International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.30, NO.3, SUMMER 1999

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.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7-2 Kanda Nishikicho, Chiyoda-ku, Tokyo, Japan (Tel. 03/291−5717−8, 3671−4)

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Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

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

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

This is the 104th issue since its maiden issue in the Spring of 1971

EDITORIAL

Increasing Food Availability

As the next millennium approaches, most countries of the world—developed or developing, and international bodies such as the Food and Agriculture Organization (FAO) of the United Nations are being called upon to give top priority in their agenda on agricultural development efforts to the subject of increasing food availability. This is because so many people around the world still continue to die from starvation and scores of children still go to bed hungry. Also being called upon are countries with wealth and power to share their fortune with their less fortunate counterparts in terms of helping provide some means of increasing food availability.

In this regard, Japan is no exception in the sense that a bill on the Revised Fundamentals of the Agriculture Act is expected to pass the Diet in July—by the time this summer issue of AMA will be in circulation. As might be expected, the revision envisions putting emphasis on raising domestic food self-sufficiency rate and diversifying the functions of agriculture and forestry. This is because, truth to tell, Japan's self-sufficiency in food is by far the lowest among the developed countries—less than 40 percent on calorie basis. And as the next century expects world population to increase against a decrease in arable lands per capita, there is no assurance for Japan to be able to import food in the future through the power of money from developing countries where food is likewise in short supply. To do this will jeopardize people in those countries who will go hungry. Therefore, in view of the food problem of the world, it is only logical that Japan makes efforts to increase domestic food production making the most of her favorable climate and availability of modern farm machineries and technology.

It has since been the obsession of AMA to help, in ways that it can, to help strengthen international cooperation among developed and developing countries; among farm mechanization experts and scientists; among agricultural research institutes in matters of increasing food availability through the utilization of available wide varieties of farm machineries and equipment. In this way, farm mechanization will not only minimize farm work drudgery but more importantly, increase crop yields and quality.

This editorial reiterates the need for governments of developing countries to embark on farm mechanization in order to catch up with developed countries.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
July, 1999

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 30, No. 3, Summer 1999

Comparative Utilization of Natural Energy in Agriculture

(Solar Energy Required and Predicted in Two Different Countries)

by
Ibrahim E.A. Elbatawi
Department of Agricultural Engineering
Faculty of Agriculture
Okayama University
1-1-1 Tsushima Naka
700-8530 Okayama, Japan.

Kentaro Mohri
Department of Agricultural Engineering
Faculty of Agriculture
Okayama University
1-1-1 Tsushima Naka
700-8530 Okayama, Japan.

Abstract

Egypt as a developed country still has no electricity in many villages but at the same time has enough natural energy such as solar energy. Solar radiation data is not always available in many areas of the world and they have to be estimated using some sort of empirical model. The results of this prediction are compared for the measured data of two different countries: Japan (Okayama City) and Egypt (Giza City). The comparison shows a good agreement of the prediction.

As an example in a June day, actual total insolation was 18.88 MJ/m^2 for Okayama and 22.79 MJ/m^2 for Giza and the simulated one was 20.31 MJ/m^2 and 24.03 MJ/m^2 for Okayama and Giza, respectively. The solar water heater in the worst solar month (January) provides about 35% of the energy for Okayama and 40% for Giza.

Introduction

The estimation of solar radiation is one of the most fundamental techniques used for energy calculation in solar energy applications. The purpose of this study is to predict the solar energy required for agriculture such as heating (inside a greenhouse), farm use or drying, with an acceptable level of accuracy.

For instance, the thermal behavior of buildings is an interaction of concurrently existing various phenomena and hence its modeling becomes inherently complicated and interdisciplinary in nature. It has been demonstrated that the estimated results of energy requirement for buildings for the identical conditions are often different by as much as a factor of two depending upon the calculation methods used (Kusuda and Alereza, 1989).

Chronologically, the models for energy calculation have been evolved in the daily simulation with use of the full set of collected weather data (Elbatawi et al., 1997).

Because of the influence of various meteorological parameters and their mutual interdependency on the environment, the analysis of radiation should contain some information regarding how to deal with the correlations among these parameters. Any improvement of modeling techniques requires a careful choice of meteorological data.

Many sets of weather data are provided by public institutions, particularly for the purpose of energy calculations. For example, the complete set of weather data created by the U.S. National Climate Center and recommended by ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) is so-called WYEC, the Weather Year for Energy Calculations. The source of weather data in Egypt is called Giza National Meteorological Agency (GNMA) and in Japan called, Okayama Meteorological Agency (OMA).

Updating or creating weather data for a new location is time consuming and extremely expensive, and hence, efforts were concentrated recently on modeling weather characteristics.

Great interest was in solar radiation phenomena for which many models have been introduced and verified by comparing with measured data (Ineichen et al., 1988) and (Coppolino, 1990). Recently, an overview of the methodology for the synthesis of hourly weather data has been presented (Knight et al., 1991). Most of these models considered only solar radiation itself and they were

Acknowledgements: The authors wish to express their profound gratitude to GTZ and DSE of the Federal Republic of Germany for sponsoring the research project.

created for use in solar engineering. The model presented in this paper is to be used in the field of energy calculations of greenhouses which is easly accessible, simple and agrees well with reality.

There are two different approaches to weather data generation. The first is to combine the existing statistical information, distribution, autocorrelation and possibly cross-correlation by constructing the random number generator which produces sequences indistinguishable from those of the recorded data. The second approach is deterministic and relies on two main methods: (a) the synthetic sequence is constructed from the real long-term data, and (b) the deterministic formula is derived which usually describes the average weather conditions.

The one recommended by ASHRAE, 1993 can be categorized as deterministic equation. The pertinent parameters considered in the present study are the maximum values of daily radiation, the shape of daily progression, the sequence of the daily maxima, and the interdependence with other climatic parameters such as temperature and humidity. The development of the random analysis is based on the assumption that every sequence of the real data which represents local climate, has the same probability of occurrence as the simulated data as long as they maintain the same statistical properties.

Hot air can be used for both heating (the present study) or drying. Solar energy can replace about 19% of the electrical requirements of drying (Kranzler and et al., 1981) and on a monthly basis the ratio of solar energy to total energy input varied between 11% and 53% with minimum ratio occurring in December (Maghsood, 1979). Solar energy also is varied among countries. For example, in Madison (USA) the partial or full demand could be met by solar energy depending on location and load pattern in the plant and a collector with 3 000m^2 would be able to meet 70% of the total demand of food dehydration (Singh et al., 1983). In UK a solar panel area of 6 m^2 with a 280 ℓ preheat storage tank was able to contribute 10% of the annual total demand for heating 75% of the annual requirement for udder washing (Carpenter et al., 1986).

Sensible heat storage of high capacity calls for water as the working medium (indirect heating system). In any case, energy getting into the storage unit forms a part of the energy gained by the collector system. Also, the use of heat storage will necessarily involve a decrease in the temperature level of the energy obtained (Mujumdar, 1995).

Due to water medium, the solar collector can be connected to greenhouse, hot storage tank, hot water making system and other technological heat consumers (Farkas, 1991). Hot water can also be used either direct or indirect to the houses or farms. As an example, the energy demand in a beverage plant in Australia contributed over 40% of the total heat required in the form of hot water (Proctor and Morse, 1975). On the other hand, the hot water in a solar water heating system unit was able to contribute 28.9% of the energy during nine months milking period in New Zealand (Studman, 1979).

In view of the fact that the efficiency of the collector is over one part of operation time greater than the long-term efficiency, the energy utilized by the collector over this period is greater than the necessary value. In an investigation at West Verginia University of several different designs of flat plate solar collector installed on the south side of a poultry panel, efficiencies of approximately 55% were achieved (Harman, 1967). A similar study was done in UK during the drying season from October to December and efficiency of 37% was obtained (Chau et al., 1980).

The objectives of this study were:

1. To store the energy gained from the sun by solar system during the day time and use it for heating the water which can be used for some agricultural purposes;
2. To compare the energy collected and required under Japanese conditions with that under Egyptian conditions; and
3. To predict the energy required using a simulation model for comparison with the actual one.

Materials and Methods

The Proposed System

The proposed system is shown in **Fig.1** for Okayama. The collecting area of the solar collector is 4.22 m^2, and the storage tank capacity is 219 *l*. The hot water which is kept in a storage tank was transfered to a heat exchanger. The heat exchanger is 640 x 430 mm fine area. The ambient air passes across the heat exchanger by a fan, and its temperature increased. The fan is 400 mm diameter and is connected by a duct for heating a greenhouse. Both hot water and hot air can be used for many proposes such as heating (inside a greenhouse), farm use for hot water and drying some agricultural products.

The weather data collected in Japan was at the Okayama University, Faculty of Agriculture (OUFA). The data collected in Egypt was at the Agricultural Engineering Research Institute (AERI), Dokki, Giza.

Simulation Model

There are many cases in which the estimation of radiation reaching the earth's surface is proportional to the amount of radiation that would reach the surface if there were no attenuation due to the atmosphere. Thus a method of calculating this radiation is needed.

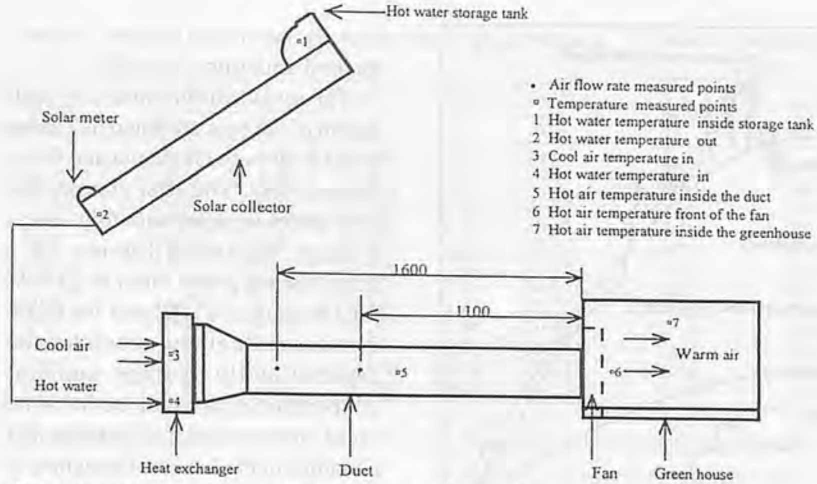

Fig. 1 Experimental system of solar collector and heat exchanger.

Theoretical Radiation

The theoretical radiation outside the atmosphere on a horizontal plane can be described as (Donald, 1991):

$I_o = I_{on} \times \text{COS}\ \theta_z$

Where; $\text{COS}\ \theta_z = (\text{COS}\ \delta \times \text{COS}\ L \times \text{COS}\ \omega) + (\text{SIN}\ \delta \times \text{SIN}\ L)$

And; $\delta = 23.45 \times \text{SIN}[360 \times ((284 + n) / 365)]$

Where:

I_o = Theoretical radiation (W/m^2).

I_{on} = Extraterrestrial radiation (W/m^2) $= I_{sc} \times \{1 + [0.034 \times \text{COS}\ ((360 \times n) / 365.25)]\}$

I_{sc} = Solar constant (1353 W/m^2).

θ_z = Solar zinith (degrees).

δ = Solar declination (degrees).

L = Latitude (degrees).

ω = Hour angle (degrees) = 15 times number of houres from solar noon (Richey and et al., 1961).

n = Julian day number.

Daily Total Solar Radiation

The daily total solar radiation can be estimated by integrating the equation of theoretical radiation between sunrise and sunset using the sunset hour angle:

$I_{total} = (T/\pi) \times I_{on} \times \{[\text{COS}\ \delta \times \text{COS}\ L \times \text{SIN}\ \omega_\sigma] + [(2\pi\ \omega_\sigma / 360) \times (\text{SIN}\ \delta \times \text{SIN}\ L)]\}$

I_{total} = Total daily solar radiation (W /m^2.d).

T = The length of the day (h).

ω_σ = Sunset hour angle (degrees), where $\text{COS}\ \omega_\sigma = -\text{TAN}\ L \times \text{TAN}\ \delta$

Results and Discussions

Simulation Results

There is a residual difference among the inaccuracy of hour-by-hour approximation and also in the energy calculations. In this case, the emphasis is placed on simplicity rather than on accuracy. Introduced in the following is the simulation method which is used for comparison with the actual data by measurement.

The described simulation procedure was applied to generate the radiation data for Giza and Okayama. Parameters for the simulation's equations were identified based on the OMA for Okayama and GNMA for Giza assuming one weather type. The results were compared with the measured data. The daily progression of radiation was calculated for each simulated day and compared with integrals obtained from measurements.

The results of the daily progression fit were presented for some days in June and January for Okayama and Giza in **Figs. 2** and **3**, respectively. It is observed that the approximation of the daily progression by the proposed simulation gives a good agreement for the total radiation with the measured results.

The method discussed here in the context of the solar radiation simulation is an integral part of the random weather simulation for energy calculations. The results of the daily progression fit are presented for bright days in June and January for both locations. It is observed that the approximation of the daily progression by the proposed simulation gives a good agreement for the total radiation with the measured results. For example, in a June day, actual total insolation was 18.88 MJ/m^2 for Okayama and 22.79 MJ/m^2 for Giza. On the other hand, simulated total insolation was 20.31 MJ/m^2 for Okayama and 24.03 MJ/m^2 for Giza.

In a January day, actual total insolation was 4.93 MJ/m^2 for Okayama and 5.49 MJ/m^2 for Giza. On the other hand, simulated total insolation was 9.02 MJ/m^2 for Okayama and 4.48 MJ/m^2 for Giza.

The actual and simulated solar radiation were close to each other for clear sky radiation for both locations in June. In January, the actual radiation was almost near half of the simulated one in Okayama because cloud cover was intermittent. A good agreement was found in the case of Giza because winter season is almost sunny.

Predicted Energy

We need to be able to predict, in advance, the monetary value of the energy produced at various seasons of the year, in order to understand the economics of using a water heating system and to arrive at an optimum system size to suit our needs. A fixed quantity of hot water is supposed to be ready every day at sundown. The solar water heater is filled with cold water at sunrise each day.

The amount of energy, Q, collected at the time Δt that elapses between sunrise and the instant the water reaches its maximum temperature is:

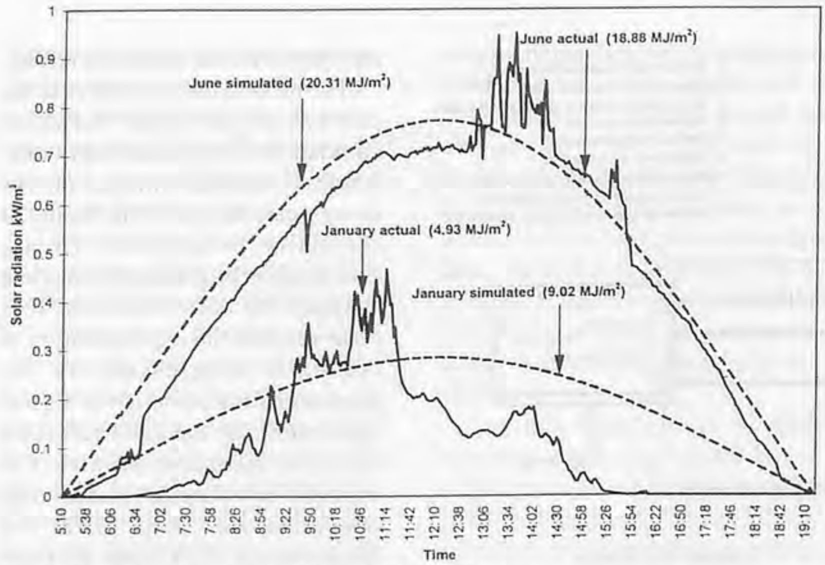

Fig. 2 Comparison for a June and January day for Okayama.

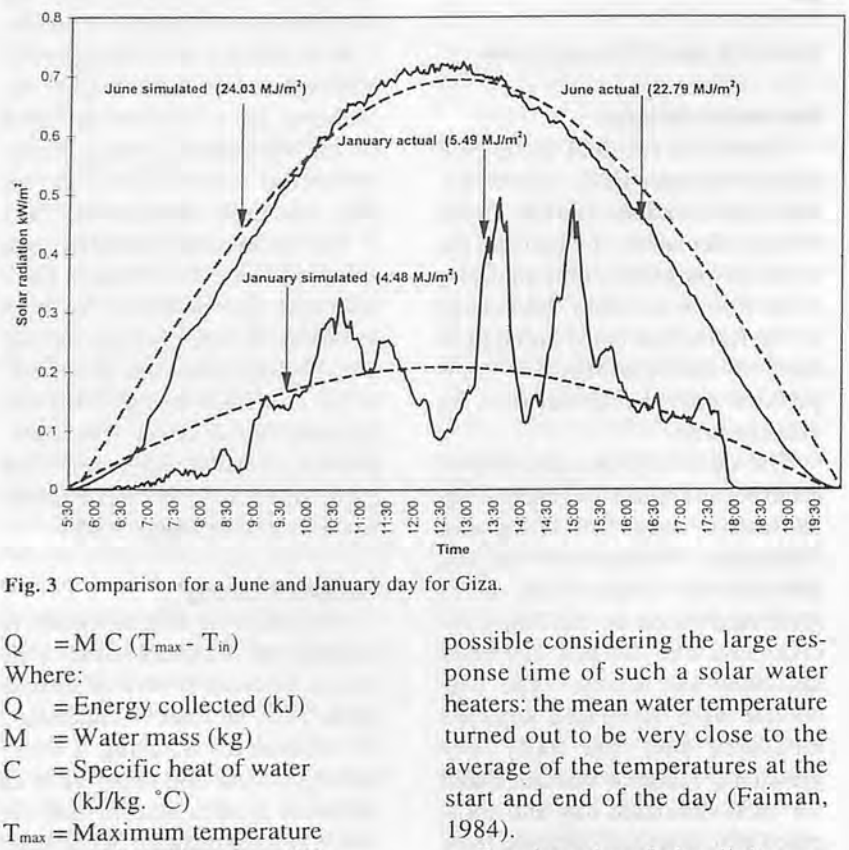

Fig. 3 Comparison for a June and January day for Giza.

$Q = M\,C\,(T_{max} - T_{in})$

Where:

Q = Energy collected (kJ)

M = Water mass (kg)

C = Specific heat of water (kJ/kg. °C)

T_{max} = Maximum temperature achieved by water (°C)

T_{in} = Collector inlet water temperature (°C)

In the equation above, T_{max} represents the maximum temperature and T_{in} is the temperature of the cold water in the solar heater at sunrise. Further simplification is possible considering the large response time of such a solar water heaters: the mean water temperature turned out to be very close to the average of the temperatures at the start and end of the day (Faiman, 1984).

For the sake of simplicity, we take the starting cold water temperature as equal to the mean monthly ambient air temperature at the location in question. This assumption is not necessary in order to solve the equation — it simply makes them simpler — but it will often be a good approximation of the real situation.

The results of this study for each month of the year are listed in **Tables 1** and **2** for both Okayama and Giza, respectively. The first column for both tables contains monthly-daily-average insolation figures for a south-facing plane tilted at 34° 39' for Okayama 30° 02' and for Giza. The second column tabulates the monthly-daily-average ambient temperature data, obtained from the local meteorological service for Giza but in the case of Okayama, it was obtained from the data collected during the experiment by personal computer. The third column contains the approximate length of daylight for each month at the site in question. Finally, columns four and five tabulate the predicted mean-maximum-daily temperature and daily useful energy collected for each month.

At Okayama, the optimum temperature required for vegetable germination was 15.5°C (Ib Libner, 1989). Water was required each evening at a temperature of 50°C which can provide enough heating air temperature for heating a nighttime greenhouse. For the worst month (January), T_{max} =20.71°C. The amount of auxiliary heating is accordingly MC(50 - 20.71) = 26.85 MJ/d. Large as this figure might appear, it is a considerable improvement over the 41.47 MJ/d that would be needed where there was no solar pre-heating of the water. We thus see that in this worst solar month the solar water heater still provides 35.25% of the energy.

At Giza, the water is required each evening at a temperature of 60°C for taking shower when the farmers return from field work in the late afternoon during their training in the field of the research center. Using the same way as before, in the worst solar month (January) the solar water heater still provides 40.37% of the energy.

Table 1. Predicted Performance of a No-flow Solar Water Heater at Okayama

Month	Ic (Δt)	T_a	Δt	T_{max}	Q
	Mj/m²	°C	s	°C	MJ
Jan.	6.92	4.76	37 080	20.71	14.62
Feb.	8.01	4.35	39 600	23.68	17.72
Mar.	12.62	8.31	43 200	32.15	21.86
Apr.	16.64	11.89	46 800	41.18	26.85
May	14.23	19.08	49 320	51.23	29.47
Jun.	11.77	23.41	50 400	53.68	27.75
Jul.	17.03	27.65	49 320	58.89	28.64
Aug.	14.67	29.47	46 800	61.87	29.70
Sep.	10.03	24.02	43 200	52.86	26.44
Oct.	8.80	18.26	39 600	47.69	26.98
Nov.	7.54	11.54	37 080	34.59	21.13
Dec.	7.61	7.45	36 000	29.45	20.17

Table 2. Predicted Performance of a No-flow Solar Water Heater at Giza

Month	Ic (Δt)	T_a	Δt	T_{max}	Q
	Mj/m²	°C	s	°C	MJ
Jan.	10.11	10.63	36 780	30.56	18.27
Feb.	14.94	11.32	39 900	35.89	22.52
Mar.	19.08	14.98	43 800	42.03	27.80
Apr.	21.97	20.86	47 580	47.59	24.50
May	25.01	23.85	50 760	56.89	30.29
Jun.	26.66	27.18	52 140	64.59	34.30
Jul.	27.21	30.53	51 060	70.87	36.98
Aug.	27.67	30.86	48 120	71.76	37.49
Sep.	20.54	24.32	44 460	57.18	30.12
Oct.	17.69	20.56	40 620	49.08	26.15
Nov.	12.14	15.87	37 200	44.13	25.91
Dec.	9.83	11.23	35 460	37.18	23.79

Conclusions

The comparison of the proposed simulation method with the measured data showed a good agreement. Moreover, in order to update the measurement data, it is also possible to include the local climate changes. As presented here, the result of the proposed simulation method belongs to the class of random processes, and in this sense is an extension of the means which have been applied so far to energy calculations.

For example, in a June day, actual total insolation was 18.88 MJ/m² for Okayama and 22.79 MJ/m² for Giza. On the other hand, simulated total insolation was 20.31 MJ/m² for Okayama and 24.03 MJ/m² for Giza.

In a January day, actual total insolation was 4.93 MJ/m² for Okayama and 5.49 MJ/m² for Giza. On the other hand, simulated total insolation was 9.02 MJ/m² for Okayama and 4.48 MJ/m² for Giza.

We can see also that in the worst solar month (January) the solar water heater still provides 35.25% of the energy for Okayama and 40.37% for Giza.

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A Case Study of Tractor Utilization by Farmers, Coimbatore District, India

by
P.K. Balasankari
Former Graduated Student
Asian Institute of Technology
Bangkok, Thailand

V.M. Salokhe
Professor of Agriculture Engineering
Asian Institute of Technology
Bangkok, Thailand

Abstract

A survey was carried out to study the tractor utilization by farmers in Coimbatore district of Tamilnadu State, India. In all, 88 farmer-respondents were interviewed. It was found that only about 12.5% of the farmers surveyed had proper training for use and maintenance of tractor and about 45% of them had a license to drive the tractor. Inconveniences involved in maintaining animals (75%), reduced labour availability during peak seasons (67%) and timeliness of operations (64%) were the main reasons given by the farmers for buying a tractor. As the farmers above middle age had established a good rapport among the villagers, they hired their tractors out more than the young and middle aged farmers. Their behaviour was determined by asking them if they would buy a tractor which was assumed to be completely "vibrationless", but with the price one and a half times higher than the present price of the tractor. About 45% of them expressed that they would buy such a tractor. Difficulty in repaying the loan for such a high investment was ex-pressed by a majority of the farmers as the main reason for not being able to buy such a tractor.

Introduction

In agriculture, the tractor has changed the tasks as well as the daily routine of farmers. The machine has changed the pattern of their work, work days, and their interaction with co-workers during working and leisure times (Easterby, 1975). Hence, the adoption of tractors, apart from economic considerations, depends on many other factors too: social and cultural factors alike, availability of hired or family labour for field operations, farmer's traditions and skill in animal cultivation, prestige attached to tractor ownership, their attitude towards hiring or lending the trac-tors when not in use in their own farms, mechanical skills; political factors such as land tenure system, credit, tractor hiring scheme, rural employment, agricultural policies, cultural identity, foreign exchange rates, availability of second hand tractors, and marketing and training facilities (Cattermole, 1978).

The choice of a tractor mainly depends upon various factors like size of the farm, nature of work required of tractor, crop and soil type, engine and transmission of tractor, ground drive (2 or 4 wheel drive), design factors like tractor vibration, noise, micro-climate inside the tractor cab and other facilities available regarding the health, comfort and safety of the operator (Matthews, 1982).

Also, the use of tractor mainly depends upon its practical usefulness (Matthews, 1982; Sjøflot, 1982), the availability of the service from the dealer (Sjøflot, 1982), and maintenance and repair cost associated with a particular tractor.

This research undertaking studied the pattern of utilization of tractors by farmers in a selected district of South India (Balasankari, 1997). This study was conducted with a view to obtaining useful information for understanding the tractor utilization and attitude of the farmers in the study areas. The study area, Coimbatore district, is situated in the northern part of Tamilnadu State. The district has 250 thousand land holdings of which 70% are less than 2 ha in size. But, owing to the migration of agricultural labourers into industries, and the inconveniences involved in maintaining work animals, more and more tractors are being brought into the field for farm work. There was about a 98.6% increase in tractor usage between 1989 and 1994. More than 50% of the tractors are of 23-30 kW size, and the most common ones are of 26 kW. The use of tractors below 15 kW and above 38 kW is very small in proportion. Agriculture is still in a semi-mechanized state in the district and tractors are the main agricultural machinery used for various purposes like primary tillage, secondary tillage, seeding, cultivating, threshing and transporting of agricultural products, fertilizers, farm yard manure and people.

Methodology

The study area lies 450 km northwest of Chennai, capital of Tamilnadu State. The total area of the district is about 7 468 sq. km. The population consists of 1 663 381 (47%) rural and 1 844 993 (53%) urban people. The average family size is 3.7 persons. About 66% of the total population is engaged in agriculture. The Coimbatore district is divided into nine sub-districts. The total cultivable area is 335 973 ha. The major crops grown are rice, millet and other cereals, cotton, groundnut and pulses. The total net irrigated areas is 147 285 ha and the gross irrigated area is 163 282 ha (1995-1996).

For this study, the villages were selected randomly throughout the district. A total of 88 farmers were interviewed. For the data collection, a structured questionnaire was prepared. All the data was collected through personal interviews. Care was taken to include only first-hand information from the subjects so as to keep the bias in data to a minimum. Whenever there was a doubt in the validity of the data, these were discarded during the analysis.

All the data collected were coded and analyzed using SPSS (Statistical Package for Social Sciences). It was used for both summarizing as well as cross-tab analysis. The cross-tab analysis was done by correlating vaÅvrious variables for better understanding of the prevailing situation in the study area. All the variables were correlated mainly with respect to age group of the farmers in order to understand their attitudes towards tractor use.

Results and Discussion

General Information

The average age of the subjects was 43 years (ranging from 20 to 75 years). On average, they had about 21 years of experience in farming, i.e., they had taken up the responsibility of tractor driving at the age of 22 years. Their education level was about 10th standard (secondary education). **Table 1** shows the ownership of land by the farmers who owned tractors. The table shows that most of the marginal and small farmers were out of reach for buying a tractor.

Nearly 94% of farmers had ground water as the source of irrigation (wells and bore wells). Only about 6% of them had purely rainfed land. **Table 2** shows the availability of water for farming. Availability of water meant better production and hence a better economic return. So only those who could expect significant return could do multiple cropping and also invest in a tractor. Only about 12.5% of the farmers grew seasonal crops alone. Otherwise all the others had planted annual or perennial crops with seasonal crops as intercrops.

Table 1. Size of the Land Holdings Owned by the Farmers

Land holding size	Perecent of farmers
Marginal (<1 ha)	1.1
Small (1-2 ha)	8.0
Semi medium (2-4 ha)	20.5
Medium (4-10 ha)	40.9
Large (>10 ha)	29.5

Table 2. Number of seasons of availability of water to the farmers

No. of seasons of availability of water	Percent of farmers
one	10.6
Two	14.9
Three	74.5

Tracrtor Utilization

Only about 12.5% of the farmers training in use and maintenance of the tractor. Some 8.0% of the farmers obtained training from the dealer, 3.4% from a private training centre and 1.1 from both dealer and a private training school. About 44.8% of the farmers had a license to drive a tractor for an average of 8.3 years.

Most of the farmers believed that ploughing with animals produced better soil tilth, especially well suited for seed bed preparation and also bund forming was better done with animal ploughing. About 12.5% of the farmers were still using bullocks for selected field operations, though they owned tractors and were using them for other field operations.

About 9.1% of the farmers owned more than one tractor. Owning more than one tractor did

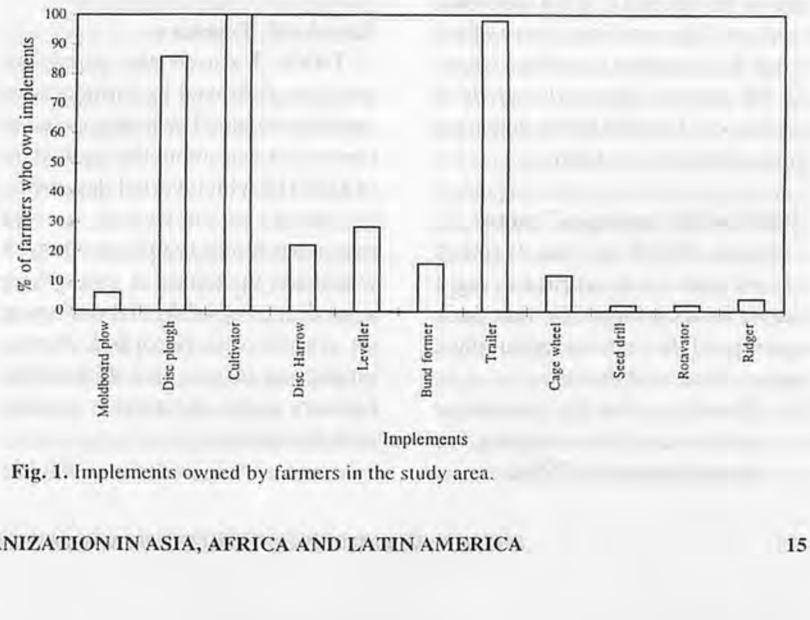

Fig. 1. Implements owned by farmers in the study area.

not mean that their land size was large. They used the tractor as a source of self-employment. They hired the tractor to others to earn extra income. The average age of the tractor was about 6.4 years (ranging from 0.1 to 30 years) and with about 29 kW power available for the farm (ranging from 18 to 45 kW). About 8% of the tractors were bought second hand and the remaining 92% were purchased new from a dealer.

Fig. 1 shows the implements owned by the farmers. All of them had a cultivator, 98.9% of them owned a trailer and 87.5% of them, a disc plough. Due to heavy sun in the study area, farmers mostly used disc plough and cultivator. As most of the off-farm work was transportation, the majority of the farmers had a trailer.

The study revealed that 81.8% of the farmers hnd borrowed money from commercial banks and 3.4% from a private finance company for buying the tractor. About 14.8% of them purchased the tractor from their own savings. This clarifies why farmers want to rent out their tractors which help them earn extra money to repay the loans.

The farmers were using tractors for about 11 years. Before buying a tractor for themselves, they had hired the tractor for more than about 1.5 years. On average, the farmers used their tractors for about 1 241 h/year. Of this total, they used their tractor for about 611 h for their own work and the remaining hours they hired their tractors to others. About 65.9% of the farmers hired their tractors out to other farms when not in use in their own farm.

Reasons for Buying a Tractor

Some 97.6% of the farmers agreed that it was worth buying a tractor for their farm. The first three rankings of the reasons for buying a tractor were as follows:

(1) Owning a tractor was more convenient than carrying for feeding animals (75%);

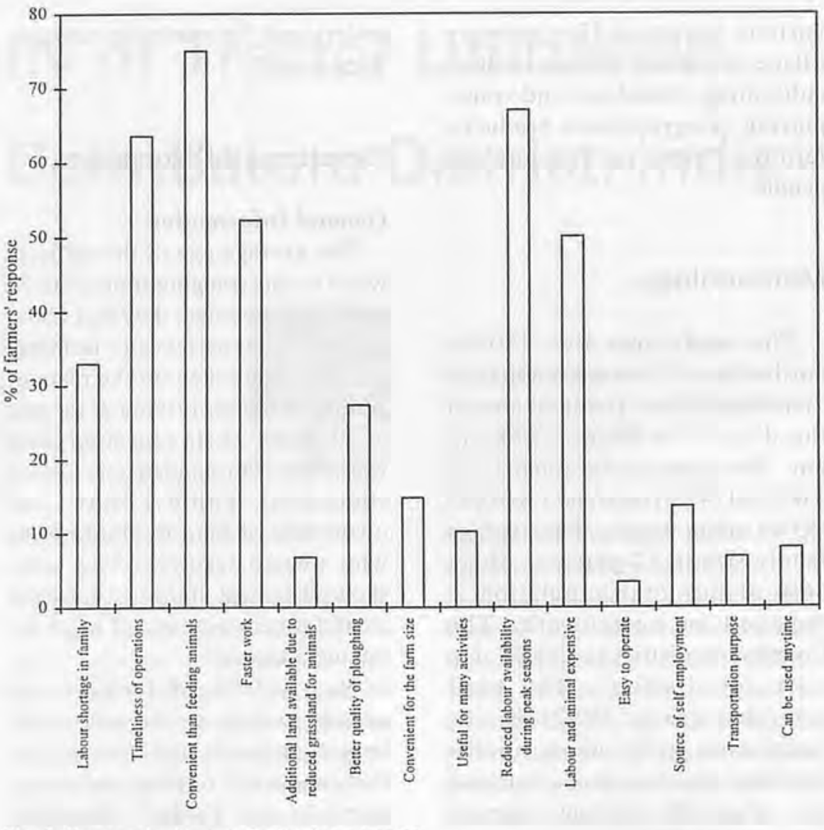

Fig. 2. Reasons by farmers for buying a tractor.

(2) Reduced labour availability during peak seasons (67%); and

(3) Timeliness of operations (63.6%).

