International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

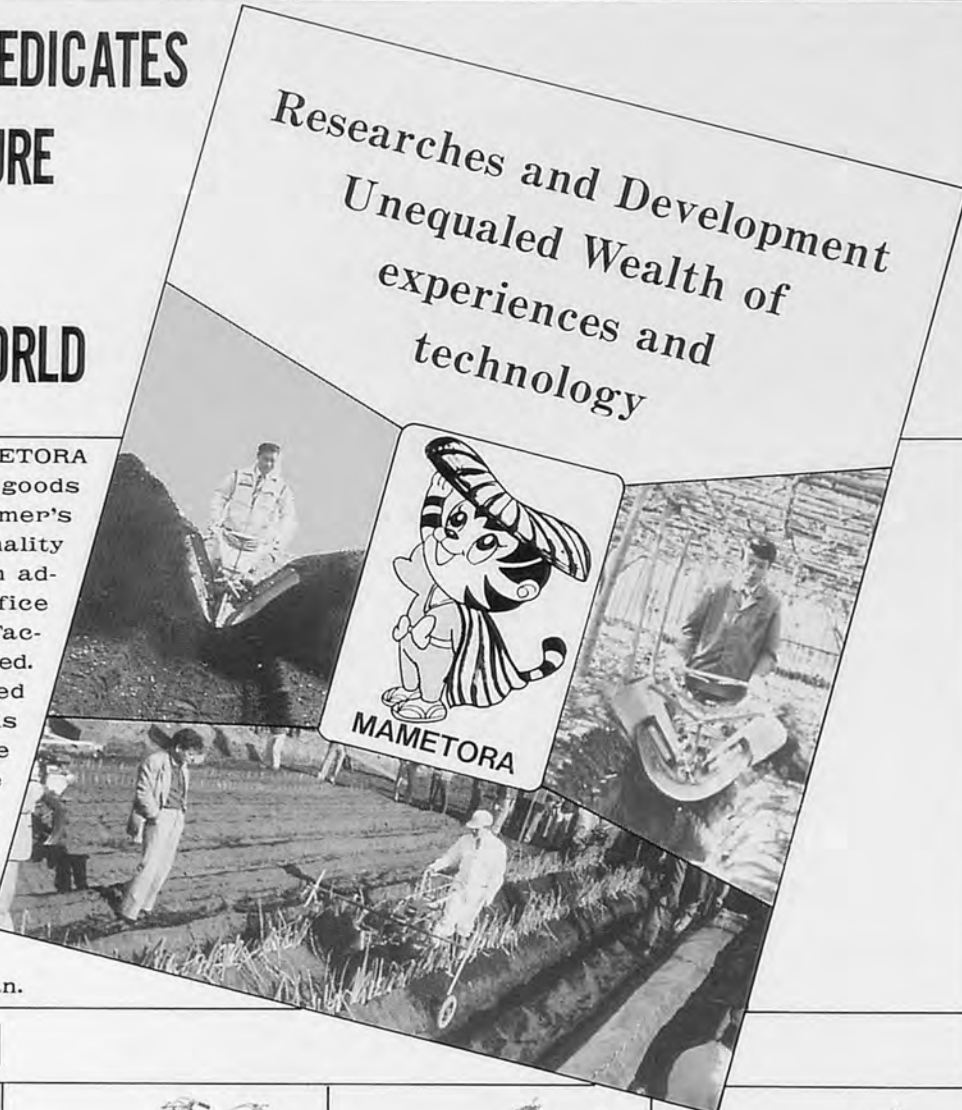
AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.26, NO.4, AUTUMN 1995

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

MAMETORA DEDICATES TO AGRICULTURE ALL OVER THE WORLD



It is the motto of MAMETORA that we manufacture goods in order to meet customer's benefits with originality trusty and hearty. In addition to the head office in Okegawa Kisakata Factory has been established. Now that we have formed the much steadier basis as a comprehensive manufacturer. We are always making efforts to manufacture goods of high quality and are pleased to devote ourselves to the food industry in the world as well as that in Japan.

EXPORT SERIES

MC-8C
MINI POWER TILLER MULTING ROTOR SET (1.7ps)

MC-AII
ONE WHEEL POWER TILLER (4.0ps)

DMC-700V
POWER TILLER (7.0ps)

HMD-V-RB
POWER TILLER(8.0ps)

SRV-4V
POWER CULTIVATOR (7.0ps)

TP-3V
VEGETABLE TRANSPLANTER

MH-750
HAMMER KNIFE MOWER

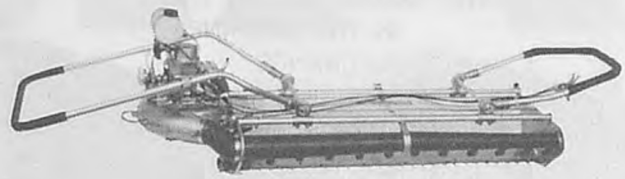
SC-10
CRAWLER CART

MAMETORA AGRIC. MACHINERY CO., LTD.

HEAD OFFICE ADD: 9-37, NISHI-2 CHOME, OKEGAWA-SHI, SAITAMA-KEN, JAPAN.
TELEPHONE: 0487-71-1181 FAX: 0487-71-1529

OCHIAIi is the top-ranking tea-leaf piker manufacturer in Japan. OCHIAI's products are used in tea-producing areas worldwide.

OMS-2 Riding type pest control machine



L-SIZED TEA PLUCKER *V-8*

L-SIZED PRUNER *R-8*

HIGH-EFFICIENCY RIDING TYPE SERIES

OM-25 Full-width tea picker

ENGINE PRUNER *E-6*

GUIDE TO OCHIAI

- Succeeded in devising Japan's first automatic tea-leaf picker in 1959.
- Received the Director of the Board of Scientific Technology Award in 1967.
- During the intervening period (1959-1967) obtained a number of patents, as well as receiving a variety of awards and prizes in the domain of science and technology.
- The top-ranking tea-leaf picker and tea-tree trimmer producer, holding 60% of the shares in the same line of business in Japan, surpassing the other manufacturers in sales and product, and leading the related business worlds in its expansion and development.

OCHIAI-SHOJI CO., LTD.

OCHIAI HAMONO KOGYO CO LTD

Head Office: 58, Nishikata, Kikugawa-cho, Ogasa-gun, Shizuoka-ken, Japan
Tel. Kikugawa (05373) 6-2161~5 Telex 03965824 STPA J ATTN OCHIAI

International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.26, NO.4, AUTUMN 1995

Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

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

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

This is the 89th issue since its maiden issue in the Spring of 1971

EDITORIAL

With population increase of late years, the concern about the food production ability has been rising. In China, having more than 1.2 billion population, it is getting hard to keep self-supply of food. Chinese authorities decided to raise Government's purchasing price of food by 40% to encourage farmers. By the year of 2000, China must increase grain production by 50 million ton. Considering China needed about ten years to increase production by 50 million ton, it seems quite certain that China will import more than 20 million ton food in 2000. The recent economical growth in China brought about the gap between urban and rural areas. The young farmers are inclined to move to cities leaving farmland. At the same time farming population in rural areas tends to decrease due to the extension of industrial plant into those areas. Abnormally unfair trade system between farm products and industrial ones is also furthering the youngster's going away from agriculture. Today even in developing countries, population is being rapidly concentrated in cities. So it seems natural that the world should be more influenced by city powers.

Under these circumstances, agricultural policy is not for the benefit of farmers but for consumers in cities, which throws farmers and agriculture into impoverished conditions. Not only agriculture but also whole ecological system will be impoverished. How can we protect agriculture for the future human life under such circumstances without making active communications and linkage of farmers all around the world?

In developing countries as well as developed countries, labor shortage in farming, seasonally or all through the year, is one of the most serious problems, for this has caused a drop in agricultural output. Here arises the need for further promotion of farm mechanization which can reduce farm labor. To cope with multifarious farm crops and different regional conditions throughout the world, the research and development of massive kinds of farm machines are essential. The number of agricultural engineers, however, is decreasing, particularly in developed countries. Some universities have even quit agricultural engineering researches. Agricultural engineering is really important issue for mankind and our continuing effort is largely expected.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
October, 1995

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol. 26, No. 4, Autumn 1995

Development and Evaluation of Low-cost Power Tiller Bend Tynes under Field Conditions

by
S.C. Pradhan
Associate Professor
AICRP on Power Tiller
Dept. of F.M.P., CAET
OUAT, Bhubaneswar 751003
Orissa, India

N. Mahapatra
Assistant Professor
AICRP on Power Tiller
Dept. of F.M.P., CAET
OUAT, Bhubaneswar 751003
Orissa, India

R.C. Dash
Lecturer Gr. I
Deott. of F.M.P.
CAET, O.U.A.T.
Bhubaneswar 751003
Orissa, India

Abstract

Power tiller tynes are subjected to considerable amount of wear and tear under field conditions and need frequent replacement. In order to reduce the cost per effective working hour, a set of tynes was fabricated from old leaf springs of jeeps and the hardness and composition of these tynes were studied. These tynes were evaluated under field conditions of sandy loam type of soil and compared their performance with Mitsubishi company tynes and locally manufactured low-cost tynes from old leaf springs of trucks. The life of these fabricated tynes were nearly at par with Mitsubishi company tynes and the cost per effective working hour has been reduced by 66%. Even though the locally manufactured tynes from old leaf springs of trucks are gaining popularity among the power tiller owners in Orissa because of their low cost, these tynes need proper heat treatment to avoid distortion and breakage.

Acknowledgement: The authors thankfully acknowledge the Indian Council of Agricultural Research, New Delhi for providing the financial assistance to undertake this investigation.

Introduction

In Orissa, India, 76% of the farmers are under small and marginal categories and they posses only 40% of cultivable land. The average size of holding is 1.6 ha only. Due to small and scattered land the farmers depend mostly upon the draft animals inspite of their high feeding and maintenance cost. The initial investment on tractor is very high which is beyond the reach of a common farmer. On the other hand, considering the power spectrum in the agriculture sector, the power available in the state is only 0.39 hp/ha which is much less as compared to power availability of 0.54 hp/ha in all-India basis.

Considering the socio-economic condition of the farmers and to augment the farm power, an intermediate source like power tiller has been introduced in the State. As a result, the sale of power tillers exceeded 1 200 in number during the period 1987-1992.[1] But it has been observed that power tiller tynes wear very fast and need frequent replacement thereby increasing the operational cost per hour. Therefore, steps have been taken to develop low-cost power tiller tyne from old leaf springs of jeeps or trucks and to compare its performance with the Mitsubishi company tyne in respect of its life and cost.

Materials and Methods

An old leaf springs of jeeps with 45 mm width and 5 mm thickness was used to fabricate the tynes. Each piece of the leaf springs was kept 340 mm long. These pieces were heated and bent to the required shape of tynes. The hardness of Japanese blade tip is usually kept 55 to 60 HRC whereas the holdon portion of the blade is adjusted to 40 to 48 HRC.[2] Thus the holdon portion of the rotary blade has a good springy structure as the blade tip is hard enough to resist wear and tear under field conditions. Under the hardening process these tynes were heated to 800°C followed by quenching with SAE-40 oil. Subsequently, the tempering process is carried out in two stages. First of all, the cutting tip portion of the tyne was heated up to 300°C and cooled to room temperature. Thereafter, the holdon portion of the tyne was heated up to 500°C followed by cooling to room temperature to obtain required hardness.

Samples of fabricated tyne from old leaf springs of jeeps, locally manufactured tynes from old leaf springs of trucks and Mitsubishi company tyne were sent to the Regional Research Laboratory, Bhubaneswar to determine the hardness and composition of the material. Considering the hardness at tip, holdon and middle portion of the tyne the average hardness was calculated. The tynes from a set were numbered and tested under field conditions with sandy loam type of soil in the Central Farm, OUAT, Bhubaneswar. The weights have been recorded after 50 hours of interval for each tyne to asses their wearing pattern. The effective operating hours was measured under field conditions until one of the tynes' tip was completely worn out. In addition, the wearing pattern, breakage and distortion, if any, were also studied.

Table 1. Average Hardness and Composition of Three Sets of Power Tiller Tynes

Source of Power Tiller Tyne Set	Average Hardness	Carbon Content (%)	Manganese Content (%)	Silicon Content (%)
Mitsubishi tynes	HRC46.3	0.521	0.70	1.56
Fabricated tynes from old leaf springs of jeeps	HRC42.6	0.581	0.74	1.60
Locally manufactured tyne from old leaf springs of trucks	HRC36.3	0.578	0.76	1.65

Table 2. Test Results of Mitsubishi Power Tiller Tynes

Tyne No.	Initial weight (gm)	After 50 hrs. of Operation				After 83 hrs. of Operation			
		Weight (gm)	Weight loss (gm)	Wear rate (gm/h)	Mean wear rate (gm/h)	Weight (gm)	Weight loss (gm)	Wear rate (gm/h)	Mean wear rate (gm/h)
1	561.50	528.00	33.50	0.67		495.90	65.60	0.79	
2	525.00	503.00	22.00	0.44		486.75	38.25	0.46	
3	495.50	441.00	54.50	1.09		412.69	82.81	0.99	
4	481.00	460.50	20.50	0.41		450.63	30.37	0.36	
5	575.50	525.50	50.00	1.00		498.40	77.10	0.92	
6	473.00	453.50	19.50	0.39		443.88	29.12	0.35	
7	524.00	506.50	17.50	0.35		496.39	27.61	0.33	
8	479.50	436.50	43.00	0.86		414.38	65.12	0.78	
9	549.00	538.50	10.50	0.21	0.52	530.65	18.35	0.22	0.50
10	552.00	528.00	24.00	0.48		512.45	39.55	0.47	
11	585.50	574.00	11.50	0.23		566.75	18.75	0.22	
12	586.00	570.50	15.50	0.31		561.13	24.87	0.29	
13	609.50	594.50	15.00	0.30		585.85	23.65	0.28	
14	574.00	549.50	24.50	0.49		534.15	39.85	0.48	
15	552.00	527.50	24.50	0.49		513.25	38.75	0.46	
16	604.00	553.50	50.50	1.01		527.39	76.61	0.92	
17	538.50	517.00	21.50	0.43		504.70	33.80	0.40	
18	495.00	481.50	13.50	0.27		470.18	24.82	0.29	

Results and Discussion

The average hardness and composition of fabricated leaf spring tyne, locally manufactured tyne and Mitsubishi company tyne obtained from the Regional Research Laboratory, Bhubaneswar are presented below in **Table 1**.

It was observed that carbon, manganese and silicon content of old leaf spring tynes were slightly more than that of the Mitsubishi company tynes. The composition of tynes fabricated from old leaf springs of jeeps and trucks were nearly identical. The average hardness of fabricated tyne from old leaf springs of jeeps after heat treatment process was HRC 42.6 which is less than the Mitsubishi tynes. The hardness at the tip portion of fabricated tyne from old leaf springs of jeeps was maximum and it gradually decreased towards the holdon portion. But in the case of commercially manufactured tynes from old leaf springs of trucks, the average hardness was only HRC 36.3 because of improper heat treatment process adopted.

The wearing pattern of company-supplied tynes after 50 and 83 working hours are presented in **Table 2**. The data reveal that after 50 and 83 working hours the mean wear rate were 0.52 gm/h and 0.50 gm/h, respectively. The three wearing patterns of these tynes such as maximum, typical and minimum are shown in **Figs. 1** to **4**. Since the tyne surface is polished during field operations its mean wear rate has been reduced during the latter period. These tynes could be successfully used for 83 hours as per the periodical inspection of which 30 hours were engaged for dry tillage and 53 hours for wet puddling.

The weights of fabricated tynes from old leaf springs of jeeps after 50 and 76 working hours are presented in **Table 3** which shows that the mean wear rate of tynes after 50 and 76 hours of operation were 0.61 and 0.58 gm/h, respectively. It was observed that the tynes could be successfully used for 76 hours of operation, of which 24 hours were engaged for dry tillage and 52 hours for wet puddling.

The weights of tynes fabricated from old leaf springs of trucks after 50 and 74 working hours are presented in **Table 4**. The mean wear rate of these tynes after 50 and 74 hours were 0.64 and 0.60, respectively. The tynes could be successfully used for 74 working hours of which 29 hours were engaged for dry tillage and 45

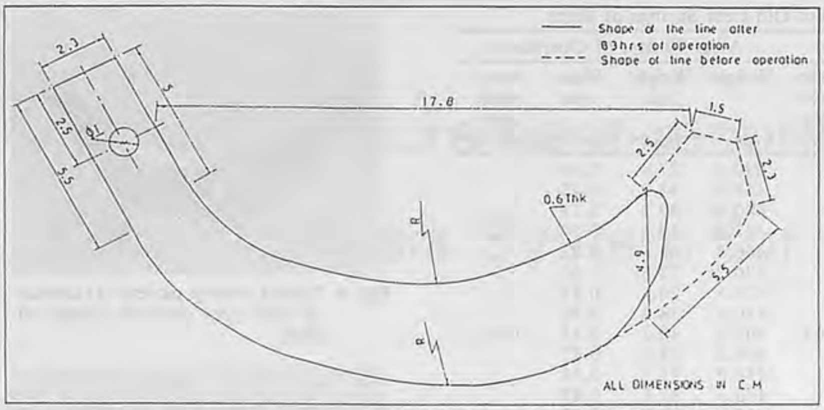


Fig. 1 Wearing pattern of maximum worn out Mitsubishi company supplied tyne No. 3 before and after 83 hours of operation.

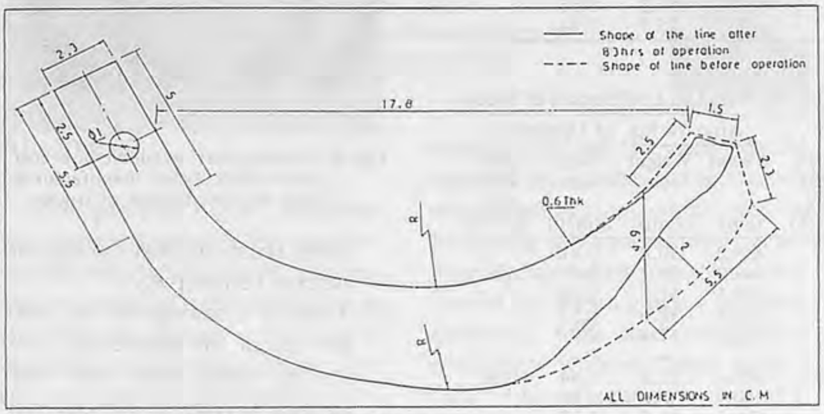


Fig. 2 Typical wearing pattern of a Mitsubishi company suppiled tyne before and after 83 hours of operation.

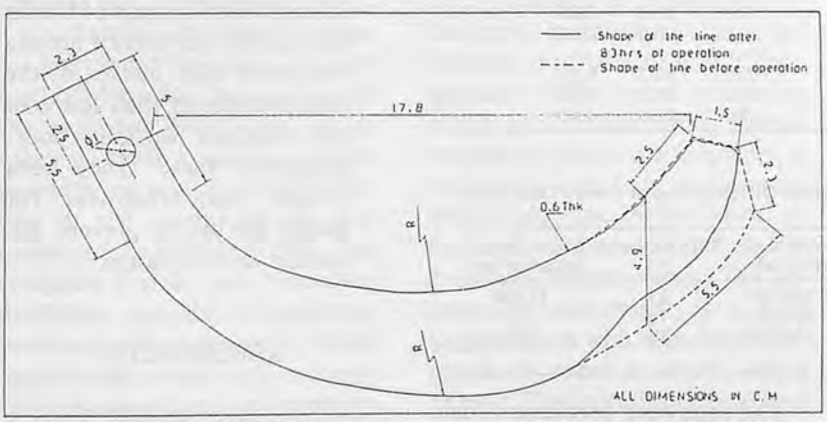


Fig. 3 Wearing pattern of minimum worn out Mitsubishi company supplied tyne No. 9 before and after 83 hours of operation.

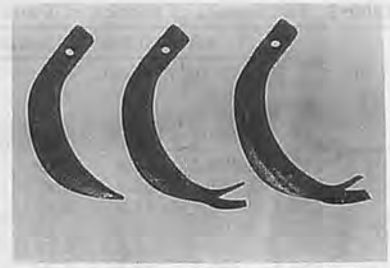


Fig. 4 Maximum, typical and minimum wearing patterns of Mitsubishi tynes.

hours for wet puddling. It was also observed that the tyne No. 6 was broken after 62 hours of operation and tyne No. 15 was distorted after 65 working hours.

Considering the wearing patterns of these three sets of tynes under field conditions, maximum mean wear rate of 0.64 gm/h after 50 hours of field operation was observed for the locally manufactured tynes from old leaf springs of trucks whereas the minimum rate for the Mitsubishi tynes was 0.52 gm/h. In addition, breakage and distortion of tynes were also noticed for the locally manufactured tynes from old leaf springs of trucks. The breakage and distortion of tynes were due to low HRC value obtained as proper heat treatment process was not adopted for them. The wearing pattern of fabricated and locally manufactured tynes were observed to be similar to the company-supplied tynes. One of the typical wearing patterns of fabricated tynes is shown in **Fig. 5**. It was also observed that the maximum, typical and minimum wearing of a particular tyne was irrespective of its position in the rotavator. The commercially available low-cost power tiller tynes manufactured from old leaf springs of trucks is shown in **Fig. 6**.

The requirement of power tiller tynes is approximately 5 000 sets per annum in the State of Orissa, India. The above requirement can be met from the existing old leaf springs of jeeps or trucks. Therefore, low-cost power tiller tynes can be fabricated out of these low-cost materials if proper heat treatment process is adopted. The power tiller owners of the State stand to be benefitted to a great extent.

The life and cost per working hour of these three different sets of power tiller tynes is shown in **Table 5**.

From the test it was observed that the Mitsubishi company tynes costing Rs. 1 300 per set could be used for 83 working hours costing Rs. 15.66/h. whereas the tynes fabricated from old leaf springs of jeeps cost only Rs. 400 per set and this could be used for 76 hours costing only Rs. 5.26/h. Thus the cost of operation could be reduced by about 66%. The effective operating time of the fabricated leaf

Table 3. Test Results of Fabricated Tynes from Old Leaf Springs of Jeeps

Tyne No.	Initial weight (gm)	After 50 hrs. of Operation				After 76 hrs. of Operation			
		Weight (gm)	Weight loss (gm)	Wear rate (gm/h)	Mean wear rate (gm/h)	Weight (gm)	Weight loss (gm)	Wear rate (gm/h)	Mean wear rate (gm/h)
1	517.5	498.1	19.4	0.39		490.1	27.4	0.36	
2	491.0	467.4	23.6	0.47		456.8	34.2	0.45	
3	500.1	458.6	41.5	0.83		440.8	59.3	0.78	
4	526.0	499.1	26.9	0.54		482.6	43.4	0.57	
5	529.6	485.6	44.0	0.88		466.5	63.1	0.83	
6	450.5	395.7	54.8	1.09		370.7	79.8	1.05	
7	502.1	483.1	19.0	0.38		475.5	26.6	0.35	
8	489.1	462.5	26.6	0.53		450.9	38.2	0.50	
9	503.5	475.7	27.8	0.56	0.61	463.2	40.3	0.53	0.58
10	517.8	476.5	41.3	0.82		459.2	58.6	0.77	
11	499.1	470.5	28.6	0.57		458.0	41.1	0.54	
12	502.3	480.4	21.9	0.44		466.5	35.8	0.47	
13	525.1	504.1	21.0	0.42		495.4	29.7	0.39	
14	479.0	452.4	26.6	0.53		440.8	38.2	0.50	
15	476.0	449.9	26.1	0.52		438.7	37.3	0.49	
16	505.5	458.6	46.9	0.94		438.6	66.9	0.88	
17	494.6	459.8	34.8	0.70		444.3	50.3	0.66	
18	476.0	457.7	18.3	0.36		450.1	25.9	0.34	

Fig. 5 Typical wearing pattern of fabricated tyne from old leaf springs of jeeps.

Fig. 6 Commercially available low-cost power tiller tynes manufactured from old leaf springs of trucks.

Table 4. Test Results of Locally Manufactured Tynes from Old Leaf Springs of Trucks

Tyne No.	Initial weight (gm)	After 50 hrs. of Operation				After 74 hrs. of Operation			
		Weight (gm)	Weight loss (gm)	Wear rate (gm/h)	Mean wear rate (gm/h)	Weight (gm)	Weight loss (gm)	Wear rate (gm/h)	Mean wear rate (gm/h)
1	500	479.8	20.2	0.40		469.2	30.8	0.41	
2	583	558.9	24.1	0.48		546.8	36.2	0.48	
3	630	585.7	44.3	0.88		568.5	61.5	0.83	
4	500	473.8	26.2	0.52		461.4	38.6	0.52	
5	480	431.7	48.3	0.96		412.6	67.4	0.9	
6	540	509.7	30.3	0.60		—	—	—	
7	440	419.2	20.8	0.41	0.64	407.4	32.6	0.44	0.60
8	480	453.9	26.1	0.52		441.7	38.3	0.51	
9	620	561.4	58.6	1.17		538.4	81.6	1.10	
10	550	519.9	30.1	0.60		506.9	43.1	0.58	
11	440	394.3	45.7	0.91		376.5	63.5	0.85	
12	435	410.5	24.5	0.49		399.3	35.7	0.48	
13	420	397.7	22.3	0.44		398.8	21.2	0.28	
14	410	381.3	28.7	0.57		369.4	40.6	0.54	
15	450	421.6	28.4	0.56		—	—	—	
16	420	374.9	45.1	0.90		359.8	60.2	0.81	
17	455	416.3	38.7	0.77		406.5	48.5	0.65	
18	430	409.4	20.6	0.41		400.4	29.6	0.40	

Table 5. Life and Cost per Working Hour of Three Different Sets of Power Tiller Tynes Under Field Condition

Source of power tiller tyne set	Initial cost (Rs)/set	Life of tynes (h)	Cost (Rs) / working hrs.
Mitsubishi tyne	1 300.00	83	15.66
Fabricated from old leaf springs of jeeps	400.00	76	5.26
Locally manufactured from old leaf springs of trucks	430.00	74	5.81

spring tynes is nearly at par with the Mitsubishi company tynes whereas the cost per set of these tynes has been reduced by Rs. 900. Even though the locally manufactured tynes from old leaf springs of trucks is gaining popularity among the power tiller owners because of their low cost, these tynes need proper heat treatment to prevent distortion and breakage.

Conclusion

The following conclusions can be derived from the above study:

i. The hardness and composition of old leaf springs of jeeps and trucks are suitable for fabrication of low-cost power tiller tynes if proper heat treatment process is adopted.
ii. The effective operating hours under field conditions are 83,76 and 74 hours for the Mitsubishi tynes, tynes fabricated from old leaf springs of jeeps and locally manufactured tynes from old leaf springs of trucks, respectively.
iii. There is a savings of Rs. 900 per set in the fabricated leaf spring tynes from old leaf springs of jeeps in comparison to Mitsubishi company tynes.
iv. Locally manufactured tynes from old leaf springs of trucks has gained popularity among the power tiller owners of the state because of their low cost per effective working hour. However, these tynes need proper heat treatment for longer life and to prevent distortion and breakage.

REFERENCES

1. Anonymous Annual Report, 1990-91. All-India Co-ordinated Research Project on Intensive Testing of Power Tillers and Research and Development of New Machines to Make them Versatile, OUAT, Bhubaneswar.
2. Sakai, Jun and Hai, Lam Van, 1980. Production Technology of Japanese Rotary Blades for Rotary Tillage, Agricultural Mechanization in Asia, Africa and Latin America: Vol. XI, No. 3, 17-23.

■■

Force Measurement-recording and Data Analysis System for Tillage Tools

by
Santos Gabriel Campos Magana
Senior Researcher
Agric. Mechanization Dept.
National Agricultural Research Institute
Apdo. Postal 429 Veracruz Ver.
Mexico

Brian M.D. Wills
Senior Lecturer
Faculty of Agric. and Biological Science
University of Newcastle Upon Tyne
Newcastle Upon Tyne
UK

Abstract

The present paper describes the system employed for measuring the magnitude of soil reaction forces acting on a disc coulter and tine furrow opener system on a precision no-till maize planter for tropical regions. The system comprises an improved design of an octagonal ring transducer for two dimensional force measurements, a six channel data logger system for high speed digitation, and the methodology for the analysis of the recorded data using power spectral density analysis which provides an accurate determination of the magnitude and frequency of the forces involved. The complete system and procedure described provides information necessary for planning tillage experiments where an accurate force measurement and analysis is required.

Introduction

The requirements of knowing the precise magnitude adn direction of the soil reaction forces, horizontal and vertical, acting on a particular agricultural implement for optimum design requires the use of a transducer for accurate measurement of these parameters. One of the most useful types of transducer is the extended octagonal ring, which has the following advantages over other transducers when precision location of the strain gauges has been achieved: high and predictable sensitivity without large deflections; insignificant cross sensitivity; no frictional parasitical forces on the mounting; relatively small size; accuracy as a function of the strain, independent of the load location, etc. An appropriate complement of the forces measuring transducer is the recording system. This has to match the frequency at which the soil fails in order to obtain accurate measurement of the force magnitude and frequency of the failure planes. The appropriate equipment is a data logger system with high speed digitation in order to avoid signal aliasen. The analysis of the recorded random data requires to be transformed from time domain to frequency domain in order to determine the significant frequency soil failures and to differentiate from other frequencies such as the implement and transducer frequencies. The appropriate analysis can be conducted by using power spectral analysis.

Transducer Design Considerations

An extended octagonal ring transducer (ORT) was designed and constructed by taking into consideration the maximum moment expected during the implement evaluation (600 Nm) and by considering a stiffness ($K = l/r$) of 1.6 which provided a moment sensitivity ($Ms = \epsilon Ebt^2/M$) of 0.40, from equation 1.

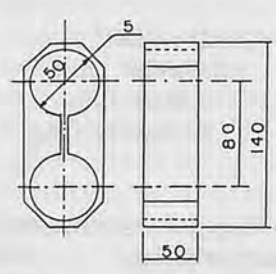


Fig. 1.1 General dimensions of the designed extended octagonal ring transducer.

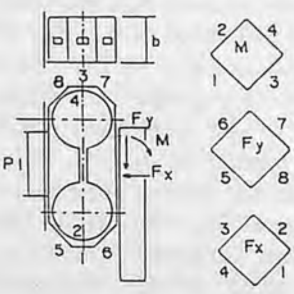


Fig. 1.2 Full wheatstone bridge wiring diagram for the different gauge arrangements (Fx, Fy and M).

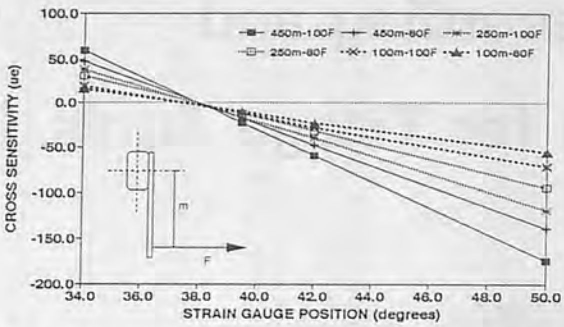


Fig. 2 Cross sensitivity error. 70mm PLATE/100. 450mm POSITION/0.443HF

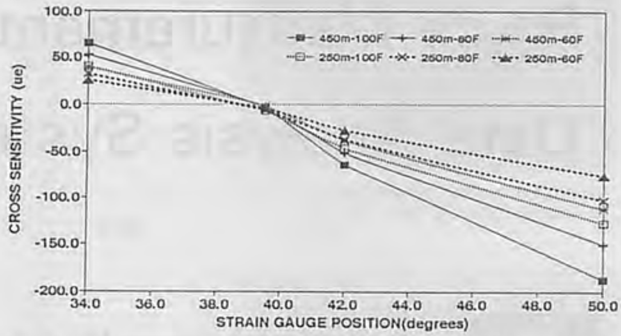


Fig. 3 Cross sensitivity error. 56mm PLATE/250-450mm POSITION/0.443HF

$$K = 6.626 - 19.63Ms + 21.142Ms^2 - 8.699Ms^3 \quad (1)$$

All these characteristics were combined into a developed computer programme in order to obtain the specific dimensions of the desired ring (**Fig. 1**). The selected material was steel with a maximum tensile stress of 384 MPa. The location of the gauges were selected according to the suggestions made by Godwin (1977) at $\theta_{34°}$ and $\theta_{90°}$ for the node location of the horizontal (F_x) and vertical (F_y) force, respectively. During the initial stages of calibration the gauge located at $\theta_{34°}$ showed a high cross sensitivity error due to F_x and also being affected by the location of the loads. Other gauges were attached at $\theta_{50°}$ and $\theta_{42°}$ and also three different plate lengths were used for ring evaluation (**Fig. 1**). The cross sensitivity error due to the different gauge locations plate length combinations are shown in **Figs. 2** and **3**. These figures showed that the node for Fx was located at $\theta_{38°}$ for Pl = 70 mm and $\theta_{39°}$ for Pl = 56 mm. Three other gauges were attached, two to the mentioned positions and another at $\theta_{39\ 1/2°}$. This last gauge was located opposite to the gauge at $\theta_{39°}$ in order to obtain another gauge location at $\theta_{39\ 1/4°}$ by using a half Wheatstone bridge arrangement (**Fig. 4**). The results are shown in **Table 1**. From these it can be appreciated that zero cross sensitivity was obtained for F_x at $\theta_{39\ 1/4°}$ completely independent of the load location. The equations below show the experimental strain sensitivities as a function of the ring characteristics:

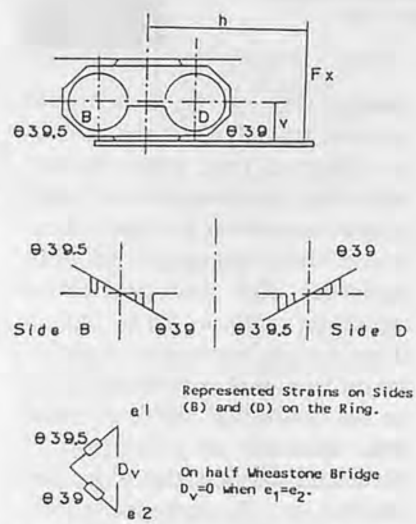


Fig. 4 Gauge arrangement of ($\theta_{39°}$ in C) with ($\theta_{39\ 1/2°}$ in T) for obtaining as average ($\theta_{39\ 1/4°}$) gauge position in half wheatstone bridge arrangement.

$$\epsilon_{90°} = 2.12Fxr/Ebt^2 \ldots 1.639\mu VN^{-1}V_{ex}^{-1}$$

$$\epsilon_{39\ 1/4°} = 2.24Fyr/Ebt^2 \ldots 1.732\mu VN^{-1}V_{ex}^{-1}$$

Data Logger Instrument Characteristics

The data logger system is integrated by a personal computer with an IBM IEEE-488 standard interface bus card which acts as the controller of the system, a six channel amplifier with one excitation voltage and a gain scale ranging from 100 to 10 K and an analogue to digital converter system. The digital converter system consists of six differential analogue input voltage modules (ANIDS) with a minimum full scale of 1 mv. and a maximum of 10 v., a high speed analogue to digital conversion control (HSC), which provides the facilities to the

Table 1.1. Slope of Cross Sensitivity Errors as a Function of Plate Length

Gauge locations (θ)	plate length (mm)		
	80	70	56
34°	−0.137	0.091	0.093
42°	−0.060	−0.100	−0.103
50°	0.038	−0.269	−0.283

[a]with (Fx) Load location at 250 mm.

Table 1.2. Slope of Cross Sensitivity Error at ($\theta_{39\ 1/2°}$) due to the Load (Fx) Position.

Plate length (mm)	Load locations (mm)		
	100	250	450
56	−0.023	−0.016	−0.007
70	−0.030	−0.038	−0.053

Table 1.3. Slopes of Cross Sensitivity Errors due to (Fx) at Different Gauge Locations

Gauge location (θ)	load (Fx) 450	position (mm) 250
39°	−0.013	−0.018
39 1/2°	−0.007	−0.016
39 1/4°	0.000	0.000

[a]with 56 mm Plate Length.

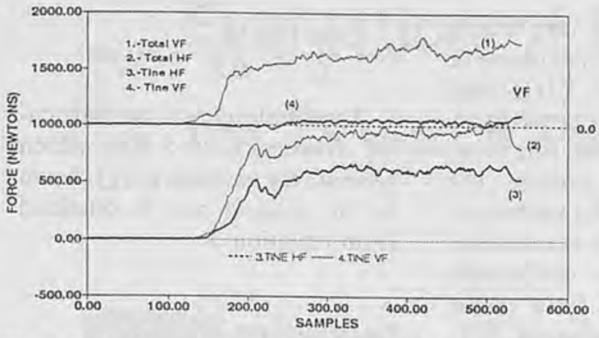


Fig. 5 Vertical and horizontal force. DISC COULTER-TINE OPENER SYSTEM

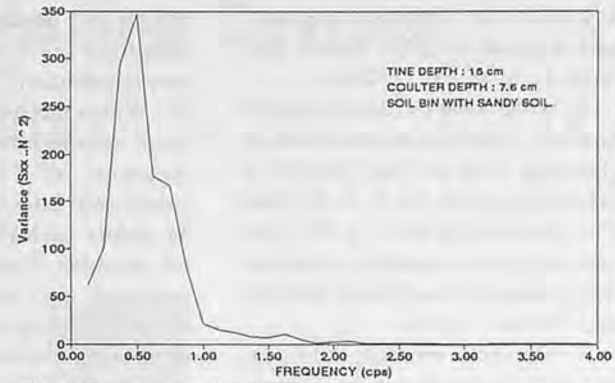


Fig. 6 Power spectral density.

system for high speed digitation of analogue signals at fixed intervals. There is also a 12-bit resolution Analogue-to-Digital converter module (A-12D) which accepts data from an analogue signal conditioning module and converts it into digital form for the IEEE-488bus. The complete system is capable of sampling six different inputs at the same time, ranging from 975 to 625 (10^3) samples per second. During the sampling process up to six graphs are plotted on the computer screen in x-y coordinates. The (X) axis is the samjpling time which ranges from 0-5 minutes and the (Y) axis is the output provided by the different analog inputs and ranges from 0-4 095 binary numbers. The 0-4 095 scale can be modified independently for each channel depending upon the appropriate scale and the magnitude of the amplified input signal. The system also provides the facility for detecting force directions (upwards and downwards). This is achieved by offsetting the zero reference for a given channel at the centre of the 0-4 095 scale. The adjustments for the appropriate output ratio (Conversion ratio between the voltage input signal and its equivalent to the real input which could be measured in Newton) is done in the CAL-DAT file provided with the software. The system is also provided with the facility for including a secondary (Y) axis scale for one of the channels. **Fig. 5** gives an example of the graphs plotted during the recording of data. The total vertical and horizontal froces of the coulter-tine opener system and the soil reaction forces due to the tine opener, are shown.

