International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.33, NO.3, SUMMER 2002

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

NEW TECHNOLOGY IN GRAIN POSTHARVESTING

by Ritsuya Yamashita
Professor emeritus of Kyoto University

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

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

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

Price: Japanese ¥6,000 (US$65.00). including air mail postage.
Size: 21cm × 15cm, soft cover, 208 page
Published by Farm Machinery Industrial Research Corp.,
Shin-Norin Build., 7,2-chome Kanda Nishikicho,Chiyoda-ku,Tokyo 101-0054,Japan
Tel:+81-(0)3-3291-5718, Fax:+81-(0)3-3291-5717
E-mail:sinnorin@blue.ocn.ne.jp URL:http://www.shin-norin.co.jp

TWO-WHEEL TRACTOR ENGINEERING
for Asian Wet Land Farming

by Jun Sakai
Professor emeritus of Kyushu University , Co-operating Editors of AMA

A present to the students who dream to be an international-minded specialist in farm machinery science&technology
Intoduction of new "Tractor-Tillage Engineering" based on a global view of agricultural civilizations in the world
Two-wheel tractors contribute to the industrial promotion of agri-countries consisting of small-scale family farms.
The textbook with new guidelines for international technical cooperation with a better mutual understanding.

CONTENTS

Difference between Euro-American and Asian farming civilizations
New wheel dynamics and tractor-vehicle engineering in the 21th Century
New plowing science of walk-behind tractors originated from Asian paddy farming
Scientific creation and systematization of rotary tillage engineering in Asia

English-Japanese Version

Price: Japanese ¥2,600 Size: 21cm × 15cm, soft cover, 311 page
Published by Shin-norinsha Co., Ltd.
Shin-norinsha Co., Ltd..
7-2Kanda Nishikicho,Chiyoda-ku,Tokyo,Japan
(Tel:+81-(0)3-3291-3671~4) , (Fax:+81-(0)3-3291-5717)
E-mail:sinnorin@blue.ocn.ne.jp URL:http://www.shin-norin.co.jp

UPDATED FINDER SYSTEM FOR TECHNICAL ARTICLES IN AMA AND OTHER AGRICULTURAL ENGINEERING PERIODICALS

A computerized index of technical articles appearing in 13 agricultural engineering periodicals, including Agricultural Mechanization in Asia, Africa and Latin America since it's beginning in 1971, has been updated through the end of 1999. The index database comes with it's own MS-DOS-based search engine.

There are four ways to get this free-of-charge index system:

1. Connect your Internet browser to the URL: http://asae.org, click on "Publications" , then scroll down to "Computerized Agricultural Engineering Incex" and click again to download the file, AE-NDX99. EXE.
2. Connect your Internet browser to the URL:
   http://www.engr.ucdavis.edu/~bae/Outreach/aeindex.html
   The first letter of "Outreach" should be a capital "O". to download the file, AE-NDX99. EXE.
3. Use File Transfer Protocol (FTP) from SWEETPEA.ENGR.UCDAVIS.EDU (or **169.237.204.225** for those wishing to use the IP address). Give as a User name: anonymous, and as a Password: guest. Before "getting" aendx99.exe, first type: binary (enter)
4. Mail two formatted (IBM Compatible) 1.44 Mbyte, 3 1/2-inch diskettes to:
   W, J, Chancellor
   Biological and Agricultural Engineering Department
   University of California
   Davis, CA 95616-5294, USA

The file, AE-NDX99. EXE, will be transferred to the diskettes, and the diskettes will be returned to the sender. The file, AE-NDX99. EXE, should be placed on a hard disk drive in a subdirectory by itself. Then, typing AE-NDX99(enter) followed by typing: HOW2LOAD (enter) will provide installation instruction.

Those who have access to the Internet may search on-line an expanded agricultural engineering finder system index by TELNETing to SWEETPEA. ENGR. UCDAVIS. EDU (or **169.237.204.225**), and when the prompt: "Username:"appears, type: SEARCH tenter). No password is required, and there is no charge.

International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.33. NO.3. SUMMER 2002

Edited by

YOSHISUKE KISHIDA

Published quarterly by

Farm Machinery Industrial Research Corp.

in cooperation with

The Shin-Norinsha Co., Ltd.

and

The International Farm Mechanization Research Service

TOKYO

Editorial, Advertising and Circulation Headquarters
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan
URL : http://www.shin-norin.co.jp
E-Mail : ama@shin-norin.co.jp

FARM MACHINERY INDUSTRIAL RESEARCH CORP,
SHIN-NORIN Building
7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan
Printed in Japan

This is the 116th issue since its maiden issue in the Spring of 1971

EDITORIAL

Quest for Global Sustainable Development

The world summit on Sustainable Development held in Johannesburg, South Africa recently, was attended by over a hundred heads of state. The theme of the 10-day conference was how to ensure that global development without ruining the environment in the interest of future generations.

In effect, the summit was a follow up of the Earth Summit held in Rio de Janeiro former capital of Brazil, 10 years ago. Between then and now, the world has made little progress in achieving the aims outlined in the Earth Summit. Instead the ecological crisis is expanding world-wide. It is now estimated that the desertification around the world progresses at the speed of 6 million ha per year as a rapid depletion of plant life and loss of topsoil are prevalent in desert boundaries. Deforestation in the Amazon forest refuted to be the world's greatest water and oxygen resource, is now experiencing a fast decrease in area due to indiscriminate burning to expand pasture land.

The Johannesburg Summit adapted a declaration to stop the destruction of the environment and measures to deal with the worsening global environment crisis. But like the "lotus that multiplies fast in the pond," environmental issues often becomes too late to work when we notice it.

A way to assure sustainable and long life on our planet, mechanization of farming helps to realize that harmony. As the ecological crisis is more severe in developing countries wherein governments tend to expand farm sizes in order to support the increasing population. Raising land productivity offers the more useful was to save forests from destruction.

More precise and appropriate farm work realized through mechanizing agriculture will assure higher land productivity.

Developing countries really need he support of developed countries in order to mechanize agriculture. There could be no acceptable future unless we deal decisively with all the challenges we face. Mechanization of agriculture not only increases the harmony between man and other life systems.

Yoshisuke Kishida

Chief Editor

Tokyo, Japan

September 2002

CONTENTS

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol.33, No.3, Summer 2002

Devices for Inter-cropping Green Manure in Wet Seeded Rice

by
Dr. A. Tajuddin
Professor
Zonal Research Centre
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore 641 003
INDIA

by
Dr. P. Rajendran
Professor and Head
Agricultural Research Station
Tamil Nadu Agricultural University
Bhavanisagar 638 451
Erode District
INDIA

Abstract

A manually-drawn seeder was developed to sow pre-germinated paddy and green manure crop (*Sesbania aculaeta*) (local name is daincha) in alternate rows on puddle soil. On attaining a height of 400 mm after about one month of sowing, the daincha crop was trampled using long handled IRRI design cono-weeder which simultaneously does the weeding operation. The seeder sows four paddy rows and four daincha rows in a single pass. Using one (male) operator and two women labourers half of ha can be sown with the seeder in a day of 8 hours. Paddy is sown at 80 kg/ha seed rate and green manure crop at 30 kg/ha seed rate. The distance between the adjacent rows is 125 mm. Grain yield of wet seeded rice inter-cropped with green manure is at par with the transplanted rice. The globally unique technology enables reduction in the cost of rice cultivation at US $60 per hectare. When compared to sole wet seeded rice, weeds are better controlled in the wet seeded rice inter-cropped with green manure. As the rice is sown in rows, weeding and inter culture operations are made easy by the use of long handled tools. The seeder along with three cono - weeders costs US $150.

Introduction

Transplanting of paddy seedlings in wetland is the widely accepted cultivation practice. Labour involved in nursery raising and transplanting constitutes 30 per cent of total labour required for paddy cultivation. Paddy transplanting is a tedious farm operation requiring 50 labourers per hectare. Even the available agricultural labourers do not maintain the optimum plant population. Usually they plant paddy seedlings at greater depth than required which results in poor yield. During peak transplanting seasons, labourers are not easily available. This leads to delayed transplanting with aged seedling, resulting in reduction in yield. The direct paddy seeder is useful pre-germinated paddy seeds directly in wetland without transplanting.

Advantages of Wet Seeding

a) Most of the field experiments and on-farm researches have established that wet seeded paddy, if properly managed, can yield as high as transplanted rice.

b) The input requirement and investment in direct-seeded paddy are much lower than in transplanted rice.

c) Direct seeded paddy has an edge over transplanted paddy because the direct seeded paddy matures a week or 10 days earlier than the transplanted paddy because the transplanting shock is avoided. This period looks to be very small but has greater significance in the intensive cropping system.

Importance of Organic Manuring

Due to intensive paddy cultivation, nutrients are continuously removed from paddy soils which ultimately result in poor soil health. By organic manuring, soil health can be improved and thereby paddy yields can be increased. Green manure, one of the important sources of organic manuring in paddy soils do not receive due attention because the green manure is neither food nor cash crop to attract the present generation of farmers. Further, fertilizers come is handy to replace the manures, in spite of the fact that such a practice would degrade the soil in the long run. Organic manuring in paddy has come down significantly due to the reluctance of farm labourers to trample green manure crop. Inter-cropping green manure in direct seeded paddy in wet lands will supply organic matter to paddy soils, thus avoiding separate cultivation of green manure crop.

Organic manuring is more useful but is not widely prevalent. For resource poor farmers inter-cropping daincha is more advantageous in terms of growth and higher productivity of paddy with less additional expenses (Srinivasan, 1996). Inter-

Fig 1. Paddy-cum green manure seeder.

Fig 2. Field after inter-cropping of Daincha in between standing rows of paddy.

cropping of daincha (Sesbania aculeata) in paddy was evaluated and found beneficial (CRRI, 1992; Palanisamy, 1992). Sesbania aculeata is one of the commonly grown green manure crops in India. Weed growth reduce under paddy + Sesbania aculeata over sole paddy has been reported by Mathew and Bridigit (1991). Increased plant height, dry matter weight, leaf area index in green manured plot over control have been reported by Jayachandran (1994). Green manuring is equal to or better than applying urea in increasing grain yield of rice (Singh et al., 1990).