Other reasons given were expensive labor and animals and faster farm work by tractor. The above main reasons given by the farmers are very relevant. Other interesting reasons given by the farmers are shown in **Fig. 2.**

Repair of Tractors

Table 3 shows the repairing practices followed by farmers who owned a tractor. The average annual repair cost was about the equivalent of US$415 which varied depending on the age of the tractor, type of repair work and the place where it was taken for repair. A case where a maximum of US$1110 was spent on repairs was recorded. It was interesting to note that 45% of the farmers carry out tractor repairs with the dealers.

Table 3. Repairing Practices Followed by Farmers

Sources of repair	Percent of farmers
All, Dealer	45.0
All, Local repair shop	26.5
All, self	6.2
Major, Dealer	12.3
Major, Local repair shop	9.9

Concern for Safety and Comfort

To Understand the attitude of the farmers towards the ergonomic aspects, a tractor was assumed to be totally vibration free, but its cost one and a-half times higher than the present price of the tractor. About 45.3% of the farmers were willing to buy such an assumed tractor. The main reasons given by the farmers for buying this proposed vibrationless tractor were:

(1) Due to the existing driver problem - 15.6%; and

(2) Could afford to buy the tractor - 29.7%.

The reason given by some farmers for not being willing to buy the vibrationless tractor were:

a) Due to annual crop, not much use of tractor was required - 3.1%;
b) Loan payment difficult - 42.2%; and
c) Abundant labour available - 9.4%.

Table 4 shows the attitude of farmers towards buying the assumed vibrationless tractor with a high, according to the land holding sized.

Medium and semi-medium sized farmers were willing to buy the assumed tractor because they faced certain difficulties like getting a regular driver who would stay for a considerable period of time, and most of them were driving the tractor by themselves and hence knew the difficulty involved in driving. Most small farmers could not commit to buy this tractor as it was too expensive for them. Large farmers, in general, did not drive the tractor by themselves and employed drivers. They were in a better economic condition than the other farmers and could pay enough for the labour. As long as they had a labourer to drive their tractor (and they don't have to drive it), they would not invest such a large amount in the proposed expensive tractor.

The data above show that the farmers were not much aware of the importance of ergonomic aspects more than human comfort and safety. This might be true for farmers in other parts of the country. There is a need to educate farmers to consider ergonomic aspects of tractor design seriously.

Preferences on Make of Tractor

Table 5 shows the preferences of the farmers on the make and model of the tractor. The Mahindra tractor was preferred more by the farmers because it was considered to be suitable for the field work and other rough work. The second preference was given to the Massey Ferguson tractor, as it was considered handy

Table 4. Attitude of Farmers Towards Buying the Assumed Expensive, Vibrationless Tractor with Respect to Land Holding Size

Category of farmers	Percent willing to buy
Small	16.7
Medium	55.2
Semi medium	54.5
Large	33.3

for driving due to its compact configuration. It needs less maintenance and has a good resale value. The Swaraj was preferred for its low price and Ford for its ergonomical aspects. Ford was comfortable to drive and had good resale value but the maintenance and repair cost was very high.

Cross-tab Analysis

The farmers were grouped into 3 categories according to their age, viz. (1) <24 years (young); (2) 25-35 years (middle-aged) and (3) >35 years (above middle-aged). Dependent variables like mode of ploughing, utilization of tractor in leisure time, training to use the tractor, license, and whether the tractor ploughing produced better quality than animal ploughing, were all analyzed with respect to the age group of the farmers.

For better understanding, certain other variables were also analyzed:

(1) Attitude towards buying the tractor, annual hours of using the tractor for own purpose, and annual hours of using tractor with the size of the land owned;
(2) Crop type with water availability; and
(3) Tractor age and place where it was taken for repair with the repair cost.

Among those who had training to use the tractor, 9.1%, 18.2% and 72.7% were young, middle-aged and above middle-aged farmers, respectively. The higher percentage of the training obtained by the above middle-aged farmers was because 2000 h. All the marginal farmers and a majority of the small farmers (42.9%) used their tractor for about

Table 5. Preference on the Make and Model of the Tractor

Make and model of tractor	Percent preferred
Mahindra	30.3
Massey Ferguson	26.6
Swaraj	24.4
Ford	15.2
Others	3.5

Table 6. Possession of License by Various Age Groups of Farmers

Age group	% of farmers
<24	33.3
25-35	55.6
>35	41.9

such training was offered by the dealers when initially the tractor sale was started and they had to boost up the sale. Currently, such training is not available. **Table 6** shows the possession of license by different age groups of farmers.

As most of the young farmers were new to the profession, they had not obtained a license for themselves. As most of the above middle-aged farmers were not driving the tractor, they were not very much bothered about getting a license for themselves.

The cross-tab analysis showed that none of the young farmers were using animals for field operations. About 5.3% and 16.1% of the middle-aged and above middle-aged farmers, respectively, were using animals for certain field operations.

Some 33.3%, 57.9% and 77.2% of the young, middle-aged and above middle-aged farmers, respectively hired out their tractors when not in use in their own farm. A further detailed relation of the attitude of the farmers towards hiring out their tractors to other farms, according to their age group, showed a relation as given in **Fig. 3**. The reason that the above middle-aged farmers hired out their tractors more was because they were known to the villagers for a very long time and had established a good rapport with them. The relation between the percentages of farmers hiring out their tractors and the age group was

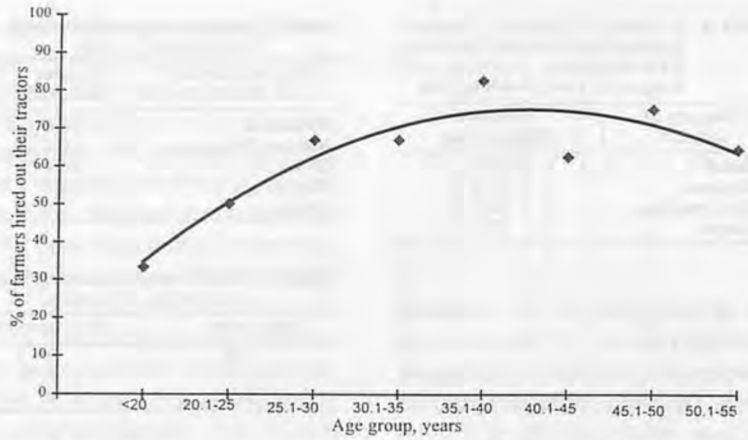

Fig. 3. Attitude of farmers towards hiring out their tractors when not in use in their field, by age group.

obtained as,

$$y = -1.9339x^2+21.514x+15.116$$
$$R^2=0.836$$

Relation Between Repairs, Age of Tractor and Sources of Repair

The annual repair cost was; divided into four categories, namely (1) <US$80, (2) US$81-280, (3) US$281-555 and (4) > US$555. Tractors were grouped according to their age as (1) <1year, (2) 1-5 years, (3) 5-10 years and (4) > 10 years. No exact relation could be derived between the age of the tractor and annual repair cost, as there were other variables such as type of maintenance and repair work to be done, make and model of tractor, the place where it was taken and the quality of servicing. Most of the tractors (71.4%) below one year old cost less than US$80 per year for repair and maintenance. Also, most of the tractors (45.9%) of age 1-5 years cost US$ 281-555 and the tractors of age (42.9%) 5-10 years old cost US$ 555 per year. But the farmers spent only around US$ 80 to 280 for the tractors which were above 10 years old. As the tractor had crossed its salvage value, they had an attitude to use it as long as it could be used.

No proper relation was drawn between the source of repair and the repair cost. But it was evident that repairing all the major and minor breakdowns in the dealer shop cost more than at the local workshop. However, it also involved other factors such as reliability of the service and the quality of service and spare parts.

The annual usage of tractor was categorized as follows for better understanding. (1) < 400 h, (2) 400-1000 h, (3) 1001-2000 h and (4) > 2000 h. All the marginal farmers and a majority of the small farmers (42.9%) used their tractor for about 401-1000 h annually. Most of the medium (47.2%) and semi-medium (55.6%) farmers used their tractors for 1001-2000 h annually. That was possible only if they hired out their tractors to other farms. The majority of large farmers (38.5%) used their tractors for 401 to 1 000 h only, which meant that they did not hire their tractors out as much as the semi-medium and medium farmers. Also the group of farmers who used their tractor for more than 2 000 h consisted of 40% of large farmers and 60% of medium farmers which again confirmed that it was the medium farmers who hired out their tractors to other farms when not in use in their own farm.

Conclusions

1. Farmers used their tractors for about 1 241 h a year, out of which they used them for 611 h for their own purpose. About 65.7% of the farmers hired out their tractors to others when not in use in their own farm.
2. Three main reasons given by the farmers for buying a tractor were: owning a tractor was more convenient than feeding animals, reduced labour availability during peak seasons and timeliness of operations.
3. No exact relation could be drawn between the type of repair and the repair cost as it involved many other interdependent variables.
4. About 45.3% of the farmers were willing to buy the assumed vibrationless, expensive tractor. Most of the semi-medium and medium farmers were willing to buy the tractor, as they hired out their tractors more.
5. A tractor which was considered fit for field work and other kind of bit rough work was preferred by the farmers.

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Location of Controls and Operator's Activities in Indian Tractors

by

V.G. Arude
Former Student
Dept. of Agric. and Food Eng.
I.I.T.,
Kharagpur 721 302
India

D.T. Pacharne
Associate. Professor.
Dept. of Farm Machinery and Power
College of Agric.Eng.
Mahatma Phule Agric. Univ.
Rahuri 413 722,India

V.K. Tewari
Assistant. Professor.
Dept. of Agric. and Food Eng.
I.I.T.,
Kharagpur 721 302
India

Abstract

The study was undertaken to locate the existing control locations in popular Indian tractor models and tractor operator's activities from the driver seat while performing the ploughing operation. A significant difference in placement of clutch, brake, hydraulic control lever, steering wheel and foot rest from Seat Reference Point in the tractor work place of the different models was observed. The frequency of operation of clutch, brake, hydraulic control lever and backward views was 0.5, 1.55, 3.13 and 8.55 times/min, respectively.

Introduction

Operating a tractor vehicle imposes definite levels of physical and mental performance stresses upon the operator. If the operator's controls are not properly adopted to his anatomy, the demanded performance of him may reach quickly and even sometimes exceeds the limits of tolerance. As a result of excessive stress, premature fatigue and impaired health; the possibility of accidents will increase. Therefore, great emphasis must be placed on adopting the operating controls to the physical needs of the human operator.

The tractor driver sits in the operator's seat for about 8 hrs a day, operates various controls and monitors the operatios. The dimensions of seat, location of controls are useful in designing the tractor workplace (Gite and Yadhav,1989). The optimum locations are important from the viewpoint of operator's safety and comfort. The locations of the controls should be such that these are easily accessible to the operator. If the operation of the controls is easy then the chances of accidents are minimzied.

The energy spent by the operator is dependent on the number of times (frequency) the controls operated and their respective locations. Hence the unifomity in locations of controls is extremely important for putting identical metabolic demamd on the subjects in all tractors (Henrich Dupuis,1959). In India substantial efforts have not been done on this aspect (Rajvir,1995). Hence in the present study, attempts have been made to determine the existing locations of the controls in some of the Indian tractors and to study the tractor oerator's activities from the seat while performing a field operation.

Materials and Methods

Five, four wheel Indian tractor models designated as T_1,T_2,T_3,T_4 and T_5 were selected to measure various work place design parameters. The tractor models were in the range of 35 to 50 hp. The controls such as brake, clutch, hydraulic control lever, steering wheel, seat and foot rest were considered for the study. The forward horizontal distance, vertical distance, lateral horizontal distance from the seat reference point (SRP) for brake, clutch and hydraulic control lever were measured. The steering wheel diameter, steering column angle and steering wheel angle with horizontal were measured. Similarly, forward horizontal distance and vertical distance of front edge of steering wheel from SRP, foot rest height above ground level and seat dimensions were measured.

The seat was kept in the middle

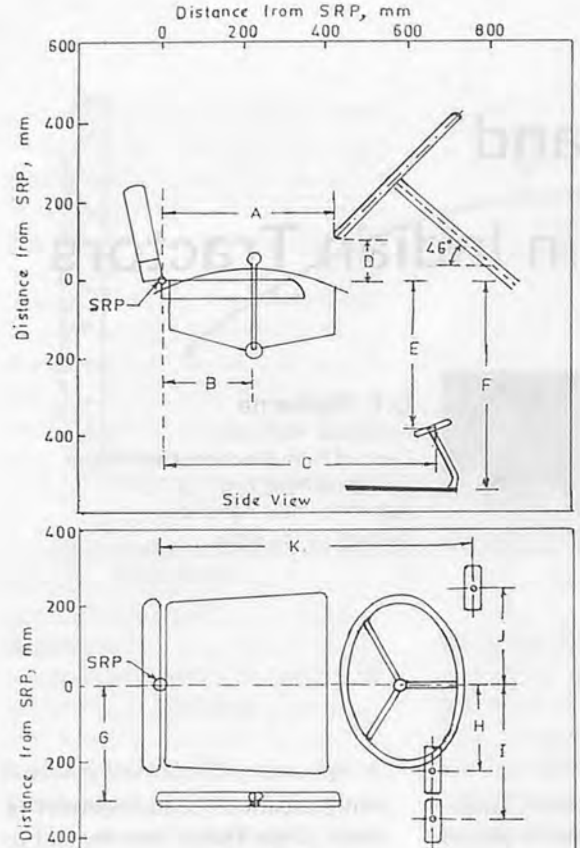

Fig. 1 Tractor operator's workplace, T_1.

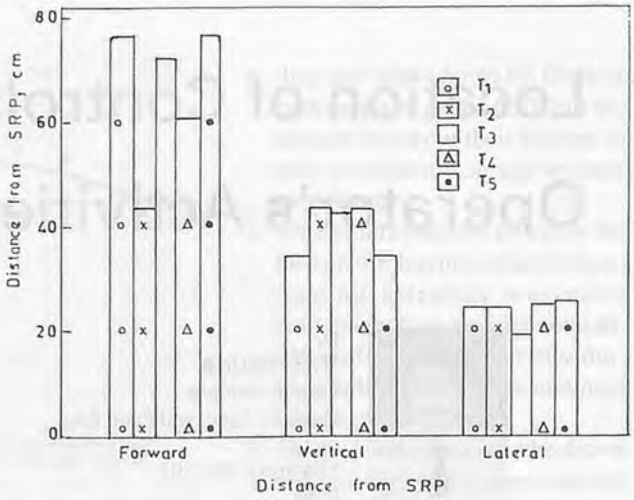

Fig. 2 Comparative locations of cluth pedal in different tractor models.

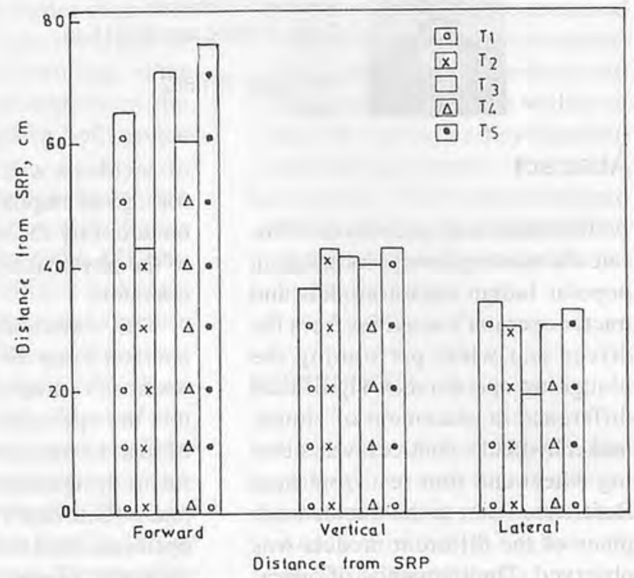

Fig. 3 Comparative locations of brake pedal in different tractor models.

position of its adjustments range, both vertically and horizontally. At this position the 50th percentile to be comfortably fit in the workplace was expected. The tractor was made to stand on level ground surface during the measurements.

The tractor operator's activities included the operation of clutch, brake and hydraulic control lever and backward views. The frequencies of these activities were recorded during the ploughing operation.

Results and Discussion

Figure 1 shows the tractor operator's workplace of model T_1. All prominent dimensions from SRP, such as forward horizontal distance of front edge of steering wheel (A), foward horizontal distance of hydraulic control lever (B), foward horizontal distance of brake pedal (C), vertical distance of front edge of steering wheel (D), vertical distance of brake pedal (E), vertical distance of foot rest (F), lateral distance of hydraulic control lever (G), lateral distance of inside brake pedal (H), lateral distance of outside brake pedal (I), lateral distance of clutch pedal (J), forward horizontal distance of clutch pedal (K) were measured.

Brake and Clutch Pedal

There was variation in the foward horizontal distance of brake and clutch pedal from SRP in the range of 43.3 to 76.4 cm and 43.3 to 76.5 cm, respectively, in all the tractor models (**FIgs. 2** and **3**). The respective coefficients of variation (CV) were 20.20 and 21.50%. Much variation was not observed in the clutch and brake pedal forward distances of the same tractor model.

The vertical distance from SRP for brake and clutch pedal; was in the range of 36.8 to 43.2 cm and 34.1 to 43.2 cm, respectively (**Table 1**). The respective coefficients of variation were 6.46 and 9.59%. There was a little variation between the clutch and brake pedal vertical distance from SRP. However, large variation was found among the different tractor models. The comparative locations of clutch pedal and brake pedal in different tractor mod-

Table 1. Locations of Brake, Clutch and Hydraulic Control Lever in Selected Indian Tractors (Unit:cm unless otherwise mentioned)

Parameter	T_1	T_2	T_3	T_4	T_5	Range	Mean	S.D.	C.V. (%)
Brake									
Forward horizontal distance from SRP	65.5	43.3	72.0	60.5	76.4	43.3 - 76.4	63.54	12.84	20.20
Vertical distance from SRP	36.8	43.2	41.9	40.5	43.2	36.8 - 43.2	41.12	2.66	6.46
Lateral horizontal distance from SRP (inside/outside)	22.0/ 34.5	18.5/ 30.5	19.1 -	20.2/ 30.7	20.4/ 33.2	18.5 - 22.0/ 30.5 - 34.5	20.04/ 26.18	20.04 26.18	6.70 6.36
Clutch									
Forward horizontal distance from SRP	76.5	43.3	72.0	60.5	76.4	43.3 - 76.5	65.74	14.14	21.50
Vertical distance from SRP	34.1	43.2	41.9	43.0	43.2	34.1 - 43.2	41.08	3.94	9.59
Lateral distance from SRP	24.5	24.2	19.1	25.0	25.5	19.1 - 25.5	23.66	2.60	10.98
Hydraulic contorol lever									
Forward horizontal distance from SRP	20.0	5.5	5.3	37.0	36.0	5.50 - 37.0	21.66	15.56	13.59
Vertical distance from SRP	16.5	31.4	33.0	33.0	31.7	16.5 - 33.0	29.12	7.09	24.30
Lateral horizontal distancefrom SRP	30.0	31.5	29.0	30.0	32.0	29.0 - 32.0	30.5	1.22	4.00

els are shown in **Figs. 2** and **3**.

Hydraulic Control Lever

The comparative locations of hydraulic control lever are shown in **Fig. 4**. The forward horizontal, vertical and lateral distance for hydraulic control lever varied between 5.5 and 37.5, 16.5 to 33.0 and 29.0 to 32.0 cm, respectively. The values of coefficient of variation were 21.5, 9.59 and 10.59%, respectively. Thus, a large variation was found in forward distance of hydraulic control lever.

Steering Wheel

The steering wheel diameter was almost similar in all the tractor models. The forward and vertical distance of front edge of steering wheel from SRP were 30.5 to 46.5 and 11.5 to 20.0 cm with coefficient of variation of 16.6 and 22.9%, respectively (**Fig. 5**).

Foot Rest

The foot rest locations are indicated in **Fig. 6**. Foot rest height below SRP showed a little variation. However, a large variation in the range of 45.0 to 75.0 cm was observed in foot rest location above ground level.

Seat specification

Non-uniformity was observed in the seat design parameters (**Table 3**) of the driver seat. The variations in the seat width and depth ranged from 31.8 to 47.0 and 28.0 to 41.5 cm, respectively, and the respective coefficient of variation values were 18.10 and 14.77%. The variation in backrest height and width was 18 to 33 and 32 to 45 cm and the corresponding values of coefficient of variation were 22.96 and 14.95%, respectively. Thus there was a large variation in seat design parameters.

There should be uniformity in the placement of these controls on all the tractors to accommodate the Indian operators leading to an efficient and comfortable operation.

The study reveals that the locations of main controls such as clutch, brake and hydraulic control lever in the work place of the tractor varied widely in the different models of the Indian tractors. This data on different locations on tractor controls can help in proper design of the tractor workplace for better efficiency, safety and more human comfort.

Operator's Activities

The tractor operator was always busy in operating hand and leg controls during farm work. The steer-

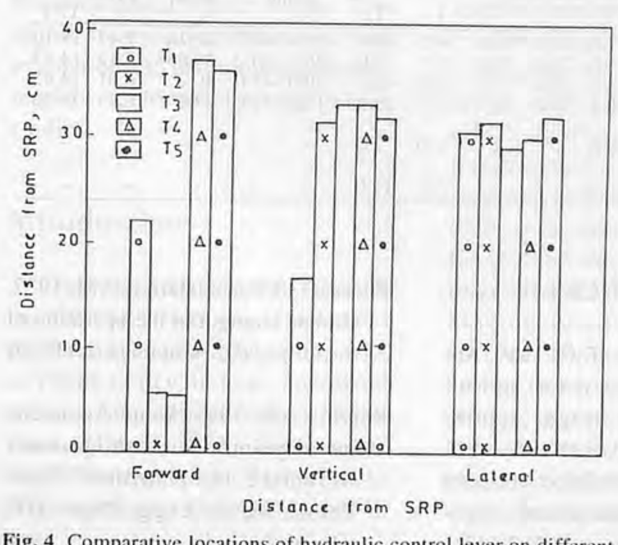

Fig. 4 Comparative locations of hydraulic control lever on different tractor models.

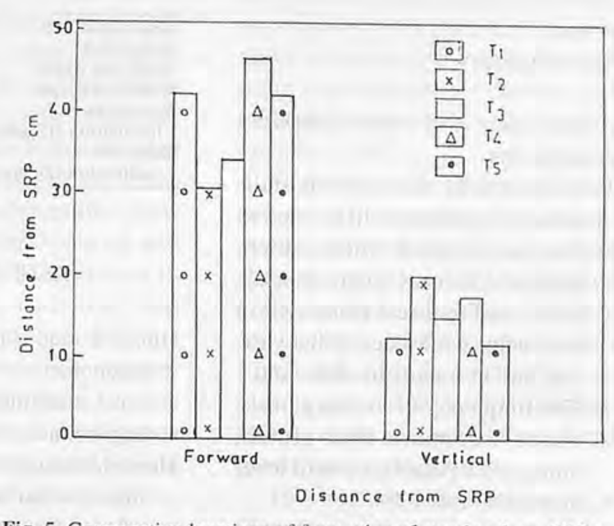

Fig. 5 Comparative locations of front edge of steering from SRP in different tractor models.

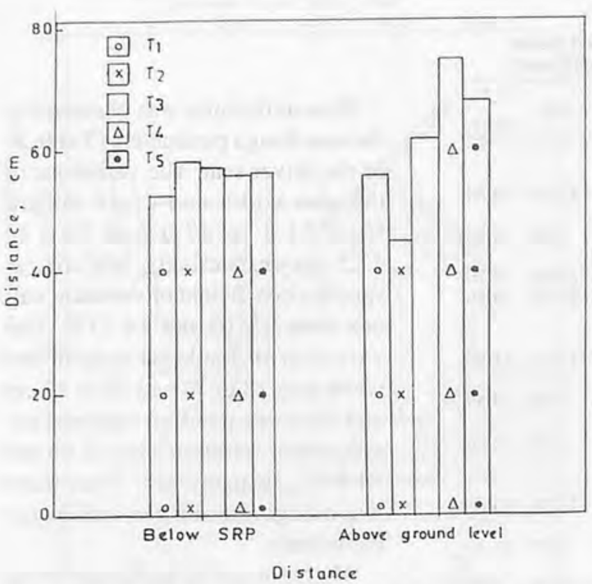

Fig. 6 Comparative locations of foot rest in different tractor models.

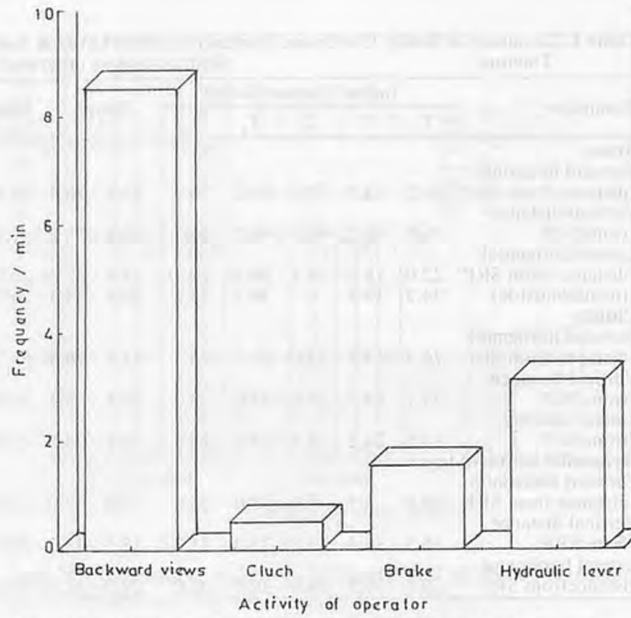

Fig. 7 The frequency of operator's activities during field operation.

ing wheel was continuously held and moved while operating the clutch, brake and hydraulic control lever. The various activities of the operator during ploughing operation are shown in **Fig. 7**. The frequency per min of backward views were highest (8.55) follwod by the movement of the hydraulic control lever (3.13), brake (1.55). The frequency of clutch operation was low (0.5) as the clutch was applied only at the turns. The highest frequency of backward views indicated that the operator spent comparatively more time in viewing backward while performing field operation.

Table 2. Locations of Steering. Wheel in Tractor Workplace of Selected Indian Tractors (Unit: cm unless otherwise mentioned)

Parameters	Indian Tractor Model					Range	Mean	S.D.	C.V. (%)
	T_1	T_2	T_3	T_4	T_5				
Steering wheel diameter	44.0	43.0	43.0	43.0	44.0	43.0 -44.0	43.44	0.55	1.26
Steering wheel angle with horizontal(Degree)	44.0	21.0	21.0	16.0	34.0	16.0 -44.0	27.20	11.52	42.30
Steering column angle with horizontal(Degree)	46.0	69.0	69.0	74.0	56.0	46.0 - 74.0	62.80	11.52	18.34
Horizontal distance of front edge of steering wheel from SRP	42.0	30.5	34.0	46.5	42.0	30.5 -46.5	39.00	6.54	16.60
Vertical distance of front edge of steering wheel from SRP	12.5	20.0	15.0	17.5	11.5	11.5 -20.0	15.30	3.51	22.90

Table 3. Seat Specifications of Selected Indian Tractors (Unit:cm unless otherwise mentioned)

Parameters	Indian Tractor Model					Range	Mean	S.D.	C.V. (%)
	T_1	T_2	T_3	T_4	T_5				
Seat width	47.0	47.0	31.8	34.5	46.0	31.8 -47.0	41.26	7.47	18.10
Seat depth	35.0	28.0	31.8	41.5	37.0	28.0 - 41.5	34.66	5.12	14.77
Back rest width	44.0	45.0	30.0	40.0	42.0	30.0 -45.0	40.2	6.01	14.95
Back rest height	23.2	18.0	20.0	33.3	29.5	18.0 -33.0	24.8	6.44	25.96
Seat surface inclination (Degree)	0.0	–	–	4.0	2.0	–	–	–	–
Back rest inclination (Degree)	9.0	–	–	5.0	11.0	–	–	–	–

Conclusion

The study lead to the following conclusions.

1. Locations of the controls indicated a significant difference in the placement of brake, clutch, hydraulic control lever, steering wheel and foot rest from SRP in the tractor workplace of the various Indian tractor models; and
2. The frequency of viewing backwards was more than clutch, brake and hydraulic control lever operation activities.

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Field Evaluation of Animal Traction Equipment for Soil Tillage in Brazil

by
Augusto Guilherme de Araújo
Researcher
Agricultural Engineering Dept.
Agronomical Institute of Paraná/IAPAR
Caixa Postal 481 - Cep: 86001970
Londrina/PR - Brazil

Paulo Roberto A. de Figueiredo
Researcher
Agricultural Engineering Dept.
Agronomical Institute of Paraná/IAPAR
Caixa Postal 481 - Cep: 86001970
Londrina/PR - Brazil

Ruy Casão Júnior
Researcher
Agricultural Engineering Dept.
Agronomical Institute of Paraná/IAPAR
Caixa Postal 481 - Cep: 86001970
Londrina/PR - Brazil

Abstract

Two experiments were conducted to compare the performance of 10 models of animal traction plows in three types of soils at Paraná State, south of Brazil.

The main problems related with the use of traditional plows are the low quality of the soil work, the low labour productivity of the operation and the high stress for both animal and man resulting from the low quality of the equipment construction and it's poor design. This report presents the results of a field evaluation and recommends the best models of plows for each soil type studied.

Introduction

The Paraná State, south of Brazil, is famous for agricultural production, specially grains like soybeans, dry beans, corn and wheat. According to the official census (Brasil, 1985), the state has 466397 farms. About 71% of these farms are lower than 20 ha each in size.

The small farms are concentrated in the southwest, central-north and southeast regions of the state where the main types of soils are the Entisols, Alfisol and Oxisol associated or not with Entisols and the Inceptisols (according to U.S. Soil Taxonomy cited by Derpsch et al., 1991).

Animal power for land preparation is largely used due to the slope of the lands, which hampers mechanization. Also, the soils are shallow and the scarcity of capital on the part of farmers to buy or rent tractors (Henklain and Casão,1994).

The animal traction equipment utilized by farmers vary by region. At the southwest, the most common tillage implement is the "fuçador" which consists of a wooden drawbar fastened to the yoke of the oxen team, a leg and a shovel like plow body. The fuçador loosens and mixes the soil but doesn't turn it, leaving residues over the soil surface. It's advantages become apparent on lands with steeper slopes, great quantities of tree stumps, roots, stones and crops residues because it can easily avoid obstacles (Schmitz et al., 1991). However, the work with fuçador is very strenuous for both man and animal.

At the southeast region, plowing is done with the reversible "pointed share" mouldboard plow that requires low draft power and commonly two light horses pull it. The plow is cheap and manufactured by rural craftsmen with pre-fabricated shares. The shape of the mouldboard and the position of the share determines a good ability to avoid clogging where the residues and weeds are high but often, burning of the vegetation is associated with the use of this plow. This may be a result of it's poor construction and maintenance, specially because there is no template to control it's working characteristics and stability (Araújo, 1991).

At the central-north part of Brazil the most commonly used equipments are the duckfoot plow share (Lampe and Zaske,1987) also called "bico de pato" and the reversible "twin share" mouldboard plow (or turnwrest plough, according to Lampe and Zaske, 1987). The conventional (no reversible) mouldbord plows are less important.

The bico de pato consists of a plow frame of wood upon which is mounted a sweep share and is employed for both seedbed preparation as well as weed control. It's advantages are its low cost, simple maintenance, and the low draft power requirement since just one animal, like a horse or a mule, pulls it. However, the plow works the soil surface (under 10 cm), doesn't turn it and leaves unworked strips of residues and weeds.

The twin share mouldboard plow is manufactured by industries in different sizes to adapt to the used draft animals. It has a symmetrical body with a cylindrical double mouldboard and two separated shares but, when the residues are high, the clogging problems are frequent due to the shape of the mouldboard and to the small clearance between the share and the frame.

In general, the low quality of the soil work, the low labour productivity of the operation and the high stress, for both animal and man, are the main problems related with the use of these traditional equipment for land preparation. Otherwise, the low quality of the equipment construction and it's poor design are the reasons for these problems.

Despite the problems, other equipment are rarely used in these regions and no data is available about their field performance compared with the traditional ones. The Brazilian agricultural machinery industry produces a great diversity of designs of animal traction plows but they haven't been evaluated in these regions of the state yet.

This paper presents the field evaluation results of differents types of plows, compared with traditional ones, realized under the soils types described. The best alternatives for land preparation with animal traction are recommended. The soil conditions, the weight and design parameters of the plows were identified and the following variables, related with the cited problems, were considered in the evaluation: incorporation of the weeds and residues; clogging occurrence; draft power required; depth and width of the plow furrow; specific resistance of the soil to the plows; turning time; and theoretical field capacity.

Materials and Methods

Two experiments were conducted in three regions of the state representing the different soil types, traditional equipment and draft animal species. The amount and types of implements evaluated varied according to the suitability of the available plows for local conditions. All the plows were evaluated during the same day.

The experimental design was a randomized block for the draft force evaluation and for the soil work quality assessment, with different replications for each region. The first experiment had a variable plot length and the second had 60 m^2 plot.

The draft force was recorded by a load cell with resistive strain gages, model Interface/ULC, connected to a digital indicator, model Interface/IM-5, and the data were registered by a potentiometric register, model ECB/RB101. The speed of the plow and the time to maneuver the equipment was measured by a manual chronometer and the width and depth of the plow furrow were a manual measurement too.

The weight of the residues over the soil surface was estimated before plowing and, after it, the non-incorporated residues were collected and weighted. The number of occurrences of plow clogging was observed during the operation and the need for another primary tillage operation after the plowing work was a visual and qualitative measurement. The soil bulk density was determined through the core method with a cylindrical metal sampler with 100 cm^3 which was pressed to 20 cm depth into the soil profile (Blake, 1965). The soil water content was measured to 20-cm depth by the gravimetric method.

Results and Discussion

Table 1 presents the design parameters of all the plows evaluated in three types of soil. **Figs. 1** to **8** illustrate the design parameters.

The plow called Tamanduá was a mouldboard plow prototype designed by the agricultural en-

Table 1. Design Parameters of the Evaluated Plows

Plows	Weight (N)	Share: setting angle (θ_0) (degrees)	Share: cutting angle (γ) (degrees)	Share: length (cm)	Down suction (mm)	Side suction (mm)
1. Tatu AT - 12 - mouldboard / conventional	363	48°	29°	43	10	16
2. Tamanduá - Iapar 4 mouldboard / conventional	353	45°	28°30'	38.5	20	35
3. Tamanduá - Iapar 5 mouldboard / conventional	382	45°	27°30'	42.5	20	35
4. Tatu RS-mouldboard / reversible	412	44°	54°	35	17	20
5. Tamanduá - Iapar 3 mouldboard / reversible	363	45°	26°30'	34	20	10
6. Tamanduá - Iapar 4 mouldboard / reversible	412	45°	26°30'	38.5	20	35
7. Fuçador	754	—	—	41	—	—
8. Sans 155 - mouldboard / reversible	706	30°	16°	35	0	0
9. Policultor 600 - mouldboard / reversible	735	43°	40°	28.5	25	10
10. Pointed share - mouldboard / reversible	353	44°	26°	47.5	16	35

Fig. 1 View of the conventional mouldboard plow Tatú AT-12.