Data Analysis

The reproduction of a discreet random signal that has been digitized depends largely on the sampling interval and the limits to which cycles in the signal can be recovered and is mostly determined by the choice of the sampling period (Δt). Four main types of statistical function are used to describe the basic properties of random data: (a) mean square values, (b) probability density functions, (c) autocorrelation functions and (d) the power spectral density functions (Bendat and Piersol, 1986). The mean square value presents a rudimentary description of the intensity of the data. The probability density function presents information concerning the properties of the data in the amplitude domain. The auto correlation function and the power spectral density function present similar information in the time domain and frequency domain, respectively.

The periodicity at which the soil reaction force has been recorded depends upon the length of the soil failure planes (c, in metres), which is largely a function of the soil paramenters and depth of the tool (Sohne, cited by Licsko and Harrison, 1988), and by the working velocity (V, in m/s) of the implement. This frequency (f_c) can be expressed as follows:

$$f_c = V/c \text{ Hz}$$

which suggests that for determining the real magnitude of the soil reaction forces it is only necessary to consider the data which appears at the particular frequency (f_c) rather than to take the sample mean (μ) of the data which has a high total variance (σ^2). The system of analysis suggested for determining the frequencies with the major partial variances [Sxx(f)] is the Power Spectral Density Function (PSD) (Licsko and Harrison, 1988). The PSD can be defined as the distribution of variance (mean square value) of a time history over the frequency.

There are four basic requirements which have to be met which are mostly concerned with data collection and record length and how these two quantities have to meet certain specifications (Jenkins and Watts, 1968).

1. The sampling interval (dt) must be small enough so that the spectrum can be estimated in the range of interest ($0 < fc < 1/2\Delta t$). The frequency f_N =

$1/2\ \Delta t$ is the Nyquist frequency and is equal to ($2f_c$). Hence (Δt) must be at most, ($1/2f_c$).

2. Care must be taken to avoid aliasing. This can be achieved by choosing (Δt) so that [Sxx(f)] is effectively zero for $f > (1/2\Delta t)$ The choosing of $\Delta t = 1/(4f_c)$ for accurate power spectra measurements should be sufficient (Bendat and Piersol, 1986).

3. For finite records, the extent to which the peaks can be estimated is influenced by the variance of the estimator. Hence, to be able to trust the fine structure in the spectrum, it must be possible to tie down the estimate to given stability. This may be accomplished by specifying the number of degrees of freedom (v). The larger ($v > 30$) the lower the percentage of the proportional erro will be. [for example a ($v = 30$) represents a 30% proportional error at 80% CI, from a CHI-Sq table] then the record (sec) can be expressed as,

$$T = v/2B_e = N \cdot \Delta t$$

where, (T) is the record length (sec) and (B_e) is the equivalent resolution bandwidth (cps).

4. The fourth consideration is the size sample (N) and this is given by:

$$N = v/(2B_e \cdot \Delta t) = T/\Delta t$$

Other important aspects to be considered during the analysis are the level of error that can be accepted during data collection and data analysis. This can be expressed by,

$$\epsilon = 1/\sqrt{(B_e.T)}$$

where, (ϵ) is the normalized standard error (standard deviation relative to the value being estimated, (i.e., percentage error, or in statistical terminology the "coefficient of variation").

The programme Spectrum (X{t}, M) performs fast fourier transform (FFT) analysis of one or two sequences (X{t}, Y{t}) using the Welch method of power spectrum estimation. The (x{t}) sequences of N points are subdivided into K (B_e) sections of M points each (M is the number of complex Fourier coefficients averaged and must be a power of two.) Using an M-point FFT, successive sections are Hanning windowed, FFT'd and accumulated.

The final part of the data analysis using PSD is by plotting the Spectrum function [$Sxx(f) = \int \Gamma xx(f)\, df$] against the Nyquist frequency (f) and from there detecting the frequencies of {Sxx(f)] peaks which contribute more to the total variance (σ^2) of the data set. The magnitudes of the forces are extracted from the frequency band of interest. This can be expressed as follows (Bendat and Piersol, 1986):

$$X_t = \mu + \sqrt{\int_{f'}^{f''} \Gamma xx(f)\, df}$$

where, (Sxx) is the eight of the spectrum histogram at a particular frequency, (Γxx) is the total area under the spectrum plot and is equal to the total variance (σ^2) of the time series (X{t}), (μ) is the mean value [$\Sigma(xi)/N$] of the time series (X{t}) and (f' and f'') are the frequencies intervals at the peak of interest.

An example of the power spectral density plot is given in **Fig. 6**. This shows where the variance of the force involved is heavily concentrated as a function of the soil failure frequencies (f_n). The peak shows that every 0.5 Hz there is failure then by considering the travel speed ($V = 5$ cm/sec), at which this tine opener was evaluated, the distance between failure planes can be obtained and is given by:

$$c = \frac{V}{f_n} = \frac{5}{0.5} = 10 \text{ cm}$$

The amplitude at that particular frecuency (0.5 Hz) which generate the variance (S_{XX}) shown in the spectral plot is obtained from equation 2.

Conclusions

The corrected gauge location on the ORT at $\theta_{39\ 1/4°}$ guaranties the accurate measurement of the F_y reaction forces without this being affected by cross sensitivity error.

The 56 mm plate length which corresponds to 70% of the distance between ring centres, was shown to be the most appropriate for getting the best performance of the ORT.

The data logger system described provides all the high speed digitation needed for data recording of most tillage tools working at high speeds.

Power spectral density analysis is a powerful tool which allows the right data interpretation for the evaluation of tillage implements, and also provides the facility for their dynamic analysis.

Appendix.

Working Example for Computing the Spectra

Consider a distance between shearing failure planes (c) on a tillage tool of 5 cm and a travel rate (Vo) of 2 m/s. So the expected frequency will be

$$f_c = \frac{Vo}{c} = \frac{2}{0.05} = 40Hz$$

The sampling period is given by considering the Nyquist frequency in order to avoid "aliasing"

(Continued on page 21)

Evaluation of Seeding Devices for Dryland Paddy

by

B.K. Behera
Lecturer
Dept. of F.M.P.
College of Agril. Engg. and Tech.
OUAT, Bhubaneswar
Orissa, India

P.K. Sahoo
Research Assistant
RBDTC, Dept. of F.M.P.
College of Agril. Engg. and Tech.
OUAT, Bhubaneswar
Orissa, India

S. Swain
Chief Research Engineer
FIDU
College of Agril. Engg. and Tech.
OUAT, Bhubaneswar
Orissa, India

D. Behera
Lecturer
Dept. of F.M.P.
College of Agril. Engg. and Tech.
OUAT, Bhubaneswar
Orissa, India

Abstract

An evaluation of different seed-cum-fertilizer drills (SCFD) were undertaken in order to select the most suitable in Orissa condition for dryland agriculture. Of the four SCFDs evaluated, the Naveen which was developed at CIAE, Bhopal gave the best performance with an overall performance index of 0.880. Among the seeding devices, the GSFC seed-cum-fertilizer drill was suitable for small and marginal farmers for its low initial cost and better overall performance over the CAET SCFD.

Introduction

One of the most important factors that influences the germination of seeds is the uniformity of distribution of seeds at proper depth. This results in a better crop stand thereby increasing the crop yield. By putting the seeds in line, inter-cultural operations like weeding, hoeing and top dressing of fertilizer become easy besides being time saving and economical.

In the state of Orissa 76% of the total number of farmers are under small and marginal categories and they posses only 40% of cultivable land. The average size of land holding is 1.6 ha. Due to small and scattered land holding pattern, the farmers mainly depend upon draft animals for farm power. Therefore, suitable bullock drawn seed-cum-fertilizer drills are essential for the farmers to complete the seeding operation in time.

The present experiment was conducted for three years (1988-1990) to evaluate the performance of different SCFDs and to determine the best one for Orissa conditions.

Materials and Methods

Four SCFDs were evaluated in 1990 at the Dryland Agriculture Research Project Area, OUAT, Bhubaneswar. These SCFDs were shortlisted, based on the performance of eight different SCFDs which were evaluated in the previous years (1988 and 1989). The details of SCFDs are given in **Table 1**. The soil properties of the test site is coarse textured, well drained, strongly acidic in nature and low in nutrient contents. The soil type is basically sandy clay loam.

The field trials were conducted on plot size of 400 m^2 (40 × 10 m) laid out in a randomized block design with three replications. Paddy variety DR 92 was sown with recommended doses of farm yard manure (FYM) (5 t/ha). Fertilizer was applied to all the treatments at the rate of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha. Twenty-five % of N fertilizer and full doses of P and K fertilizers were applied at the time of sowing the seeds. The rest, 75% of N, was appied in two splits, i.e., 50% at the time of tillering and 25% at the time of

Acknowledgement: The authors are grateful to the Indian Council of Agricultural Research for providing financial assistance to carry out this experiment.

Table 1. Main Features of Seed-cum-fertilizer Drills

Treat-ment	Name of SCFD	Width of coverage (cm)	Seed metering device	Fertilizer metering device	Type of furrow openers	Draft range (kgf)	Weight of the machine (kg)	No. of persons engaged
T_1	Naveen	3 × 20	Aluminium Fluted rollers (12 nos)	Aluminium Fluted rollers (8 nos)	Shoe	45-65	65	1
T_2	Implement Factory	3 × 20	PVC Cell type roller	Gravitational dropping with sliding plate	Shovel	32-50	70	1
T_3	CAET	5 × 20	Manual	Manual	Shovel	25-30	18	3
T_4	GSPC	2 × 20	Manual	Manual	Shovel	18-21	20	3

Table 2. Weight Distribution of Seed-cum-fertilizer Drill Performance Parameters

Parameters	Weight (w_i)
Draft	0.20
Field capacity	0.20
Plant spacing uniformity	0.20
Plant population ha^{-1}	0.10
Field efficiency	0.05
Cost of operation ha^{-1}	0.05
Facility for simultaneous placement of seed and fertilizer	0.05
Depth of placement desirable/undesirable	0.05
Row width adjustability	0.05
No. of labour required for operation	0.04
Yield	0.01
	1.00

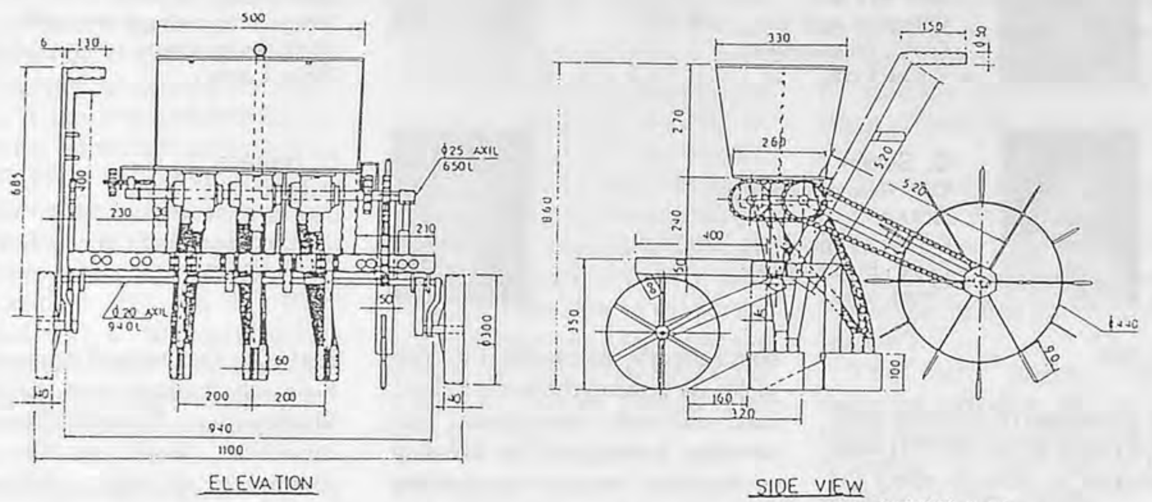


Fig. 1 Naveen seed-cum-fertilizer drill.

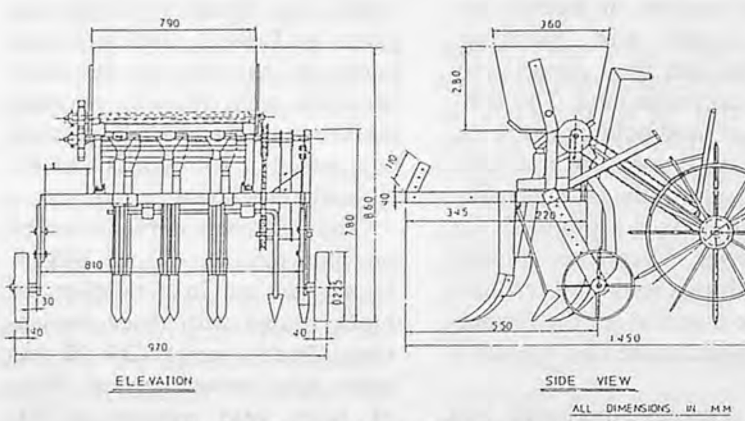


Fig. 2 Implement factory seed-cum-fertilizer drill.

panicle initiation stage.

Considering all the parameters, the overall performance index (OPI) was analyzed on the basis of the following formula (Mayande, 1989).

$$OPI = \sum_{i=1}^{n} W_i R_i$$

where,

OPI = Overall Performance Index

W_i = Weightage of ith parameter

R_i = Rating of the ith parameter based on its observed/calculated value.

The performance parameters and their individual weights are presented in **Table 2**.

The cost of inputs and different operations were calculated in order to determine the benefit-cost ratio for each SCFD. A tractor-drawn, nine-tyne cultivator was used for land preparation. The cost of inputs like seed, fertilizer and FYM were calculated taking into account the rate of application and the prevailing market prices of each item. The cost of weeding, harvesting, threshing and cleaning were calculated on the basis of the actual average expenditure incurred during the field experiment. The cost of operation of each SCFD was calculated from their effective field capacity taking into account the bullock and labour charges. The total return was calculated from the grain and straw yield.

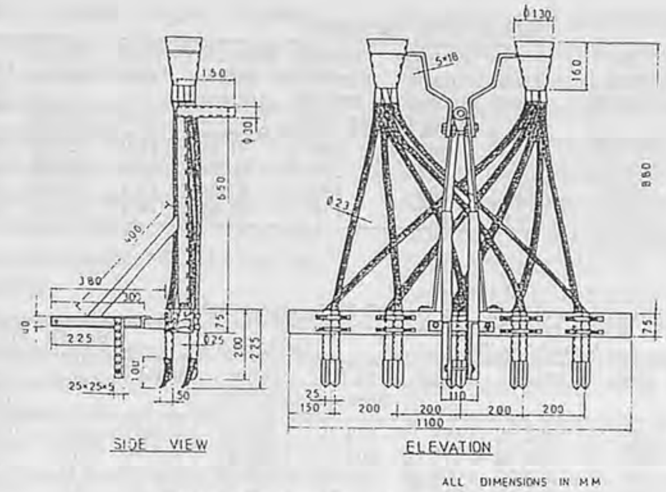


Fig. 3 CAET seed-cum-fertilizer drill.

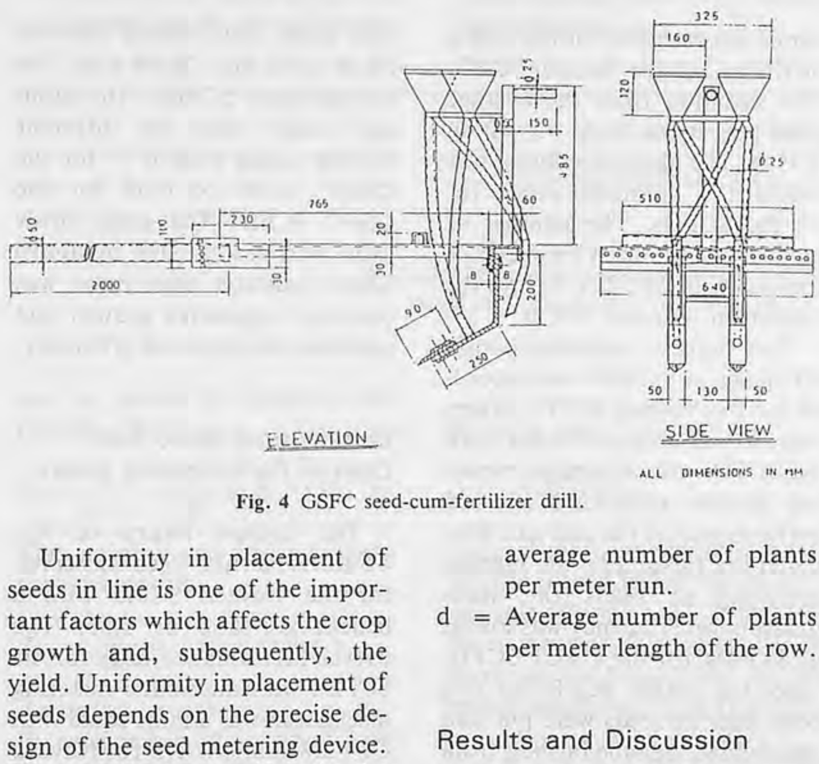


Fig. 4 GSFC seed-cum-fertilizer drill.

Uniformity in placement of seeds in line is one of the important factors which affects the crop growth and, subsequently, the yield. Uniformity in placement of seeds depends on the precise design of the seed metering device. To quantify how uniformly the seeds are placed in the soil along the line, the following equation was used (Senapati et al, 1988).

$$S_e = 100\ (1 - Y/d)$$

where,

S_e = Seed distribution efficiency of seeding device.

Y = Average numerical deviation of number of plants per meter length of a row from average number of plants per meter run.

d = Average number of plants per meter length of the row.

Results and Discussion

The Parameters

The seed-cum-fertilizer drill parameters which included the average strip spacing, field capacity, field efficiency average draft requirement and total energy utilization for seeding operations are in **Table 3**.

The row-to-row spacing in each of the SCFDs was adjusted at 20 cm. The strip spacing, which is the distance between two rows of two adjacent strips of the SCFD varied from 21.20 to 21.56 cm from the desired spacing of 20 cm. The variation of strip spacing from the desired row spacing was about 8%. This gives credence to the better manoeuvarability of all the SCFDs. The strip spacing which also depends on the skill of the ploughman should be equal to the row spacing as far as possible in order to facilitate easy mechanical interculture operations like weeding and hoeing.

The actual seed rate in the field condition was highest in Naveen SCFD. An increase of 9.28% from the predetermined seed-rate was recorded in Naveen SCFD. The reason may be the falling of excess seeds into the seed tubes due to vibration while in operation. The actual seed rate in the case of the implement factory SCFD was 78.23 kg/ha. The actual seed rate for the CAET and GSFC was kept constant at 75 kg/ha. The average depth of placement of seeds has been recorded to vary from 3.70 cm to 4.25 cm. The variation was not significant.

The average draft requirement of all the SCFDs was within 60 kgf with maximum draft of 57.70 kgf for the implement factory SCFD followed by 53.50 kgf for the Naveen SCFD. The draft requirement for the other two SCFDs where there was manual metering of both seed and fertilizer, varied from 21.05 kgf to 26.75 kgf for GSFC and CAET SCFDs, respectively. The average draft produced by a pair of bullock of this region is 60 kgf. Considering the stamina of a pair of bullocks, all four SCFDs were suitable to the Orissa region without any modification in reducing the draft requirement.

The field capacity and field efficiency were maximum for the CAET SCFD because of wider coverage than other SCFDs. The CAET SCFD covered one meter in

Table 3. Seed-cum-fertilizer Drill Parameters

Treatment	Variation from desired strip spacing (per cent)	Actual seed rate in field condition (kg/ha)	Average draft (kgf)	Actual field capacity (ha/h)	Field efficiency (percent)	Total energy utilization (MJ/ha)
T_1	6.05	81.96	53.50	0.073	80.21	204.36
T_2	7.80	78.23	57.70	0.080	76.92	188.40
T_3	7.65	75.00	26.95	0.170	83.59	188.84
T_4	6.00	75.00	21.05	0.059	74.04	309.24

Table 4. Crop Parameters

Treatment	Average plant population per sq.m.	Average number of panicles per sq.m.	Seed distribution efficiency (per cent)	Grain yield (t/ha)	Straw yield (t/ha)	Grain straw ratio
T_1	247	200	91.38	18.93	25.06	0.76
T_2	243	207	90.84	16.82	23.68	0.71
T_3	233	190	87.84	16.35	20.48	0.79
T_4	232	178	89.61	14.92	21.64	0.69

Table 5. Benefit-cost Ratio and Overall Performance Index

Treatment	Return, Rs/ha			Cost, Rs/ha			Benefit cost ratio	Overall performance index
	Grain	Straw	Total	SCFD operation	Other operations	Total		
T_1	3 691.35	1 002.40	4 693.75	122.79	3 339.59	3 462.59	1.35	0.880
T_2	3 279.90	947.20	4 227.10	108.75	3 339.59	3 448.34	1.23	0.875
T_3	3 188.25	819.20	4 007.45	124.94	3 339.59	3 464.53	1.16	0.754
T_4	2 909.40	865.60	3 775.00	223.78	3 339.59	3 563.37	10.6	0.769

one run. The field capacities of the Naveen and Implement Factory SCFDs are almost equal (13.75 and 12.50 h/ha, respectively). The field capacity for the two row GSFC SCFD was 16.94 h/ha. The field efficiencies for all the SCFDs were above 74% with a maximum of 83.59% for the CAET SCFD. This shows that all the SCFDs worked nicely in the field without causing much interruption during their operation.

The total energy utilization for seeding operations for different SCFDs shows that GSFC requires more energy than any other SCFDs. Among all the SCFDs GSFC puts seeds and fertilizer in two rows and requires three persons for seeding operation. For the other three SCFDs the total energy utilization is almost equal inspite of the fact that the number of persons required to operate the Naveen and Implement-Factory SCFDs is only one compared to for the CAET SCFDs. The total energy utilization was calculated by multiplying the bullock pair hour and human hour utilized for seeding operation with their equivalent energy per hour (10.14 MJ/h for a pair of bullock and 1.94 MJ/h for one person).

Crop Parameters

The crop parameters which include average plant population and number of panicles/sq.m, seed distribution efficiency, grain and straw yield and straw-grain ratio are presented in **Table 4**.

The plant population/sq.m varied between 232 for the GSFC SCFD to 247 for Naveen SCFD. The variation from the average plant population/sq.m was within 3.35%. The plant population was within the optimum range for all the SCFDs. The number of panicles/sq.m varied between 178 for the GSFC SCFD to 207 for the Implement Factory SCFD.

The highest seed-distribution efficiency at 91.38% was recorded for the Naveen SCFD. Otherwise, it was above 90% for both the SCFDs with automatic metering devices indicating a good performance of the cell and fluted roller types. For the manual metering of seeds the seed-distribution efficiency was lowest at 87.84% for the CAET SCFD. Since the CAET SCFD has five rows and the seeds were put into one funnel, the tube farthest from the seed funnel got less number of seeds as compared to the tube nearest to the funnel.

It is observed that the highest and lowest grain yield of 18.93 q/ha and 14.92 q/ha have been recorded for the Naveen and GSFC SCFDs, respectively. The highest plant population and panicles/sq.m was observed for the Naveen SCFD where there was an increase of 12.94% yield from the average yield of all the treatments. The straw yield varied between 25.06 q/ha and 20.48 q/ha for the different SCFDs. The grain and straw ratio for different SCFDs varied from 0.79 for the CAET SCFD to 0.69 for the GSFC SCFD. The grain straw ratio was nearly 70% or above which indicates that there was optimum vegetative growth and optimum nitrogen use efficiency.

Benefit-cost Ratio and Overall Performance Index

The highest return of Rs. 4 693.75/ha has been observed for the Naveen SCFD with a benefit-cost-ratio of 1.35. The overall performance index for the SCFDs with automatic metering mechanism was almost equal with OPI 0.880 and 0.875 for Naveen and Implement Factory SCFDs, respectively. For the SCFDs with manual metering of seed and fertilizer the OPI of 0.769 was highest for the GSFC SCFD **(Table 5)**.

Conclusion

On the basis of field trials of the SCFDs the following conclusions are drawn:

1. The highest return, highest benefit cost ratio, better vegetative growth and highest seed distribution efficiency was observed for the Naveen SCFD.
2. The overall performance index which is a measure of the performance of the SCFD in total was also highest for the Naveen SCFD.
3. Between the two SCFDs with manual metering of seed and fertilizer, the GSFC SCFD gave a higher OPI of 0.769 over the CAET SCFD (0.754) although the later had the highest field capacity field efficiency and lowest cost of operation.
4. Considering all the seed-cum-fertilizer drill parameters and crop parameters it is suggested that medium and large farmers in Orissa should use Naveen SCFD whereas the small and marginal farmers should use GSFC SCFD for seeding operations. The latter, being a low cost seeding device, will be acceptable to the smal farmers besides being used for other crops like wheat, ragi, mustard, peas and grams. The Naveen SCFD can also be used for crops like wheat, gram, soybean, safflower, sunflower other than paddy by changing the flutted ruller with minor adjustment.

REFERENCES

Annonymous (1987). Agricultural Statistics of Orissa, Directorate of Agricultural and Food Production, Govt. of Orissa, Bhubaneswar.

Annonymous (1990). Annual Report 1990, I.C.A.R. Ad hoc Scheme on Evaluation and Adoption of Bullock-drawn Seed-cum-fertilizer Drills for Orissa, O.U.A.T., Bhubaneswar.

Senapati, P.C., Mohapatra, P.K. and Satapathy, D. (1988). Field Performance of Seeding devices in Rainfed Situation in Orissa, India, AMA 19(1): 35-38.

(Continued from page 16)

Force Measurement-recording and Data Analysis System for Tillage Tools

and is given by (Bendat and Piersol, 1986).

$$\Delta t = \frac{1}{4f_c} = \frac{1}{160} = 62.5 \times 10^{-3}\text{sec}$$

The sampling rate for this tillage tool should be:

$$S_R = \frac{1}{\Delta t} = 160 \ samples/s$$

Recorded Length

By considering 30 degree of freedom (v) which will represent a 30% proportional error at 80% CI. Also consider that it is necessary to differentiate frequencies between 2 Hz = Be. The record length will be given by:

$$T = \frac{v}{2B_e} = \frac{30}{4} = 7.5 \ Sec$$

$$N = \frac{T}{\Delta t} = \frac{7.5}{6.25 \times 10^{-3}}$$
$$= 1200 data...$$

For performing the Spectral Analysis the record length has to be a multiple of two i.e. 2^n. Therefore, the number of data points has to be raised to, N = 2 048. So the record length has to be raised to,

$$T = N \times 6.25 \times 10^{-3} = 12.8 \ Sec$$

The expected standard error will be:

$$\epsilon_o = \frac{1}{\sqrt{B_e T}} = \frac{1}{\sqrt{12.8 \times 2}} = 0.1976$$

REFERENCES

1. Bendat, J.S., Piersol, A.G., (1986). Random Data, Analysis and Measurement Procedures. *Second Edition, John Wiley & Sons.* New York, USA.
2. Cook, N.H., Rabanowics, E. (1963). Physical Measurement and Analysis. *First edition*, Addison Wesley Publishing Company, Massachusetts.
3. Goodwin, R.J. (1975). An Extended Octagonal Ring transducer for Use in Tillage Studies. *J. Agric. Engng. Res. Vol. 20, 347-352.*
4. Licsko, Z.J., Harrison, P.H. (1988). Acquistion and Processing of soil Reaction Forces on Tillage Tools. *Transactions of the ASAE, Vol. 3(2), 315-318.*

An Agricultural Implement for Non-inversion Tillage in Semi-arid Regions

by
H. Ortiz Laurel
Professor
Regional Center to Study Arid and Semi-arid Zones
Postgraduate College
Iturbide 73, Salinas de Hgo., S.L.P.
78600 Mexico

Abstract

Two tillage implements were designed and tested under dry land conditions to evaluate their performance and assess their potentials for soil moisture retention and soil erosion prevention. They differ from the disc and mouldboard ploughs used for primary tillage in such a way that there is no soil inversion. The soil fails in tension producing shear failure lines that reached the soil surface. There was minimum soil surface disturbance which is adequate to drill the crop in the same operation. The tools consisted of three loosening shanks with V-shaped sweeps working up to a depth of 300 mm with a cutting width of 2.0 m. The power requirement at this stage was over 75 kW although a better control of tractor wheelslip is needed. The design of several modifications to the early designs could anticipate a power demand of 65 kW.

Introduction

Most agricultural activities in dry climate regions depend on natural rainfall. Soil and water conservation are most important and the success of introducing new technology in such areas often depends on how the system can be adapted to it.

Soils in hot dry climates often have poor structure and low permeability, so that rainfall runs off readily. Under these conditions, it is unlikely that many stable forms of food production can be maintained without some form of cultivation, if only to provide for soil and water conservation. Cultivations must, therefore, prevent water movement on the surface, encourage infiltration, and control weeds while providing a seedbed in which crops can be readily established. In some cases, there is evidence that tillage beyond the minimum required to achieve these ends is of any benefit and much evidence that more tillage can increase the risk of water loss and soil erosion by wind and water.

Mechanized cultivations using conventional implements such as discs and mouldboard ploughs might break down the soil so finely that it washes or blows away, bury plant residues so completely that the surface rapidly becomes relatively impermeable under rainfall or, in some conditions, create below tillage depth a dense layer or pan which holds up water movement down the soil profile. The detrimental effects of these practices increase in semi-arid climates, where a change for alternative practices or the development of suitable tillage equipment is needed.

This paper presents the development of an implement for non-inversion tillage. This tool presents V-shaped sweeps attached to a shank performing a horizontal cut in the soil which fails in tension. Two prototypes were tested in order to assess their performance under semi-arid conditions. The power demand for a three loosening shanks implement with a working width of 2.0 m and at a depth of 300 mm was over 75 kW. Several modifications to the early designs could anticipate a decrease in power of 13%. This tool could be usable as a tillage and a direct drill equipment.

Literature Review

Tillage on agricultural soils in semi-arid regions face the growing problem of topsoil erosion through conventional farming methods. According to Hawkins (1967), dry land cultivation is usually most safely based on some form of tined cultivation for the primary tillage operation. Plant residues are retained in or near the surface, water enters easily and the typical cloddy and slightly ridge surface produced is resistant to erosion by wind and water.

The adoption of the stubble-mulch method in the 1940s (Bennett 1942), put in practice the process of protecting cultivated or bare land in such a way as to conserve soil and soil moisture by favouring infiltration and reducing surface evaporation through the use of a complete, or partial surface covering composed of some form of crop stubble or residue. This method involved special tillage operations that do not turn the soil over. Various configurations of tools used with the practice were tested. The most common type were implements with V-shaped sweeps in different variations for tilling the soil without burying the residue. Duley et al., (1942) showed the advantage of having angled blades attached at the bottom part of a rigid shank.

One of the main characteristics accomplished by such implements was that only a minimum amount of the surface should be disturbed or trenched by the shanks of the machine without undue clogging. Also, it should be possible to change the distance between the shanks. Although this equipment performed the cutting of the shed roots efficiently, they were quite adaptable to operate at shallow depths. On the other hand, sweeps must have overlap, and to have overlap they must be offset; that is, every other one is set ahead.

Materials and Methods

Due to the number of special characteristics that should be fulfilled by tillage operations of agricultural soils in semi-arid climates, there is need for a tillage implement that can widely meet these goals. Although the early designs were intended to destroy weeds they worked well at shallow depths with no soil inversion.

Fig. 1 Non-inversion plough (1st prototype).

Fig. 2 Non-inversion plough (2nd prototype).

Following the principles stated by Chase (1942) the configuration of the proposed design is similar to that of subsurface tillers with V-shaped sweeps **(Fig. 1)** with a pitch angle of 10 degrees. The blades were swept back at angles of 70 degrees. The design of the shanks to which the sweeps are attached were strong straight blades with 25 mm thickness. Three shanks were mounted on a double bar frame. In the operation of the implement, the sweeps run perfectly flat. Soil penetration is obtained through the suction of the leading point and the height lift of the blades, and a certain extent through the weight of the machine. The sweeps are strongly built, highly resistant to wear and have sufficient pitch to give the soil enough "throw" to pulverize it.

The sweeps of the second design **(Fig. 2)** had a pitch of 30 degrees. The approach angle of the tool shank and the length and lift angle of the leading point were changed to allow easy penetration in hard soil. The double bar frame had the provision for mounting the seed drill units.

A significant modification was the design of the V-sweeps which allowed that each shank is supported in three points only; the leading point and the rear heels of each blade.

The tractor wheelslip was measured by counting the number of wheel revolutions with the implement at work and in the transport position during the field trials.

The working width on both designs was 2.0 m with an overlap of 50-100 mm, which allowed the tractor to run over undisturbed soil in the next pass.

Results and Discussions

Several disadvantages were found with the first tool. The pitch of the blade was not as good as it was thought when the implement was allowed to work at the normal ploughing depth (250 to 300 mm). The soil was slightly lifted and went back to its position, without great shattering. Its best working depth was 150 mm where good control of weeds was performed. Overlap was necessary to obtain an even cut through the whole working width. Finally, the design of the blades tear the bottom of the tillage depth, producing a hard pan similar to that of a mouldboard or disc plough. Although the frame design of double bar configuration for mounting the shanks allowed them free movement, it was unnecessarily heavy.

The second design showed improved performance over the previous one. The pitch of 30 degrees in the blade lifts the soil over and put it under tension cracking along its natural failure planes and thus reducing the power requirement. At present it is estimated at over 75 kW for a three loosening shanks machine. The lift height of the blade was sufficient to cause shear failure

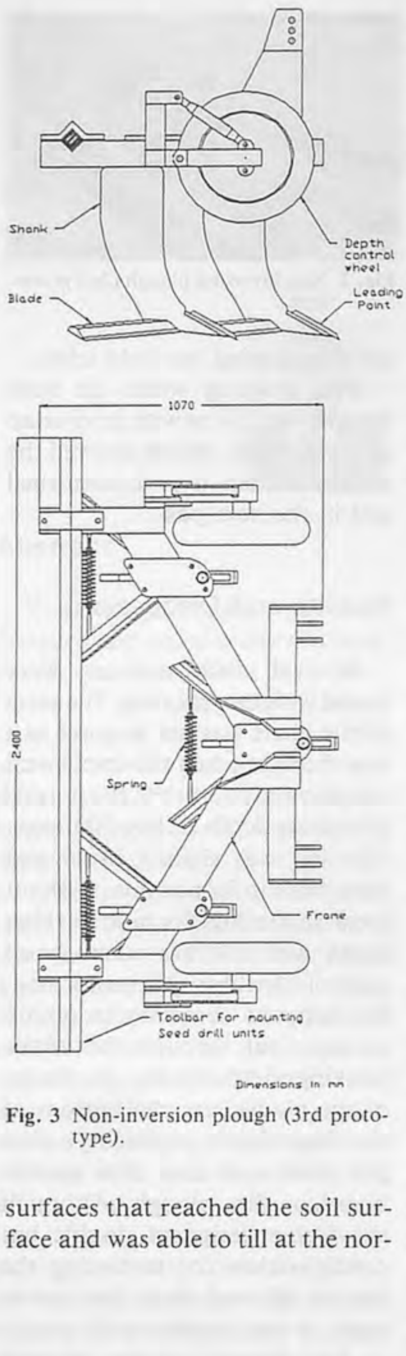


Fig. 3 Non-inversion plough (3rd prototype).

surfaces that reached the soil surface and was able to till at the normal ploughing depth satisfactorily with no soil inversion. At depths of 150 mm or less there was soil inversion and mixing. There was no tearing at the bottom because of the three suspension points feature, and there was also little furrowing caused by the shanks.

These considerations were taken into account in proposing a new frame configuration. This is a V-form structure (**Fig. 3**) that might allow free shank movement as the early ones but reducing weight. This frame would also have the provision for mounting the seed drill units on a toolbar.

The high demand for power could be justified in the sense that this tool is considered as a passive implement. In order to reduce this demand for power several modifications were sought so that the tool's blades might act as cutting knives. This could be done by attaching a spring between the blades.

The design proposed for the sweeps with a spring between both blades could aid in reducing the power requirement and would also help to work in stony soils. Hitting a rock at the wing part of the sweep throws such a wind or twist that can be absorbed by the spring and then released back when the obstruction has passed. This effect could be seen as a cutting knife. It is sought that the demand for power could be of 65 kW.

The little furrowing produced by the shanks could be minimized further by the use of rolling coulters ahead of each shank to cut a clean and narrow slot wide enough, allowing the shank to pass through with minimum soil disturbance.

The measured tractor wheelslip was 20 percent which is considered high. In order to reduce it, it is necessary to mount extra weight on the tractor rear axle. Further field testing of the third design is under way.

REFERENCES

Bennett, H.H. (1942). Conserving soil and water with stubble mulch. Agricultural Engineering. Vol. 23, No. 2, pp 37-38, 42.

Chase, L.W. (1942). A study of subsurface tiller blades. Agricultural Engineering. Vol. 23, Njo. 2, pp 43-45, 50.

Duley, F.L. and Russel, J.C. (1942) Machinery requirements for farming though crop residues. Agricultural Engineering. Vol. 23, No. 2, pp 39-42.

Hawkins, J.C. (1967). Systems of mechanization for agriculture in developing semi-arid countries. Proceedings of the Institution of Agricultural Engineers. Vol. 23, No. 2, pp 53-59. ■■

Mechanized Land Clearing and Tractor Traffic Effects on Agricultural Soil and Crop Growth

by
K. C. Oni
Professor and Head
Dept. of Agric. Engineering
University of Ilorin
Ilorin, Nigeria

J. S. Adeoti
Senior Lecturer
Dept. of Agric. Engineering
University of Ilorin
Ilorin, Nigeria

Abstract

To fully mechanize agricultural production, there is the ever pressing need to bring more land under cultivation. However, this should not be compromised with the need to protect agricultural lands from such deleterious effects of land clearing machines as excessive soil compaction.

An experiment was conducted on a land previously cleared mechanically to determine the influence of repeated tractor passes on soil compaction and growth of cotton. The treatments were No Tillage (NT), Disk Harrowing (D) and Disk Ploughing - Disk Harrowing (DD), respectively, each with varying number of tractor passes.

The result shows an increasing trend of soil compaction with increasing number of tractor passes. Plant growth on No tillage with zero tractor pass was better than for the other two treatments. The fact that disk ploughed - disk harrowed plots gave better overall crop performance than disk harrowed plot pointed to the need for deep ploughing to relieve subsurface compaction.

There is, however, the need to evolve guidelines on proper time to conduct land clearing operations for each ecological zone. Further tillage work is also needed to determine the yearly optimum number of tractor and equipment passes on agricultural soils, all aimed at limiting the damaging effects of those machines on agricultural land.

Introduction

For agricultural production, land clearing involves the removal of such unwanted vegetation as grasses and shrubs, and retention of the top soil for crop growth. The land clearing operation in which stumps are not completely removed is better than one in which the top soil is much disturbed. While the former is an unfinished job, the later is a spoilt job.

Several methods are employed in land clearing operation, namely; manual, chemical and mechanical methods, but the common ones are the manual and mechanical methods. However, the manual method has obvious limitations in terms of output and capacity and any attempt to change this must be accompanied by socio-economic and political considerations.