A collaborative effort between the Disciplines of Agronomy and Agricultural Engineering in Tamil Nadu Agricultural University, Coimbatore has resulted in the development of a manually drawn paddy cum green manure seeder.

Description of the Seeder

The seeder simultaneously sows paddy seeds (pre-germinated) and green manure (daincha- *sesbania aculeata)* seeds (not pre-germinated) in alternate rows on puddle soil. The seeder has two drum hoppers made of galvanised iron sheet, two skids, a ground wheel and a handle (**Fig.1**). The seeder weighs 15 kg. The seeder sows four rice rows and four green manure rows covering one metre in a single pass. The spacing between rice rows is 250 mm *(Rajendran et al.,*1998).

Field Performance of The Seeder

Using two to three labourers 0.50 hectare can be sown in a day by the seeder The seeder is suitable for all types of soils and rice varieties and easy to operate. The hoppers are filled 50 to 75 percent and not filled fully as complete filling of hoppers may block the fall of seeds. Using the seeder, rice is sown at the rate of 80kg/ha and daincha is sown at the rate of 30 kg per hectare. The two skids are concurrently used as markers. On reaching the field ends, the seeder is lifted and without turning placed parallely such that the first skid lies over the impression of the second skid obtained in the earlier pass. The handle is unhooked, brought to the other side of the seeder, hooked again and the seeder is drawn for the next pass. In this pass the first skid moves over the impression left by the second skid in the previous pass. In this way the field is covered one pass after another.

Paddy seeds are put in gunny bags and soaked in water for 12 to 24 hours to pregerminate the seeds. The gunny bags with paddy seeds are then taken out of water and kept in dark for incubation for another 24 hours. The field needs adequate puddling and proper care should be taken for good leveling to ensure uniform germination. Sowing is done using the seeder with a thin film of water (10 mm) throughout the field. The green manure rows raised in between rice rows are trampled into the puddle soil when the green manure crop attains 400 mm height (about one month after sowing) using long handled IRRI design single row double cono-weeder. Thus, organic manuring is done at the rate of seven tones per hectare for the benefit of crop as well as soil. While trampling the green manure crop, weeding is also done by the cono weeder in between the standing rows of the paddy crop (**Fig.2**). Other than seed cost, this type of green manuring does not require any other expenses. The seeder along with three cono-weeders costs US $150.

Organic manuring in paddy by this new technique helps to reduce 25 per cent of urea applied as basal dose. Organic manuring will be beneficial to the problem soils especially saline and alkaline soils. Weeds are better controlled by this technique when compared to direct wet seeding of paddy without green manure crop. Sowing paddy at a relatively wider row spacing facilitates weeding and inter-culture operations.

The Tamil Nadu Agricultural University is the pioneer in this ingenious approach which is expected to become popular in India and other rice growing countries in the years to come.

Advantages of the technology

The field test results of the seeder are quite promising. This technology has good scope in the paddy growing countries due to the following advantages.

1. Nursery raising and transplanting of rice crop are avoided. Thus there is scope to save considerable labour as well as cost of cultivation.
2. Exclusive cultivation of green manure crop is eliminated, which further reduces the cost of cultivation.
3. Organic manuring is done at the rate of seven tonnes per hectare in about four weeks for the benefit of crop as well as soil.
4. Growth of competitive weeds is checked due to the shading effect of the green manure crop.

(Continued on page 20)

Effect of Incorporating Organic Wastes on the Moisture Retention of Three South Western Nigerian Soils

by

J. A. Osunbitan
Department of Agricultural Engineering,
Faculty of Technology
Obafemi Awolowo University, Ile-Ife
NIGERIA

K. O. Adekalu
Department of Agricultural Engineering,
Faculty of Technology
Obafemi Awolowo University, Ile-Ife
NIGERIA

O. B. Aluko
Department of Agricultural Engineering,
Faculty of Technology
Obafemi Awolowo University, Ile-Ife
NIGERIA

Abstract

This paper reports on the results of an investigation on the effects of incorporating organic wastes on moisture retention of three South Western Nigerian soils as influenced by the organic matter type, level of application and incubation period. The soil samples were air-dried and passed through 2mm sieve. The organic matter contents of the soils were then increased by adding 2,4 and 6%, respectively, of each of poultry waste, cow dung and goat dung. Following organic waste incorporation, the soils were allowed to incubate for periods of 7, 14 and 21 days before the moisture retention of the soils was determined. The moisture retention of the soils was determined using a pressure plate at a suction of 1.0 bar.

All the three factors considered significantly affected the moisture retention of the loamy sand and sandy loam soils at 0.1% probability level. Only the organic matter level affected the sandy clay loam soil at 0.1% probability level while the other two main factors affected moisture retention of this soil type at 0.5% probability level. The two-way interaction between organic waste type and incubation period for the loamy sand and sandy loam soils, was significant at the 5% probability level. For the loamy sand soil, in particular, this two - way interaction was also significant at 0.1% probability level.

Introduction

The phenomenon of moisture retention is extremely important in determining the quantum of water available in the soil for plant use. This is because the bulk of the gravitational water drains through the soil before it can be used consumptively by plants. The field capacity of a soil is the moisture content of the soil after drainage of gravitational water has become very slow and the moisture content has become relatively stable (USDA, 1960). At field capacity, the large soil pores are filled with air, the micro pores are filled with water and any further drainage is slow. The field capacity is the upper limit of available moisture range in soil moisture - plant relations (Michael, 1992).

The moisture equivalent or moisture retention of a soil is defined as the amount of water retained by a sample of initially saturated soil material after being subjected to a centrifugal force of 1000 times that of gravity for a definite period of time, usually 30 minutes (Michael 1992; Hansen et al, 1982). To determine the moisture retention, a small sample of soil is whirled in a centrifuge with a centrifugal force of 1000 times that of gravity. The moisture remaining in the sample is then determined. This moisture content when expressed as moisture percentage on oven dry basis, gives the value of the moisture equivalent. In medium textured soils, the values of field capacity and moisture retention are nearly equal. In sandy soils, the field capacity exceeds the moisture retention. In very clayey soils, the field capacity is generally lower than the moisture retention (Michael, 1992; Black, 1957). The moisture retention function typically varies across soil types (Klute, 1986). The Moisture retention characteristics of organic material were examined by Boelter (1969) who found that enhanced decomposition resulted in greater moisture retention at higher matrix suction. Variations in bulk density within a forest floor profile, which result from changes in conductivity and moisture retention of black spruce forest floor and reduction in pore size and organic material with a small fraction of large pores would retain more water at higher suction. (Sharrat, 1997).

Lawes (1965) reported the field capacity of silty soils of northern Nigeria to be at 0.3 bar suction and corresponded to moisture retention between 16 and 23 % whereas at the wilting point, the moisture content was between 5 and 13 %. Similar ranges in moisture retention have been reported for the soils of western Nigeria (Babalola, 1972 and Lal, 1979) while estimates of field capacity and wilting point of some Zambia soils indicated that 0.05 or 0.1bar suction value would give a better estimate of the field capacity (Maclean and Thomas, 1972). Kowal (1969) reported that 75% of available water in the soils of northern Nigeria is released at 1 bar suction.

In Nigeria, the readily available information on moisture retention characteristics of soils is scanty and little attention has been given to the effects of incorporating different types of organic matter on this soil physical property. The objective of this study, therefore, was to investigate the effect of incorporating different types of organic matter on the moisture retention of three South western Nigeria soils.

Materials and Methods

The three soil types used in this study were a loamy sand, a sandy clay and a sandy loam. The loamy sand (Alfisol) consisted of 80.4% sand, 4.7% silt, 14.9% clay and 1.56% organic matter. The sandy clay loam (Entisol) consisted of 73.7% sand, 4.3% silt, 22.0% clay and 1.61% organic matter. The sandy loam soil (Inception) consisted of 67.7% sand, 15.3% silt, 17.0% clay and 2.15% organic matter. The soils were obtained from the upper 120mm layer of a cultivated field at the Teaching and Research Farm of Obafemi Awolowo University, Ile-Ife, Nigeria.

The soil samples were air-dried to bring the soils to a moisture content of 6% (dry basis). The dried soils were pulverised and then passed through 2mm sieve to get rid of stones, gravels and big crumbs. The three organic waste types used were cow dung, goat dung and poultry waste. The organic wastes were also air dried to a moisture content of 8% (dry basis) and allowed to pass through 4mm sieve. The organic wastes and the soils were then thoroughly mixed to raise the organic matter content of the soils by 2%, 4% and 6%.

The experimental design was a 3×4×3 factorial design with organic matter type, level of incorporation and incubation period being the factors. The levels of incorporation are 0% (control), 2, 4, and 6% while 7, 14 and 21 days were the incubation period levels. Two replicates were performed for each experimental run.

The moisture retention of each soil was determined at a suction of 1.0bar using a pressure plate extractor. A tension table with a hanging water column was used and the water was allowed to drain for 30 minutes after applying the pressure plate. The soils were then oven dried at 110°C for 24hrs in order to determine the moisture content by the gravimetric method. The experiment was repeated for different incubation periods, organic matter types and percent incorporation into the soils. The moisture content was determined after drainage for 30 minutes that corresponds to the moisture retention or the moisture equivalent of the soils at 1.0bar.

Results and Discussion

The values of average moisture retention for loamy sand, sandy clay loam and sandy loam soils are presented in **Tables 1**, **2** and **3** while the results of the analyses of variance are given in **Tables 4**, **5** and **6**, respectively. The relationship between moisture retention and percent organic waste incorporation for loamy sand, sand clay loam and sandy loam soils is shown in Fig. 1. Each data point is a mean of the three incubation periods considered. The data were analysed using the Statistical Analysis System institute procedure (SAS, 1987).

