ventilating air had to negotiate two right angles. Spot measurements of airflow indicated lower values than for the naturally ventilated store.

In the case of the solar collector at ground level with an evaporative pad, there was even higher resistance to airflow than in the previous case and this resulted in very little ventilating air passing through the tubers, resulting in a tuber temperature well above the mean ambient temperature.

The September trial results indicate that there was only a slight reduction in tuber temperature by using a solar collector rather than natural ventilation with evaporative cooling. The probable reason for the small difference was that the solar cooler lost its heat too rapidly; the coral rock temperature had dropped to only 9°C above the ambient level from an initial temperature of 60°C, within one hour of the flap being opened.

Funding constraints have prevented further trials.

Four main factors were identified as possible subjects for any future trials:

a) The solar collector needs to be insulated to reduce heat loss. Adequate insulation could be achieved by using traditional materials in the same way as the sides of the actual store are insulated.
b) The quantity of rocks should be increased to the ratio of 1 300 kg/t of potatoes, which is the estimated requirement from the existing 440 kg/t.
c) The collector needs to be well sealed to ensure that the air passing through the hot rocks has come from the potatoes and no other source.
d) The quantity of air passing through the collector should be restricted for an initial period. At present, the initial velocity of air passing through the tubers is too high to fully utilize the cooling potential available. A system which gradually opens the flap as the night progresses, such as a water filled counter balance having an adjustable trickle leak, should be incorporated into the final design.

All four factors would assist in slowing the rate at which the solar collector cooled down, therefore, ensuring a longer period of enhanced ventilation with cooler night air.

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A Portable Torque and Power Measurement System for Small-farm Equipment Based on Instrumented Pulley

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Abstract

A portable torque and power measurement system for small-farm equipment based on an instrumented pulley was developed. The prototype pulley was machined from mild steel, with spokes serving as strain beams. Strain gauges mounted on the spokes sensed the bending strain due to the torque. The bridge circuit converted this into millivolt output. Calibration results showed the torque-millivolt relationship was linear, while the hysteresis and error were less than 1% full scale.

For power measurements, an additional tachometer with dc voltage output was necessary. With the tachometer, error in power measurement was ±1.03 W or 0.2% full scale. Field tests showed that this system had advantages over other methods for small farm equipment, such as ease of installation, no machine alterations needed and safety.

Introduction

Methods of measuring power, directly or indirectly (through torque and speed) for small farm equipment field testing are limited and are often invasive, inconvenient to use and inappropriate. One such indirect method, mounting electric resistance strain gauges on a shaft requires enough space for the gauges. Extending the shaft to accomodate the gauges would often result in an imbalanced machine which could affect its field performance. Off-the-shelf commercial torque cells are inappropriate for similar applications.

Another method, a direct power measurement type, uses a calibrated motor and an AC power meter, such as the one described by Mazaredo et al (1990) in the measurement of the power requirement of the IRRI Hydrotiller, a floating type rotary tiller for preparing wetland paddy field that consisted of a rotating toothed cylinder in front which is driven by a single-cylinder engine mounted on the double-pontoon body that serves as a flotation device (**Fig. 1**). The method involved calibration of a motor (with equivalent hp as the original engine prime mover) to establish the input power-output power relationship. The motor was later installed on the engine frame and an AC power meter was connected to its voltage supply wires. The components of the instrumentation based on the calibrated motor are shown in **Fig. 2**. The power meter measured the input power (kW) and through the calibration relationship, the output power (kW) which was the power required to drive the machine, was determined.

While the calibrated motor method has merits in laboratory measurements, it has problems when used in the field, such as weight addition due to the motor (5 to 10 kg depending on the motor) which can affect field performance of the machine, especially flotation, limitation of tests to places where electric power is accessible, inconvenience and risks of electric shock.

An alternative portable method of torque and power measurement was developed for small-farm equipment, based on an instrumented pulley. It offers the following advantages:

1) Ease of attachment, without any alteration to the machine;
2) Negligible change in weight relative to the original prime mover; no modification of its original effects, such as, vibration or noise level;
3) Compact, safe and convenient to use; and
4) Can be easily fabricated in the workshop with available materials and manufacturing equipment.

In this study an instrumented pulley for field measurement of torque for small-farm equipment testing was designed. It was evaluated in order to determine linearity, accuracy, sensitivity and field performance.

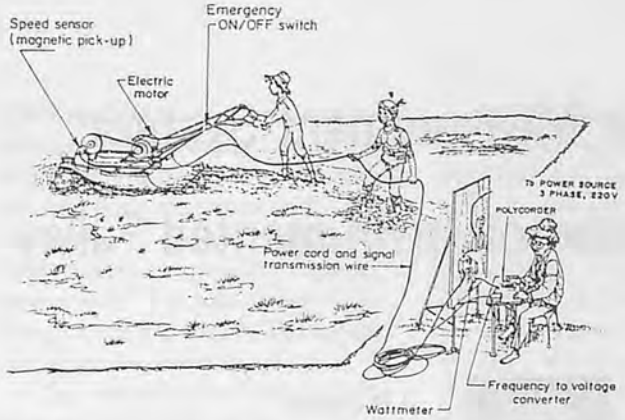

Fig. 1 Instrumentation set-up for the measurement of power requirement of the hydrotiller.

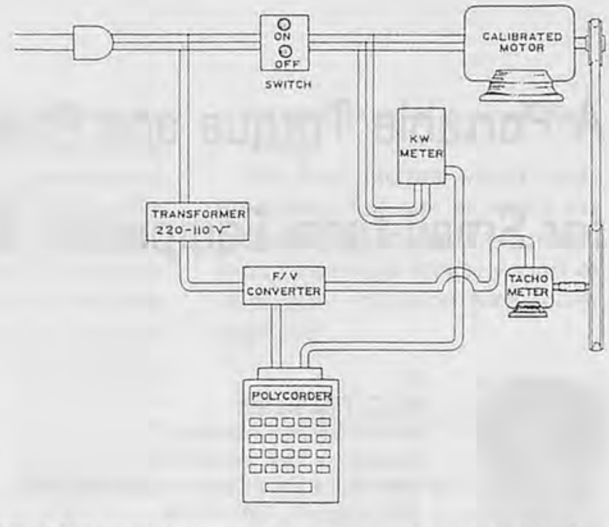

Fig. 2 Schematic diagram of the instrumentation system based on the calibrated motor.

Design of the Instrumented Pulley

Principle of Operation

When transmitting load, the spokes of the pulley are subjected to bending stress. To resist this stress, the flat side of the cross-section is normally parallel to the bending force. In the instrumented pulley, the spokes serve as strain beams. By designing the flat side of the spoke cross-section to be perpendicular to the bending force, the spoke becomes sensitive to bending strain. The material should also be elastic and, therefore, the original brittle material (cast iron) needs to be replaced. The bending strain in the spokes is related to the torque acting on the pulley.

Design of the Spoke Cross-Section

The bending force, F per spoke can be expressed as

$$F = P/wdn$$

where P is power in Watts, w is angular velocity in rad/s, d is the distance from the point of application of bending force to the center of the sensor location (treating one spoke as a cantilever beam), and n is the number of spokes. For example, a Mini Hydrotiller (a smaller version of a floating rotary tiller earlier described) with a 5 hp (3.7 kW) engine has a recommended speed of 630 rpm at the input axle. For a 304.8 mm (12 in.) driven pulley with three spokes, the distance from the point of application of bending force to the sensor is 105 mm. The bending force per spoke is 179.48 N. Hence, the section modulus is

$$Z = \frac{1.5\ (179.48\ \text{N})(105\ \text{mm})}{(250\ \text{N/mm}^2)}$$

$$= 113.07\ \text{mm}^3$$

This is satisfield by a 15 × 7 mm rectangular cross-section for each spopke. The groove of the pulley was designed to accommodate a B-section V-belt. A threaded extension was added to accommodate a slip ring **(Fig. 3)**.

Basic Principle of the Strain Spoke

The total bending force acting on the pulley should be divided equally among the spokes. A strain results in each spoke due to this bending force, the top surface is in tension while the bottom surface is in compression. With uniaxial strain gauges bonded to the spokes, parallel to the length of the spokes and directly opposite each other, the four-strain gauge bridge will have an output change in voltage proportional to the bending force F. The relationship between the output voltage E_o with bending force F at the gauge location x can be derived and expressed as

$$E_o = \frac{6F \times GE_i}{bh^2E} = kF \qquad (1)$$

where:

$$k = \frac{6 \times GE_i}{bh^2E}$$

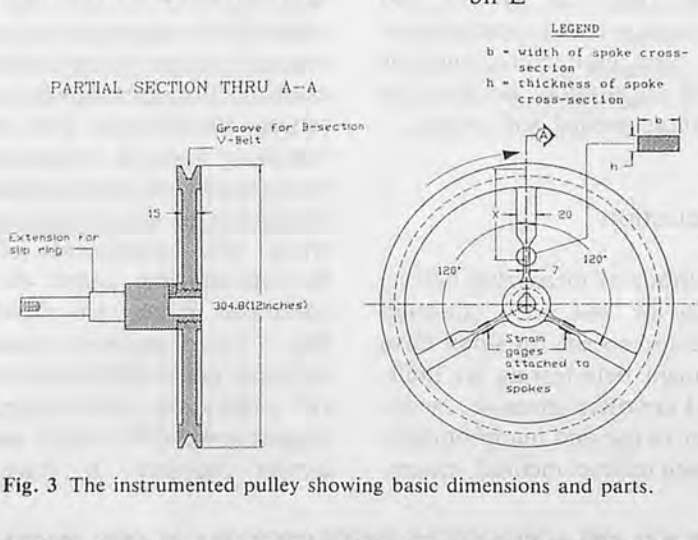

Fig. 3 The instrumented pulley showing basic dimensions and parts.

and:
G = gauge factor
E_i = input voltage
E = modulus of elasticity
b = width of spoke cross-section
h = height or thickness of spoke cross-section

Equation 1 indicates that the output voltage is linearly proportional to the bending force F by the calibration constant k. Sensitivity is the ratio of output (millivolt) to the input (torque), or E_o/Fx. From equation 1, it can be expressed as

$$\frac{E_o}{Fx} = \frac{6GE_i}{bh^2E} \quad (2)$$

Calibration and Field Tests

Calibration Set-up and Procedure

The static calibration rig consisted of a fixed horizontal shaft, a 1 m loading beam, calibrated deadweights, and a Polycorder, a portable data logger (OMNIDATA, 1985). The pulley was keyed to a horizontal fixed shaft. One end of the loading beam was attached to one spoke of the pulley, while on the other end dead-weights were hung. The wheatstone bridge circuit, consisting of four 120-ohm strain gauges, was excited by a constant 5 Vdc source from the Polycorder which was programmed to store the keyed torque values, scan 10 voltage output values, and store the average voltage.