The traditional method of land clearing operation in Nigeria is manual, involving stumping and clearing of shrubs with such inefficient tools as handhoes, cutlasses/matchettes, diggers, and spades. The cleared woody debris is then gathered around bigger trees to burn. Often tree felling by use of axes and cutlasses led to unfinished job and such fields are hardly conducive for subsequent large scale mechanization. Moreover, the man-hour requirement by manual land clearing is usually very high. Reports indicate that the capacity for manual land clearing varied between 50 and 200 man-h/ha. (Odigboh, 1991; Musa, 1979; Opara-Nadi and Lal, 1982).

A primary objective of mechanization is to bring additional land under cultivation, either by clearing new areas or by utilizing land otherwise unsuitable for land cultivation. The prospects of farm mechanization in the savannah regions of Nigeria are better than in the forest zones of the south because the vegetation density in the former is lower. This implies low costs of land clearing and tillage operations and reduced mechanical breakdown. In terms of capacity, figure as low as 0.84 h/ha for land clearing has been reported (Toledo, 1982).

Mechanized land clearing often leaves the land in such a state as to render it susceptible to surface erosion and soil compaction, particularly with the passage of time. Research has shown that increased use of agricultural machinery and equipment on farmland can lead to soil degradation cumulating in how infiltration, increased soil erosion, increased soil compaction and reduced crop yield (Douglas et al., 1980; Negi et al., 1980; Oni and Adeoti 1986).

The incessant removal or bulldozing of valuable top soil is sometimes due to the inexperience of tractor operators as shown in **Figs. 1** and **2**. Besides, the repeated passes of agricultural tractors and tillage equipment are often responsible for progressive soil compaction at the sub-soil or plough layer. This process is indeed accelerated by the initial overburden pressure resulting from the very heavy track-type crawler tractors operating on deformable soils under moist or wet soil state. This influence is illustrated in **Fig. 3** and **Table 1**. Negi et al. (1980) contended that soil compaction induced by repeated passes of agricultural machines on farm lands does not only increase the bulk density but causes formation of a dense subsoil layer which obstructs water flow and root penetration. He further concluded that the subsurface compaction can be relieved to an appreciable level by deep ploughing thereby improving the water retention capacities and hence crop growth on such soil. This, therefore, points to the need for studying the implications of mechanically cleared lands in relation to land cultivation for food production. There is also the need-for policy guidelines on the deployment of heavy land clearing machines on agricultural lands.

Oni (1981) reported that tillage research in Nigeria and methods of reporting such research are so varied that meaningful interpretations of their relevance to Nigerian farming systems are often difficult if not impossible. He, therefore, suggested, among other things, institutional and governmental involvements in soil dynamic programmes and the establishment of uniform standards in tillage experimentation and reporting in Nigeria.

This paper attempts to highlight the influence of mechanized land clearing and the repeated passes of agricultural tractors on the compaction of agricultural soil and their resulting effects on crop growth.

Table 1. Weight and pressure range over soil produced by various compacting agents

Compacting Agents	Power kW[1]	Weight m.t	Pressure range kPa[2]
Bulldozer	135	18.3	65.7 - 59.8
Bulldozer	203	28.1	93/2 - 67.7
Bulldozer	290	38.8	93.2 - 74.5
Tree crusher: G-40	431	45.0	101.0 - 98.1
Tree crusher: G-60	356	65.0	134.4 - 98.1
Horse	—	0.4	392.3 - 98.1
Cow	—	0.3	343.2 - 86.3
Man	—	0.07	46.1 - 22.6

Source: Toledo and Navas (1982).
[1, 2] Converted from hp and kg/cm^2 to kW and kPa, respectively.

Fig. 1 Bulldozing of top soil by crawler-type tractor.

Fig. 2 Excessive top soil removal by a land clearing machine.

Fig. 3 Evidence of soil compaction along tracks of a crawler tractor.

Experimental Procedure

A completely randomized block experimental design was laid out for plots which were initially disk ploughed. Each plot was 2 m by 20 m. Compaction levels of 0, 5, 10 and 15 tractor passes were initiated over this loamy soil as designed statistically. Two tillage treatments were carried out to investigate the extent of relief of the induced compaction. These were ploughing with a two-bottom, 66 cm disk plough followed by harrowing with a tandem harrow with 7 disks per gang, on the one hand, and harrowing only, on the other hand. The objective was to study the applicability or otherwise of each tillage treatment in relieving or reducing soil compaction at plough layer. The control plot with no tillage and no tractor passes was referred to as NTO. Each treatment was replicated twice. Prior to tractor passes, boronated superphosphate at a rate of 125 kg/ha was applied to the plots. A 45 kW, two-wheel drive tractor was used to induce the required levels of compaction by allowing the tractor to run over each plot in accordance with the design of the experiment.

Immediately after the tractor passes, the soil bulk density and soil resistance to the penetration of a handheld cone penetrometer pressure determination were undertaken at soil depths of 5, 10, 15 and 20 cm. Each plot was then ploughed using the appropriate tillage implement and again the bulk density and soil resistance to cone penetrometer pressures were taken.

Cotton seeds were planted at 75 cm spacing with three rows of plants per plot. A pre-emergence herbicide was applied immediately after planting. This was a mixture of fluridone, diuron and paraquat at the rate of 0.5 + 0.5 + 0.5 active ingredients per hectare. Movement over the experimental plots was curtailed and the seedlings were later thinned to 2 plants per hill.

At 6 weeks after planting, some plant parameters were taken. These were plant height, root length and the number of leaves per plant. Sampling was carried out at random on each plot and each value was considered average of four readings.

Results and Discussions

Figure 4 illustrates the influence of repeated passes of agricultural tractors prior to tillage treatments. It will be observed that soil bulk density and soil resistance to cone pressure increased with depth, attaining maximum values at 10 cm depth. The 5 tractor passes gave the least variation in soil bulk density as depth was increased but was consistently higher in value than the zero tractor pass at each soil depth.

Figures 5 and **6** are plots of cone penetrometer pressures and bulk density values for disk ploughed-disk harrowed and disk harrowed fields, respectively. It can be observed that there is a substantial reduction in the measured values at each depth when compared with measurements before the tillage treatments. The disk ploughed-disk harrowed plots have also indicated greater reduction in the soil compactive state than the disk harrowed plots. This points to the need for periodic deep ploughing to relieve subsurface compaction.

Figure 7 illustrates the influence of induced compaction on cotton growth for the different tillage treatments. The No-Tillage treatment with zero tractor pass (NTO) gave the best overall performance followed by disk ploughed-disk harrowed treatment for each level of induced compaction (tractor passes). The fact that the plant root **(Fig. 7b)** is deeper for disk ploughed-disk harrowed treatment further justifies the need for deep ploughing. Similar results were obtained for plant height and number of leaves per plant.

Conclusion

Of the different land clearing methods employed in Nigeria, the mechanized Knock Down method is the most cost effective. Hand labour is not very conducive to large scale mechanization but small- and medium-sized land clearing machines with low capi-

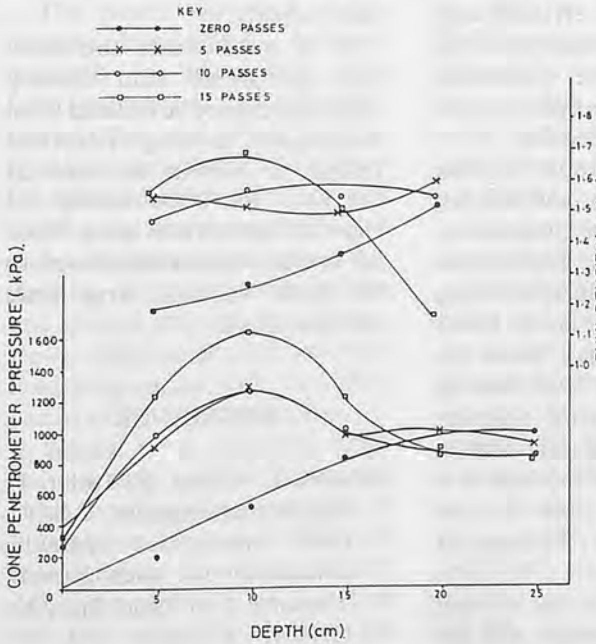


Fig. 4 Effect of repeated tractor passes on agricultural soil.

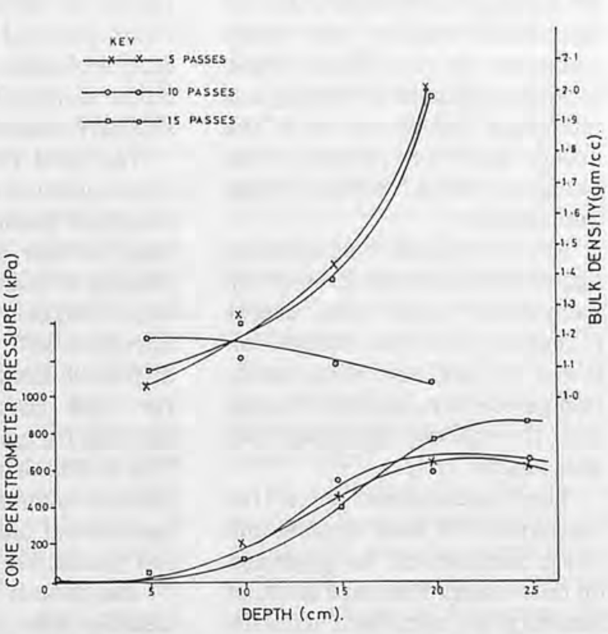


Fig. 5 Effect of disk-ploughing and disk-harrowing on compacted agricultural soil.

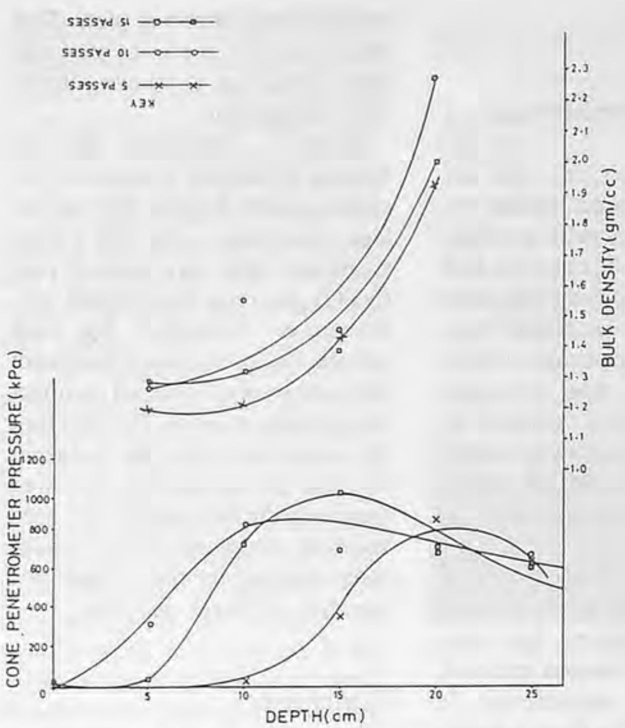


Fig. 6 Effect of disk-harrowing on compacted agricultural soil.

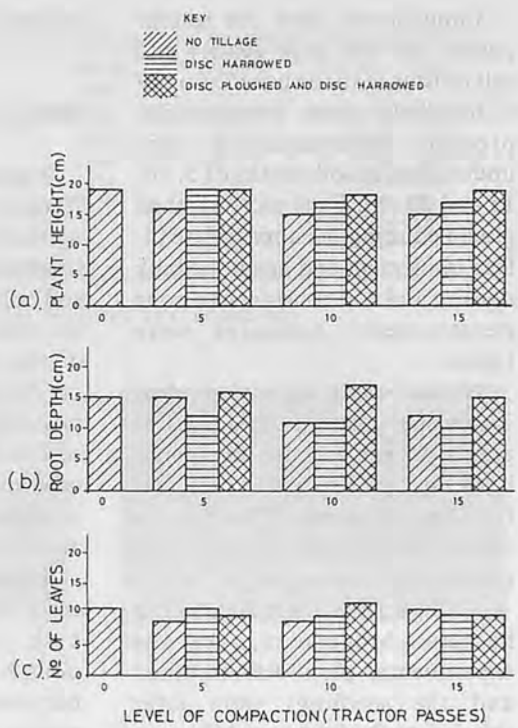


Fig. 7 Effect of soil compaction on the growth of cotton plant.

tal investment are available and have proven to be superior to hand labour. Several approaches have been adopted for reducing soil compaction resulting from these heavy land clearing machines and the subsequent repeated passes of agricultural tractors and tillage equipment on farm lands. These include simultaneous clearing and ploughing operations with the dozers and the periodic deep ploughing using relevant tillage implements.

Results obtained from an investigation with different levels of soil compaction show that deeper ploughing with disk plough followed by disk harrowing operation gave better crop performance than the shallow ploughing with disk harrow only.

The inconsistencies in the deployment of land clearing and tillage machines call for guidelines on their usage. This need must, of necessity, be correlated with the degree of mechanization, soil type and soil state, vegetation density and timing of operation. Low ground pressure (LGP) land clearing equipment should be employed on lands susceptible to soil compaction and those with low vegetation density. The optimum period for the most efficient land clearing should be established for each ecological zone. Guidelines on the costing of the operation are similarly urgently needed.

The need for proper training of the operators for land clearing machines cannot be overemphasized in view of the tremendous amount of damage currently being done to agricultural lands. Many operators still do not know the difference between land clearing for civil engineering purpose and that for agricultural purpose. The bulldozing of top soil is a serious economic loss to our agricultural industry in terms of soil productivity.

The present high cost of land clearing does not augur well for large scale mechanization. Some States' Ministries of Agriculture do, however, carry out custom land clearing operation. This practice has to be intensified since ownership of land clearing machines by individual farmers is not likely without heavy government subsidy.

It is quite clear, therefore, that mechanized land clearing operation cannot be isolated from integrated farming practice. Indeed, it should be seen as the basis for transforming the Nigerian agricultural sector from its present subsistence level to the more efficient large scale mechanization.

REFERENCE

Douglas, E, Mickye, E; Taylor, F; Negi, S. and Raghavan, G.S. V., 1980. Unsaturated hydraulic conductivity of a tilled clay soil. (Canadian J. of Agric. Eng., 22: 153-161.

(Continued on page 32)

Power Tiller Industry in Indonesia

by
V.M. Salokhe
Associate Professor
Asian Institute of Technology
Bangkok, Thailand - 10501

Agung Hendriadi
Center of Agricultural Engineering
P.O. Box 2, Serpong 15310
Jawa Barat, Indonesia

Abstract

This paper presents the current status of the power tiller industry and future prospects of power tiller use in agriculture in Indonesia. Based on available data in the literature and published by the government, predictions were made for the future prospect of the power tiller industry.

Introduction

The power tiller is a multipurpose hand-tractor designed primarily for tilling and other farm operations. In Indonesia, power tillers are mostly used in food crop agricultural fields where the average holding size of farm is about 1 ha. Rice is the staple food and secondary crops like corn, cassava, soybean, sweet potato and ground nuts are also grown. Power tillers are generally used for land preparation with very little use in other farm operations.

Several types of power tillers are currently used in Indonesia, either locally made or imported as knockdown machines which are assembled in the country. Power tillers can generally be classified into two categories: those which can be used only for pulling plows, levellers, harrows, trailers, etc. are called traction type; while the others which can be used not only for traction but also for driving rotary cultivators are called driving type (Yasumasa, 1988). Most of the power tillers manufactured in Indonesia are traction type and the driving type is produced by only one manufacturer or they are imported. Engines of 4.85 to 8.95 kW are used as prime movers.

The total number of power tillers in Indonesia in 1986 was 11 219 which increased to 25 129 in 1990, an increase of about 22.3% every year (Anon, 1991a). The individual ownership of power tillers accounts for 50% while joint ownership accounts for 20%. Most of these power tillers are locally made.

The agricultural activities are supported by better irrigation, use of high yielding varieties and fertilizer and efforts to increase food production by introducing appropriate agricultural machines. Due to these policies, up to the end of the fourth five-year development plan, rice production in Indonesia increased by 3.3%/year, while the production of secondary crop such as corn increased by 7.8%, soybean by 21.3%, cassava by 6.0%, groundnut by 6.3%, and green-nut by 9.8% (Anon, 1991a). During 1987-1990, the average growth rate of cultivated area under food crops was about 3.26% per year, and occupied 67% of the total cultivated area of agriculture (Anon, 1991b). The cultivated area planted to food crops was 20 132 thousand ha which increased to 22 255 thousand ha in the year 1990.

Table 1. Population Engaged in Food Crop Production

Year	Population (million)
1987	6.3
1988	26.9
1989	27.5
1990	28.1

Source: Anon (1991b).

For agricultural operations, the power input comes from human, animal and mechanical power sources. **Table 1** shows the details of the population engaged in food crop production. Increase in cultivated area was 3.4% per year but increase in active population in agriculture is much less than the increase in cultivated area. This has resulted in a shortage of laborers and increased demand for power tillers.

By assuming that the power available from one person is about 0.373 kW, draught animal about 0.746 kW, a commonly used engine of 6.34 kW for power tiller and assuming available draught animals are constant during

1987-1990, the power available for land preparation in food crop agriculture which comes from the existing power tillers contributed only 2.5% of total power need for crop production. This encouraged the government and local manufacturers to produce more power tillers to replenish the decreasing input power from human sources.

Present Status of the Power Tiller Industry

The development of the industrial sector in Indonesia is directed to create employment opportunities, minimize imports, development of the economy and the export of industrial commodities. The objectives of the agricultural machinery industry are to develop industry components capable of meeting all domestic demands; promote export of agricultural machineries and tools; improve the design capability of agricultural machinery and tool manufacturers and to increase the purchasing power of farmers through the provision of bank credits (Anon, 1989).

Power tiller industries have tried to fulfill these objectives through the development of new prototypes or by modifying the existing designs to make them more simple, inexpensive, technically and socially acceptable to the farmers, and as much as possible, using local raw materials. As a result, the production of power tillers increased from 5,940 in 1986 to 12,482 in the year 1990 (Anon, 1991c).

Up to 1990, about 62% of total power tiller production was locally made, and others were imported knocked-down machines assembled in Indonesia, such as Kubota and Yanmar. There are 10 manufacturers in Indonesia who produce locally-made power tillers. These manufacturers either develop their own design or simplify the technology of the existing imported power tillers The list of manufacturers and their production in 1990 is given in **Table 2**. The commonly used implements with these power tillers include mouldboard plows, rotavators, harrows, levellers and trailers. The clssification of locally made power tillers is given in **Table 3**. The specifications of locally made power tillers are given in **Table 4**. **Fig. 1** shows a schematic diagram of locally-made power tiller and **Fig. 2** shows a schematic presentation of some

Table 2. Manufacturers and Their Production, 1990

Name of Manufacturer	Production (Units)
CV. Suratman	25
PT. Fongso Indonesia	200
CV. Karya Hidup Sentosa	1 000
PT. Armindo	150
PT. Rhok Phala Indonesia	200
CV. Bima Sakti	240
PT. Kubota Indonesia	2 400
PT. Yamindo	1 000
PT. Bhineka Swadaya Int.	1 000
PT. Agrindo	1 500

Source: Anon (1991c).

Table 3. Classification of Locally-made Power Tillers

Type	Engine Capacity (kW)	Steering Clutch	Transmission System	Speed Levels
Driving type	6.34	With	Full gear	2F*, 1R*
	7.83	-do-	Gear-sprocket-chain	3F, 1R
	8.95	-do-	-do-	3F, 1R
Traction type	4.85	With or without	Full gear	1F
	6.34	-do-	Gear-sprocket-chain	1F, 1R
			Sprocket-Chain	2F, 1R

*F = Forward, R = Reverse.

Table 4. Specifications of Locally-made Power Tillers and Some Implements

Item		Specifications
Power tillers:		
1. Net weight		210 - 350 kg
2. Over all-dimensions	Length	2 170 - 3 170 mm
	Width	826 - 1 085 mm
	Height	1 025 - 1 250 mm
3. Transmission	Types	Full - gear Gear-chain-sprocket Chain-sprocket
	Speed level	Reverse: 0-1 Forward: 1-3
	Steering clutch	Gear-clutch Dock-clutch
	Main clutch	Tension pulley
4. Tyre	Rubber tyre	
	Cage wheels	Diameter 800-900 mm
5. Engine	Power	4.85-8.95 kW
	Type	Diesel, 4 cycles
	Fuel consumption	Rated speed = 0.9-1.6 ℓ/h Max speed = 1 800-2 200 rpm = 2 200-2 400 rpm
Implements:		
6. Mouldboard plough	Single bottom	Width: 250-320 mm Plowing depth: 130-200 mm Field capacity: 10-15 h/ha (1 Pass) Field efficiency: 70-80%
	Double bottom	With: 380-450 mm Ploughing depth: 130-200 mm Field capacity: 7-12 h/ha (1 Pass) Field efficiency: 60-70%
7. Cultivator	Rotary	Width: 550-650 mm Field capacity: 10-12 h/ha (1 Pass) Field efficiency: 80-85%
8. Harrow		Type: Spike-tooth Width: 1 200-1 500 mm Field capacity: 8 h/ha
9. Leveller		Width: 1 200-1 500 mm Field capacity: 8 h/ha

Source: Anon (1991b).

implements used with power tiller.

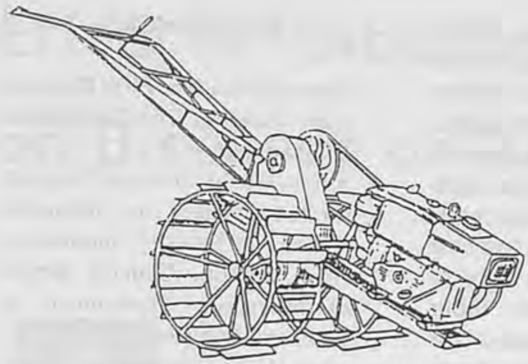


Fig. 1 A schematic diagram of locally-made power tiller without steering clutch.

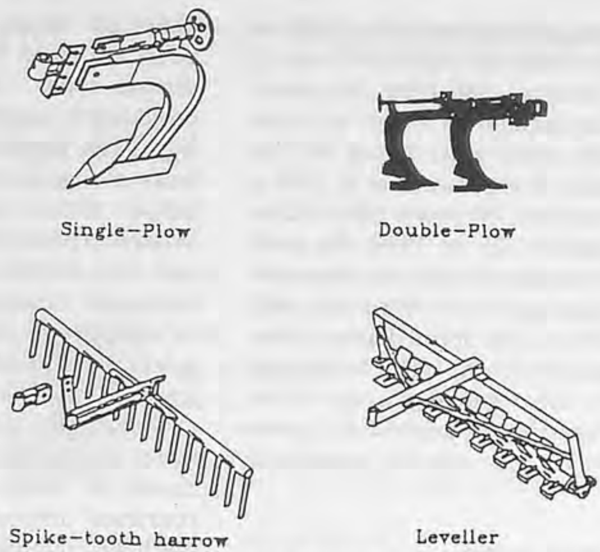


Fig. 2 A schematic presentation of some implements used with locally-made power tiller.

Manufacturing Schemes

Local power tiller manufacturers can be grouped into two categories: workshop type and industrial type manufacturers. Workshop type manufacturers do not possess the type of hardware as the industrial types have. Sophisticated machines are used occasionally. Working hours and labor force are not fixed and the capacity varies significantly. Not much design considerations are given during manufacturing but most of the modifications are done on a cut and try basis.

Industrial type manufacturers employ a full range of machine-tools for manufacturing and assembling of power tillers. They also have design capabilities. However, they do not have 100% design capability. The deficiency in design capability varies from 20% to 80% (Anon, 1991a). In some cases, industrial type and workshop type manufacturers cooperate with each other and sub-contract jobs.

Marketing Scheme

The sales system of workshop type manufacturers is by direct contact among the owner and farmers. They don't participate in tender business. They advise farmers to obtain loans from financing institutions. These loans are given directly to workshop owners but not to the farmers. Some workshops sell power tillers on installment but the interest charged is very high (Anon, 1991a). None of the workshop type manufacturers provide any after-sales service

The industrial type manufacturers utilize various sales channels: their own trading company, shops and dealers and they participate in tender business. These manufacturers have branches and shops to provide a complete after-sales services under a service contract. The government also tries to promote the use of power tillers by providing several credit patterns with low interest, and popularizing power tillers at farm level by demonstrations and exhibitions.

Manufacturng and Marketing Problems

Along with the increased production and utilization of power tillers in Indonesia, several problems exist on the manufacturing and marketing fronts. Manufacturing is affected by shortages of raw materials; inadequacy of supporting infrastructure like transport facilities, low level of design skills; no standardization; low level of industrial skill of laborers; lack of detailed evaluation of power tillers in the field as well as laboratory; and lack of coordination among institutions guiding the manufacturers.

On the marketing front, problems arise due to low purchasing ability of farmers and their loss of interest in the government's credit facilities and shortage of after-sales service and spare parts, especially at the provincial level.

Future Prospects

Several factors will affect the prospects of the power tiller industry in Indonesia. They include future demand of power tillers; utilization of licensed capacity of manufacturers; and purchasing ability of farmers.

The future demand for power tillers can be estimated on two criteria: on the basis of present demand and on the basis of pattern of increase in cultivated areas.

During 1980-1990 the power tiller demand increased by about 22% every year. Based on this data it is expected that in 1995 a total of 68,750 power tillers will be required. Up to 1989, the total production of local manufacturers producing power tillers was only 42% of the licensed production capacity (Anon, 1989). It indicates that there is enough scope to increase the production of power tillers to cope with future demand.

Conclusions

The average holding size of land in Indonesia is only 1 ha. Power tiller demand is increasing every year. These machines are mostly used for primary or secondary tillage. Most of these power tillers are locally made. Power tillers are either traction type or driving type. They are either produced by workshop or industries. The manufacturing sector lacks in engineering design capabilities. Efforts are being made to develop power tillers at low cost and with simple design. Due to decreased human power input in agriculture, the demand for power tillers in industry and boost agricultural productivity.

Some of the policies which will increase manufacturing and utilization of power tillers include restricted import of build-up machines, requirement for use of local raw materials, introducing national standards, provide financial assistance to farmers and provide technical assistance to local manufacturers.

REFERENCES

1. Anon (1989a). The Fifth Development Planning. The Government of Indonesia.
2. Anon (1989b). Survey of Agricultural Machinery in Indonesia. Ministry of Industry, Indonesia.
3. Anon (1991a). Country Report of Indonesia. Government of Indonesia Publication.
4. Anon (1991b). Pocket Year Book. Central Bureau of Statistics of Indonesia.
5. Anon (1991c). Monthly Report of Basic Metal Industry. Ministry of Industry, Indonesia.
6. Yasumasa K. (1988). Farm Machinery, Vol. 2. Tsukuba International Agricultural Training Center Publication, Japan. ■■

(Continued from page 28)

Mechanized Land Clearing and Tractor Traffic Effects on Agricultural Soil and Crop Growth

Musa, H.L., 1979. Traditional tillage operations and development and use of animal drawn equipment. Proceedings of the Appropriate Technology Workshop. Institute for Agricultural Research (I.A.R.). Ahmadu Bello University, Zaria, Nigeria. pp 29-42.

Negi, S. C, Mikyes, E., Taylor, F., Douglas E. and Raghavan, G. S. V., 1980. Crop performance as affected by traffic and tillage in a clay soil. Trans. of the ASAE, 23 (6): 1364-1368.

Odigboh, E. V., 1991. Continuing controversies on tillage mechanization in Nigeria. Journal of Agriculture. Science and Technology, 1 (1): 41-49.

Oni, K. C., 1981. Tillage research: A soil-tool overview. Proceedings of the Nigerian society of Agricultural Eng., 5: 50-60.

Oni, K. C. and Adeoti, J. S., 1986. Tillage effects on differently compacted soil and on cotton yield in Nigeria. Soil and Tillage Research, 8: 89-100.

Opara-Nadi, O. and Lal, R., 1982. Effects of land clearing methods on soil physical and hydrological properties in southwest Nigeria. Paper presented at the International Symposium on Land Clearing and Development in Relation to Environment Protection in Humid and Sub-Humid Tropics, Ibadan, Nigeria. November 23-26.

Toledo, J. M. and Navas, J., 1982. Land clearing for pasture in the Amazon. Paper presented at the International Symposium on "Land and Development in Relation to Environment Protection in Humid and Sub-Humid Tropics". Ibadan, Nigeria. November 23-26. ■■

Effect of Parboiling and Milling Parameters on Breakage of Rice Grains

by
S.M.Farouk
Professor
Dept. of Farm Power and Machinery
Bangladesh Agricultural University
Mymensingh, Bangladesh

M. N. Islam
Lecturer
Dept. of Manufacturing and Quality Systems
University of Western Sydney
Macarthur, Cambelltown 2560, Australia

Abstract

Three varieties of rough rice (Pajam, BR-2 and BR-11) were selected as test materials. A parboiling set-up and a cabinet type tray dryer were fabricated. A rubber roller dehusker and an abrasive type rice polisher were used for milling the test materials. Five kg samples were taken for steaming and both hot and cold soakings were applied. Three samples of one kg each were dried using heated air at 40, 60 and 80°C. One sample was dried under direct sunlight. After drying the samples were kept in air-tight plastic bags and crack generation was observed at an interval 12 hours until further crack generation was found to cease. After the completion of crack generation test, the samples were milled for different speeds and duration and milling-output parameters (breakage, yields, recovery, whitening and loss) were calculated. Milling loss was calculated taking 4% loss as base. Cooking and eating tests were also performed.

Milling loss was reduced with the increase of steaming temperature and duration. Cold soaking applied for Pajam and BR-11 varieties resulted in low milling loss for the steaming duration and temperature of 15 min and 150°C, and 20 min and 150°C, respectively. Hot soaking applied for the BR-2 variety resulted in low loss for the steaming duration and temperature of 15 min and 150°C, respectively. Samples dried in sunlight and with the low air temperature of 40 to 45°C showed about 32 and 50% cracked grains within the storage period of 84 h. About 100% cracked grains were observed within the storage period from 48 to 72 h. when dried at 60 to 80°C air temperature. Drying air temperature over 40°C causing rapid drying also caused increase in breakage during milling and resulted in increased milling loss. The speed of mill-rotor during the whitening process was also indicated as a factor affecting milling loss; 1 300 rpm generally caused 50% or lesser loss compared to 1 500 rpm. Low milling loss was observed within the moisture content range of 15.0 to16.5%. Samples parboiled and milled in the above mentioned test took 13 to 16 min to cook and the taste and odour of the cooked rice were found satisfactory.

Acknowledgment: The authors acknowledge with gratitude the financial support obtained from the Bangladesh Agricultural Research Council (BARC) and the laboratory facilities obtained from the Department of Farm Power and Machinery, Bangladesh Agricultural University and the Bangladesh Rice Research Institute.

Introduction

Several factors (cracking of kernels, immature and chalky kernels, moisture content, shape and hardness of the kernels and type and design of the milling equipment) are generally recognized as probable causes of breakage of rice during milling. *Autrey et. al. (1955)* showed that rice breakage was related to milling conditions, particularly the prevailing relative humidity, temperature and the extent of milling.

Progressive milling of rice with laboratory equipment showed, surprisingly, that most of the breakage occurred during the earliest stage of milling or even at the shelling stage. Similarly, grains remaining unbroken after shelling gave little breakage when separated and milled *(Bhattacharya, 1969)*.

The dramatic restoration of milling quality left no doubt that any type or extent of cracking was healed by parboiling. Similarly, the immature paddy had very low breakage when parboiled. Examination in transmitted light not only confirmed the absence of crack in the parboiled lots but also showed the absence of chalkiness in any of the kernels. Even the tiny immature kernels, observed especially in the sample of immature paddy, appeared flinty and translucent and remained unbroken after milling.

Parboiling improves the milling quality of rough rice. Kernel defects such as cracks, chalkiness and immaturity are completely eliminated on parboiling, apparently owing to realignment and cementing of the grain constituents after cooking of the starch, and that improvement in milling quality is evidently related to this phenomenon. Breakage, therefore, should always be negligible after parboiling. Progressive milling of parboiled rice showed absolutely no increase in breakage with longer milling time *(Bhattacharya, 1969)*.

Parboiling not only restores the milling quality of damaged raw paddy but also of parboiled paddy with induced cracks. Reparboiling could be useful in salvaging damaged parboiled paddy. The reparboiled samples were a shade more yellow than the original parboiled lots but otherwise were indistinguishable *(Bhattacharya, 1969)*.

The main objectives of the project were (a) to study the behaviour of crack generation in rough rice after drying with respect to various parameters of parboiling treatments (soaking water temperature and duration, and steaming temperature and duration) and the drying rates, (b) to study the effects of milling machines and moisture contents of rice on breakage, and (c) to study the cooking and eating qualities of rice subject to different degrees of milling.

Materials and Methods

Parboiling Set-up

A parboiling set-up with steam boiler was designed and fabricated by 14-gauge galvanized iron sheet and mild steel angle bars. Provisions for measuring steam temperature and pressure in the steam boiler were made by thermometer and pressure gauge, respectively. A pressure release valve was set to maintain constant pressure **(Fig. 1)**. A steaming kettle of same metal was made to hold 4.0 kg paddy. A coal furnace was used as the source of heat.

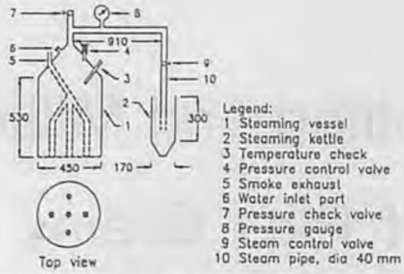


Fig. 1 Parboling set-up (all dimensions are in mm).

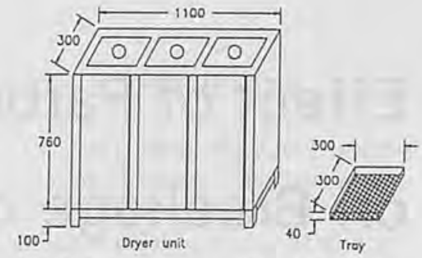


Fig. 2 Cabinet type tray dryer (all dimensions are in mm).

Rough Rice Dryer

A cabinet-type tray dryer was designed and fabricated for drying paddy **(Fig. 2)**. It consists of three compartments made of wood. Asbestos lining was put to its inner walls to reduce heat loss and to protect the wooden structure from burning. Provision was made to set 10 trays in each compartment. Electric heating coils were used as source of heat. A set of thermocouples was placed at different sections of the dryer to measure temperature. A precision electronic temperature controller was used with heating coil to control the temperature inside the dryer. An electric blower was used to supply air at variable rate through plastic pipe network to the dryer. Provision was made to supply variable air flow to the different chambers of the dryer.

A parboiling set-up along with other necessary accessories, and a cabinet type tray dryer along with other instrumentation were installed at the Farm Power and Machinery Department, BAU. All types of milling tests were performed at the Nutrition Division Laboratory in Bangladesh Rice Research Institute.

Pre-steaming

Five kg of rough rice was taken for pre-steaming for each test run. Pre-steaming was done for a duration of 10 min at the steam pressure of 482.79 kN/m^2 (150°C).

Cold Soaking

Five kg rough rice was taken for soaking and was soaked for the duration of 20 and 24 h at normal day temperature for the Pajam rice variety. For the BR-11 variety 96, 72 h of soaking duration was applied. Cold soaking was not applied for the BR-2 variety.

Hot Soaking

Five kg of rough rice was taken in an insulated pot for hot soaking. Hot water at 100°C was poured into soaking bath with rough rice. After mixing rough rice, soaking temperature rose at 70°C. The soaking temperature could not be precisely controlled. As a result, soaking temperature gradually decreased with the passage of time. Expected soaking was achieved within the range of 70°C to 55°C temperature. The moisture contents of the samples of rough rice were measured at 30 min interval by a resistance type instant moisture meter. The final moisture content was determined by oven method. Soaked rough rice at 30% moisture content was taken for steaming.

In another method, hot soaking was accomplished at constant controlled temperature of hot water to see the effect of soaking temperature on rice milling. In this method Pajam variety was soaked at 70°C temperature for the duration of 30, 50 and 80 min, BR-11 variety was soaked at 90, 80, 70, 60, 50, and 40°C temperature for the durationn of 1.0, 1.25, 2.0, 2.75, 3.0, 3.25, 3.75 and 4.0 h and that of BR-2 variety soaking duration and temperature were 4.0 h and 60°C, respectively. Water was heated in an insulated pot by electric heater up to the expected soaking temperature. Five kg rough rice was poured into the hot water in soaking pot. Soaking temperature was controlled by an electronic temperature controller. The moisture contents of rough rice samples were measured by a resistance type instant moisture meter. The final moisture content was determined and recorded using the oven method. Soaked rough rice at 30% moisture content was taken for drying.

Steaming

Five kg of soaked rough rice of Pajam variety was steamed at 100, 120, 135, 140, and 150°C for the duration of 10, 15, and 20 minutes. For the BR-11 variety, steaming was done at 100, 125, 140, and 150°C temperatures for the duration of 10, 15 and 20 min and that of BR-2 variety steaming temperature and duration were 150°C and 15 min, respectively. Steaming was done by producing steam into the steam boiler. When steam temperature was achieved at pre-selected value, then steaming of rough rice was continued for the selected duration. Steam temperature was measured by a digital thermometer.

Heated Air Drying

Three samples each of one kg were taken from each batch of steamed rough rice and were dried by the artificial heated air in the dryer. Controlled temperature heated air drying was performed at 40, 60 and 80°C simulaneously in three chambers of the cabinet tray dryer (**Fig. 2**). One kg of steamed rough rice was spread on each tray and the trays were put into the dryer. Heated air was supplied to the dryer from an electric blower. The temperature of drying air was controlled by an electronic temperature controller. The moisture content of rough rice was monitored continuously at half-hour interval by instant moisture meter with the progress of drying. Grains at moisture content 12-14% were taken away from the dryer and kept in plastic bags for further tests.

Sun Drying

One kg from each batch of steamed frough rice was sun-dried. The rough rice was spread on concrete floor maintaining a two centimeter thickness of rough rice layer. Periodic stirring of rough rice was done. Drying was continued up to 12 to 14% moisture content and were kept in plastic bags for further tests.

Crack Test

Twenty-eight samples of dried Pajam variety were taken for crack test to observe the behaviour of crack generation after completion of drying. More than 100 grains were hand-peeled from each sample and spot light was passed through the peeled grains to identify the number of cracked grains in a sample. The tests were continued until further crack generation at 12-hour interval of holding period ceased.

Dehusking

Two hundred grams of rough rice from each sample were dehusked using a rubber roller dehusker (Laboratory Rubber Roll Unit, SATAKE RICE MACHINE, Type-THU-class 35A, 0.224 kW, 1 900 rpm). The percentages of dehusked and broken kernels were determined by hand-sorting of broken kernels. A kernel having equal to or more than 75% intact was considered as whole kernel.