Moisture Retention of Loamy Sand Soil

The different factors (organic matter type, percent organic matter incorporation and incubation period) as well as the two-way interaction between organic matter type and incubation period were significant at a 0.1% probability level. Furthermore, the two - way interaction between percent incorporation and the incubation period was significant at a 5 % probability level. The moisture retention on the average increased steadily from 13.32% when the percent incorporation was 0 % to 16.31 % and when the percent incorporation was 6%. On the average, the incubation period also increased the water retention from 14.18 % after 7days to 15.46 % after 21 days. Comparison of the three different organic waste types

Table 1. Moisture Retention of Loamy Sand Soil as Influenced by Organic Matter

Organic matter type	Incubation period (days)	Moisture retention (%) Percent incorporation of organic matter			
		0	2	4	6
Poultry waste	7	13.2	13.6	14.4	15.2
	14	13.2	16.0	16.8	17.6
	21	13.2	16.8	17.6	17.8
Cow dung	7	13.2	14.0	14.8	15.2
	14	13.2	14.4	15.2	16.6
	21	13.2	14.8	15.6	16.8
Goat dung	7	13.2	13.8	14.4	15.2
	14	13.2	14.2	15.2	16.0
	21	13.2	14.4	15.2	16.4

Table 2. Moisture Retention of Sandy Clay Loam as Influenced by Organic Matter

Organic matter type	Incubation period (days)	Moisture retention (%) Percent incorporation of organic matter			
		0	2	4	6
Poultry waste	7	20.7	20.8	21.2	21.6
	14	20.7	21.2	21.6	22.4
	21	20.7	21.6	22.4	22.6
Cow dung	7	20.7	21.2	22.0	22.4
	14	20.7	21.4	22.4	22.8
	21	20.7	21.6	22.4	23.2
Goat dung	7	20.7	21.1	21.4	21.6
	14	20.7	21.2	21.5	22.0
	21	20.7	21.6	22.3	22.8

Table 3. Moisture Retention of Sandy Loam Soil as Influenced by Organic Matter

Organic matter type	Incubation period (days)	Moisture retention (%) Percent incorporation of organic matter			
		0	2	4	6
Poultry waste	7	17.6	18.0	18.4	19.2
	14	17.6	19.2	19.2	19.4
	21	17.6	19.2	20.8	20.8
Cow dung	7	17.6	18.4	18.8	19.2
	14	17.6	19.6	20.0	20.8
	21	17.6	20.8	20.9	21.6
Goat dung	7	17.6	17.6	18.0	18.4
	14	17.6	18.0	18.1	18.4
	21	17.6	18.4	18.8	19.2

shows that poultry waste had the greatest effect on the moisture retention of the soil while the goat dung had the least. When poultry waste was incorporated from 0 % to 6 %, the moisture retention was observed to increase by 27.7 % while cow dung and goat dung resulted in corresponding increases of 22.7 % and 20.2 %, respectively. No significant difference is evident in the effects of cow dung and goat dung on the moisture retention of the soil. On the average, the moisture retention of this soil increased by 23.5 % when the three organic wastes were incorporated at the four levels for the three incubation periods considered.

Moisture Retention of Sandy Clay Loam Soil

For the sandy clay loam soil, only the percent incorporation of organic matter was significant at a 0.1 % probability level. The other two factors (i.e., organic matter type and the incubation period) were significant only at the 5% probability level. The effect of cow dung on the moisture retention of this soil was significantly different from those of the other two waste types. The effect of poultry waste and goat dung on the moisture retention of the sandy clay loam soil did not exhibit any significant difference. On the average, the highest water retention of 21.84 % occurred with cow dung incorporation. Poultry waste incorporation gave a water retention value of 21.48 % while goat dung incorporation gave a value of 21.47 %. The moisture retention of the sandy clay loam soil also increased steadily from 20.88 % at a percent incorporation of 0 % to 22.27 % at a percent incorporation of 6 %. The four levels of percent incorporation had significantly different effects on the moisture retention of the soil. On average, the moisture retention also increased as the incubation period increased. The 7-day incubation period showed significant difference from the 14-and 21-day periods in its effects on moisture retention of the sandy clay loam. However, the 14 day and 21 day incubation periods were not significantly different in their effects on the moisture retention of the soil. On the average, when cow dung was incorporated up to 6%, the moisture retention increased by 10.14 %. This percent increase in moisture retention falls to 7.24 % and 6.92 % when poultry waste and goat dung were incorporated, respectively. The moisture retention of the sandy clay loam soil, on the average, increased by 8.1% when the three organic waste types were considered at the different levels of incorporation for the incubation periods considered.

Moisture Retention of Sandy Loam Soil

The moisture retention of the sandy loam soil increased steadily with percent organic waste incorporation, the highest value occurring when cow dung was incorporated. Comparing the values obtained for the three different waste types, the goat dung gave the least. All three organic waste types had different effects on the moisture retention of the sandy loam soil.

Also, as the incubation period increased, the moisture retention of the sandy loam soil increased from an average value of 18.23% for an incubation period of 7 days to 19.44% for an incubation period of

21 days. All the three factors were significant at 0.1% probability level. The two-way interaction between organic waste type and incubation period was also significant, but at the 5% probability level. On the average, the moisture retention of the sandy loam soil was observed to increase by 16.7% when cow dung was added to it, 12.5% when poultry waste was added and 6.1% when goat dung was incorporated. The moisture retention, on the average, also increased from 17.78% to 19.66% as the percent organic matter incorporation increased from 0% to 6%. The moisture retention also increased, on the average, from 18.23% to 19.44% as the incubation period increased from 7 days to 21 days. The moisture retention of the sandy loam soil increased by 11.8% when the three organic waste types were considered and as influenced by the levels of incorporation for the three incubation period under consideration.

Table 4. Analysis of Variance for Moisture Retention of Loamy Sand Soil

Source	DF	Sum of Squares	Mean Square	F value
Organic matter (OMT)	2	6.88	3.44	39.69**
Percent incorporation(PI)	3	43.62	14.54	167.77**
Incubation period (IP)	2	10.88	5.44	62.77**
OMT * PI	6	0.91	0.15	1.73^{NS}
OMT * IP	4	4.44	1.11	12.8**
PI * IP	6	2.65	0.44	5.08*
Error	12	1.04	0.09	
Corrected total	35	70.42		

Table 5. Analysis of Variance for Moisture Retention of Sandy Clay Loam Soil

Source	DF	Sum of Squares	Mean Square	F value
Organic matter (OMT)	2	1.07	0.535	6.17*
Percent incorporation(PI)	3	10.57	3.523	40.65**
Incubation period (IP)	2	1.88	0.940	10.80**
OMT * PI	6	1.05	0.175	2.02^{NS}
OMT * IP	4	0.47	0.118	1.36^{NS}
PI * IP	6	1.11	0.185	2.13^{NS}
Error	12	1.04	0.087	
Corrected total	35	17.19		

Table 6. Analysis of Variance for Moisture Retention of Sandy Loam Soil

Source	DF	Sum of Squares	Mean Square	F value
Organic matter (OMT)	2	11.80	5.90	40.70*
Percent incorporation(PI)	3	17.58	5.86	40.41**
Incubation period (IP)	2	8.81	4.41	30.41^{NS}
OMT * PI	6	2.02	0.34	2.32^{NS}
OMT * IP	4	2.11	0.53	3.64^{NS}
PI * IP	6	3.73	0.62	4.29*
Error	12	1.74	0.15	
Corrected total	35	47.80		

NS:Not significant
* Significant at 5% probability level
** Significant at 0.1% probability level

Conclusion

The experiment carried out investigated the effect of incorporating three different types of organic waste on the moisture retention of three South Western Nigerian soils. Organic matter type, percent incorporation, the incubation period and the two- way interaction between organic matter type and the incubation period were significant at 0.1% probability level for the loamy sand soil while only the main factors were significant at 0.1% level for the sandy loam soil. The percent incorporation was, however, the only factor that was significant at 0.1% probability level for the sandy clay loam soil. Other main factors significantly affected the moisture retention of the sandy clay loam at 5% probability level. On the average, when the three soils were conditioned by incorporating different organic waste types for different incubation periods, the moisture retention of the sandy clay loam was the highest. This was followed by that of the sandy loam soil and lastly, by that of the loamy sand soil. This is probably because of the relative percentage clay content of the soils. A relatively high clay content enhances the retention of water in a soil and so reduces the impact of organic matter addition whereas a relatively high sand content (as in the case of the loamy sand soil) which enhances the flow of water through the pore spaces of the soil (Hansen et al., 1982) requires that soil moisture retention be enhanced by the incorporation of organic matter. The moisture retention of the sandy clay loam soil increased by 8.1% between 0% and 6% organic waste incorporation. Moisture retention of the sandy loam and loamy sand soils increased by 11.8% and 23.5% respectively between 0% and 6% organic waste incorporation.