Loads were incremented by adding deadweights until the maximum design torque (8.163 kgf-m or 80 Nm) was reached. Load was then decreased by the same magnitudes until zero was reached. For each load, a corresponding torque value was keyed into the Polycorder which then stored this value, then read and stored the corresponding millivolt output of the strain gauge circuit. There were four replications. The torque (kgf-m) - millivolt relationship was established through a regression analysis. Hysteresis and error (for torque measurement) were determined from the calibration results. Error for power (product of torque and speed) measurement was quantified by uncertainty analysis (Holman and Gajada 1978).

The dynamic calibration set-up was one typically used in motor calibration. It consisted of a driving motor, a torque meter, a generator and resistive elements such as lamps or heaters (**Fig. 4**). This motor was connected to the torque meter through a coupling; the torque meter was connected to

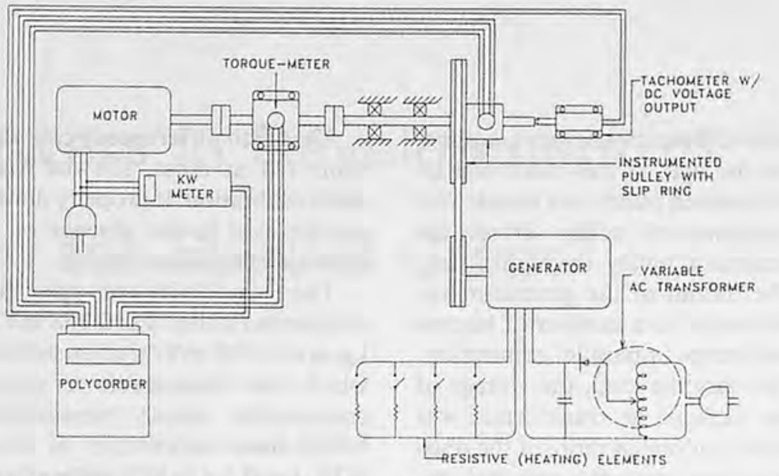

Fig. 4 Schematic of dynamic calibration set-up for instrumented pulley.

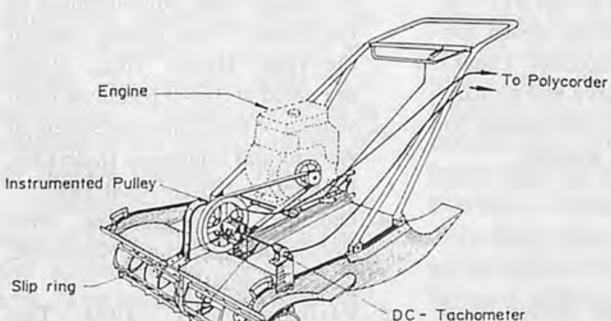

Fig. 5 Instrumented pulley, slip ring and speed sensor (dc - tachometer) measuring system for mini hydrotiller.

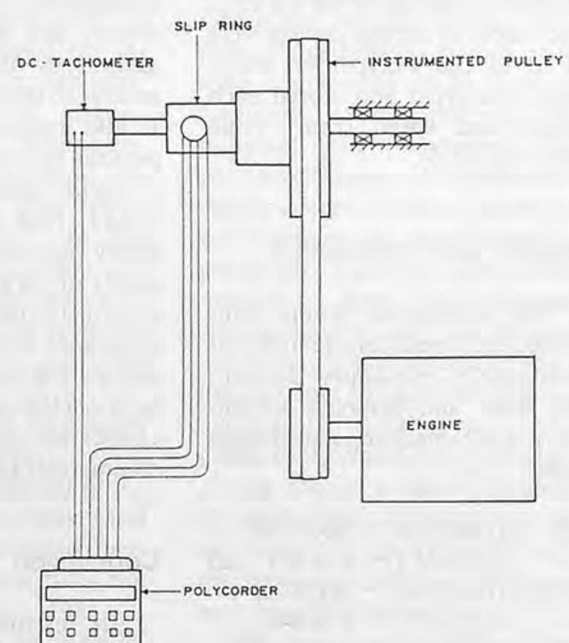

Fig. 6 Schematic diagram of the instrumentation system of the mini hydrotiller (based on the instrumented pulley).

a shaft through another coupling. At the end of this shaft the instrumented pulley was keyed. This instrumented pulley drives the generator pulley through a belt. The output of the generator was connected to a number of heaters and lamps in parallel connection. The vary the load, the voltage of the variable ac transformer was varied, or one or more of the resistive elements were switched on. For each load setting, the polycorder scanned and recorded the millivolt output of the instrumented pulley. Simultaneously, the polycorder scanned the millivolt output of the torque meter, converted this into torque and recorded this.

Field Tests

For field tests, the instrumented pulley was attached to the corresponding input shaft of the mini hydrotiller (Pakistan, 1993). A detachable shaft extension was provided for the slip ring. A dc-tachometer with 0 to 2 V output (for a range of 0 to 2 000 rpm) was attached to the end of the slip ring. The output of the two devices were wired to the Polycorder which read, converted and stored each torque and speed (rpm) value (**Figs. 5** and **6**).

Results and Discussion

The calibration results confirmed the linear torque-millivolt relationship previously deriven. For static and dynamic calibrations, the respective relationships were:

MV = 0.465508 * KGF-M − 0.83351 (r^2 = 0.99), and
MV = 0.440345 * KGF-M − 0.83817 (r^2 = 0.99).

where:
MV = voltage in millivolts
KGF-M = torque in kilogram (force)-meter

The small difference in calibration, 7% at most, showed that static calibration, if properly done, can be used in the absence of a dynamic calibration set-up.

The sensitivity of the instrumented pulley was 0.468 mV/kg-m or 0.763 mV/V of excitation which was comparable to some commercial torque transducers which have sensitivities of 0.6, 0.75, 1 and 1.5 mV/V, depending on application (KYOWA, 1990). The slightly low sensitivity could be attributed to the material and strain gauges used. Heat treatment plus the use of eight strain gauges on four spokes, instead of the present four could improve sensitivity as proven in other dynamometer designs. For torque measurement, hysteresis was negligible at 0.71% and error was 0.75%. Error in power measurement was ± 1.03 W or 0.02% full scale.

Field tests showed the advantages of the instrumented pulley over the calibrated motor and other methods, namely: ease of installation, convenience of use, safety, and absence of machine alterations and weight addition relative to the engine prime mover. It also required less number of persons to test a field machine.

Farm equipment researchers would find the instrumented pulley very useful in field measurements of torque and power. The cost of the pulley is about $170 as compared to $1 000 or more for commercial torque sensors. Clearly, it is a less expensive but a more application-specific alternative to commercial torque meters.

Conclusion

An instrumented pulley was developed as the transducer of a portable torque and power measurement system for small farm equipment. The torque cell exhibited highly linear response, high accuracy, negligible hysteresis and fairly acceptable sensitivity. Improvements could still be made for increasing sensitivity by heat treatment of the spoke material and the use of eight strain gauges on four spokes, instead of four strain gauges on two spokes.

Field tests showed its advantages over other methods, such as ease of installation, convenience of use, safety, absence of machine alterations and weight addition relative to the original engine prime mover. It is also a less expensive but more application-specific alternative to commercial torque meters.

Recommendations

The inclusion of an overload protection device, heat treatment, and the use of four spokes and eight strain gauges for improved sensitivity of the instrumented pulley are recommended.

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Involving Growers in Development of Mechanization for Special Crops

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Introduction

Mechanization of agricultural production in developing countries is a problem discussed in huge number of papers. Recently, some ex-communist countries from the Central and Eastern Europe could also be considered as developing countries, primarily due to change in ownership and hence generated problems in farm mechanization (Clarke and Morrison, 1993, Križnar and Martinov, 1993, Tešić and Martinov, 1995).

The institutions involved in the introduction of new techniques and machinery in developing countries are faced with many problems, related not only to engineering (Gifford, 1991, Guntz and Morris, 1991).

Success in developing and manufacturing of agricultural machinery depends much on politics, economics and even sociology. The engineers working in developing institutions are often in isolation from real conditions of the market (Sutton, 1990).

Technology and mechanization must be relevant to the social goals and applicable to the particular area. The team for development and transfer of agricultural machinery technology should with that reference, in addition to others, include a cultural anthropologist and/or rural sociologist. Recognition of local conditions is very important for the success of introducing mechanization in any region, and in most cases, the models from developed countries are not directly usable (Datt and Ojha, 1988, Ambe, 1994).

For identification of mechanization needs and selection of technology and machinery, the respect of local growers' opinion is very important. Khan, Murray-Rust and Bhuiyan, 1987, concluded: "A self-reliant approach to mechanization — based on indigenous manufacture with optimum use of local labor, production methods, and materials — seems to be the most appropriate strategy for many developing countries." In the same sense Sutton, 1990 expressed: "Each farmer has a very clear idea of which type of design is best suited to his particular needs and will often go to considerable trouble and expense to obtain this. The farmers or villagers must never be left out of the planning process for they, and only they, best understand their environment that constitutes the farming systems (FAO, 1981)."