Polishing

Dehusked samples were polished using an abrasive type rice polisher (Rice Whitening and Cracking Machine, SATAKE Eng. Co. Ltd., Japan) for the maximum duration of one minute at 1 500, 1 400, 1 300 and 1 200 rpm machine speeds.

The milling loss was determined by taking four percent polishing of brown rice as base (*Tani, 1983*). Any polishing above four percent was considered loss and any below four percent was considered no loss in operation.

Milling loss (%)

$$= 100 - \text{Milling recovery} - 4 \qquad (1)$$

The other milling parameters were determined as follows:

Broken kernel (%)

$$= \frac{\text{Weight of broken kernel}}{\text{Weight of milled rice}} \times 100 \qquad (2)$$

Head rice yield (%)

$$= \frac{\text{Weight of whole kernel}}{\text{Weight of milled rice}} \times 100 \qquad (3)$$

Milling yield (%)

$$= \frac{\text{Weight of milled rice}}{\text{Weight of rough rice}} \times 100 \qquad (4)$$

Milling recovery (%)

$$= \frac{\text{Weight of milled rice}}{\text{Weight of brown rice}} \times 100 \qquad (5)$$

Breakage rate (gm/sec)

$$= \frac{\text{Weight of total broken kernel}}{\text{Time}} \times 100 \quad (6)$$

Whitening rate (gm/sec)

$$= \frac{\text{Weight of bran removed}}{\text{Time}} \times 100 \quad (7)$$

Cooking Tests

Two grams of white rice washed with water was taken in a test tube. An amount of 2.0 cm^3 of water was added in it. The test tube was then placed in boiling water in a beaker that was boiled by an electric heater. Cooking was considered complete when the rice appeared to burst electric longitudinally and there was no hard part in the kernel. The duration of cooking was recorded.

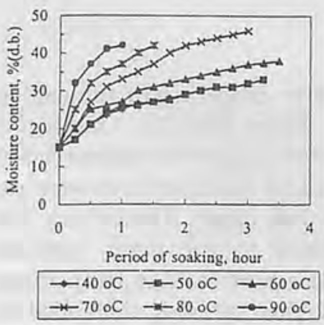


Fig. 3 Effect of temperature on soaking with respect to soaking period.

Table 1. Effect of Soaking Duration, Milling Speed and Drying Air Temperature on Milling Loss

Soaking		Drying		Milling	
Water Temperature (°C)	Duration (h)	Air Temperature (°C)	Final M.C. (%)	Speed (rpm)	Loss (%)
70	80	60	13.90	1 300	8.51
				1 400	9.64
				1 500	13.93
70	50	60	14.00	1 300	13.31
				1 400	15.12
				1 500	15.77
70	50	40	14.19	1 300	2.01
				1 400	2.31
				1 500	2.79

Table 2. Effect of Steam Temperature, Steaming Duration and Final Moisture Content on Milling Loss

Soaking		Steaming		Drying		Milling	
Water Temperature (°C)	Duration (h)	Temperature (°C)	Duration (min)	Air Temperature (°C)	Final Temperature (%)	Speed M.C. (rpm)	Loss (%)
26	72	150	15	60	14.02	1 200	2.51
						1 300	2.52
						1 400	2.56
						1 500	3.27
26	72	125	20	60	15.14	1 200	0.87
						1 300	1.84
						1 400	2.22
						1 500	2.53
26	72	125	15	60	14.94	1 200	2.03
						1 300	2.36
						1 400	3.79
						1 500	4.13
Effect of final moisture content on milling loss							
60	4	150	15	60	13.30	1 200	1.65
						1 300	2.05
						1 400	3.51
						1 500	4.56
60	4	150	15	60	15.54	1 200	0.00
						1 300	2.33
						1 400	3.64
						1 500	8.83

Results and Discussion

Soaking

The water absorption rate of rough rice increased with an increase of soaking temperature **(Fig. 3)**. The rate of absorption of water by rough rice was low at 60°C soaking temperature and reached essentially an equilibrium moisture content at 30% to 37% at the temperature of 40°C to 60°C. Water absorption rate was higher than 60°C soaking temperature. This indicates that the critical soaking temperature lies between 60°C to 70°C that was also reported as gelatinization temperature *(Bhattacharya, 1966)*. Absorption of water by rough rice was very rapid above the gelatinization temperature.

The soaking duration had direct effect on milling loss. Milling loss decreased with an increase of soaking duration as 80 min of soaking caused relatively higher loss than 50 min of soaking for identical soaking bath temperature (70°C) identical drying temperature (60°C) and almost identical final grain moisture content (13.9% to 14.0%) at all three milling speeds **(Table 1)**.

Steaming

Milling loss increased very slightly (0.48% and 0.16%) at 1 200 and 1 300 rpm mill speeds due to the increase in steam temperature **(Table 2)**. At higher mill speed of 1 400 and 1 500 rpm, milling loss slightly decreased (0.86% to 1.26%) with an increase in steam temperature. For the steaming duration, milling loss decreased consistently with an increase in steaming duration **(Table 1)**. Increase of steaming duration from 15 min to 20 min caused a decrease of milling loss ranging from a difference of 0.52% to 1.6%.

Drying

Drying air temperature had direct effect on milling loss which decreased with a decrease of drying air temperature **(Table 1)**. Milling loss was low, ranging from 2.01 to 2.79% at low drying air temperature (40°C) at all three milling speeds of 1 300, 1 400 and 1 500 rpm. Milling loss was very high, ranging from 13.31 to 15.77% at drying air temperature of 60°C and at all milling speeds. Milling loss increased with an increase of grain moisture content at 1 300, 1 400 and 1 500 rpm milling speeds **(Table 2)**. At 15.54% moisture content, the milling loss difference was very low, 0.13 to 0.28% at 1 300 and 1 400 rpm and this difference was higher 4.27%

at 1 500 rpm milling speed. At low milling speed of 1 200 rpm, there was no loss at 15.54% grain moisture content, whereas 1.65% milling loss was noted at 13.30% moisture content.

Crack Generation

Crack generation in dried grain was dependent directly on drying air temperature and inversely on the final moisture content of grains. Due to an increase of drying air temperature, the number of cracked grain also increased whereas crack generation decreased with an increase in grain moisture content **(Table 3)**. The percentage of cracked grains was low when the grains were dried at low drying air temperature of 30 to 40°C and that was high at 60 to 80°C drying air temperature. Samples dried in the direct sunshine showed about 32% cracked grain after 84 h of storage period. This percentage of cracked grain at the same storage period was about 50% when the grains were dried by heated air of 40 and 45°C temperature. About 100% of cracked grain were observed within the storage period ranging from 48 to 72 h, when samples were dried with the air of temperature ranging from 60 to 80°C.

The rate of crack generation was not well understood because the cracks were tested after hand peeling. The force exerted on the grain during hand peeling can also create a crack in grain. Modern x-ray method, used for crack test by some researchers would produce more authentic results *(Matthew, et. al., 1970)*.

Breakage

The breakage percentages of Pajam rice variety were high within the moisture content range of 11% to 15% both after dehusking and whitening **(Figs. 4 and 5)**. For the BR-11 variety, the break-

Table 3. Generation of Cracks During Holding Period after Drying

Moisture content (%)	Drying Temperature (°C)	Holding periods, h								
		0	12	24	36	48	60	72	84	96
Variety: BR-2										
12	70	72	86	79	71	84	70	89	81	78
13	66	51	51	52	58	35	51	70	40	65
14	40	12	28	44	23	41	14	32	34	30
16	32	38	51	44	41	30	35	47	40	52
16	32	3	9	8	10	10	9			
16	67	11	20	12	24	13	22	16	21	
18	40	17	16	6	14	23	17	19	18	
18	63	5	17	10	19	18	11	20		
Variety: Pajam										
8.5	70	7	58	94	100	100				
8.5	80	86	92	98						
9.5	55	100	100	100						
9.5	76	24	76	92	98	100	32	32		
11.5	45	3	20	29	30	32				
11.5	55	29	40	80						
11.5	62	76	90	98	100	100				
11.5	70	79	94	96						
11.5	76	52	90	94	96	100	100	100		
11.5	80	65	98	100						
12.5	40	2	10	12	14	20	21	24		
12.5	45	91	95	96						
12.5	62	33	60	67	74	76	78	80		
12.5	70	93	85	65						
12.5	76	57	67	74	74	74	80	84	86	
12.5	76	20	30	36	43	45	50	55	56	
13.5	29	10	17	16						
13.5	45	30	30	30	34	34	50	50	50	
13.5	55	86	70	76						
13.5	62	5	23	24	20	14	22	20		
13.5	76	22	26	34	28	23	22	20	32	35
14.5	29	15	15	21						
14.5	40	44	38	40						
14.5	45	10	26	16	10	26	20			
15.5	29	2	4	5	6	7	3	10		
15.5	40	17	12	12						
15.5	62	81	98	94	87	96	89	86	97	
17.5	29	3	8	4	6	4	0	4	4	

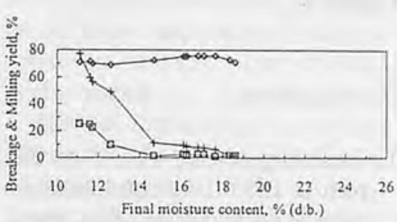


Fig. 4 Effect of final moisture content on breakage and milling yield. [Rough rice variety: Pajam, Drying air temperature = 30°C, Steaming temperature = 100°C, Steaming duration = 10 min., Air flow rate = 150 m/min].

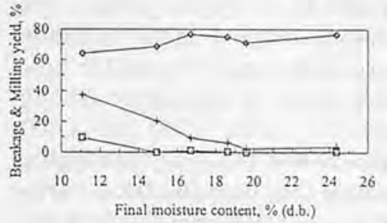


Fig. 5 Effect of final moisture content on breakage and milling yield. [Rough rice variety: Pajam, Drying air temperature = 30°C, Steaming temperature = 135°C, Steaming duration = 10 min, Air flow rate = 150 m/min].

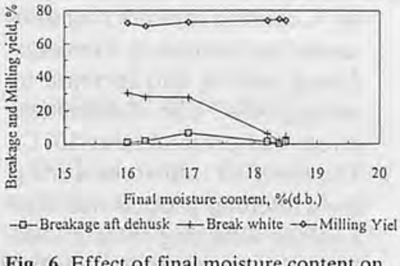


Fig. 6 Effect of final moisture content on breakage and milling yield. [Rough rice variety: BR-11, Drying air temperature = 30°C, Steaming temperature = 100°C, Steaming duration = 10 minute, Air flow rate = 150 m/min].

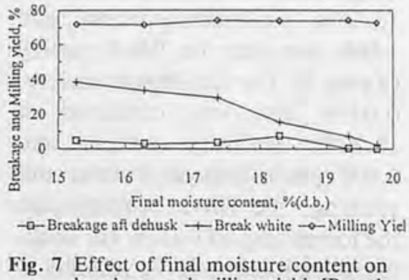


Fig. 7 Effect of final moisture content on breakage and milling yield. [Rough rice variety: BR-11, Drying air temperature = 30°C, Steaming temperature = 140°C, Steaming duration = 10 minute, Air flow rate = 150 m/min].

age percentage after dehusking was low and that after whitening was high within the moisture content of 15.27 to 18.30% (**Figs. 6** and **7**). The percentage of breakage increased with an increase in drying air temperature for both cases of dehusking and whitening (*Farouk, 1992*), while increased milling yield increased with an increase in steaming temperature. Breakage percentage for both dehusking and whitening decreased with an increase in steaming temperature. A kernel was considered broken if smaller in size then three-fourths of a whole kernel. The sum of whole rice and broken rice was expressed as milled rice.

Polishing

The milling loss increased with an increase in milling speed in all cases (**Tables 1** and **2**). Pajam variety had the highest and BR-11 had the lowest milling loss for the 60 seconds milling duration (**Table 4**). In Pajam variety, hot soaking only, without steaming was applied and this was the possible cause of the higher milling loss. At 1 200, 1 300 and 1 400 rpm the BR-11 variety had higher milling loss than the BR-2 variety, but at 1 500 rpm this loss was greater for the BR-2 variety. The combinations of pre-milling treatments and milling conditions for minimum losses are shown in **Table 5**. Hot soaking for a duration of 4 h had the best result of only 0.01% loss while milled at 18.55% moisture content and 1 500 rpm for the BR-2 variety (**Table 5**). For the Pajam variety, 0.03% loss was obtained at 18.34% moisture content and 1 400 rpm mill speed. For the cold soaking, the BR-11 variety had the lowest loss of 0.07% for soaking duration of 72 h, milling at 14.94% moisture content and 1 300 rpm mill speed. In most cases the breakage and whitening rates increased with an increase in milling speed and decreased with an increase in milling duration. The milling loss increased with increased milling duration (Farouk, 1992). Rice was cooked in 13 to 16 min and the taste and odour of the cooked rice were satisfactory (**Table 6**).

Table 4. Effect of Grain Variety on Milling Loss

Variety	Soaking Water (temp. °C)	Duration (h)	Steaming Temperature (°C)	Duration (min)	Drying Air (temp. °C)	Final M.C. (%(d.b.))	Milling Speed (rpm)	Loss (%)
BR-2	60	4	150	15	60	15.54	1 200	0.00
							1 300	2.33
							1 400	3.64
							1 500	8.83
BR-11	26	72	125	15	60	14.94	1 200	2.03
							1 300	2.36
							1 400	3.79
							1 500	4.13
Pajam	70	30 min	—	—	60	14.68	1 300	5.63
							1 400	8.05
							1 500	9.20

Table 5. Minimum Loss and Pre-milling Treatments and Milling Conditions

Variety	Pre-steaming		Soaking		Steaming		Drying		Milling		
	Temperature (°C)	Duration (min)	Water Temp. (°C)	Duration (min)	Temperature (°C)	Duration (min)	Air Temp. (°C)	Final M.C. (%)	Speed (rpm)	Duration (sec)	Loss (%)
Pajam	—	—	70	50 min	—	—	40	14.19	1 400	20	0.03
BR-11	150	10	26	72 h	125	15	60	14.94	1 300	20	0.07
BR-2	150	10	60	4 h	150	15	80	18.55	1 500	20	0.01

Table 6. Pre-cooking and Cooking Parameters/Tests

Sample size (g)	Moisture Content (%(d.b.))	Cooking condition: Water (Temp. °C)	Cooking condition: Duration (min)	Eating quality: Bad smell	Eating quality: Taste
2	20.48	100	14	no	good
2	12.73	100	13	no	good
2	21.35	100	13	no	good
2	18.90	100	14	no	good
2	18.48	100	16	no	good
2	19.04	100	16	no	good
2	11.11	100	16	no	good
2	14.41	100	13	no	good
2	22.84	100	16	no	good
2	21.36	100	16	no	good
2	18.20	100	13	no	good
2	12.61	100	14	no	good
2	19.05	100	13	no	good
2	16.96	100	15	no	good

Conclusions

1. Steaming of rice, for 15 to 20 min at 125°C, in combination with pre-soaking at room temperature for a minimum of 72 h appeared to be another acceptable alternate to parboiling process resulting in relatively low loss in subsequent milling operation.
2. Drying air temperature over 40°C causing rapid drying also caused an increase in breakage during milling and increase in milling loss. The detrimental effect was prominent at 80°C.
3. The speed of mill-rotor during the whitening process was also a factor affecting milling loss: 1 300 rpm generally caused 50% or lesser as compared to 1 500 rpm.
4. Higher moisture content (within the range of 15.0 to 16.5% moisture content) generally causes less loss during milling.
5. The grains dried by heated air at low temperature (below 45°C), including sun-drying were better than those dried at higher temperature.

These conclusions based on the experimental results will be useful to the rice-mill operators; short training courses may be arranged for them to make them better aware of the effects of different parameters affecting the quantitative and qualitative aspects of rice milling.

(Continued on page 43)

Domestic Absorption Refrigeration System Powered by Heat Loss of Woodburning Cookstove

by
J.T.V. Pereira
Prof. and Head
Faculty of Mechanical Engineering
State University of Campinas -UNICAMP
P.O. Box: 6122 Campinas -13180 -S.P.
Brazil

G. Martins
M.Sc. Mechanical Engineering
Energy Department
FEM-UNICAMP
P.O. Box: 6122 Campinas -13180 -S.P.
Brazil

Abstract

The current utilization of woodburning cookstoves in Brazil was surveyed. A traditional heavy-mass woodburning cookstove was studied as a thermal equipment and its thermal efficiency was evaluated by two methods. A new combustion chamber was designed and tested, presenting relevant efficiency increase. A closed two-phase thermosyphon using water as working fluid was designed, built and connected to the combustion chamber of the cookstove. The heat flux and temperature level available during stove operation were determined. Finally, a commercial absorption refrigerator was coupled with the stove through the thermosyphon. The overall results of the coupling signalled a successful country-side applications.

Introduction

A significant part of Brazilian rural population, as in many other countries in Latin America, Africa and Asia, depend on biomass fuels for cooking and water heating. The low availability of commercial energy sources in the rural areas and the low efficiency of the woodstoves reported in literature motivated the authors to study the Brazilian southeast traditional woodstove model and evaluated its mass and energy fluxes in order to improve the thermal performance.

Basides improving its cooking efficiency, the utilization of part of the waste heat of the stove to power a Platen-Munters (Electrolux) absorption refrigeration system may also increase the ratio of useful energy output to energy input. These refrigerators generally use liquefied gas or kerosine as heat source, which are expensive and hard to obtain in remote areas.

Woodstove Utilization

Official data[1] show that the number of woodstoves in the country has been keeping almost constant from 1960 to 1980. In the same period the number of homes using gas stoves increased more than 6 times. **Table 1** presents the evolution of the number of homes using woodstoves and gas stoves both in urban and rural areas.

Table 1. Trend in Growth of Numbers of Stoves ($\times$ 10^3)

Item	1960			1970			1980		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Wood	8 291	2 562	5 728	7 947	2 145	5 802	7 734	2 031	5 703
Gas	2 464	2 317	147	7 528	7 125	403	15 803	14 796	1 007
Other	2 743	1 471	1 173	1 788	1 006	1 147	1 673	944	730
Total	13 498	6 350	7 048	17 623	10 276	7 352	25 210	17 771	7 440

Table 2. Number of Users of Different Stoves and Total Population, 1980

Item	Total	Urban	Rural
Wood	39 512 026	10 056 430	29 455 596
Gas	70 352 944	65 403 627	4 949 317
Other	7 483 316	3 857 695	3 625 621
Total	117 348 286	79 317 752	38 030 534

The growth in the number of gas stove users is due to urbanization process, but the rural part of the country has kept rather steady in the predominant use of woodstoves.

In terms of population, in 1980, roughly 1/3 of the Brazilians depended on woodstoves, most of them country dwellers (**Table 2**).

Thermal Analysis of the Woodstove

Although wood has probably been the first fuel used by man, its combustion is still not completely understood. The great number of parameters influencing

Fig. 1 Photograph of a traditional Brazilian wood-burning cookstove.

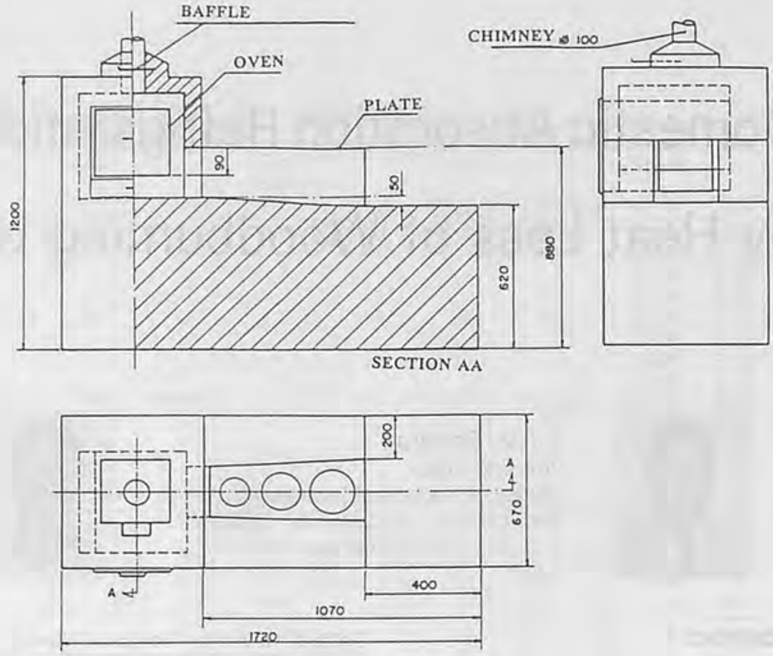


Fig. 2 Traditional Brazilian Woodburning Cookstove.

the behavior of wood fires makes it difficult to devise a standard test procedure for woodburning devices.

A traditional woodstove, used in Southeast Brazil (**Figs. 1 and 2**) was built with masonry. During the construction, 19 types of J thermocouples were inserted in the body of the stove: 14 in the base of the combustion chamber, 4 in its sides and one in the start of the chimney.

This stove was first tested using the provisional international standard for the testing of efficiency of woodburning cookstoves, a test procedure proposed by V.I.T.A.[2]. The water boiling test is divided in two phases. The first, a high power phase, aims to bring the water in the first pot to boil as quickly as possible, and keep it boiling at this power for 15 min.

The second and low power phase starts then, aiming to keep the water within 2°C from boiling temperature for 60 min, using the least amount of wood possible.

A series of 5 tests were made and the results are: the efficiency of each pan (η) and their standard deviation (S) and coefficient of variation (COV) are presented in **Table 3**. From these results we can see that the efficiency falls drastically from the first to the third pan.

Table 3. Water Boiling Test Results (V.I.T.A. procedure)

Item	1st phase			2nd phase		
Pan no.	η	S	COV	η	S	COV
1	2.60	0.27	0.10	2.18	0.42	0.19
2	2.36	0.56	0.24	1.10	0.48	0.44
3	0.93	0.14	0.16	0.20	0.10	0.51
Total	5.89	0.74	0.13	3.49	0.90	0.26

Results of the temperature distribution in the main points of the body of the stove during one of the tests, using eucaliptus wood with a moist content of 14% (dry basis) and a Low Heating Value of 16 100 kJ/kg are presented in **Fig. 3**.

An analysis of this figure shows that the combustion occurs only in the entrance of the combustion chamber (up to 300 mm from the begining), and that the gas temperatures in the entrance of the chimney increases rapidly and keeps high only during the burning of volatiles. The higher and steadier temperatures observed occurred under the combustion zone, near the entrance of the combustion chamber.

Using a test procedure more adequate for the evaluation of woodstoves in laboratory, described in details by Martins[3] and based in Prasad[4], it was possible to plot an efficiency-versus-power graph of this stove, shown in **Fig. 4**.

From **Fig. 4** we observe that the ideal power for this stove is between 10 and 11 kW, when the highest efficiency (around 9%) is achieved. In the range of power tested, as the power increases we observe a decrease in efficiency of the first pan, a slow increase up to stagnation in the efficiency of the second pan and an increase in the efficiency of the third pan.

From the results of both series of test we concluded that:

- The combustion chamber should be reduced to a length of 300 mm.
- To increase the heat transfer to the second and third pans, the passage of the hot gases under these pans should be reduced in order to increase the speed and the heat transfer coefficient.
- The most apropriate zone to transfer heat from the stove to the absorption system is under the combustion chamber.

An approximate heat balance

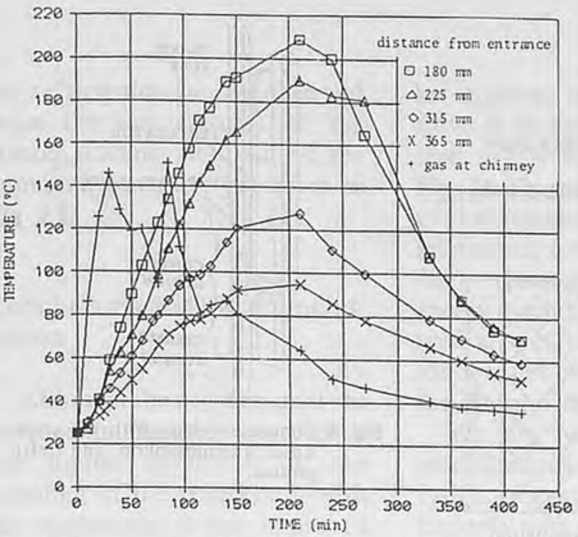


Fig. 3 Temperature evolution during a test in the main points of the stove.

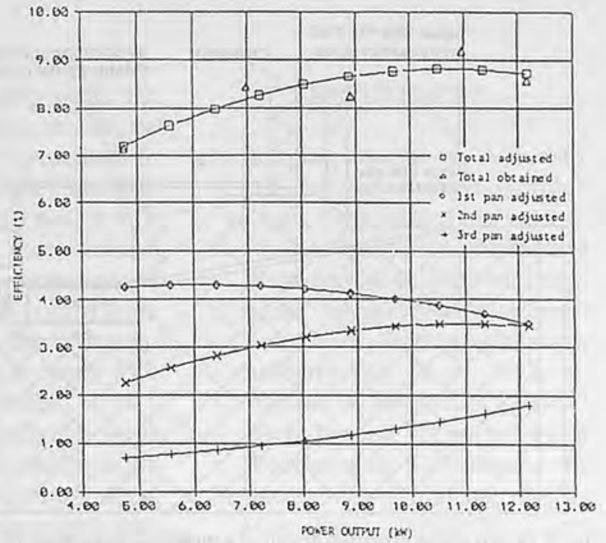


Fig. 4 Efficiency X power graph for the traditional stove.

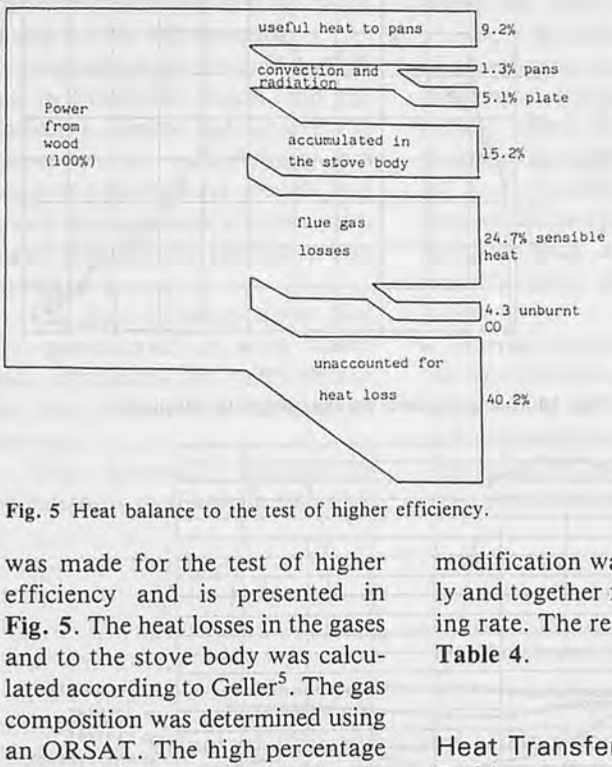


Fig. 5 Heat balance to the test of higher efficiency.

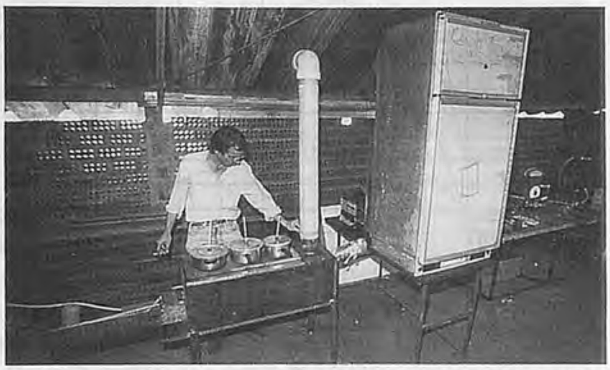


Fig. 6 Photograph of the experimental assembly with the modified cookstove and refrigerator.

was made for the test of higher efficiency and is presented in **Fig. 5**. The heat losses in the gases and to the stove body was calculated according to Geller[5]. The gas composition was determined using an ORSAT. The high percentage of losses not accounted for is an indication of the difficulties of closing heat balances in a woodstove.

A new combustion chamber was designed, incorporating the modifications proposed, a front door and an ash compartment, according to **Fig. 7**. The oven was not incorporated in this modified stove, since its performance was not considered in either of the test procedures. The effect of each modification was tested separately and together for the same burning rate. The results are shown in **Table 4**.

Heat Transfer from Stove to Refrigerator

A domestic absorption refrigeration system available in the market requires about 350 W for operation and the temperature of the ammonia generator is around 180°C. From the results presented, it was clear that our woodstove would comply easily with these requirements.

From a perspective of low cost, high confidence and durability, we chose a two-phase closed thermosyphon using water as working fluid to transfer the heat from the basis of the combustion chamber of the stove to the ammonia generator of the refrigerator.

It was designed for operation at 280°C, corresponding to a pressure of 6.4 MPa, for a heat flux of 350 W, using experimental correlations presented by Bezrodnyi and Sakhatsii[6] for the critical

Table 4. Effects of Modifications on Efficiency

Item	Normal Stove	Comb. Chamber reduced	Door	Both
Pan no.	η [%]	η [%]	η [%]	η [%]
1	3.56	4.69	5.01	5.70
2	2.97	4.44	4.10	4.70
3	1.10	1.79	1.59	2.15
Total	7.63	10.92	10.70	12.55

* Feed rate for all tests: 400 g of wood every 10 minutes.

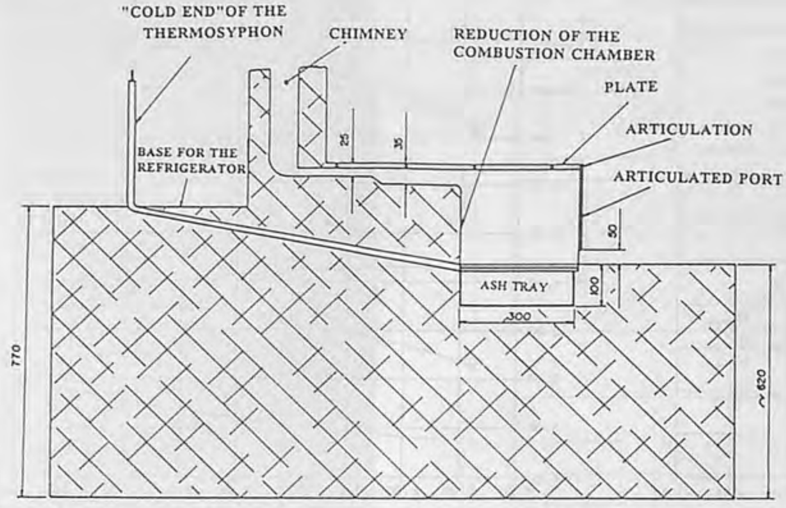


Fig. 7 Details of the proposed design of a modified stove ready for the installation of the refrigerator.

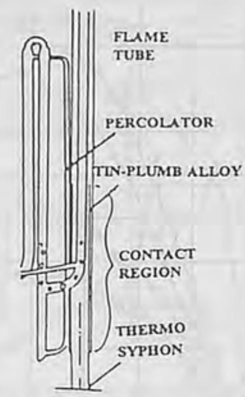


Fig. 8 Complete system with the cook-stove, thermosyphon and refrigerator.

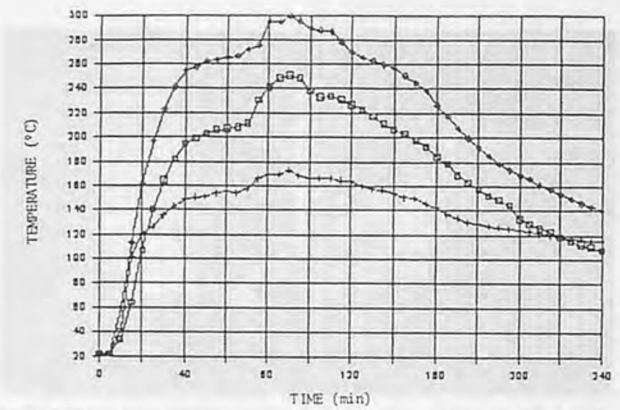


Fig. 9 Evolution of temperatures of adiabatic zone (◇), Condenser (□) and Percolator tube (+).

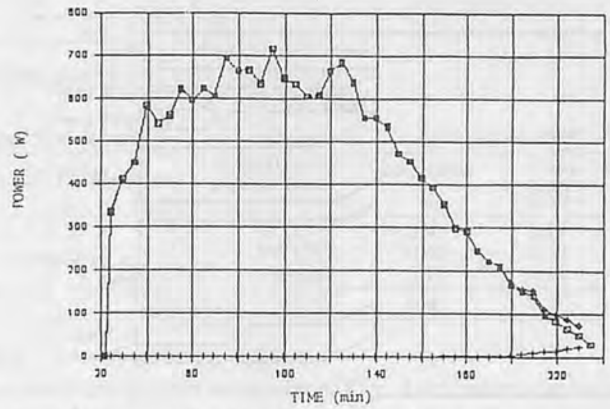


Fig. 10 Heat transfered by thermosyphon during test.

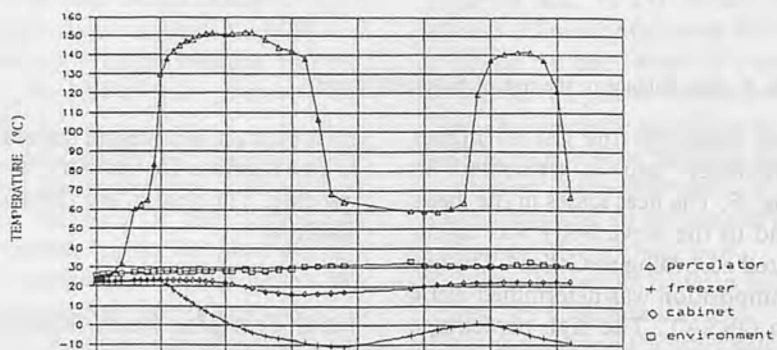


Fig. 11 Evolution of temperatures of the System Stove-Refrigerator coupled for the stove fed during 100 min, left for 150 min and lit again for 50 min.

heat flux.

The thermosyphon was constructed in stainless steel of 19 mm external diameter and 1 mm wall and mounted in the stove according to **Fig. 7**.

The determination of the heat transfered by the thermosyphon during the stove operation was made coupling its condenser (cold end) to an ammonia generator of a refrigerator, depressurized and using water as working fluid, measuring the rate of vapor generated and the rate and temperature of the water pumped by the percolator tube. **Fig. 8** shows the detail of this coupling.

The test was made feeding the stove every 10 min with constant weight charges of wood, according to the second test procedure. The results of a test using 10 charges of 600 g each of eucaliptus (15% moist, LHV = 16 000 kJ/kg) are presented below. **Fig. 9** shows the temperature of the adiabatic zone, of the condenser of the thermosyphon and of the percolator tube. **Fig. 10** shows the heat flux transfered by the thermosyphon.

Finally, using the same thermosyphon, we coupled the stove to a refrigerator and tested the system under a feed rate of wood of 400 g every 10 min, trying to simulate the daily routine of the stove operation. The behavior of the refrigerator can be observed from the temperatures of the freezer, cabinet and exit of the ammonia generator presented in **Fig. 11**.

Conclusions and Recommendations

Although the new design of the combustion chamber was part of the studies developed for the coupling of the refrigerator with the cookstove, it has improved reasonably the efficiency of the stove and the modifications can be performed even without the instalation of the refrigerator.

The cookstove studied is typical in Southeast Brazil, but the concepts applied to achieve the improvement in efficiency are valid for other stove models that could become more efficient with small changes in the utilization habits.

The heat balances show that the presence of an oven would not influence the performance of the woodstove-refrigerator system.

The domestic absorption refrigerator available in the market operates well only while the stove is in operation, as can be seen in the results presented in **Fig. 11**. Since the usual utilization of the woodburning cookstove is intermitent (two or three times a day), although the amount of energy available and temperature level are sufficient, the refrigerator does not operate properly with the intermitent heat flux.

We are now studying some modifications in the refrigeration system to enable it to work satisfactorily with an intermitent heat flux.

The position of the refrigerator above the level of the stove is not very practical, but the use of a heat-pipe, instead of a closed two-phase thermosphon would permit more flexibility to its location. From the thermal point of view, however, the proposed location did not present any inconvenience such as excessive heat transfer from the stove to the cabinet.

We recommend extreme care in the construction of the thermosyphon, since its working pressure and temperatures are very high (temperatures around 350°C and pressures of about 220 Bar).

REFERENCES

1. Brazilian Institute of Geography and Statistics (Demographic Census 1960, 1970 and 1980).
2. V.I.T.A. Testing the Efficience of Wood-burning Cookstoves: Provisional International Standards. Volunteers in Technical Assistance, Arlington, VA. 72 p. - 1982.
3. Martins, G. Absorption Refrigeration System Powered by a Woodburning Cookstove - A Theoretic-Experimental Study. M.Sc. Thesis - UNICAMP, Campinas - Aug. 1989.
4. Prasad, K. Khishna; Sangen, E. and Visser, P. Woodburning Cookstoves. In Advances in Heat Transfer. Academic Press, New York, v. 17, p. 159-317, 1987.
5. Geller, H.S. Cooking in the Ungra area: Fuel efficiency, energy losses, and opportunities for reducing firework consumption. In Biomass 2. Applied Science Publishers LTD, England, p.83-101, 1982.
6. Bezrodnyi, M.K. and Sakhatsii, A.A. Laws of limiting heat transfer in inclined evaporative thermosyphons. Teploenergetika. 24(3), p.75-77, 1977. ■■

(Continued from page 38)

Effect of Parboiling and Milling Parameters on Breakage of Rice Grains

REFERENCES

Autrey, et. al. (1955) Effects of milling condition on breakage of rice grain. J. Agric. Food Chem. vol.3: 593-599.

Bhattacharya, K.R. and Rao, P.V.S. (1966) Effect of processing condition on quality of parboiled rice J. Agric. & Food Chem. vol. 14: 476-479.

Bhattacharya, K.R. (1969) Breakage of rice during milling and effect of parboiling. Cereal Chem. vol. 46: 478-485.

Farouk, S.M. (1992) Study of factors affecting milling loss of rice, Res. Report, Dept. of Farm Power and Machinery, BAU.

Matthew, J.; Abadic, T.; Deobald, H.J. and Freeman, C.C. (1970). Relation between head rice yield and defective kernels in rough rice. Rice J.: 6-12.

Tani, T. (1983) Milling quality and eating quality of rice. Group training course in post-harvest rice processing. Rice Millers Assc., Japan, Tokyo. ■■

Performance Evaluation of a Modified Bicycle Pedal-operated Grain Mill

by
J.S. Adeoti
Department of Agricultural Engineering
Faculty of Engineering and Technology
University of Ilorin
Ilorin P.M.B.1515
Nigeria

Abstract

A bicycle pedal-operated grain mill for cereals was modified, fabricated and tested with a view towards ameliorating grain milling problem at the village level. It consists of the milling, power transmission and support units. Grinding is achieved by a combination of impact forces between the grain and the rotor, and, further crushing of the grain takes place by the regulated clearance between the rotor and fixed screen rim.