There seems to be soil type / organic waste interaction in the behaviour of the moisture retention of the soils. Loamy sand responded more to poultry waste than to cow dung while sandy clay loam and sandy loam responded more to cow dung probably because soil clay ratio plays an important role in organic waste - soil dynamics as observed by Adekalu et al., (2000). Cow dung reduced the infiltration rate of soils more than poultry waste and the reduction is higher in sandy soils than soils with higher colloidal content (Haraldsen and Sveistrup, 1994). Thus, loamy sand

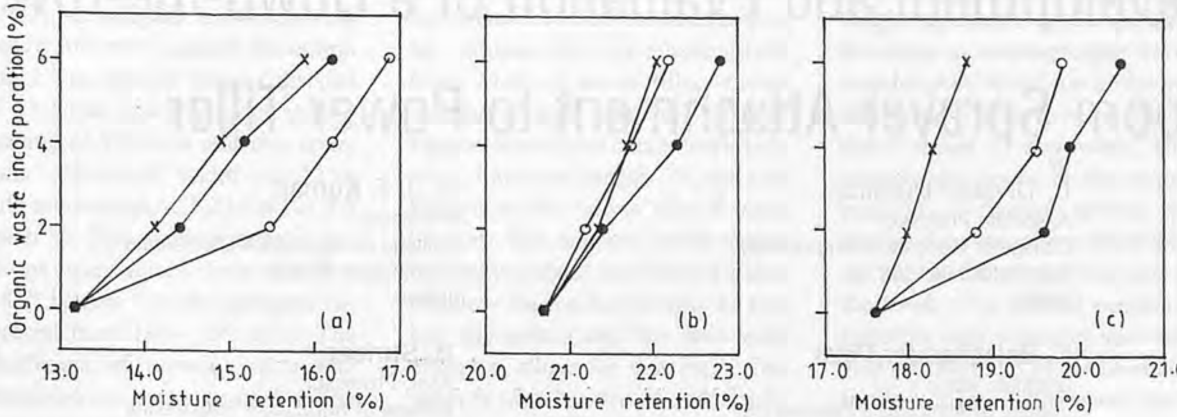


Fig. 1 Variation in moisture retention of loamy sand (a), sandy clay loam (b) and sandy loam (c) soils with organic waste incorporation. (○ : poultry waste; ● : cow dung; × : goat dung)

was able to absorb more water when mixed with poultry waste than when mixed with cow dung and the relative loss of water under a given tension will be less under poultry waste - soil mixture. However, for the other soils, the differences in reduction in infiltration due to the wastes are little and only the clay ratio will influence the retention of water under a given tension

Generally, the moisture retention of the soils increased with increasing level of incorporation and incubation periods. Thus better moisture retention is obtained when the wastes are incorporated early enough before the on set of rain / irrigation. However, the level of incorporation will depend on the response of the crop to be grown. The texture of the soils seems to play a dominant role over the initial organic matter.

REFERENCES

Adekalu, K.O; Aluko, O.B and Osunbitan, J.A. (2000). Hydrological and erosion indices of some Nigerian soils as affected by animal wastes incorporation. Soil Use and Management (in press).

Babalola, O. (1972). Particle size analysis by hydrometer method and its use in estimating the lower limit of available water. Niger. Agric. J. 9: 19-55.

Black, C.A. (1957). Soil-Plant- relationship. John Wiley and Sons, New York 332p.

Boelter, D.H. (1969). Physical properties of peats as related to degree of decomposition. Soil sci. Soc. Am. Proc. 33. 606 - 609.

Hansen, Y.E., Israelson, D.W. and Stringham, G.E. (1982). Irrigation principles and practices. Fourth Ed., John Wiley & Sons. New York.

Haraldsen, T.K and Sveistrup, T.E. (1994). Effect of cattle slurry and cultivation on infiltration in sandy and silty soils from northern Norway. Soil and Tillage Research. 29, 307 - 321.

Klute, A. (1986). water retention: Laboratory methods. In - Methods of soil analysis, Part 1. Physical and Mineralogical methods, 2nd Ed. A. Khite (ed). ASA Madison, WI, pp. 635-662.

Kowal, J. (1969). Some physical properties of soils of Sumaru Nigeria. Storage of Water and its use by crops. Niger. Agric. J. 6: 18-29.

Lal, R. (1979). Physical properties and institute retention characteristics of some Nigerian Soils. Geoderma 21: 209-223

Lawes, D.A. (1965). A note on the soil moisture storage capacity of the Sumaru soils. Northern Nigeria. Sumaru Mise: Rep; 5: 55-58

Maclean, A.H. and Thomas, U.V., (1972). Available water capacities of Zambian soils in relation to pressure plate measurements and particle size analysis. Soil Sci., 113: 23-29.

Michael, A.M. (1992). Irrigation theory and practice. Vikas publishing house, PVI Ltd, New Delhi, pp. 448 - 581.

SAS Institute Inc. (1987). SAS/STAT Guide for personal computers. Version 6 edition. NC: SAS Institute Inc: 1087

Sharratt, B.S. (1997) Thermal Conductivity and Water retention of a black spruce Forest floor. J. of Soil Sc: Vol 162 (8). pp 576 - 582.

United States Department of Agriculture (1960). National Engineering Handbook, Section 15. Oh. 1, Soil-plant-water relationships USDA, SCS, Washington, D.C. 72p. ■■

Development and Evaluation of a Down-the-row Boom Sprayer Attachment to Power Tiller

by
C. Divaker Durairaj
Associate Professor
College of Agriculture Engineering
Coimbatore 641003
INDIA

V. J. F. Kumar
Professor
College of Agriculture Engineering
Coimbatore 641003
INDIA

K. Balachander Pillai
Graduate student
College of Agriculture Engineering
Coimbatore 641003
INDIA

B. Shridar
Asst. Professor
College of Agriculture Engineering
Coimbatore 641003
INDIA

Abstract

The concept of plant protection using power tillers has not yet been fully realized in developing countries, due to the lack of proper matching equipment. A power tiller-operated down-the-row boom sprayer suitable for row crop was developed and its performance tested in the laboratory and field. The length of the trussed boom was 6 m with 3 m on either side of the tiller. The tread width of the system could be adjusted from 55 to 85 cm and could accommodate spraying of various crops ranging from groundnut to cotton. It allowed the operator to take the sprayer into the cropped field by adjusting the tread width of power tiller wheels and the support wheels. It had a compact spray tank, pump and boom, that could be fitted with the required number of nozzles to suit the crop being sprayed. The spray distribution pattern of the boom sprayer was measured using a patternator. The spray distribution pattern at 350 mm and 400 mm nozzle spacings showed that a minimum spray deposition of 20 cm^3 and 11 cm^3 were obtained, respectively, at the centre of the patternator at 196 kPa nozzle pressure.

In separate field trials on spraying row cropped cotton and spraying herbicide, a coverage of 0.8 to 1.0 ha was observed. A relatively higher field efficiency of 60 percent was possible because the maneuverability of the system was commendable and all the controls were within the operator's reach. The cost of sprayer attachment is US$ 335 and its operating cost was US$ 2.0 per hectare. The savings in cost compared to conventional spraying using mist blower, was 40 percent and the relative saving in time was 300 percent.

Introduction

Agricultural productivity is linked with the availability of farm power in a timely manner. So far in developing countries, the power requirement of small farms was met by bullocks and other draught animals. Now that this source of power is dwindling, power tillers are visualized as appropriate source of power for medium farms. Though there are indigenous manufacturers of power tillers in these countries, their production and sales have remained substantially low. The reasons are many, of which the most important, one is the non-availability of matching attachments towards making it versatile for all agricultural operations of different crops. Particularly, the power tiller will be well utilized in crops such as cotton, if this requirement is met. This is because such crops demand intensive field operations at all phases of crop growth. All the more, the use of pesticides has become essential in modern agriculture that too for commercial crops such as cotton. For instance, India has 160 million ha of cultivable area of which 80 million ha of crops are forced to use chemical pesticides against pests. So far, in developing countries, the concept of plant protection using power tillers has not been fully realized, due to the lack of proper equipment and the will for laying out the crop suiting down-the-row operation of the power tiller in the cropped field.

The objectives of the study were to develop a power tiller operated down-the-row boom sprayer suitable for row crops, to test the performance of the developed boom sprayer in the laboratory and field and to the economics of the developed unit.

Review of Literature

Cannon (1979) developed a tractor-mounted wide boom ground sprayer with an actual field capacity of 23.8 ha h^{-1}. The swath width of the sprayer was 24.4 m to cover 24 rows spaced 1.016 m apart. It was observed that the spray application efficiency was high. Sukla *et al.*, (1987) developed a wide-swath tractor mounted sprayer for cotton crop. The sprayer boom consisted of 13 triple action nozzles with a spacing of 750 mm and two spray guns. The swath width was 12 m with a coverage of 1.2 ha h^{-1} at 3.5 km h^{-1}. The average nozzle discharge was varied from 0.458 - 0.820 lit min^{-1} as the pressure increased from 196 - 392 kPa. The coefficient of variation of nozzle discharge at a pressure of 294 kPa was observed at 6.76 percent. Mathew *et al.*, (1992) developed a power tiller-operated boom sprayer for groundnut and other row crops. It was observed that the coefficient of variation of discharge among nozzles was within 2 percent for pressure range of 294 - 392 kPa. It saved the cost of operation by 29 percent per hectare compared to knapsack hand compression sprayer

Methods and Materials

Description of the Unit

A spraying system was developed to suit the power tiller which can be used as a row crop machine (Fig. 1). The tread width of the system can be adjusted from 55 to 85 cm and can accommodate spraying of various crops ranging from groundnut to sugarcane. It allows the operator to take the sprayer into the cropped field by adjusting the tread width of power tiller wheels and the support wheels. The dual support wheels are carried on a separate frame of length 75 cm and hitched to the power tiller's hitch bracket. The support wheel frame can swivel about the vertical plane to allow the trailed wheels to follow the terrain and the horizontal plane to allow for turning. The support wheels were provided with a caster each, so that they can self-align themselves to the drive wheels. This type of hitching allowed for a shorter articulated turning with a minimum turning radius of 1.1 m. The system was also made rugged to carry the chemical tank and the operator.

The length of boom was 6 m with 3 m on either side of the power tiller. It was chosen so for better maneuverability, adjustability and avoidance of excessive sag. The boom sections on either side of the power tiller were made into truss structures, having more width at the point of hinging, converging down to the outer end. The truss sections were 2.5 m in length and a foldable extension boom of 0.5 m was provided at the extreme end of the boom on either side of the power tiller. The boom was mounted on the front of the power tiller, on a separate mast and carried by a height adjustable apron sliding on the mast to accommodate various crop heights. At the top of the mast, two guide rollers were provided to direct a pair of stay wires, which support the boom in the required position. A manual reeling spool provided on the power tiller's handle winds the stay wires and lifts the boom to a vertical position facilitating easy transport and also to fold the boom up in the head lands. Each section of the boom can be fitted with the required number of nozzles to suit the crop. Hydraulic energy nozzles of the required type can be fitted on the boom and slid into position at the desired crop spacing. Hence the nozzle spacing is continuously adjustable.