Fig. 2 Different sizes of conventional mouldboard plows Tamanduá/ Iapar.
Numbers 4 and 5 are the last two at the right side of the figure.

Fig. 3 View of reversible mouldboard plow, Tatú RS.

Fig. 4 Different sizes of reversible mouldboard plows Tamanduá/ Iapar.
Numbers 3 and 4 are the last two at the right side of the figure.

Fig. 5 View of the Fuçador plow.

Fig. 6 View of the reversible mouldboard plow, Sans 155.

Fig. 7 View of the reversible mouldboard plow Policultor 600.

Fig. 8 View of the reversible "pointed share" mouldboard plow.

gineering department of Paraná Agronomic Institute (Iapar), with four sizes, according to the type of animal, and in reversible and non-reversible models. These plow was not commercially available during the tests.

The other plows were used by farmers in the regions of the experiments and manufactured by large industries, like numbers 1, 4, 8 and 9 (**Table 1**) or by small industries, like numbers 7 and 10.

Evaluation of Plows on Oxisol

Six mouldboard plows were tested in the experimental station of Iapar, at Londrina (23°23'S and 51° 11'W) on an oxisol with 82% clay, 13% silt and 5% sand, where soybean had been grown in the previous year. The soil water content was 30.6% between 0 and 20 cm and the soil bulk density was 1.19 g.cm^{-3} for the same depth.

Of the mouldboard plows evaluated, three of them were of the twin share type (numbers 4, 5 and 6 in **Table 2**) and the others were conventional ones (numbers 1, 2 and 3), with different sizes.

The experiment had six treatments and three replications and the plot for the draft force evaluation had 10 meters long.

On the plot for quality work assesment was managed with an animal traction disc harrow and a pair of oxen was the power source.

The conventional plows (numbers 1, 2 and 3) have the bigger working width and their specific soil resistance were statistically different from the reversible ones (numbers 4 and 5) with the exception for the treatment number 6.

The residues incorporation was better with the reversible plows and the same was true for the clogging ocurrence. The Tamanduá 4 plow

Table 2. Operational Parameters of Mouldboard Plows Evaluated on Oxisol

Mouldboard Plows	Working width* (mm)	Working depth* (mm)	Draft force* (N)	Specific resistance* (N.mm^{-2})	Residues incorporation (%)	Clogging ocurrence (number)
1. Tatú AT-12	317 ab	167 a	1881 bc	0,034 b	60	11
2. Tamanduá 4	326 a	179 a	2234 abc	0,038 ab	80	07
3. Tamanduá 5	339 a	186 a	2577 a	0,041 ab	70	10
4. Tatú RS rev.	241 c	170 a	2009 bc	0,049 a	80	04
5. Tamanduá 3 rev.	267 bc	173 a	2264 abc	0,049 a	80	02
6. Tamanduá 4 rev.	337 a	182 a	2391 ab	0,039 ab	90	0

* Duncan test 5%

(treatment 2) showed good results.

No data was collected about the turning time and speed of the plows.

Considering all the evaluated parameters, the reversible plow Tamanduá 4 showed the better performance with a low specific resistance, but not statically different from the conventional plows; a good ability to incorporate the residues and no clogging ocurrence even with a high content of residues over the soil surface.

Evaluation of Plows on Entisol

Five plows were tested in a small farm at Pato Branco (26°04'S and 52°50'W) on a 25% slope land with stones and roots.

The soil water content was 18% for a depth of 0 to 20 cm and the soil bulk density was 1.08 g.cm^{-3}.

Four of the tested plows are the mouldboard twin share type (numbers 2, 3, 4 and 5 in **Table 3**) and one (fuçador) has a shovel share for loosening the soil. A pair of oxen were used for the tests.

There were five treatments and six replications in a plot with 20 meters long for the draft force evaluation. The amount of vegetation incorporated and the clogging ocurrence was evaluated. The results are shown in **Table 3**.

The Tatu RS showed the best performance of all the plows evaluated with a lower specific resistance and turning time as well as a good percentage of incorporated vegetation and clogging ocurrence.

The performance of the plow Tamanduá 3 was very close to Tatu RS, except for a small increase in the specific resistance and in turning time. However, the theoretical field capacity of the Tamanduá 3 was better than that of Tatu RS.

The turning time required by Sans 155, Policultor 600 and Fuçador was high due to the weight of these plows. The high clogging ocurrence for Policultor 600 resulted from a small clearance between the plow frame and the soil surface.

Table 3. Operational Parameters of Plows Evaluated on Entisol

Plows	Working width* (mm)	Working depth* (mm)	Draft force (N)	Specific resistance* (N.mm^{-2})	Residues incorpor. (%)	Clogging ocurrence (number)	Turning time (s)	Field capacity (ha.h^{-1})
1. Fuçador	461 a	173 a	3234 a	0,040 a	50%	low	63	0.143
2. Tatu RS-rev.	383 bc	159 b	1196 c	0,020 c	70%	low	22	0.069
3. Sans 155-rev.	337 c	175 a	1803 b	0,031 b	60%	medium	44	0.061
4. Policultor 600 rev.	403 b	176 a	1921 b	0,027 b	70%	high	39	0.065
5. Tamanduá 3 rev.	406 b	161 b	1480 bc	0,023 bc	60%	medium	26	0.082

* Duncan test 5%

Table 4. Operational Parameters of Plows Evaluated on Inceptisol.

Plows	Working width* (mm)	Working depth* (mm)	Draft force (N)	Specific resistance (N.mm^{-2})	Residues incorpor. (%)	Clogging ocurrence (number)	Turning time (s)	Field capacity (ha.h^{-1})
1. Pointed share-rev.	253 a	133 a	1068 a	0,032 a	100%	low	22	0.091
2. Tamanduá 3-rev.	211 a	142 a	1196 ab	0,040 ab	93%	medium	40	0.068
3. Tatu RS-rev.	223 a	139 a	1418 b	0,046 bc	90%	high	44	0.088
4. Policultor 600 rev.	203 a	133 a	1373 b	0,051 c	95%	medium	23	0.073

* Duncan test 5%

The soil conditions for planting were good three days after the tillage for all the plows evaluated.

Evaluation of Plows on Inceptisol

At Rio Azul (25°45'S and 50°50'W), four models of mouldboard plows were tested on an Inceptisol with 28% clay, 17% silt and 55% sand.

There were four treatments and eight replications in a plot with 15 meters long. The soil bulk density was 1.38 g.cm^{-3} and the soil water content was 26.4% for 0 to 20-cm depth.

Two models of mouldboard twin share plows (Tamanduá 3 and Tatu RS) were compared with a traditional pointed share and with a half turn plow (Policultor 600). A pair of horses served as the source of power. **Table 4** shows the field results of the evaluation.

The low specific resistance of the pointed share mouldboard plow together with a low clogging ocurrence, turning time and theoretical field capacity demonstrates it's better performance compared with those of all the other plows evaluated.

The frame design of the pointed share plow allows an operation with a high amount of residues over the soil surface without clogging problems. In consequence of a long time of artisans's empirical design the mouldboard is well adapted to this type of soils resulting in a fast operation and a low draft requirement.

The Tamanduá 3 and Tatu RS presented a good penetration capacity but had problems with residues clogging between the mould board and the plow frame and so required a great turning time. The Policultor 600 may not be recommended for horses as power source due to its high soil specific resistance.

Conclusions

The main conclusions of the study are:

1. The conventional mouldboard plows showed a smaller soil specific resistance than the

their ability to operate with residues is low, resulting in poor soil work quality (low incorporation and high clogging ocurrence);

2. On Oxisol soil the reversible mouldboard plow Tamanduá 4 performed better than the other plows with a low soil specific resistance and a good work quality ;
3. For areas with limited slopes (up to 30%) and small size rocks and roots, the mouldboard plow Tatu RS proved to be a good alternative to substitute for the fuçador plow on Entisols. Its theoretical field capacity and animal draft requirement are better than the traditional plow as well as its ability to operate with residues over the soil surface; and
4. The pointed share mouldboard plow is the better equipment for land preparation on Inceptisol since their correct design parameters are maintained.

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Animal-drawn Tillage System for Rice Cultivation under Rainfed Condition

by
A. K. Dave
Junior Scientist (Farm Machinery and Power)
Indira Gandhi Agricultural University
Zonal Agricultural Research Station
Kumhrawand, Jagdalpur (M.P.)
India. Pin - 494 005

Abstract

Five treatments with different combinations of animal-drawn plough, puddler and plank were chosen for study. Puddling index, depth of puddling, weed population, implements' performance, rice grain and straw yield, and energy use pattern were recorded/measured. An economic analysis was carried out. Keeping the draft requirement within the range of local animals, the combination of M.B. Plough (15 cm) + Puddler + Plank and M.P. Plough + Puddler + Plank was found to be the right choice being economical in land preparation and less energy intensive treatment for high rice grain yield. In the pre-vailing farmers practice the cost of puddling could be reduced by using animal-drawn puddler.

Introduction

The primary aim of puddling is to prepare the soil under wet condition for rice cultivation. Rice crop needs good seedbed preparation for increasing its water retaining capacity and for better weed control, especially under rainfed conditions. Rice is the lowest productive crop per unit of water among cereals, but water requirement is 10^7 l/ha which implies the importance of water usage and minimization of percolated water loss. This loss could be minimized by improving puddling quality. Under the transplanted system of paddy prevalent in the southeast portion of Madhya Pradesh, India, tillage operation starts after the onset of monsoon when ample rainwater accumulates in bunded fields. Ploughing and puddling before planting the crop is done with the help of country plough four to five times followed by planking — a practice among the farmers. Tillage is energy intensive operation, keeping in view the energy crisis, it is imperative to select more energy efficient implements suiting to the capacity of local animals.

Materials and Methods

The experiment was conducted at the Zonal Agricultural Research Station, Indira Gandhi Agricultural University, Jagdalpur during the kharif season 1933-94, under rainfed conditions. The soil was silty clay in texture and acidic in reaction. The five methods of tillage were operated after opening the land with two passes of plough as per treatment under wet soil conditions following a randomized block design with four replications. Before transplanting, each plot was puddled as per treatment plan followed by common planking operation to level the field. The IR-36 rice variety was transplanted in 20x15 cm spacing. The crop was fertilized with NPK 60:40:20 kg/ha. Full dose of phosphorus and potash with one third dose of nitrogen were applied at the time of puddling. The remaining nitrogen was applied at tillering and panicle initiation stages in equal splits.

The energy consumption was calculated as suggested by Mittal and Dhawan (1988). The draft was measured by a spring dynamometer. The samples of the puddled soil were taken from 10 locations of each plots (40x6 m^2) in graduated glass cylinders of thin wall and then the soil particles were allowed to settle down. The total volume of the soil samples were measured after 48 hours which was subtracted from the volume of the clear liquid and was expressed as percentage of total volume of the sample as puddling index. The performance of implements was noted on the basis of field capacity in ha/day. The depth of puddling, and weeds population was calculated as per the standard procedure.

Results and Discussion

Implement Performance

The comparative performance of different tillage implements is presented in **Table 1**. The actual field capacity was highest with M.B. plough 25 cm (T_3) and lowest under M.B. plough 9 cm (T_1). The draft requirement to work M.B. plough (25 cm) was higher and beyond the capacity of local animals for long duration ploughing. The M.B. plough (15 cm) treatment was observed to rank second in capacity and draft requirement within the capacity of local animals. The actual field capacity of country plough (farmers' practice) was found to be lowest in comparison to all other treatments. On the basis of implements' performance, draft requirement and body weight of local animals the M.B. plough (15 cm) was found to be superior over other treatments. However, the M.P. plough performance was also better as compared to the country plough. The animal-drawn puddler was found to have one and a half times puddling capacity than that of farmers' practice added with that the draft requirement was also within the capacity of local animals.

Table 1. Performance of Plough

Parameter	M.B. Plough (small)	M.B. Plough (medium)	M.B. Plough (big)	M.P. Plough (lohia)	Country. Plough (local)
Width (cm)	9.00	15.00	25.00	13.00	12.00
Actual width (cm)	9.00	14.90	23.90	13.00	10.10
Depth (cm)	6.80	10.00	11.30	7.30	7.20
Draft (kg)	43.30	50.96	69.28	60.62	60.62
Speed of travel (km/h)	2.24	2.12	1.95	2.05	2.03
Field efficiency (%)	76.52	74.56	70.35	73.85	72.51
T F C (ha/h)	0.0201	0.0318	0.0487	0.0266	0.0243
A F C (ha/h)	0.0153	0.0236	0.0342	0.0196	0.0176
Average power output (kW)	0.3590	0.4070	0.5000	0.4600	0.4550

* TFC: Theoretical field capacity. AFC: Actual field capacity.

Table 2. Puddling Quality and Weed Population as Influenced by Tillage Operation

Treatment	Puddling index (%)	Depth of puddling (cm)	Weed population (m^{-2})	Rice yield ($t\ ha^{-1}$)
T_1-M.B.plough(s) + Puddler	55.60	10.35	130.69	3.07
T_2-M.B.plough(m) + Puddler	69.50	13.65	109.00	4.10
T_3-M.B.plough(b) + Puddler	63.56	12.95	110.00	3.82
T_4-M.B.plough(l) + Puddler	61.38	11.38	114.00	3.63
T_5-Country plough(f) alone	50.08	9.90	143.00	3.37

s- Small, m- Medium, b- Big, l- Lohia, f- Farmers' practice.

Table 3. Effect of Different Tillage Systems on Energy Parameters in Rainfed Rice Cultivation

Parameter	T_1	T_2	T_3	T_4	T_5
Energy for land Preparation (MJ/ha)	1 746.95	1 235.26	944.62	1 446.73	1 717.54
Energy for weeding (MJ/ha)	509.60	489.40	480.56	529.50	575.30
Total input energy (MJ/ha)	7 632.91	7 147.12	6 872.64	7 360.69	7 677.30
Specific energy main product (MJ/ha)	110.42	77.36	79.96	90.04	101.19
Total output input energy ratio	12.20	17.42	16.85	14.96	13.31
Yield (t/ha)	3.07	4.10	3.82	3.63	3.37

Table 4. Economic Analysis

Treatment	Expenditure on land preparation (Rs/ha)	Total expenditure (Rs/ha)	Additionl income due to improved implements (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)
T_1-M.B.plough(s) + Puddler	1 352.51	7 681.88	44.09	9984.00	2 302.12
T_2-M.B.plough(m) + Puddler	1 027.50	7 611.35	367.10	13 344.50	5 733.15
T_3-M.B.plough(b) + Puddler	894.15	7 415.05	500.45	12 415.00	4 999.95
T_4-M.B.plough(l) + Puddler	1 152.54	7 632.33	242.06	11 807.25	4 174.92
T_5-Country plough(f) alone	1 394.60	7 816.97	—	10 959.00	3 142.03

Puddling Quality

The puddling by M.B. plough (15 cm) + puddler (T_2) was found superior, followed by M.P. plough + puddler (T_4) compared with farmers' practice (**Table 2**). This was due to the higher puddling index, deeper depth of puddling and lower weed population. Whereas, the animal-drawn country plough (farmers' practice) showed the lowest puddling index, shallow depth of puddling and maximum number of weeds. These effects were very well reflected on rice grain yield results.

Energy Use Pattern

The energy required in land preparation and weeding operation for different plots of tillage treatments are indicated (**Table 3**). The farmers' practice (country plough 4 passes) required 1.39 times more energy for land preparation and 1.17 times more energy for weeding as compared to M.B. ploughing (15 cm) followed by two passes of puddler, but producing 1.21 times lower rice grain yield. Specific energy requirements for the cultivation of paddy was highest in farmers' practice whereas lowest output input energy ratio was recorded due to lowest rice grain yield. On an average total energy requirements for the cultivation of paddy was 7 500 MJ/ha.

Economic Analysis

Table 4 shows the economic analysis of the different tillage practices on rice production. On the basis of cost of operation for land preparation the net savings of Rs. 72.03, 367.15, 500.45 and 242.06 was obtained, respectively, due to treatments T_1, T_2, T_3 and T_4 over the farmers' practice. The highest net saving was recorded under treatment T_3. Somehow the same was not recommended for this region due to its high draft farmers practice for treatments T_2 and T_4, respectively.

Conclusion

Tieing the capacity and draft requirement together the cost of operation, the "M.B. Plough + Puddler + Plank" and "M.P. Plough + Puddler + Plank" have come out to be the right choice being economical land preparation for transplanted paddy under rainfed condition. The farmers' practice of land preparation could be improved by incorporating the use of puddler which saves the cost of puddling by Rs. 180.

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New Co-operating Editor

Ali Mufarreh Saleh Al-Amri

Nationality: Saudi Arabia
Birth Date: December 19, 1960
Qualifications:

Ph. D Mechanical, Materials, Manufacturing and Processing Eng., University of Newcastle upon Tyne Newcastle upon Tyne, Uk, 1992.

M. Sc. Chem. Eng., University of Missouri-Rolla, USA, 1986.

B. Sc. Chem. Eng., College of Engineering, King Saud University, Riyadh, Saudi Arabia, 1983.

Experience:

June, 1997 - Present: Associate Professor, Department of Agricultural Engineering, College of Agricultural and Food Sciences, King Faisal University.

August, 1996 - September, 1996; Acting Dean for the College of Agricultural and Food Sciences, King Faisal University (KFU).

Janualy, 1996 - February, 1996: Acting Dean for the College of Agricultural and Food Sciences, KFU.

August 1995 - September, 1995:Acting Dean for the College of Agricultural and Food Sciences, KFU.

August 1995 - September, 1995:Acting Dean for the College of Veterinary Medicine and Animal Resources, KFU.

May, 1994 - May, 1997: Vice Dean of the College of Agricultural and Food Sciences, KFU.

May, 1994 - Present: Head, Department of Agricultural Engineering, College of Agric. and Food Sciences, KFU.

March, 1993 - June, 1997: Assistant Professor, Department of Agricultural Engineering, College of Agric. and Food Sciences, KFU.

September, 1989 - November, 1992: Studying abroad on a scholarship for Ph. D degree, at University of Newcastle upon Tyne, UK.

December, 1986 - September, 1989: Lecturer, Department of Agricultural Engineering, College of Agric. and Food Sciences, KFU.

June, 1984 - December, 1986: Studying abroad on a scholarship for M. Sc. Degree at University of Missouri-Rolla, USA.

June, 1983 - June, 1984: Teaching Assistant (Demonstrator), Dept. of Chemical Engineering, King Saud Univ., and Agric. Eng., KFU.

Current Position:

Associate Professor, Department of Agricultural Engineering, College of Agricultural and Food Sciences, King Faisal University, Al-Ahsa, Saudi Arabia.■■

Comparative Performance of Single- and Double- action Rocking Sprayers

by
Adarsh Kumar
Scientist
Divison of Agricultural Engineering
I.A.R.I., New Delhi-110012,
India

N.P.S. Sirohi
Sr Scientist
Divison of Agricultural Engineering
I.A.R.I., New Delhi-110012,
India

Abstract

A double-action rocking sprayer, combining two conventional rocking sprayers and a single-action rocking sprayer were tested for comparative performance. While the field coverage with double-action rocking sprayer was enhanced, the increase in a manual energy requirement was marginal and was within the 'light work' category of human energy consumption. The effective field capacity of the double-action rocking sprayer, with four nozzles working at 250 kPa pressure was 0.15 ha/h compared to 0.07 ha/h with the single action sprayer with the same number of nozzles.

Introduction

On most Indian farms, manually-operated spraying equipment are used. These sprayers have a disadvantage of operating on low hydraulic pressure which results in poor atomization and low field capacity. Nevertheless, low cost and no fuel requirement make these spraying systems economically more viable for small farms. Among the manually-operated spraying equipment, the rocking sprayer produces better spray as it works on relatively high pressures.

This sprayer consists of a cylinder and plunger assembly which is rocked by means of a long handle with mechanical advantage ranging from 10 to 12. Using this lever, it is possible for one operator to develop hydraulic pressure up to about 800 kPa with one working nozzle. In this kind of operation, only one stroke of the lever is compression stroke which develops pressure through a single piston-cylinder assembly. The capacity of the sprayer can be increased if both strokes are made to develop pressure in the system. This could be conveniently achieved by mounting and interconnecting two cylinders aligned opposite to each other in a way that both, inward and outward rocking actions of the handle, develop pressure in the system (Sirohi, 1994).

Operation of such a double-action system would require more energy than a single-action one. However, if the increase in the energy demand remains within the moderate limits of human effort, the improvements in the work efficiency should more than compensate for its use. With the above considerations in view, a double-action rocking sprayer was developed and evaluated for its comparative performance with respect to the conventional single-action sprayer.

Materials and Methods

The double-action rocking sprayer (**Fig. 1**) was tested along with the conventional single-action rocking sprayer for its comparative performance in terms of the parameter shown in **Table 1**.

Before conducting the tests care was taken to replace the plunger washers and nozzles with new ones. The suction pipes were fitted with fine strainers and placed in a water tank. The sprayer was operated for 15 min to clean the lines and nozzles before testing.

All the tests were conducted on the same operator who was 170 cm tall and weighed 68 kg. He was made to stand in a most comfortable position to actuate the handle during the tests. The desired level of operating pressure, at the given number of nozzles, was maintained by varying the frequency of strokes. For each set of operating pressure and number of nozzles, discharge rate, rocking frequency and piston forces were measured. A strain gauged load cell was used to record the piston forces under dynamic conditions. The energy requirement was calculated for each combination of independent variables.

Aspects of human capacity to operate the double-cylinder sprayer vis-à-vis the single-cylinder sprayer at different combinations of independent variables were also studied. Each test was conducted for a period of 60 min. Observations on fatigue, discomfort, heart-rate and

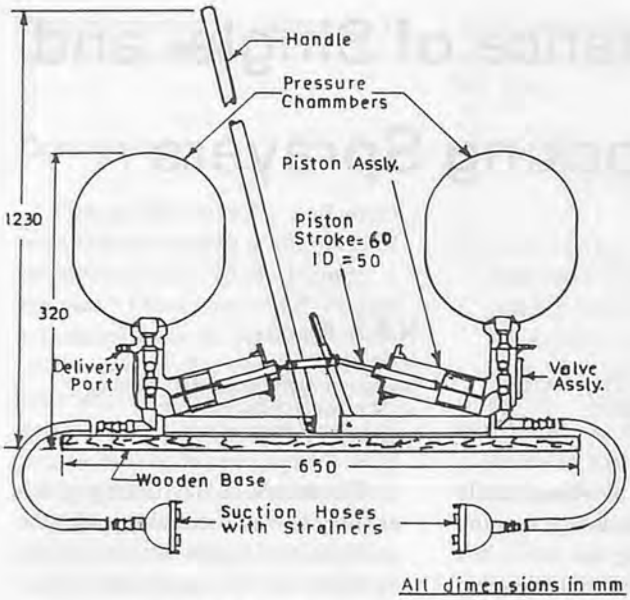

Fig. 1 Twin cylinder rocking sprayer.

Table 1. Conparative Performance of Parameters

Parameter	Unit	Level(Values)
Independent		
Hydraulic Pressure	kPa	5(100,150,200,250)
Number of onozzles	–	5(1,2,3,4,6)
Dependent		
Discharge /nozzle	mℓ/min	Corresponding to the above
Rocking frequency	Strokes/min	
Energy requirement	N-m/min	

Table 2. Forces at Pistons and Handles of Test Sprayers

System hydraulic pressure, kPa	Force required during each stroke,N			
	at piston rod		at handle (m.a.=12)	
	No of cylinders		No of cylinders	
	Single	Double	Single	Double
100	270	320	22.5	26.6
150	350	408	29.1	34.0
200	470	523	40.0	43.6
250	542	600	45.0	50.0
300	650	710	54.2	59.1

rest pause were taken at intervals ranging from 5 to 15 min which depended on severance of load. The ambient conditions remained unchanged during the test.

Results and Discussion

Operating Forces

The average values of the force measured at the piston rod at different operating pressures during compression of both the types of sprayers are given in **Table 2**. Piston rod forces at 100 kPa pressure for single- and double-piston sprayers were 270 N and 320 N, respectively, which increased to 542 N and 600 N at 250 kPa operating pressure. With a mechanical advantage of 12, these forces were reduced by 1/12 at the level of hand grip. The difference in piston forces of two types of sprayers by about 55 N was due to additional friction force between the piston and cylinder wall for the double-piston sprayer. Thus, to develop the operating pressure of 250 kPa, a hand force of 50 N was required during each stroke (push or pull) of double-piston sprayer, while it was 45 N with one compression stroke of the single-piston sprayer.

Rocking Frequency

The frequency of strokes to maintain the desired operating pressure was important in determining the energy requirement and capacity of the operator to operater the sprayer continuously for given duration. The frequency of the strokes increased as the operating pressure or the number of working nozzles increased (**Table 3**). For the same pressure and number of nozzles, the rocking frequency was almost half with double-cylinder sprayer due to volumetric efficiency of the system. With four working nozzles at 200 kPa pressure the rocking frequency of the double-cylinder sprayer was 23 strokes/min as compared to 45 strokes/min with the single-cylinder sprayer.

Energy Requirement

The energy levels required to operate both test sprayers at different pressures and number of nozzles are shown in **Table 4**. Energy expense increased as the operating pressure and number of working nozzles increased. With

Table 3. Rocking Frequencies of Test Sprayers at Varying Operating Pressures

No. of working nozzles	No. of cylinders	Rocking frequency,strokes/min at operating pressure,kPa			
		100	150	200	250
1	1	17.0	17.0	17.0	20.0
	2	8.0	8.0	8.0	10.0
2	1	23.0	23.0	25.7	29.0
	2	12.0	12.0	13.0	14.0
3	1	29.0	32.0	37.0	42.0
	2	15.0	16.0	18.0	20.0
4	1	36.0	41.0	45.0	55.0
	2	19.0	20.0	23.0	26.0
6	1	*-	*-	*-	*-
	2	22.0	24.0	30.0	34.0

*These levels could not be achieved.

Table 4. Energy Requirement of Test Sprayers

No. of working nozzles	No. of cylinders	Energy (N-m/min)required at operating pressure,kPa			
		100	150	200	250
1	1	230	296	408	540
	2	255	327	419	600
2	1	310	401	600	783
	2	383	490	680	840
3	1	391	558	888	1134
	2	479	653	942	1200
4	1	486	715	1080	1485
	2	606	816	1203	1560
6	1	*-	*-	*-	
	2	702	979	1570	2040

*These levels could not be achieved.

four nozzles working at 250 kPa pressure, the energy requirements for the test sprayers were 1 485 N-m/min and 1 560 N-m/min. Considering the human physical effort efficiency as 20% for a similar work (Grandjean, 1988), the values of human energy consumption would be five times the value of energy required for the operation. This energy consumption of about 10 000 N-m/min would fall in the 'light work' category (Nag, 1980). Although the energy requirements were marginally higher with the double-cylinder sprayer, the rocking frequency was almost half, which made the operation of this sprayer easily manageable with more working nozzles. However, it was not possible to keep the single-cylinder sprayer operating even for short periods with six working nozzles because the rocking frequency exceeded 60 strokes/min which was difficult to maintain.

Operational Discomfort

The levels of human discomfort to operate the test sprayers were determined using the Paffenburgar scale (Yoshitake, 1971) and body part discomfort ranking method developed by Corlett and Bishop (1976). With four working nozzles at all pressure, the operator felt 'slightly tired' with an average rate of 90 beats/min during a one-hour operation of the double-cylinder sprayer. After every 15 min of operation, a rest for 2 min was required. The body parts subjected to discomfort were the right foot, right palm, right shoulder, right arm, lower back, right leg and neck, in that order.

The level of discomfort increased substantially with six working nozzles at all the operating pressures. As a result, the operator was not able to operate the sprayer for more than 10 min at a stretch. He required 5-min rest after every 10 min of work. The pulse rate reached 120 beats/min after 10 min operation. It was observed that rocking frequency, which was also the determinant of energy requirement, was important in causing the operator's fatigue. Rocking frequencies exceeding 30 strokes/min caused discomfort to the operator.

Field Capacity

Four nozzles spaced 30 cm apart on a boom were operated at 250 kPa pressure with the double-action rocking sprayer. An area of 0.15 ha was covered in one hour by two persons. The operational time included tank filling and shifting of equipment within the field. In comparison, the single-action rocking sprayer could be operated with only two nozzles which covered 0.07 ha in one hour.

Conclusions

The double-action rocking sprayer had the principal advantage of enhanced effective field capacity. Its energy requirement was marginally higher compared to that of the single-action rocking sprayer. Each stroke of the former sprayer caused fluid flow to the delivery system. Consequently, the rocking frequency were almost halved to operate the given number of nozzles at the specified pressure. The increased level of energy requirement for the double-action rocking sprayer did not cause appreciable fatigue to the operator and was found to be within the 'light work' category of human energy consumption.

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Hand Tools for Harvesting Prickly Pear Fruits

by
Arturo Lara-López
Professor of Mechanical Engineering
the University of Guanajuato
México.

José Manríquez- Yepez
Professor of the Institute for Technology
and Superior Studies of Monterrey
México

Agustín Escamilla-Martínez
Researcher at the Center for Research and
Technical Assistance of the State of Querétaro
(CIATEQ), México.

Abstract

The development process for two hand tools to harvest prickly pear fruits is discussed. One of these tools harvests the fruit by twisting them around their longitudinal axis, while the other one cuts a small piece of the pad at the base of the furits. The dimensions of such designs are based on the distribution of sizes and cutting forces for the small and large varieties of prickly pear fruits. Both designs resulted in simple and light tools with acceptable percentage levels of damage and speed of harvesting. Both tools showned performances superior to those of direct manual harvesting.

Introduction

A report by the Center for Prickly Pear of the State of México (Centro de Nopal y Tuna del Estado de México, Conjunto CODAGEM, 1983) established that prickly pear is grown on 30 million ha distributed in the states of Coahuila, Nuevo León, San Luis Potosí, Guanajuato, Hidalgo, Chihuahua, Tamaulipas, Durango and Aguascalientes. Most of the crops are not cultivated and grow wild averaging about 200 plants/ ha. Cultivated plantations have 625 plants/ ha and the height is controlled by pruning to keep the fruit low for manual harvesting. Pads are located and oriented randomly on the plant.

However, most of the fruits are on the edges of the pads. The production of each plant varies from 20 to 30 kg, depending on variety, age, soil type and soil moisture. The products of the prickly pear fruits such as pigments, sugar and wine have been obtained on a laboratory scale. However, industrial exploitation of the prickly pear is limited by the high labor required for manual harvesting (160 kg/man day). In addition, harvesting may be harmful to workers due to spines on pads and fruits, that limit the harvesting time to the morning hours only, when the moisture from dew prevents the small spines from becoming easily disloged.

The problem in this study pertains to the development of hand tools to aid in harvesting the prickly pear fruits. Such tools must be light, easy to operate and versatile to harvest fruits in places of difficult access. After field research to determine the typical values for the size of fruit and cutting forces, two different principles were used in the design of the tool, both of which were evaluated during the field tests.

Crop Characteristics and Cutting Forces

Agronomy experts recommend, for cultivation of prickly pears, a spacing of four meters between rows for a total of 625 plants/ ha. However, in some places spacing between rows is as narrow as 3 meters. Due to difficulty in pruning often the clear space between plants is as narrow as 0.3 meters. Plant height is normally controlled at to 2.8 meters. at the most. In addition, often the stony and sloping farms are the ones chosen for prickly pear fruit growing.

Twisting the fruit about its longitudinal axis proved to be a good method for removing the fruit with very minimum damage to the fruit (Lara-López and Manríquez-Yepez, 1986). Minimum damage was also obtained by cutting the fruit with a small piece of the pad still attached

Aknowledgement:The costs of development of the hand tools were provided by the Coordinating Commission for the Agricultural and Livestock Development of the State of Mexico (CODAGEM) and the University of Guanajuato. The authors express appreciation of this help in undertaking the study.

Table 1. Distribution of dimensions, mass and cutting torque for the Test Hand Tool

Variable	Morada Variety			Alfajayucan Vatiety		
	Mean	S.D	Variance	Mean	S.D	Variance
Max.diameter[mm]	48.0	3.0	1.1	50.5	2.5	5.7
Height[mm]	50.0	6.0	3.0	67.0	5.5	28.7
Mass[g]	59.2	11.95	131.0	86.9	11.8	116.2
Torque[Nm]	0.27	0.09	0.007	0.43	0.26	0.06

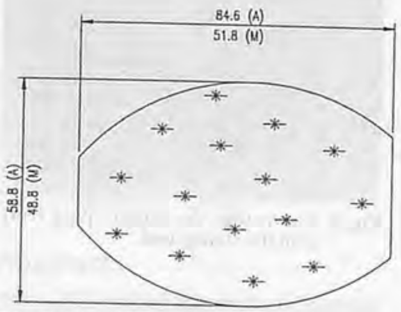

Fig. 1 Dimensions of the 99.9 percentile for large (Alfaiayucan, A) and small (Morada, M) varieties of prickly pear fruit.

to it (Lara-López and Escamilla-Martínez., 1991). The shape and size of the fruit play an important role in the tool design. Therefore, both small and large varieties have been sampled resulting in the statistical characteristics given in **Table 1**. **Fig. 1** shows the 99.9 percentile for large and small fruit varieties. Using statistical data, it was possible to predict the torque required to cut off 99.9% of the fruit, which was 1.168 Nm.

This value was used as a basis for the design of the tool.

Design of the Hand Tool

Tow different designs of hand tools for harvesting prickly pears were developed. One of these designs, called the cutting tool, is based on a jaw type mechanism having a sharp edge that cuts off a small piece of the pad along with the fruit. A second design, called the twisting tool, is based on the principle of twisting the prickly pear fruit around its longitudinal axis until detachment of the fruit occurs.

The configuration of the cutting tool was selected for maximum simplicity and a minimum weight, **Fig 2**. The selection of dimensions for the tool was conditioned by several design constraints, including the extreme dimensions of the fruit, height of plants and ergonomic recommendations. **Table 2** includes the main design constraints, which may apply to both designs.