Tests conducted on the prototype, using maize and sorghum varieties, gave an output range of 8.0-13.0 kg/h, and grain loss of 1.2-2.3 percent at flour particle diameter of 1.20-2.42 mm. The resulting data were much influenced by the endurance limit of the operator in pedalling continuously to operate the rotor type and physical characteristics of grain and the milling machine parameters. As presently developed, the quality of the resulting flour indicates that the equipment is more applicable to animal feed milling.

Acknowledgement: The work forms part of an approved research project of the Agricultural Mechanization Research Programme of the Institute for Agricultural Research, Samaru. The permission of the Director to publish this report is grateful acknowledged.

Introduction

Some of the food crops cultivated in Nigeria are grains such as sorghum, maize, millet, rice, wheat and legumes. Studies have shown that their whole grains cannot be effectively digested by neither man nor animal. They are, therefore, milled to make flour and paste for human consumption or crushed for feeding livestock (Kay, 1984; Ituen et al., 1985).

Milling of agricultural products is one of the post-harvest processes to describe the relative reduction of grain into flour. The milling of grains may be dry or wet depending on choice or application of end products. In a survey conducted in Nigeria, it was found that about 0.5 t of cereal grains is ground each day of which the dry grinding accounted for over 80% (Ituen et al., 1986). Milling principles depend on bio-physical characteristics of the grain as well as some basic parameters of the mill. It embraces a wide range of technologies; from simple grinding of whole seed between stones, use of mortar and pestle to the use of modern day complex mills.

The different types of existing milling devices include hammer mills, roller mills and burr mills. The hammer mill is an impact mill consisting of a series of rotating beaters called hammers, and a heavy perforated screen. Its beaters rotate at 1 500-4 000 RPM while beating and pounding the material until it is small enough to pass through the screen (Henderson and Perry, 1976). The roller mill consists of long cylinderical rolls geared together so as to run in counter rotating pairs. The material to be ground is spread evenly along the length of the roll. Its grinding action is partly one of shear and partly of crushing. The burr mill, otherwise called plate mill, consists of a pair of moving surfaces.

The surface are hard and have rough texture. Its principle of operation involves shearing of the grains trapped in the space between the moving hard surfaces. Comparatively, the burr mills have the advantage of initial low costs, uniformity in the output and low power requirements. Similarly, the roller mills produce larger particles but their power requirement is low. However, the hammer mills are more versatile (Cremer and Davies, 1957). For any of these mills, the large-scale sizes with capacities varying between 150 and 450 000 metric tonnes per annum are found only in the cities. Some of the problems associated with them in most developing countries which make them unapplicable in the rural areas include inadequate or absence of such basic infrastructural facilities as water and electricity, lack of capital and technical skill for their repairs and maintenance (CAD, 1980).

A large percentage of the output of these large-scale mills are industrial input while as much as 80% of grains for human and animal consumption is still processed at the village level. In these villages, milling is done either manually, by traditional methods of pounding in mortar and pestle and the grinding on stones, or by an engine powered (4-5 kW) burr mill. A feasibility study in selected villages in Kaduna and Katsina States of Nigeria indicate that as much as 60% of households use the traditional manual methods while others use both the traditional methods and the engine powered burr mill. The majority of the rural households opt for the manual methods, ostensibly because the power operated mills are either unavailable or are not sufficiently backed by repair and maintenance facilities. Other major complaints include mixing up and pilfering of products at poorly organized village mills (Mittal et al., 1984). However, the traditional methods have their problems. The alternate wetting and drying to which the mortal and pestle tools are subjected result in the rapid wear of the equipment. The use of grinding stones also results in wear with the stone particles mixing with milled flour. Both methods are labour intensive. Efforts are being intensified to find better alternatives to these traditional milling devices. The main objective of the work being reported, therefore, was to evaluate the performance of a modified bicycle pedal operated using locally produced grains.

Development

A bicycle pedal-operated grain mill previously designed by Pison (1979) was further modified, fabricated and evaluated at the Institute for Agricultural Research, (IAR) Samaru, Zaria, Nigeria.

Mechanics of Grain Milling

The pedal-operated grain mill works on the principle of impact at high speed so as to achieve continuous size reduction. This process is similar to that of conventional power-harmmer milling. Its basic milling part is the rotary arm rotating inside a fixed screen rim as shown in **Fig. 1**.

Grinding is achieved by a combination of impact force between the grain seed and the rotating rotor. Further crushing action of the grain is ensured by the regulated clearance between the rotor and fixed screen rim. A screen-mesh wound around the screen rim controls the finess of the flour in the grinding process as only the grain particles whose diameter is less than the screen-mess hole can pass through. The bigger particles continue to be crushed till they also can pass through.

The required high revolution per minute (RPM) of the rotor is achieved through the bicycle pedalling system. The operator pedals a bicycle wheel at the normal cycling speed. The cycle wheel, in turn, drives a roller shaft on its outer edge at a speed of about 5 000 RPM. The pedalling system is adopted since less effort is required when one operates with the leg rather than arm (Whitt and Wilson, 1985).

Description of the Prototype

The main characteristic of the mill is that it is bicycle pedal-operated. This makes it more apropriate for application at the rural farming level where bicycle is presently used for transportation only (Adeoti, 1988).

The various components of the milling device can be divided into three units, namely; the milling unit; the power transmission unit; and the support unit.

The milling unit contains the basic components of the mill which performs the grinding action. The components include, mill front plate, chute, mill back plate, bearing housing, roller shaft, rim setting disc, screen rim, sieve and the rotor arm **(Fig. 2)**.

The power to operate is supplied by man and its transmission system is a standard bicycle **(Fig. 2)**. The power is transmitted

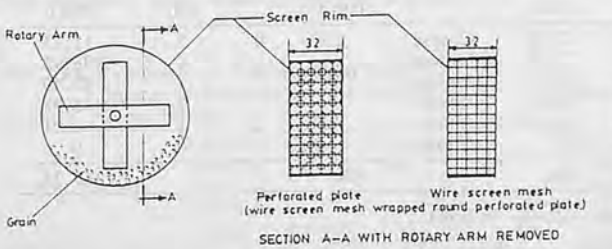


Fig. 1 Schematic view showing milling arm and screen mesh arrangement.

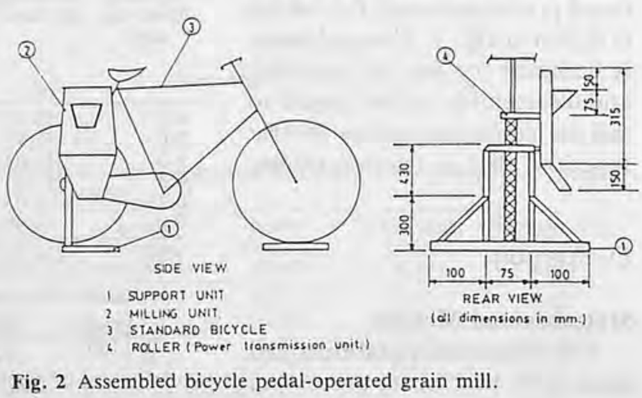


Fig. 2 Assembled bicycle pedal-operated grain mill.

Fig. 3 Fabricated pedal-operated grain mill ready for testing.

through the bicycle tyre with its rubber surface rubbing on the mills roller shaft. Based on Pison's design (1979), the roller shaft was to be made of annealed steel surface which is hard and rough. This, however, caused excessive wear and tear on the bicycle tyre. In order to reduce this wear and tear effects, the roller shaft annealed steel surface was modified to knurled wood surface, thus the bicycle tyre rubber surface rubbed on the mill's roller wood surface.

The support unit ensures firm support for the operator, the power unit and milling unit. Pison's design (1979) was modified to accommodate the locally available standard bicycle. The support unit consists of the upper and lower arms, and the main stand (**Fig. 2**). The bolts and the stands provide the means of mounting the cycle and ensuring the needed contact with the mill roller shaft for optimum power transmission.

The schematic diagrams of the assembly, showing some features of the bicycle pedal-operated grain mill are shown in **Fig. 2**. A fabricated prototype ready for testing is shown in **Fig. 3**. The equipment is designed for ease of assembly and disassembly on the bicycle so that the bicycle can perform its other function, that is, transportation.

Evaluation

Materials and Method

The fabricated pedal-operated grain mill, that is, its prototype, together with the two traditional village milling devices, that is, mortar and pestle and grinding stones were tested for quality and quantity of products. Other testing materials were sorghum and maize, stop-watch, weighing balance, sets of SI Tyler sieve, screens and rotor arms.

The mortar and pestle and the grinding stone were test-run for the purpose of comparing their performance with the earlier designed pedal-operated grain mill. The pedal operated grain mill was more extensively tested for performance and durability; varying grain input, crop variety, and equipment grinding parameters especially the rotary arm and screen apperture. For the mortar and stone, milling operations were performed as per the custom in the locality. For the pedal-operated grain mill, milling was done by two operators. One person cycled while the second person fed in the grain manually. To avoid clogging, the pedalling should commence first before grain feeding; the pedalling should be continuous as long as grain is fed, and, small handful of grain should be fed into the chute at a time. However, in the event of clogging, the grain could be released by slightly loosening the front plate holding bolt, and shaking the milling unit. After every milling operation the same cleaning operation should be performed.

The operation for measured quantity of each type of grain variety was repeated for a particular rotor length and sieve apperture. For the milled flour's quality assessment, the Tyler sieve was used based on the outline by Henderson and Perry (1979).

Analysis of Experimental Data

The performance of the mill was determined by the quantity and quality of its product. The quantity of the product the mill was capable of handling, i.e., its capacity, was assessed in terms of its output rate (kg/h), grain loss (%). The quality of its product was assessed in terms of grain size reduction, that is the initial and final size of the product, and the range in size of the finished product. The later was determined by the particle size analysis of which sieving is one of the basic methods (Perry and Chilton, 1973) which is also commonly used in Nigeria. At least two parameters are required to adequately describe a particle size distribution function and for making general comparison of ground products (Chung et al., 1977). The two parameters used in the sieve analysis were the

Table 1. Analysis of Finess Modulus, (FM), Uniformity Index (UI), and Diameter (Dav) Milled Grain Using Pedal Operated Grain Mill.

Sieve Opening (Mesh size mm)	Material Retained on Sieve (g)	Percent toal material retained on Sieve R (%)	US* Analysis Fraction Class	Cummulative material (%) retained in class (S)	UI	FM** Analysis Assigned Number (N)	Product (NR)
4.0	53.55	2.35	Coarse	2.35	0	5	11.75
2.0	1 642.75	72.23	Medium)	88.00	9	4	288.92
1.0	360.08	15.83	Medium)			3	47.49
0.5	215.95	9.49	Fine)			2	18.98
0.25	2.05	0.10	Fine)	9.59	1	1	.01
Pan	0.00	0	Fine)			0	0
Total	2 274.13	100		100			367.24

$* = $ Nearest whole No. of $\frac{S}{10} = 0{:}9{:}1$

$** = \frac{\Sigma(NR)}{100} = \frac{367.24}{100} = 3.67$

Average size of product. Dav $= 0.104(2)^{FM} = 0.104(2)^{3.67} = 1.32$ mm.

Finess Modulus (FM) and Uniformity Index (UI) as recommended by Henderson and Perry (1976). The finess Modulus value is used to estimate the average size of the ground product, i.e., the flour while the Uniformity Index gives information concerning the distribution of sizes into coarse, medium, and fine classes.

A typical analysis of FM, UI, and average size of milled grain (Dav.) by the pedal-operated grain mill is shown in **Table 1**.

Results and Discussion

The test results of the developed pedal-operated grain mill along with the existing traditional grinding methods are summarized in **Table 2** and **Fig.** 4. The pedal-operated grain mill had the highest average grinding capacity of 11.1 kg/h with over 250 and 800% advantage ratio over the stone and mortar, respectively. However, the developed pedal-operated grain mill is two-person operated while the traditional equipment are one person-operated each. Also, its ground particle had the highest proportion of coarse/medium particle of size of 1.22 mm which is largely due to the size of screen mesh used as discussed later.

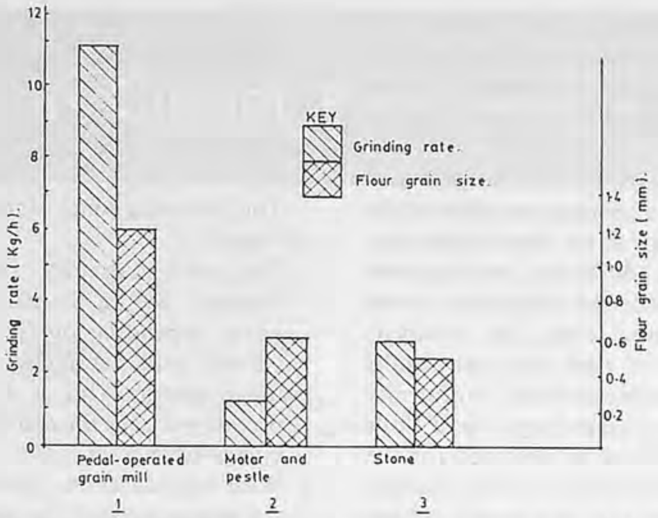


Fig. 4 Grinding rate and flour grain size for the three manual milling devices.

Tables 3a, 3b, 3c are summaries of the performance data for the pedal-operated grain mill varying grain input per cycle of operation, crop variety, and the equipment grinding parameters, that is, its rotor arm length and screen mesh opening. From these data the following trends were observed:

1. The mill's output rate decreased with an increase in the input per cycle of operation. This variation is mainly due to human factor as pedalling for longer periods are generally tiring and at lower speed. Indeed for the highest input of 5 kg the operator had to adopt rest periods during the cycle of operation as commonly practiced in manual operation.
2. The types and varieties of crop affected the mill's work rate **(Table 3b)** with the mill working faster with soghum. This may have to do with the bio-physical characteristics of the grain which vary with crop variety.
3. Generally, grain loss during the operation was low, ranging

Table 2. Performance Data for Three Manual Milling Devices

Milling Devices	Capacity (kg/h)	Finess Modulus	Uniformity Index	Average Diameter of flour (DAV) (mm)
Grinding stone	2.91	2.21	0:3:7	0.481
Mortar-Pestle	1.16	2.55	1:5:4	0.609
Pedal operated mill	11.10	3.55	0:8:2	1.22

Crop: Sorghum, Grain Moisture Content: 8% (db).

Table 3(a). Summary of Performance Data of Bicycle Pedal-Operated Mill Varying Grain Input per Operation

Grain Input per cycle of operation (kg)	Output Rate (kg/hr)	Grain Loss (%)
0.5	12.9	1.8
1	9.5	1.3
5	8.2	1.6

Crop: Maize, Variety: Ex-Funtua

Table 3(b). Summary of Performance Data of Bicycle Pedal Operated Mill Varying Crop Variety

Crop Variety	Grain Input per cycle of operation (kg)	Output rate (kg/hr)	Grain loss (%)
Maize (ex-Funtua)	5	7.6	1.7
Maize (White-Yellow)	5	8.5	1.9
Sorghum (L.S. 187)	5	11.1	2.8

Table 3(c). Effects of Equipment Parameters on Quality of Ground Materials

Rotor arm Length (mm)	Screen Apperture (mm)	Finess Modulus (FM)	Uniformity Index (UI)	Average Size of flour (mm)
203	1.59	3.52	2:6:2	1.20
203	2.36	3.86	3:6:1	1.51
200	1.59	4.41	5:4:1	2.21
200	2.36	4.54	6:3:1	2.42

Crop: Maize, Variety: Ex-Funtua.

between 1.3 and 2.8%. This has been achieved by making the joints between the front plate and back plate air-tight using rubber tube.

4. The rotor arm-length and screen opening size affected the quality of the flour (**Table 3c**). With different combinations of rotor arm length and screen opening size, the analysis showed that the best results for finess modulus, uniformity index and average size of flour particle were obtained for the longest rotor arm and smallest screen size. This trend is consistent since the longer the rotor arm, the smaller the clearance for grain passage between the rotor arm and screen (**Fig. 1**). Also, the small screen opening allows only the very finer particle to pass through. The quality of the ground of average diameter ranging from 1.20 to 2.42 mm, obtained so far is not yet fine enough for most dishes for human consumption. It is suitable for most animal feed, e.g., poultry. Therefore, the mill has greater potential for poultry farmers in its present design stage. However, with modifications on the rotor arm length and screen opening size; finer particles can be obtained.
5. For the duration of the test, the equipment was durable and maintenance free. The excessive wear and tear observed on the cycle tyre based on Pison (1979) recommended materials have been eliminated by changing his rotor shaft annealed steel surface to knurled wood surface.

Conclusion

The following conclusions may be drawn.

1. The mill capacity ranged between 8.0 kg/h and 13.0 kg/h, depending on the crop variety, mill parameters, and the operator. This is an improvement over the traditional village mills.
2. With regards to the quality of the ground grain, the average particle diameter ranged from 1.2 mm to 2.4 mm. This is suitable for some food menu for human consumption but more for animal feeds. The equipment, therefore, has greater potential for animal feeds on its present design.
3. The equipment enables the rural dwellers who own bicycle to use it for dual purpose, that is, for transportation and milling.

REFERENCES

Adeoti, J.S. and R.N. Kaul (1988). Assessment of Available Vehicles for Small Farmers in Rural Areas in Nigeria. In proceedings of C.I.G.R. Inter-Sections Symposium edited by K.C. Oni; 124-128.

Cremer, W.K. and T. Davies (1957). Chemical & Engineering Practice. Vol. 3. Butterworths Scientific Publications London.

Centre for Agricultural Development (CAD) (1980). Grain Processing Mills in Kano States. A report of CAD, Ibadon-Nigeria.

Chung, C.S., S.J. Clark, J.C. Lindholm, R.J. McGinty and C.A. Watson (1977). Comination Parameters for Wheat Hardness Measurement. Trans. ASAE 20(2): 375-379.

Henderson, S.M. and R.L. Perry (1976). Agricultural Processes Engineering, 2nd Ed. AVI Publishers, West Port.

Ituen, E.U.U., J.O. Mittal and J.S. Adeoti (1985). Particle Size Characterization of Selected Cereal Grains Under Wet Grinding. Journal of Food Process Engineering 7(4): 287-305.

Kay, M. (1984). The Ruminants Requirements. The Agricultural Engineer 39(2): 58-60.

Mittal, J.O., J.S. Adeoti, R.N. Kaul (1984). Comparative Performance of Selected Village Level Grinding Under Dry milling conditions. Proceedings of 2nd International Conference on Agricultural Mechanization. Amsterdam: 342-348.

Perry, R.H. and C.H. Chilton (1973). Chemical Engineers Handbook, 5th Ed. McGraw-Hill Book Company, New York.

Piston, G.S. (1979). A pedal-operated Grain mill. Rural Technology Guide 5. Published by Tropical Products Institute, London.

Whitt, R.F. and D.G. Wilson (1985). Human Power Generation in Bicycle Science, 2nd Edition, The MIT Press London: 29-67. ■■

Developments in Ginger Processing

by
Radha Charan
Assistant Professor
Dept. of Processing and Food Engineering
College of Technology and Agricultural Engineering
Udaipur 313 001 (Rajasthan) India

Abstract

Ginger, an important commercial crop, is known for its aromatic rhizome. Its peeling is very essential in hastening the process of drying. Despite the availability of various peeling methods for other root vegetables, no peeler has been developed for ginger. At this Institute different peeling methods have been tried. An abrasive type power operated ginger peeler was developed which has a sample peeling efficiency of 83.5% with 4.3% material loss. Its capacity is 200 kg/h. A small manual abrasive type ginger peeler was also developed to suit small farmer giving 71% bulk peeling efficiency with 1.3% material loss. It has a peeling capacity of 24 kg/h for fresh ginger. With pre-treated ginger in lye solution, it gives 83% peeling efficiency and 2% material loss.

Drying of peeled ginger was carried at different temperatures and moisture contents for its best organoleptic and biochemical qualities. Drying peeled ginger in two stages, i.e., up to 50% moisture content (wb) at 85°C and to required moisture content at 65°C is recommended.

Introduction

Ginger (*Zingiber officinale* rosc), an important commercial crop grown for its aromatic rhizome, has a distinctive spicy penetrating flavour. The principal constituents of ginger are starch (40 to 60%), a yellow colour volatile oil (4 to 10%), protein, mineral matter and fibre. The volatile oil is responsible for its characteristic flavour and oleoresin attributes its pungency. Ginger is mainly used as spice in cooking as flavouring agent. It is also used in medicine and in preparations of confectionary and preserved in syrup. Dry ginger is used for manufacturing of by-products as ginger oil, ginger essence, ginger oleoresins or soft drinks, and non-alcoholic beverages. It is also used as flavourant in food products like pies, cookies, cakes and biscuts. In distillaries it is used for the preparation of ginger beer, ginger brandy and ginger wine.

Processing of ginger basically involves peeling and drying besides cleaning, washing and soaking it. Drying refers to the removal of moisture that brings about an unfavourable environment for microorganisms responsible in spoilage.

Peeling is the most important single operation in processing. Being a fibrous crop peeling it is somewhat difficult. The indigenous methods used in peeling are by rubbing the ginger on jute cloth and scrapping with the bamboo knives after overnight soaking in water. The scrapped produce is washed and dried under the sun for 6 to 8 days and hand-rubbed. It is again stepped in water for 2 hours, dried and then rubbed to remove all the remaining bits of the skin. These methods are very laborious, time consuming and also causes high loss of material and quality. Sunlight also bleaches the product.

Despite the availability of various peeling methods, no single method is universally applicable and satisfactory for ginger. There are basically four methods of peeling potatoes and other root vegetables: abrasive peeling; lye peeling; steam peeling; and flame peeling or combination of heat and lye peeling. Other methods include brine peeling and oil peeling.

Review of Literature

A low-cost manually-operated ginger peeling machine was developed by the Radha Charan

Acknowledgement: The author acknowledges the cooperation of staff and students of the Department of Agricultural Processing and Food Engineering and Post Harvest Technology Scheme in undertaking the study.

(1993), which can be built and repaired by local artisans using locally available materials. One of the abrasive surfaces was kept stationary with sufficient inclination to facilitate downward movement of ginger. Manual drive was given to the machine in order to minimize its cost. Brushes made of coconut fibres were used in moving as well as on stationary abrasive surfaces. The hardness of coconut fibre results in better abrasive action while flexibility helps in cleaning the grooves or irregular surface of epidermic layer.

The combined effect of lye and abrasive peeling was also studied by Trivedi (1984).

Jabar Singh (1986) also carried out the peeling of ginger by hand, gunny bag, lye and by sand blasting using fine sand at a pressure of 2 to 2.5 kg/cm^2.

Sutar (1986) studied the effect of drying temperature on the drying characteristics of ginger and its quality. Peeled ginger was dehydrated at temperatures of 40, 50, 60, 70, 80 and 90°C. The volatile oil content of dried ginger powder was determined using IS specifications. The organoleptic qualities were determined using a seven-member consumer panel.

Mantri (1991) established the best time temperature combination for multi-stage dehydration. He dried the peeled ginger at 65, 75, 85 and 95°C. At each temperature dehydration was cut off at the times corresponding to 30, 40, 50 and 60% moisture content (wb). The remaining moisture was removed at control temperature of 65°C until the ginger reached 12% moisture content (wb).

It was observed that, initially, the peeling efficiency in hand-peeling was 100% but after 2 to 3 h of continuous peeling the efficiency was reduced to 85-90%. The material loss was also increased from 2% to 5%. The capacity of peeling was 30 kg/day (8 h).

Fig. 1 Ginger peeler profile.

Fig. 2 Ginger peeling work.

Peeling by gunny bags was found to be faster but the efficiency was only 70% because of the inability of gunny bag to enter into the grooves of ginger pawns. The capacity of peeling was 50 kg/day (8 h) per labourer.

The peeling efficiency of ginger by lye (sodium hydroxide) peeling method was increased from 42 to 70% by increasing the lye concentration from 1.0 to 20% and dip time from 10 min. to 30 min. at 70°C. The increased dip time did not affect efficiency. The material loss increased significantly from 1.35 to 15.3% maximum by increasing the temperature and concentration of lye and dip time of ginger.

Peeling efficiency of 52% with 1-2% material loss was observed in sand blast peeling. This method could remove the skin from surfaces only and not from grooves.

Sodhi (1980), and Khandelwal (1984) developed abrasive type power-operated, ginger-peeling machine and suggested standardized operating and constructional parameters. Jain (1985) developed a prototype with these standard parameters to give 83.5% peeling efficiency with 4.3% material loss. This machine has a peeling capacity of 200 kg/h with the following constructional and operating parameters:

Fig. 3 Ginger before peeling and after peeling.

Brush wire height
: 20 mm
Brush wire spacing/set
: 19 × 19 mm
Brush wire density
: 2 864 set/m^2
Peeling zone
: 1 350 mm × 300 mm
Space between brush wire tips in two surfaces
: 10 mm
No. of 32 gage steel wire per set
: 20
Belt relative speed
: 1 990 mm/s

Materials and Methods

An abrasive type ginger peeling machine was designed and developed by Agrawal (1983) because of the following reasons:

a) Abrasive peelers are simple in construction, compact, have low installation cost and are convenient to operate;
b) Abrasive peelers are safe to operate as they do not use any chemical for peeling; and
c) Little extra equipment such as washers are required with abrasive peelers.

This machine consists of two endless canvass belts mounted on flat pulleys moving in opposite directions with a relative velocity of 1 990 mm/s downward. The belts have steel wire brushes on their outer surface and are d riven by a power transmission system consisting of 1 hp motor (single phase). Later on it was modified by Khandelwal (1984).

It was, however, felt that this machine may not be suitable for small farmers for two reasons;

a) The cost of the machine would be approximately 20 000 Rs. (including motor) which is beyond the reach of small farmers in India; and
b) The machine consists of specially cast pulleys and specially built brush belts lending it suitable for commercial manufacturing only.

Results and Discussion

The manually operated small ginger peeling machine using coconut fibre was developed to give 71% peeling efficiency with 1.3% material loss in its full capacity operation (24 kg/h) in 5 passes with the fresh ginger.

In the combined effect of lye and abrasive peeling, the peeling efficiency and ginger meat loss by this machine was 83% and 1.9%, respectively, in 4-pass operation. The recommended operating parameters are:

Lye concentration
: 7.5%

Temperrature of lye solution
: 30°C

Time of immersion
: 05 min

Sutar (1986) observed that the ginger dehydration follows only falling rate period and constant rate period was absent. The volatile oil content of ginger (dried) ranged from 0.06 to 0.08 mℓ/10 g. It was maximum at 70°C. The ginger pungency was best in the sample dried at 60 and 70°C. He recommended the ginger dehydration at 60-70°C, based on the quality factor grades and volatile oil content.

Mantri (1991) recommended the ginger to dry at 85°C up to a moisture content of 50% (wb) during I stage and then at 65°C up to 12% or a desired moisture content level. He observed a saving of 4 h in drying time in relation to single stage dehydration in the recommended two stage drying process.

Table 1. Peeling Efficiency and Ginger Meat Loss in Various Peeling Methods

Peeling Method	Peeling efficiency (percent)	Ginger meat loss (percent)
Hand peeling with knives	85-90	5
Gunny bag peeling	70	—
Sand blasting	52	2
Abrasive peeler (power operated)	83.5 (5 pass)	4.3
Abrasive peeler (manual)	71 (5 pass)	1.3
Lye and abrasive peeling (manual)	83 (4 pass)	1.9

REFERENCES

1. Jabar Singh & Ali Y. 1986. Agro processing model for ginger and termeric at village level. A report on Post Harvest Technology. C.T.A.E. udaipur, India.
2. Jain, G.C. and Kapadi, S.S. 1985. Prototype development of brush type ginger peeling machine. An unpublished B. Engg. (Ag) Thesis. C.T.A.E. Udaipur, India.
3. Khandelwal, N.K. and Sharma, P.K. 1984. Modification of brush type ginger peeling machine. An Unpublished B. Engg. (Ag) Thesis. C.T.A.E. Udaipur, India.
4. Mantri, A.R. 1986. Process development for ginger dehydration. An unpublished M. Engg. (Ag) thesis. C.T.A.E. Udaipur, India.
5. Radha Charan and, Agrawal, Y.C., Bhatnagar, S., Mehta, A.K., 1982. Application of abrasive and lye peeling of ginger at individual farmers level. Agricultural Mechanization in Asia, Africa and Latin America. Vol. 24, No. 2 1993, pp 61-64.
6. Agrawal, Y.C., Singhvi, A., and Sodhi, R.S. 1983. Ginger Peeling I. Development of an abrasive brush type ginger peeling machine. Jour. Agri. Engg., Indian Society of Agricultural Engineers, Vol. XX, No. 3 & 4. pp 179-182.
7. Sutar, R.F. 1986. Studies on heated air drying of ginger. An unpublished M. Engg. (Ag) thesis, C.T.A.E. Udaipur, India.
8. Trivedi, M. & Dave, N.K. 1984. Comparative evaluation of abrasive & lye peeling of ginger. B. Engg. thesis, C.T.A.E. Udaipur, India.

Simulation of Materials in Handling System in Sugarcane Mill Yard: A Case Study

by

M.O. Marenya
Graduate Research Assistant
Dept. of Agric. Engineering
University of Nairobi
P.O. Box 30197 Nairobi
Kenya

Pascal G. Kaumbutho
Lecturer
Dept. of Agric. Engineering
University of Nairobi
P.O. Box 30197 Nairobi
Kenya

Daniel A. Mutuli
Lecturer
Dept. of Agric. Engineering
University of Nairobi
P.O. Box 30197 Nairobi
Kenya

John N. Kamau
R & D Engineer
Mumias Sugar Co.
Private Bag, Mumias
Kenya

Abstract

A study was conducted at Mumias Sugar Company (MSC) in Western Kenya to model the MSC factory mill yard operations between November, 1991 and May, 1992. In developing the model, parameters that determine the flow rate of cane into and out of the factory's mill yard were identified. The study utilized current as well as previously recorded (historical) data where available.

A computer simulation model was developed for evaluating existing or proposed MSC Mill Yard configurations. The model, MSC-MYSM (Mumias Sugar Company-Mill Yard Simulation Model), dynamically simulates the effects of varying input variables and parameters on the mill yard performance measures such as the average cane trailers waiting time and the queue length outside the weighing bridges. MSC-MYSM was validated using the MSC historical operational data.

Introduction

In a sugarcane processing plant, the mill yard plays an important part as it forms the link between the transport trailers and factory. As a result, the operations of the mill yard affect both transport and factory operations.

Sugarcane mill yard systems are made up of several workers and pieces of equipment. Because of the complexity of the interactions among the components of these systems, it is often difficult to determine, in advance, the performance of a new system or what effects changes will have on an existing system. Computer modelling is a tool that can provide useful information quickly and economically to persons involved in making decisions about sugarcane mill yard operations.

A typical Kenyan sugarcane mill yard system consists of cane, tractor-hauled transport trailers, unloading equipment and the people required to operate the system. The efficiency of the entire mill yard is dependent on the planning, interactions and capabilities of the system's components. One method of determining component interaction and probable system performance is through a dynamic computer simulation.

Objectives

The objectives of this study were:

1. To model the operations of the Mumias Sugar Company's (MSC) Mill Yard system, and
2. To demonstrate how the model might be used to improve cane flow efficiency through the mill yard.

Previous Research

Research interest, especially relative to cane flow in sugarcane processing systems, goes back to the work of Todd as reported by Peart et al., (1963) according to whom, Todd analyzed a sugarcane harvesting and processing system and designed a revised system using industrial engineering methods.

Shukla et al., (1972) developed a computer program for analyzing harvesting, loading and transportation of sugarcane. The computer program developed was used as a means of providing quick answers to questions such as:

1. What kind of transport system should be used under a particular set of conditions?
2. How many hours should these machines be used every day?
3. Is it more economical to use one system or a combination of systems?

The output of the program provided answers to the questions posed above without interfering with the actual operational system.

Whitney and Cochran, (1976) developed a model for predicting sugarcane mill delivery rates. The developed model was used for predicting the delivery rate of cane to the mill for a single loader transport system. The model was based on the assumption that the interval of time between arrivals at the field is random and Poisson distributed. It was further assumed that loading occurred in a random fashion with exponentially distributed loading times. The cane delivery rate to the mill was obtained from the average rate of loading units or by the rate of hauling by the transport units. The model was finally presented in a graphical (nomograph) form to facilitate its use for field management.

Crossly (1987) developed a computer program code-named PABAC and applied it to analyze the sugarcane transport system in a developing country. The system analyses comprised of conventional tractor/trailer units with either two- or four-wheel drive tractors. In validating the program, predicted and actual system performance values were compared. This program could be used interactively to model a transport system and produce predictions of the performance and operating costs of vehicles used.

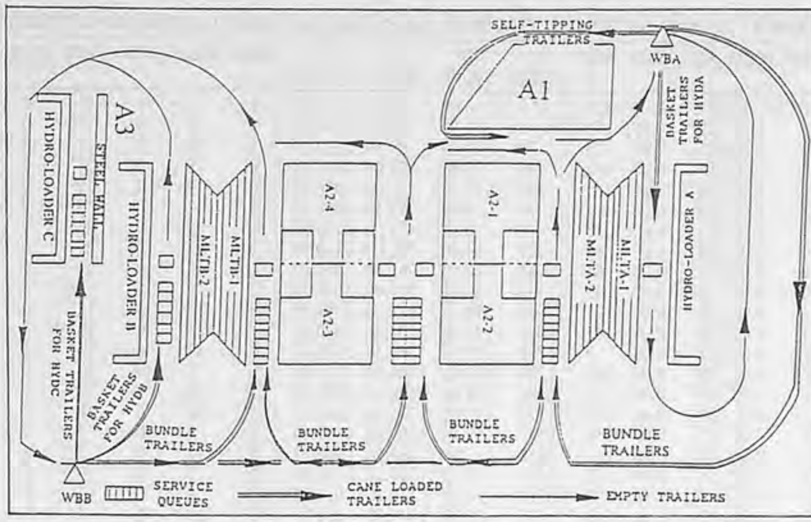


Fig. 1 Schematic representation of the MSc Mill Yard traffic flow.

System and Model Configuration

The Mumias Sugar Company - Mill Yard Simulation Model (MSC-MYSM) is a discrete model of the MSC Mill Yard operations laid out as shown in **Fig. 1**. The program was written in Turbo Pascal Version 5.5.

Cane loaded trailers arriving from the fields are weighed-in through the weighbridges WBA and WBB before entering the mill yard on a First-Come, First-Served (FCFS) basis. When the arrival rate of the trailers is higher than the service (weighing-in) rate, queues of cane loaded trailers develop outside the weighbridges.

Once a cane loaded trailer has been weighed-in, it proceeds to its service (unloading) point. At the service point, an arriving trailer is unloaded immediately if there is no service queue or joins the service queue and waits for its turn to unload. The unloading operation at all service points is carried out on FCFS.

As presented in **Fig. 1**, all cane trailers once unloaded, proceed to the weighbridges and are weighed-out. A cane trailer that weighed-in through WBA is weighed-out through WBA. The same case applies to the second weighbrige (WBB). This is to enable weighbridge clerks to determine the tonnage of cane delivered to the Mill Yard by a given trailer unit. The delivered tonnage is the difference between a loaded and unloaded cane trailer. The amount of cane delivered forms the basis of payment to cane farmers and is, therefore, important.

Using the model, existing or proposed MSC Mill Yard operating systems can be defined and modelled. The model simulates the MSC Mill Yard operations and presents a summary set of statistics indicating performance of the system configuration in terms of cane delivery, average hourly trailer waiting times and the number of operational Gantry cranes during any hour of operation. MSC-MYSM is a *what if* type model, that is, the model simulates a given MSC Mill Yard system but makes no attempt to optimize individual components.

Table 1. Example of MSC-MYSM Print-out Showing the Input Information and Selected Mill Yard Performance Measures

Time	MillA	MAI	MillB	MBI	GC-STOCK	ST-STOCK	T-STOCK	R-STOCK	NWGC	ONBA	RNBA	ONBB	RNBB	ONBDGS	RNBDGC	ONBDST	RNBDST	WBA	WBB	WST
7	31.50	135	0.00	155	0	0.00	0.00	6670.00	2	11	0	14	0	13	0	3	0	17	12	10
8	0.00	125	0.00	175	6	0.00	0.00	6490.00	1	7	0	17	0	20	0	5	0	4	24	35
9	0.00	115	0.00	55	70	24.00	93.50	5320.00	1	14	0	22	13	14	0	4	0	14	38	20
10	0.00	85	0.00	145	242	33.00	275.00	4950.00	0	8	0	24	1	28	0	7	0	11	22	23
11	0.00	95	0.00	125	345	32.50	377.00	4598.00	0	9	0	12	0	25	0	6	0	13	7	12
12	0.00	135	0.00	115	377	0.00	377.50	4380.00	2	11	0	9	0	16	0	4	0	9	14	26
13	0.00	135	0.00	175	479	0.00	479.50	4298.57	1	10	0	22	0	27	0	7	0	15	28	29
14	0.00	115	0.00	165	707	54.00	761.00	4100.00	0	24	6	25	0	38	0	9	0	27	24	30
15	0.00	155	0.00	165	742	20.50	762.50	3950.00	1	15	0	16	0	16	0	4	0	15	26	17
16	0.00	5.50	0.00	145	794	56.50	851.00	3528.70	0	6	5	9	0	23	0	6	0	51	7	22
17	0.00	65	0.00	115	919	96.50	1018.00	3191.50	0	16	6	12	0	30	3	7	0	29	12	27
18	0.00	125	0.00	45	1076	126.50	1202.50	2870.50	1	18	0	13	6	26	0	6	0	29	29	20
19	0.00	85	0.00	0	1208	155.50	1363.50	2500.81	0	12	0	14	14	22	0	6	0	15	60	40
20	0.00	105	0.00	165	1306	100.00	1406.50	2303.93	2	3	0	23	0	19	0	5	0	4	23	27
21	0.00	105	0.00	145	1402	136.00	1538.00	2085.30	1	18	1	14	0	24	0	6	0	31	17	32
22	0.00	145	0.00	145	1572	143.00	1715.00	1882.75	0	16	0	18	0	33	0	3	0	19	18	37
23	0.00	115	0.00	135	1547	52.50	1600.00	1653.44	2	1	0	5	0	13	0	3	0	3	4	31
0	0.00	125	0.00	0	1612	17.00	1630.50	1380.17	2	11	0	7	7	11	0	3	0	12	60	28
1	0.00	35	0.00	185	1565	19.50	1584.50	1147.50	1	3	0	9	0	13	0	3	0	1	9	29
2	0.00	75	0.00	155	1515	14.50	1530.00	918.10	1	8	0	7	0	10	0	3	0	18	10	29
3	0.00	85	0.00	195	1430	19.00	1449.50	695.79	0	11	0	4	0	14	0	3	0	8	2	13
4	0.00	85	0.00	165	1360	0.00	1380.00	465.50	0	3	0	6	0	14	0	3	0	10	6	14
5	0.00	135	0.00	155	1300	0.00	1300.50	235.24	2	5	0	12	0	16	0	4	0	13	16	20
6	0.00	145	0.00	145	1190	0.00	1190.50	0.00	0	5	0	7	0	14	0	3	0	5	10	15

Terms used in Table 1 are as follows:

- Time - This is the hour of the day (normal time)
- MillA - Final Mill A milling rate value (after an hour's milling operation)
- MAI - Initial Mill A milling rate value read from the disk file at the beginning of an hour.
- MillB - Same as MillA above
- MBI - Same as MAI above
- GCSTOCK - Cane stock under the Gantry cranes unloading area, i.e., A2 in Figure 1.
- STSTOCK - Cane stock in the self-tipping trailers, i.e., A1 in Figure 1.
- TSTOCK - Total stock available in the mill yard at the end of any given hour.
- RSTOCK - Estimated required stock at the end of an hour's operation based on mean milling rate requirement.
- NWGC - Number of gantry cranes that were not engaged in unloading bundle cane trailers at the end of an hour, i.e. idle unloading channels.
- ONBA - Initial (arriving) number basket trailers through weighbridge A to be unloaded by Hydro-loader A.
- RNBA - Number of unloaded trailers that arrived at the begin of the hour to be unloaded by Hydro-loader A.
- ONBB - Same as ONBA, but passing through weighbridge B to the unloaded by Hydro-loader B.
- RNBB - Same as RNBA.
- ONBDGC - Bundle trailer units arriving to be unloaded by hte gantry cranes for both weighbridges.
- RNBDGC - Number of unloaded bundle cane units at the end of an hour.
- ONBDST - Initial number of self-tipping trailers at the beginning of the hour.
- RNBDST - Remaining number of the unloaded self-tipping trailers at the end of an hour.
- WBA - Average hourly waiting time for basket trailers through weighbridge A.
- WBB - Same as WBA, but for units through weighbridge B.
- WST - Average hourly waiting time for self-tipping trailers.