The wide spread attitude of experts for agriculture mechanization in developing countries is that the machinery should be primarily produced by local manufacturers or industry. The introduced mechanization should fulfil the social, cultural, employment and productive needs of local farmers (Ambe, 1994). Small Machinery Program for Philippines, Thailand and Indonesia indicates that the mechanization is possible with small farm machines that are specially developed and manufactured locally (Khan, Murray-Rust and Bhuiyan, 1987).

Development of the mechanization is not possible without support of institutions having staff with engineering skills, Schulze Lammers, 1994. Gilfford, 1991 indicated need of having program for development of machinery; Ambe, 1994, made suggestion for agricultural mechanization procedure. Datt and Ojha, 1988, noticed a need for extension service having duty to prepare manufacturing drawings, including drawings for jigs and fixtures, eventually prototype and guidance, to enable the production of machinery in local factories or workshops. Nonetheless, the advantage of locally produced machinery is in better maintenance and repairing possibility.

The mentioned problems and considerations about development and introduciton of mechanization in developing countries have been even emphasized in the case of special crops. Under the term special crops are understood some intensive crops grown on relatively small area to cover relatively limited market. Some of those are, for example: medicinal plants, pumpkins, hemp, sorghum etc.

The growing special crops is for some regions or areas is important. It is a lucrative activity and brings in more profit compared with mass cultures. The main prerequisites for growing the special crops are:

- Specific agroclimate and agropedological conditions;
- Good conditions for cultivation of endemic crops or varieties;
- Tradition; and
- Specific advantage, like inexpensive man-power.

Special Crops and Mechanization

Diversity of crops and varieties, technique for their production and limited number of producers influence the development costs. That caused almost total exemption of machines offered by industry. The prices of rare machines for special cultures produced in developed countries are regularly too high for the growers in developing countries. With some exemptions, the production of special crops in developing countries has not been mechanized, although the same problem is well known in developed countries, too. It is not expected, in this regard, that development of mechanization for special crops could be realized without government or public institutions financial and engineering support.

The techniques and machinery developed by some growers are highly protected secrets of the inventor, who is trying to keep benefit of reduced production costs for himself.

Desirable mechanization for special cropping should be developed otherwise. Connected to the mentioned problems, and as the result of authors' experience, the following can be concluded:

1. Development of mechanization for special crops should be supported by development institutions having staff with engineering skills.
2. Help of institutions or financial support from the government in realizing prototypes of machinery obligated dissemination of the know-how by publishing of reached results.
3. Engineering knowledge is necessary, but not sufficient for realization of adequate technique and machinery.
4. Involving growers in development of mechanization should help in identification of problems and finding adequate producing technique and machinery. All growers, and especially best of them, are the "army" of highly interested, and motivated thinking persons whose creativity and creativity potential must not be neglected. It is expected that the growers' ideas should contain the elements of social conditions and influences, as well as the understanding of local needs and manufacturing possibilities.
5. Developed mechanization should be designed in a way to fulfill the need of growers, but it is very important to create possibility to manufacture machinery in local workshops, using available raw materials, standard parts and machine parts.

This paper aspires to promote acceptance and use of growers creative potential in development of mechanization for special crops in developing countries, but it is also a call for appreciation of all involved in the same activity in order to improve proposed method.

Proposed Method of Development of Machinery for Special Crops

The proposed method is shown on **Fig. 1** in a form of flow chart, describing machine developing actions. The left-side activities are taken by growers, right-side ones by development institutions — engineers, and center ones by both.

Identification of the need for the machine or implement is a usual first step. However, as early as the second step, the tasks are separated. The activity of institution — engineers is a typical action of searching for new ideas for machine working principles. Specific are the tasks of growres, who are animated and stimulated by the engineers, and expected to express their ideas. This attitude towards the role of growers is specific in the proposed method. It is expected that the described role of the growers could sublimate all peculiarity of the special crop production and local conditions. Engineers' knowledge should help to overcome potential engineering mistakes of, in that sense, not educated growers. Growers' ideas could integrate all non-engineering, and non-economical influences upon producing technique. On the other hand, number of growers, already involved in production problems, is a great potential for searching of new ideas, which have to be used.

The next two steps are common actions, already practiced in developed countries for long time, and newly incorporated in the ISO 9004 standard, in this case, as a step of the method for improvement of the quality.

Engineering articulation of the selected idea or ideas for prototype

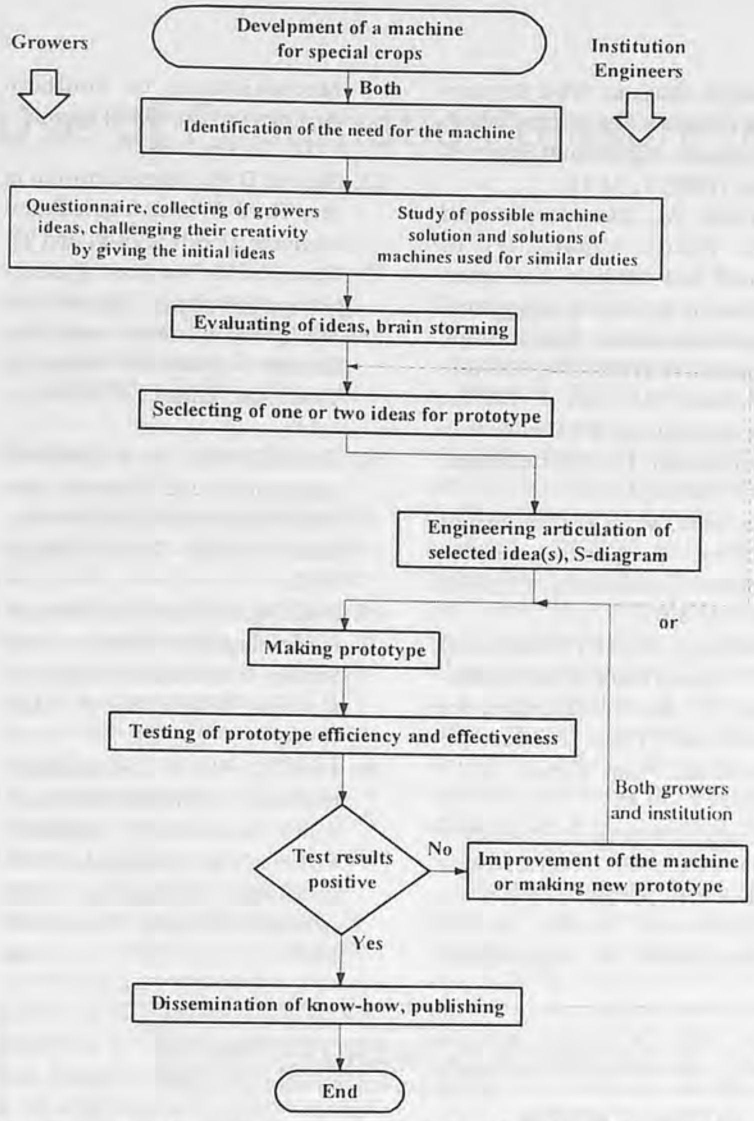

Fig. 1 Flow chart of proposed method in developing of machinery for special crops.

is a duty of professionals from institutions. They should have in mind, beside basic principals of design machines, the following demands: machine should be inexpensive, made, if possible of locally available raw materials, standard elements and machine parts and producing technique of local manufacturers. The engineers should, at the same time, accept evaluation of the design used in developed countries, using, for example, VDI 2225 introduced S-diagram for engineering and economic evaluation of the product.

Making of prototype could be realized in the institution, by local manufacturer or even in a growers' workshop. The production costs could be covered by the grower — owner of the prototype, but partly supported from government sources planed for development. Service of the institution should be financed by public sources responsible for development of agriculture.

Testing of the prototype and evaluation of reached results is a joint task for both, grower and the institution. In most cases, needed improvement of the machine is also a duty for both involved actors in development.

Very important action, following successful development of the mechanization for special crops, is a dissemination of know-how. Reached experience and knowledge is not now an ownership of one person or a group. The participation of the society obligates the grower and institution to publish the new technique and mechanization for producing special culture.

The proposed method has been applied and improved by the development of some new machines, primarily for medicinal plants, in Yugoslavia over the last 15 years (Martinov and Müller, 1990, Martinov, Tešić and Müller, 1992, Martinov and Adamović, 1994).

Conclusions

A number of problems of farm mechanization in developing countries have been noticed and most of them are not the typical engineering ones. They are even more emphasized in the case of special crops. The development of mechanization for special crops is faced with some other difficulties connected with specific production demands and relatively small market for machinery.

Cooperation in machinery development between the developing institutions having staff with engineering skills and the growers of special cultures, with financial support from government, seems to be a successful model.

The growers creativity helps in searching for ideas, but sublimate the knowledge about desirable growing technology, habitat conditions and local manufacturing possibilities, too.

Institutions and government support obligate growers to permit dissemination of the know-how, first of all by publishing the results.

Proposed method for development of mechanization for special crops could be improved. All colleagues are kindly invited to suggest new steps or adaptations.

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Use of Pneumatic Pressure in Parboiling Paddy

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Abstract

A method of quick parboiling of paddy was developed using pneumatic pressure which reduces the parboiling time and saves energy considerably. Soaking at 3 to 4 kg/cm^2 pneumatic pressure for 2.5 h at a temperature of 70°C saved time significantly as compared to atmospheric soaking at the same temperature to attain a moisture content of about 38% (w.b.). In this process negligible amount of white bellies were observed in the polished rice. No boiler was necessary as it involves no steaming operation for gelatinization of rice kernel. Evacuation followed by pneumatic pressure was found to be a very effective method of reducing soaking time for parboiling of paddy.

Introduction

Parboiling is a hydrothermal treatment given to paddy which changes the physical, chemical and organoleptic properties of the rice kernels (Gariboldi, 1972 and Bose, 1988). Parboiled rice is produced in India by both traditional and modern parboiling processes. The traditional process consists of soaking the paddy in cold water for 24 to 48 h followed by open steaming for 10 to 15 min in iron kettles. The steamed paddy is then sun dried. The modern method of parboiling has minimized most of the inadequacies of traditional parboiling method such as long soaking time, development of certain flavour in rice kernels and high labour requirement. The modern method of paddy-parboiling carrying out soaking and steaming operation in the same-large parboiling unit involves a long processing time. This results in a large amount of steam and other energy consumption per tonne of paddy. Moreover, the resultant produced in the modern method has a deep colour owing to long exposure to steam.