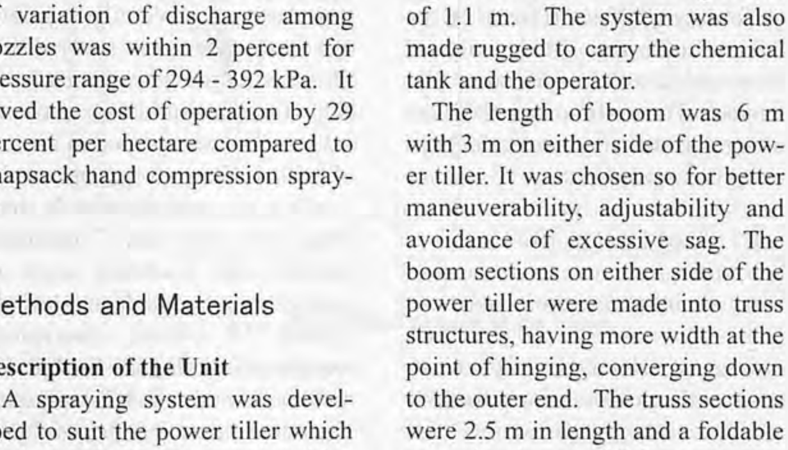


Fig.1 Sketch of the down-the-row boom sprayer.

The chemical tank is an integral reinforced fibre glass tank of 100 litre capacity, whose dimensions suit the available space between the tiller's handle and the trailed hitch frame. The necessary spray input (bypass) and output (suction) openings were moulded-in. A properly capped opening on the top was provided for filling up of the tank. A suction trough in the bottom of the tank for positive emptying of the tank and a strainer, which can be screwed-on to the suction inlet were also provided. For design purpose, the maximum application rate was assumed at 600 lit ha^{-1} with the discharge rate of hollow cone nozzles fitted on the boom as 0.73 lit min^{-1} per nozzle at an operating pressure of 392 kPa. The boom had 10 nozzles with a total discharge rate of 7.3 lit min^{-1} at the said pressure. A single stage reciprocating pump fitted with valve type regulator (ASPEE Make, Bombay, India) was selected. It pumps the spray fluid to the boom and has the following specifications:

suction capacity , 14 lit min-1; operating pressure, 1500 kPa; pump speed, 950 rpm; and power input, 1 HP

The spray pressure could be

controlled using the bypass valve and the pump gauge. A two-way shut-off valve was provided to avoid the spray drip from the nozzles while spraying is stopped which was installed on the power tiller handle at the operator's position. The valve either discharged the pump output to the boom or totally cut it off by diverting it to the tank again.

Two foliage deflectors made of 3 mm sheet bent to blunt 'V' shaped shields, were provided on both the front of the power tiller drive wheels and the tail wheels. These help to deflect the crop canopy spread in the rows, thus avoiding damage by treading of wheels while in operation. The deflectors were hinged to the central axis of the wheels themselves so that they can swing up when obstructed by bunds while traveling.

Laboratory Testing of the Sprayer

In the laboratory, the spray booms were mounted on the power tiller and the discharge rate of each nozzle using plain water as spray fluid was measured at various pressure settings. The system pressure was varied at levels of 196, 294 and 392 kPa by adjusting the regulation valve provided on the by-pass line. The liquid from each nozzle was collected in a measuring jar for a period of one minute. The coefficient of variation (c.v.) of discharge among the nozzles on the boom was also determined. The trial at each pressure setting was repeated thrice.

The spray distribution pattern of the boom sprayer was measured using a patternator, consisting of 55 triangular-shaped channels. Each channel was of the size 1250 x 30 x 100 mm made of 1 mm thick galvanized iron sheet. The depth of the channels were 100 mm and the liquid collected ran directly into the measuring jars of 200 cm^3 capacity. The spray boom was fitted on a stand over the patternator, so that the axis of the nozzle was 90 degrees with respect to the patternator surface and 400 mm above it. Since of the limitation in length of the patternator, the spray distribution was determined only for two adjacent nozzles at the extreme end of the boom. The patternator centre was aligned with the centre of the two extreme nozzles The volume of liquid collected from each channel of the patternator was measured to acquire the distribution. The spray distribution was acquired at nozzle spacing of 350, 400, 450, 500 mm and at each operating pressure of 196, 294 and 392 kPa. Each treatment was replicated thrice.

The spray distribution was further analyzed by calculating the uniformity coefficient, based on the volume of spray fluid collected from each channel of the spray patternator. The uniformity coefficient of spray distribution was calculated using the expression:

$$(1 - \sigma_n / \bar{x}) \times 100$$

where,

σ_n -standard deviation; and

$\bar{x}$- mean volume of spray collected from the different channels.

Field Trials on Pesticide Spraying

The conventional practice of planting cotton in ridges and furrows at 60 X 30 cm spacing did not allow for taking the power tiller into the field, due to limitations in ground clearance. Hence, the field to be sown was laid out appropriately for spraying with the power tiller down-the-row boom sprayer. In consultation with cotton scientists and agronomists, the field was laid out as to have 120 cm lanes for every 6 m width of the cropped ridges. This was achieved by skipping one row for every 6 m and board leveling the ridge at that row. Headlands of 1.2 m were provided on the ends of the field plot for turning the sprayer at the plot ends. This provided for operating the sprayer down-the-row on the crop.

A field of 0.41 ha, was exclusively laid out as explained for down-the-row operation of the unit. It was sown with "MCU 10" cotton at a spacing of 60 x 30 cm. Spraying of "Metasystox" was taken up on the 15^{th} and 31^{st} days of crop duration. The nozzle spacing was set at 60 cm to suit the spacing of the sown crop. In all the spraying runs, the area covered, the time for turning, that for filling pesticide and the total time were observed and recorded towards computing the field performance of the unit.

Field Trials on Herbicide Spraying

A field of 0.50 ha sown with maize using a power tiller operated cup feed planter was sprayed with "Atrazin", a pre-germination herbicide. Two hundred litres of chemical solution was sprayed in the area of 0.50 ha. The unit was operated at 1.45 km h^{-1}; with the wheels straddling the sown rows, previously marked. The headlands were not sprayed with herbicide and left as a control. All relevant observations towards calculating the field performance were recorded. Weed counts were made at an interval of 7 days for a total duration of 1 month.

Results and Discussion

Discharge Rate of the Spray Boom

The average discharge rate of 0.732 lit min^{-1} was recorded for 392 kPa followed by 0.616 and 0.481 lit min^{-1}, respectively, for 294 and 196 kPa operating pressures. The nozzle discharge increased by 34.3 percent as the operating pressure increased from 196 to 392 kPa. The total discharge rate of the boom was observed at 4.81, 6.16 and 7.32 lit min^{-1} for operating pressures of 196, 294 and 392 kPa, respectively. The coefficient of variation among the discharges of nozzles on the boom for 294 kPa operating pressure was 1.73 percent. The same

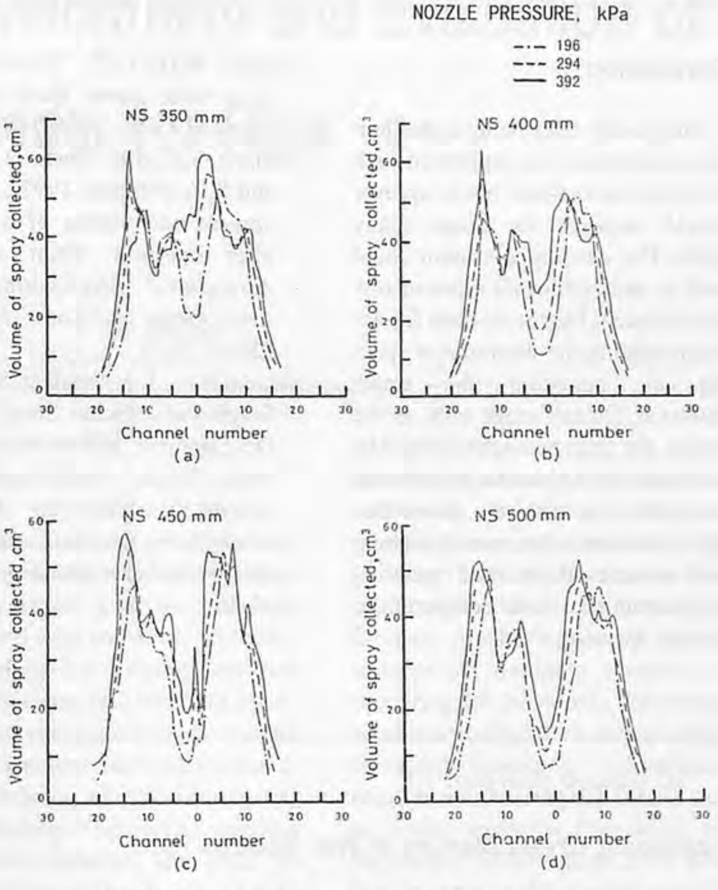


Fig.2 Spray distribution pattern of the boom.

for 196 and 392 kPa operating pressures was 4.30 and 2.14 percent respectively, which were statistically insignificant.

Spray Distribution Pattern and Uniformity of Distribution

The spray distribution pattern at 350 mm nozzle spacing (Fig. 2a)

Table 1. Uniformity of Spray Distribution

Nozzle pressure	Nozzle spacing mm	Uniformity coefficient percent
196 kPa	350	61.24
	400	52.29
	450	59.75
	500	51.60
294 kPa	350	67.19
	400	59.78
	450	61.75
	500	58.36
392 kPa	350	67.34
	400	68.67
	450	64.61

showed that a minimum spray deposition of 20 cm^3 was obtained at the centre of the patternator at 196 kPa nozzle pressure. The spray distribution pattern at 400 mm nozzle spacing (Fig2b) showed a minimum spray deposition of 11 cm^3 at the centre of the patternator for 196 kPa pressure. Compared to 350 mm nozzle spacing, there was a reduction in spray deposition of 45, 47 and 40 percent at the centre of the patternator for nozzle pressures of 196, 294 and 392 kPa, respectively. The reduction in deposition must have been due to the lesser overlap of the spray cone. At 450 mm nozzle spacing (Fig. 2c), the spray distribution pattern indicated that the minimum spray deposition at the centre was 9 cm^3 at 196 kPa. There was a reduction in spray deposition of 55, 61.8 and 57.8 percent at the centre of the patternator compared to 350 mm nozzle spacing for nozzle pressures of 196, 294 and 392 kPa respectively. The spray distribution pattern at 500 mm nozzle spacing (Fig. 2d) indicated a minimum spray deposition of 7 cm^3 at the centre of the patternator for 196 kPa nozzle pressure. There was a reduction in spray deposition of 65, 67.6 and 66.7 percent compared to 350 mm nozzle spacing for 196, 294 and 392 kPa nozzle pressures, respectively.