Model Inputs

The only input to the model entered interactively at the Keyboard is the length (in terms of days) of time one needs to conduct the simulation. The trailers inter-arrival time is assumed to follow the exponential distribution and the mean hourly delivery values for each trailer type are read from a disk file.

The second input provided for the MSC-MYSM is the hourly milling rates. These are also read from a disk file. The program then uses the hourly values for all input parameters to determine the average waiting times for all trailer types and the cane quantity available (for the mill) in the yard stockpile at the end of every hour.

Program Logic

The MSC-MYSM is a discrete-event simulation model. When a discrete event occurs, a situation is usually created whereby another event is scheduled or the entity involved is placed in a waiting line. For example, when a cane loaded trailer arrives at the unloading point (a discrete event) it enters the serving point (if there is no other trailer in service) and is scheduled to arrive at weighbridge (out-going weighbridge arm). However, if there is another trailer in service, the trailer is placed in a waiting line (queue).

Model Outputs

The output from MSC-MYSM is composed of a listing of input information read from the disk files. This forms the first 5 columns of the print-out. It is followed by a listing of the determined operational parameters such as the hourly average waiting times for all trailer types, the quantity of cane in the yard at the end of the hour, the original and remaining number of cane trailers at the end of an hour's operation, among others. A print-out example is presented in **Table 1**.

Model Validation

The MSC-MYSM was validated by simulating mill yard opera-

Table 2. Simulated and Actual Milling Rates Frequency Distribution for Mill A

MID-CLASS	ACTUAL-A	SIMUL-A	Contribution to Chi-square
0.0	244	241	0.037
5.5	6	4	*
15.0	29	26	0.714*
25.0	49	58	1.653
35.0	48	54	0.750
45.0	59	53	0.610
55.0	57	60	0.158
65.0	95	82	1.779
75.0	99	95	0.162
85.0	155	157	0.026
95.0	197	191	0.183
105.0	313	305	0.205
115.0	469	477	0.135
125.0	640	641	0.002
135.0	668	673	0.037
145.0	528	516	0.273
155.0	310	315	0.081
165.0	110	118	0.582
175.0	31	38	0.581
185.0	12	13	0.083
195.0	0	0	—
205.0	0	0	—
215.0	0	0	—
Total	4 119	4 117	8.051

*Chi-square contribution for combined classes.
ACTUAL-A = Actual Mill A milling rate data collected from the MSC factory laboratory.
SIMUL-A = Simulated Mill A milling rate values obtained after running the simulation computer program for a period of six months.
Conclusoin: There is no statistical evidence to suggest that the simulated and the actual milling rates data for mill A come from two different populations.

Table 3. Simulated and Actual Milling Rates Frequency Distribution for Mill B

MID-CLASS	ACTUAL-B	SIMUL-B	Contribution to Chi-square
0.0	191	199	0.335
5.5	6	7	0.167
15.0	19	18	0.053
25.0	23	27	0.696
35.0	27	32	0.926
45.0	24	29	1.042
55.0	29	32	0.310
65.0	41	52	2.951
75.0	49	60	2.469
85.0	44	51	1.114
95.0	51	43	1.255
105.0	79	75	0.203
115.0	91	94	0.099
125.0	167	177	0.599
135.0	273	290	1.059
145.0	428	411	0.675
155.0	671	674	0.013
165.0	733	725	0.087
175.0	606	584	0.799
185.0	319	304	0.705
195.0	176	160	1.455
205.0	56	68	2.571
215.0	10	8	0.400
Total	4 113	4 120	19.983

ACTUAL-B = Actual Mill B milling rate data collected from the MSC factory laboratory.
SIMUL-B = Simulated Mill B milling rate values obtained after running the model for a long period.
$X^2_{critical} = X^2_{0.05}$, 22 df = 33.90
Conclusion: There is no statistical evidence to suggest that the simulated and the actual milling rates data for mill A come from two different populations. Thus, the simulated milling rates generated by the model for Mill B are statistically acceptable within the set limits.

Table 4. Mean Hourly Number of Loose and Bundle Cane Units

HOUR	ABK	BBK	ABBD
7.00	10.14	12.92	16.47
8.00	9.49	13.53	21.76
9.00	9.98	14.22	24.62
10.00	11.18	12.28	28.79
11.00	10.95	11.83	26.78
12.00	9.25	9.28	22.09
13.00	11.30	17.45	36.31
14.00	19.29	25.55	50.76
15.00	9.59	12.91	26.25
16.00	10.72	12.18	26.55
17.00	11.44	12.22	28.12
18.00	11.24	11.89	27.37
19.00	10.07	8.60	23.79
20.00	8.38	8.51	20.08
21.00	11.33	13.89	32.87
22.00	15.42	19.05	40.17
23.00	5.11	8.04	18.43
0.00	6.66	4.31	18.74
1.00	6.84	4.18	17.34
2.00	6.72	8.22	17.57
3.00	6.05	6.82	16.65
4.00	5.72	6.95	15.82
5.00	6.94	13.08	16.37
6.00	5.13	7.00	16.30

ABK - Basket type trailers through Weighbridge A.
BBK - Basket type trailers through Weighbridge B.
ABBD - Double and single bundle units (Self-Tipping units inclusive)

Table 5. Simulated Units Delivery at 14.00 Hours

	NBA	NBB	NBD
	17	23	42
	17	22	53
	21	25	47
	20	22	46
	21	33	49
	20	28	52
	19	30	58
	21	23	47
	26	35	44
	18	22	56
	22	31	55
	19	22	37
	11	30	39
	14	38	55
	16	27	39
	18	23	68
	16	23	51
	15	29	45
	15	28	43
	18	20	58
Actual mean	19.29	25.55	50.76
Simulated mean	18.20	26.70	49.20
Standard deviation	3.32	5.01	7.81
t-calculated	− 1.47	1.03	− 0.89

NBA - Number of Basket arrivals through Weighbridge A.
NBB - Number of Basket arrivals through Weighbridge B.
NBD - Number of Bundle arrival through both Weighbridges.

tional data for a period of six months and comparing the simulated data with the real operational data. *Chi-square-goodness-of fit* test was performed at 5% significance level to determine the degree of fit between the simulated and the historical data where frequency distribution comparison tests were necessary. For comparison of mean values, the hypothesis "There is no difference between the means of simulated and historical data" was performed at 5% significance level.

Table 6. Simulated Units Delivery at 21.00 Hours

	NBA	NBB	NBD
	11	19	36
	16	15	32
	12	18	38
	10	11	21
	12	20	31
	18	16	38
	11	19	43
	15	12	31
	11	12	29
	7	6	22
	16	9	22
	9	12	32
	11	20	32
	10	12	42
	9	14	28
	10	18	34
	14	13	35
	9	14	29
	16	15	35
	14	12	25
Actual mean	11.33	13.89	32.87
Sample mean	12.05	14.35	32.05
Standard deviation	2.98	3.82	6.35
Calculated t-value	1.08	0.54	−0.58

Table 7. Mean Waiting Time Data obtained from a 24 Day Simulation Run for all Trailer Types

WBA	WBB	WST	WGC
14.8	24.8	14.9	37.8
22.6	14.8	19.0	37.4
21.5	17.5	24.9	41.2
20.9	18.1	29.0	35.1
13.5	22.7	10.8	34.8
17.1	17.3	20.9	41.1
19.1	21.5	20.6	31.1
21.5	18.2	30.4	32.6
19.7	19.3	28.5	30.2
22.8	15.7	24.8	34.8
17.5	21.4	22.1	42.7
18.5	12.3	22.5	36.3
15.2	20.5	23.4	41.5
27.1	16.0	23.6	32.9
14.9	14.5	18.1	31.3
13.1	12.3	26.8	46.5
18.5	17.7	23.3	36.3
21.1	16.5	17.6	38.9
20.2	15.3	28.7	31.8
12.2	16.1	24.5	37.2
20.5	18.5	24.9	34.5
17.2	14.8	26.0	36.7
13.5	14.6	26.6	36.3
12.5	18.1	16.2	34.3

WBA = Waiting time of Basket type trailers unloaded by Hydro-Loader A.
WBB = Waiting time of Basket type trailers unloaded by Hydro-Loader B.
WST = Waiting time of the Self-Tipping bundle trailers.
WGC = Waiting timeof Ordinary bundle trailers unloaded by the Gantry Cranes.

Table 8. Results of Waiting Time Data Obtained from a 24 Day Simulation Run

Item	μ	X	σ_{n-1}	$t_{calculated}$	$t_{tabulated}$
WBA	23	18.2	3.859	−6.094*	2.069
WBB	23	17.5	3.130	−8.608*	2.069
WST	24	22.8	4.857	−1.210	2.069
WGC	38	36.4	4.054	−1.933	2.069

*Significant at 5% level.
μ - Actual mean waiting times for various truck types.
X - Simulated mean waiting times for various truck types.
σ_{n-1} - Variance for the simulated waiting times.

Tables 2 and **3** give the simulated and the actual milling rate frequency distribution values for mills A and B. From these two tables, there is no statistical evidence to suggest that the simulated and real milling rate values were different. The model, therefore, generates acceptable milling rates.

For the cane delivery, two representative hours, namely, 14th and 21st were selected. **Table 4** gives the actual mean hourly cane delivery rates for all trailer types. For the selected hours, a simulation was performed for a period of 20 days. Results obtained from the simulation run are presented in **Tables 5** and **6**. In order to determine the agreement between the simulated and the actual cane delivery rates for the selected hours, a two-tailed t-test was performed at 5% significance level. The results indicated that the simulated and the actual mean hourly cane delivery rates are indistinguishable at a 5% significance level. By extension, the above should hold for all the hours of operation since the only changing factor is the mean hourly cane delivery rate used in calculating the number of arriving cane trailers.

Table 7 gives the average daily waiting times obtained for a continuous (simulation run) period of 24 days. Results obtained after analyzing **Table 7** are presented in **Table 8**. From the analysis, the mean waiting time for basket (bin) trailers are observed to be significantly lower at 5% significance level. Also, from **Table 8**, the simulated average waiting times are lower than the actual mean waiting time values for all trailer types. The low simulated average waiting time for all trailer types observed, is attributed to other mill yard time consuming activities that were considered negligible and were, therefore, not incorporated in the model. Such activities included the time taken by the trailers to traverse the distance between the service points and the weighbridges, time taken to weigh the trailers into and out of the mill yard and time taken to remove the occasional spill-over cane in trailers carrying cane that was not properly loaded.

Model Application and Discussion

The MSC-MYSM can be used to evaluate a wide range of existing or proposed MSC mill yard unloading systems. Several mill yard configurations were investigated using the MSC-MYSM model. During the investigations,

Table 9. Waiting Times Data for Various Numbers of Fixed Unloading Gantry Cranes

DAY	N=2	N=3	N=4	N=5	CONTROL
1	52.1	27.6	29.1	29.9	31.2
2	53.5	29.3	28.0	26.8	33.1
3	49.4	28.1	26.4	27.3	39.8
4	53.4	31.8	29.8	27.7	38.6
5	54.5	28.5	26.8	25.2	31.2
6	52.0	27.2	29.9	27.4	36.8
7	53.1	35.0	27.1	27.9	36.0
8	50.0	30.1	28.3	28.5	38.7
9	54.0	29.3	27.9	28.1	34.5
10	51.2	29.7	29.1	28.7	31.9
S	—	296.60	282.40	277.50	351.80
SS	—	8 844.78	7 988.78	7 714.59	12 472.28
Mean		29.66	28.24	27.7	36.18

N = Number of gantry cranes engaged to do bundled cane unloading for a given simulation run. This is fixed for a duration equivalent to 10 days in the above experiments.
CONTROL = Normal operating Cane Yard operations.

Table 10. ANOVA Table for Fixed Number of Unloading gantry Cranes

Variation source	df	S	MS	F-Calculated	F-Tabulated 5%	1%
Gantry	3	171.15	57.05	6.875*	2.912+	4.390+
Error	36	349.36	9.71			
Total	39	520.51				

+ Values of F-Tabulated obtained by interpolation
* Significant at both 5% and 1% levels.
Conclusion: The effect of the number of working gantry cranes on the average waiting time of ordinary bundle trailers is significant. Thus, the number of operating gantry cranes have an effect on the average waiting time of the Ordinary Bundle trailers.

Table 11. ANOVA Table for N=3 and N=4 on Average Waiting Time

Source of Variation	df	S	MS	$F_{Calculated}$	$F_{Tabulated}$ 5%	1%
Gantry	1	10.082	10.082	2.964	4.41	8.29
Error	18	61.228	3.402			
Total	19	71.310				

Conclusion: Not significant. Thus as far as the average waiting time is concerned, when 3 or 4 gantry cranes are used in unloading the ordinary bundle cane trailers, there is no significant difference in the average waiting time.

Table 12. ANOVA Table for N=4 and N=5 on Average Waiting Time

Source of Variation	df	S	MS	F-Calculated	F-Tabulated 5%	1%
Gantry	1	1.2005	1.2005	0.734	4.41	8.29
Error	18	27.569	1.532			
Total	19	28.7695				

Conclusion: The effect of 4 or 5 gantry cranes operating on the average waiting time of the Ordinary Bundle trailers is not significant.

Table 13. Mill A Side Loose Cane Trailers Average Waiting Time for Various Conditions

	N	N+2	N+3
	15.6	22.5	19.7
	19.0	24.6	36.8
	18.5	20.2	18.7
	13.3	21.3	21.1
	24.1	21.3	20.5
	20.9	14.0	26.0
	19.9	18.3	16.3
	23.1	22.8	22.1
	10.9	26.1	33.9
	14.2	29.5	26.2
S	179.50	220.60	241.30
SS	3 391.19	5 029.02	6 223.23
Mean	17.95	22.06	24.13
Variance	4.34	6.67	4.25

N = Normal operating condition (i.e., N = Normal mean cane units delivered).
N+2 = Hourly delivery rate (input) is increased by 3 units transferred from the loose cane units
N+3 = Hourly delivery rate (input) is increased by 6 units transferred from the Bundle cane.

Table 14. ANOVA Table for Waiting Time of Loose Cane on Mill A Side

Source of Variation	df	S	MS	F-Calculated	F-Tabulated 5%	1%
Columns	2	197.898	98.949	3.647*	3.35	5.49
Error	27	732.410	27.126			
Total	29	930.305				

*Significant at 5% level.
Conclusion: The waiting times of loose cane trailers feeding Mill A are significant at 5% level.

Table 15. Mill B side Loose Cane Trailers Average Waiting Time for Various Conditions

	N	N+2	N+3
	15.8	19.3	23.1
	14.0	20.8	29.7
	14.8	23.4	15.6
	14.1	19.2	27.8
	16.8	16.3	26.8
	17.3	20.2	17.0
	27.5	22.7	19.3
	16.3	23.4	20.8
	18.9	24.1	30.5
	13.5	22.0	21.1
S	169.00	211.40	221.70
SS	3 006.42	4 522.72	5 125.73
Mean	16.90	21.14	22.17
Variance	4.09	2.44	4.84

relevant input variables and parameters were altered and their effect on the mill yard operations analyzed statistically. The investigations were aimed at providing quick answers to "*what-if*" questions. The effects analyzed were:

1. Altering the number of operational (unloading) gantry cranes and its effect on the average waiting time of the ordinary bundle cane trailers, and
2. Reducing the average hourly arrival rate of the bundle cane trailers and increasing the hourly arrival rate of loose cane units and observing the effect on the average waiting time of various trailer types.

Altering the Number of Unloading Gantry Cranes

The average waiting time obtained for various levels of available (with assumed availability of 100%) unloading gantry cranes are given in **Table 9**. For each set-up, 10 days were simulated. A casual look at **Table 9** shows that the average waiting time for

Table 16. ANOVA Table for Waiting Time of Loose Cane Units on Mill B Side

Source of variation	df	S	MS	F-Calculated	F-Tabulated 5%	1%
Columns	2	156.038	78.019	5.08*	3.35	5.49
Error	27	414.685	15.359			
Total	29	570.723				

*Significant at 5% level.

Conclusion: The waiting times of loose cane (basket type) trailer feeding Mill B are significant at 5% level. Therefore, shifting of bundle trailers to loose cane trailers affects the waiting time of loose cane trailers.

Table 17. ANOVA Table for N = 3 and N = 4 on Average Waiting Time

Source of Variation	df	S	MS	$F_{Calculated}$	$F_{Tabulated}$ 5%	1%
Gantry	1	10.082	10.082	2.964	4.41	8.29
Error	18	61.228	3.402			
Total	19	71.310				

Conclusion: Not significant. Thus, as far as the average waiting times are concerned, when 3 or 4 gantry cranes are used in unloading the ordinary bundle cane trailers, there is no significant difference in the average waiting time.

N = 2 (N is the number of fixed available gantry crane) are higher than the rest. The analysis of variance technique (ANOVA) was applied at 5% significance level to test whether there existed a difference between the average waiting time of the remaining set-ups. The results of the analysis are presented in **Table 10**. Separate analysis using the same result (i.e., **Table 9**) was performed to determine whether a difference existed for operating gantry cranes of 3 and 4, and 4 and 5. The result of these latter analyses are presented in **Tables 11** and **12**, respectively.

Since statistical analysis indicate that there is no difference in the average waiting time when three (3) or four (4) gantry cranes are deployed to do unloading, for economic reasons, three gantry cranes should be available for unloading bundle cane trailers during any operational time. Due to the random nature of individual gantry crane breakdowns, the fourth gantry crane should, however, be on standby to replace any of the three unloading gantry cranes in case of a breakdown. By looking at the data gathered from the simulation runs (**Table 9**), it is apparent that the normal operating conditions (CONTROL), gantry cranes available are inadequate to keep the bundle trailers average waiting time at or below the budgeted 30 min.

Effects of Shifting Bundle Cane Units to Loose Cane Units

Simulation runs were carried out to determine the effect of transferring 4 and 6 bundles cane unit to loose cane units. Data collected and analyses are presented in **Tables 13** to **17**.

Waiting time data was gathered for the gantry cranes unloaded bundle cane trailers to establish whether this action resulted in lowering the average waiting time of the bundle trailers. Results and analysis presented in **Tables 15** and **16** indicate that such an action results: low average waiting time of the bundle trailers appreciably.

Conclusion

The MSC-MYSM is a simulation model that can be used to evaluate the existing system or the effect of possible modification to the MSC Mill Yard system. It has been validated under actual MSC Mill Yard operating conditions and accurately describes MSC Mill Yard operations. It allows the MSC management to experiment with various mill yard configurations without modifying the existing equipment. The use of this model will result in efficient and economically sound MSC Mill Yard expansion designs.

REFERENCES

Peart R.M., Isaacs G.W. and French C.E., 1963. Optimizing Materials Handling Systems by Mathematical Programming. Transactions of the ASAE, pp 26-31.

Shukla L.N., Chisolm T.S. and Philips A.L., 1972. Computer Program for Analyzing Harvesting, Loading and Transportation of Sugarcane. Transactions of the ASAE, Vol. 16(3) pp 420-425.

Whitney R.W. and Cochran B.J., 1976. Predicting Sugar Cane Mill Delivery Rates. Transactions of the ASAE, 1976, pp 47-48.

Crossly C.P., 1987. The Application of a Computer Program to Analysis of Sugar Cane Transport - a Case Study. Journal of Agric. Engineering Research (1987), OVl. 36, pp 17-30.

Crossly C.P., 1982. Examples of the Use of "CARTA". A Computer Program to Predict Transport Vehicle Performance and Costs in Developing Countries. Journal of Agric. Engineering Research (1982), VOl. 27, pp 155-162.

Crossly C.P., 1982. Rural Transport in Developing Countries - The Development of the "CARTA" Computer Program. Journal of Agric. Engineering Research (1982), Vol. 27, pp 139-153. ■■

ADVERTISED PRODUCTS INQUIRY

Product	Advertiser	Vol., No., Page

EDITORIAL REQUEST TO AMA

Your Name :

Address :

Occupation :

SUBSCRIPTION/ORDER FORM

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA (AMA)
Issued Quarterly

Subscription Rate (includes surface mail postage)

Annual (4 issues) ------------¥.6,000
Single copy ------------¥.1,700

Back Issues (1971−75, ¥.2,000 per copy)
(1976−77, ¥.1,200 per copy)
(1978−80, ¥.1,500 per copy)

★Spring, 1971
★Vol.2 Autumn, 1971
☐Vol.3 No.1, 1972
☐Vol.3 No.2, Summer, 1972
★Vol.4 No.1, Spring, 1973
☐Vol.4 No.2, Autumn, 1973
★Vol.5 No.1, Summer, 1974
☐Vol.6 No.1, Spring, 1975
★Vol.6 No.2, Autumn, 1975
☐Vol.7 No.1, Winter, 1976
☐Vol.7 No.2, Spring, 1976
☐Vol.7 No.3, Summer, 1976
☐Vol.7 No.4, Autumn, 1976
☐Vol.8 No.1, Winter, 1977
☐Vol.8 No.2, Spring, 1977
☐Vol.8 No.3, Summer, 1977
☐Vol.8 No.4, Autumn, 1977
☐Vol.9 No.1, Winter, 1978
☐Vol.9 No.2, Spring, 1978
★Vol.9 No.3, Summer, 1978
★Vol.9 No.4, Autumn, 1978
☐Vol.10 No.1, Winter, 1979
☐Vol.10 No.2, Spring, 1979
☐Vol.10 No.3, Summer, 1979
☐Vol.10 No.4, Autumn, 1979
★Vol.11 No.1, Winter, 1980
★Vol.11 No.2, Spring, 1980
☐Vol.11 No.3, Summer, 1980
☐Vol.11 No.4, Autumn, 1980
★: Indicates issues out of stock.
☐ **Abstract and Index, 1971-80 (Special Issue, 1983)**

(Check issues and number of copies you wish to order)

Back Issues from 1981, ¥.1,700 per copy (Vol. 12 No. 1 and No. 4 are out of stock)
Abstract and Index, Special Issue, 1983, ¥2,000 per copy.

Vol.____ No.____, 19____, ____ copy/copies

(check one)

☐ Please invoice me/us

☐ I/We enclose remittance for ¥________

****

Name: ________________

Firm: ________________

Position: ________________

Address: ________________

(block letters)

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7, 2-chome, Kanda Nishikicho, Chiyoda-ku,
Tokyo 101 Japan
Tel. (03)−3291−3671∼4, 5718

STAMP

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

7, 2-CHOME, KANDA NISHIKICHO, CHIYODA-KU

TOKYO, 101 JAPAN

1st FOLD HERE

2nd FOLD HERE

Optimization of Tractor-trailer Performance in Hauling Operation

by
Aitha Bheemsen
Research Scholar
Dept. of Agric. Engg.
I.I.T. Kharagpur
West Bengal - 721 302
India

R.K. Datta
Professor
Dept. of Agric. Engg.
I.I.T. Kharagpur
West Bengal - 721 302
India

Abstract

An investigation was carried out to optimize some operational parameters of a tractor-operated, four-wheel trailer for hauling operation from the standpoint of fuel economy. The experiments were conducted with two levels of each of the parameters of trailer load, hitch point height, travel speed, ballasting and inflation pressure of drive wheels. The data obtained were analyzed statistically and the ANOVA was computed using a standard package, STATGRAF. A FORTRAN programme was used to develop a mathematical model. The QSB package was used to optimize the selected parameters for best fuel economy. The optimum levels of parameters were, 8.16 t of trailer load, 556.90 mm of hitch point height, 25.65 kmph of travel speed, 123.66 kg of drive wheel ballasting and 1.27 kg/cm^2 of inflation pressure of drive wheels.

Introduction

Transportation is an important component in the agricultural scenario of a country. In India, animal-drawn carts and tractor-trailers are more common in rural areas. However, the bullock-carts, though more popular, have some drawbacks. Their suitability is limited to shorter distances, may be in the order of 10 km; the tonnage transported is low and may not exceed 2 t even for improved carts. Besides, it is also a slow process of transportation. At the present time there is an increasing trend in the use of tractors for hauling operation. One estimate suggests this figure to be as high as 70% (Mohan, 1990). The total tonnage carried by trucks and tractor-trailer combinations was estimated to be in the order of 1 00 000 million t - km (Bheemsen, 1991). This is second in volume hauled by the Indian railways. It is believed that some of the customers are purchasing tractors mainly for using in hauling operations. This is considered to be a more profitable proposition.

Tractors are broadly designed for performing agricultural operations. However, in view of their greater use for transportation operation, it is necessary to check their suitability from the consideration of hauling operation too. One of the possible approaches is to optimize some of the operational parameters for hauling operation. This includes trailer load, hitch point height, speed of operation, ballasting of the drive wheels and inflation pressure of drive wheels. A farmer is also concerned with fuel economy. Hence an investigation was carried out with a view to optimizing the above parameters from the consideration of minimum fuel consumption.

Methods and Materials

For this study a commercially available 2 WD tractor and a four-wheel trailer were selected. **(Fig. 1)**

Brief Description of the Parameters

For hauling operations vis-à-vis fuel economy, the parameters considered relevant are listed and briefly explained below:

i) *Trailer load* — The highest benefit can be achieved when the tonnage is maximum. This, in turn, will affect the fuel consumption. For varying the load, iron castings were used in the present investigation.

ii) *Hitch point height* — Within the design constraints, the higher the speed, the more advantageous it is. However, the speed will affect the fuel consumption.

iii) *Travel speed of tractor* — Within the design constraints, the higher the speed, the more advantageous it is. However, the speed will affect the fuel consumption.

Fig. 1 A view of the test tractor with loaded trailer.

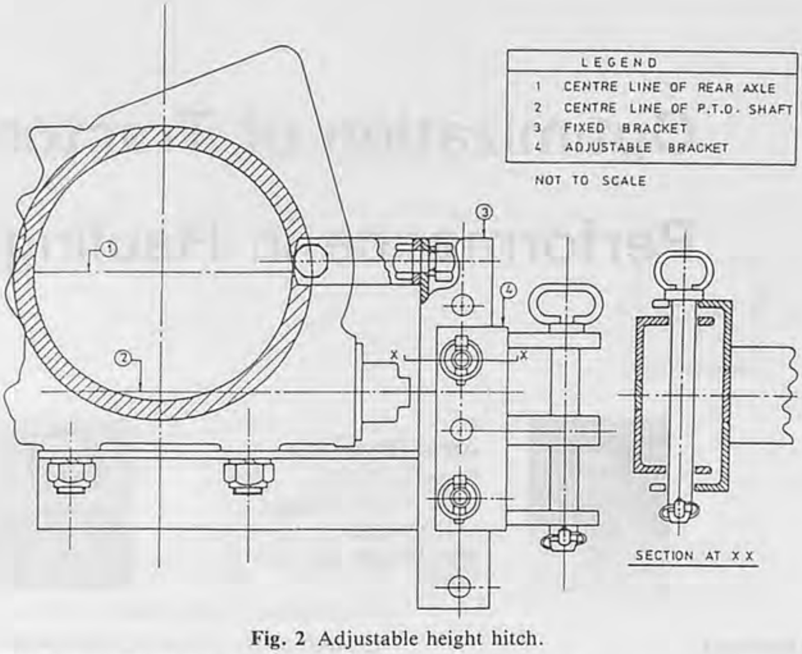


Fig. 2 Adjustable height hitch.

iv) *Drive wheel ballasting* — It is important to maintain the desired level of load coming on to the rear axle from the consideration of traction as well as fuel consumption. The maximum weight of ballasting could be evaluated by taking into consideration the weight transfer and slope of surface, if any. Bolt-on-weights method of ballasting is simpler than the liquid ballasting and is, therefore, preferred in the present study.

v) *Inflation pressure of drive wheels* — Wheel pressure affects the rolling resistance as well as fuel consumption. In fact, the effect of tractor tyres on fuel consumptin may be expressed in terms of the tyre rolling resistance. According to a study, a change of 0.001 in rolling resistance coefficient resulted in a change of 1.5 cc/km of fuel consumption over the highway (Anon. 1982). During the exploitation of tyres on road, their load carrying capacity can be increased by increasing the inflation pressure. But with the increase in pressure, the contact area of tyre with the road decreases. This results in the decrease in grip and increase in rolling resistance causing a higher fuel consumption. When inflation pressure is reduced, the reverse will happen. So, there exists an optimum value at which the load carrying capacity will be greater and fuel consumption will be less.

vi) *Fuel consumption* — Fuel consumption is the most important factor considered in the present study. It is evaluated in terms of cc/t - km. It is the main criterion used for optimizing the levels of selected variables.

Fabrication of Some Components

i. *Adjustable height hitch* — An adjustable height hitch was designed, developed and fabricated (**Fig. 2**). This was incorporated in the experimental tractor for varying the hitch point height.

ii. *Auxiliary fuel tank* — For a more accurate measurement of fuel consumption, an auxiliary fuel tank was developed and fabricated (**Fig. 3**). This was used in the experimental tractor.

The Experiment

In order to optimize some operational parameters for hauling operation for best fuel economy, the following independent and dependent variables were taken into account.

Independent variables

Load carried by the trailer
: 2 levels, 5 and 7 t

Hitch point height
: 2 levels, 505 and 655 mm

Travel speed of tractor
: 2 levels, H_3 and H_2 gears

Drive wheel ballasting
: 2 levels, 166 and 332 kg

Inflation pressure of drive wheels
: 2 levels, 1 and 1.5 kg/cm^2

Dependent variables

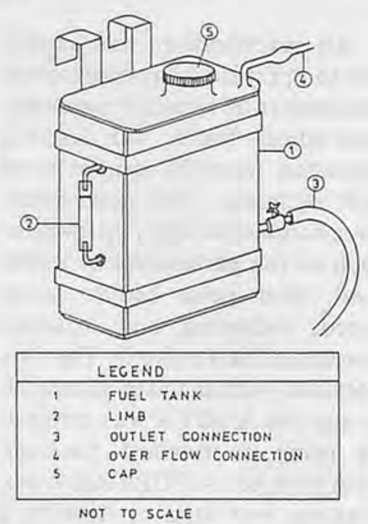


Fig. 3 Schematic view of the auxiliary fuel tank.

Fuel consumption
: cc/t - km

Replications
: 2

The inflation pressures of tractor front tyres and trailer tyres were kept constant at 2.5 kg/cm^2 and 6.32 kg/cm^2, respectively.

Procedure

A 3-km long stretch of tar-macadam road with 4.88% slope was selected for conducting the trials.

For each combination of independent variables the tractor with the trailer was run and the fuel consumption was accurately

Table 1. ANOVA Table Showing the Effect of Operational Parameters on Fuel Consumption

Source of variation	DF	Sum of squares	Mean sum of squares	F-Ratio	Significance level
Load	1	6.324	6.324	12 648.000	**
Hitch height	1	0.006	0.006	12.000	**
Travel speed	1	1 473.34	1 473.34	3 143 115.95	**
Ballasting	1	0.015	0.015	30.000	**
Pressure	1	0.357	0.357	714.000	**
Load vs. hitch height	1	0.002	0.002	3.142	
Load vs. travel speed	1	0.001	0.001	2.863	
Load vs. ballasting	1	0.001	0.001	2.677	
Load vs. pressure	1	0.001	0.001	2.268	
Hitch height vs. speed	1	0.001	0.001	2.394	
Hitch height vs. ballasting	1	0.001	0.001	2.259	
Hitch height vs. pressure	1	0.001	0.001	2.054	
Travel speed vs. ballasting	1	0.002	0.002	4.269	
Travel speed vs. pressure	1	0.002	0.002	3.834	
Ballasting vs. pressure	1	0.002	0.002	3.200	
Error	1	0.008	0.008	—	

**Significant at 1% level of significance.

measured. The entire experiment was replicated twice. The data so callected were statistically analyzed using a standard package, STATGRAF and the ANOVA (**Table 1**). A multiple regression equation was developed through a FORTRAN programme to indicate the relationship between fuel consumption and other selected variables (Eqn. 1). The parameters were then optimized for minimum fuel consumption by a package, QSB on a microcomputer.

Results and Discussion

From **Table 1** it appears that all the variables selected have significant effect on fuel consumption. The multiple regression equation developed by using the FORTRAN programme is of the following form:

$$FC = a_0 + a_1L + a_2H + a_3S + a_4B + a_5P \quad ...(1)$$

where,

FC = Fuel consumption, cc/t - km

L = Load carried by the trailer, t

H = Hitch point height, mm

S = Travel speed of tractor, kmph

B = Drive wheel ballasting (total), kg

P = Inflation pressure of drive wheels, kg/cm^2

a_0, $a_1 \sim a_5$ = Coefficients

The coefficients of the above mathematical model are presented in **Table 2**.

The selected variables were then optimized and the optimum value for trailer load was 8.16 t. The optimum value for hitch point height was 556.90 mm. This value for the hitch point is less than the height of the centre line of the tractor rear axle. Hence, no stability problem is likely to occur. However, in actual practice it may cause little vibration.

The optimized value for speed was 25.65 kmph. This speed can be attained in highest gear only which is an advantage for hauling operations. As the speed is less than 32 kmph, it is considered to be safe. It has been stated that beyond 32 kmph there occurs severe stability problem for transportation with tractor - trailer combination (Crolla and Hales, 1979). The optimized value for ballasting was 123.66 kg This value lies within the load carrying capacity range of the drive wheel tyres. The optimum value for the inflation pressure of drive wheel tyres was 1.27 kg/cm^2. This value lies within the working range of pressure of the drive wheel tyres. This value is also in close agreement with the recommended pressure range, i.e., 1.27 to 1.41 kg/cm^2 (18 psi to 20 psi) for the haulage operations (Nakra, 1987). For the above optimum values of selected parameters, the corresponding optimal value of fuel consumption is observed to be 17.89 cc/t - km.

Table 2. Values of Coefficients of the Mathematical Model (vide eqn. 1)

Particulars	Coefficient	Stnd. error
Constant	60.215	2.909
Trailer load	−1.814	0.197
Hitch point height	0.001	0.003
Travel speed	−1.177	0.050
Ballasting	−0.001	0.002
Inflation pressure	1.759	1.602

Conclusion

With the use of optimized values of the parameters of trailer load, hitch point height, travel speed, drive wheel ballasting and inflation pressure of drive wheels, maximum fuel economy can be achieved in hauling operations with a tractor - trailer system.

REFERENCES

Anonymous. 1982. A system to control tractor tyre inflation pressure on - the - move. The Agril Engr, 37(4): 109 - 112.

Bheemsen, A. 1991. Optimization of operating parameters of a tractor for haulage operation. Unpublished M. Tech thesis, Agril Engng Deptt, I.I.T., Kharagpur, India.

Crolla, D.A and Hales, F.D. 1979. The lateral stability of tractor and trailer combinations. J. Terramech. 16(1) : 1-22.

Mohan, B. 1990. Design of a synchromesh gear box for an agricultural tractor. Unpublished M. Tech. thesis, Agril Engng Deptt, I.I.T., Kharagpur, India.

Nakra, C.P. 1987. Farm machines and equipment. Dhanpat Rai and Sons, New Delhi. India. ■■

Earth-tube Heat Exchangers for Poultry Buildings

by
Alchalabi Dhia
Associate Professor
College of Agriculture
Agric. Mechanization Dept.
Baghdad, Iraq

Abstract

Earth tempering of ventilating air for poultry is very limited, including the design criteria. Depending on the season, incoming ventilation air is heated or cooled as it passes through a buried tube. The soil serves as a heat sink in the summer and also a heat source in winter, thus giving almost year-round temperature modification. It has the potential to significantly reduce heating cost during winter and provide zone cooling during summer.

The system is used as two-stage air cooling in poultry houses during summer months. It uses one 30-m length steel tube with 30 cm in diameter and 4 mm thick connected to a closed plywood box with thickness of 20 mm, size 1.2 × 1.2 m, with three openings size 60 × 60 cm each for servicing the air cooler. Part of the tube which is connected to the box of the air cooler was unsulated by glass wool thickness 5 cm to depth of 1.2 m. The air cooler served as ventilator in winter. It's flow rate is fixed to 1 200 m^3/h which is the flow rate of the tube.

The tube has a shape of the letter U, connected to a central collection sump. The tube has a slope of 1% to the sump, and buried to an average depth of 2.5 m.

During the month of January treated air temperature varies from 6 to 14.2°C which outside temperature ranges from 0 to 14°C. The average treated air temperature for January 17-18 was 9.58°C with sd. of 2.88°C, and the average of outside temperature was 6.04°C with sd. 3.9. For January 18-19 the average treated air temperature was 10.3°C with sd. 4.7, while the outside temperature was 8.2°C with sd. 6.3.

The peak sensible heating during this period was calculated at 7 am on January 17-18, with ventilation rate of 3.3 m^3/h bird was equal to 5.896 W/bird or 15 284 kJ/month bird. This was the recovery, if this peak is divided by 26 865 kJ/L of L. P. Gas then this is the energy contained in 0.57 L of propane per bird.

This system will save more energy in the north, where the air temperature drops below zero for long period.

Introduction

Earth tempering of ventilating air for swine is being considered, but tempering of ventilating air for poultry is very limited, including the design criteria. Depending on the season, incoming ventilation air is heated or cooled as it passes through a buried tube. The soil serves as a heat sink in the summer and also a heat source in winter, thus giving almost year-round temperature modification. It has the potential to significantly reduce heating cost during winter and provide zone cooling during summer.