Reduction in energy requirement of the paddy parboiling process and elimination of the undesirable characteristics of the parboiled rice such as hard texture and deep colour are some of the objectives of this research project.

Materials and Methods

The paddy variety IET 7251 is grown under normal agronomical practices was used for all the experiments. A 200-g clean raw paddy sample was used for hydration studies at atmospheric pressure.

A pressure vessel to hold 500 g of paddy was designed and fabricated **(Fig. 1)** to determine the effect of pneumatic pressure on soaking characteristics of paddy. In the pressure vessel, the temperature of hot water was maintained throughout the experiment at the desired level with the addition of small amount of steam as and when required from an autoclave. The perforated container bearing 500 g of clean paddy was dipped into the hot water inside the pressure vessel. The pressure inside the vessel was raised to the desired level with the help of a compressor and then the valve connected to the compressor was closed to maintain constant pressure for the required duration.

The effect of evacuation fol-

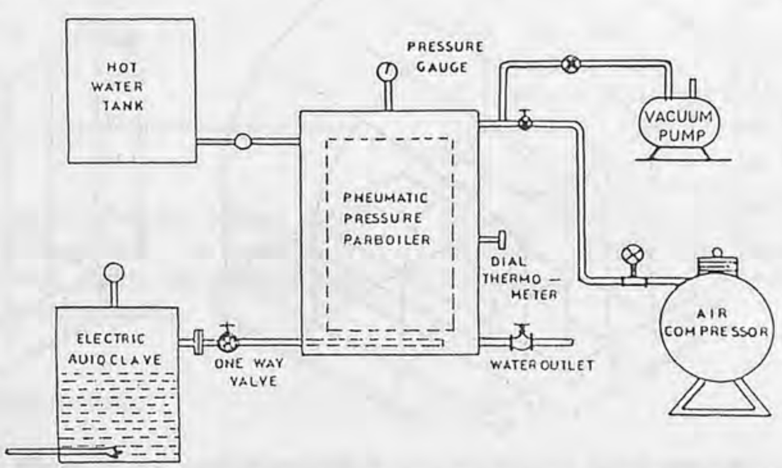

Fig. 1 Schematic diagram of experimental set-up for pneumatic parboiling of paddy.

lowed by pneumatic pressure on soaking characteristics of 500 g clean paddy was determined in the same set up. The pressure inside the vessel was reduced to 700 mm of Hg with the help of a vacuum pump. The valve connected to the vacuum pump was closed to maintain vacuum for 30 min. The vacuum was released and hot water was poured inside the vessel. Then the pneumatic pressure in the pressure vessel was increased to 4 kg/cm^2 with the help of a compressor and maintained for different durations. The hydrothermally treated sample was taken out and it was kept in a heap for about 15 min for tempering and then spread on a tray. When the samples attained room temperature, the moisture content of each sample was determined by a standard oven drying method (100 ± 2°C for 24 h). All samples were shade-dried and milled using a Satake laboratory milling machines for quality analysis.

Results and Discussion

Effect of Pneumatic Pressure on Soaking Characteristics of Paddy

The variation in moisture content of paddy with soaking time at each of the soaking temperature of 50, 60 and 70°C under pneumatic pressure of 1, 2, 3 and 4 kg/cm^2 is shown in **Figs. 2** through **4**. It is evident that at all temperature levels, the rate of moisture absorption in paddy is high during the first half hour of soaking. The moisture absorption-rate increased with the temperature of soaking. The outer husk and the pericarp layer of brown rice are relatively porous. Owing to the application of pneumatic pressure during soaking, water diffused rapidly into the rice kernel and was quickly saturated. Initially, this change might also be due to moisture sorption in the void space between the husk and kernel. However, after the initial stage of soaking the rate of water uptake declined subsequently owing to a reduction in moisture gradient.

Fig. 5 shows that the time required for attaining the desired moisture content at 70°C decreased as the pneumatic pressure increased to 4 kg/cm^2. Soaking time could be substantially saved at 70°C for attaining the desired level of moisture at pneumatic pressure of 4 kg/cm^2.

Effect of Evacuation Followed by Pneumatic Pressure

A combination of evacuation followed by application of pneumatic pressure during soaking was also used. **Table 1** shows that if the temperature and time of hot water treatment increases, the percentage of white bellied rice decreases. With a combination of 30 min evacuation before soaking at 60°C for 45 min and hot water treatment at 70°C for 15 min under pneumatic pressure of 4 kg/cm^2, a low percentage of white bellied rice could brought about. It shows that the hot water treatment at a gelatinization temperature and or longer soaking duration are required in the above combination to bring down the white bellies to a zero level.

Effect of Pneumatic Pressure and Soaking Temperature

The percentage of white bellies for different soaking temperatures under varied pneumatic pressures is shown in **Fig. 6** which decreased

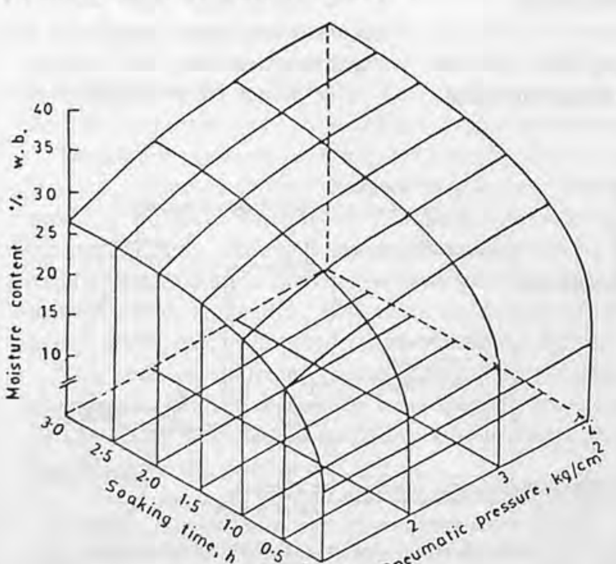

Fig. 2 Response surface of moisture content (% w.b.) at soaking temperature of 50°C.

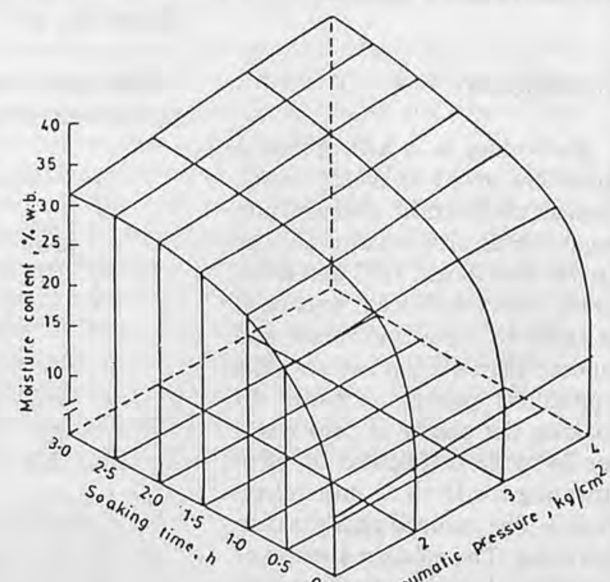

Fig. 3 Response surface of moisture content (% w.b.) at soaking temperature of 60°C.

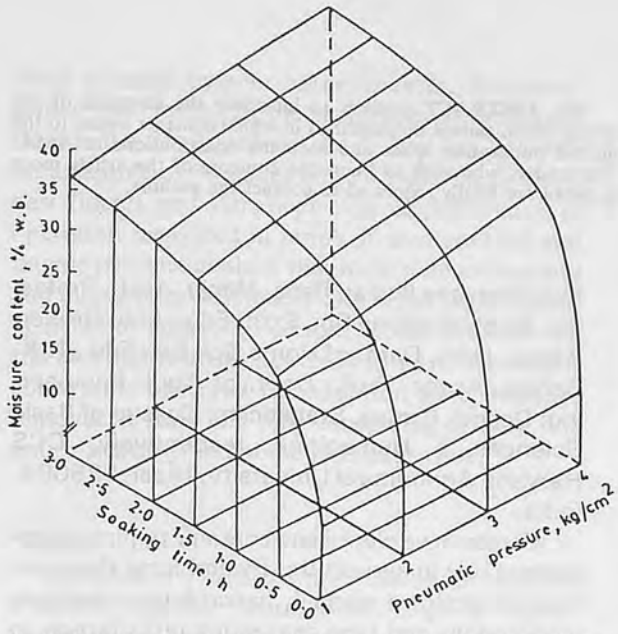

Fig. 4 Response surface of moisture content (% w.b.) at soaking temperature of 70°C.

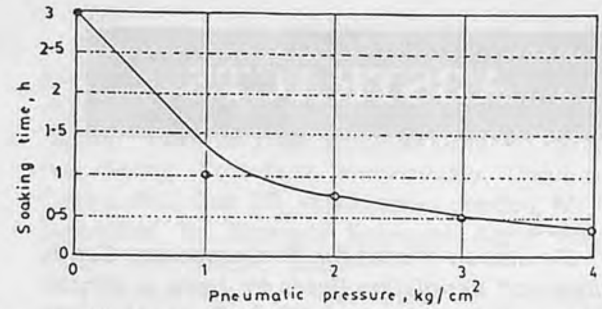

Fig. 5 Effect of pneumatic pressure on soaking duration required for attaining m.c. level of 30% (w.b.) at 70°C.