An initial design was built and tested to observe the performance of the tool in the field. A dynamometer was incorporated in the cutter actuating wire to determine the force on the sharp edge, the maximum value of which was 31.29 N. The maximum forces for different positions of the hand grip were determined by mechanical analysis of the tool, considering this as a four bar likange and ploted in **Fig 3**. The forces on the operator's hand average was approximately 88 N, (Escamilla, 1991). Once these values were determined an optimization process was carried out to minimize the weight and mass moment of the cutting tool relative to the hand grip. In **Table 3** the parameters for the prototype and the proposed design are presented.

The twisting tool is shown in **Fig**

Table 2. Design Parameters Test

Parameter	Dimension
Maximum height of furuit,[mm]	84.6
Maximum diameter of furuit,[mm]	58.3
Maximum height of furuit,[mm]	51.8
Maximum diameter of furuit,[mm]	48.8
Height of plant,[m]	1.5
Diameter of plant spread of branches[mm]	2.0
Minimum thickness of pads,[mm]	25.0
Maximum thickness of pads,[mm]	70.0
Maximum displacement by hand,[mm]	157.0
Maximum hand closing force,[N]	1.17
Maximum required torque for fruit detachment,[N m])	1.1

Table 3. Parameters of the cutting Test tool

Parameter	Prototype	Optimized design
Mass,[kg]	1.1	0.71
Moment of force,[N m]	5.27	2.47
Distance from handgrip pivot to the cutting element pivot r_1[mm]	1200	940
Length of hand grip,r_2[mm]	70	90
Length of connecting wire,r_3[mm]	1230	880
Length of of cutting device,r_4[mm]	85	85
Length of cutting device,r_5[mm]	90	90

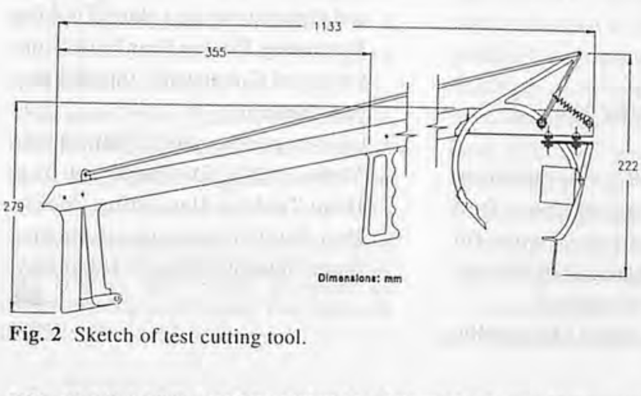

Fig. 2 Sketch of test cutting tool.

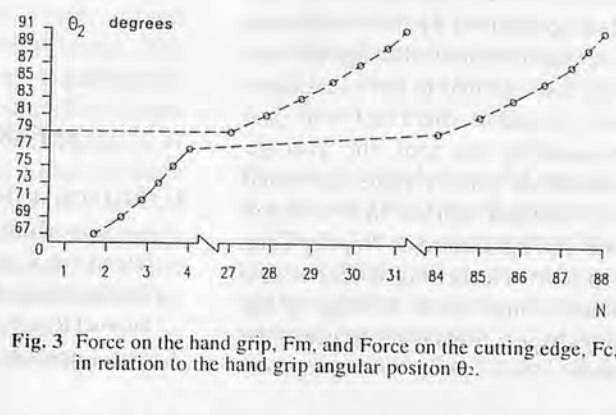

Fig. 3 Force on the hand grip, Fm, and Force on the cutting edge, Fc, in relation to the hand grip angular positon θ_2.

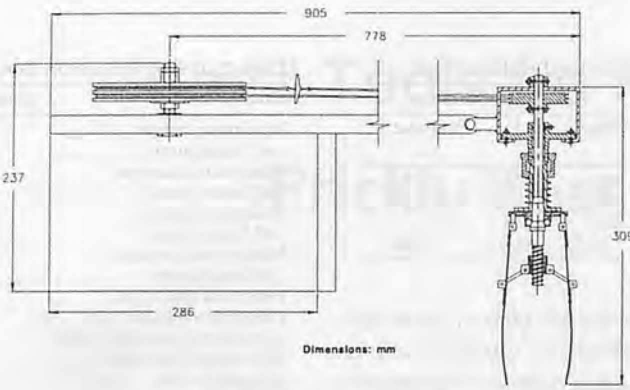

Fig. 4 Sketch of the twisting tool.

4. When the central shaft with square-based thread rotates with the pulley in the proper sense, the nut moves, closing the fingers until they press on the fruit. At this point the nut stops moving along the shaft and rotates with it, causing the detachment of the fruit. A mechanical analysis of the tool was done to simulate its performance for different sizes of fruits and to calculate the resistance of the main elements.

Field Tests

Field test for the two hand tools were performed, recording the time for harvesting one hundred fruits (**Figs. 5** and **6**.) Damaged fruits were counted based on visible damage. Data reported in this report correspond to those for a plantation in which the height of the plants was 1.60 m and the maturity of the fruits was proper for harvesting. **Table 4** shows the results of tests for both tools.

The speed of harvesting were almost identical for both tools. The damage caused by both tools was very minimal low, although the cutting tool seemed to have less damage because the fruit was not pressed by the tool. the average amount of prickly pears harvested by hand per worker in five hours was 200 kg (Centro de Nopal y Tuna Op. Cit). According to the tests a worker may pick 312 kg of the prickly pear fruits with the use of the tool.

Conclusions

A comparative evaluation of the designs of hand tools for selective harvesting of prickly pears yields the following observations:

1. Hand tools are needed essentially to aid havesting prickly pears from tall trees. However, for short trees the tool helps the worker in avoiding the spines.
2. Both tools cause minimum damage although the cutting tool causes less damage, due to the fact that the fruit is not pressed by the tool.
3. The speed of harvesting was almost identical for both tools (62.4 kg/h) compared with to the speed of hand harvesting (40 kg/h).
4. The weight of the cutting tool is 40 percent of the weight of the twisting tool. In that respect the cutting tool is more convenient to handle.
5. From the point of view of manufacture, the cutting tool is simpler to fabricate than the twisting tool

Fig. 5 Harvesting the prickly pear fruit with the cutting tool.

Fig. 6 Harvesting the prickly pear fruit with the twisting tool.

Table 4. Tests results on Performance of Test Tools vs Hand Harvesting (Unit: Time, sec.)

	Cutting tool	Twisting tool	Hand harvest
Mean	5.78	5.85	8.96
S.D.	1.11	1.20	---
Variance	1.18	1.22	---

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■■

A Mathematical Model of Heat Transfer in a Sheeted Bag Stack of Maize

by
K. A. Dzisi
Dept. of Agricultural Engineering
University of Science and Technology
Kumasi
Ghana

B. C. Stenning
Silsoe Campus
Cranfield University
Silsoe, Bedford
United Kingdom

M. P. Douglass
Silsoe Campus
Cranfield University
Silsoe, Bedford
United Kingdom

Abstract

A two-dimensional heat transfer model was used to describe heat transfer in a sheeted bag stack of maize. The results of the model were compared with actual measurements taken in a warehouse in Ghana. Although there were slight variations in figures, temperature plots of the model showed many similarities with those obtained from actual measurement. Linear regression was carried out on the results with the observed temperature plotted against the computed temperature. The best plot gave a relationship of the form:

Observed = 1.00 Computed

with a coefficient of regression of 0.773 for 52 pairs of readings.

Introduction

The temperature of grain in storage has a major influence on its keeping ability and on control measures necessary to protect it from insect pests and damaging microflora (Champ and Highley, 1983 and 1984). Rates of respiration and multiplication of insect pests and fungi and respiration of the grain itself are substantially dependent on temperature (Oxley, 1948a). These biological activities largely determine the rate of degradation and loss of the grain. Temperature gradients in grain bulks can give rise to convection, leading to moisture transfer and sometimes to localized regions of excessive moisture content and consequent grain damage Griffiths, 1964).

Grain temperatures are a major factor in the degradation of contact insecticides (Desmarchelier and Bengsten, 1979), and the action of fumigants and controlled atmospheres on insect pests (Bailey and Banks, 1980). While there are many individual studies on these important temperature effects, there is as yet no general predictive model to determine the temperatures to be expected in a bag stack storage. Similarly, there is no model relating the effects of temperature on the storage characteristics of grain in a particular store under given environmental conditions. The problem is complex. A quantitative description of heat transfer in grain involves a diverse set of sources of heat gain and loss. Some of these heat sources are:

i) environmental influences such as the degree of insulation of the storage structure and heat loss by ventilation;
ii) heat and mass transfer processes within the grain bulk; and
iii) metabolic activity of the grain and associated organisms.

Mathematical Models

Previous studies of temperature in grain bulks have generally used one of the following approaches:

(i) Analytical, where surface temperatures were taken to vary sinusoidally and convection cannot be included (Babbitt, 1945; Oxley, 1948b; Converse et al., 1973).
(ii) Iterative simulation of radial conductive transfer into cylindrical bins with no con-vection (Lo et al., 1975; Yaciuk et al., 1975).
(iii) Iterative simulation of radial and vertical conductive transfer into cylindrical bins with convection included but found to be negligible (Muir et al., 1980).
(iv) Iterative simulation of three-dimensional transfer in a hemispherical bunker with constant heat transfer by convection (Gough, 1985).

Proposed Model of Heat Transfer in a Sheeted Bag Stack of Maize

The purpose of developing a heat transfer model of a sheeted bag stack of grain was to gain an insight into the heat transfer processes occurring within the sheeted stack

Acknowledgements: The authors wish to express their profound gratitude to GTZ and DSE of the Federal Republic of Germany for sponsoring the research project.

when changes occur in ambient weather conditions. The ability to predict the temperature distribution in the grain stack would be useful in determining aeration periods so as to reduce convection currents which might result in moisture transfer from one part of the stack to another.

The model was expected to predict the heating and cooling waves through the stack as ambient temperatures rose and fell during the day and night, respectively.

The general partial differential equation describing heat transfer is:

$$\rho C_v \, \partial T/\partial t - \nabla(\kappa \nabla T) - s = 0 \quad (1)$$

Where:

- T = temperature
- C_v = specific heat at constant volume
- t = time
- κ = thermal conductivity
- s = a source or sink of energy
- ρ = density of the mediunm

Assuming heat production in the stack to be negligible and heat conduction from the surroundings is the main source of heat in the stack, the above equation can be rewritten in the following form:

$$\rho C_v \, \partial T/\partial t - \partial/\partial x \, \kappa \partial T/\partial x - \partial/\partial y \, \kappa \partial T/\partial y - s = 0 \quad (2)$$

where x, y are Cartesian coordinates in a two dimensional system.

An algebraic, finite difference counterpart of the differential equation quoted above was derived by Gosman et al., (1985). A FORTRAN Computer program, TEACH - C written by Gosman et al, (1985) was modified by Dzisi, (1989) to predict temperatures in a sheeted bag stack of maize.

Constant values used in the computer program include:
Bulk density of maize - 721 kg/m^3
Thermal conductivity of maize - 0.18 J/ms K. Specific heat at constant volume, Cv - 2.03 J/kg K (ASAE, 1989). The ambient temperatures at the top, bottom and sides of the stack were also fed into the program.

The model was used to predict the temperature distribution in the bag stack under various ambient conditions.

Temperature measurements were carried out over a period of seven months on a 62.5 tone stack in a warehouse in Tema, Ghana using thermistors and Squirrel data loggers. The stack, which was 6 m square at the base and 3.5-m high, was built using locally produced maize stored in woven polypropylene bags.

The validation of the model was carried out by:

(i) comparing temperature profile plots from the model with plots from the measured temperature readings. Temperature profile plots are of horizontal sections representing the bottom, central and top planes of the stack. The plots were obtained by interpolating the data using an interpolation program devised by Robinson (1989) and plotting the results on the UNIRAS package of the Silsoe College Minicomputer system; and

(ii) carrying out a linear regression analysis of the measured data plotted against the computer data.

Results and Discussion

Temperature Plots

Figure 2 shows the changes in temperature at the centre of the stack and average ambient temperature with time. The peak temperature at the centre of the stack of 34.8°C lags behind the peak average ambient temperature of 32.5°C by about five weeks. The temperature distribution within the stack does not show any regular pattern. The plots from the model however, show a regular distribution throughout the stack.

START
↓
Prescribed initial temperature field in the stack
↓
Store stack old temperatures
↓
Advance time $t = t + \partial t$
↓
Calculate coefficients
↓
Iterate on temperature field using line-iteration and block adjustment procedures
↓
Test: Is residual source sum sufficiently small?
↓
Yes
↓
Test: Has required time interval been covered?
↓
Yes
↓
STOP

Fig. 1 Flow chart of the solution procedure.

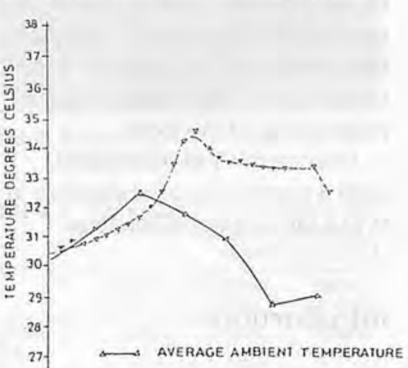

Fig. 2 Changes in stack centre temperature and average ambient temperature.

A comparison between plots of measured and computed temperature data in the first week of the experiment are shown in **Figs. 3a, 3b** and **3c.** As can be seen from the plots of measured data, the temperature distribution within the stack does not show any regular pattern. The plots from the model, however, show a regular distribution throughout the stack. At the top of the stack, the plots of measured and computed temperatures are a bit similar.

By the 16th week (**Figs. 4a, 4b** and **4c**), the measured and computed temperature profiles show many similarities, especially the bottom and central planes. By this time, the temperature distribution has stabilized throughout the stack. This appears to suggest some kind of steady state.

Plots for the 25th week (**Figs. 5a, 5b** and **5c**) show good agreement between the measured and computed values, especially in the central and top planes. The bottom plane, however, shows a high discrepancy in the minimum and maximum temperature values. This discrepancy is a result of the lowest layer of thermistors being influenced by the very close proximity to the concrete floor and to localized temperature effects.

Statistical Analysis

Linear regression of the measured and computed temperature data was carried out and is presented in **Figs. 6, 7,** and **8.** For the first week, **Fig. 6**, an equation of the form:

Observed = 1.03 Computed

was found to describe the relationship between the computed and observed results with a re-gression coefficient of 0.419 for 52 pairs of observations. Similar analysis of the results for the 16th week, **Fig. 7**, yielded a relationship of the form:

Observed = 0.952 Computed

with a regression coefficient of 0.527.

An equation of the form:

Observed = 1.00 Computed

was found to describe the relationship between the measured and computed data in the 24th week (**Fig. 8**) with a coefficient of regression of 0.773.

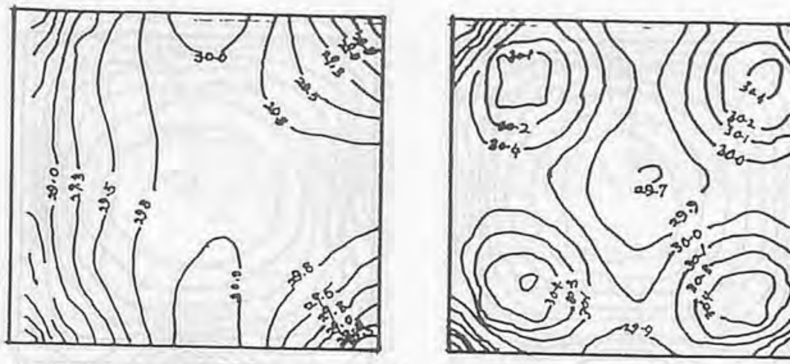

Fig. 3a Comparison between measured and computed temperature profiles in the stack. Week 1: Bottom plane.

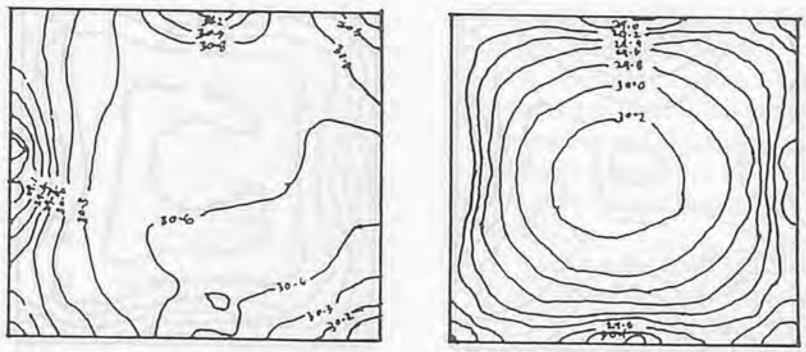

Fig. 3b Comparison between measured and computed temperature profiles in the stack. Week 1:Central plane.

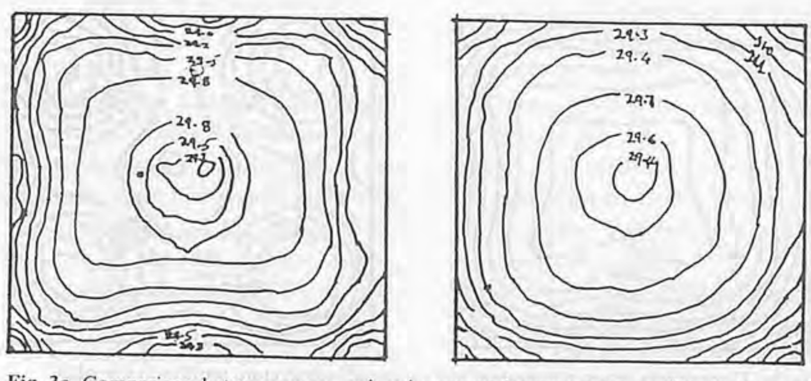

Fig. 3c Comparison between measured and computed temperature profiles in the stack. Week 1: Top plane

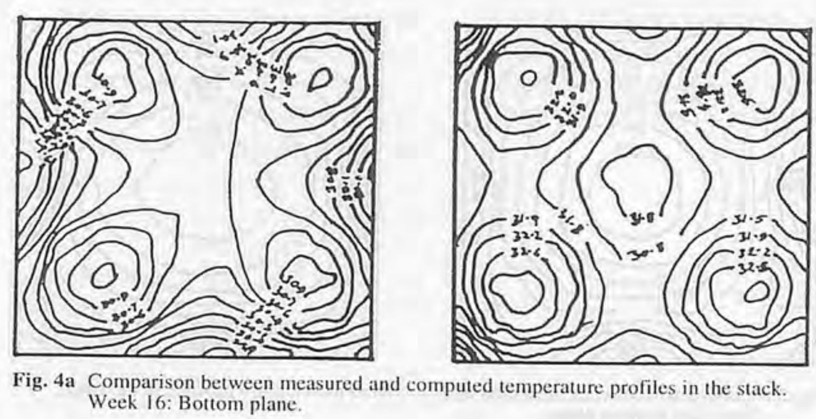

Fig. 4a Comparison between measured and computed temperature profiles in the stack. Week 16: Bottom plane.

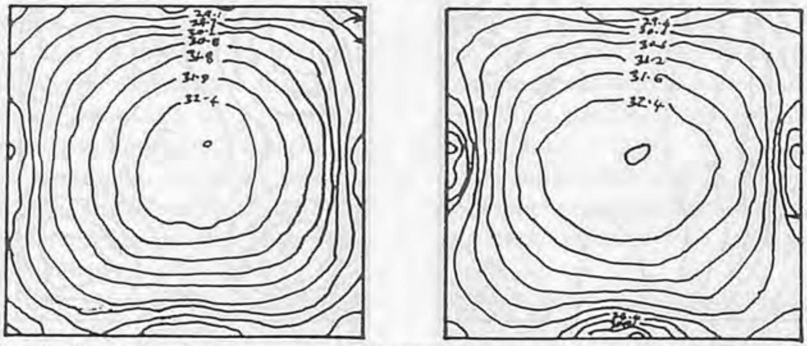

Fig. 4b Comparison between measured and computed temperature profiles in the stack. Week 16: Central plane.

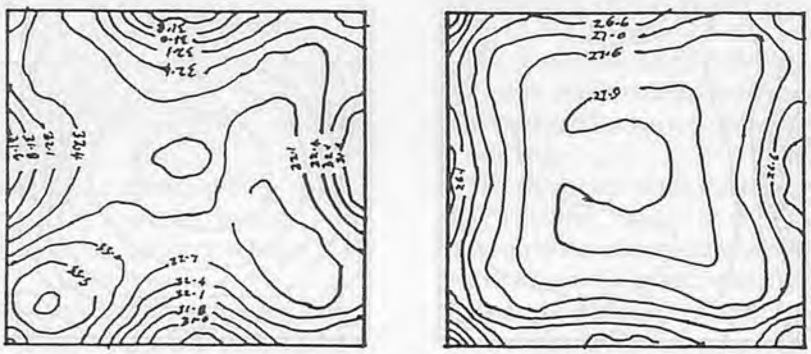

Fig. 4c Comparison between measured and computed temperature profiles in the stack. Week 16: Top plane.

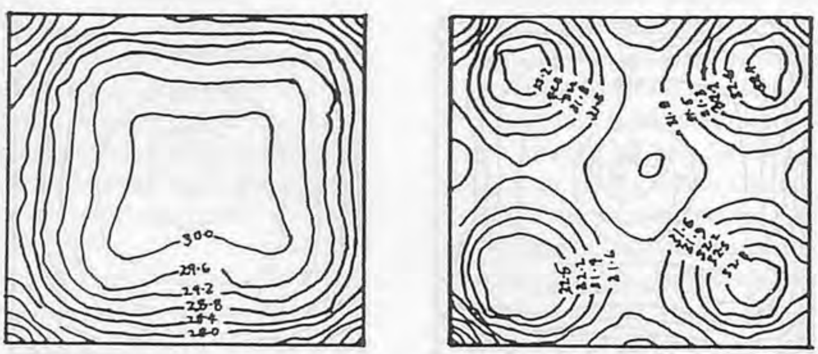

Fig. 5a Comparison between measured and computed temperature profiles in the stack. Week 24: Bottom plane.

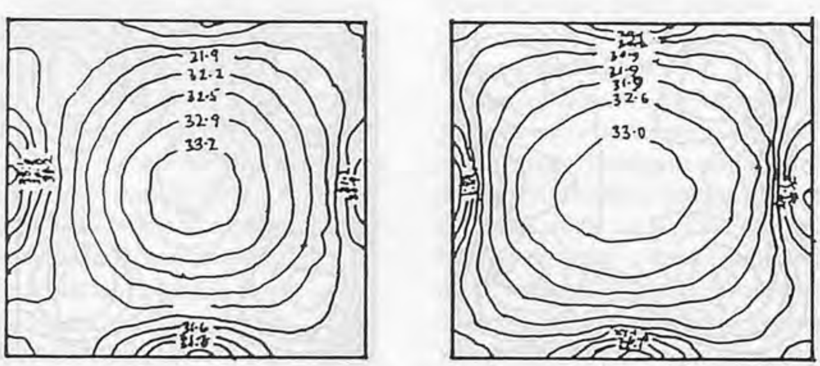

Fig. 5b Comparison between measured and computed temperature profiles in the stack. Week 24: Central plane.

Conclusion

The mathematical model describes the temperature distribution in the sheeted stack quite well. The temperature profile plots of the various horizontal sections show many similarities with the measured data.

The actual data values for the various positions vary quite a bit between the measured and computed data sets. The variations account for the low coefficients of regression obtained from the regression analysis.

Natural convection occurs in the stack, but the convection rates are so low that they are insignificant as far as temperature changes are concerned. This agrees with work done by Muir et al. (1980).

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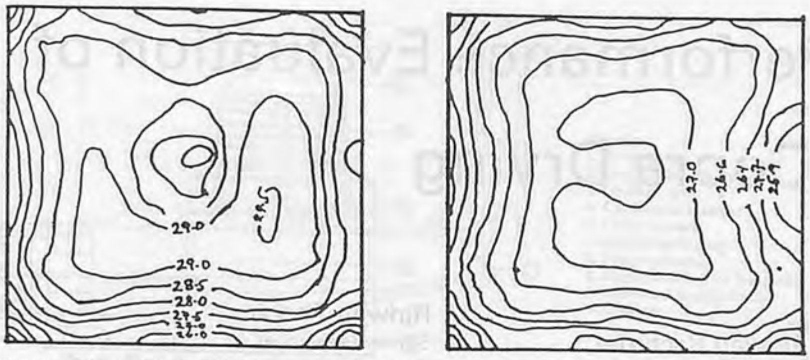

Fig. 5c Comparison between measured and computed temperature profiles in the stack. Week 24: Top plane.

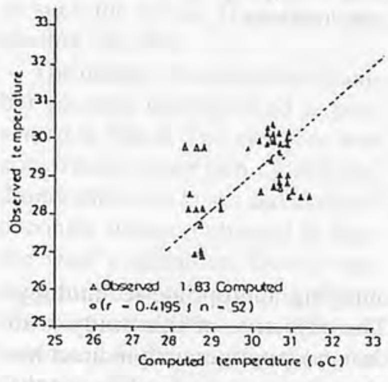

Fig. 6 Statistical comparison between observed and computed temperatures in the stack (Week 1).

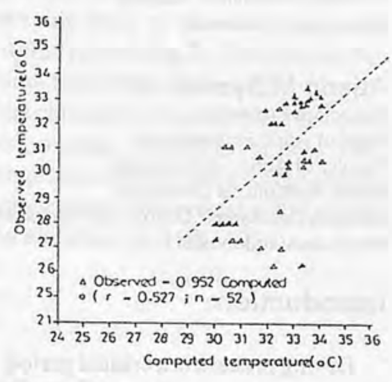

Fig. 7 Statistical comparison between observed and computed temperature in the stack (Week 16).

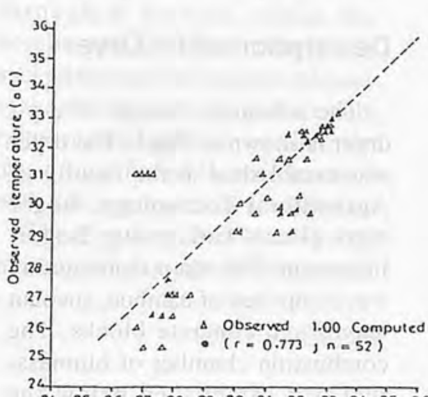

Fig. 8 Statistical comparison between observed and computed temperature in the stack (Week 24).

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Design and Performance Evaluation of Pit Dryer for Copra Drying

by
Ridwan Rachmat
Researcher
Rice Research Institute, Sukamandi
AARD, Ministry of Agriculture, RI
Jl. Raya Sukamandi, Subang
West Java, Indonesia

Ridwan Thahir
Senior Researcher
Centre for Development of Agric. Eng.
AARD, Ministry of Agriculture, RI
Situgadung Legok, Tangerang
Tromol Pos 2 , Serpong 15310
West Java, Indonesia

Atjeng M.Syarief
Associate Professor
Dept.of Agric.Engineering
Faculty of Agric. Technology
Bogor Agricultural University
Kampus Darmaga P.O.Box 122, Bogor 16001
West Java, Indonesia

Abstract

A pit dryer with indirect hot air aeration was developed. The design and performance of the drying system were evaluated for copra drying and the drying characteristics are discussed. The result of performance evaluation exhibited that the utilization of chimney to suck the smoke of combustible biomass increased the driving forced of hot air for drying. The average drying rate was 1.2%w.b./h, and cumulative energy consumption was 20.3 kcal/h from the combustion of coconut husks and shells. The cumulative drying efficiency was 10.72% and the average quality of dried copra those were analyzed comprised of oil content (62.1%) and free fatty acid (1.4%).

Acknowledgements : The authors wish to express great appreciation to Dr. Kazuo Horibe, Professor in Laboratory of Process Engineering and Machinery, Dept. of Bioproduction and Machinery, Faculty of Bioresources, Mie University, for his support in publishing this paper.

Introduction

Drying process is a critical period in post-harvest handling of agricultural products to prevent the development of a favorable environment for the growth of molds and insects that normally cause spoilage.

Copra is dried as the initial process of oil extraction from coconut (*Cocos nucifera*) in conventional method. Generally, in developing countries where coconuts are grown farmers produce copra by natural drying such as solar energy utilization. This method is the cheapest but completely dependent on weather and takes 4-5 days to reduce the moisture content of coconut meat from 45-55%w.b. to 7-11% w.b. (Grimwood, 1976). Another method, copra is dried by direct heating treatment on the racks or above the conventional stoves. This method could reduce the drying time between 36 and 40 h and results in dark-brown dried copra with low extracted oil quality. In this regard, there is a need in rural areas of developing countries to establish a modern drying system applying appropriate technology. The objective of this study is to design a pit dryer with indirect hot air aeration and to discuss the performance of the drying system.

Description of Pit Dryer

The schematic design of a pit dryer is shown in **Fig.1**. The dryer was established at the faculty of Agricultural Technology, Bogor Agricultural University, Bogor, Indonesia. The main construction was comprized of bamboo, coconut leaves and concrete blocks. The combustion chamber of biomass-fuel was established below the ground with 355 cm in length, 130 cm in width and 130 cm in depth from the earth surface. The drying chamber was covered by bamboo mats divided into two stories. The lower part was used for the first period of drying and the upper part contains 12 drawers for the second step drying. The top part of drying chamber is opened as the exhaust duct for evaporating the material's water vapor. The exhausted earth-clay-chimney with 450 cm in height

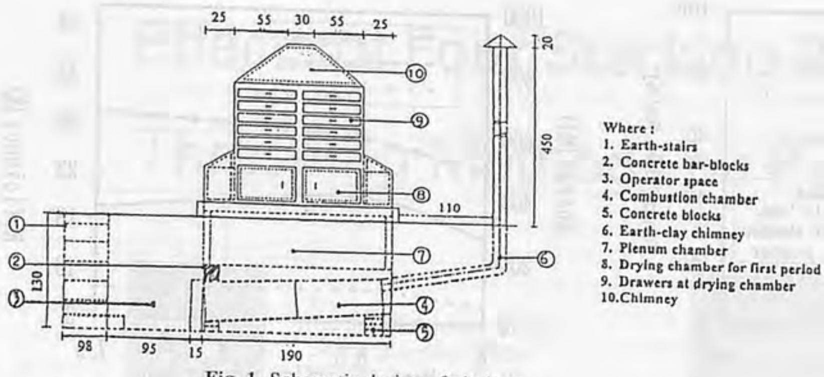

Fig. 1 Schematic design of pit dryer.

from the earth surface is established to suck the smoke from the combustion chamber.

The design of combustion chamber located underground is presented in **Fig.2**. The chamber was constructed from two cylindrical drums where the husks and shells of coconuts were combusted to heat the wall's chamber. Due to the accumulation of conduction and free convection heat transfer and buoyancy force employed by the chimney effect, the hot-air is forced from the wall of combustion chamber to the drying chamber through a plenum, while the combusted biomass's smoke is sucked through the exhaust chimney to the environment. To protect from rainy season and bad weather, the dryer was shaded by wooden roof with coconut leaves as roof tiles.

The slopes of the chimney and top part of drying chamber were designed based on the critical driving force of dew-bulb from the water vapor (**Fig.3**). To prevent the dew-bulb drops to the copra's layer, the chimney's slope at the upper part of drying chamber meets the required driving force of dew-bulb movement. Theoretically it is stated in equation 1) (Hall, 1980):

Where: Fs = driving forced(newton)
g = gravitational force (m/s^2)
S = stress of water surface (= 6.62x10^{-2}N/m at 80°C)
fÏ = specific weigh of water (kg/m^3)
fÆ = angle of wall's slope
F = vertical component of force (newton)
W = resultant of force (newton)

Evaluation Procedures

The performance testing of the pit dryer was conducted three times with 300 nuts (320 kg of coconut meat, including the shells). The average initial moisture content was 53% w.b. The drying process was divided into two periods, in the 12 h of first period, raw coconut with their shells were dried in the half slices for ease in removing the shells from the meats, then in 26 h of second period, the half dried coconut meat only (without the shell) was dried. Temperatures of the system were measured by copper constantan thermocouples transmitted to an analog recorder graphically. Air velocity was measured by a thermistor anemo-meter, while air relative humidity was measured by a hygrometer. The moisture content of copra was tested by sampling method in each drawer with infrared moisture meter. Sampling was conducted every 2 h for the first period of drying and every four hours at the second one. The oil content of the dried copra was evaluated using Soxhlet (Woodman method, 1941) and the Free Fatty Acid (FFA) was evaluated by Mehlenbacher method(1960).

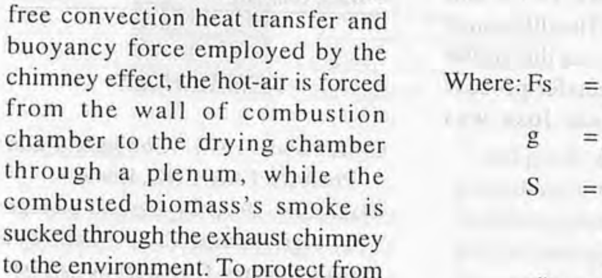

Fig. 2 Design of combustion chamber.

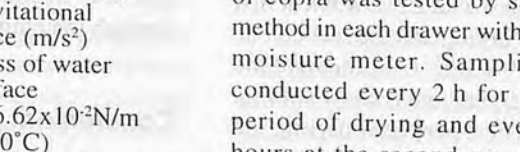

Fig. 3 The slope of chimney cover at the drying chamber.

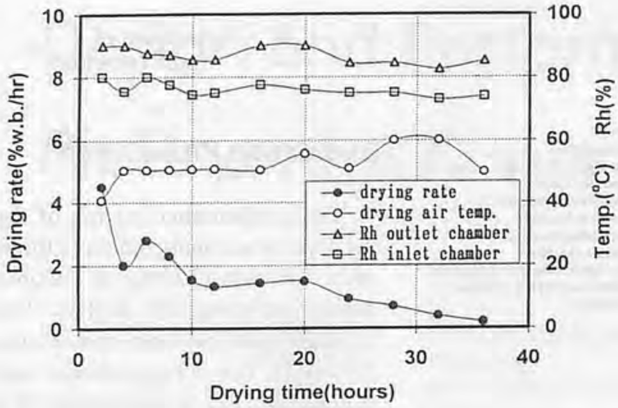

Fig. 4 Drying rate for copra.

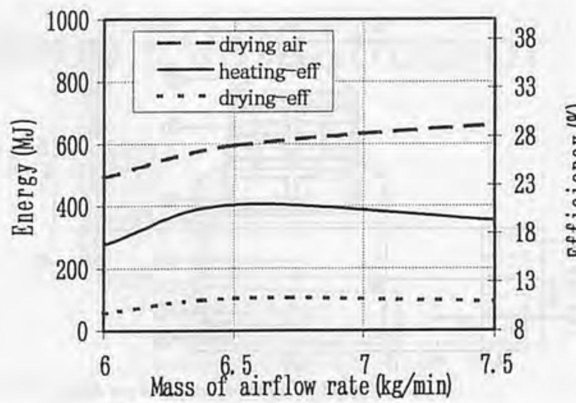

Fig. 5 Efficiency and consumed energy.