The temperature 2 to 3 m underground does not vary appreciably throughout the year. What temperature ventilation does occur is about three months behind surface temperature variations, which increases the heating and cooling ability of the system.

Literature Review

In recent years, interest has increased in the use of the earth's climate at shallow depths to help condition air for use above ground buildings. However, this concept is not new.

N.R. Scott (1965) reported that an Iowa barn was cooled during summer months in 1978 using a 152.4 m underground passage as heat exchanger duct. Other, more, elaborate system using filed drainage tile system components was used as tempering devices from 1940 to the present for various uses, including poultry houses and private homes. In 1965 a rather extensive research project was initiated at Cornell University to determine the feasibility of such installations using 134.1 m length of 45.7 cm diameter corrugated steel pipe buried to an average depth of 2.4 m as facility for their experiments. In the winter of 1980-1981 W. H. Peterson et al conducted a study on earth tempering swine ventilation system in central Illinois using non-perforated corrugated plastic drainage tubing heat exchange for four earth tube system for heating and cooling.

Objectives

The objective was determine the feasibility of earth-tube heat exchangers installation in poultry houses.

Methods

System Description

The system is used as two-stage air cooling in poultry houses during summer months. It uses one 30 m length tube with 30 cm in diameter and 4 mm thick steel connected to a closed plywood box with thickness of 20 mm, size 1.2 × 1.2 m, with three openings size 60 × 60 cm each for servicing the air cooler (**Fig. 1**). Part of the tube which is connected to box of the air cooler was insulated by glass wool thickness 5 cm to a depth of 1.2 m. The air cooler served as ventilator (in winter). It's flow rate was fixed to 1 200 m^3/h which is the flow rate of the tube.

The tube has a shape of the letter U, connected at a central collection sump. The tube has a slope of 1% to the sump, and buried to an average depth of 2.5 m.

Soil Temperature

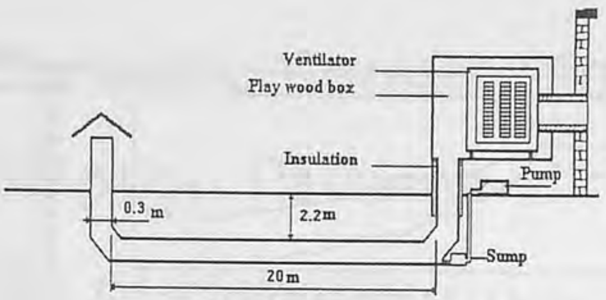


Fig. 1 System design.

Soil temperature is one of the important factors affecting the design and performance of earth-tube heat exchanger systems. Soil temperatures vary with soil type, depth, moisture content, time of year and geographic location.

The extent of temperature variation decreases as depth increases. The time of the year when the ground temperature is at the extreme is also important in the design and performance of the system. Soil temperature fluctuations lag behind surface temperature changes due to the heat storage capacity of the soil. The soil surface reaches maximum temperature during the heat of summer, but soil 3-3.5 m deep may not reach its peak in temperature until almost three months later. This thermal lag helps both the heating and cooling performance of these systems. During the winter, soil temperature at 3 m depth is at the fall season level, making the soil near the mean annual ground temperature, thus adding to the heating capabilities. The reverse is true during the summer months, when soil temperature at 3 m depth are spring-like and can cool the ventilation air.

Soil type and moisture content also affect the ground temperature variation. Soil with increasing sand content tend to have temperature variations at deeper depths than clay soils. Soil moisture and ground water elevation also affect soil temperature. Seasonal temperature variation is larger in very moist soils as compared to very dry ones due to the increase in heat transfer through soils whose voids are filled with water.

Data Collection

The outside temperature for several days was collected in January 1993, that varied from 0°C to 13°C. The earth-tube air temperatures ranged from 5.5°C to 14°C. Air flow was fixed to 1 200 m^3/h which is the flow capacity of the tube. The soil temperature at 3 m depth was 19.5°C, the summer soil temperature was 24°C (Appendix A).

Economic Payback

As with other alternative energy systems (solar and heat ex-

APPENDIX A

Table 1. Hourly outside and tube temperatures, 17-18/1/1993

Time	Tube Temperature	Outside Temperature
Pm 12	12.0	8.5
1	13.5	10.0
2	14.0	11.0
3	14.0	11.5
4	14.2	12.0
5	14.0	13.0
6	13.0	10.0
7	12.0	8.5
8	11.0	6.4
9	10.5	5.6
10	10.0	4.1
11	9.2	4.0
Am 12	9.0	3.8
1	8.2	3.0
2	8.0	2.0
3	7.5	2.0
4	7.2	1.1
5	6.7	1.1
6	6.5	0.9
7	5.0	0.0
8	6.5	4.0
9	8.0	6.5
10	9.5	7.0
11	10.5	9.7
	Average 9.58	Average 6.04
	sd. 2.88	sd. 3.88

Soil Temperature at 3 m deep = 19.5°C

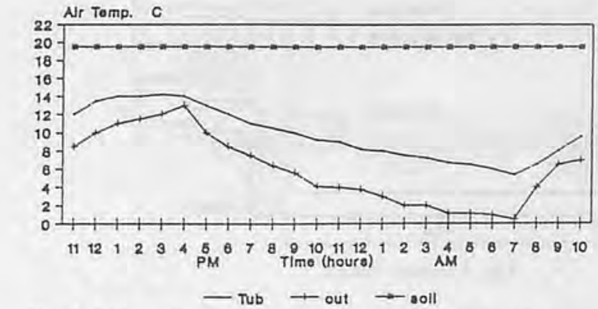


Fig. 2 Effect of soil temperature on ventilation air, Jan. 17-18, 1993.

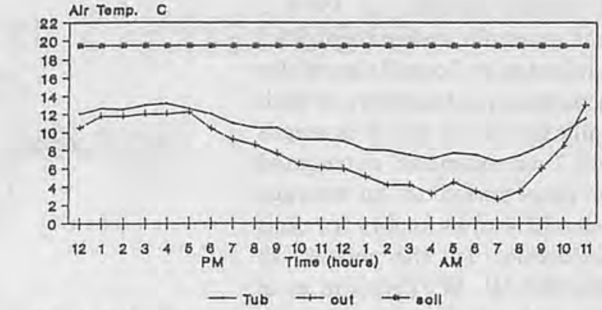


Fig. 3 Effect of soil temperature on ventilation air, Jan. 18-19, 1993.

changers), tempering of ventilation air by earth tubes is not free. Since the cost and returns vary considerably for earth tube systems, a rigorous economic analysis would be both difficult and lengthy. However, to give some indication of economic payback for a system, the amount of energy recovered per heating month can be found using the following relationship.

$$q = Ma\ Cp\ (To - T)$$
$$q = (Q/v)\ Cp\ (To - T)$$
$$q = (Cp/v)\ Q\ (To - T)\ 24\ Dm$$

where

q = Heat recovered by the system kJ/month bird

Q = Ventilation rate 3.3 m^3/h bird

Cp = Specific heat of air 1.0035 kJ/kgd a C

v = Specific volume 0.78 m^3/kgd a

To = Temperature exiting the tube °C

T = Average outside temperature °C

Dm = Number of days in a month

Ma = Mass of air flow kgd.a/h

The equation will be as follows:

$$q = 1.3\ Q\ (To - T)\ 24\ Dm$$

Results and Discussion

The temperature of the system is shown in **Figs.** 2 and 3. All monitoring was done at air flow of 1 200 m^3/h. During January treated air temperature varied from 6 to 14.2°C while outside temperature ranged from 0 to 14°C. Average treated air temperature for January 17-18 was 9.58°C with sd. of 2.88°C, and the average of outside temperature was 6.04°C with sd. 3.9. For January 18-19 the average treated air temperature was 10.3°C with sd. 4.7, while the outside temperature was 8.2°C with sd. 6.3.

The peak sensible heating during this period was calculated at 7 am on January 17-18, with ventilation rate of 3.3 m^3/h bird was equal to 5.896 W/bird or 15 284 kJ/month bird. This was the recovery, if this peak is divided by 26 865 kJ/L of L.P. gas then this is the energy contained in 0.57 L of propane per bird.

Because of unusual rain in the fall, soil temperature was lower than expected. So the air tube temperature would be higher than measured, and this would make the energy recovered even higher. This system will save more energy in the north where the air temperature drops below zero for long periods.

REFERENCES

Alchalabi Dhia. 1993. Farm buildings. Unpublished text book.

Cramer, C.O. and D.W. Kammel. 1981. Underground air inlets for farrowing houses cooling. A case study ASAE paper No. 80-4556. 18p.

Energy tips, Department of Engineering, College of Agriculture University of Illinois at Urbana-Champaign. Sept. 81.

Garson, W.M., K.C. Watts, and F. Desir. 1980. Design data for air flow in plastic corrugated drainage pipes. Transactions of ASAE. pp 409 413, 418.

Goethsch, W.D. and A.J. Muehling. 1981. Earth tube heat exchangers for swine buildings. Energy No. 2, Department of Agricultural Engineering, Cooperative Extension service, University of Illinois at Urbana-Champaign 7p.

Mokdad, M.M. and D. Alchalabi. 1990. Two-stage air cooling of poultry houses by buried tube and evaporative air cooler. Iraqi Union of Agricultural Engineers. Seventh conference.

Scott, N.R., R.A. Parsons, and T.A. Koehler. 1965. Analysis and performance of an earth aid heat exchanger. ASAE paper No. 65-480. 46.

Soil surveys of sangamon, Macoupin, Montgomery and Mason counties. United State Department of Agriculture Soil Conservation Service in cooperation with Illinois Agriculture Experiment station.

Warren, D. Goetsch. 1981. Field study of earth tempered swine ventilation system. Michigan State University, Extension Bulletin. Sept. 85. ■■

Non-commercial Domestic Cooking Fuels and Energy Consumption Patterns in Rural Households of Haryana

by

Binoo Sehgal
Assistant Professor (H.Sc.)
Dept. of Family Res. Management
College of Home Science
CCS Haryana Agricultural University
Hisar-125004, India

Sudesh Gandhi
Assistant Professor (H.Sc.)
Dept. of Family Res. Management
College of Home Science
CCS Haryana Agricultural University
Hisar-125004, India

D.N. Sharma
Professor (Agril. Engg.)
College of Agril. Engg. and Tech.
CCS Haryana Agricultural University
Hisar-125004, India

Veena Sangwan
Associate Professor (H.Sc.)
Dept. of Family Res. Management
College of Home Science
CCS Haryana Agricultural University
Hisar-125004, India

Abstract

The non-commercial fuels required for cooking are crucial for human survival as the fuel energy needs of domestic sector are location specific and depend upon living standard and working conditions. For household cooking, generally conventional fuels like firewood, coal crop residues, dung cakes, kerosene oil and bio-gas are mostly used depending upon the locality and availability of fuels. A study was conducted to assess the availability, utilization and consumption patterns of non-commercial fuel energies for domestic cooking in Hisar district of Haryana state. The study shows that in the district the monthly consumption of agro-waste, a non-commercial fuel, was highest among large families (234.15 kg) followed by landless (174.00 kg). Dung cakes occupied second position, but there was minimum consumption of firewood (5.41 to 13.67 kg).

The highest amount of non-commercial energy per month was consumed by the large farming families (4 040 MJ) followed by landless (3 648 MJ), medium (3 336 MJ) and small (3 156 MJ). This is due to higher income and larger number of family members in the family because of joint families. There was no significant effect of occupation on per capita energy consumption from non-commercial fuels. The average per capita energy consumption for domestic cooking was 15.59 MJ/day in the district.

Introduction

Energy is a vital input for the economic development of a society and improvement in quality of life of its people. The problem of energy shortage that surfaced in India is due to rapid increase in population and technological advancement. Such increased demands will place heavy strain on the limited sources of the country. The growing dependence on traditional sources of energy like fossil fuels has led to problems of scarcity of wood, deforestation and competitive land use. It is, therefore, necessary to take stock of energy sources which are under-utilized, conserve them and consider the possibility of other sources which are not utilized at present.

In India, the energy needs for domestic sector are location specific and depends upon living standards as well as working conditions. No other form of energy is more crucial for human survival or more sensitive to environmental conditions than the energy required for domestic cooking. According to Fuel Policy Committee Report (1974) about 57% of the total energy was consumed in the domestic sector of which 50% was utilized for cooking only. For household cooking, generally conventional fuels, biogas, kerosene oil, liquefied petroleum gas, and electricity are mostly used depending upon the locality and availability of fuels. But in rural areas mostly firewood, agricultural waste and dung cakes are used in traditional mud stoves. The traditional mud stove consumes the largest amount of energy and its thermal efficiency is very low. According to Girja Saran (1984), on an average, a household uses about 42 kg of fuel/week for cooking purposes. These requirements will be still higher for the farming family. Thus, there is an immediate need to assess the fuel and energy consumption of rural households for domestic cooking and to find suitable measures for energy conservation and to develop appropriate energy saving technology for improving the existing traditional mud stoves.

Materials and Methods

The study was undertaken to assess the availability, utilization and consumption patterns of non-commercial fuel energies in Hisar district. Four villages, Ladwa and Mirjapur from Block-I and Balsamand and Rawalwas from Block-II were selected in the district. From each selected villages 40 respondents (10 each) from different land tenure categories, i.e., landless, small and marginal, medium and large farmers were selected randomly thereby making a total sample of 160 households. A standard questionnaire was prepared and a sample survey in each village was carried out in order to determine the types and quality of fuels, i.e., firewood, mix of cottonsticks and dung cakes and agro-waste available and used for domestic cooking in each category. The data were analyzed by classifying the respondents according to land tenure and family size. The equivalent heat energy values for each type of non-commercial fuels were computed in order to determine the monthly energy consumption patterns by using the energy indices.

Table 1. Distribution of Respondents According to Family's Demographic Profile in Different Land Tenure Categories

Item	Land Tenure Category				Total
	Landless (n = 40)	Small & Marginal (n = 40)	Medium (n = 40)	Large (n = 40)	
Age of respondents					
Below 25 years	4	6	1		13 (8.12)
25 to 35 years	13	13	7	5	38 (23.75)
35 to 45 years	15	11	18	12	56 (35.00)
Above 45 years	8	10	14	21	53 (33.12)
Level of education					
Illiterate	40	39	40	40	159 (99.4)
Primary	—	1	—	—	1 (0.6)
Type of family					
Nuclear	22	26	21	8	77 (48.1)
Joint	18	14	19	32	83 (51.9)
Size of family					
Small (1 to 4 members)	17	25	17	6	65 (40.6)
Medium (4 to 9 members)	21	14	18	26	79 (49.4)
Large (9 and above)	2	1	5	8	16 (10.0)
Average number of members per family	7.4	6.4	8.3	10.0	—

Results and Discussion

Table 1 shows the classification and distribution of respondents based on land tenure, family type, age group, family size and educational status. It is clear from the table that the major percentage of respondents were from the farming group (75%). The households were categorized into different family sizes, i.e., small (0-5 members), medium (6-10) and large (more than 10 members). It is evident from the table that the respondents were mostly from medium (49.35%) and small family size (40.62%). The maximum percentage (35.00%) were in the age group (36-45 years) followed by above 45 years (33.12%) and 26-35 years (23.75%). The sample contained about 48.12% and 52.00% as nuclear and joint families, respectively. It is also clear from the table that most of the respondents (99.38%) are illiterate the main reason for not using improved mud stoves for cooking.

Agro-waste, dung cakes and firewood were three main sources of non-commercial fuels used for cooking and meal preparation in the rural households. The fuel consumption increased significantiy with the increase of family size which is due to increase in quantity of food to be cooked. The family monthly consumptions of vairous non-commercial fuels are given in **Fig. 1** and **Table 2**. The highest quantity of non-commercial fuel was used by the large farmers (457.71 kg) followed by landless (330.77 kg), medium (309.24 kg) and small and marginal farmers (291.87 kg) with an average consumption of 347.40 kg/month. These requirements are more than double that reported by Girija Saran (1984) according to which, on an average, a household uses about 42 kg of fuel/week for cooking purpose. The high consumption of fuels by the farming families is due to larger numbers of family members and farm labour, cooking of concentrates for animals, heating of water and milk and use of conventional mud stoves. Since more than 99% of the respondents were illiterate and used traditional mud stove for cooking their meals inspite of the fact that a variety of improved

Table 2. Familywise Monthly Fuel and Energy Consumption of Different Non-commercial Fuels N = 160

Land tenure categories of respondents	Average size of family	Non-commercial Fuels Used: Firewood kg	Firewood MJ	Dung cakes kg	Dung cakes MJ	Agro-waste kg	Agro-waste MJ	Total fuel and energy kg	Total fuel and energy MJ	Per capita energy consumption
Landless	7.4	13.67 (4.14)	206.01 (5.64)	143.10 (43.26)	1 259.28 (34.51)	174.00 (52.6)	2 183.70 (59.84)	330.77	3 648.99	16.44
Small	6.4	8.67 (2.98)	130.66 (4.14)	149.10 (51.08)	1 312.08 (41.56)	134.10 (45.95)	1 682.95 (53.31)	291.87	3 156.90	16.44
Medium	8.3	11.43 (3.69)	172.25 (5.15)	152.91 (49.45)	1 345.61 (40.33)	144.90 (46.86)	1 818.49 (54.51)	309.23	3 336.35	13.40
Large	10.0	5.41 (1.18)	81.53 (1.66)	218.15 (47.66)	1 919.72 (38.86)	234.15 (51.15)	2 938.58 (59.49)	457.71	4 939.83	16.47
Total	32.10	39.18	590.45	663.26	5 836.69	687.15	8 623.72	1 389.58	15 082.07	62.75
Average	8.00	9.79 (2.82)	147.61 (3.91)	165.82 (47.73)	1 459.17 (38.70)	171.80 (49.45)	2 155.93 (57.18)	347.40	3 770.52	15.69

Figures in parentheses indicate percentages.

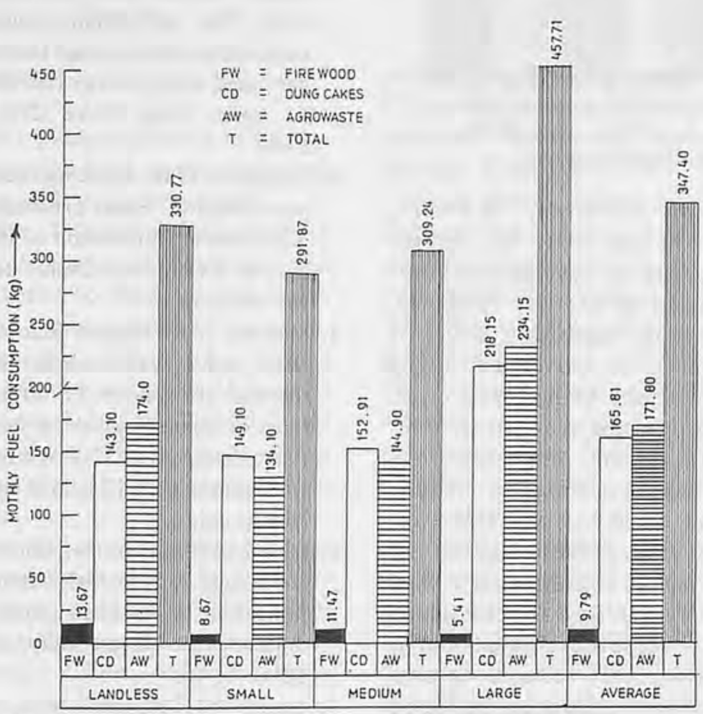


Fig. 1 Family consumption of different non-commercial fuels.

stoves like Nada and Sahyog "chulha" with thermal efficiencies around 20% are being popularized by various agencies. These demands could very well be reduced by 50% with the use of improved mud stoves. According to Sharma et al. (1991), the thermal efficiencies obtained with improved Sahyog and Nada stoves were as high as 20.59 and 18.35%, respectively, with the use of damper sets.

Among the non-commercial fuels agro-waste occupied first position for domestic cooking. The highest quantity of agro-waste was used by large farmers (234.15 kg) followed by landless (174.0 kg), medium (144.90 kg) and small and marginal farmers (134.10 kg). The consumption of dung cakes observed was also highest among large farmers (218.15 kg) and there was no significant difference in the consumption of dung cakes among the other three categories of respondents that ranged between 143-152.0 kg/month. These findings are in confirmation with the observation of Bakshi et al. (1988). According ot them, farming families especially large households, required significantly higher non-commercial fuels than non-farming families. The share of agro-waste ranged between 35.71 and 55.9% while for dung cakes it was 32.76-39.40%. This was due to large family size and presence of farm labour who are also given meals in farming families.

The actual supply of fuel in India comes from coal, 28; oil, 5.6%; cattle dung, 32%; and agricultural residues, dry leaves, etc. 34.40% (Singh et al., 1986). Cow dung has lower calorific values as compared to wood and crop residues. Moreover, it generates a lot of smoke during its burning. The farmers generally use dung cakes in combination with firewood and crop residues. Therefore, the use of dung cakes in traditional mud stoves further reduces its heat utilization efficiency in cooking. The consumption of firewood in all the categories was almost negligible. This is due to shortage of firewood and availability of agro-waste and cattle dung in abundance on the farm. The average total consumption of non-commercial fuels in Hisar district was 347.40 kg with major share of agro-waste, cattle dung and firewood were 171.80 kg, 165.81 kg and 9.79 kg, respectively.

The family energy consumption from different non-commercial fuels is also reported in **Table 2**

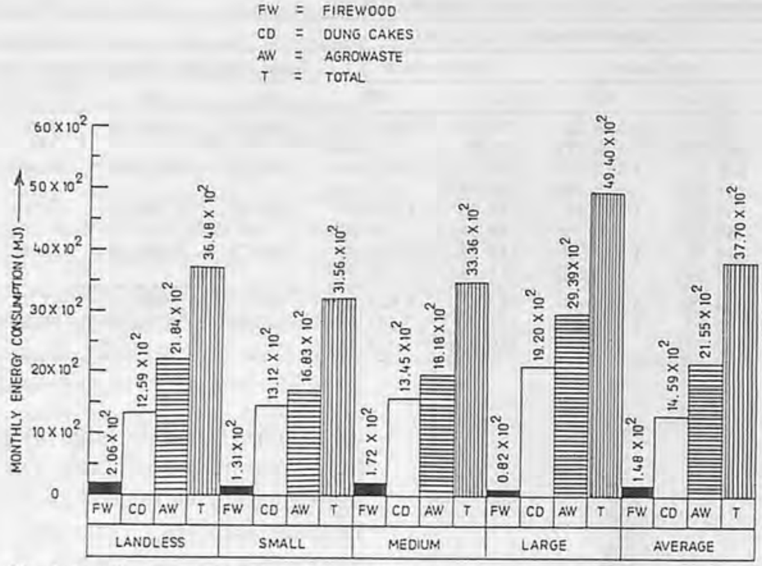


Fig. 2 Family energy consumption of different non-commercial fuels.

and **Fig. 2**. The highest total energy consumed from these non-commercial fuels, viz., agro-waste, cattle dung and firewood, was among the large households (40.40 × 10^2 MJ/month) followed by landless (36.40 × 10^2 MJ/month), medium (33.36 × 10^2 MJ/month) and small and marginal farmers (31.56 × 10^2 MJ/month). The higher quantities of fuels were used by the large households for cooking their foods, in addition to farm labour and heating of water and milk, etc. However, higher energy consumption in non-farming (landless) category may be due to the greater number of family members in this category. However, there is no significant difference between the energy consumption in medium and small and marginal farmers.

The average energy consumption of non-commercial fuels was 37.70 × 10^2 MJ/month (agro-waste 21.55 × 10^2 MJ, and cattle dung 14.59 × 10^2 MJ/month). The family daily per capita consumption of non-commercial energies for domestic cooking in rural areas for landless, small and marginal, medium and large farmers were 16.44 MJ, 16.44 MJ, 13.40 MJ and 16.47 MJ, respectively, with an average consumption of 15.69 MJ/day **(Table 2)**. There is no significant effect of occupation on per capita energy consumption. Maheshwari et al. (1990) reported that energy consumption from non-commercial fuels for cooking in village amounts to 20 MJ/day. However, Bakshi et al. (1988) observed per capita energy consumption as high as 37.19 MJ/day for Ludhiana district. These requirements can be very effectively reduced to one-half by using improved smokeless mud stoves with thermal efficiencies as high as 20% and one-third by passing the cattle dung through biogas plants. According to Sharma et al. (1991) the heat of biogas available for productive work obtained from the dung of 3-4 animals is 3.14 times than the heat of dung cakes for cooking purpose. Thus, the thermal efficiency of heat energy of cattle dung can be increased considerably by converting it into biogas which has calorific value as high as 18.84 MJ/m^3 as compared to 8.9 MJ/kg of dung cakes.

REFERENCES

1. Anonymous. 1974. Report of Fuel Policy Committee, New Delhi. Indian Documentation Service, Govt. of India.
2. Bakshi, R.; Paneshar, B.S., Singh, M.P. and Sandhar, N.S. 1988. Energy input for household activities in rural areas of Ludhiana district - A case study. J. Agric. Eng. ISAE, 25(1): 73-82.
3. Maheshwari, R.C., Bohra, C.P., Singh, Harpal and Randhawa, S.N. 1990. Self-reliant development studies for a village Islamnagar based onbio-energy resources. J. Agric. Eng. ISAE 27(1-4): 57-84.
4. Saran, G. 1984. Cooking fuels in north Gujarat. Paper presented at XXI Annual Convention of ISAE held at IARI, New Delhi. paper No. 84-116.
5. Sharma, D.N., Sehgal, Binoo and Batra, Asha. 1991. Comparison of thermal efficiencies of different types of domestic cooking stoves. Paper presented at XXVIII Annual Convention of ISAE held at IARI, New Delhi.
6. Sharma, D.N., Sethi, N., Batra, A. and Sehgal, Binoo. 1991. Optimum utilization of animal dungs as domestic fuel - A case study. AMA 22(4): 75-78.
7. Singh, N., Kairon, M.S. and Malik, B.S. 1986. Better farming system for rural development. Bulletin. Dept. of Agronomy, HAU, hisar. ■■

Potentials of Integrated Farm Energy Production and Use-management in Nigeria

by
A.J. Akor
Department of Agricultural Engineering
Rivers State University of Science and Technology
Port Harcourt
Nigeria

M.J. Ayotamuno
Department of Agricultural Engineering
Rivers State University of Science and Technology
Port Harcourt
Nigeria

Abstract

The general picture of energy production and use-management in agriculture is presented.

The Nigerian situation is brought into the picture and compared to those of two states in the United States of America. Using data collected for Nigeria and literature for the U.S.A., it was found that the United States uses about 18 times as much energy in agriculture than Nigeria does.

Agricultural productivity is twice to thrice as high for the United States as Nigeria. The potentials of increasing energy use in Nigerian farms, including fossil fuels, biomass and direct solar collection are discussed. These three sources were found to have a better future than others as energy sources for agriculture.

Introduction

Energy use-management in agriculture, as in other industries, remains a latent but crucial factor in the development of the Nigerian economy. It has been found to have a multiplier effect on agricultural productivity. Investment of energy from petroleum, electricity, chemical, direct solar, biomass, wind and other sources in agricultural production permits one U.S.A. farmer to produce enough food for more than 50 other persons, Cast (1977).

Farm energy use-management increases the quality and quantity of agricultural outpuut per unit area; it releases labour in the farm for other productive sectors of the economy; and it reduces the drudgery inherent in agricultural activities. In this context, energy use-management in agriculture is synonymous with mechanized agriculture.

Integrated energy production and use-management is a concept already in use in the crude and unplanned form in Nigeria. The concept of integrated energy production and use-management is based on research findings, i.e., farm income is greatly enchanced by increased use of energy produced on the farm.

The first settlers in Nigeria merely collected food as needed. They were hunters and gatherers of food. As population increased over time, Nature's supply was no longer sufficient and the people had to cultivate the land to harvest sufficient crops. Today, the population is growing at a rate so high (about 3% per annum) that labour intensive agriculture is no longer good enough to produce the needed food and fibre. Productivity of labour is very low while the cost of hiring labour is high, (Isirimah et al, 1990). On the average, labour costs N10.00/manday, excluding feeding and entertainment, making it difficult for farmers to hire labour except when absolutely essential. This situation has been worsened by the presence of the oil companies as competitors in the rural labour market and the urban drift problem of rural communities in Nigeria.

The most promising approach to solving this problem of low labour-agricultural productivity in Nigeria is increasing the energy use in agriculture and using more energy produced by agriculture (energy-intensive agriculture). It has become necessary for agriculture to look inwards for energy because of the facts that fossil fuel sources of energy are depletable, and that there has been politicization of petroleum. Sustainable agriculture must depend more on reliable and renewable sources of energy that can easily be handled by farmers.

When sources of energy used on the farm are available on the farm and are an integral part of the products of the farm, agriculture activities fully harnessed and incorporated in the overall planning of the farm, then integrated energy production and use-management is in practice.

According ot Dvoskin and

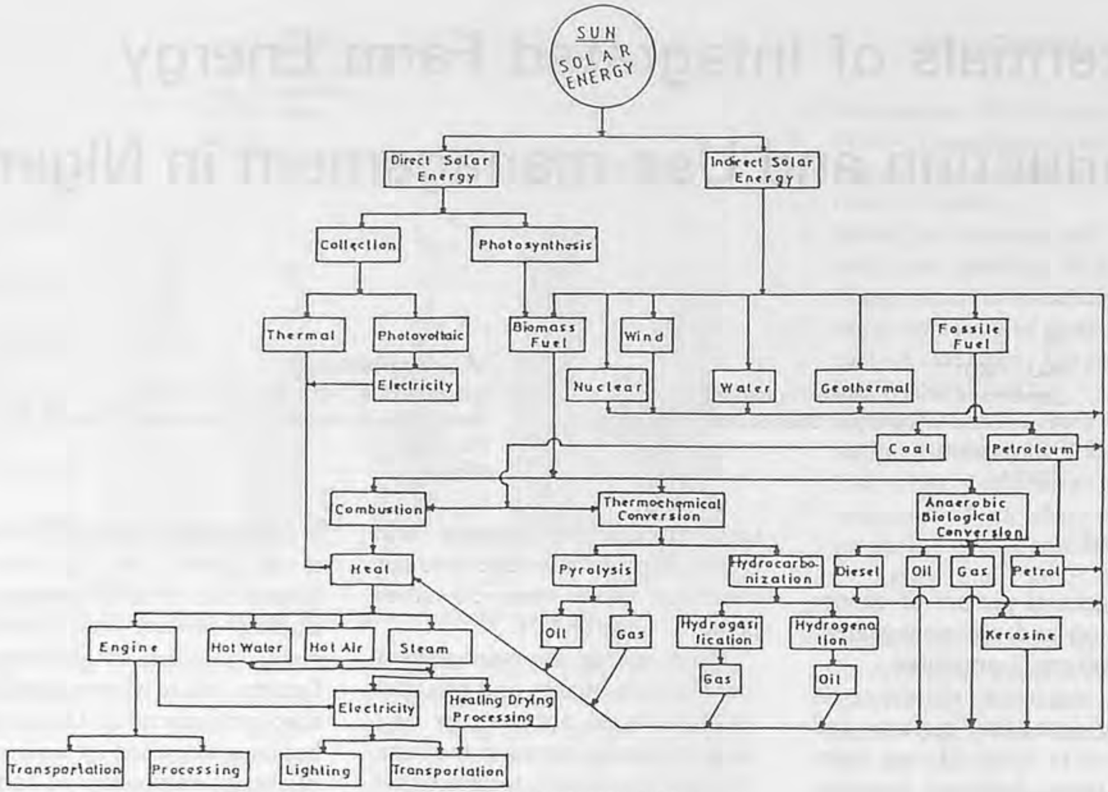


Fig. 1 The solar energy system.

Heady (1976b), doubling energy prices results in a 13% increase in farm commodity prices. An energy shortage of 5% in the farm would result in a 26% increase in farm commodity prices (Dvoskin and Heady 1976a).

Because of the need to increase agricultural production in Nigeria, and the fact that integrated energy production and use-management has been shown to be the most viable means of doing so, it is the purpose of this paper to provide evidence of this production increasing characteristic, to the extent necessary to convince farmers and researchers to think in this direction (awareness). The need for energy in the various sectors of the food system deserves the careful attention of both policy makers and customers, Price et al, 1977.

Materials and Methods

The potential of integrated energy production and use-management in Nigerian agriculture can best be illustrated by providing data from the country and comparing such data with those from other countries where work has been carried out in that area. Nigerian energy data were collected from the Nigeria Meteorological Services Oshodi, Meteorological Stations in all the states of Nigeria, from interviews of farmers, and from the Digest of Statistics of the Federal Republic of Nigeria (1985). On the other hand, data from other countries were obtained from literature on those countries. These data were then analyzed and compared with the Nigerian situation to highlight the potential of integrated energy production and use-management in the Nigerian agriculture.

Results and Discussion

Sources of Energy for Nigerian Agriculture

All energies used by man are derived from the solar system. **Figure 1** below shows the forms of energy available for the Nigerian farm. From the figure, there are six possible ways of tapping energy from the sun for agriculture-direct collection from insolation, biomass fuel, wind energy, water energy, geothermal energy and fossil fuel energy. Out of these, fossil fuel, biomass and solar energy have greater potentials than the others.

Fossil Fuel Energy

Petroleum fuels, gasoline, diesel, fuel oil and kerosene predominate as the sources of energy in use in Nigeria. But the use of petroleum fuel as an energy source is mostly in the domestic and industrial sectors. A survey carried out on this topic in the late 1970's before the Green Revolution Government Program, shows that 80% of the energy used by the farmers in Nigeria in their agricultural activities came from human labour. Very few individual and group-farms mechanize agriculture to a reasonable level on the regular basis. Because of the poor maintenance tradition prevalent in this area, even planned mechanization schemes fail within a few years from commencement. This leaves agricultural systems in Nigeria at the mercy of manual labour and Nature for energy supply with concommitant inefficiency and poor productivity. In highly efficient and productive agriculture, petroleum energy is used in the form of fertilizers, herbicides, kerosene, gasoline, diesel fuel, fuel oils, and aviation fuel.

The use of petroleum energy in the form of fertilizer is practically negligible in Nigeria because of the low level of awareness, and the skewed fertilizer distribution pattern, in which only the rich and influential farmers can obtain fertilizers at a fair price and regularly. Most of the Nigerian farmers do not belong to this group. As a result, fertilizer use in field crops and vegetables is left for Nature.

The production of fertilizer requires fossil fuel inputs, 80% of which are natural gas. The manufacture of nitrogen fertilizers use natural gas as a source of hydrogen gas for making ammonia. Ammonia is used directly or after conversion into other nitrogenous compounds as fertilizer. Nearly all soils require supplemental nitrogen for efficient prodction of non-leguminous crops.

Fertilizers are used to increase both the quantity and quality of food produced. Without fertilizer food production would be drastically reduced (Cast 1977).

According to estimates by the U.S. Department of Agriculture (USDA, 1973) "the use of nitrogen fertilizer alone is credited with providing one-third of the productive capacity of crops".

Table 1. Comparative Energy Use: Nigeria and U.S.A.*

Operation	Nebraska conventional tillage	No till	Rivers state manual tillage
Fertilizer	0.040	0.010	0.009
Tillage and Seeding	0.284	0.284	0.005
Herbicides and Insecticide use	0.010	0.012	0.011
Irrigation	0.289	0.289	0.002
Harvesting	0.010	0.010	0.006
Drying	0.128	0.128	0.002
Transportation	0.027	0.011	0.008
Total	0.788	0.761	0.043

* Fuel energy equivalent for producing irrigated corn with conventional tillage and no-till in Nebraska (Withmus et al, 1975) compared with that of a State in Nigeria.

Table 2. Annualized Energy Balance for a 136-Tree Oil Palm Stand on One Ha of Land.

Operation	Energy input (KJ)	Energy output (KJ)
Land clearing +	6 095	
Pre-nursery +	8 644	
Nursery +	13 298	
Field planting +	13 298	
Fertilizers −	3 362 396	
Slashing	1 772 148	
Harvesting +	361 805	
Fruit bunch pick-up +	219 758	
Transportation (16 km)	945 147	
Fruit sterilization	8 255 289	
Fruit stripping	126 576	
Meceration	158 220	
Pressing	527 400	
Separation	110 754	
Fiber drying	1 094 993	
Nut drying	566 544	
Nut cracking	126 576	
Kernel oil extraction	997 358	
Palm oil		88 750 948
Palm kernel oil		12 034 427
Fiber		21 135 106
Nut shell		15 800 000
Palm kernel cake		7 622 315
Subtotal	18 666 299	145 342 796
Current practice subtotal	7 384 086	108 407 690
Bunch stalk		26 642 644
Palm fronts		24 622 154
Total	18 666 299	196 629 594

Note: Average annualized yield over a 30-year span is 83.47% of that of the yield of a mature stand.
Mature stand yield is assumed to be 13 500 kg fresh fruit bunches/ha year.
+ Manual operation charged at 5 384 KJ/$ (1976).
+ 50 kg N, 50 kgp_2 O_6 and 37 kg K_2 O/ha.
In current practice with full scale processing, fiber and nut shells are burned to provide heat for all processing operations. In some cases this is also used to generate electrical or mechanical power for all inplant operations (power generation not considered in current practice subtotal shown here).
Currently palm fronts and bunch stalks are not generally used as energy sources, although there exists a potential for such use.
Source: Akor, 1980, investigations of the potential use of palm oil and kernel oil as a source of motor fuel, M.S. Thesis, University of California, Davis, California.

Fertilizer accounted for an estimated 33% of the total energy input in crop production in the United States in 1974 (U.S.D.A., 1976).

When the energy use level present in the Nigerian agriculture is compared to that of the State of Nebraska (U.S.A.), as shown in **Table 1**, it becomes obvious why the productivity of U.S.A. agriculture is 2 to 3 times more than that of Nigeria.

Table 1 shows that Nebraska uses about 18 times as much energy per hectare as Rivers State of Nigeria does.

Mechanized agriculture requires petroleum fuels, either directly or through electricity generation, in land clearing, cultivation, irrigation, pesticide application, herbicides, harvesting and processing of agricultural commodities. Nigerian agriculture is still in the manual stage approaching the transition to mechanization.

Biomass Energy

This is a term applied to energy derived from plant and animal materials. Biomass is energy renewable since its supply is guaranteed as long as solar system supports life on earth. For this reason, biomass energy is attractive as an alternative or extender of petroleum fuel. Besides, biomass are by-products of agricultural activities that end to pollute the environment, if allowed to accumulate over time.

In the Nigerian agriculture there is no controlled use of biomass. Wood materials and oils are burnt to supply cooking heat in open fire places. However, more efficient technological procedures for converting biomass to energy are already available. (Typical conversion processes are presented in **Fig. 1**)

Combustion at standard atmospheric conditions is the method in use in rural Nigeria, primarily to produce hot water, drying and for cooking. The task for researchers in this area is to device appropriate combustion chambers to improve on the efficiency of using biomass-materials.

The potential of the use of biomass as an agricultural energy source is exemplified by annualising the energy balance for a 136-tree oil palm stands on one hectare of land, **Table 2**.