Table 1. Effect of Evacuation Followed by Pneumatic Pressure

Treatment	Moisture content % w.b. after soaking	Percentage of white bellies
Evacuation for 30 min followed by soaking at 50°C for 30 min and hot water treatment at 70°C for 30 min under 4 kg/cm^2	31.0	47
Evacuation for 30 min followed by soaking at 60°C for 30 min and hot water treatment at 70°C for 15 min under 4 kg/cm^2	33.4	26

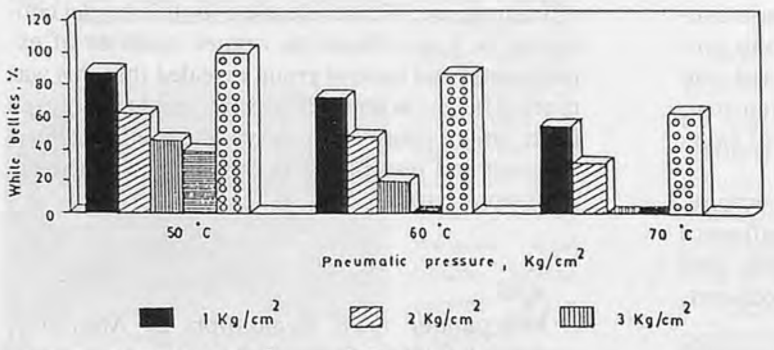

Fig. 6 Effect of pneumatic pressure and soaking temperature on percentage of white bellies (for a total soaking time of 2.5 h).

as soaking temperature and pneumatic pressure increased. A very low level of white bellied rice kernels were observed in paddy soaked at 60°C temperature for 2.5 h at 4 kg/cm^2 pneumatic pressure. Similarly, white bellies of acceptable levels were obtained in the milled rice while paddy was soaked at 70°C for 2.5 h at 3 and 4 kg/cm^2 pressure. Hence, it can be stated that it is possible to parboil paddy by soaking only without steaming.

Conclusions

1. The minimum level of moisture of paddy during soaking for elimination of white bellies completely from the milled rice was 38-40% (w.b.).
2. Soaking under pneumatic pressure of 4 kg/cm^2 saved considerable time compared to atmospheric soaking to attain a moisture content of 38% (w.b.) at soaking temperature of 70°C.
3. A good quality parboiled rice with an acceptable level of white bellies could be obtained by soaking the paddy above gelatinization temperature under pneumatic pressure without any steaming.
4. A combination of evacuation followed by soaking under pneumatic pressure was found to be a very effective method of reducing the soaking time.

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2. Gariboldi, F. 1972. Parboiled rice in Rice Chemistry, Edited by Houston, D.F. AACC, St. Paul, Minnesota. ■■

ABSTRACTS

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

353

Simulation Model for Environmental Conditions and Ventilation Rates for Hens in Winter: Alchalabi, Dhia A., Agri. Mech. Dept., University of Baghdad, Baghdad, Iraq; and Howard H. Person, Agri. Eng. Dept; Allan Rhan, Poultry Dept., respectively, Michigan State Univ., East Lansing, U.S.A.

In the broad sense, environment may be interpreted as all external conditions that might affect animals. The concept of "environment" can be divided into Social, Physical, Chemical, and Biological components. The social factors pertain to animal behaviour, such as crowding and social "Peeking order". The physical factors pertain to all of the surroundings, such as lighting, sound, cages, floor and the equipment. The thermal factors pertain to air temperature, humidity, and air movement. Chemical factors pertain to all gases as Oxygen, Carbon dioxide, Carbon monoxide, Ammonia and other gases, and also to water and feed.

The system in this study was the environment produced with in a poultry house. The house contained two identical laying rooms. Each room contained two rows of deep pyramid reversed and shallow cages. These cages were modified stair step, four-tire design, that contained eight lines of cages per row, and 60 cage pre line.

The simulaiton model predicted air temperature, relative humidity, ventilation rate and the influence of these environmental conditions upon daily feed consumption, energy use, egg production, feed cost, electricity cost, and revenues.

The model also gives management information like number of birds, age of birds, average body weight, and bird mortality on daily bases. For the outside conditions the model gives the hourly air temperature and relative humidity average daily temperature and relative humidity. Number of hours that water condensation accures on the inside walls average daily inside and outside temperature and relative humidity, maximum and minimum inside temperature.

475

Field Evaluation of Light-weight Wheel Hand Hoe Developed for Women Clientele: Study from Rural Haryana (India): Rana, Manju, Asstt. Professor, Dept. of Home Sci. Extn. Edu.; Indu Grover, Assoc. Prof., Dept. of Home Sci. Ext. Edu.; N.K. Bansal, Assoc. Prof., Dept. of Agril. Engineering; Deepak Grover, Statistician, College of Basic Sciences & Humanities, respectively, CCS Haryana Agricultural University, Hisar-125004, India.

Women have played and continue to play an important role in agriculture. By and large they continue to perform manual, harzardous, repetitive, monotonous and time consuming tasks largely in transplanting, weeding, harvesting, storage and processing. In other to reduce their drudgery it is imperative to develop and popularize efficient tools and implements for activities which remain predominately their domain of work. One such implement is the wheel hand hoe. However, when the model available and recommended was tested on women clientele they reported that although it saved time, it caused higher fatigue. Thus, a light weight model of wheel hand hoe was developed. This model was cost effective, lighter in weight and more efficient in use. Field evaluation for this model conducted in four villages on women clientele of experimental and control group revealed that this was more efficient in terms of area covered and caused lesser fatigue measured in terms of pulse rate, blood pressure and respiration among women in the experimental group.

476

Intergender Field Evaluation of Manually-operated Cotton Stalk Puller and Associated Constraints: Aneja, Sanjna, Ph.D. Scholar, Dept. of Home Science, College of Home Science; Indu Grover, Associate Professor, Dept. of Home Science, College of Home Science; D.N. Sharma, Professor & Head, Dept. of Farm Machinery and Power, College of Agril. Engineering; D.K. Grover, Scientist, Computer Centre, College of Basic Sciences, respectively, CCS Haryana Agril. Univ., Hisar, India.

Traditionally cotton stalk removal the final field operation is performed manually by cutting the stalk a few cms above ground surface. These remaining stalks and roots cause numerous problems for sowing of the next crop and deteriorate soil when affected by root-borne diseases. The intergender field testing of the prototypes of the cotton stalk puller developed was conducted for 2 models on a sample of 30 males and 30 males in fields of *desi* (local) and American cotton. Efficiency in operation measured in terms of area covered and fatigue parameters show that there were inter-group and intergender differences with better performance in fields of American cottón, model with tyre on rim and higher efficiency among males. The major constraints observed for adoption were, namely, removal of stalk is a time consuming activity, the puller is heavy and somewhat expensive.

503

Analysis of Performance Indices for Manual Irrigation Pumps: Yusuf, D.D., Dept. of Agric. Engineering, Faculty of Engineering; A. Ahmed, Institute for Agricultural Research, respectively, Ahmadu Bello University, Zaria, Nigeria.

Fig. 1 The three different diaphragm pumps tested: X, type I; type II; Z, type III.

Fig. 2 Evaluating the performance of the manually-operated irrigation pumps.

Three manually-operated irrigation pumps were tested. The relationships between their performance indices: discharge volume, suction lift, efficiency and power requirement in terms of operator's body weight and brake horse power were analyzed.

Results show an inverse relationship between discharge and suction head. Discharge rates varied from 0.3 to 3.5 ℓ/s depending on pump type and suction head. Similarly, pump efficiency gave an inverse relationship with suction head where higher efficiencies of more than 70% were obtained at heads of less than 0.5 m. A linear relationship was obtained between discharge and operator's body weight. Threshold weights of 30 to 50 kg were estimated depending on pump and suction head. Leakages through the vacuum chamber and hose couplings greatly reduce pump efficiencies at higher suction heads.

505

Design, Development and Comparative Evaluation of a Ground Driven vs PTO-driven Metering Mechanism for a Fertilizer Applicator: Mohd., Sami H., Former Grad. Student; Omar A. Rahama, Assoc. Professor, respectively, Univ. of Gezira, P.O. Box 20, Wadmedani, Sudan; M. I. Dawelbeit, Sr. Research Scientist, Agric. Res. Corp., Wadmedani, Sudan.

A ground wheel drive mechanism was developed to control the metering system of a fertilizer applicator. Comparison of the performance of the newly designed drive mechanism (a tractor PTO drive mechanism) shows that the both had generally the same efficiency. Furthermore, the ground drive mechanism was not affected by the type and model of the tractor and better in checking the amount of fertilizer placed. It was simpler and less expensive and can be manufactured locally.

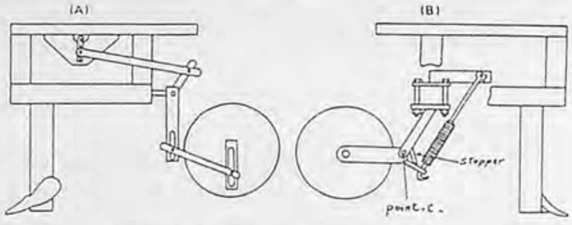

Fig. Driving Wheel Assembly: a) cranking system b) wheel holder

508

Influence of Wheel Materials on Performance of Rigid Towed Wheel on Deformable Soil: Gangde, C.N., Asst. Professor, Dept. of Farm Power and Machinery. Punjabrao Krishi Vidyapeeth, Akola (M.S.), India; K.P. Pandey, Professor, Agric. Engineering Dept., Indian Institute of Technology, Kharagpur (W.B.), India.

The effect of different wheel materials on wheel performance was studied. The four different types of model wheels were wooden wheel with steel rim, wooden wheel with rubber rim, steel wheel and steel wheel with rubber rim. They tested in an indoor soil bin at four different normal loads and three moisture levels on the sandy clay loam soil. On the basis of rolling resistance, it was found that the performance of all the four wheels was almost at par.

511

Computer Simulation of Cold Storage Plant: Vyas, D. M., Assoc. Professor (Process Engg.), College of Agril. Engg. & Technology, G.A.U., Junagadh (Gujarat), India; D. K. Gupta, Professor & Head; B. P. N. Singh, Professor and Co-ordinator, Centre of Advanced Studies in Post Harvest Tech., Dept. of PHP & FE, College of Tech., G. B. Pant Univ., Pantnagar (U.P.), India.