Results and Discussion

Drying Rate

The evaluation on drying performance was conducted in three replications. The performance of one experiment is presented in **Table 1**. The fluctuation of drying temperature in the drying chamber was 50°C-60°C with relative humidity of 70%-80%. This condition led to the average drying rate of copra with 2.0% w.b/h at first period of drying and the second one was 1.3%w.b/h. Graphically, the average drying rate is shown in **Fig. 4.** In the first period of drying, the moisture content at the surface of the materials were in a condition of free moisture which was easy to evaporate by diffuse process with drying air, while in the second step it was lower than the first one due to diffused capacity and capillary forced from the inner to the surface parts of the copra were lower. This condition resulted in the water evaporation from the surface that proceeded slowly.

Energy Consumption

The difference in temperature condition was due to the existence of heat loss through heat transfer process. In the case of drying air movement through the bulk of copra in drawers, the higher content of water vapor in air resulted in a lower evaporation capacity of drying air. This phenomenon exhibited by the consumed energy in heating drying air and low drying efficiency is shown in **Fig 5**.

The average feeding rate of coconut husk and shell into the combustion chamber were 3.8 kg/h and 1.4 kg/h, respectively. The average of cumulative heating and drying efficiency were 19.1% and 10.7%, respectively. The difference in efficiency values was due to the heat loss by mass transfer process and the highest heat loss was through the chimney .

Conclusion

1. A pit dryer for copra drying was developed using low-priced materials.
2. The utilization of coconut husk and shell for combustion energy as waste product of coconut led to the advantage condition for cost saving in drying copra.
3. The application of chimney effect gave the benefit of the indirect hot air aeration and smoke exhaust.
4. It is recommended that the door/ regulator at the entrance of chimney exhaust of the combustion chamber be used to reduce heat loss.

Table 1. Performance of Copra Drying

Components	Values
Initial weight(included shells)	320 kg
Initial moisture content	52.2 %w.b.
Drying time	38 h
Final moisture content	11. 4%w.b.
Biomass fuel consumption:	
Husks	131.9 kg
Shells	42.7 kg
Dried copra quality :	
Oil content	62.1%
Free Fatty Acid (FFA)	1.2%
Water content	10.6%

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Effects of Four Stacking Periods and Threshing Methods on Paddy Quality

by
Abdul Kaddus Miah
Senior Scientific Officer
FMPHT Division, BRRI
Gazipur-1701
Bangladesh

B.C. Roy
Senior Scientific Officer
Agronomy Division, BRRI
Gazipur-1701
Bangladesh

Md. Hafiz
Scientific Officer
Agronomy Division, BRRI
Gazipur-1701
Bangladesh

M. Haroon
Senior Scientific Officer
Agronomy Division, BRRI
Gazipur-1701
Bangladesh

S.B. Siddique
CSO and Head
Agronomy Division, BRRI
Gazipur-1701
Bangladesh

Abstract

An experiment was conducted in Gazipur during transplanted aman,1994 in order to observe the effects of four different stacking periods and threshing methods on quality of paddy.

The study revealed that the significant increase of threshing output was observed from 0-5 days stacking and no significant increase of threshing output was observed between 5-15 days stacking periods. The threshing outputs of different methods differed significantly among the treatments.

The obtained results showed that the threshing capacity of pedal thresher (96 kg/h) was higher than other methods irrespective of stacking periods. Significant unthreshed grain were observed in bullock treading (9.97%),manual treading (5.73%) and drum beating (1.44%) and least in pedal threshing (only 0.46%).

All paddy seeds gave satisfactory germination results irrespective of threshing methods and stacking periods during June-July. However, the germination percentages of pedal threshed seeds ranged from 96-90%, 96-99%, 97-99% and 100-99% for 0-, 5-, 10- and 15-day stacking, respectively.

On the whole, 0-5-day stacking materials threshed by pedal thresher performed better than others in respect of threshing outputs and germination of paddy.

Introduction

Bangladesh is an agricultural country. Rice is the main food of her people. It grows in the tropical countries. Rice is staple food not only in Bangladesh but also in India, Myanmar, Thailand, China, Vietnam, Philippines, Malaysia, Indonesia, many parts of Africa and Latin America.

In Bangladesh, about 10.74 millon hectares of land are used for rice production (BBS, 1992) which produce about 28.00 million tone (mt) of rough rice (Miah,1994) in four different seasons, i.e., Aus (March-August), Broadcasted Aman (April-November) Transplanted Aman (July-December) and Boro (January-May). Both the high yielding (HYV) and local varieties (LV) are grown in Bangladesh. The yield of LV is very low (1.25 t/ha) (FAO,1993) which can not meet the food requirement of the country. The total population of the country is about 120 million. At the moment the country is not self-sufficient in food. Miah, et al., (1994) reported that the average threshing loss of rice in Bangladesh is about 4% which is equivalent to 0.80 mt. The total value of this quantity of food in terms of money is about $300 m. This quantity of food could have been used to feed a population of 5 million a year.

However, this loss occurs due to practice of traditional threshing devices, adverse weather condition and sticky varieties of paddies. Inspite of that, most of the losses occur during Boro and Aus seasons as harvest is done during rainy season. Due to rainy season, farmer harvest the paddy quickly and try to thresh them as soon as possible by using traditional methods to avoid losses.

Moreover, there are some varieties that are very difficult to thresh. Nevertheless, these varieties are usually appropriate for rainy season because the rain and gusty wind can not easily separate and fall off the grain from the panicle in the field and cause loss. These varieties are stacked for certain periods, when temperature rises inside the stack the grains are separated quickly from the panicles. Sometimes a high temperature generates inside the stack which causes germination, contamination and fungus attack to the grain.

Samajpati and Sheikh (1981) reported that mechanical threshing is very rare in Bangladesh. Pedal threshers are used in some districts at a limited scale which reduces the labour requirement and improves the quality of grain.

In Bangladesh, the common methods of paddy threshing are manual treading, bullock treading and drum beating. The pedal thresher and power thresher are used at limited scale in public rice production farms.

About 80% of the Bangladesh farmers are poor and they can not afford to buy the mechanical thresher so they use the inexpensive traditional devices. As a result a large quantity of grain deteriorates during threshing operation.

Miah, et al., (1994) reported that in Bangladesh usually farmers lack knowledge and information about threshing methods and stacking periods during rainy periods. For this reason, a huge quantity of threshing materials are stacked by the farmer for a long time and thus significant quantities of grains are damaged during stacking. Moreover, the cattle population is gradually decreasing in Bangladesh. As a result farmers are facing shortage of animal power both for plouging in the field and threshing the crops. Furthermore, threshing done by the cattle is subjected to more grain loss during operation. Drum beating system also causes more internal fissuring of grain during operation which is attributed to breakage during milling, pest attack and viability loss.

This study was undertaken with the purpose of determining and selecting appropriate stacking period and threshing method for producing better quality of grain for seed purpose.

Materials and Methods

This experiment was conducted during T. Aman. 1995 at Jugitola village which is about 3.5 km away from Bangladesh Rice Research Institute (BRRI). The 'Nizershail' is an improved local variety which was available in that village and most of the villagers grow it. Therefore. Jogitola was selected for this experiment.

The Naizershail paddy field was located in the middle of the village: 0.25 ha of land was selected. When the paddy looked golden or brown in the field the plants were cut by traditional sickle by 3 people at a moisture content of 22% (w.b).

The threshing floors were divided into 4 parts and stacking materials were divided into 16 parts for the experiment: 4 stacks were made in oval and conical shape which is common throughout the country. However, 4 piles for 0-day stacking (T_1), 4 piles for 5-day stacking (T_2), 4 piles for 10-day stacking (T_3) and 4 piles for 15-day stacking (T_4) were made for this study.

The piles were made with equal quantity of threshing materials. Ambient conditions were recorded by sling psychrometer and stem hygrometer. Stop watch, balance, thermocouple with digital comark, stop watch,threshing devices, sample divider, sieve, sample bag, calculator and other necessary equipment were used for this experiment.The most common traditional paddy threshing methods were used for this experiment. These are Bullock Treading (BT), Pedal Thresher (PT), Manual Treading (MT) and Drum Beating (DB). Four threshing methods and four stacking periods were selected in a split plot design with three replications.

Grain Straw Ratio

The randomized paddy bundle was weighted at different moisture contents. The grains were separated by stripping method and weighted. Let,

Wt. of bundle = 'X' kg at a moisture content K%(w.b)

Wt. of grain = 'Y' kg at the same moisture content

Wt. of straw = (X – Y) kg

Grain : Straw = Y : (X – Y)

Drying

After proper cleaning, all sample were sun-dried in the morning and afternoon. Drying temperatures ranged from 25-26°C. The sample were dried for 3 days. However, the thin layer drying was used to exposed entirely to the air moving through the product. At a given relative humidity, the drying rate is proportional to the difference between grain moisture content and equilibrium moisture content. Besides, the rate of drying is proportional to the difference between vapour pressure of grain and vapour pressure of drying air. The removal of moisture during drying operation was represented by the following equation:

$$dM/dt = -k (M - M_e)$$

integrating the equation.

$$dM/(M - M_e) = -kdt$$

or, $(M - M_e)/(M_o - M_e) = e^{-kt}$

Where,
dM/dt = Rate of drying/h
M = Moisture content (d.b) of grain at any time, t
M_o = Original moisture content (d,b.)
M_e = Equilibrium moisture content
t = Time, in h
k = Drying constant.
$(M - M_e)/(M_o - M_e)$ = Moisture ratio.

Storage of Seed

The paddy seeds of different threshing methods and stacking periods were dried at 12% m.c. (w.b.) and finally 1 kg seed was stored for ten months in polythene bag in controlled condition.

Sampling

Samples of different threshing methods (BT, PT, MT and DB) for different stacking periods (t_1, t_2, t_3 and t_4) were collected from polythene bag. 100 pure seed were slected out from each sample bag at monthly interval for germination test.

Germination Test

Petridish method was used for germination test. 100 pure seeds were placed on soaking paper on a petridish. Each of treatments was replicated thrice. The seeds were soaked for 24 h then after the water was drained out from petridish which were kept into a oven at a temperature of 40°C. After seven days the germinated seeds were counted.
Number of original seed = 100
Number of germinated seeds after 7 days = 'X'
i.e. % germination = (X/100) x 100

Results and Discussion

Temperature and Relative Humidity of Ambient Air

The ambient weather has a profound effect on threshability and quality of grain. The drybulb temperature (dbt), wet bulb temperature (wbt) and relative humidity (rh) of the air ranged from 22-25°C, 17-22.5°C and 56-63% (**Table. 1**), respectively. The initial dbt was 22°C and gradually increased to 25°C on 15 days stacking. Similarly,wbt increased from 170°C to 19.8°C on the final stacking day. The rh were 60%, 63%, 56% and 60% for 0-, 5-, 10- and 15-days stacking periods. During the experiment all days were sunny.

Moisture Content, Temperature Rise and Relative Humidity of Air Inside the Pile During Stacking Periods

The initial moisture content of the seed was 23.55% and final moisture content was 22% (wb) (**Table 2**). On the first day the temperature was measured from top, middle and bottom part of the stack. The average temperatures were 19.5°C, 30°C, 33°C and 27.3°C for 0-, 5-, 10-, 15-days stacking, respectively. However, the rh of air inside the pile ranged from 65-93% during whole stacking periods. The obtained results showed that there was a direct relation between temperature and relative humidity (**Table 2**). As the average temperature increased so the relative humidity increased but it has reverse relation with the grain moisture content. The grain-straw ratio was 0.225 which has a great effect on threshing output.

Table 1. Ambient Weather Condition

Stacking periods (days)	Dbt (°C)	Wbt (°C)	Rh (%)	Sunshine
0	22	17	60	good
5	24	19.4	63	good
10	28	22.5	56	good
15	25	19.8	60	good

Threshing Output

It was found that the threshing methods and stacking periods have combined effects on threshability and quality of paddy (**Table 3**). The average threshing capacities of BT, PT, MT and DB were 58, 96, 29 and 78 kg/h, respectively.

Significant increasing of threshing was observed from 0-5-day stacking but no significant increase was observed between 5-15-days stacking periods. The threshing outputs varied significant among the treatments. The threshing output of PT was always higher than other methods irrespective of stacking periods. Miah, et al., (1994) reported that pedal thresher provides higher threshing output (103 kg/h) than other traditional threshing methods. This study also supports the study of Miah, et al., (1994). However, the threshing output of grain depends on machine, or method itself, quality of paddy, grain-straw ratio, weather condition, physical condition of lobour and so on. The analysis of

Table 2. Moisture Content, Temperature Rise and Relative Humidity of Paddy During Stacking Period

Stacking periods (days)	Grain straw ratio	Moisture content (%)	Stacking temp. (°C)			Average temp. (°C)	Rh (%)
			Top	Middle	Bottom		
0	0.225	23.55	19.50	19.50	19.50	19.5	65
5	0.225	23.00	29.00	32.00	29.00	30.0	92
10	0.225	22.30	31.50	34.00	32.50	32.7	97
15	0.225	22.00	27.00	28.00	27.00	27.3	93

Table 3. Threshing Output (kg/h) as Influenced by Stacking Periods and Threshing Methods

Stacking period/ Threshing methods	Days after harvest				Mean
	0	5	10	15	
BT	50.9	59.3	60.8	61.9	58.23
PT	4.0	97.7	100.2	102.3	96.04
MT	23.5	28.3	30.6	31.9	28.58
DB	64.0	76.6	80.6	91.4	78.15
Mean	55.6	65.5	68.1	71.9	65.25

Table 3a. Analysis of Variance for Threshing Outputs

SV	DF	SS	MS	F
Replication (R)	2	1.17399	0.58699	<1
Duration (D)	3	1 736.17327	578.72442	515.05**
Error (a)	6	6.74121	1.12354	
Threshing method (T)	3	30 102.87907	10034.29303	10 660.41**
DxR	9	375.53618	41.72624	44.33**
Error (b)	24	22.59040	0.94127	
Total	47	32 245.09412		

cv (a) = 1.6%; cv (b) = 1.5%
** = Significant at 1% level

Table 3b. DXT Table Means for Threshing Output (kg/h) (Average of 3 replications)

Threshing method (T)	Duration (day) 0	5	10	15	T-mean
BT	50.900cC	59.300cB	60.800cAB	61.900cA	58.225
PT	84.000dC	97.730aC	100.170aB	102.270aA	96.043
MT	23.530dC	28.300dB	30.600dA	31.900dA	28.583
DB	64.000bD	76.590bC	80.620bB	91.410bA	78.155
D-mean	55.607	65.480	68.048	71.870	65.251

* In a column values followed by a common small letter are not significantly different at 5% level by DMRT.
** In a row values followed by common capital letters are not significantly different at 5% level by DMRT.

Table 4. Average Moisture Content of Seed During Storage from January-October

Storage period (month)	Average m.c.% (w.b)
January	12.8
February	12.8
March	13.0
April	12.2
May	12.5
June	13.7
July	14.1
August	14.2
September	14.0
October	14.0

variance for threshing outputs are shown in **Table 3a**. The stacking periods and threshing methods are significant at 1% level.

In **Table 3b**, in a column, values followed by a common small letters are not significantly different at 5% level by DMRT. In a row, values followed by common capital letters are not also significantly different at 5 % level by DMRT.

Seed Germination at 0-day Stacking

Fig. 1 represents the relationship between germination and storage periods. The obtained results showed that during April-July the seed gave higher germination results than other months irrespective of threshing methods and stacking periods. This may be due to low moisture content of seeds. During January-March, the seed did not germinate well due to its dormancy. Again in the month of February all seed were germinated and grew up, although it was below 40%. However, in the month of March it again increased sharply. Among all threshing methods, the DB threshed seed provided the highest results, 84%. The others were below 70%. During April-July all seed germinated very well (93-100%). Usually the farmers take their seed from their store or from other source for seed bed in the month of June-July. From the results it can be seen that the MT seed gave the highest germination in the month of May, whereas it decreased slowly in the month of June (96%) and again it increased slowly in the month of July (97%). May-be due to fluctuation of moisture content throughout the storage period of paddy seed. However, during April-July the germination percentages were 96-98, 93-99, 94-100 and 85-97% for BT, PT, MT and DB, respectively. From July-August the viability of all seeds decreased sharply and finally decreased drastically to "0" in the month of October irrespective of threshing methods. The paddy seed samples were stored at a moisture content of 12.8% (wb) in the month of January which remained in the month of February. After two-month storage, the moisture content increased gradually but in the 3rd month it decreased sharply to 12.2% (w.b). After 4 month of storage it increased gradually and again grew to 14.1%. However, for season to season storage all seeds threshed from differ-

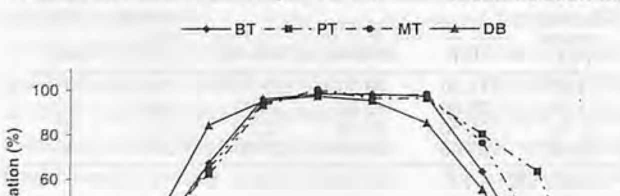

Fig. 1 Germination results of 0-day stacked seed, T. Aman 1995, Jugitola, Bangladesh.

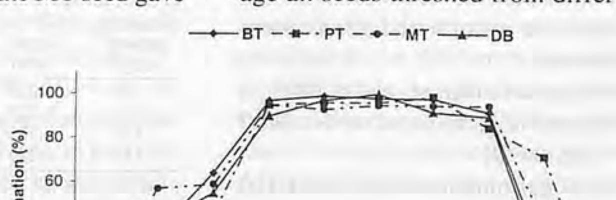

Fig. 2 Germination results of 5-day stacked seed, T. Aman 1995, Jugitola, Bangladesh.

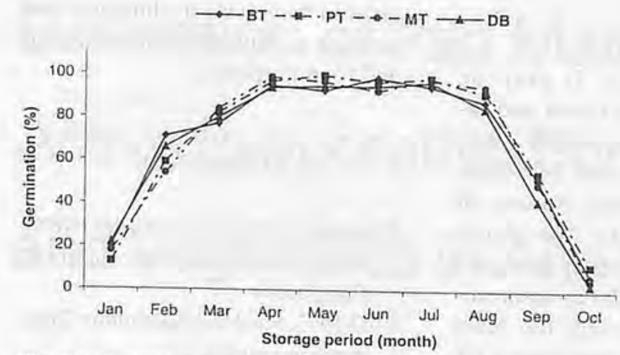

Fig. 3 Germination results of 10-day stacked seed, T. Aman 1995, Jugitola, Bangladesh.

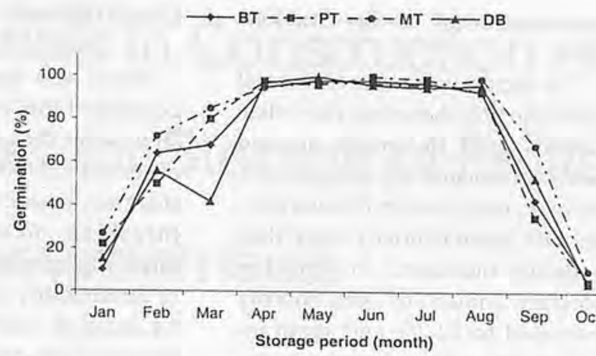

Fig. 4 Germination results of 15-day stacked seed, T. Aman 1995, Jugitola, Bangladesh.

ent methods gave satisfactory results.

Germination Results of 5-day Stacked Seed

Figure 2 shows the relationship between germination and storage period. In January, the germination of paddy seeds were found to be 14%, 23%, 11% and 18% for BT, PT, MT and DB, respectively, where the moisture content of seed was 12.8% (w.b). Dormancy of the seed may be attributed the poor germination of seed irrespective of threshing methods. As can be seen in the figure, all the germinations increased gradually up to March and again they grew in the month of April. However, germination percentages were quite satisfactory during April-August irrespective of threshing methods. In the month of April, May, June and July the germination percentages ranged from 97-99, 95-99, 93-95 and 90-100% for BT, PT, MT and DB, respectively. Among them DB and PT threshed seed gave the highest results in the month of June (100%) and July (99%), respectively. During this period the moisture content of seed ranged from 12.2-14.1%. Finally, the viability of all seeds decreased drastically to zero from August to October.

Table 5. Germination Results of 0- and 5-Days Stacked Seed During January-October

Storage period (month)	Threshing method with 0-day stacking				Threshing method with 5-days stacking			
	T_1BT	T_1PT	T_1MT	T_1DB	T_2BT	T_2PT	T_2MT	T_2DB
January	17	06	10	12	14	23	11	18
February	32	37	30	39	37	45	57	41
March	67	62	65	84	64	46	59	55
April	96	93	94	95	97	95	95	90
May	98	99	100	97	99	96	93	97
June	98	96	97	95	98	96	95	100
July	97	96	98	85	98	99	95	92
August	63	80	76	55	92	85	95	90
September	20	63	34	13	28	72	43	22
October	00	00	00	00	07	05	00	00

Table 6. Germination Results of 10- and 15-Days Stacked Seed During January-October

Storage period (month)	Threshing method with 10-days stacking				Threshing method with 15-days stacking			
	T_3BT	T_3PT	T_3MT	T_3DB	T_4BT	T_4PT	T_4MT	T_4DB
January	20	13	18	22	10	22	27	15
February	71	59	54	66	64	50	72	56
March	77	82	84	80	68	80	85	42
April	95	97	99	94	95	98	95	97
May	93	100	97	95	98	96	97	100
June	99	97	93	95	98	100	97	96
July	95	99	98	97	97	99	96	95
August	88	92	95	85	93	93	99	96
September	52	55	50	42	43	35	68	53
October	07	12	05	03	05	05	10	04

Germination Results of 10-day Stacked Seed

The **Fig. 3** represents the relationship between germination and storage duration for 10-day stacked seed. During whole storage period, the moisture content of seeds ranged from 12.2-13.0, 12.5-14.0 and 14.0-14.2% for January -April, May-July and August-September, respectively. In the month of January all seeds gave poor germination, perhaps due to dormancy. In the month of February, it sharply increased but gradually increased in March. In the months of April, May, June, July and August the germination for all seeds irrespective of threshing methods gave very satisfactory results. However, from April-July the germination percentages of seed ranged from 93-99, 97-100, 93-99 and 92-95% for BT, PT, MT and DB, respectively, while the moisture content of seeds over the same period of storage ranged from 12.2-14.2%. From August the viability of seed sharply decreased for all seed and finally it drastically decreased in the month of October when moisture content of seed ranged from 14.0-14.2%, respectively.

However, at the time of seed sowing the pedal-threshed seed gave the highest percentage of germination (99%) but the DB seed the least.

Germination of 15-day Stacked Seed

The seeds were stored for 10 months in polythene bag like other methods' seed. In January, all seed poorly germinated due to dormancy, however, they grew in February except DB. From February-April they gradually increased. In April the moisture content of seed sharply decreased to 12.2% and again increased throughout the storage periods except September and October. From April-August all seed gave good germinations irrespective of threshing methods (above 90%). The germination percentages ranged from 95-98, 98-100, 95-97 and 97-100% for BT, PT, MT and DB for April, May, June, and July, respectively. In August the germination percentages were found to be 93, 93, 99 and 96% for BT, PT, MT and DB, respectively. Then after one month of storage it drastically decreased for all methods and finally hit to 0 percentage in the month of October (**Fig. 4**).

Conclusions

From the study, it may be concluded that significant and insignificant threshing outputs were observed from 0-5- and 5-15-days stacking, respectively. Among all threshing methods, the pedal thresher performed better in respect of threshability. As far as unthreshed grain is concerned, the least quantity was observed during PT operation whereas BT gave the highest percentages of unthreshed grain.

During experiment the most damage in grain was in BT but this data obtained in PT threshing was statistically insignificant. During storage all seeds from different threshing methods gave similar trend in connection with grain viability irrespective of stacking periods.

Finally, the 0-5-day stacking and threshing with pedal thresher, may be recommended as an appropriate method in Bangladesh and other rice growing countries of the world in order to minimize threshing loss and produce quality paddy both for seed and food purposes.

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Evaluation of Pad Materials in Construction of Active Evaporative Cooler for Storage of Fruits and Vegetables in Arid Environments

by
A. U. Dzivama
Dept. of Agricultural Engineering
University of Maiduguri
Nigeria.

U. B. Bindir
Dept. of Agriculture,
University of Technology
Lae, Papua New Guinea.

F. O. Aboaba
Dept. of Agricultural Engineering
University of Ibadan
Nigeria.

Abstract

Four pad materials (ground sponge, stem sponge, jute fibre and charcoal) were tested as pads for an active evaporative cooler. At an ambient temperature of 32°C and relative humidity of 25%, the stem sponge gave the best performance of a temperature depression of up to 18°C and relative humidity increase to 84%. Using stem sponge in varied system settings resulted in temperature depression of over 20°C and humidity increase up to 73% under a system setting of 90.0 ml s⁻¹ water flow rate, pad thickness of 60 mm and an air suction velocity of 2.7 m s⁻¹.

On the varied settings, the structure was evaluated for storing mango (*Mangifera indica*), banana (*Musa sapientum*) and tomato (*Lypersicon esculentum*). Results indicated that the produce kept in good physical condition for 18 days in the cooler compared to 9 days in ambient conditions.

Introduction

Fruits and vegetables are the main food and economic items in the tropics. They are the main sources of dietary fibre, many essential vitamins and minerals (Pykes[14], Fox and Cameron[5]). Despite their importance in the fresh state, their ease of deterioration in ambient conditions is a major problem, mainly due to physiological and microbial activities (Anon[1], Wills et al.[18]); and improper post-harvest treatment. Post-harvest losses in fruits and vegetables can be greatly minimized by storing them at low temperature and high relative humidity environment (Hall[7], Wills et al.[18], FAO/SIDA[4]).

To achieve these storage conditions, storage techniques such as refrigeration, hypobric ice-bank cooling and evaporative cooling have been advocated (FAO[3]). In view of its simplicity, acceptable levels of efficiency and low running cost, evaporative cooling storage is favoured, particularly in developing countries. However, its advantages are yet to be exploited, particularly in the semi-arid regions, such as Northern Nigeria, where large amounts of fruits and vegetables are produced (Olorunda and Tung[13]).

Evaporative cooling occurs when dry warm air is blown across a wet surface. Heat in the air is utilized to evaporate the water resulting in air temperature drop and a corresponding increase in relative humidity (Harper[9], Henderson[11], Kays[12], FAO/SIDA[4]). According to Rusten[15], evaporative cooling is generally more efficient where air temperatures are high; relative humidity very low; water is available for the purpose and air movement is available. In Northern Nigeria, these conditions are typical making this storage technique attractive.

An evaporative cooling system consists of a pad (moist material), storage cabin, and an air pump (fan or natural breeze). The pad is the most important component of the system as temperature and humidity changes take place there. Industrial pad materials are available (Hanan et al.[8]), however, they are complicated to manufacture, they are costly and not readily available, particularly in rural agricultural areas. There is, therefore, a need to assess the locally available materials for use as pads.

A good pad material should be porous enough to allow free flow of air to effect evaporation. It should be able to absorb water and allow evaporation. The material should be locally available and inexpensive, and should easily be constructed into the required shape. Based on these attributes, some locally available materials, gourd sponge, stem sponge, jute fibre and charcoal were assessed in a study with the objectives of evaluating their performance to select one for use as pad on evaporative cooling systems; studying the effect of water flow rate, air flow rate and pad thickness on the saturation efficiency of an evaporative cooling system; and assessing the efficiency of the evaporative cooler (based on ii) for the storage of selected fruits.

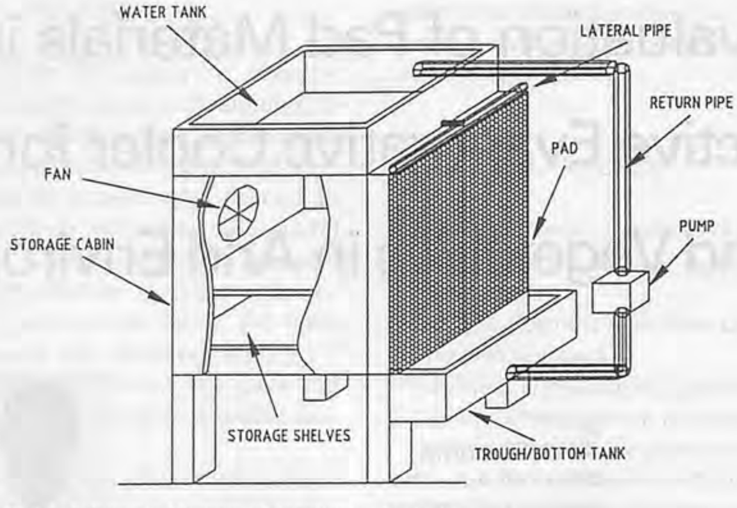

Fig. 1 Schematic Diagram of experimental test-rig.

Materials and Methods

Four pad materials size 1 000 x 1 000 mm face area and of varying thickness were selected for investigation. These are made of gourd sponge which is fibrous; stem sponge which is stringy; jute fibres obtained from used jute bags; and charcoal. The cooling chamber used in the experiments was of 1 m^3 capacity, constructed of polystyrene and plywood sheets. The complete test-rig is shown schematically in **Fig. 1**.

Experiments

Three different experiments were conducted. The first experiment was carried out to select the pad material with the highest operation cooling effect. Using pad 20 mm thick, test runs were carried out under the same ambient condition of temperature (32°C) and relative humidity (30%). The cooler was operated at an air suction velocity of 3.2 m s^{-1} and water flow rate of 90 ml s^{-1}. The changes in temperature and relative humidity inside the storage cabin was monitored with a hygroskop GT - L Hygrometer. Readings were taken at 30 min interval until a steady state condition was reached. The experiments were conducted in three replicates. The differences between the ambient, chamber temperature and relative humidity, indicating the level of cooling and humidification was calculated.

The second experiment involved an interactive study of the effects of the water flow rate W_R, the pad thickness P_T and the air suction velocity A_V on the saturation efficiency η_s of the cooler. Three levels of water rate (72.4, 90, and 112.5 ml s^{-1}); three levels of pad thickness (30, 60, 75 mm) and four levels of air suction velocities (1.7, 2.2, 2.7, 3.2 m s^{-1}) were used. The levels of parameters were chosen based on available information (Wievauna, 1969 and Bechan et al., 1974) and factors related to the construction of pads, particularly using the stem sponge.

The parameters were combined in a split-split plot design experiment, which is best suited to three parameters experiments (Gomez and Gomez[6]). The water flow rate was considered as the main plot, the pad thickness and air velocity were referred to as the sub plot and sub-sub plot, respectively. Each parameter was considered an independent variable.

To each level of water flow rate randomly selected was assigned a pad thickness and air velocity levels also randomly selected. The evaporative cooler was then operated to determine the saturation efficiency. Each test was conducted in three replicates. The performance efficiency of the system was evaluated in terms of its saturation efficiency as suggested by Harris[10]. The estimate was calculated using the following relationship:

$$\text{Saturation efficiency } \eta_s(\%) = \frac{T_1(db\text{-}T_2(db)}{T_1(db\text{-}T_1(wb)} \times 100$$

where;

$T_1(db)$ = dry bulb outdoor temperature °C

$T_2(db)$ = dry bulb cooler temperature °C

$T_1(wb)$ = wet bulb outdoor temperature °C

Statistical analysis was carried out to determine the level of significance and the combined effect of the three parameters on the saturation efficiency of the cooler. The third experiment was done to assess the suitability of the cooler for the storage of fruits and vegetables.

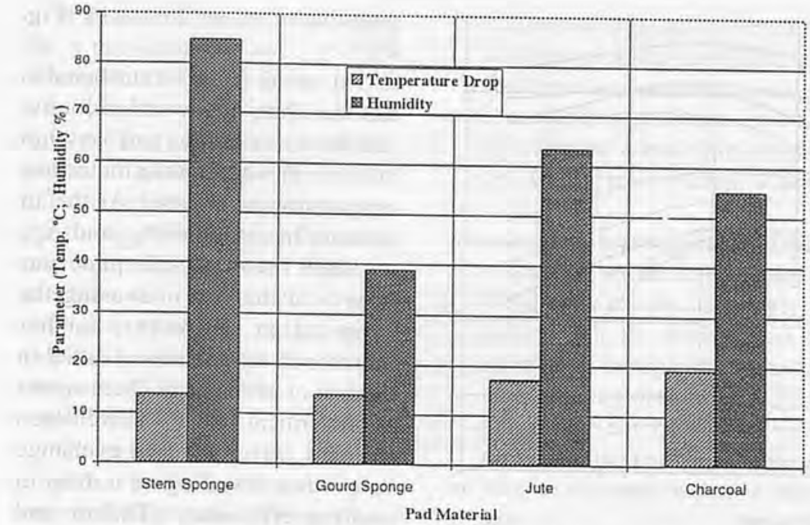

Fig. 2 Temperature and Humidity reading for different pad materials.

Mango, banana and tomato were selected for this experiment. Matured fruits were harvested and washed, then each was divided into two portions, one portion for ambient storage (A_{ST}) and the other for evaporative cooling storage (E_{CS}). Weight changes in the fruits were monitored at 3-day intervals using a top loading digital balance. For each fruit category, five samples from each treatment were weighed, and the average change in weight was calculated.

Results and Discussion

Results from the first experiment is shown in **Fig. 2**. The low temperature recorded along with the highest humidification manifestation indicates that the stem sponge was a superior pad material for this purpose. Naturally, this was used in the second experiment. **Table 1** shows the mean values of saturation efficiency from the replicated experiment.

Table 1 Saturation Efficiency of the Cooler Operated under an Ambient Condition of Temperature (38°C) and Relative Humidity (11%).

		Saturation Efficiencies			
		Air verocity A_V m/s			
W_R ml/s	P_T mm	1.7	2.2	2.7	3.2
72.4	30	43.4	53.2	61.4	37.1
	60	54.1	65.4	69.9	63.0
	75	54.5	54.0	60.3	49.3
90	30	54.1	64.0	66.0	57.6
	60	69.0	80.5	86.8	83.0
	75	60.5	74.5	81.5	76.0
112.5	30	49.5	58.0	62.4	52.7
	60	63.9	70.0	80.5	79.2
	75	59.0	66.2	77.1	75.7

An analysis of variance was carried out on the mean values which showed that the three main factors: $W_R P_T$ and A_V were all significant at 1% level.

Effect of Water Flow Rate on Cooler Saturation Efficiency

The results of the saturation efficiency under increasing water flow rates and constant value of pad thickness and velocity (**Fig. 3**), showed a significant increase and then a marginal decline.