The spray distribution was further analyzed in terms of the uniformity coefficient. The uniformity coefficient of the spray distribution for different treatments at 196, 294 and 392 kPa nozzle pressures and nozzle spacings are summarized in **Table.1**. The uniformity of spray deposition at 400 mm boom height for various nozzle spacings, was generally between 51 to 69 percent. Maximum uniformity coefficient of 68.67 percent was obtained at 400 mm nozzle spacing for 392 kPa nozzle pressure.

Results of Field Trials

Results on pesticide spraying - In the trials on spraying of cotton, an area of 0.4 ha was covered within 30 minutes, inclusive of the time for filling and turning in the headlands. Since all the controls were brought within the reach of the operator riding on a seat at the back, the time required for control and operation was very minimal. Similarly, observations made in the herbicidal spraying trials indicated an appreciable performance. Since the field was conveniently of 25 x 200 m size, the spraying job was completed in four adjacent passes. The whole operation took a time of just 30 minutes of which only 3 minutes was spent in the headlands.

In both cases, a relatively high field efficiency of 60 percent was possible because the maneuverability of the system was commendable during the operation and all the controls are within operator's reach.

Results on herbicidal spraying - For about 21 days, there were virtually no weeds in the treated field, whereas the weed count was at an average of 180 m^{-2} in the untreated headland. After this period, the weeds started emerging very slowly in the treated field and 28th day observation indicated a meager count of 32 m^{-2}, whereas the control was completely weed-infested.

Cost economics of the boom sprayer - Based on the field observations, the field capacity of the unit was 0.8 to 1.00 ha h^{-1}. The operating cost of the boom sprayer was US$ 2.0 per hactare. The cost of sprayer attachment is US$ 335. The savings in cost compared to conventional spraying using mist blower was 40 percent and the relative saving in time was 300 percent.

Conclusion

The power tiller being a medium source of power, an implement such as the down-the-row boom sprayer would improve its usage many folds. The developed system could well be utilized for all types of row crops since it has provisions for accommodating the desired row spacing by adjusting the tread. However, for tall crops such as the cotton, the crop geometry should be conveniently altered to provide for lanes for the system's down-the-row operation. Because of its high field capacity, the cost of operation is substantially less compared to manual spraying.

REFERENCES

Cannon, M.D., 1979. Development of a wide boom field sprayer. *Trans of ASAE*, **22**(5) : 997-999.

Mathew, V.J., S.K. Dash, D.K. Das and S.C. Pradhan, 1992. Development and testing of a power tiller operated boom sprayer. *Agricultural Mechanisation in Asia, Africa and Latin America*, **23**(4) : 25-27.

Shukla, L.N., N.S. Sandhar, Surenda Singh and Joginder Singh, 1987. Development and evaluation of wide swath tractor mounted sprayer for cotton crop. *Agricultural Mechanization in Asia, Africa and Latin America*, **18**(2) : 33-36. ■■

(Continued from page 10)

Devices for Inter-cropping Green Manure in Wet Seeded Rice

5. As the paddy crop is sown in rows, subsequent weeding and inter culture operations are made easy using long handled tools.
6. Transplanted paddy normally experiences establishment shock. In direct sown crop this shock is avoided. As a result, the maturity of the paddy crop is reduced by 7 to 10 days.

REFERENCES

Annual Report.1991-1992. Central Rice Research Institute, Cuttack:28

Jayachandran, M. 1994. Green manure inter cropping and nitrogen economy in semi dry rice. M.Sc.(Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Mathew, G.D.A. and Bridigit, T.K.1991. Intercropping cow pea as an ideal green manure for semi dry rice. Indian Farming, 41(2): 21-22.

Palaniswamy, M. 1992. Inter cropping in semi dry rice. M.Sc.(Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Rajendran, P., Tajuddin, A. and Ramaswami,C. 1998. Rice -cum-green manure culture with modified drum seeder under low land condition. International Rice Research Notes, 23(3): 31 - 32.

Singh,V., Singh,B., Meelu, O.P. and Maskina, M.S.1990. Nitrogen equivalence of green manure for wet land rice on course textured soils. International Rice Research Newsletter, 15(1):23

Srinivasan, J.1996. Investigation on the effect of varieties, inter cropping daincha (*Sesbania aculaeta)* and herbicide use on semi dry rice. M.Sc.(Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore. ■■

Development and Evaluation of a Star-cum-cono Weeder for Rice

by
B. C. Parida
Sr.Scientist
Central Rice Research Institute
Cuttack-753006, Orissa
INDIA

Abstract

An improved and modified IRRI cono-weeder for wet field condition was developed. Its performance was compared with conventional manual weeding and existing low-cost weeders. Using it in wet field condition the field capacity of the weeder was.02 Ha/hour and it gave a weeding efficiency of 80% during the first weeding. The cost of weeding with this weeder amounted to Rs480.00 per hectare while manual weeding costs Rs1200.00 per hectare and use of finger type weeder costs Rs 600/Ha. With the use of this weeder 60% of time could be saved in comparison to manual weeding. Saving in cost of weeding was 60%.

Introduction

Weed control is one of the most expensive agricultural operations in rice cultivation. Land preparation before planting though destroys the weeds but they are not completely eliminated. The weeds in upland rice comes up more easily and vigorously than in low-land rice. Weeds hamper the growth of crops by competing with them for air, water, sunlight and nutrients. The cost of production in rice increases due to high infestation of weeds and their removal. In the Eastern states of India, Orissa in particular, manual uprooting of the weeds is the common practice in wet land rice cultivation. With the advent of mechanization and adoption of high yielding varieties interest in mechanical weeders is seen among the farmers. Mechanical weed control reduces the drudgery involved in uprooting of the weeds. Moreover mechanical weeders besides killing the weeds loosen the soil between rows thus increasing the air and water intake capacity. Depending on the density of the weeds 20 to 30% loss in grain yield is quite usual if the plot is left unweeded.

Review of literature

DeDatta (1981) reported that the yield loss due to weeds was 11.8% in Asia. At the International Rice Research Institute, Philippines, losses were estimated to be 34% in unweeded plots. Haq and Islam (1985) have reported that in lowland rice the cost of manual weeding was 21.6% of the total production cost. They reported that the Khurpi (traditional weeding tool in Bangladesh) had a very low field capacity of0.003 hectare per hour. In India it is estimated that about 4.2 billion rupees are lost due to weed infestation in the production of major crops. Syedul Islam et al (1991) of the Bangladesh Rice Research Institute, Bangladesh designed a mechanical weeder for rice which is reported to work better than the Japanese weeder in Bangladesh soil. It is reported to work well in sandy as well as clay loam soil. The BRRI weeder has a single set of spikes and require less power to operate than the Japanese weeder. It worked very well on wet soil and gave a field capacity of.035 hectare per hour. Igbeka (1984) indicated that timing rather than frequency of weeding is a major determining factor in effective weed control for rice. Gill et al; (1981) studied that depending on weed density, 20-30% loss in grain yield is quite usual which may increase to 50% when the crop management practices are not properly followed.

Materials and Methods

Construction Features

The width of the weeder is dependent on the space between the two consecutive rows. As the row spacing commonly followed in this part of India is 20 cm, the width of the weeder is kept at 13.5 cm for easy workability. The weeder consists of a frame, a handle, a float, star wheels and a serrated cone. The frame consists of tubular mild steel pipe of 25 mm diameter. The handle is welded at a distance of 165 cm. from the ground contact and the height of the handle can be adjusted to suit the operator of any height. The float gives floating action to the weeder thus reducing the draft of the weeder and is 12 cm by 31 cm in

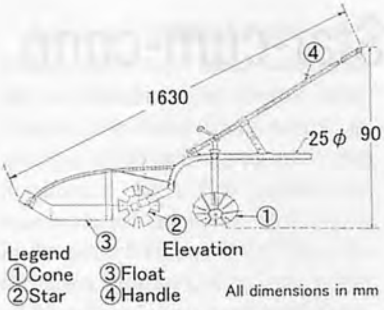


Fig. 1 Sketch of the star-cum-cono weeder.

size. The star wheels which are fixed in front of the serrated cone are meant to cut into the soil and cut the succulent weeds. They are essentially circular blades of diameter 14 cm. which are punched to give 6 serrations at the periphery. They rotate on the frame through a shaft and a bush. The cono weeder is a hollow cylinder which has serrated and plane blades fixed on it in alternate arrangement. The diameter of the cone at the two ends are 14 cm. and 6 cm. The length of the cone is 14 cm. The height of the plane blades are 4 cm. and serrated blades are 3 cm (**Fig.1**)

Results and Discussion

The average field capacity of the weeder was 0.02 hectare per hour. The field capacity varied between 0.018-0.022 hectare per hour depending upon the capability of the operator, weed density, type and condition of the soil at the time of weeding.

Weeding efficiency:

Number of weeds before weeding, W1= 380

Number of weeds after weeding, W2= 76

Weeding Efficiency = 80%

Field capacity:

Average area covered =1440 sq. metre

Average time taken =7 hours 12 minutes

Capacity = 0.02 ha /hr

Comparison with Finger Weeders

As the finger weeder is the only equipment used in research farm for weeding, the performance of the star-cum-cono weeder was compared with that of the finger weeder. Results are as shown (**Table 1, Fig 2 and Fig2a**).