A study was undertaken up to develop a computer simulation model to predict hourly refrigeration load for a commercial potato cold storage plant. Data on ambient temperature and loading schedule were taken at U. P. Seeds and Tarai Development Corporation's cold storage plant, Haldi for 38 days loading season. Six different heat gain sources, i.e., heat conduction through walls and roof, heat conduction through door, air infiltration, electric appliances, occupants and product load were analysed. Heat conduction through walls and roof, the largest contributor, was computed by using transfer function coefficient approach. The simulated operation hours of the plant during loading season were in agreement with the actual operation hours, with deviation in the range of −14.36% to +7.71%.

513

Development and Testing of a Two Row Seed-gun for Planting Maize: Bhuyan, J.S., Graduate Student; H Raheman, Asst. Director, respectively, Dept. of Farm Machinery & Power, College of Agricultural Engg. and Tech., Bhubaneswar-751003, Orissa, India.

A manually-operated, tow-row seed-gun for planting maize was fabricated at the College of Agricultural Engineering and Technology, Bhubaneswar, India using locally available materials. The seed-gun worked satisfactorily and no bending or squatting was necessary for its operation. Moreover, in one stroke both soil opening and seed dropping in the hole were possible and maintained uniform row-to-row and plant-to-plant distance. The field capacity and speed of operation of the seed-gun for planting maize were 0.0213 ha/hr & 8.66 m/min, respectively. The cost of the seed-gun was $18. Farmers appreciated this implement.

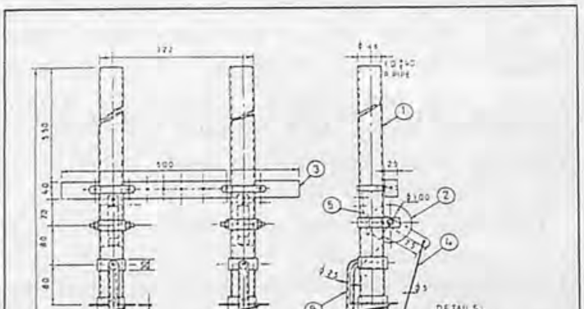

Fig. 1 Manually operated two row seed-gun.

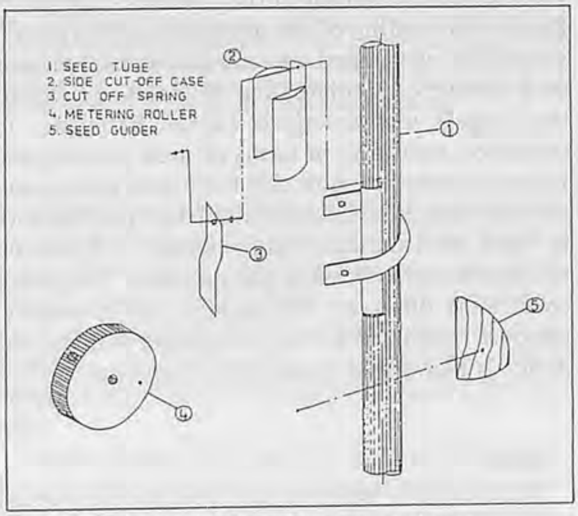

Fig. 2 Metering mechanism of two row seed-gun.

515

Analysis on the Test of Hydraulic Servo Automatic Elevating and Balancing Equipment of Tractor: Guo-Zhen, Wu, Chai Jian-ping, Rao Xiu-qing, respectively, Zhejiang Agricultural University, Hang Zhou, China.

In this paper, the function, composition of equipment and the principle of the elevating and balancing equipment are presented. The experiment of property, the precision of balancing weight and it's error are analyzed in detail.

For the sake of high availability and multi-function, a set of automatic elevating and balancing equipment was installed on the front of a "benye-250" tractor produced by Ningbo Tractor Factory. The Automatic Controlling Ploughing Depth of Tractor Hydraulic Servo System (ACPDTHSS) is used as automatic elevating, with the help of which agricultural products can be elevated, balanced and transported automatically. Besides, the aims we need ahead, high productivity and less working strength have been obtained also.

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The equipment is made up of three parts: hydraulic servo component, load elevating component and automatic balancing component. In order to understand its performance, some tests were conducted successfully and the results were satisfactory.

518

Development and Evaluation of a Manually Operated Paddy-cum-Groundnut Planter for Small Farmers: Pradhan, S.C., Assoc. Professor; D. Behera, Lecturer; B. Mahapatra, P.G. Scholar; B.C. Sahoo, Teaching Asst., respectively, College of Agric. Engg. and Tech., O.U.A.T., Bhubaneswar, Orissa, India, 751 003.

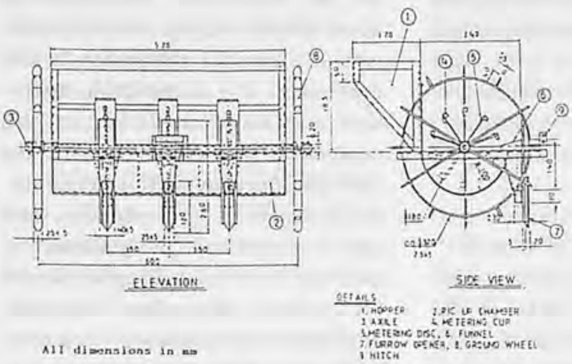

Fig. 1 Manually-operated paddy-cum-groundnut planter.

Fig. 2 Field operation of manually-operated paddy-cum-groundnut planter.

A manually-operated paddy-cum-groundnut planter was developed at College of Agric. Engineering and Technology, O.U.A.T., Bhubaneswar and its performance was evaluated both in laboratory and field condition for paddy and groundnut crop. Laboratory studies include percentage variation of seed discharge among the rows and mechanical damage of seeds. Field studies include actual seed rate, depth of placement of seeds, seed distribution efficiency, effective field capacity, field efficiency, labour requirement and field machine index. The field efficiency and field machine index of the planter were found to be more than 78 and 80 per cent, respectively. Net savings of Rs. 362.58* and Rs. 358.21/ha were obtained as compared to local practice of sowing. The cost of the planter is estimated to be Rs. 965.00 which is well within the investment capacity of small farmer's of the state.

*Current rate of exchange is Rs. 30.85 = U.S.$1.00

527

On-farm Chemomechanical Strategies for Salt Affected Soils Reclamation: Razzaq, Abdul, Senior Subject Matter Specialist (Engg.), A.R. Farm, Sheikhupura, Pakistan.

The paper describes the extent of salt-affected soils in Pakistan. Various sources of salt accumulation damaging agricultural land at an alarming rate in the country and the physiochemical condition of the different categories of salt affected soils have been a major concern in the country. Appropriate chemomechanical reclamation strategies for the saline, saline-sodic and sodic soils were enunciated for an on-farm adoption by farmers alongwith prerequisites. Preventive measures were conducted in order to keep salts level low in fields for a better crop production.

565

Irrigation-based Mechanization for Bangladesh: Paul, S.C., Research Associate; C.P. Gupta, Professor, respectively, Agricultural and Food Engineering Program/SERD, Asian Institute of Technology, GPO Box 2754, Bangkok, 10501, Thailand.

An experiment was conducted in Bangladesh to study the present status of mechanization using electric-powered tube well irrigation schemes, rural rice mills and power threshers. In the study area, investors provide irrigation water to a group of farmers' land on share-crop system; rice mill owners mill the rice of local people at cash payment system; and power threshers are only used at the research stations. Selected irrigation-based integrated operations for mechanization were carried out.

The finding indicate that irrigation-based integrated agro-industrial operations based on soil can give 2.5 to 5.5 times and 9 to 16 times of profit by covering the present and potential command area, respectively, compared to the present single irrigation practive. Investors can earn Tk.3 474 to Tk.17 196 and Tk.7 197 to Tk.20 681 per month, respectively, from these projects by creating employment opportunity. Electricity supply by Rural Electrification Board (REB) in integrated projects at a marginal rate is suggested to encourage mechanization in Bangladesh. ■■

NEWS

Agritechnica '97
November 11-15, 1997
Hanover, Germany

The world market of agricultural machinery will be open to the international specialist public at the Fairgrounds in Hanover from 11 to 15 November 1997. Two trade preview days have again been scheduled for 9 and 10 November 1997.

Following the successful "AGRITECHNICA" in 1995 and the equally successful "EuroTier '96" which has just come to a close, the concept of the organizer, the German Agricultural Society (Deutsche Landwirtschafts-Gesellschaft, DLG), of holding "AGRITECHNICA" and "EuroTier" in alternating sequence at Hanover as central European agricultural venue has been accepted by exhibitors and visitors alike. This concept satisfies the needs for information as well as the information-gathering behaviour of the visitors in full, especially of the professional and specialized farmers.

Already in 1995 the Agricultural Centre Hanover proved to be the right choice for "AGRITECHNICA". It is located at the heart of Europe's important agricultural regions and consequently lies in the catchment area of high-performing farms with farm managers who collect information, who invest and who have a forward-looking philosophy. More than 178 000 visitors from 74 countries, including 114 000 visitors from practical farming, 35 000 from the sector of agricultural machinery and trade, and 29 000 from the fields of services, craft trades, consultancy, public authorities and scientific institutes were guests at "AGRITECHNICA '95".

In addition to the complete agricultural programme covering classical agricultural machinery and the proven special sectors of forest technology (SILVATECHNICA), municipal applications and landscape conservation, as well as renewable industrial raw materials and renewable energy sources, a further focal segment will be out door vegetable cropping for the first time. This reflects the growing importance of large-scale vegetable production. All appropriate product programmes such as special tractors, soil tilling and cultivation machinery, fertilizing and plant protection machinery, as well as harvesting and storage machinery and processing equipment too will be combined in this "AGRITECHNICA-Special", together with a wide spectrum of plant and seed material.

The complete exhibition programme of "AGRITECHNICA '97" will be presented in the proven exhibition halls 2, 3, 4, 5, 6, 7, 14, 15, 16, 17 and 18 as in 1995. Hall 4, newly constructed in 1994, is included too.