For all the settings, the peak performance is localized around the water flow rate setting of 90 ml/s. The initial increase in efficiency from W_{R1} to W_{R2} setting could be explained by the fact that, at low level of water flow rate (W_{R1}), the water could only moisten the pad partially. This reduced the surface area for air-water contact which also reduced the amount of evaporation taking place. As the water flow rate increase to W_{R2}, the pad became sufficiently moist and this improves the rate of evaporation. However, further increase in water flow rate (W_{R3}), the pad become excessively wet. The excess water might have blocked the pore spaces within the pad thus, impeding the flow of air to effect evaporation. This could have accounted for the marginal decline in efficiency.

Effect of Air Velocity on Cooler Saturation Efficiency

The results at various constant value of pad thicknesses and water flow rates under increasing air velocity showed a similar pattern

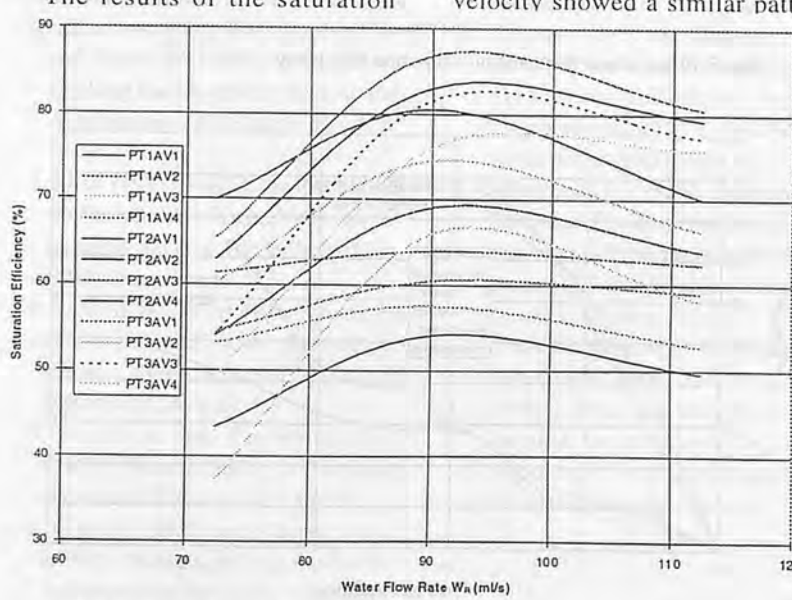

Fig. 3 Effect of water flow rate on saturation efficiency.

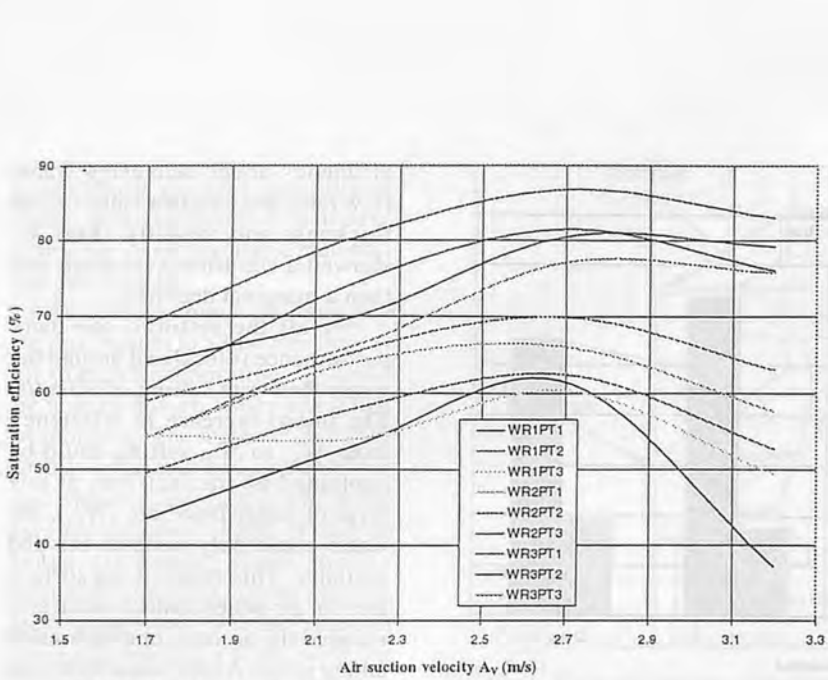

Fig. 4 Effect of air suction velocity on saturation efficiency.

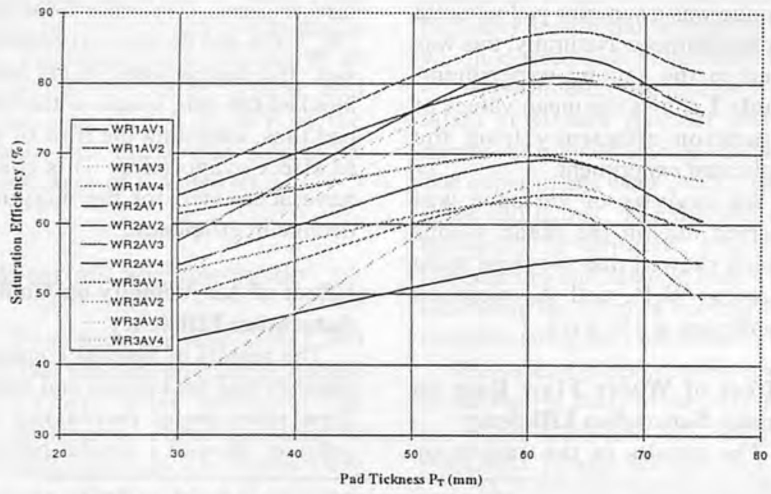

Fig. 5 Effect of pad thickness on Saturation Efficiency.

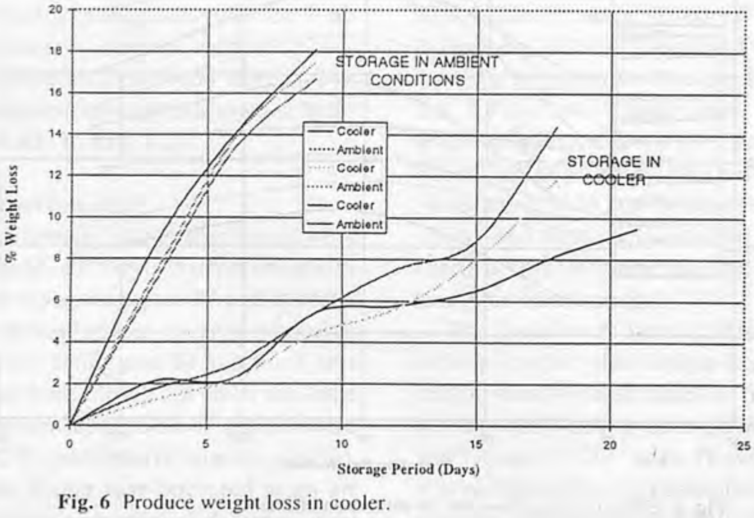

Fig. 6 Produce weight loss in cooler.

with that of water flow rates (**Fig. 4**).

This result could be attributed to the fact that, at low air velocity, suction through the pad was not effective thus accounting for the low evaporation manifested. As the air velocity increased to A_{V2} and A_{V3}, suction through the pad was improved thereby increasing the evaporation. However, further increase in air velocity resulted in decline of efficiency. There seems to be a critical velocity above which the time period for heat exchange drops thus resulting in a drop in cooling efficiency (Thakur and Dhina[16]). The additional air pressure through the pad results in physical displacement of water mass instead of evaporation. This was evidenced by the presence of water droplets at A_{V4}.

Effect of Pad Thickness on Cooler Saturation Efficiency

From **Fig. 5**, it is evident that there is a significant increase in cooling effect with increase in pad thickness within a certain range of air velocity and water flow rate. All the curves show a dramatic increase to the peak level at pad thickness between 60 mm and 70 mm which is then followed by a marginal decline.

This result could be due to the fact that at low pad thickness, the pad is porous enough to allow fast passage of air thus reducing the heat exchange period and for evaporation to occur. Increasing the pad thickness to 60 mm reduces the pad porosity which subsequently increases the heat exchange period thus improving the cooling efficiency. However, a further increase in the pad thickness to 75 mm reduced the porosity drastically thereby reducing the flow of air, hence evaporation and, consequently, the cooler efficiency.

Optimum Operating Condition of the Cooler

In this study, the optimum setting for a peak performance of 87% saturation efficiency of the cooler was found to be at water flow rate of 90 ml/s, a pad thickness of 60 mm and an air suction velocity of 2.7 m/s. These settings were used to assess the storage efficiency of the cooler on selected vegetables. **Figure 6** presents the results of the physiological change in weight of the vegetables stored in the cooler compared to those stored in ambient conditions.

The results under the ambient condition generally showed higher rates and magnitudes of weight loss for all produce compared with the results under the cooler storage. The mean percentage rates of weight loss for the three produce in ambient and cooler conditions is in the order of 1.89%/day and 0.62%/day, respectively, indicating that the rate of weight loss in ambient conditions is more than 3 times the weight loss in cooler storage. This advantage is as a result of the increased humidity in the cooler along with the drop in temperature, which minimizes physiological activity such as respiration and evapo-transpiration of the fruits with a consequent reduction in weight loss (Anon[1], Wills et al.[18])

In addition, the samples stored under ambient condition showed visible drying-out effects after 18 days, while those under the cooler condition maintained a fresh look even after 21 days of storage.

Conclusions

From the investigation made, it could be concluded that:

a) The stem sponge showed superior pad material qualities compared to the other three tested. It gave a temperature reduction of over 18°C and an increase in relative humidity of nearly 55% from ambient conditions.
b) The saturation efficiency of the cooler investigated under varied settings of water flow rate, pad thickness and air suction velocities was best at a water flow rate of 90 ml/s, a pad thickness of 60 mm and an air suction velocity of 2.7 m/s.
c) As evapo-transpiration and respiration are the main causes of weight loss in fruits in storage, the effect can be minimized by increasing the relative humidity and reducing the temperature of the storage environment. Evaporative cooling techniques offers a inexpensive approach to achieve this.
d) It was also evident that under an evaporative cooling system, fruits could maintain longer shelf lives and freshness than those under ambient condition.
e) Further investigations are recommended on more pad structure, construction materials for the cooling chamber and the water application system.

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Effect of Preheated Corn Oil as Fuel on Diesel Engine Performance

by
D. Erdogan
Professor
Department of Agricultural Machinery
Ankara University
Ankara, Türkiye

A. A. Mohammed
Engineer
Petroleum Institute
Petroleum Ministery
Baghdad, Iraq

Abstract

A single-cylinder, 0.359 l, direct injection diesel engine was operated on a diesel fuel, corn oil-diesel fuel mixture and neat corn oil which is used as fuel at room temperature and preheated to higher temperature. The objectives of this study were to determine the feasibility and examine the effect of corn oil used as fuel on the performance of a small diesel engine. Based on the evaluations, the most appropriate values obtained by 90°C preheated corn oil and 50% corn oil-diesel fuel mixture were found bo be closely similar to those of diesel fuel.

Introduction

The use of vegetable oils as a substitute or an alternative for diesel fuel is not new. Dr. Rudolph Diesel used peanut oil as fuel on one of his engines at the Paris Exposition of 1900. Vegetable oils have proven to be promising alternative fuel sources for diesel engines by short term performance tests (Mazed et al., 1985). The most important advantage of vegetable fuel oils is that they are a renewable energy sources compared to limited resources of petroleum. Agriculture and industry use diesel-powered engines for many purposes but the supply of fuel is limited.

In recent years, engineers and scientists from many countries have directed research toward the use of vegetable oils as alternate fuels in internal combustion engines. Pryde (1981) mentioned problems of high viscosity and non-volatility of vegetable oils, which result in inadequate fuel atomization and incomplete combustion.

The objectives of this investigation were:
1-To evaluate the performance of a blend of 50% corn oil and diesel fuel and neat corn oil as fuel at room temperature and to compare the results with diesel fuel; and
2-To evaluate the performance of neat corn oil at high temperature (50°C and 90°C) and to compare the results with diesel fuel.

Materials and Methods

A Lombardini 6 LD diesel engine with a direct fuel injection system, 0.359 l displacement with a 82 mm bore and a 68 mm stroke, naturally aspirated, air cooled and with continuous rating of 5.5 kW at 3400 rpm was selected as the test engine.

Mazed et al. (1985) reported that naturally aspirated engines represent a large part of the engine population used in agricultural and construction equipment during the last 20 years. Naturally aspirated engines are more sensitive to fuel quality due to longer ignition delays and lower performance ignition equipment.

A hydraulic dynamometer (Model DP x D Herman Froude) equipped with a speed indicator was used to measure engine torque and speed. The fuel supply system was modified so fuel measurement could be made on a mass basis and engine could be started on diesel fuel before swithing to a corn oil fuel. And electric fuel preheater was used to maintain the fuel inlet temperature at constant 50°C and 90°C. Compared to room temperature (28°C), these had the effect of changing the viscosity of corn oil closer to that of diesel fuel.

The measured viscosities of commercial grade diesel fuel and commercial corn oil used in tests, are shown in **Table 1**.

The engine was started on commercial grade diesel fuel and warmed up for 30 min before swithcing to the test fuel. After the initial switch to a corn oil fuel, a 30-min period was used to allow the engine to stabilize at the first load.

Table 1. Viscosities of Fuels Used in Tests

Fuel	Temperature (°C)	Viscosity (mm^2/s)
Corn oil	28	34.1
Corn oil	50	16.0
Corn oil	90	10.8
50% Corn + 50% Diesel	28	9.4
Diesel	28	3.5

Data were recorded at the beginning and end of a 15-min interval for each load tested. A 15-min stabilization period was used between load settings. The initial test on each fuel at 12 different load settings lasted approximately 6 hours.

Results and Discussion

The engine performance results were analyzed and are presented as test values. Initially, performance tests were conducted in duplicate to compare the performance of corn oil fuel with diesel fuel at room temperature and at preheated fuel.

The variation of engine torque in relation with engine speed for diesel fuel, neat coron oil and diesel fuel-corn oil mixture at room temperature (28°C) are shown in the lower curve in **Fig. 1**. At lower speeds, effective torques with neat corn oil and diesel fuel-corn oil mixture were slightly higher than with diesel fuel. However, at higher speeds torque with neat corn oil and diesel fuel-corn oil mixture were reduced rapidly. These results are similar to those of other researches (Hemmerlein et al., 1991). It was appeared that the same relation with neat corn oil at 50°C and 90°C as is shown in the lower curve in **Fig. 1**. This may be due to higher viscosity of corn oil. Increased viscosity would cause the injection pump to have less leakage loss than with diesel fuel.

Also, as shown in **Fig. 2**, the variation in engine power in relation with the engine speed for diesel fuel, neat corn oil and diesel fuel-corn oil mixture is shown. A low speed, the difference between power curves is negligible. However, above 2 800 rpm, power with neat corn oil decreased more rapidly than with diesel fuel (Mazed et al., 1985, Mc Donnell et al., 1995).

Specific fuel consumption is one of important parameters of engine performance. When using neat corn oil as fuel, the specific fuel consumption of the engine was significant. Consumption varied depending on the load of the engine. As shown in **Fig. 3**, specific fuel consumption curves are similar to each other with the exception of little higher values of corn oil at room temperature. Whereas, brake specific fuel consumption curves for neat corn oil and corn oil-diesel fuel mixture at high temperature are not different between them. The specific fuel consumption was 14.9%

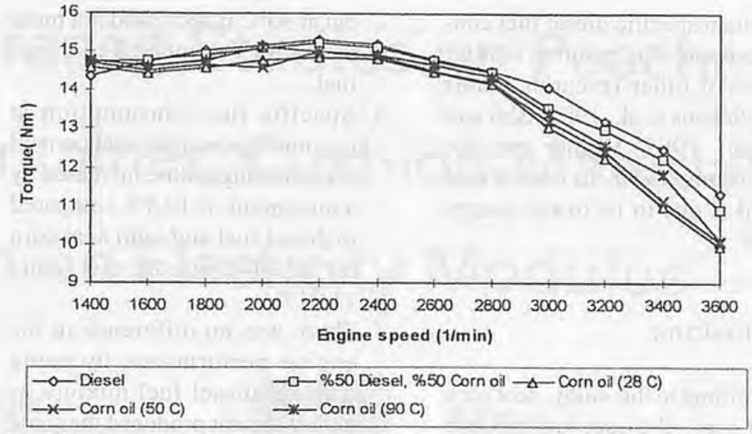

Fig. 1 Torque curves for diesel fuel, diesel fuel-corn oil mixture, neat corn oil 28°C, 50°C and 90°C.

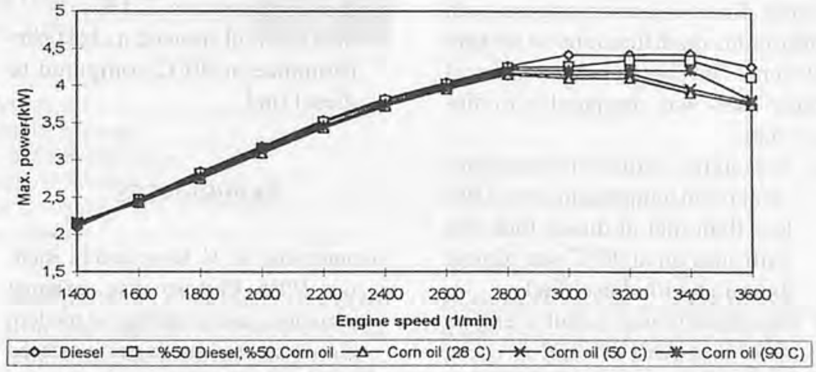

Fig. 2 Power curves for diesel fuel, diesel- corn oil mixture, neat corn oil at 28°C, 50°C and 90°C.

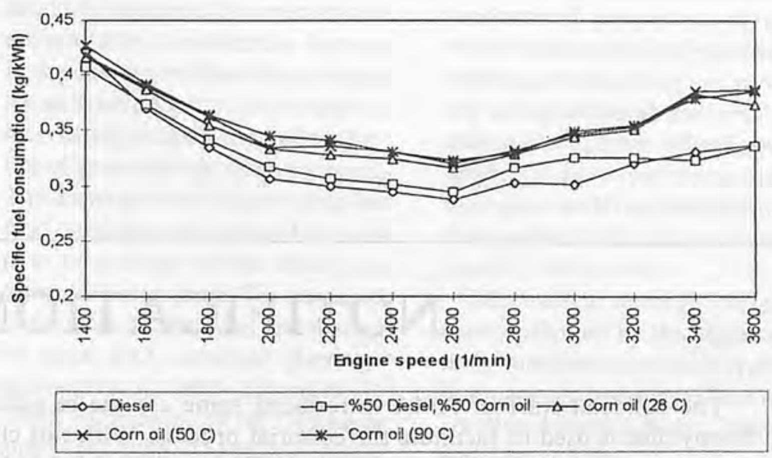

Fig. 3 Specific fuel consumption curves for diesel fuel, diesel fuel-corn oil mixture, neat corn oil at 28°C, 50°C and 90°C.

higher than specific diesel fuel consumption and this result is similar to those of other research (Tahir 1985, Niehaus et al., 1986, Ishii and Takeuchi, 1987) Higher specific fuel comsumption in the case of neat corn oil is due to its lower energy content.

Conclusions

According to this study, neat corn oil and corn oil-diesel fuel mixture can be used at short term as direct replacement for diesel fuel in a small direct injection engine with minimum modifications to its fuel system. The engine performance of these fuels was comparable to diesel fuel.

1. The engine torque with neat corn oil at room temperature was 2.9% less than that at diesel fuel, but with corn oil at 90°C was almost the same with diesel fuel.
2. Maximum power output of engine with neat corn oil fuel at room temperature decreased by much as 6.5% compared to diesel fuel, but at 90°C it decreased not more than 4.85% compared to diesel fuel.
3. Specific fuel consumption at maximum power for neat corn oil at room temperature increased by a maximum of 10.8% compared to diesel fuel and with neat corn oil at 90°C almost the same, 11.81%.
4. There was no difference in the engine performance by using corn oil-diesel fuel mixture as fuel. It almost produced the same torque and brake power as diesel fuel, with slightly greater specific fuel consumption, 2.1%.
5. Neat corn oil showed its best performance at 90°C compared to diesel fuel.

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NOTIFICATION

The editorial staff of AMA introduced some change in editorial policy in 1994 in which floppy disk is used to facilitate the editorial process. With this change in policy, it was decided that the main author is given an article on floppy disk with AMA true format other than 5 free copies of the AMA issue wherein their articles are published. As of now, however, we have not yet fully prepared for the editorial process using floppy disk. Therefore the sentence "In addition, the main author is given an article on floppy disk with AMA true format." in item C, Rejected/Accepted Articles in INSTRUCTIONS TO AMA CONTRIBUTORS should be omitted and reprints of the article will be sent to each author as before.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7-2 Kanda Nishikicho, Chiyoda-ku, Tokyo, Japan (Tel. 03/3291-5718, 3671~4)

Simulated Transit Studies on Peaches: Effects of Container, Cushion Materials and Vibration on Elasticity Modulus

by

H.Ögüt
Associate Professor.
Dept. of Farm Machinery
Agricultural Faculty
Selçuk University
Konya, Turkey

A.Peker
Assistant Professor.
Dept. of Farm Machinery
Agricultural Faculty
Selçuk University
Konya, Turkey

C.Aydin
Assistant Professor
Dept. of Farm Machinery
Agricultural Faculty
Selçuk University
Konya, Turkey

Abstract

Damage to fruits for processing and fresh consumption during transportation can be quite significant. This problem can be studied from the context of vibration theory based upon which, it is possible to reduce the damage by avoiding resonance vibration. Elasticity modulus is a very important mechanic property of agricultural products and variation of elasticity modulus described as damage in transportation.

In this study, as the product (peaches) grown in Turkey uses a package (wooden container) and as cushion materials paper-board cartons, sponge and strofor have been used. This study had been realized with the help of vibration simulator in laboratory conditions. The minimum variation of elasticity modulus was obtained by using paper-board carton material.

Introduction

In Turkey's conditions, agricultural products are loaded on trucks from the point of production to the point of consumption. Those trucks' suspension systems influence the damage to sensitive agricultural products in transit. No precautions, are not taken to reduce the damage in the containers. Peaches are lined up as single layers in containers. Harvesting, classifying and replacing of products are done by hand. The damage takes place when the road conditions are bad and the suspension systems of the trucks are either soft or too hard. The damaged to the fruits are bruising and tearing of skin and internal damage (Kaynap et. al., 1989; Kaynap et al., 1990; Mohsenin, 1970; Olorunda and Tung, 1985).The damage naturally reduces the market value of the fruits, particulary when they are for fresh consumption. This problem can be studied from context theory. Based on this theory, it is possible to reduce the damage by avoiding resonance vibration. This condition can be avoided by letting the natural frequency of the container of fruits to be away from the range of frequency of the excitation force while in transit (Zohadie, 1980).

Elasticity is the capacity of a material for taking elastic or recoverable deformation.It is one of the mechanical properties of fruits which is important and necessary in studying the handling and processing of agricultural products. Mechanical properties of agricultural products are most conveniently measured with the force-deformation approach which is discussed in detail by Mohsenin.

Mechanical damage is significantly affected by the stage of tomato maturity, container type, vibration and compressive load in the simulated transit study (Olorunda and Tung, 1985).

There is significant amount of damage to the fruits and vegetables during transport.The damage is always greatest on the top layer of fruit, and under severe transport conditions, it may extend down two or tree layers (O'Brien and Guillou, 1969).

Materials and Methods

In this study peaches (Golden Elberta cling) were used being an important product in Turkey. These peaches are normally big,yellow-skinned, red patched, normally thick, fuzzy skinned and red stone.The moisture of the peach is 90.8 % (w.b.) and 20°C and temperature sphericity of 96.8%.

Sensitivity to damage is influenced by numerous factors. One group of parameters concerns the physical and biological state of material (e.g., temperature, moisture content, stage of growth, ripeness), while others are related to the load characteristics (static, dynamic, oscillating, loading rate,etc.). In most cases, temperature greatly affects the mechanical properties of agricultural products and thereby their sensitivity to damage. With variation of temperature the turgor pressure of cellular material and together with it the elasticity both vary (Sitkei, 1986).

Sphericity is calculated from equation;

$$\text{Sphericity}=\frac{d_i}{d_c} \qquad (1)$$

Where d_i is the diameter of the greatest inscribed circle, and d_c that of the smallest circumscribed (Sitkei, 1986).

The containers used in this study are of 420x550x90 mm size. These have four pieces horizontal wooden bar and bottom four pieces leveled wooden bar and four pieces flat wooden vertically, fixed with nails. This is shown **Fig. 1**.

Paper-board cartons, strofor and sponge were used as cushion materials, in order to reduce the damage on the peaches in transit. Paper-board cartons, 3 mm thickness, strofor 10 mm thickness and sponge 5 mm thickness were placed at the bottom and side at the containers. The peaches were lined up in one layer in containers. The peaches are in contact with one another.

An important application of dynamic tests is the determination of the vibration properties of fruit species, in order to asses their sensitivity to damage during transit. The fruits are generally transported in containers on board motor vehicles.If during transport the resonance frequency of a fruits column packed into a container coincides with the excitation frequency of the road or vehicle, then the acceleration of the fruit will increase considerably owing to resonance and it will be damaged by impact. The resonance frequency of fruit in a container may be calculated approximately from the equation:

$$f_n=\left(\frac{1}{4\lambda}\right)\sqrt{\frac{E.g}{\rho}} \qquad (2)$$

Where:
f_n: natural frequency of the fruits, (Hz)
E: elasticity modulus of fruits (N/m^2)
g: Acceleration due to gravity (m/s^2)
ρ: density of fruit in the container (N/m^3)
λ: depth of the column of fruit (m)

Computations using Eqn(2) were found to correspond well with those of fruits in bins vibrating at resonance on a laboratory vibrator under simulated transport conditions.

The resonance frequency of fruit packed into a container and dynamic states (displacement/acceleration) of the individual layers may be examined using special test equipment (**Fig. 2**).

The vibration simulation container used in this study, like the vibration container was projected by O'Brien and Guillou at a California University (Aydyn, 1993; O'Brien and Guillou, 1969; O'Brien et al., 1969; O'Brien and Friedly, 1970).

A container full of fruits was fixed on an oscillating table and excitation was effected by means of eccentric weights rotating in opposite directions. The magnitude and angular velocity of the rotating masses may be varied. The experiment device was driven at any speed up to 2 800 rpm by belt from a 0.37 kW electrical motor. The speed of the motor was adjusted with the help of an electronic vibriator.

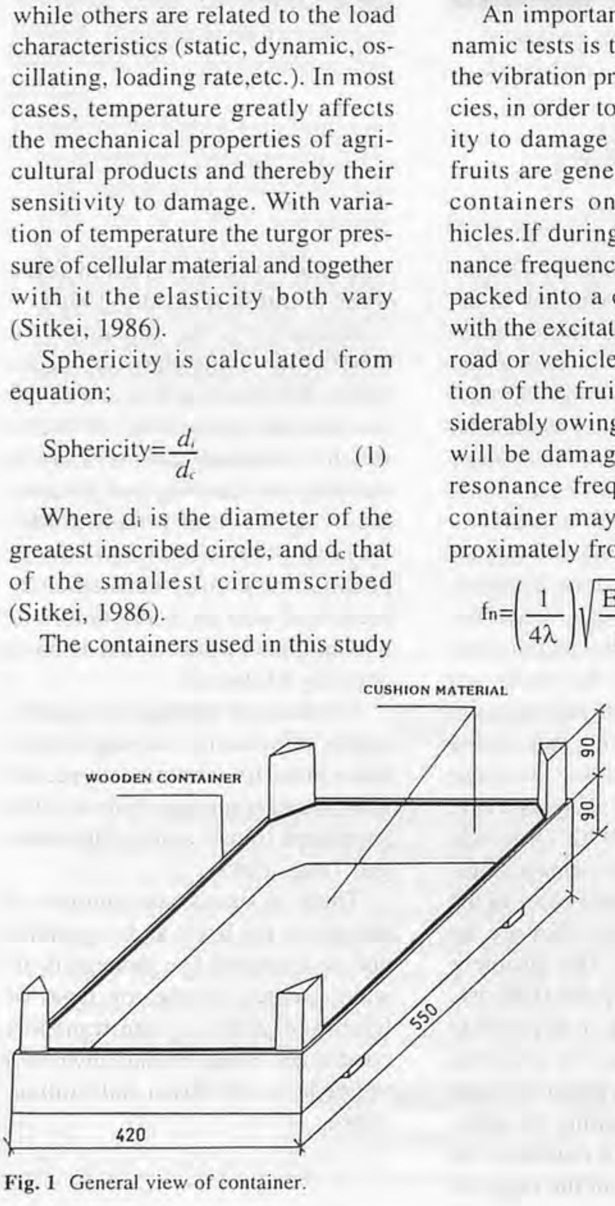

Fig. 1 General view of container.

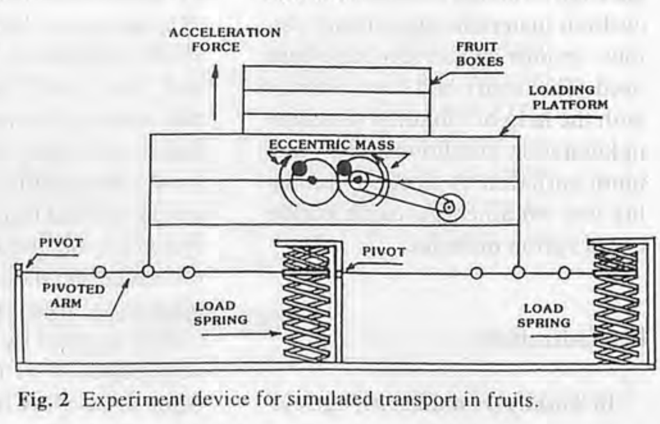

Fig. 2 Experiment device for simulated transport in fruits.

The vibration container had worked for 15 min which is equal to the transportation of truck with 270 km in Turkish highways conditions.

The values of vibration were measured and recorded on magnetic tape.

In order to determine the elasticity of the peaches, a plate test was used (Zohadie, 1982). The test equipment used is shown in **Fig. 3**.

The calculation of elasticity modulus is based on the following assumptions: a)The fruits are spherical in shape; b)very small expansion in the horizontal plane occured with compression in vertical plane;and c)each side of the fruit in contact with the flat plates has an equal deflection (O'Brien and Gentry, 1965).

According to the following expression, the modulus of elasticity was calculated following the equation:

$$E=\frac{F}{\pi\delta^{2}} \quad (3)$$

Where:

E: modulus of elasticity (N/m^2)

F: compression force (N)

δ: deformation of one-side of fruit (m)

Deformation is shown in **Fig. 4**.

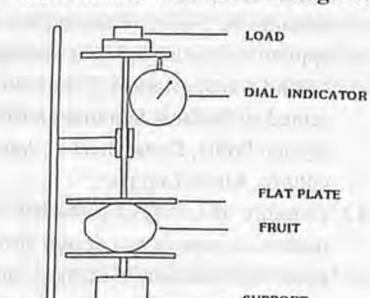

Fig. 3 Test equipment used in compression test.

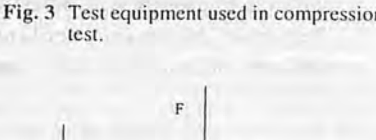

Fig. 4 Deformation of peach during compression.

Table 1. Analysis of Variance of Data obtained from Tests

Source of variation	Degree of freedom	Sum of squares	Mean squares	F value
Container position (CP)	2	98.57	49.28	0.37
Cushion material (CM)	3	2146.74	715.58	5.38**
Elasticity modulus before and after test (E)	1	4218.50	4218.50	31.73**
Interaction (CPXCM)	6	585.33	97.55	0.73
Interaction (CPXE)	2	54.27	27.13	0.20
Interaction (CMxE)	3	350.99	116.99	0.88
Interaction (CPxCMxE)	6	205.52	34.25	0.25
Error	120	15953.80	132.94	–
Total	143	26613.74	165.13	–

**Indjcates signifcance at the 1% level of probability.

In order to determine the damage during the transport, the modulus of elasticity before the fruits (which were harvested by hand) was placed on the vibration container and then the modulus of elasticity which are subject to vibration was determined

In this study, damage is described as a difference of elasticity modulus before and after the test. This study was carried out in six replications.

MSTAT was used for statistical analysis. Graphics were obtained with the aid of a Microsoft graph.

Results and Discussion

The analysis of variance in shown in **Table 1** and LSD test results which were performed to determine the differences among means of the factors are given **Table 2.**

As can be seen in **Tables 1** and **2**, the modulus of elasticity was affected significantly by the cushion materials and elasticity modulus of the vibration ($P<0.01$). But the container positions were not significant statistically.

The relationship between the variation of elasticity modulus of peaches at different container position and cushion materials is shown in **Figs 5, 6** and **7**. respectively.

At the top positions the maximum variation of elasticity modulus was seen for the wooden containers and the minimum was seen for the paper-board cartons material.

Table 2. Comparison of Variation Sources

Source of variation	E(Modulus of elasticity)
Cushion material (wooden)	23.64 a*
Cushion material (sponge)	22.89 a
Cushion material (strofor)	17.92 ab
Cushion material (paper-board cartons)	13.81 b
Elasticity modulus of before the test	24.82 a
Elasticity modulus of after the test	14.00 b

*The columns not followed by the same letter are significantly different at 1% level as judged by LSD test.

For the middle and bottom positions also, minimum variation of elasticity modulus was seen with paper-board cartons material. The damage was not prevented by the sponge material used for all the positions.

The minimum variation of elasticity modulus was obtained by using paper-board carton material for all positions.

Conclusions

The modulus of elasticity was affected significantly by the cushion materials and the vibration ($P<0.01$), the least change of modulus elasticity was seen on the containers which were cushioned by paper-board cartons. The largest change in elasticity modulus was obtained with the wooden containers for the all containers. For the given conditions the utilization of paper-board cartons cushioned containers and lining of peaches into the containers by one layer is the opti-

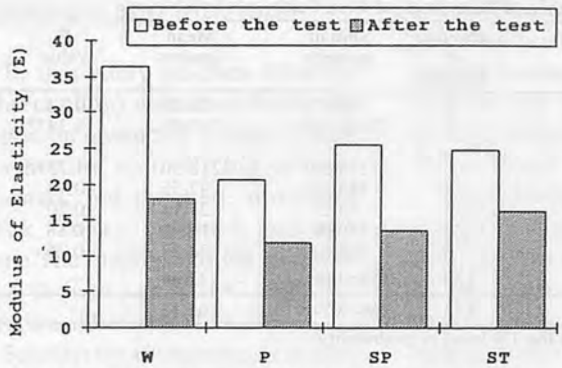

Fig. 5 Variation of elasticity module of peaches in top containers.