In the Table, the energy inputs for manual operations were based on a 1976 Nigerian production budget and included interest charges associated with distributing initial labour input over a 30-year span. Monetary values were converted to energy values by taking the ratio of commercial energy use to gross national product for Nigeria in 1976 (5 385 KJ/\$) (538.5 KJ/N). Input mechanical processing operations were determined in terms of electric motor KWH requirements and these values were converted into thermal generation inputs on the basis of 10 548 KJ/KW-h.

This energy balance shows that with current practice, an annual fossil fuel consumption of 7 384 MJ is associated with the production of palm oil and palm kernel oil having an energy content of 100 785 MJ, and a palm kernel cake having a value of 7 622 MJ. In addition, a potential 51 287 MJ of biomass fuel energy would be available if palm fronds and stripped bunches were dried and burned.

When biomass is burned at high temperature under a chemically designed atmosphere (such as in gasifiers), oils and gasses of high heating value ranging from 30 MJ/kg to 50 MJ/g are produced through thermochemical conversion. If the environment of reaction is charged with moisture and carbon, hydrogasified and hydrogenerated gas and oil result, respectively.

Biogas is the proper name for the organically derived gas produced through controlled anaerobic (without oxygen) biological processes within a closed system known as an "anaerobic digester". Anaerobic digestion is a two-stage process. In the first stage, the complete animal or plant waste matter slury is broken down into simpler organic acids. Then in the second stage, methane - forming bacteria consume and convert the acids into methane and carbon dioxide. The methane so produced is a valuable source of heat for drying and processing of agricultural products.

Typical biogas composition was found to be:

Methane	= 60-65%
Carbon dioxide	= 35-40%
Hydrogen sulphide	< 100 ppm
Ammonia	< 1 000 ppm

Direct Solar Energy Collection

Solar energy in Nigeria has traditionally been used on farms to dry crops, fish and meats in the open or in a ventilated shed or crib.

However, the open air drying predominates in use, because it is simple and does not require special mechanisms to operate. This method is uncontrolled and inefficient. Technologies are available for harnessing direct solar energy in all the above applications in more efficient ways in Nigeria, but there is the lack of awareness of the potential of the abundant solar radiation for agricultural development in this country.

Table 3 shows that insolation in Nigeria ranges from 16 MJ/m^2 /Day to 25 MJ/m^2/Day compared to that of Michigan State (U.S.A.) which ranges from 12 MJ/m^2, Day to 16 MJ/m^2, Day. Nigeria has less variations in solar radiation from month to month while Michigan State has wider variations, (DeJong, 1973), yet, technological use of solar radiation is intensely practiced in

Table 3. Designation of Radiation Zones, Including Ranges of Insolation and City Stations in Nigeria.

Designation of Radiation Zone	Range of Hr (MJ/m^2/Day)	Some City Stations in Zome
NS1	$Hr < 16$	Port Harcourt Calabar, Lagos Benin
NS2	$16 < Hr < 19$	Abeokuta, Enugu, Ibadan, Owerri
NS3	$17 < Hr < 19$	Ilorin, Ondo, Ibadan
NS4	$19 < Hr < 21$	Bauchi, Jos, Makurdi
NS5	$21 < Hr < 23$	Yola
NS6	$25 < Hr$	Sokoto, Kano

Note: Data obtained from the Federal Republic of Nigeria Digest of Statistics, 1981 to 1985.

Michigan but not in Nigeria.

Other Sources of Energy

Wind energy has some potential in the northern part of Nigeria which is located close to the Sahara desert and where the vegetation is sparse, but not so much in the southern tropical forest where the trees form wind breaks.

Water energy is used mostly to generate electricity which is consumed industrially and domestically.

Geothermal energy and nuclear energy have the least potential for production and use-management in Nigeria for different reasons. The geological formations for geothermal energy production are not close to strata of high energy content and thus geothermal energy is not expected to be a viable source of agricultural energy. On the other hand, nuclear energy is not considered because uranium is not a farm product and is more dangerous and so requires more sophisticated systems than other sources of energy.

Conclusion

Energy production and use-management in Nigeria has high potential from three sources - fossil fuels, biomass and direct solar collection. These sources can more easily be harnessed for the production of heat for processing, electricity and hot water for agricultural operations in Nigeria. Wind energy is in use in Kano and Kaduna states of Nigeria where the potentials exits, but not yet to an appreciable extent. Water energy is produced and used for industrial and domestic activities. Such use should be extended to the agricultural sector.

Geothermal and nuclear energy have the least potential because of availability, technology, cost and the danger imposed by the presence of nuclear reactors.

REFERENCES

1. Akor, A.J. (1980). "The oil palm industry as an energy resource: Problems and Prospects". ASAE Paper No. PR80 - 004 presented at the annual conference of ASAE Pacific Region, Hilo Lagoon hotel, Hilo Hawaii ASAE St. Joseph, MI March 18p.
2. Council for Agriculture and Technology (Cast) (1977). "Energy Use in Agriculture: Now and for the Future. Report No. 68, Cast, Iowa State Univ. Ames Iowa, August 28p.
3. DeJong, B. (1973). "Net Radiation Received by a Horizontal Surface on Earth". Delft University Press, Delft Netherlands.
4. Dvoskin, D. and E.O. Heady (1976a). "Economic and Environmental impacts of energy rationing in agricultural production". Paper presented at the meeting of A.A.E.A. at Pennsylvania State University, August.
5. Dvoskin, D. and E.O. Heady (1976b). U.S. Agricultural Production under Limited Energy Supplies, High Energy Prices and Expanding Exports. Centre for Agric and Rural Development, Iowa State University, Ames, Iowa CARD Rpt, 69.
6. Federal Republic of Nigeria (1985). Digest of Statistics. Federal Office of Statistics, Lagos Nigeria, p24.
7. Isirimah N.O. and M Adeniji (1990), Oil in Rural Life. A feasibility Report for Elf Nigeria, Limited, Agroconsult Extension Service Unit, RSUST Port Harcourt, Riverside Communications Pub. Co. Nigeria, pp30-32.
8. Prince, D.R., N.C. Aceto, R.E. Albers (1977). "Energy Policy for the U.S. food system: a subpart of a national energy policy". Report of a meeting sponsored by the Engineering Foundation and ASAE at the Asilimor Conference Grounds, Pacific Grove California pp.58-60.
9. U.S.D.A. (1973). Energy to keep Agriculture going. Energy letter, United States Department of Agriculture Correspondence, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.
10. U.S.D.A. (1976). "Energy and U.S. Agriculture: 1974 Data Base". Volume 1 Federal Energy Administration FEA/D76/459, Washington D.C. pp.128-188.
11. Wittmus, H., L. Olson, and D. Lane (1975). "Energy requirement for conventional versus minimum tillage". J. Soil and Water cons. USA 300: 72-75.

Reconditioning Over-dried Wheat

by
Sulaiman A. Al-Yahya
Head
Agricultural Engineering Dept.
Faculty of Agricultural and Veterinary Medicine
King Saud University-Gassim Branch
P.O. Box 1482 Buraidh, Kingdom of Saudi Arabia

Abstract

Wheat crop of 9% moisture content was reconditioned. The experiment was conducted in the grain Quality Laboratory of the Agricultural Engineering Department, College of Agricultural and Veterinary Medicine.

A small-scale wheat-drying unit and air humidifier was designed. Air was blown through the unit at 8.3 m/s. Relative humidity of the air was kept within the range of 70-80% RH. The experiment was run for 384 h. Readings were taken at about every 24 h. Grain moisture increased from 9% to 16.5% at the end of the experiment. The rate of increase in grain moisture was 0.43% per day.

Introduction

Why Recondition Wheat

Farmers in Saudi Arabia used to harvest wheat in the summer time, June-August. At this time, the weather in the country, specially in the central area, is very dry and relative humidity is 10-30%. At this level of humidity, the equilibrium moisture content of wheat is about 6%. At this level of grain moisture, the crop will be exposed to breakage during handling and shipping. Broken fines will be increased causing the economic value of the crop to be reduced. Risk of insect infestation is possible. The grains require more processing for cleaning. During milling of over-dried wheat, plates of the miller could be broken or twisted.

Grain moisture content submitted to Grain Silos in the country should not pass 12% in order to be accepted. However, most of the farmers sell their crop at moisture level not more then 7%. Prices paid are the same whether the moisture content of the grains is 7% or 12%.

Previous experiences are the reasons for establishing this experiment in that during blowing hot air by fan, water is sprayed in the way of this air. Air will evaporate out the water and then its relative humidity will increase. In conditions where the humidity is high or during rainy seasons, the grain producers recondition their dried products by just operating the fan (drying unit).

Charels and Barger in 1948 reconditioned over-dried hay in Iowa, USA. During 234 h, they raised the moisture of alfalfa from 13.5% to 16.5%. The fan was operated at 0.55 m^3/min (cmm) and relative humidity was 74%. They found that hay absorbed water very fast during the first few days. During the remaining days, when equilibrium in the lower layers is approached, the rate of absorption was slow.

Objectives

The overall objective of this experiment was to recondition over-dried wheat. The specific objectives were to:

1. Determine the variations of moisture content in the bottom, middle, and top of the grain bin during reconditioning over-dried wheat; and
2. Determine the relationship between time of exposing the over-dried wheat to humid air and wheat moisture content.

Materials and Methods

Experimental Procedure

The experiment was conducted in the Grain Quality Laboratory of the Agricultural Engineering Department, College of Agriculture and Veterinary Medicine in Al-Gassim. The wheat sample was brought from the college farm, crop of 1992. Its original moisture content was 9.2%. Sample weight was 75 kg. Relative humidity of the air in the laboratory was around 30%.

Small-scale Drying Unit

A small-scale drier was built inside the laboratory where practically all the variables could be controlled. The apparatus used is illustrated in **Fig. 1**. The bin, which was made of metal, was insulated so the room temperature would have practically no effect on the process inside. The air was passed through a humidifier which is equipped with electric heaters and water sprayers so that air of

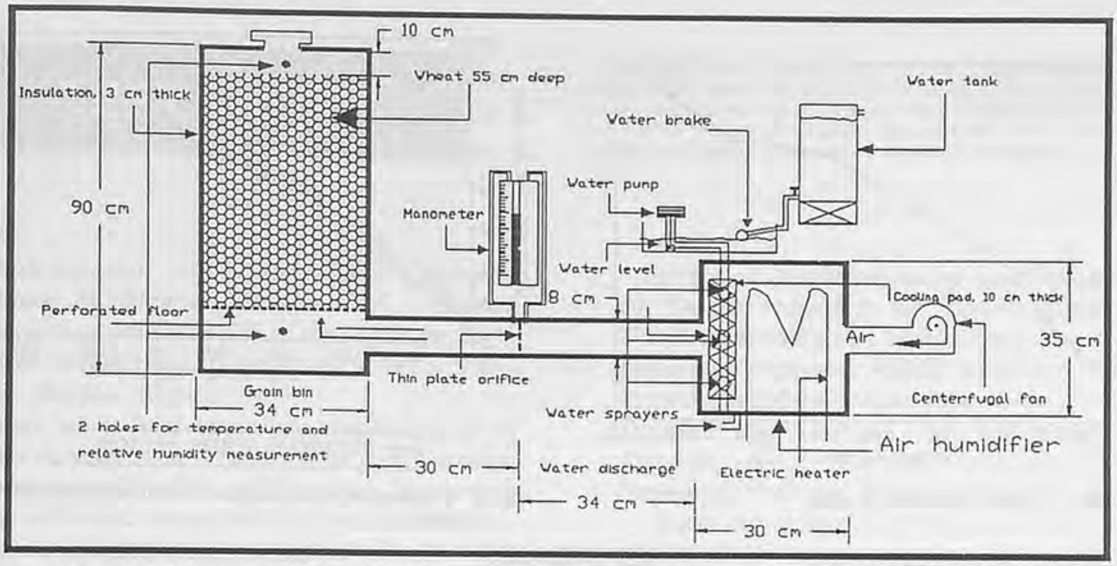


Fig. 1 Schematic diagram of a small-scale, wheat-drying unit and air humidifier used in wheat reconditioning test at College of Agriculture and Veterinary Medicine in Al-Gassim.

any desired temperature and relative humidity could be obtained. Humidity level was established by pushing water by pump and spraying it at a wide area of a cooling pad. Water discharge was 534 mm/min. Wheat to depth of 55 cm was placed in the bin, and about 8.3 m/s (2.5 cmm) of air was supplied. Air velocity was measured by the thin plate orifice and tube manometer system.

Two holes in the bin, one at the bottom and one on top, were made for measuring the inlet and outlet air temperature and relative humidity. The moisture content at the bottom of the bin, in the middle and on top was measured every 24 h. Grain moisture content was determined by an air oven method. The sample was dried in the oven for 19 h at 130°C. The samples from the middle and top of the grain bin were taken by an auger.

Results and Discussion

The results are summarized in **Table 1**. Rate of moisture content increased in the bin during the time of reconditioning **(Fig. 2)**. The experiment was run for 384 h.

Table 1. Results of Reconditioning Dried Wheat

Time (h)	Air				Final Moisture content, % wb			
	Entering		Leaving					
	Temp, C	%RH	Temp, C	%RH	Average	Bottom	Center	Top
0	17.2	80	20.1	50	9.30	9.10	9.20	9.60
24	22.2	75	26.2	45	10.4	10.2	10.4	10.6
48	20.2	75	19.2	65	10.7	10.5	10.6	11.0
72	25.2	75	25.2	65	11.3	11.4	11.0	11.5
96	25.2	77	27.2	45	12.2	12.1	12.0	12.5
120	27.2	70	27.2	45	12.7	12.6	12.7	12.8
168	26.2	78	26.2	55	13.4	13.3	13.4	13.6
240	22.5	77	23.2	65	14.5	14.2	14.5	14.8
312	21.2	80	20.2	60	14.8	14.5	14.8	15.1
360	21.2	80	21.2	65	15.6	15.1	15.3	16.5
384	22.0	80	20.0	60	16.1	15.3	16.0	17.0

Relative humidity was in the range of 70-80%. Wheat absorbed more moisture during the first two days. During the remaining days, the rate of absorption was slow. When the humidity of air was high, grain absorbed more moisture content. From **Table 1**, variations of grain moisture content in the bin layers is obvious. **Figure 3** shows the moisture content variations in the different layers. In all of the readings, the moisture content of the grain on top was highest, followed by the middle layer. The lowest moisture content was at the bottom layer. Airflow was too high and was able to carry the water vapor to the top layer of the bin. This level of air flow delayed the spoilage occurrence in the bottom layer. If the experiment was run for more time, grain spoilage may occur because the smell of bad gases had just started after 15% moisture in the bottom layer, 16% moisture in the middle layer, and 17% moisture in the top layer were obtained. This indicated that if the relative humidity of the air is high, then the possibility of grain spoilage will be very high.

Conclusion

The study would lead to the following conclusions:

(1) Reconditioning of over-dried wheat is desirable in order to reduce broken fines, reduce risk of insect infestation, facilitate grain milling, and increase the economic value of wheat.

(2) The top layer of dry wheat absorbs more moisture than in

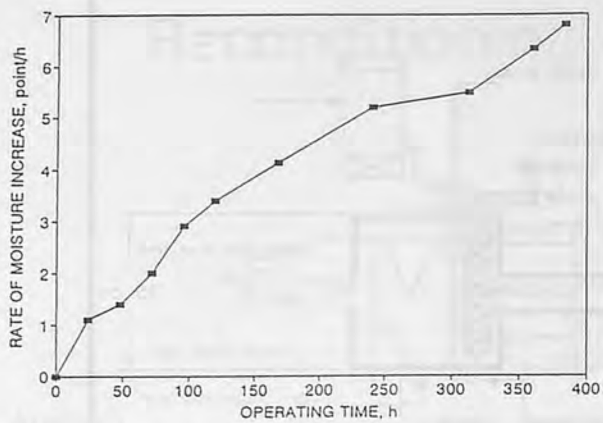


Fig. 2 Rate of moisture content increase.

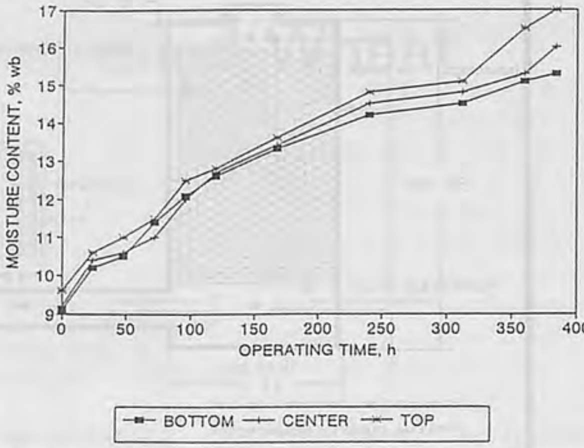


Fig. 3 Variations of grain moisture content in bin at different layers.

the bottom layer due to the high speed of air. Air was able to carry more water vapor to the top level.

REFERENCES

Charles E, Ball and E.L. Barger. 1948. Reconditioning over-dried hay. Agricultural Engineering Vol. 29 no. 7, pp.299-300.

American Society of Agricultural Engineers. 1986. Moisture Measurement - Grain and Seeds, S352.1, In: ASAE Standards 1986. ■■

New Co-operating Editor

Vilas M. Salokhe

Date of Birth: May 4, 1951
Nationality: India
Qualifications:

1974 B. Tech. (Agri. Engg.) 1st class with Distinction, First Rank Mahatma Phule Agricultural University, Rahuri, India

1983 M. Eng. (Agri.) 1st class with Distinction, Sukhadia University, Udaipur, India

1986 D. Eng., Asian Institute of Technology, bangkok, Thailand

Experience:

May '74-June '80 Assistant Professor of Agricultural Engineering, Mahatma Phule Agricultural University (MPAU), Rahuri, India.

June '80-Dec '80 Assistant Professor of Agricultural Engineering, College of Agriculture, Kolhapur.

Dec '80-June '81 Associate Professor of Agricultural Engineering, College of Agriculture, Pune.

June '81-Oct '81 Associate Professor of Agricultural Engineering, College of Agriculture, Kolhapur.

Oct '81-Dec '83 Associate Professor of Agricultural Engineering. Deputed by MPAU, Rahuri, for M. Eng. (Agri.) studies at Sukhadia University, Udaipur, India.

Jan '84-Dec '86 Associate Professor of Agricultural Engineering MPAU, Rahuri. On leave for D. Eng. studies at the Asian Institute of Technology, Bangkok, Thailand.

Jan '87-Aug '87 Associate Professor of Agricultural Engineering, MPAU, Rahuri. On leave for post doctoral research at the Asian Institute of Technology, Bangkok, Thailand, in the joint 'Tractor wheel project' between the A.F.R.C. Institute of Engineering Research, Silsoe, England and the Asian Institute of Technology, Bangkok, Thailand.

Sept '87-June '90 Visiting Faculty in the Division of Agricultural and Food Engineering, Asian Institute of Technology, Bangkok, Thailand.

July '90-present Associate Professor of Agricultural Engineering in the Division of Agricultural and Food Engineering, Asian Institute of Technology, Bangkok, Thailand.

Administrative Experience:

May '74-June '80 Head of Vehicles Section under the office of the Director of Farms, Mahatma Phule Agricultural University, Rahuri (India).

Dec '80-June '81 Research Engineer, Power Tiller Testing Scheme, College of Agriculture, Pune (India). ■■

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.

363

Modernization of On-farm Grain Storage Facilities in Nigeria: Birewar, B.R., Former Storage Specialist, CFTC, Crop Storage Unit, Federal Department of Agriculture, Moor Plantation, Ibadan, Nigeria.

Based on a field study, the traditional grain storage structures constructed from locally available materials like straw, split bamboo, mud, mud bricks and wood wre not efficient and economical. The grain s torage losses were estimated at 30-40%. Therefore, the improved designs of indoor and outdoor metalic and non-metalic grain storage structures for capacities ranging from 0.28 to 6.6 m^3 or 200 kg to 4.7 t for maize were developed and tested at the Crop Storage Unit of the Federal Department of Agriculture, Ibadan, Nigeria under the CFTC programme during the period 1987 to 1990.

According to performance test results, the improved designs proved suitable for storage of maize and would prove equally suitable for storage of other foodgrains like wheat, paddy, sorghum and millet. They could also prevent stored grains from spoiling, hence maintain the quality for longer periods. The grain storage losses due to insects, moisture and rodents were in the range of 0.5 to 4.5% in the agro-climatic conditions prevailing in Ibadan. Therefore, the improved designs were recommended for their popularization in the country.

The cost of storage of grains per tonne per annum in improved grain storage structures ranged between ₦69.50 and ₦160.00 (US$7.00 and 16.00*) against ₦251.50 and ₦940.00 (US$25.15 and 94.0*) for the traditional storage structures. (*Based on 1 USD = 10.00₦ in 1990.)

367

Effect of System Pressure and Travel Speed of Tractor-mounted Air Carrier Sprayer on Droplet Deposition on Mango Tree: Turare, C.B., Research Engineer, ASPEE Research Institute, Bombay 400064, India; Ingle, G.S., Professor, Dept. of Agric. Engg., IIT, Kharagpur, India; Pandya, A.C., Visiting Professor, ASPEE Research Institute, Bombay 400064, India.

There are various factors in air carrier spraying which influence the droplet deposition on the target. An air carrier sprayer equipped with axial flow fan was tested at various speeds and system pressures in a mango orchard. It was found that droplet deposition at all locations on mango tree was increased with increase in system pressure and decrease in travel speed. The combine effect of the system pressure and travel speed at all locations was highly significant, indicating that each factor affects the sprayed deposition on the mango tree.

377

Repair and Maintenance Cost of Farm Tractors Using Regression Technique: Bukhari, K. Hussain, Final B.E. (Agri.) Student, Bagh Colony Tandojam, Pakistan; Bukhari, Sheruddin, Professor, Dept of Farm Power & Machinery; Mahar, K. Ahmed, Associate Professor, Dept. of Statistics, respectively, S.A.U. Tandojam, Pakistan.

The regression techniques were used to study the interaction of different tractors and cost variables. It is concluded that repair and maintenance cost per hour are affected mostly by annual use and age of tractor. The farm size has no effect on cost per hour. ■■

Agricultural Equipment Technology Conference

November 1-4, 1995
Hyatt Regency Chicago, Chicago, Illinois, USA

The agricultural Equipment Technology Conference will bring together over 1 000 professionals in the agricultural equipment industry to exchange information, discuss opportunities and address challenges for production agriculture in the 21st century.

The Conference will focus on machinery and machinery systems for agricultural production. Invited speakers will address issues in safety, design, quality, profitability, ergonomics and environmental concerns. A technology exhibit will feature leading edge supplier products and systems as well as the latest academic and applied research in the industry.

Sponsored by: The Power and Machinery Division of ASAE — The Society for engineering in agricultural, food, and biological systems.

6th International Conference Computers in Agriculture

June 11-14, 1966
Marriott Casa Magna Hotel
Cancún, Mexico

This conference is the seventh in a series of conferences (and the sixth international conference) that is intended to provide an exchange or information on the applications and use of computers in all agricultural disciplines. Contributions from various countries will allow a broadened perspective for all attending.

Sponsored by: ASAE the Society for engineering in agricultural, food, and biological systems

Supported by: Instituto Mexicano de Technologia del Agua (IMTA), Association of Agricultural Computing Companies (AACC), Comisión Nacional del Agua, México (CNA), Asociación Mexicana de Ingeniería Agrícola (AMIA).

IRRI Reaches New Stage in Battle Against Major Rice Pest

A promising new stage in the struggle to find an environmentally safe method of controlling the yellow stem borer — one of the most damaging insect pests of rice — is getting under way at the International Rice Research Institute (IRRI).

Currently, many farmers attempt to control this pest by spraying chemical insecticides. The negative effects of chemical insecticide use on the health of farmers and their families, on the environment, and on the "friendly" insects which provide natural pest control have been well documented by IRRI and others.

Now scientists at the Los Baños research and training institution are beginning to study the possibility of providing built-in resistance to the borer through the incorporation into the rice plant of an insecticidal toxin from the bacterium *Bacillus thuringiensis (Bt)*.

Bt-containing sprays have been used successfully by environment-conscious farmers since the 1950s to control insects on a variety of crops. A major reason for the acceptance of the *Bt* products is that they are not toxic to humans, other animals, or beneficial insects. Research on the use of the *Bt* gene to protect other food plants — including potatoes and maize — is going on all over the world.

Seeds of transgenic rice containing the *Bt* gene will soon arrive at IRRI from the Swiss Federal Institute of Technology (ETH) in Zurich. The genes were supplied by Ciba-Geigy, an agrochemical company that has begun to explore environmentally benign alternatives to chemical pesticides, and which is willing to make its intellectual property available to IRRI.

Approval for shipment of the seeds was granted by the National Committee on Biosafety of the Philippines (NCBP), and the seeds and plants grown from them will be handled at IRRI in accordance with regulations established by the NCBP. The plants will be grown only in approved greenhouse facilities.

In addition to research on the genetic engineering of rice with *Bt* toxins, IRRI's research will evaluate the environmental impact of *Bt* rice and develop strategies for its sustainable use. The new rice will be throughly evaluated before any release to farmers is considered.

New Rice Plant Not Yet Available in Farmers Fields

Seeds of the new rice plant, popularly known as "super rice", are not yet available for planting in farmers' fields. What the International Rice Research Institute (IRRI) in Los Baños developed and harvested are prototype breeding lines of the rice plant which are currently being field-tested at IRRI.

Dr. Gurdev S. Khush, IRRI's principal plant breeder, clarified that the new plant type as it is now, is still susceptible to diseases and insects and further research and tests are aimed at the incorporation of disease and insect resistance and improving the grain quality. Thus, the new rice plant will be not be available to farmers for another five years.

The new plant type was conceptualized in 1989. Breeding work was started in 1989 when about 2 000 varieties from the IRRI germplasm bank were grown to identify donor plants for various traits. Hybridization work was undertaken in 1990. Since then, more than 1 300 crosses have been made. About 65 000 breeding lines have been produced and plant types with desired traits have been selected. In a relatively short period of five years, the new desired plant type became available in 1994.

"Scientists at IRRI are attempting to breed resistance to pests and diseases into it while further research by scientists in national research institutions, like the Philippine Rice Research Institute (PhilRice) in the Philippines, will then incorporate other desirable characteristics — such as those specific to taste — to meet individual country requirements," Dr. Khush added.

After fine tuning, field evaluation and seed multiplication, new plant type lines will be available for on-farm production by the turn of the century.

New Upland Rice Variety for Indonesia

The Indonesian Ministry of Agriculture recently released an upland rice variety with a yield potential of 3-4 t per hectare.

The upland rice variety, named *Way Rarem*, is the product of a cross among IR8, a variety developed by the International Rice Research Institute (IRRI); Carreon, a variety originating from the Philippines; and B98lk, a cross between local Indonesian varieties.

The new variety matures within 100-110 days and is resistant to two rice diseases: blast and brown spot.

'Way Rarem' yielded about 30% more than locally grown varieties Sentani, Danau Atas, Laut Tawar, Maninjau, and IR64 in experiments carried out for five planting seasons by the Central Research Institute for Food Crops in Indonesia.

The upland variety is tolerant of aluminum and iron toxicity, making it a good crop for less fertile land. Consumers in West Sumatra, who prefer rice that is not sticky, find the variety acceptable.

'Way Rarem' was first planted in Central Lampung during the 1991-92 wet season; it is grown on more than 20 000 hectares today.

TRC Launches New Rapid Patch Compound

TRC International has added a further product to its specialist range of compounds and coatings for the maintenance and repair of existing surfaces. Branded as Hydroban® Rapid Patch Compound (RPC061) it provides an instant and easy remedy for pot-holes or damaged areas in both 'black-top' and concrete roads and hard standings.

RPC061 has been formulated for use straight from the pack without further mixing and once properly laid permits immediate use by wheeled traffic, vital where lane closures are involved. Designed principally for roadways and airports it has equal application for smaller repairs to footpaths, industrial flooring, reinstatement around drainage systems and the infilling of service ducts. Its free-flowing and adhesive properties render any such repair long-lasting.

RPC061 is simple to use once the hole has been thoroughly cleared of all loose material and contamination. By tipping sufficient compound into the hole, allowing surplus for compaction, smaller areas can then be smoothed-off by hand or mechanical compactor while very large areas need rolling or the use of a vibrating plate.

For further information contact: David Hewett, Garland International, 178 Battersea Park Road, London SW11 4ND, England. Tel. +44 171 738 8008, Fax. +44 171 498 6153.

EMY - Elenfer at Two International Exhibitions

Emy - Elenfer, while pursuing its commitment of expanding on the international market and after the excellent results obtained on the domestic market, will be present at two of the most relevant internaitonal exhibitions in Europe: EIMA in Bologna (Italy) - from 04th to 08th November 1995 - Pav. 21 stand B 14 and AGRITECHNICA in Hannover (Germany) - from 12th to 18th November 1995 - Pav. 2/A stand 018a.

Emy - Elenfer will expose the outcome of its 20-year experience in the field of agricultural machines and especially in the production of power harrows, which comply with the CE-norm for safety and have a 2-year warranty.

For further information contact: EMY ELENFER di Erbelli Luciano - Via G. dalle Bande Nere, 19 - 46034 Governolo di Roncoferraro (MN) Italy. Tel. 0376/669097, Fax. 0376/668653. ■■

BOOK REVIEW

Biology and Management of Rice Insects

(India)

edited by E.A. Heinrichs

Insect pests are severe constraints to rice production throughout the world.

Integrated pest management has been accepted as the rational approach to the regulation of rice insect populations, since it is economically attractive, and ecologically and socially acceptable.

Success in the development and implementation of effective rice insect management programs has been limited in scope, and has yet to be even partially achieved in many of the rice growing areas of the world. Success and failure depend to a large extent upon our ability and preparedness to develop the required skills.

The authors have written this book to provide the basic information needed to develop this knowledge.

1994. 779 pages. 17.78 × 25.40 cm. Hardcover. HDC US$50.00, LDC (outside India) US$13.00 plus airmail (US$26.00) or surface (US$2.50) postage.

Published by H.S. Polai for Wiley Eastern Ltd., New Age International Ltd., 4835/24 Ansari Road, Daryaganj, New Delhi 110002.

Breaking the yield barrier

Proceedings of a Workshop on Rice Yield Potential in Favorable Environments, IRRI, 1993

(Philippines)

edited by K.G. Cassman

In the next 30 years, global rice production must be raised by another 300 million tons. With little scope for expanding the irrigated area, this challenge must be met by increased yields from the existing riceland.

IRRI invited scientists to attend a workshop to help delineate the boundaries of our present understanding of yield potential, to explore the frontiers of science in plant biology relevant to yield formation, and to identify the most promising approaches to develop rice varieties with higher yield potential.

This book is the result of that meeting. It contains papers by IRRI scientists, and extended abstracts of the invited papers. This is also a set of recommendations for future research as prepared by the participants.

1994. 141 pages. 15.24 × 22.86 cm. HDC US$12.00, LDC US$3.00 plus airmail (US$4.50) or surface (US$1.50) postage.

This book is available from Communication and Publications Services, IRRI, P.O. Box 933 Manila 1099, Philippines.

Hybrid Rice Technology: New developments and future prospects

(Philippines)

edited by S.S. Virmani

The world annual rough rice production must increase from today's 520 million tons to 764 million tons by 2025.

To meet this challenge, research to increase rice productivity must receive high priority. Successful development and utilization of japonica hybrid rice in China during the past two decades has demonstrated that rice yield potential can be increased by commercial exploitation of heterosis or hybrid vigor in this self-pollinated crop.

IRRI and national programs are exploring the potential of this biological phenomenon to raise tropical rice varietal yields. Results are encouraging and some national programs have recently released rice hybrids for commercial cultivation.

As part of the last International Rice Research Conference, a symposium on hybrid rice was held to review present knowledge and to make recommendations for future research.

This publication contains selected papers from that symposium, and should become a valuable source of information on hybrid rice for the coming years.

1994. 296 pages. 15.24 × 22.86 cm. HDC US$21.00, LDC US$5.00 plus airmail (US$6.00) or surface (US$1.50) postage.

Published by International Rice Research Institute, Los Baños, Laguna, Philippines.

Machine Design for Mobile and Industrial Applications

(USA)

edited by Gary W. Kruz, John K. Schueller, and Paul W. Claar, II

An ideal introductory text for the student, as well as an excellent reference for the engineer, *Machine Design for Mobile and Industrial Applications* provides the designers of mobile and industrial machines with methods for selecting and designing machine components. It is a practical and useful text which is concerned with the actual application of machine design, not just the theory. Well-illustrated with hundreds of figures and tables, the book also includes many examples of actual design problems. Each chapter includes "homework problems" and bibliographic references.

1994. 548 pages. 10 chapters Hardbound. US$59.00 Member US$69.00 List Order No. R-128.

Published by Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001 USA. ■■

INSTRUCTIONS TO AMA CONTRIBUTORS

The Editorial Staff of the AMA requests contributors of articles foı publication to observe the following editorial policy and guidelines in order to improve communication and to facilitate the editorial process :

Criteria for Article Selection

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

a. are written in the English language ;
b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are printed, double-spaced, under 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.
h. written on floppy disc.

Rejected/Accepted Articles

a. As a rule, articles that are not chosen for AMA publication are not returned unless the writer(s) asks for their return and are covered with adequate postage stamps. At the earliest time possible, the writer(s) is advised whether the article is rejected or accepted.
b. When an article is accepted but requires revision/modification, the details will be indicated in the return reply from the AMA Chief Editor in which case such revision/modification must be completed and returned to AMA within three months from the date of receipt from the Editorial Staff.
c. "The AMA does not pay for articles published. However, the writers are given collectively 5 free copies (one copy air-mailed and 4 copies sent by surface/sea mail) of the AMA issue wherein their articles are published. In addition, the main author is given an article on floppy disc with AMA true format. Co-authors can get a copy from main author.
d. Complimentary copies: Following the publishing, three successive issues are sent to the author(s).

Procedure

a. Articles for publication (original and one-copy) must be sent to AMA through the Co-operating Editor in the country where the article originates. (Please refer to the names and addresses of Co-operating Editors in any issue of the AMA). However, in the absence of any Co-operating Editor, the article may be sent directly to the AMA Chief Editor in Tokyo.
b. Contributors of articles for the AMA for the first time are required to attach a passport-size ID photograph (black and white print preferred) to the article. The same applies to those who have contributed articles three years earlier. In either case, ID photographs taken within the last 6 months are preferred.
c. The article must bear the writer(s) name, title/designation, office/organization, nationality and complete mailing address.

Format/Style Guidance

a. Article must be sent on 3.5 inch floppy disk with MS DOS format (e.g. Word Perfect, Word for DOS, Word for Windows.....) along with one printed copy.
b. The data for graphs and the black & white photographs must be enclosed with the article.
c. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
   i) a brief and appropriate title ;
   ii) the writer(s) name, designation/title, office/organization ; and mailing address ;
   iii) an abstract following ii) above ;
   iv) body proper (text/discussion) ;
   v) conclusion/recommendation ; and a
   vi) bibliography
d. The printed copy must be numbered (Arabic numeral) successively at the top center whereas the disc copy pages should not be number. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e.g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e.g., "Figure 1. View of the Farm Buildings".
e. The data for the graph must also be included.
f. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
g. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
h. Express measurements in the metric system and crop yields in metric tons per hectare (t/ha) and smaller units in kilogram or gram (kg/plot or g/row).
i. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
j. Convert national currencies in US dollars and use the later consistently.
k. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
l. When numbers must start a sentence, such numbers must be written in words, e.g., Forty-five workers..., or Five tractors..." instead of 45 workers..., or, 5 tractors.

Co-operating Editors

F M Fonteh | E A Baryeh | A M Hossay | B S Pathak | D B Ampratwum | R J Bani | I K Djokoto | D K Some | J C Igbeka | E U-Odigboh

K C Oni | U B Bindir | N G Kuyembeh | A H Abdoun | A B Saeed | Surya Nath | A I Khatibu | S Tembo | I de A Nääs | A E Ghaly

E J Hetz | A A Valenzuela | O Ulloa-Torres | H O Laurel | W J Chancellor | M R Goyal | A L Philips | G R Quick | S M Farouk | M A Mazed

M Gurung | Wang Wanjun | A M Michael | T P Ojha | S R Verma | Soedjatmiko | M Behroozi-Lar | J Sakai | B A Snobar | C J Chung


C C Lee


I Haffar


M Z Bardaie


M P Pariyar


E S Eldin


A D Chaudhry


A Q Mughal


R ur Rehman


R M Lantin


R P Venturina


S Illangantileke


S F Chang


T S Peng


S Phong-supasamit


C Rojanasaroj


G Singh


Y Pinar


P V Lang


A P Kaloyanov


P Kic

A.M. Michael
Vice-Chancellor, Kerala Agricultural University, Vellanikkara, 680654, Thrissur Dt., Kerala State, India

T.P. Ojha
Dy. Director, General, Indian Council of Agricultural Research, Krishi Bhawan, Dr. Rajemdra Prassad Road, New Delhi-110001. Inida

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

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

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

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

Bassam A. Snobar
Professor & chairman, Plant Production Dept., Faculty of Agriculture, University of Jordan, Amman, Jordan

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

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

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

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

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

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

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

A.Q. Mughal
Professor, Faculty of Agricultural Engineering, Sind Agriculture University, Tandojam, Sind, Pakistan

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

Reynaldo M. Lantin
Agricultural Machinery Expert, Regional Network for Agricultural Machinery, c/o United Nations Development Programme P.O. Box 7285 ADC Pasay City Metro Manila, Philippines

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

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

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

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

Surin Phongsupasamit
Associate Professor, Dept. of Mech. Engineering, Faculty of Engineering, Chulalongkorn University, Ban 10330, Thailand

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

Gajendra Singh
Professor and Deputy Director General (Engineering) Indian Council of Agricultural Research (ICAR) Krishi Bhawa, Dr. Rajendra Prasad Road, New Delhi-110001, India

Yunus Pinar
Associate Professor, Agric. Engineering Dept., Faculty of Agriculture, University of Ondokuz Mayis, Kurupelit, Samsun, Turkey

Pham Van Lang
Director, Vietnam Institute of Agricultural Engineering, Vien Truong, Vien Cong Cu Va Co Gioi Hoa Nong Nghiep Phuong Mai, Dong Da - Ha Noi, Viet Nam

—EUROPE—

Anastas Petrov Kaloyanov
Professor & Head, Research Laboratory of Farm Mechanization, Higher Institute of Economics, Sofia, Bulgaria

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

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

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

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

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


H Have


G Pellizzi


A A Wanders


J Kilgour

BACK ISSUES

(Vol. 25 No. 1, Winter 1994 ~)

■■

The Updated Version of the AMA Computerized Index Available

A computerized index of technical articles in Agricultural Mechanization in Asia, Africa and Latin America has been compiled for the year 1971 through 1992. Each citation includes truncated versions of the title, first and second authors' names and four keywords. Year, issue and page number of each article are given. The citations along with software for searching the database are all included on a single computer diskette for use with IBM compatible type computers.

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