Further information on "AGRITECHNICA '97" is available from the Deutsche Landwirtschafts-Gesellschaft (DLG), Eschborner Land-strasse 122, D-60489 Frankfurt am Main, telephone ++49/(0)69/24788-252 or telefax ++49/(0)69/24788-113.

International Conference on Agricultural Engineering and Technology Exhibition '97
December 15-18, 1997
Dhaka, Bangladesh

Increased and sustainable agricultural production needs modernization of agricultural operations and activities through introduction of appropriate mechanization. This can help eradication of hunger which prevails in the rural areas of most of the developing countries. If effective actions in this field are not taken, misery, poverty and starvation will increase to a disastrous level. With this end in view, Bangladesh Society of Agricultural Engineers (BSAE) has arranged an International Conference and Technology Exhibition to be held in Dhaka during 15-18 December 1997. The American Society of Agricultural Engineers (ASAE), Institution of Engineers, Bangladesh (IEB), Asian Association of Agricultural Engineers (AAAE) and other professional bodies and educational institutions at home and abroad are providing technical and financial cooperation for this conference. The deliberation, discussion and recommendation of this conference will greatly benefit the sustained development of agricultural production, agro-industries and agro-business of Bangladesh, in addition to exposing Bangladesh and her professional bodies, industries, businesses and institutions to a large body of international participants.

Objectives

The objectives of this international conference are as follows:

a) To provide a forum for sharing experiences and ideas of research and development and exchange of technologies among researchers, scholars, field engineers, users and other associated professionals in the disciplines related to food and agricultural engineering.

b) To establish a linkage between engineering professionals in general and agricultural engineers of Bangladesh in particular and their professional colleagues in other developing and developed countries for a sustainable professional development process.

Further Information

For any enquiry, one of the following persons may be contacted:

1. Dr. M A Mazed, Director General, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur 1701, Bangladesh, Fax: 880-2-841678, E-mail: dg@bari.

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AFIA AGRO MEXICO '98

March 5-7, 1998
Jalisco, Mexico

AFIA AGRO MEXICO '98 will be held March 5-7, 1998 at Expo Guadalajara in the state of Jalisco, Mexico. Featuring agricultural and livestock equipment, supplies and services from companies worldwide, AFIA AGRO is Mexico's largest agricultural exhibition.

Attendance records were broken last year, with over 6 600 qualified trade visitors, from 22 countries, visiting 214 exhibiting companies! Show organizers fully expect to surpass this number in 1998, with attendance promotion covering Central and South American countries as well as all over Mexico.

Comprehensive seminar and conferences geared towards both visitors and exhibitors are a significant part of AFIA AGRO '98. The show will once again feature the renowned AFIA Production School.

AFIA AGRO MEXICO is owned and produced by Agro Food International Associates, L.L.C., a partnership between the American Feed Industry Association, the Consejo Agropecuario de Jalisco (the umbrella organization for agricultural associations in the state of Jalisco), and International Trade Information, Inc. (an international trade show management firm specializing in Mexico and Latin America).

Contact: International Trade Information, Inc., 21031 Ventura Blvd., Suite 405 Woodland Hills, CA 91364-2203, USA. Tel: (818) 340-8864; Fax: (818) 340-7017; E mail: ITIINCUSA@aol.com.

AGROENVIRON, 98 — International Symposium on Agro-Environmental Issues and Future Strategies: Towards 21st Century

May 25-30, 1998
University of Agriculture, Faisalabad, Pakistan

Intensive agriculture, deforestation, waterlogging, salinity, industrialization and population explosion have introduced changes that are threatening life on the globe. For abatement purpose, awareness campaigns, extension programmes, legislation and research studies are being planned/executed. Both public and private agencies are working. However, there appears a gap between the word and the action since the programmes lack understanding. There is a need that the community should discuss agro-environmental problems and suggest strategies for a better future of human. In view of this, the following topics related to agro-environmental issues are proposed for paper presentation at the symposium.

Agro-ehcmicals and groundwater contamination; Agricultural machinery related noise pollution, soil compaction, erosion etc; Agro-industrial pollution and control; Acid rains and air pollution; Agro-environmental impact assessment and legislation; Industrial/sewage irrigation and soil pollution; Modeling agro-environmental systemsz: Farm wastes, recycling and energy generationz: Mountainous deforestation and management; and any other.

Paper Abstract Due on: November 15, 1997

Contact for further information: Prof. Dr. Jehangir Khan Sial, Symposium Director, Faculty of Agricultural Engineering & Technology, University of Agriculture, Faisalabad, Pakistan. Tel: 0092 (41) 30281-89 / Ext. 434. Fax: 0092 (41) 33214 / 647846 / 30679. E-mail: iqrar@ptccuaf.fsd.brain.net.bk (Att: Sajid Azeemi)

AgEng Oslo 98 — International Conference on Agricultural Engineering

August 24-28, 1998
Oslo, Norway

The Norwegian Society of Agricultural Engineering and the Agricultural University of Norway are delighted to invite you to participate at the AgEng '98 International Conference on Agricultural Engineering to be held from 24-28 August downtown Oslo - the gateway to Norway. The conference will cover all the latest topics in Agricultural Engineering in scientific sessions, posters, videos, and special interest group meetings. Get to know your colleagues at evening receptions, a fjord cruise, or a visit to one of the numerous sights of Oslo. And choose among the technical study tours to see why the Norwegian farming community is happy outside the European Union and CAP.

The language of the conference will be English.

Call for papers

Call for papers will be sent in spring 1997 to all persons and societies who have sent the preliminary registration form. Contributions can be in the form of papers, posters, video tapes, computer programmes, and maybe small items for exposition and demonstration. Abstracts in English, of no more than 400 words on no more than two pages, should be submitted before 1, December 1997.

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Conference secretariat
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UNACOMA presentation of the market results for agricultural mechanization, gardening and earth movement in '96 — Rome, March 5, 1997

A record is immediately apparent in striking the balance for agricultural mechanization in 1996. A total of 866 000 tons of tractors and agricultural machinery produced, gardening equipment included, shows an 8% increase over '95 and exceeds the results 'of mythical proportions' for 1980.

The mechanization resuls, unveiled by Unacoma President Alfredo Celli at a press conference held at the Center for Economic Documentation for Journalists, reward our industry which confirms its solid presence on the domestic market and is especially focused on those foreign markets which, in 1966, took up 61% of total production.

The export trend is especially satisfying for Italian industry, which closed '96 with exports totalling 528 000 tons, valued at 5.7 trillion lire (3.56 billion dollars), and a surplus of 440 000 tons, worth 4.6 trillion lire (2.8 billion dollars), an all-time record for farm machinery.

Reported for the sale of tractors on the domestic market was a gain of 4.7% over '95 with 29 000 units sold and the data on registration, provided by the Transport Ministry, were equally positive in confirming an increase of 21.6% over '95. The results for combine harvesters were also good with progress of 15% in sales reported, 670 machines compared to 580 sold in '95, and registrations up 15.9%. For tractors, the increases compared to '95 came to 44% in the Lombardy region, with a gain of 40.6% reported for the Veneto region, 48.3% for Emilia Romagna, 130.2% for the Marche, 17.7% for Lazio, 62.6% for Puglia and 61.3% for Calabria.

Good results were also turned in for agricultural equipment (machinery for tilling, fertilization, sowing, irrigation, plant protection, etc.) for which the only data available have been compiled in sample surveys conducted by Unacoma which make it possible to estimate growth at 6%. For engines, this sector rose 3% in the first nine months of the year and renewed interest was shown for diesel power plants. The only decline at the production level reported was for self-propelled farm machinery, a sector in which walking tractors were down 11%, motor hoes off 11.7%, motor mowers for hobbyists falling 27% and multi-purpose farm vehicles down 20%, though for these latter items registrations in Italy were in line with those for '95.

Machinery for gardening and public green areas, a sector in which 160 manufacturers produce a vast range of equipment, displayed an increase in output of 7%, below, however, the 15% gain reported for '95. Gardening machinery represents one of the spearheads for our exports iwth a trade balance surplus of 600 billion lire (375 million dollars), up 9% over the previous year.

For earth moving equipment, which is also represented by Unacoma (Comomotor), 1996 is expected to close with production of 360 000 tons valued at 3.4 trillion lire (2.13 billion dollars) for a decline of 5% under '95 related to a drop in exports offset by a gain of 12% in sales on the domestic market. Despite the downturn on the export market, the earth moving sector exported 298 000 tons of equipment last year for a value of 1 770 trillion lire (1.1 billion dollars) for a surplus of 220 000 tons worth 1.1 trillion lire (688 million dollars).

"The sound results of mechanization," Alfredo Celli commented, "should be confirmed by the '97 trend to thereby ensure the stability of the market which, for this industry like other sectors, represents the primary condition for planning activities and introducting innovations."

In '97, Unacoma information initiatives will be mounted through specific events and activities. Some of these to put on the calendar — aside from the traditional appointment with EIMA set for October 29 to November 2 — are the first edition of Comamotor in the Field in Portomaggiore April 4 and 5; two outings of Eima in the Field in Epoli in June and Cremona in October; MIGA, the gardening exhibition to be staged September 18 top 21 in cooperation with the Milan Trade Fair; as well as the conference on the issue 'Agricultural Mechanization and the Environment', scheduled for April 16 in Rome, in Confindustria's Auditorium della Tecnica. ■■

Jahrbuch Agrartechnik — Yearbook Agricultural Engineering / Edition 1996

(Germany)

by Prof. Dr.-Ing. Dr.-Ing.E.h.H.J. Matthies and Dr. agr. F. Meier

In recent years, the "Yearbook of Agricultural Engineering", whose eighth edition is available now, met with the interest of an always increasing readership. It gives us great pleasure that the number of copies which can be sent abroad has further risen. Due to the renewed support of the Bundesministerium für Ernährung, Landwirtschaft und Forsten (BELF), agronomists in all countries of Eastern Europe could be provided with the Yearbook, where they find concentrated information about the current standards and the development in the agricultural engineering sector in Germany.

The bilingual text has proved useful. The Yearbook is not only employed as a source of information, but it also serves as an "encyclopedia" at the universities.