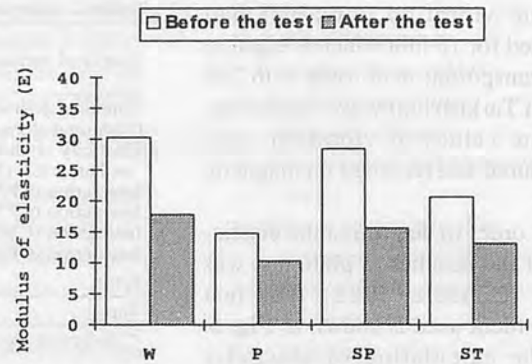

Fig. 7 Variation of elasticity module of peaches in bottom containers(W:Wooden P:Paper-board ST:Sponge ST:Strofor E:N/ $m^2.10^5$).

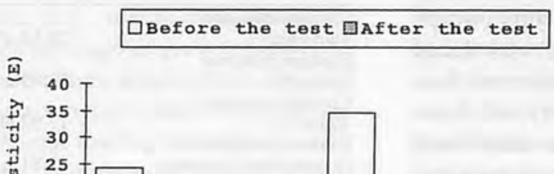

Fig. 6 Variation of elasticity module of peaches in middle containers.

mal solution.

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Function of Field Structure in Farm Land Consolidation

— Soil and Water Engineering with Practical Application (II) —

by
Masaya Ishikawa
JICA Expert and Visiting Professor
Faculty of Agric. Engineering and Technology
Bogor Agricultural University
(FATETA, Kampus IPB Darmaga
P.O. Box 220, Bogor, Indonesia)

Mohammad Azron Dhalhar
Agric. Engineer-Soil and Water Engineering
Faculty of Agric. Engineering and Technology
Bogor Agricultural University
(FATETA, Kampus IPB Darmaga
P.O. Box 220, Bogor, Indonesia)

Abstract

In many paddy farming countries, paddy fields located relatively high cannot usually be converted into an upland field freely because the groundwater level rises and water seeps from surrounding paddy fields. This means that the levees and plow-pan lose their function of impounding water in the paddy fields. The essential key solving the problem is under-standing of the field structures from the viewpoint of soil-plant-water interactions, performing appropriate water management in each plot, and constructing field structure to be independent form water level as well.

Introduction

There are paddy fields stacked up on the sides of ravines, mountains' slopes, gentle slopes of alluvial fans, spacious alluvial plains and the side of small ravines running like complicated wrinkles. Paddy fields have de-veloped on mountain sides, plains and on reclaimed tidal flats for more than several thousand years. Each paddy field is not only an old structure, but a structure working actively a useful life, which is tended and cared for as well.

Farm land consolidation is done principally to increase soil productivity. It gives vitality and fertility to fields. The primary purpose of farm land consolidation is to produce high-yielding paddy fields. Farm land consolidation is also designed to produce 'free-use' land that can be used anytime as paddy field, upland field, pasture and orchards.

In addition, farm land consolidation may also be used for increasing the efficiencies in time allocation for soil cultivation and water allocation for irrigation and drainage. The size of plot is taken as large as a plot for optimum working capacity of the machine so that the time-loss for moving to other plots can be avoided. Moreover, the right length of the plot can increase the water application efficiency for irrigation and drainage practices, whether applying ponding-method (for rice plant) or furrow methods (for non-rice plants).

The purpose of this paper is to explain the ingenious mechanism of a paddy field, to consider the possibility of rotation of paddy rice and other crops from the viewpoint of field structure, and to answer the question of how field structure should be consolidated.

The Structure of Paddy Field

All seemingly flat lands are not perfectly flat but are sloping. When sloping land is formed into paddy fields, there are steps between fields or terraces, and the steeper the land, the bigger the steps are. **Fig. 1** shows the topography of a land area formed into paddy fields that consists of a banked soil foundation and a cut soil foundation. The banked soil foundation is constructed by cutting the soil in the cut soil area, carrying cut soil to the banked area and banking it there. The cut soil layer is made of natural sedimentary soil, while the banked soil layer is artificially produced by cutting the soil and banking it there. Land consolidation work unifies these

Acknowledgements: Thanks are due to Dr. Jun SAKAI, Prof. Emeritus Kyushu Univ., for valuable advices. Special thanks are due to Dr. ISHIKAWA, Pro. Emeritus Iwate Univ., for helpful comments on an earlier draft of this paper. I gratefully acknowledge helpful discussions with Dr. Toshio TABUCHI, Prof. Emeritus Tokyo Univ., Dr. Koh-ichi TOKUNAGA, Prof. Emeritus Iwate Univ., and Dr. Masaharu KURODA, Prof. Kyushu Univ., on several points in this paper. The writing of this paper was made possible largely through a grant from Japan International Cooperation Agency (JICA). I would like to acknowledge here the generosity of the organization.

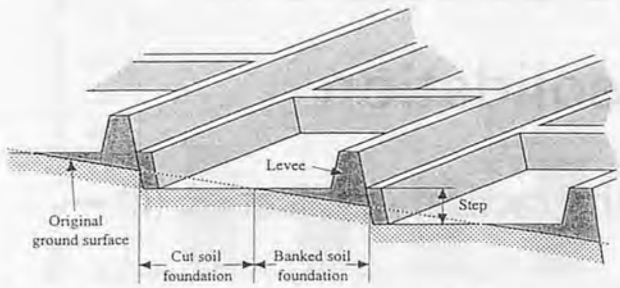

Fig. 1 Topography of a land area formed paddy fields.

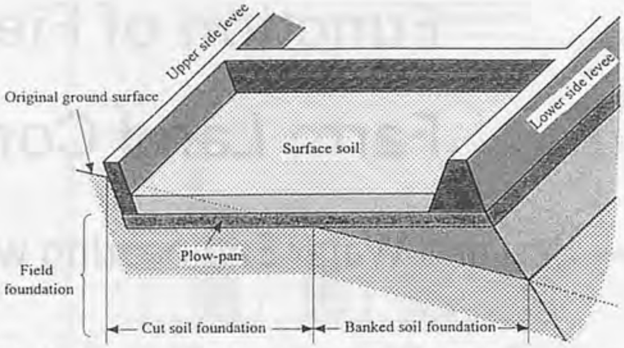

Fig. 2 Perspective view of a paddy field after farm land consolidation.

two different soil layers, and integrates them into a uniform quality soil layer.

Fig. 2 shows an anatomical view of a paddy field after land consolidation. A field foundation consists of a banked soil foundation and a cut soil foundation with "a plow-pan" of even thickness on it. The plow-pan is also called "the plow sole" or "the hard pan". The plow-pan and the soil foundations make up the field foundation. Levees are constructed close to the field foundation, being lower-side and upper-side levees. A surface soil is spread evenly over the plot surrounded by levees. A paddy field consists of four components: a soil foundation, a plow-pan, levees and a surface soil. The soil foundation is a framework of bones. The plow-pan is the internal organs enveloping different types of soil foundations of cut soil and banked soil. The surface soil is spread over like muscles covering bones and internal organs. The levees, like limbs, extend from the muscles holding the irrigation water. Muscles store energy to live. The muscles and the surface soil should be thick and elastic for high productivity.

A field with soft soil foundation tends to be a defective paddy field like an osteomalacia. The method of banking soil on the banked soil foundation is to generate a strong bone framework. The even thickness plow-pan over the soil foundation unifies two different qualities of banking soil and cutting soil, as the internal organs are supported by the bone framework. The plow-pan and the soil foundation are decisive factors that influence field machinery to work. A poor plow-pan leads an over percolation, as a man with diarrhea. Weeds overgrow the area. A man with healthy internal organs is strong, and so is a field with well-constructed plow-pan. Each paddy field plot has a mechanism similar to that of a living creature.

Significance of Levee

Fig. 3 shows a plan of a levee structure overlapping a soil profile of a paddy field in farm land consolidation. The soil profile consists of a surface soil, a plow-pan and a tectonic layer. Levees extend from the plow-pan of the soil profile. This means that a levee is the primary structure for impounding water in a paddy field by suppressing over-seepage from levees. The plow-pan protects against its vertical seepage, while the levee protects against horizontal seepage. In this sense, the levee is an exposed portion of the plow-pan.

The freeboard of the levee impounds water in the paddy field as a dam against heavy rain or other floodwater to prevent inundations and landslides. Levees catch rain water and prevents it from being discharged uselessly and let it gradually seep into the ground. At the same time, they hold water in paddy fields to be absorbed by rice plants. The freeboard of the levee shown in **Fig. 3** is 20 cm, and can hold a heavy rain of 200 mm temporarily. If all the fields in Japan were consolidated with levees like these, they would impound 81 billion t of water (Shimura, 1982). This value far exceeds the total capacity of dams constructed for flood control. In Japan, many residences are located along rivers, and their ground level is almost the same or lower than the water level of the rivers. Therefore, the storage capacity of a paddy field under

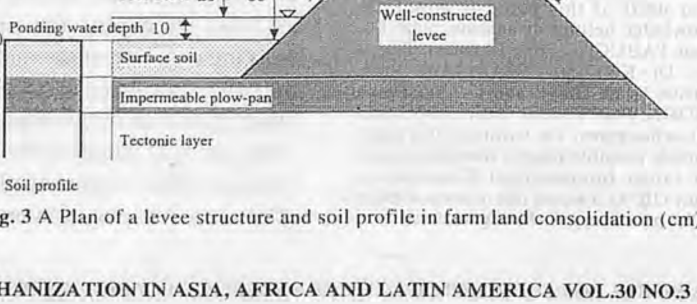

Fig. 3 A Plan of a levee structure and soil profile in farm land consolidation (cm).

heavy rainfall has a strong influence on flood control. Suppose that all the paddy field levees in Japan break down in torrential rain, the downstream cities and factories would be inundated and the damage would be inestimable. This influence will be especially remarkable for lowland areas near a big city not only in Japan but also in other farming countries where the forest area is almost diminished (Tabuchi and Ogawa, 1995).

In addition, a paddy field has a big effect on soil erosion control, because the ponding water surface flow is moderate during a rainfall due to its flatness and the levees. Paddy field levees have been set up to protect the land from inestimable disasters since old times. They have also made a good use of river basin, created and nurtured rice cultivation. They will further strengthen these functions by farm land consolidation.

Multipurpose Use of Levees

The levee structure in **Fig. 3** has a crest which is used as a footpath along with prevention of crop diseases, control of insects and transportation of harvested crops both in old times and after farm land consolidation. Some racks to hang harvested rice plants on are built on levees. Many farmers protect levees exposed to weather by planting pasture grass on them. Farmers also take snacks atop levees during their rest times. The levees are places for farmers to rest on.

Maintaining levees is not always a joy to farmers as levee-wall coating is hard work, taking 30 h/ 0.3 ha. In many cases, the levee-wall coating has to be done manually with his/her body bent forward. Levee-wall coating is necessary because the levee structure allows over-seepage from levees. Seepage through the levees without the levee-wall coating is usually 40% of the irrigation water, or 60% in extreme cases. This means that the levees lose their function of impounding water in paddy fields.

A levee structure liberates farmers from levee-wall coating. In addition, the levee has a function as a farm road and inhibits seepage of irrigation water.

Significance of Ponding Water

Farm land consolidation requires strict leveling of the surface soil because it keeps ponding water depth even. An even ponding water depth has four meanings:

First, impounded water in a paddy field absorbs solar heat. This phenomenon raises water temperature, and in northern countries, the increased ponding water temperature maintains a good environment for rice plants to grow, especially during transplanting. Water that absorbs solar heat during daytime does not cool quickly. In northern countries, it gradually releases heat in the coldness of night, and in early morning protects rice plants from the cold. On the other hand, in southern countries, the ponding water also has an effect on keeping cool atmosphere around a paddy field for evaporation. Therefore, water works as a heat insulator in a paddy field.

Secondly, the ponding water suppresses weed growth. Unlike agricultural chemicals, it does not kill seeds of weeds, nor contaminate the soil, but suppresses sprouting and growth of weeds. The surface soil of a 0.1 hectares' paddy field 1 cm in depth contains about 300 million weed seeds in Japan. Weeds lushly overgrow with a fallow paddy field. Thus ponding water works as an effective herbicide. It can be said that ponding water in the paddy field liberates farmers from weeding. Aquatic weeds are easier to be pulled out than upland field weeds.

Third, upland fields suffer from deplation due to continuous cropping that makes bacteria gather in the roots of crops. It also causes accumulation of noxious substances. Water impounded in paddy fields dilutes poisonous substances created in paddy fields and washes them away through soil layer. In this way, a paddy field is an advanced field that makes continuous cropping possible. This means that a field can be reused without lying fallow.

Fourth, ponding water serves the function of water quality conservation, from the viewpoint of environmental protection (Ishikawa and Tabuchi, 1998). This function is a denitrification of nitrate-nitrogen that flows out of the surrounding upland field.

A paddy field is a productive foundation of extremely advanced efficiency.

Field Surface Stores Light

When a paddy field is ponded with water, its surface will soon be covered with green algae which absorb sunlight, produce oxygen and synthesize the organic substances that compose their body. As rice plants grow higher, the water surface becomes shaded so the algae begin to die. They sink, covering the bottom in a yellowish brown substance like fallen leaves.

They are similar to the green leaves of a forest, taking in the sunlight, increasing the amount of chlorophyll in them and finally falling down to the earth to be stored as organic nitrogen in the soil. One cubic centimeter of ponded water contains no less than a hundred thousand to a million algae. The dead algae are stored as organic nitrogen in the surface soil, gradually decomposed into ammonium nitrogen, and finally absorbed into rice plants. Ponding water stores light and at the same time provides nutrients to the rice plants. The paddy field and surface as well as rice plants store light.

The green leaves of rice plants also grow by absorbing light. The light trips through space to the green of the rice leaves. Then, it goes on a different type of trip. The light caught in the green of rice leaves provides energy to separate carbon dioxide into carbon and oxygen. Isolated carbons change into saccharides and starches after combining with water. Sunlight is a fundamental requirement for growing rice plants. Solar heat is the energy making rice plants grow.

Rice plants also absorb inorganic compounds as nutrients through their roots. The make their bodies (organic substance) with light, heat and nutrients as auxiliary materials. When we work, heat is generated. A plant also generates heat when it works to make its body. The body of a rice plant has to be cooled down to reduce this heat. In a rice plant, water flows continuously from the roots to the leaves. A rice plant maintains its body temperature by continuous transpiration from its leaves to cool it down. **Fig 4** shows a scheme of these mechanisms.

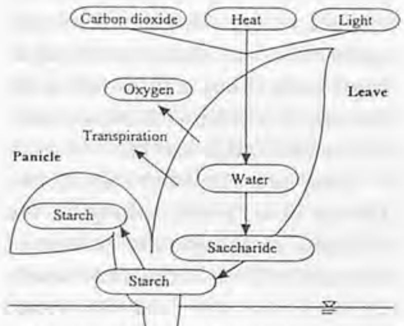

Fig. 4 Mechanisms of a rice plant growth (Simulation precess).

Surface Soil for Farm Land Consolidation

Light, heat, carbon dioxide, water and nutrients are fundamental living requisites for rice plants. Light and heat come through the space and carbon dioxide comes from the air. Water and nutrients enter rice plants from the soil only through the roots. Light, heat and carbon dioxide enter them directly. Roots spread in the soil like a net. The soil is a storage of water and nutrients for rice plants.

In farm land consolidation, the soil is called the surface soil, topsoil, or plow layer. The life of rice plants in a paddy field depends on the surface soil. The thicker the surface soil is, the wider the area where the rice plants can extend their roots is. A surface soil thickness gives the rice plants a better chance to absorb nutrients and water and surely yields a lot if provided with rich sunlight and solar heat. Generally speaking, a rice plant extends its roots deep into a well-drained paddy field, but not so deep into an ill-drained paddy field. A rice plant grows long and thin roots in an over-percolating field, and big and short roots in a paddy field of good water storage.

Suppose that the total nitrogen content in a 20 cm-thick soil is 0.2%, the soil of a 0.1 hectares' field contains 400 kg of nitrogen, which is equivalent to about 2 000 kg of ammonium sulfate. This nitrogen is not all consumed in a year, but is absorbed gradually. Therefore, rice plants grow taller by absorbing nitrogen applied as fertilizers. The roots spread in various directions seeking nutrients as the rice plant grows. They have fully spread through the surface soil and absorbed almost all the nutrients contained at the heading stage. Fertilizer shortage occurs at this time. Rice plants need fertilizer due to the smooth change from a vegetative stage (making leaves and stems) to a reproductive stage (making panicles). When the fertilizer continues to affect the rice plant after the heading stage, the yield will decline. In addition, fertilizer shortage occurs at different times depending on the surface soil thickness. Therefore, surface soil thickness is required to ensure enough nitrogen until the heading stage. Moreover, in Japan, surface soil thickness as shown in **Fig. 5** is chosen for big and strong roots to spread deeply and to have a field that soil moisture can be adjusted by water management in each plot (Tokunaga et al., 1986). It is difficult to prescribe the necessary thickness of surface soil evenly in paddy farming countries. The surface soil thickness ought to be decided from the viewpoint of maximizing the ability to grow rice. According to the circumstances, large diameter of wheels with rice transplanter may be changed into

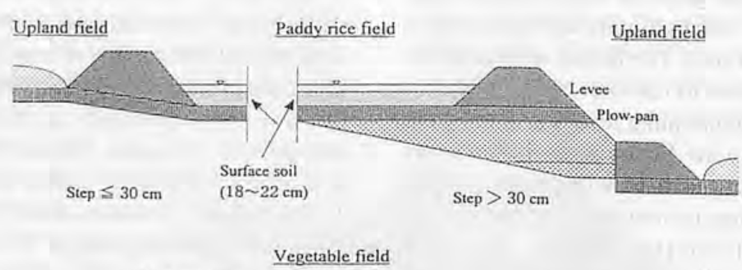

Fig. 5 Rotation of paddy rice and other crops after farm land consolidation.

fitting for practical use on the surface soil thickness. The most important condition of fields is the productivity caused by surface soil thickness.

Rotation of Paddy Rice and Other Crops

A farmland area is cared for so that it can be made into an upland field or a paddy field so that farmers can freely choose what crops to grow. Rotation of paddy crop and other crops means that the field can be used as upland fields and a paddy field alternately. Nutrients in the soil are changed annually in this way to maintain fertility. Levees and plow-pan of each field should be consolidated well to enable a rotation of paddy rice and other crops, otherwise water may seep from the adjacent field. Rotation of paddy rice and other crops with the farm land consolidation has to provide farmers with a free choice of crops to grow according to their farming management.

As experienced so far, having a field founded on the rotation of paddy crop and other crops has the following effects on farmers:

1. When an upland field is converted to a paddy field, the rice yield increases. It is most effective in a degraded paddy field area.
2. In the rotation of paddy field and other crops, paddy fields' weeds are suppressed in a converted upland field, while weeds in upland fields are suppressed in a restored paddy field. In Japan, a rotated upland field in its first year has 10% of the weeds in an ordinary upland field, and in its second or third year has 20-30% of those. The number of weeds in a restored paddy field is 10-20% in a paddy field of continuous rice cultivation. It is said that it takes 4 to 5 years for a restored paddy field to have the same amount of weeds as before, in Japan (Takahashi and Iida, 1955). If the rotation of paddy rice and other crops is effective in suppressing weeds in all paddy farming countries, this will save a lot of labor and time.
3. The upper soil layer of a restored paddy field becomes softer, more swollen and easier to plow. Soil drying effect on nitrogen mineralization also occurs.

This farming method created for the farmers' convenience will stabilize the yield, save fertilizer and agricultural chemicals, promote an effective use of agricultural machinery and equipment, reduce labor expenses, and create a cultivation method that will regain the exhausted fertility of the soil, as an appropriate method for each region. Farm land consolidation technology needs to invent a method of preparing the future foundation.

Construction of Ridges and Drainage Ditches

If paddy fields around the plot are located relatively high, the groundwater level rises and water seeps from surrounding paddy fields. Therefore, very high ridges may be formed or water may be well drained from the converted field to enable implementation of upland field farming. This is a common situation in paddy farming countries. These kinds of problems can be solved by constructing each field structure to be independent from water level, as shown in **Fig. 5.** The levees have impermeable structures and the plow-pan is very close to the levees so that water percolation from each plot will be low and conditions for raising the groundwater level will be also restricted. The problem in this field structure is that surface water in a converted upland field has to be drained when rain falls because the plow-pan has an impermeable structure. This can be solved by ridging and constructing drainage ditches in the inter-row spacings as shown in **Fig. 5**.

In addition to drainage, it is easily anticipated that the converted upland field will need to be irrigated in times of drought. Furrow irrigation to well-constructed foundation has little deep percolation loss due to the impermeable plow-pan. Irrigation water enters furrows to supply enough water in a short time. When some cash crops such as vegetables are chosen, they are grown on ridges in converted upland fields. In this case, in Japan, ridge width is sometimes 80-100 cm as shown in **Fig. 5**. The ridges are about 40-60 cm high. Furrows usually act as both working paths and drainage ditches.

The surface soil layer is compacted after rice harvesting time. In a converted upland field, plowing and ridging swell and soften it. Surface soil thickness after plowing varies depending on the type of soil. For example, volcanic ash soil swells to double its normal volume, but sandy soil does not show any obvious change. Manure is plowed in ridges by land grading in vegetable cultivation, and the surface soil swells to one- and -a-half to two times its normal thickness. Therefore, soil rate of swelling and softening should be adjusted by the plowing depth according to the type of soil. In the case of paddy field, the swelling of surface soil may often cause difficulties in manual transplanting work or use of agricultural equipment. These kinds of problems can be solved by adjustment of soil water like a midseason drainage or a surface drainage before rice transplanting.

Conclusion

All paddy fields are developed and tended by farmers. Farmers have built weirs in rivers, watered the paddy fields, impounded irrigation water and let it seep into the earth. The have not only protected their fields from storms and floods but also changed river courses, lets the water seep into the earth to retain it with groundwater dams. Simultaneously, they have grown rice plants to provide the nation's energy and promote active lives. Understanding a paddy field characteristics is important in the planning and design of farm land consolidation from the farmer's standpoint.

We have to revitalize arable lands in order to develop a flourishing agricultural industry. Soil fertility should be doubled. Farmers should be able to obtain fields on which they have the free-choice of crops to grow. At the same time the lands ought to give efficient water management in each plot as well as high labor and land productivity. Soil and water engineers need to generate their enthusiasm in farm land consolidation works .

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Technological Improvement of Production of Liquid Protein Feed-stuffs in Cuba

by
Armando V. Pineda
Researcher
Research Institute of Pig Production
Carretera de Guatao
Lisa, C. Habana,
Cuba

Pavel Kic
Associate Professor
Czech University of Agriculture Prague
Technical Faculty
165 21 Prague - Suchdol
Czech Republic

Petr Hnilica
Associate Professor
Czech University of Agriculture Prague
Technical Faculty
165 21 Prague - Suchdol
Czech Republic

Abstract

The biocycle of human nourishment produces large amounts of refuse from slaughterhouses, fish industrial processing, agriculture alimentary wastes, etc. which are often used for the production of the protein part of animal feed in many countries nowadays. Different methods and technologies have been developed for this purpose. The products gained from the wastes are mostly meat-bone flour or protein feeding paste.

The production process of the liquid feed under industrial conditions was evaluated at the plant in San Vicente during a period of one year, and included all the technical equipment for production. To improve the existing production plants for liquid feed in Cuba, the modernization of old production plants by new equipment and with changes of organization and performance of production is recommended. These technologies are important, especially for countries with an insufficiency of nourishment and with a difficult supply of feedstuffs

Introduction

Refuses from slaughter-houses, fish industrial processing and agriculture alimentary wastes are often processed for the production of the protein part of feed for animals in many countries nowadays. Different methods and technologies have been developed for this purpose. The products gained from the wastes are mostly meat-bone flour or protein feeding paste (liquid feed).

These technologies are important especially for countries with insufficiency of nourishment and with a difficult supply of feedstuffs. The collection and processing of refuse from kitchen, agriculture alimentary wastes and refuse from fish started in Cuba in 1969. The aim was to gain animal protein which could be used as a complement to the feed ration for fattening pigs.

Individual separate systems for processing kitchen and agricultural-alimentary wastes, on one hand, and for processing slaughterhouse refuse and some cadavers or their parts, on the other, were built as independent production units. The next development of that production involved a rather project of technological improvement of the processing plants, which was carried out within of framework of Ph.D. theses Pineda (1991) at the Technical Faculty of the Czech University of Agriculture Prague. It is based on the experience from the processing plants built in Cuba, but with the use of newly developed technical equipment. It is intended to increase the proportion of protein in liquid feed and to create an integral system for processing refuse and wastes of all kinds in one production unit, resulting in one common product with a high content of protein.

The most common technologies use the thermomechanical disintegration and material sterilization at the temperature of 130°C Oosterom (1985). Temperature, time and properties of micro-organisms play a decisive role in the kinetics of micro-organism inactivation Heldman and Singh (1981). Sporulating micro-organisms are especially resistive. The cause of death of an animal is, therefore, an important criterion for a veterinary decision on the body utilization for the processing.

The hitherto experience can be used for the choice of sterilization conditions. The sterilization temperature of 130°C during 30 minutes Szovatay (1982) was accepted also for cadaver processing in Cuban destructors.

Economy of production and feeding application in Cuban practice were the reasons for the decision to prefer feeding protein paste to meat-bone powders. The paste advantages are as follows: paste feeding equipment can be similar to used for liquid feeding in Cuba; the biological value of nutrients is better in feeding paste, thanks to the shorter time of its thermal treatment; and respective processing installations are simpler and cheaper.

Moreover, today's Cuban specialized plants are equipped with sufficient steam sources for manipulation with feedstuffs in a semi-liquid state. It was possible to apply the experience of Kiehn et al. (1981) obtained during the development and practical realization of the production technology of the protein paste. The results obtained from experiments with sulphuric acid conservation of the feeding protein paste were acceptable also for Cuba. Mild organic acids (e.g. propionic acid) are better from the point of view of physiology Oosterom (1985), but they can be worse applicable in Cuba because of their price.

Method

The principle of processing technology is shown in **Fig. 1**, where the experimental equipment is shown in which the pilot destructor DTM-1.0 was mounted. Raw material weighed ahead is unloaded at part 1. The destructor 4 is charged by the coveyor 2 through the hopper 3. Steam from the boiler 6 is led through the primary and secondary distributors (7, 8). Maximum pressure of steam in the destructor heating jacket is limited by the safety valve S to 0.4 MPa. Steam pressure is measured by manometers (M1 to M5) at various parts of the system, the temperature of destructor charge is measured by thermometer T (immersed in oil, preserved by a steel shell). The processed product can be discharged in two ways: either through the separator 10 to the paste reservoirs C3 and C5 where it is conserved by the addition of sulphuric acid or molasse (conservation effect of both were also tested) or to the homogenization tank 9 which is discharged without conservation (for daily use). Condensate separators (TV1 to TV3) were installed for better condensate removal. It was collected in the pots C1 and C2 hung on dynamometers.

The destructor works discontinuously. The capacity of the type DTM-1.0 is 1 t, which is mostly insufficient for industrial purposes. Nevertheless, it was necessary to collect data first from the experiments with the pilot machine of this size.The capacity of 5.5 t is proposed (type DTM-5.5) for industrial purposes. The type DTM-1.0 is shown in **Fig. 2.** All principal elements of DTM-1.0 were assumed to be kept also in the construction of DTM-5.5 including the processing requirements. In order the whole animal bodies could be charged in it the filler neck diameter will be increased to 800 mm.

One of the most important requirements for the design is the short time for attainment of sterilization temperature because the charge heating is associated with energy losses. Saturated steam used for heating at the working pressure of 0.4 MPa has the temperature of 151°C. It is fed both into the hollow jacket of the stator and into the agitator. It enters one agitator side, fills its whole tube cage and the condensate is removed from the other side through the hollow shaft and condensate separator. Steel screw band on the internal side of the agitator accomplishes three important tasks: it enables machine charging and discharging, accelerates disintegration and enables the removal of nondestructed matters. The jacket wears three flanges: one for the steam inlet, the second the air outlet at the beginning of heating and the third for the steam injection into the working space during its discharge. The destructor is discharged through the screen with the help of steam pressure and the knife attached to the agitator.

The production process of the liquid feed under industrial conditions was evaluated at the plant in San Vicente during period of one year, and included all the technical equipment for production. The technological flow chart of this plant is in **Fig. 3**. The total time of observation was 13 020 hours and included the principle data of production (efficiency of performance, material flows, energy and time consumption, etc.).

Several other experiments based on the testing of machines were also made in the same plant. Hammer mills are used in the production to disintegrate large quantities of raw materials which contain bones, egg shells, and other abrasive components. The process of disintegration takes place under conditions of high humidity (over 70 %) and acidity (pH from 3 to 4). Three sets of hammers, produced from several kinds of steel with different thermal treatment, were tested. The energy consumption and time of homogenization was measured for a new type of agitators in the homogenization tanks. Different types of seal on the agitator shaft were tested as well.

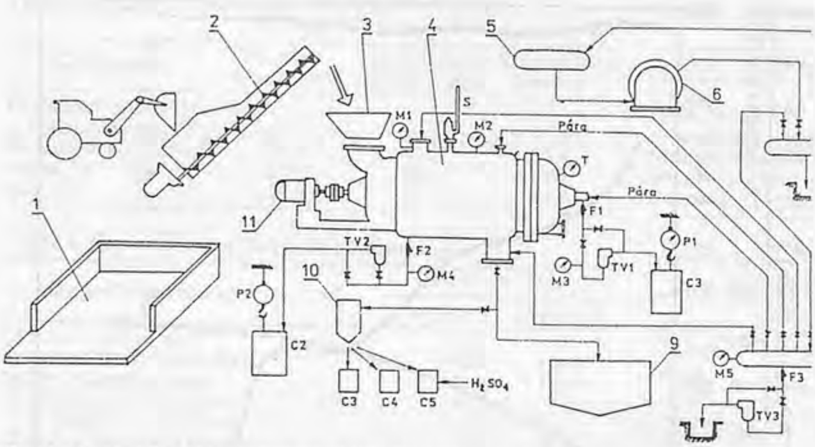

Fig. 1 An experimental technological line for protein paste production LPP-10 E model. The designation and functions of the parts of the line are described in the text.

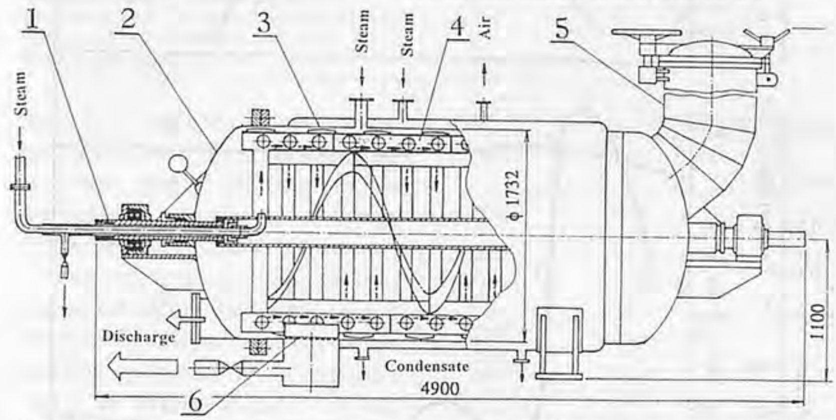

Fig. 2 A Cuban thermomechanical destructor of the DTM-5.5 model. The dimension applies to the DTM-5.5 model with a capacity of 5.5 t. Legend: 1, main steam injector; 2, cover; 3, destructor body with heated jacket; 4, agitator; 5, filling neck, 6, screen with knife.

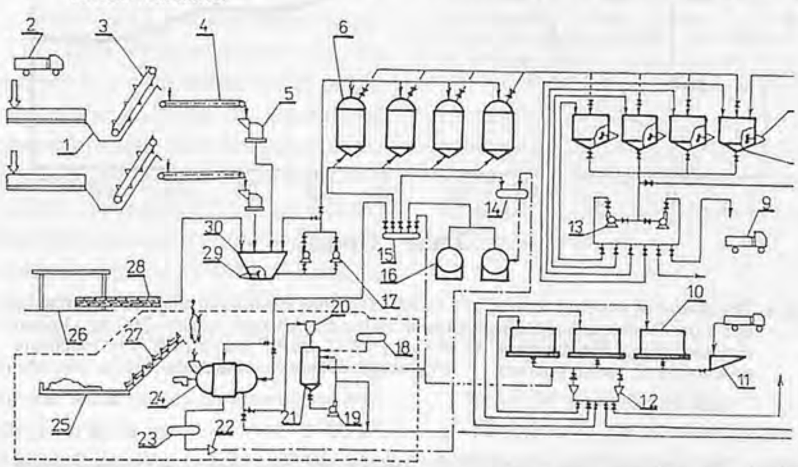

Fig. 3 Technological scheme of the processing plant PL-02 M with a new proposed improvement. Legend; 1, receptional feeding hopper; 2, transport of raw material; 3, bucket conveyer; 4, sorting belt conveyer; 5, hammer mill; 6, autoclave; 7, agitator; 8, homogenization tank; 9, removal of product; 10, tank of molasses; 11, reception of molasses; 12, pump for molasses; 13, pump; 14, reservoir; 15, distributor; 16, boiler; 17, pump; 18, acid tank; 19, pump; 20, separator; 21, feeding hopper for refuse; 22, feeding hopper of entrails; 23, hopper; 24, destructor; 25, reception of protein wastes; 26, storage of alimentary and other wastes; 27, screw conveyer; 28, screw conveyer; 29, agitator; 30, equalizing tank;
----- = proposed new part of the production plant

Results and Discussions

Ways and courses of heating of destructor charge were tested. The related energy consumption and condensate quality were measured. Operational pressures at various parts of installation, remainder quantity in the destructor after the discharge through the screen and conserved product quality were measured as well. Feeding tests were also carried out.

A more intensive contact of material with the agitator than with the jacket is significant for heating. In spite of this it was not possible to reach the required sterilization temperature 130°C by heating only through the agitator. Therefore, a less effective jacket heating must be used also in the production machine (heat losses are higher). The heating courses are shown in **Fig. 4**. The test results with heating of cadavers and slaughterhouse wastes are summarized in **Table 1**.

Chemical compositions of the feeding protein paste produced with the experimental installation and treated with sulphuric acid or molasses are given in **Table 2**. H_2SO_4 was added to the quantity of 15 and 20 g per kg of the paste (paste pH was 4 to 4.7), molasses at the quantity of 40 % of the paste dry weight (mixture pH about 5).