Conclusion

1. The field capacity of star-cum-cono weeder was 0.02 ha/hr.
2. The weeding efficiency obtained was 80%.
3. The cost of the unit was Rs 600.00
4. The operating cost of the star-cono weeder was Rs480.00 per hectare compared to Rs600/- for finger weeder and Rs 1200.00 per hectare for manual weeding.
5. The savings in cost of weeding was 60%, and saving in time was 60% compared to manual weeding.

REFERENCES

De Datta,S.K; Ross, V.E.1975. Cultural Practice in Upland Rice in Major Research in Upland Rice. IRRI, Philippines, pp160-283.

Islam, M. S; Haq, K. A. 1985. Performance of indigenous hand weeders in Bangladesh. Vol xvi, No.4, AMA. Pp47-50.

Islam, M. S; Haq, K. A. 1991. Development of a low cost weeder for low land paddy. Vol.22, No.1, AMA pp 42-44.

Igbeka, J. C. 1984. Development in rice production mechanization. AMA 10(1):27-32.

Gill, H S; Kollar, J. S. 1981. Weed Control in Rice. Progressive Farming. Vol.xii, No.10. Punjab Agricultural University, India, pp6. ■■

Table 1. Comparative of Features and Performance of Two Types of Weeders

Item	Finger Weeder	Star-cono weeder
Over all length, mm	1650	1700
Over all width, mm	75	200
Over all height, mm	900	890
Width of cut, mm	75	120
Over all weight, kg	1.2	5.0
Actual field capacity, ha/hr.	0.017	0.02
Cost of weeder, Rs	100	600
Operating cost, Rs/ha	600	480

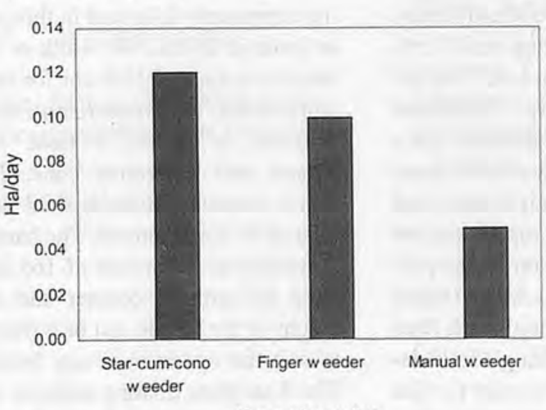


Fig. 2 Field capacity for different weeders.

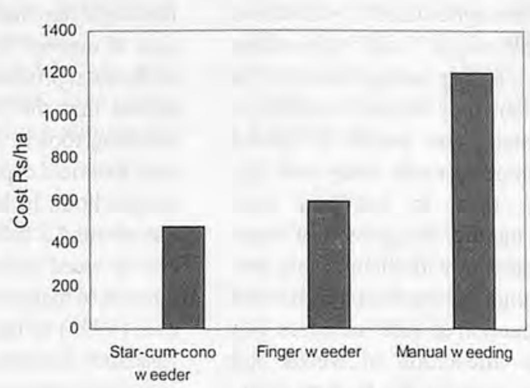


Fig. 2a Cost of weeding for different weeders.

Development and Evaluation of Tractor Operated Coconut Tree Sprayer

by

Dr. R. Manian
Professor
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore-641 003.
INDIA


Dr. K. Kathirvel
Associate Professor
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore-641 003.
INDIA

Er. T. Senthilkumar
Research Professor
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore-641 003.
INDIA

Abstract

A tractor-operated tall tree sprayer for coconut was developed. The unit consists of telescopic (60 mm and 37 mm) G.I. pipes which can extend from 8 m to 14 m high by winding a cable. The spray fluid from the chemical tank is sucked by the tractor PTO-driven high pressure pump and delivered to the spray guns through pressure relief and by pass valves. At the top of the 37 mm G.I. pipe, two spray guns are hinged so that they can be moved up and down by a rope operated from the ground level. Rotary and oscillatory movements of the spray guns, and up and down movement of the telescopic pipe enable one to reach the desired target in the canopy. The spray pattern could be adjusted to either jet or mist cone to suit the requirement. The best angle of inclination for maximum height of reach was optimized as 75° to horizontal when the height of reach was 6.92 meter from the tip of the nozzle. It was reduced to 5.10 m when two spray guns were used simultaneously. In one hour 35 coconut trees could be easily sprayed depending on the height of the tree and area of spread of the canopy. For easy transport, the unit is kept in a horizontal position. The same can be erected vertically by winding a cable. The sprayer can also be used for spraying tall orchard trees and field crops.

Introduction

Coconut production in India has been increasing over the years. From the third place on the world coconut map, India has emerged first relegating Indonesia and Philippines to the second and third position, respectively. In 1995, its share in global production was 24.65 percent and in area 15.16 percent (Thampan, 1997), Sri Lanka occupies the fourth position both in area (4.19 lakh ha – 3.71%) and production (2,755 million nuts – 5.10%) in coconut cultivation. The Ninth Plan proposals of the Coconut Development Board, India envisage higher levels of production through area expansion and productivity improvement. The objective is to achieve a production target of 24,000) million nuts from an expanded area of 2.67 million hectares by 2002 A.D. To achieve this target importance is to be given for plant protection in addition to crop management aspects.

Existing Practice of Spraying in Coconut Trees

Tall-tree sprayers suitable to spray chemicals on coconut trees are not available at present. Recently slug caterpillar and lead blights attacked coconut trees in large scale. Farmers were not in a position to apply the required plant protection chemicals in the coconut trees grown more than 8 m tall. To overcome these problem farmers used the high-pressure triplex pump developed by ASPEE and a sprayer developed for this purpose by TAFE (attached with MF tractor). These sprayers carry the chemicals in the form of jet. The reach of the spray is limited to 7 to 9 m only, hence most of chemicals dripped down on the ground. Moreover, a large volume of spray chemical is required. Farmers, therefore, are not in a position to save the crops which cannot be replanted and grown in a short period. Hence the necessity to develop a tall-tree sprayer suitable for spraying in coconut trees was keenly felt.

Review of Literature

Bindra and Singh (1977) reported that in the case of hydraulic sprayers, increase in liquid pressure resulted in increased carry of spray droplets, spray angle, liquid flow rate and smaller sprays droplets. Smith and Wilkes (1977) found that increasing pressure in hydraulic sprayer reduced the spray droplet size. The classified gear pump is positive displacement and self-priming pump. This pump available in size up to 75 lit/min has been used for developing pressure in agricultural sprayers. Tajuddin et al. (1978) found that as the speed of plunger pump fitted in a tractor-mounted hydraulic sprayer increased the uniformity of spray distribution increased.

Mathews (1979) reported that piston pumps (stretcher sprayer) are most useful for spraying large or tall trees or widely spaced bush crops. He found added that piston pumps are particularly useful for high-pressure up to 40 bar. Reichard (1982) developed an experimental orchard sprayer that can surround a tree with spray using a self propelled base unit which could straddle trees that were about 2.6 m wide and 3.7 m high. The air delivery rate was $7.8 m^3/s$ at an average velocity of 14 m/s. Manian et al., (1984) conducted experiments with ASPEE triplex pump and optimized orifice diameter as 3.18 mm to reach a spray height of 9.5m at 75 degree angle for spraying tall trees. Kathirvel et al., (1989) developed a suitable tall-tree spraying attachment to power tillers. The unit was equipped with a positive displacement pump which provides spraying up to a height of 7.5m. The total discharge rate was 7.75 lit/min.

ASPEE, Bombay developed Horizontal Triplex Pump power sprayers for orchard spraying. It developed pressure in the range of 17 to 25 kg/cm^2 powered by 3 hp engine. The spray gun was 56 cm long provided with a swirl chamber in which the swirl plunger was moving to and fro. Two types of spray, viz. Jet spray and cone spray, could be obtained with varying discharge rates. The reach of the spray material was up to 8 m. Manohar Jesudas et al., (1992) developed an orchard sprayer attachment to knapsack mist blower with a peristaltic pump and a spray lance of 6 m long. The unit discharged 60 ml of spray fluid per minute to a height of about 7 m. Gupta et al., (1994) reported that air carrier sprayers are commonly used for spray applications in orchards. The air serves as transport of the liquid droplets from the sprayer to the target foliage, penetration of the foliar canopy and deposition of droplets.

Materials and Methods

The tractor-operated coconut sprayer consists of the following components: frame structure, telescopic pipe arrangement, spray tank and pump, mechanism to provide oscillatory movement to the spray guns, mechanism to raise the telescopic pipes and rotary movement, and mechanism to fold the frame work in horizontal position for easy transport and to erect in vertical position for spraying.

Frame Structure

The frame structure was constructed in two parts: bottom frame structure and folding frame structure.

Bottom frame structure-The bottom frame structure has a box section at the bottom to hold the chemical tank and as support section at the top for holding the folding frame structure. The inner section of the box could easily accommodate a 200-litre capacity chemical tank. In the front portion of the same box section, two hitch pins are provided to attach the frame to the tractor lower links. At the top of the front portion of the box section a rectangular frame is welded rigidly to serve as resting section for the folding frame structure. This frame derives support from the top of the rear side of the box section by two support arms. To hold and guide the delivery line spray hoses, side hooks are provided to the frame at the top of the frame structure. Holes are provided on both sides at the top of the box section in front to fix the folding frame structure with hinge arrangement. A side platform is provided at the bottom of the box section for the operator to stand on it during the operation for controlling and guiding the unit.

Folding frame structure-The folding frame is hinged to the bottom frame structure with folding and erecting provisions. A conical section is provided at the top to hold and extend additional stability to the telescopic pipes. Atop the conical section, a pipe is provided to hold and guide the telescopic pipes. Holes are provided atop the conical section to hold and lock the telescopic pipe in position during transport. The folding frame can be folded and erected by means of a rope and pulley arrangement. The rope winding lever arm is fixed at a convenient height from ground level so that it can be easily rotated by the operator. For additional stability in erect position, the folding structure derives support from the chassis of the tractor by a suitable support frame.