The basic structure of the Yearbook has been retained, which allows fast orientation in the individual fields with the aid of previous editions. The Yearbook is concluded again by an extensive bibliography of German and international publications, classified according to the fields treated in the text.

277 pages, price (1996) DM 78.-

Published by Landwirtschaftsverlag GmbH, Postfach 480249, 48079 Münster, Germany (Tel. 02501/801-118, Fax. 02501/801-204).

Non-Motorised Transport in India

Current Status & Policy Issues

(India)

The Asian Institute of Transport Development (AITD), New Delhi commissioned a study on the present scenario of the NMT in India and has brought out a study report entitled, "Non-motorized Transport in India: Current Status and Policy Issues".

This report attempts to bring together the scattered and sketchy information on the NMT sector in India (chapters 2 and 3), highlights, through examples, its relevance in the international context (chapter 4), briefly delineates the role of NMT in attaining the goal of a sustainable transport system in India (chapter 5), and then discusses, in the light of the foregoing chapters, the various important policy issues related to the role of NMT (chapter 6). This is followed by a summary of observations & recommendations for action by the government (chapter 7).

The scope of this study is confined to those modes of NMT which have a significant presence in India and are likely to continue to play a vital complementary or alternative role in the transport services. These modes need recognition as well as the technological, infrastructural, and financial inputs as are provided to the motorized modes. The study does not cover the use of human or animal energy for small-scale local applications, such as 'headloading' or use of carts for hawking, trolleys and wheelbarrows. It may be mentioned in this context that even in the case of NMT modes which have been studied in detail, quantitative data has been found to be generally deficient as NMT vehicles are largely unregistered and unrecognized in the transport statistics, planning and studies.

Published by Asian Institute of Transport Development. Apt. E-5, Qutab Hotel, Shaheed Jeet Singh Marg, New Delhi - 110 016. Phones: 6856113, 6856117, Fax: +91 (11) 6856113, E-mail: Klt%aitdin@delhi.globemain.com

Merging Systems Research and Social Actor Approaches

(The Netherland)

The Royal Tropical Institute (KIT) has just released the publication *Agricultural R&D at the crossroads: Merging systems research and social actor approaches.*

The difficulties inherent in providing sustainable food supplies for the world's populaiton are becoming ever more apparent; agricultural researchers stand at a crossroads. It is becoming increasingly clear that social, political and economic processes are often as critical as — and even overshadow — technological innovation. Agricultural systems are broader than our usual definitions, and far more socially complex. To take advantage of the potential of social actor approaches, many researchers will need to acquire new skills. Are we willing to do this, to work collaboratively toward mutually defined aims? This book suggests that if we are to achieve sustainability, to create strategies with the objective of making it possible for rural populations to manage their own resources, these are exactly the areas in which we must attempt to change.

Agricultural R&D at the crossroads includes an introduction to these issues, a detailed annotated bibliography containing English and French sources of both 'grey' literature and published material, and an edited selection of papers from the 1994 Montpellier symposium on systems-oriented research in agriculture (with a focus on Africa).

Six of the seventeen chapters are in French, with English summaries.

**Agricultural R&D at the crossroads: Merging systems research and social actor approaches*, A. Budelman (ed.) ISBN 90 6832 107 2; paperback, 248 pages, English/French, Dfl. 59.-

For more information or review copies, please contact: Erica van 't Leven, KIT Press, 63 Mauritskade, P.O. Box 95001, 1090 HA Amsterdam, The Netherlands, telephone 31 (20) 5688 406 / fax 31 (20) 5688 286 / e-mail kitpress@kit.support.nl.

Proceeding of the 8th National Rice R&D Review and Planning Workshop, 1995

(Philippines)

The recent National Rice R&D Review and Planning Workshop had twofold objectives: to review the 1994 completed and on-going researches in rice, and to plan strategic rice research and development directions for the coming year.

This year, however, we did not plan only for next year but several years ahead in response to the new world trade order recently entered into by some 130 nations around the world, including the Philippines. Known as the GATT or general agreement on tariffs and trade, the 21st century will see trade barriers falling, and national economies tied into a global trade network. And this includes the trading of rice.

Can we make it in this new order? Can our farmers compete globally? Can our rice industry survive the onslaught of cheap rice from Asian neighbor countries? How can we compete in this new trade order?

These are some of the daunting issues that confront us in the scientific community. And in between this time before the barriers are finally down, we have to find solutions to the decreasing land area for rice due to rapid urbanization and industrialization; rising population pegged at 75 million by 2000; limited funding for research; insufficient infrastructures such as irrigation, roads, harvest and postharvest facilities; and unforseen calamities that have haunted us these past several years.

207 pages, 22.0 x 28.7 cm, softbound.

Published @ 1995 by the Philippine Rice Research Institute (PhilRice) Maligaya, Muñoz, 3119 Nueva Ecija, Philippines

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Provincial Rice Statistics 1995

(Philippines)

This Provincial Rice Statistical Series 1995 highlights our commitment to the development and implementation of more effective policies and programs through better information.

This new edition satisfies the need for more specific rice data by local government units (LGUs) which now plan, formulate, and implement their own development policies and programs in line with national directions. It is most useful to LGU-based rice R&D workers - from policy makers to agricultural field technicians. We believe this factbook is a handy and convenient reference material.

The contents of this edition are similar to those of the regional edition, except that information was updated to 1994. Also, national totals are now followed by selected provincial totals.

202 pages, 220 x 28.7 cm, softbound.

Published @ 1995 by the Philippine Rice Research Institute (PhilRice) Maligaya, Muñoz, 3119 Nueva Ecija, Philippines

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PhilRice Technical Bulletin 1995

(Philippines)

The primary objective of this publicaxtion is to update researchers and development workers of the PhilRice network on the latest findings in rice research.

In the past 10 years, we have generated important information in various disciplines of rice science, and several of these works have been published in prestigious international and local scientific journals. Yet, much of these information still await publication since we do not have our own journal. There are much more that need to be published and disseminated, and on a more frequent basis. We believe that this bulletin will serve this purpose for the moment.

172 pages, 220 x 28.7 cm, softbound.

Published @ 1995 by the Philippine Rice Research Institute (PhilRice) Maligaya, Muñoz, 3119 Nueva Ecija, Philippines

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No-Tillage Seeding: Science and Practice

(U.K.)

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by C.J. Baker (CINTRE, New Zealand), K.E. Saxton, (Washington State Univ., U.S.A.), W.R. Ritchie (CINTRE, New Zealand)

During the last thirty years farmers have been strongly encouraged to adopt some form of conservation tillage, primarily for long-term environmental reasons. However, the experience of many farmers of no-tillage suggests greater short-term risk, in the form of reduced seedling emergence or crop yield or even crop failure.

A major aim of this book is to show how the risks in the practice of no-tillage can be reduced. It begins by describing the inter-relationships between soils, machines, seeds and growing plants. Too often in the past in the subject has been approached from a purely engineering or a purely soils perspective, neglecting the agronomic viewpoint. The authors of this book focus on the needs of the plants which thus determine the requirements for a no-tillage seed drill. The result of their own research is the inverted T-shaped no-tillage sol slot and the Cross Slot drill™ and planter opener, which are described in some detail. By re-evaluating common assumptions about seed germination in soil, the authors provide a totally new perspective on no-tillage seeding.

272 pages, hardbound, £49.95 (US$90.00 Americas only)

Published by CAB International, Wallingford, Oxon OX10 8DE, UK.

Modern Rice Technology and Income Distribution in Asia

(USA)

Edited by Cristina C. David and Keijiro Otsuka

Two decades have passed since the introduction of modern rice varieties (MVs) and their accompanying technology in Asia. This volume looks at seven Asian countries with widely diverse production environments and agrarian and policy structures to determine to what extent the adoption of MVs only in the irrigated and the favorable rainfed-lowland areas has exacerbated inequalities in the distribution of income.

Refuting claims of Green Revolution critics, the contributors find that, when both direct and indirect effects of labor, land, and market adjustments are considered, differential adoption of MVs across environments did not significantly worsen income distribution. Instead, as MV adoption increased the demand for labor in the favorable areas, interregional migration from unfavorable areas took place, which mitigated potentially negative impacts by equalizing regional wages. Shifts to alternative crops or nonfarm employment in the unfavorable areas, as well as the enlargement of farm size, also contributed to the restoration of equity.

This book is jointly published by Lynne Rienner Publishers, Boulder, and IRRI.

475 pages. 15.24 × 22.86 cm. Paperback. HDC, send orders to Lynne Rienner Publishers, Inc., 1800 30th Street, Suite 314, Boulder, Colorado 80301 USA; LDC, send orders to IRRI. US$12.00 plus airmail (US$9.50) or surface (US$2.00) postage.

Computers in Agriculture — Proceedings of Sixth International Conference on Computers in Agriculture

(USA)

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by Fedro S. Zazueta

Computer-related professionals from around the world provide an exchange of information on new developments and applications of computers to agricultural, biological and natural resource problems.

Let experts help you:

- Discover ways to facilitate communication among those involved in the development, delivery and use of computer technologies in agriculture.
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1 149 pages, 6 × 9 inches, softbound, $80 List and $64 ASAE member.

Mail to ASAE, Dept. 1663, 2950 Niles Rd., St. Joseph, MI 49085-9659 USA.

Evapotranspiration and Irrigation Scheduling — Proceedings of the International Conference

(USA)

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by C.R. Camp, E.J. Sadler, and R.E. Yoder

Co-sponsored by the Irrigation Association and the International Committee on Irrigation and Drainage, this proceedings provides an exchange of information on new developments in the area of evapotranspiration and irrigation scheduling.

Scientists and practitioners from all over the world...

- Report new technology
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- Identify and prioritize future needs

Researchers, consultants, designers, instructors, extension specialists, practitioners, managers, users, and manufacturer representatives of instrumentation used for evapotranspiration and irrigation scheduling will benefit from this excellent source of information shared by professionals around the world.

1 166 pages, 6 × 9 inches, softbound, $59 List and $48.95 ASAE member.

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