The concise information on the results of feeding trials with fattening pigs by the conserved paste is given in **Table 3**. Feeding effects of torula proteins are given for the comparison.

It was possible to calculate the design and performance data for the destructor type DTM-5.5 from the pilot experiment data using the similarity criterions (Pineda et al., 1992). The geometrical similarity will be kept so the basic dimensions are given only by the machine capacity. The filling coefficient is 0.7. The revolutions of the production machine agitator were selected at n_P=20 min^{-1}. They are already used in practice.

The charge heating time for DTM-5.5 was calculated from the pilot data with the help of heat transfer coefficient α_p. The following similarity relationship was derived for the ratio of machine and model coefficients.

$$\alpha_p / \alpha = (D_p / D)^{1/3} \cdot (n_p / n)^{2/3}$$

where D_p and D are diameters at the same significance of the the machine and model, respectively.

The pilot experiments were so arranged, that the peripheral speeds of the agitators were the same. Therefore, it was $n = 36\ min^{-1}$. As the heat was transferred to the material both from the jacket and agitator it was

$$\alpha = \frac{\alpha_c S_c + \alpha_s S_s}{S_c + S_s}$$

where: indices c and s denote jacket and agitator, respectively; S are respective surfaces for heat exchange.

Formulas known from thermodynamics were used for all other thermal calculations. Condensate heat can be economically exploited for the new raw material preheating. The heat recuperation at higher temperatures is more effective but Cuba meets with lack of pumps able to operate over 80°C.

Table 4 gives the technical data of the both Cuban destructors DTM. The energy parameters calculated for the processing of the dead animal bodies in DTM-5.5 are given in **Table 5**.

Results from the performance tests are summarized in **Table 6.** Most interesting is the large amount of time wasted on unplanned interruption such as breakdowns (4 821 hours) which indicates a rather bad time efficiency for the equipment. The time used for the repairs indicates the poor reliability of some parts of the technological equipment, especially the sorting belt conveyer, hammer mill and reservoir pump.

Looking at the whole technological equipment, most important is the number of autoclaves. If two

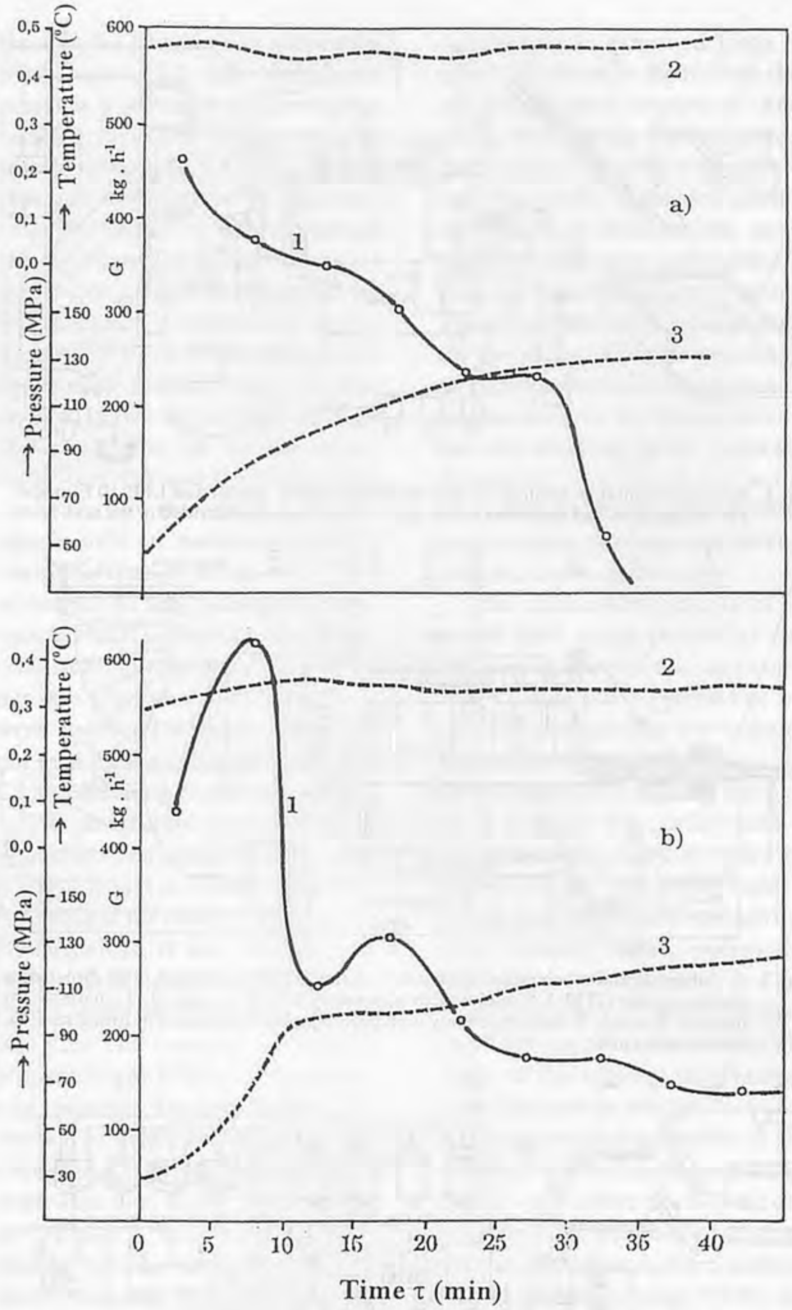

Fig. 4 The course of material heating in a DTM-1.0 destructor through a heated jacket and a agitator. Processed material: animal cadavers. Charge weight 700 kg. Initial temperature of the material: a) 36°C; b) 47°C. Curve indications: 1, condensate production; 2, steam pressure; 3, temperature of processed material.

Table 1. The Results of Experiments With Cadavers and Slaughterhouse Wastes Obtaind With a DTM-1.0 Destructor

Number of measurements	Dry matter of charge (%)	Initial charge tempereture (°C)	Condensate (kg)	Heat(MJ)	Oil specific consumption (kg.t⁻¹)	Power input for agitator (kW)	Time to sterilis. temperature 130°C attainment (h)
5	33.3±3.3	42.8±7.3	117±10	357±27	10.7±0.8	9.5±1.1	0.52±0.05

Table 2. Chemical Composition of Feeding Protein Paste (Average % contents on dry matter basis)

Component	Without conservation	Treated with sulphuric acid	Treated with molasse
Dry matter content of initial material (%)	33.3	30.5	41.6
Proteins as Nx 6.25 (%)	45.3	40.2	23.5
Lipids (%)	25.8	25.8	21.2
Fats (%)	28.0	24.7	14.8

Table 3. The Results of Feeding Trials with Molasses-treated Protein Paste Performed with Fattening Pigs (Unit: percent)

Item	Proportion of the total protein content in the feeding does		
Torula	62.90	40.90	19.10
Protein paste	0	26.50	52.80
Mean initial weight of pigs (kg)	29.80	28.90	29.40
Mean final weight of pigs (kg)	92.90	91.90	85.30
Weight increases ($kg.day^{-1}$)	0.78	0.78	0.70
Conversion ($kg.kg^{-1}$)	3.03	2.95	3.33

Table 4. Specifications of Cuban DTM Destructors

Design Characteristics	Destructor Type	
	DTM-5.5	DTM-1.0
Effective volume (m^3)	5.5	1.0
Weight of the machine (kg)	8 400	1 500
Internal diameter (mm)	1 768	1 000
Wall thickness-body (mm)	16	10
Wall thickness-jacket (mm)	10	8
Diameter of agitator (mm)	1 450	805
Diameter of agitator heating tubes (mm)	89	60
Agitator angular speed ($rad.s^{-1}$)	1 995	3 570
Surface of heat exchange-jacket (m^2)	14.5	5.0
Surface of heat exchange-heating tubes (m^2)	27.5	6.0
Surface of heat exchange-total (m^2)	42.0	11.0
Power input installed (kW)	30	13

Table 5. Energy Parameters of the DTM-5.5 Destructor for Cadaver Processing (calculated)

Basis for Calculations	Specific Consumption of Heating Oil ($kg.t^{-1}$)			Electric Energy Consumption ($kWh.t^{-1}$)
	Without Heat Recuperation	Recuperation from Condensate at 80°C	Recuperation from Condensate at 151°C	
Fresh weight of raw material	19.2	16.8	14.4	5.1
Dry weight of raw material	58.2	51.0	43.0	15.4

autoclaves are used for production the efficiency of their performance is better, whilst the use of four autoclaves results in a lower efficiency but higher reliability.

The most important factors measured during the testing period were the flow of processed materials and the consumption of fuel and water in different parts of the technological process. The average fuel consumption was 1 240.17 kg and every time the boiler is started it uses 97.21 kg of fuel twice a day. The fuel consumption can be reduced by continuous boiler usage and by the reducing the quantity of water brought into the autoclaves. The biggest specific consumption of electric energy for 1 t of processed material was seen in the homegenization tanks (0.82 $kWh.t^{-1}$) and in the hammer mills (0.58 $kWh.t^{-1}$).

The consumption of energy in the hammer mills increases according to the wear on the hammers, so the steel for their production must be of high quality and needs a good heat treatment. The best results were for hammers produced from double-treated steel of class 13 270, which were first hardened and then tempered at a temperature of 200°C. To bring down the energy consumption during the process of

Table 6. Average Times for Necessary Activities and Coefficients of Time Efficiency

Index	T_1 (h)	T_3 (h)	T_4 (h)	T_{04} (h)	$T_7 + T_8$ (h)	T_{08} (h)	K_{04} (-)	K_{08} (-)
KD	436	80	–	516	282	798	0.84	0.55
TD	436	76	36	548	251	799	0.80	0.55
KS	436	72	65	573	219	792	0.76	0.55
CZ	146	73	30	249	515	764	0.59	0.19
CV	997	5	–	1 002	43	1 045	0.99	0.95
HN	3 101	8	–	3 109	73	3 182	0.99	0.97
CK	396	106	–	502	547	1 049	0.79	0.38
CM	40	22	–	62	155	217	0.65	0.18
NM	860	4	–	864	29	893	0.99	0.96
A	774	–	–	774	2 707	3 481	1.00	0.22
Total	7 622	446	131	8 199	4 821	13 020	0.98	0.59

KD, bucket conveyer; TD, sorting belt conveyer; KS, hammer mill; CZ, pump for reservoir; CV, water pump; HN, tank of homogenization; CK, pump for liquid feed; CM, pump for molasses; NM, tank of molasses; A, autoclave; T_1(h), machine time; T_3(h), time for maintenance, setting-up time; T_4(h), time for repairs to equipment; T_{04}(h), production time; T_7(h), idle time caused by the machine; T_8(h), idle time caused by reasons not related to the tested machine; T_{08}(h), working time of machine; K_{04} (-), $T1.(T_{04})^{-1}$, efficiency factor of production time; K_{08} (-), $T1.(T_{08})^{-1}$, factor of total working time of machine.

homogenization an agitator with high power and short time requirement for homogenization is recommended.

Conclusions

It can be concluded that:

a) The protein paste production is effective and suitable for practice in Cuba. Weight increases of fattening pigs and the nutrient conversion obtained have shown a high potential for this protein source;

b) The destructor DTM - 1.0 and DTM - 5.5 have desired properties for operation in the installations of different capacities;

c) It is not possible to attain the sterilization temperature by heating the processed materials in DTM destructor only by the agitator. To improve this function, it is recommended to design the agitator cage as a continuous spiral. This might reduce partially the steam supply limitation by the condensate removal. Preheating of raw material by the heat recuperated from the condensate can be also used; and

d) Feeding protein paste can be well conserved by the sulphuric acid or molasse for 7 days.

In order to improve the existing production plants for liquid feed according to the results of the present research it is possible to recommend the following measures:

a) Modernize old production plants by new equipment which enables the processing of all types of waste in one production unit;
b) Construct large collecting spaces for the reception of kitchen wastes with concrete floors and walls;
c) Use hammer mills with hammers produced from the materials recommended;
d) Regulate the quantity of water added to the production process before the autoclave;
e) Increase the storage capacity of homogenization tanks to 50 t;
f) Use high power agitators of diameter 265 mm with mechanical seals; and
g) Achieve a continuous performance of the boiler it is necessary to organize the performance of the destructors so that one is in the process of cooking, while the other is in the process of sterilization.

In spite of the rather high production costs of liquid feed, the use of this technology under conditions of regular and proper veterinary control can be one possible partial solution to a difficult situation in obtaining feed for animals in countries which a lack food-stuffs.

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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.

721

Effects of Fertilizers on Physical and Mechanical Properties of Soils: Rahimi, Hassan Associate Professor and Rasoul Ilkhani, Graduate student, respectively, Tehran University, Iran.

Since the use of different types of fertilizers for improving and maintaining soil productivity is inevitable, the main objective of this research was to assess the long-term effects of fertilizers on the physical and mechanical properties of soils.

Any changes in physico-mechanical properties of soils, especially fine grained soils, can affect the stability of irrigation and drainage structures founded on such soils and resistance of the soil against agricultural mechinery as well.

To evaluate the effects of fertilizers on behaviour of soils, a fine grained , low plasticity soil, which is a typical agricultural soil in Karaj area, Iran, was chosen for the experimental part of the research. The soil was classified as CL-ML in USCS system.

The soil was then saturated at different rates by urea, ammonium phosphate and potassium sulphate, which are common fertilizers in the country. The experiments conducted on fertilizer saturated samples, include Atterberg limits determination, compaction, derect shear, unconfined compression, triaxial and consolidation tests.

Based on the overall results of the different expreiments conducted, it was found that, adding urea: reduced the liquid and plastic limits of the soil which means reduction of water holding capacity; increased the maxmum dry density in standard compaction test while reducing optimum water content; reduced the cohesion and angle of internal friction; and reduced the compressibility index and coefficient of cosolidation.

The addition of ammonium phosphate and potassium sulphate showed similar effects on soil behaviour, which can be listed as follows: increased in liquid and plastic limits, the effect of ammonium phosphate is more pronounced; reduced the maximum dry density while the optimum moisture content increased; reduced ammonium phosphate chohesion and increased the angle of internal friction, while the effect of potassium sulphate is reversed; and the compressibility index and coefficient of consolidation are not affected by the fertilizers.

As a whole, it can be concluded that common fertilizers will reduce the shearing strenght of fine grained soils, considering the higher rate of effect for urea and ammonium phosphate.

722

Status of Manual Auger Diggers in India: Varshney, A.C., Principal Scientist, Central Institute of Agricultural Engineering, Nabibagh Berasia Road, Bhopal 462 038, India.

The traditional method of digging pits by crowbar or mattock for erecting poles, foundations, seedling trasplany—tion etc. is time consuming and expensive. In order to dig pits at a faster rate, the manual auger diggers are being used more and more and have become popular in India. Power tiller and tractor auger diggers are also being used where large scale afforestation is done. However, a systematic research efforts are needed to improve the performance of these diggers by making design changes and service life can be improved by using good quality material in the critical parts of auger diggers.

723

Process Optimization for the Production of Particle Board from Coir Pith: Visvanathan R., Assistant Professor; R.Kailappan, Professor and Head; and L. Gothandapani, Professor (Retd.), respectively, Department of Agricultural Processing, College of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore - 641 003, India.

Particle board of 250 mm x 250 mm with 12 mm thickness and 0.9 g/cc density, using phenol formaldehyde and urea formaldehyde resins were produced from coir pith and evaluated. the optimum level of process parameters proportion of resin, curing duration and curing temperature, were, 16.7%, 26 min and 138°C for the phenol formaldehyde resin and 20.4, 16.6 and 139°C for the urea formaldehyde resin, respectively.

The highest values of the mechanical properties obtained for modulus of rupture, tensile stress along parallel to surface, perpendicular to surface, screw and nail holding capacity along face and edge, lateral nail resistance and impact strength were 15.5 MPa, 3.53 MPa, 0.160 MPa, 957 N, 713 N, 560 N, 220 N, 543 N and 10.3 Nm for the phenol formaldehyde bonded boards and 10.36 MPa, 2.11 MPa, 0.11 MPa, 5.77 MPa, 2.67 MPa, 410 N, 150 N, 453 N and 8.7 Nm, for the urea formaldehyde bonded boards, respectively.

Water absorption and swelling were minimum for the phenol formaldehyde bonded boards made with larger sized particles. The mean thermal conductivity of the phenol formaldehyde and urea formaldehyde bonded boards were 0.20 and 0.11 kcal/h m°C, respectively. The mean sound absorption coefficient ranged from 0.10 to 0.30 and the noise reduction coefficient was 0.183. The transmission loss was from 4.4 to 32.4 for the boards in the frequency range of 200 to 4000 Hz. ■■

International Workshop and Study Tour on Compound Fertilizer Production and Bulk Blending

August 9-20, 1999
Muscle Shoals, Alabama, USA

The International Workshop and Study Tour on Compound Fertilizer Production and Bulk Blending will be held August 9-20, 1999, in the United States. The 2-week program consists of 1 week of classroom presentations and discussions at IFDC Headquarters on production methods and marketing of granular NPKs, compacted NPKs, bulk blends, and fluid NPK fertilizers. The second week of the program involves visits to granular NPK, bulk blend, and fluid fertilizer production and distribution facilities; attendance at a fertilizer and agriculture equipment exhibition; and presentations by fertilizer equipment manufacturers. The study tour will culminate in Indianapolis, Indiana, where participants wil make country presentations.

Objectives:

1. Provide an overview of the various alternatives to produce NPK fertilizers.
2. Provide an understanding of the use and marketing of various types of NPK fertilizers.
3. Develop the ability of the participants to analyze and make practical and economic decisions concerning which option or options for NPK production may be most appropriate to their situation.

The program consists of a week each of workshop and study tour. The workshop segment at IFDC will include technical presentations, discussions, and practical demonstations in IFDC pilot plants. The study tour will include visits to NPK fertilizer production, storage and handling, and marketing operations in Alabama, Georgia, and Florida.

Program topics include:

- Technology and design criteria for the production of conventional granulated NPKs and urea-based NPKs, bulk blends, compacted NPKs, and fluid NPKs.
- Marketing considerations for granulated, blended, and fluid NPKs.
- Quality control in NPK production.
- Environmental considerations in the design and operation of NPK production facilities, including handling of raw materials and products.
- Estimating the cost of developing NPK production facilities and the cost of production.
- An overview of the process equipment available for manufacturing various types of NPKs.
- Practical demonstrations.

The study tour will provide participants with an opportunity to observe and study NPK fertilizer production, storage and handling, and marketing operations. Participants will meet production and marketing personnel and equipment manufacturers. Each participant will receive extensive printed material, including a copy of the new UNIDO/IFDC Fertilizer Manual.

Contact:

International Fertilizer Development Center
P.O.Box 2040, Muscle Shoals, Alabama 35662, U.S.A.
Tel: 256-381-6600, Fax: 256-381-7408, E-Mail: hrd@IFDC.org
Web Site: http://www.ifdc.org

EIMA - International Agricultural Machinery Manufacturers Exhibition

November 13-17, 1999
Bologna, Italy

EIMA, the International exposition of machinery for agriculture, agro-industry, animal husbandry, gardening and public parks marks its thirtieth anniversary on November 13-17. Organized once again by UNACOMA SERVICE srl at Bologna with BolognaFiere, EIMA can move into the birthday celebrations looking back on a clearly positive balance sheet. Set up by UNACOMA in 1969, the number of participants has grown, year by year, and so has the area covered by the exhibits, the level of the services, and the number of visitors: about 200 exhibitors with just over 11 000 visitors at the start, and in 1998, 1 578 manufacturers from 34 countries offering over 20 000 models on 150 000 square meters of exhibition space for over 130 000 visitors.

The figures measure the success of an exhibition divided into fourteen product groups so as to make things easier for the professionals and to let visitors find their way round the pavilions more easily, as well as offering an international comparison between what machines are on offer and what people want to buy.

With gardening dealt in a separate show, EIMA Garden, EIMA's aim is to promote agricultural mechanization and technological innovation. One of the tools is the exhibition of technical novelties in a competition organized by UNACOMA each year, and the CONAMA exhibition of certified and innovative machines.

But EIMA also offers an international forum for debating technological evolution in the varied social and economic realities that farmers work in. This is thrust of events such as the Club of Bologna, where experts make a more extended consideration of mechnization issues, the days devoted to exchanges and coopeeration with other countries, conferences on political and economic issues.

Product Sectors:

I	Endothermic and electric engines
II	Land-reclamation and forestry equipment
III	Tractors, walking tractors, motor hoes, motor mowers, and multipurpose farm vehicles

IV Soil-working, sowing and fertilizer-distribution equipment
V Plant and crop protection equipment
VI Irrigation equipment
VII Harvesting machines
VIII Threshing, selection and conditioning equipment
IX Livestock husbandry equipment
X Product processing and Dairy-work equipment
XI Crop transportation equipment
XII Components and accessories
XIII Gardening equipment, small powered and manually-operated machines
XIV Miscellaneous equipment for agriculture

Technical data:

- Bologna's Fair neighbourhood covers a total surface of 315 000 square metres: 20 covered air-conditioned pavilions for an exhibition of 150 000 square metres.
- Airport at 6 Kms, railway station and town centre at 2 Km; the super-highway exit directly to the fair (n. 8); parking for 4.200 cars;
- Special railway station directly to the fairgrounds;

Service Available to Exhibitors and Visitors:

- Business Centre to receive foreign visitors; interpreters on hand;
- EIMA Organization Offices; Press Office; ICE Office and Foreign Ministry Offices;
- Travel agencies, banks, import-export offices; specialized press area;
- Official Hotel Booking Office: CONVENTION AND TRAVEL, Piazza Costituzione, 5/E - 40128 Bologna, Tel: 051-6375111, Fax: 051-6375149, e-mail: bocongressi@posta.alinet.it;
- Conference halls and meeting rooms (Palazzo Congressi, Service Centre, pav. 34 and 36);
- Refreshments: 3 restaurants/self-service and 15 coffee and snack bars within the Fairgrounds.

Data XXIX Edition ('98)

- Exhibitors: 1578, (of which 388 foreign);
- Machinery on exhibit 20 608
- Visitors: 127 359, of which 10 008 from 101 different countries;
- Official Missions from 34 countries.

World Engineers' Convention

June 19-21, 2000
Hanover, Germany

Engineers from all over the world are going to discuss their visions and solutions for EXPO 2000's central theme 'Man-Nature-Technology' at the forthcoming World Exposition in Hanover, Germany.

The first World Engineers' Convention will be the 'technical preliminary event' of Hanover's EXPO 2000. the three day event from 19-21 June 2000 will be organized by the VDI the Association of Engineers in collaboration with the EXPO 2 000 GmbH. With 130 000 members the VDI is Europe's largest organization in the field of science and technology.

Dedicated to EXPO's dominant theme 'Man-Nature-Technology' the Convention is to cover all aspects of technology. It aims at evaluating the visions and solutions of the international technical community with regard to the key issues of the new century and at incorporating them into the world wide debate. An estimated 3 000 participants are expected to attend to the five Professional Conferences of the event focusing on the subjects of Mobility, Information and Communication, Energy, Environment-Climate-Health and the Future of Work. The technical direction of the World Engineers' Convention will be co-ordinated by independent international committees supported by an Advisory Board including Presidents of leading engineering associations. Leading personalities have already promised their participation, including Jürgen E. Schrempp, Chairman of the Board of Daimler-Chrysler AG, James D. Wolfensohn, World Bank President and Klaus Töpfer, Director of the United Nations Environmental Programme (UNEP).

The World Engineers' Convention strives to bridge the boundaries between industrialized, newly emerging and developing countries as well as different generations. This will be achieved through talks and workshops and will include real and virtual forums which are also open to students and school children. The technical seminars will be supplemented by an attractive supporting programme.

Contact:

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4th National Irrigation Symposium

November 14-16, 2000
Phoenix Civic Plaza, Phoenix, Arizona, USA

The conference will provide for interchange among researchers, educators, consultants and industry representatives who desire to explore opportunities for improved design and management of irrigation systems. The conference will focus on current irrigation practices of national interest and examine the future of irrigation for the next decade.

Session Types:

The conference will include both lecture and poster session. Papers are being sought for inclusion in the Symposium Proceedings. These papers will be presented during the Symposium in either lecture or poster presentations. Papers will be selected and type of presentation assigned based on submitted abstracts. Proposals are due August 1, 1999.

A second option for Symposium presentations is Poster presentations and New Product oral presentations without printed papers. Abstracts will be printed in the Proceedings. Proposals for these presentations without papers will be due May 1, 2000. Poster presentations must be posted early on Tuesday (Nov 14) and left up through the conference. Poster session presenters are expected to be available at a specified period of time to discuss their work.

Topic Areas:

The focus of the National Irrigation Symposium will be on Historical Perspectives, Technology Reviews, Research Needs, and Visions of the Future within the broad topic areas listed below and on topics of national interest. Papers describing narrowly-focused research or developments, research in progress, and international case studies will be accepted as poster presentations. Suggested topic areas include, but are not limited to:

- Turf and landscape irrigation technology and management
- Irrigated agricultural production of food and fiber
- Economic, environmental and sociological impacts of irrigation
- Water supply issues – quantity, quality, allocation, transfers, water law, economics
- Irrigation methods and technology
- Irrigation management and scheduling
- New products and technologies

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The World Food Prize

The World Food Prize Foundation requests nominations for the year 2000 World Food Prize, which recognizes outstanding individual achievement in improving the quality, quantity, or availability of food in the world. The Prize emphasizes the importance of a nutritious and sustainable food supply for all people and recognizes that improving the world's food supply for the long term depends on nurturing the quality of land, water, forests, and other natural resources.

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

The laureate will receive $250 000 and a sculpture created by world-renowned designer Saul Bass. The award is based solely on individual achievement with no consideration of nationality, ethnicity, political persuasion, religion, sex, or age.

For a brochure detailing nomination procedures, contact The World Food Prize, Office of the Secretariat, David Acker, College of Agriculture, Iowa State University, Ames, IA 50011-1050; tel. (515) 294-2883; fax (515) 294-9477; e-mail: bjelland@iastate.edu; or http://www.wfpf.org.

The deadline for submission of nominations for the year 2000 World Food Prize is December 31, 1999.

BOOK REVIEW

Guideline VDI 1000 Establishing Guidelines and Procedures

(Germany)

Editor: VDI Verein Deutscher Iengenieure (The Association of Engineers)

The publication VDI 1000 'Establishing Guideline and Procedures' is of essential importance for all VDI-quidelines. This new edition supersedes the 1981 edition. It explains in detail the purpose, methodology and legal aspects of the VDI-guidelines to interested parties both in Germany and abroad, and serves as a basis for working out individual VDI-guidelines. The new 'VDI 1000' is being issued in a German-English edition. This production is the result of the modification of the draft of March 1998.

The different objectives of the VDI-guidelines as comprehensively approved engineering standards are described at length. These aims include innovative working papers, assistance in decision making, and criteria for judgement and evaluation. Also included objectives are practical explanations and supplements to applicable national, European and worldwide technical regulations. The drafting of national positions in the basis for national, European and international technical regulations in cooperation with the proper authority. The VDI-guidelines must be in accordance with the EU-guideline 98/34/EG.

The essentials of the process of establishing VDI-guidelines are described in a concise form. This encompasses the initiation of proceedings to the appointment of committees, the determination of organizational questions, the way to a draft, dealing with opposition to a draft and the establishing of a valid guideline (white paper). Contributions on copyright and royalties conclude the work.

Release: March 1999, Price: DM 43,-
Substitutes the issue of October 1981 and the draft of March 1998.
Released in German and English Language.
Available from: Beuth Verlag GmbH, D-10772 Berlin, Germany.
Tel.: ++49/30/2601-2260, Fax: ++49/30/2601-1260.

ASAE Standards 1999 - Standards Engineering Practices Data

(USA)

The American Society of Agricultural Engineers keeps you on top of the latest developments in standards and engineering practices with ASAE Standards 1999. This hardbound 46th Edition contains more than 200 standards, engineering practices, and data – one-third of which were newly adopted, revised, or reaffirmed in the past year. ASAE places at your fingertips the latest standards for equipment and systems involved in producing, storing, handling, and processing biological products.

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—ASIA and OCEANIA—

Shah M. Farouk
Professor and Vice-Chanceller, Bangladesh Agricultural University, Mymensingh, 2202 Bangladesh

Mohammed A. Mazed
Director General, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh

Manbahadur Gurung
Natural Resource Training Institute, (Construction) Lobesa, P.O. Wangdiphodrang, Bhutan

Wang Wanjun
Senior Engineer of Chinese Academy of Agricultural Mechanization Sciences, Honorary President of Chinese Society of Agricultural Machinery, No. 1 Beishatan, Deshengmen Wai, Beijing, China

A.M. Michael
1/64, Vattekunnam, Methanam Road, Edappally North P.O., Cochin, 682024, Kerala State, S. India

T.P. Ojha
H.I.G.-30, Gautam Nagar, Bhopal 462 023, India

S.R. Verma
Prof. of Agricultural Engineering, College of Agril. Engg., Punjab Agricultural University, Ludhiana - 141004, India

Soedjatmiko
Head of Subdirectorate of Agric. Engineering, Ministry of Agriculture, Jakarta, Indonesia

Mansoor Behroozi-Lar
President, Iranian Society of Agricultural Machinery Engineers, P.O. Box 31585-574, Karaj, Iran

Jun Sakai
Professor Emeritus, Dept. of Agric. Engineering, Faculty of Agriculture, Kyushu University 46-05, Hakozaki, Higashi-ku, Fukuoka 812, Japan (Mailing address: 31-1, Chihaya 2-chome, Higashi-ku, Fukuoka 813, Japan

Bassam A. Snobar
Vice President, Professor of Agricultural Engineering, Jordan University of Science & Technology, P.O. Box 3030 Irbid 22110, Jordan

Chang Joo Chung
Emeritus Professor, College of Agriculture and Life Sciences, Seoul National University, Suweon 441-744 Korea 103

Chul Choo Lee
Reserch Professor, Seoul Woman's University, Mailing Address: Rm. 514 Hyundate Goldentel Bld. 76-3 Kwang Jang Dong Ku, Seoul, Korea

Imad Haffar
Associate Professor of Agric. Mechanization, Faculty of Agricultural Sciences, United Arab Emirates University, Al Ain, P.O. Box 17555 UAE

Muhamad Zohadie Bardaie
Professor and Deputy Vice Chancellor (Development Affairs), Universiti Pertanian Malaysia, 43400 UPM, Serdang, Selangor, Darul Ehsan, Malaysia

Madan P. Pariyar
Consultant, Rural Development through Self-help Promotion Lamjung Project, German Technical Cooperation, P.O. Box 1457, Kathmandu, Nepal

ElTag Seif Eldin
Mailling Address: Dept. of Agric. Mechanization, College of Agriculture, P.O. Box 32484, Al-Khod, Sultan Qaboos University, Muscat, Sultanate of Oman

Nawaf A. Abu-Khalaf
Engineer, the Project Directorate in Palestinian Agricultural Ministry, P.O.Box 405, Hebron, Palestine, Telfax: 972-2-2227846/7, E-mail abukhalaf@hebronet.com

Allah Ditta Chaudhry
Professor and Dean Faculty of Agric. Engineering and Technology, University of Agriculture, Faisalabad, Pakistan

A.Q.A. Mughal
Vice Chancellor, Sindh Agriculture University, Tandojam, Pakistan

Rafiq ur Rehman
Director, Agricultural Mechanization Reserch Institute, P.O. Box No. 416 Multan, Pakistan

Reynaldo M. Lantin
Interim Head, Agric. Engineering Div., International Rice Research Institute, P.O. Box 933, 1099 Manila, Philippines

Ricardo P. Venturina
President & General Manager, Rivelisa publishing House, 215 F, Angeles St. cor Taft Ave. Ext., 1300 Pasay City, Metro Manila, Philippines

Saleh Abdulrahman Al-suhaibani
Professor, Agricultural Engineering Dept., College of Agriculture, King Saud University, P.O. Box 2460 Riyadh 11451, Saudi Arabia

S.G. Illangantileke
Head, Dept. of Agric. Engineering, Faculty of Agriculture, University of Peradeniya, Sri Lanka (Mailing Address: Postharvest Specialist and Regional Representative South West-Asia, International Potato Center (CIP), Regional Office, IARI Campus, New Delhi 11012, India)

Sen-Fuh Chang
Professor, Agric. Machinery Dept. National Taiwan University, Taipei, Taiwan

Tieng-song Peng
Deputy Director, Taiwan Agricultural Mechanization Research and Development Center, FL. 9-6, No. 391 Sinyi Road, Sec. 4, Taiwan

Surin Phongsupasamit
Professor of Agricultural Engineering, Dept. of Mechanical Engineering, Faculty of Engineering, Chulalongkom University, Phyathai Road, Patumwan, Bangkok 10330, Thailand

Chanchai Rojanasaroj
Research and Development Engineer, Dept. of Agriculture, Ministry of Agriculture and Cooperatives, Gang-Khen, Bangkok 10900, Thailand

Vilas M. Salokhe
Professor, AFE Program, Asian Institute of Technology, P.O. Pox 4, Klang Luang, Pathumthani 12120, Thailand

Gajendra Singh
Professor, AFE Program, Asian Institute of Technology, P.O. Box 4, Klongluang, Pathumthani 12120, Thailand

Yunus Pinar
Professor, and Head, Agric. Machinery Dept., Faculty of Agriculture, University of Ondokuz Mayis, Kurupelit, Samsun, Turkey

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—EUROPE—

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H Have


G Pellizzi


A A Wanders


J Kigour


M Martinov

Pavel Kic
Associate Professor, University of Agriculture Prague, Faculty of Agric. Engineering, 165 21 Praha 6-, Suchdol, Czechoslovakia

Henrik Have
Prof. of Agric. Machinery and Mechanization at Institute of Agric. Engineering, Royal Veterinary- and Agricultural University, Agrovej 10 DK2630 Tastrup, Denmark

Giuseppe Pellizzi
Director of the Institute of Agric. Engineering of the University of Milano and Professor of Agric. Machinery and Mechanization, Via G. Celoria, 2-20133 Milano, Italy

Aalbert Anne Wanders
Staff Member, Dept. of Development Cooperation, Netherlands Agricultural Engineering Research Institute (IMAG), Wageningen, Netherlands

John Kilgour
Senior Lecturer in Farm Machinery Design at Silsoe College, Silsoe Campus, Silsoe, Bedford, MK45 4DT, UK

Milan Martinov
Associate Professor of Agricultural Engineering, University of Novi Sad, Faculty of Engineering Sciences, Institute of Mechanization, Novi Sad, Yugoslavia ■■

REMINDER

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c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
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j. Convert national currencies in US dollars and use the later consistently.
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BACK ISSUES

(Vol. 29 No. 1, Winter 1998 ~)

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