Telescopic pipe arrangement-The main purpose of the telescopic pipes is to reach the canopy of the coconut trees at a desired height and selected according to the average height of the coconut trees. Two GI pipes of 65 mm and 42 mm were fixed one unto the other. The height of the inner pipe can be extended from 9 m to 14 m by lifting the inner telescopic from the outer telescopic pipe. A rope and pulley with ratchet arrangement was provided for lifting or lowering of the telescopic inner pipe. The ratchet was provided to hold the telescopic pipes at any required height

Spray tank and pump-A 200 litre capacity spray tank is mounted inside the bottom frame structure. A triplex ASPEE make plunger pump is mounted above the PTO of the tractor with a suitable frame. The pump mounting frame is rigidly fixed to the tractor body.

The power to drive the pump is taken from the PTO of the tractor. The pump is connected to the chemical tank by means of flexible hoses. The delivery from the pump is provided with a three-way cock, pressure relief bypass valve and a pressure gauge. The excess chemical fluid pumped is returned to the tank through the bypass valve. Through the two-way cock, the chemical fluid is supplied through high pressure hoses to the two spray guns mounted on the telescopic pipes with balancing assembly.

Mechanism to provide oscillatory movement to the spray guns-wo spray guns are fixed to the aluminium rods so that the nozzle in the spray gun is 1.25 m away from the telescopic pipe axis. The two aluminium rods are hinged to the spray lance mounting frame which, in turn, is fixed to the top of the inner pipe of the telescopic arrangement through coupling. The other end of one aluminium rod is connected to two nylon ropes so that when the ropes are pulled and released from the ground, the spray guns will oscillates up and down through an angle of 70 degrees.

Mechanism to raise the telescopic pipes and rotary movement-One end of the flexible wire rope is connected to the bottom portion of the inner pipe. The wire rope is passed through a pulley fixed on the top of the outer pipe and the outer end is connected to the ratchet arrangement fixed at the bottom portion of the outer pipe. Thus when the ratchet is rotated, the inner pipe is moved up and can be locked in any desired position. By releasing the lock of the ratchet the inner pipe can be moved down to any position. A handle is provided at the bottom of the telescopic pipe to rotate the telescopic pipes in any angle between 0 to 360 degrees. The handle is provided at optimum height to be easily operated by the operator standing on the platform. Thus the following movements are provided to spray the chemical at any height, at any angle, and in any position:

a. Up and down movement of the telescopic pipe to reach the required height;
b. Rotary movements of the telescopic pipes about its vertical axis through 360 degrees to spray the chemical in any direction; and
c. Oscillating movement (up and down through 70 degrees) of the spray guns to target the required position of the canopy.

These features of the sprayer ensure that the entire canopy at the top of the tree could be sprayed without any difficulty.

Folding mechanism-A wire rope is fixed to the top of the folding frame. A roller with handle is fixed at the rear portion of the bottom frame which the other end of the rope is fixed to this roller through guide pulleys. When the roller is rotated after disconnecting the rear portion of the folding frame from the bottom frame, the folding frame along with telescopic pipe arrangement is folded and kept horizontal for easy transport. Laboratory and intensive field trials are to be conducted with the unit for evaluating its performance.

Results and Discussion

The unit was tested for proper functioning of all its three components. The sprayer is in working position as shown in **Fig. 1**. For easy transport, the unit is kept in a horizontal position as shown in **Fig. 2** and the same is erected vertically by winding a cable.

Fig. 1 The sprayer for coconut trees.

Fig. 2 The sprayer in transport position.

Field Evaluation

During the field evaluation the following parameters were noted:

Crop parameters-tree height; time taken to cover a tree; and quantity of chemical sprayed per tree.

Operational parameters-sprayer pump rpm; pressure developed; discharge rate; spray distribution; and height of reach.

The following observations were made during the testing:

a) The minimum height of the spray guns was 8 m. When the telescopic pipes are moved up, the spray guns were at maximum height of 15 m;
b) The tractor engine was operated at half throttle as the power requirement to operate the triplex

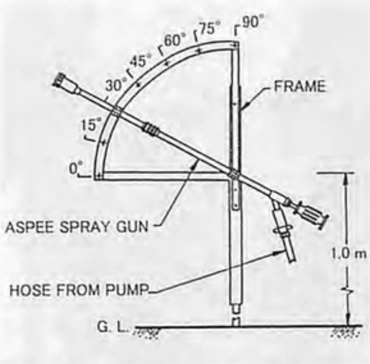


Fig. 3 Spray gun tests at different inclinations.

pump was low;

c) The PTO rpm was 360 and to that of pump was 950 (rated);
d) The pressure developed was 20.4 kg/cm^2 which was sufficient to supply the spray chemical at the required spray pattern;
e) The spray pattern could be adjusted to either jet or mist cane as needed;
f) From the tip of the nozzle, the height of reach was 6.92 m and it was reduced to 5.10 m when two spray guns were used simultaneously;
g) Adjusting the control valve could vary the quantity of chemical fluid pumped;
h) The recommended spray application rate of 5 to 8 litres per tree could be easily sprayed;
i) The tractor along with sprayer unit could be easily moved in between the rows. One side of the tree canopy in a row was first sprayed and moving the tractor in the next row covered the other side of the row;
j) In one hour 35 to 45 coconut trees could be easily sprayed depending on the height and area of spread of the canopy;
k) Spraying could be done easily from a height of 8 m to 20 m;
l) If the coconut trees are less than 8 m high, the two spray guns are removed from the telescopic pipe. Two men can hold the guns and do the spraying; and
m) This arrangement easily sprayed orchard trees and field crops.

A separate study was conducted to determine the trajectory of the spray jet by keeping the spray gun at various inclinations (**Fig. 3**). The spray pattern with 2.38 mm size orifice plate at different inclinations of the spray gun are shown in **Fig. 4**. The maximum height of reach from the nozzle tip was 9.0 m for 90 degrees in vertical position of the gun. But this was difficult as the chemical dripped on the operator and hence the best angle of inclination for maximum height of reach was considered at 75 degrees to horizontal when the height of reach was 6.92 meters. To increase the velocity and height of reach, either the pressure or the discharge has to be increased. When the pressure was increased the jet broke into fine spray that drifted away and hence the height of reach could not be increased beyond a critical value. The variation of output per spray gun, total discharge of spray fluid and the pressure developed with respect to number of spray guns were also observed and the results are shown in **Fig. 5**. The maximum height of reach from the tip of the nozzle were 6.92 m, 5.10 m and 4.20 m for single, double and triple guns, respectively. The atomization was fine using a single gun. The total pressure decreased from 24.2 kg/cm^2 to 18.9 kg/cm^2 with an increase in the number of spray guns from 2 to 3.

Conclusion

A tractor-operated tall-tree sprayer for coconut suitable for spraying up to a height of 20 m was developed. The rotary and oscillatory movements of the spray guns, and the up-and-down movement of the telescopic pipe enabled them to reach the desired target in the canopy. The spray pattern could be adjusted to either jet or mist cane as needed. The best angle of inclination for maximum height of reach was optimized as 75 degrees to horizontal when the height of reach was 6.92 m from the tip of the nozzle. It was reduced to 5.10 m when two spray guns were used simultaneously. The salient features of the unit are:

(continued on page 34)

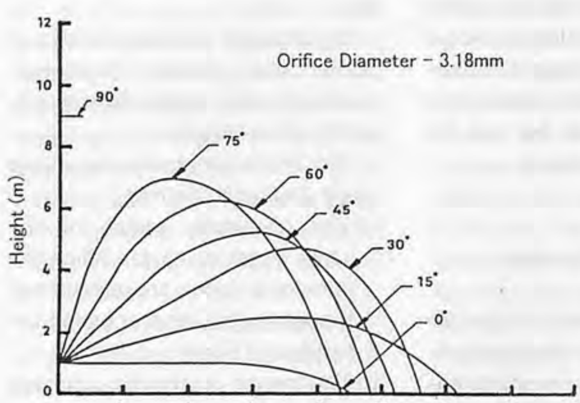


Fig. 4 Spray distribution pattern at various inclinations.

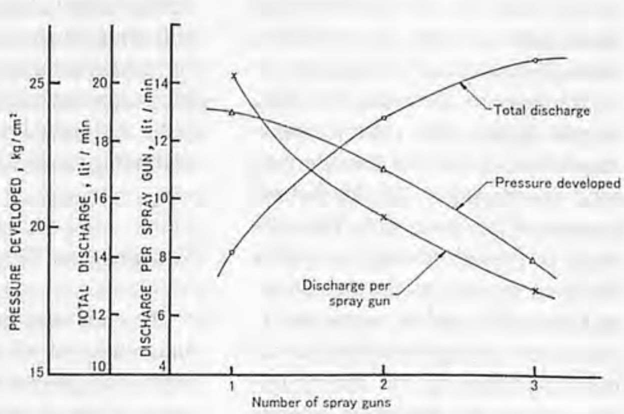


Fig. 5 Variation of pressure and discharge with reference to number of spray guns.

Development and Evaluation of Power Tiller-operated Orchard Sprayer

by
Dr. K. Kathirve
Associate Professor
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore-641 003.
India

Dr. R. Manian
Professor
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore-641 003.
India

Dr. T. V. Job
Professor
College of Agricultural Engineering
Tamil Nadu Agricultural University
Coimbatore-641 003.
India

Abstract

Horticultural crops constitute a significant component of total agricultural production in India. Their contribution to the total agricultural export is substantial. Power tillers are visualized as potential source of power for horticultural farming due to their compact size and easy manuevorabilities. In view of the potential of the power tiller in orchards, a tall-tree sprayer operated by power tiller has been developed. The unit consists of three aluminum hollow sections (50 × 25 mm) of 4 m length to which three spray lances of 1.8 m long each are fixed. Each lance consists of 5 nozzles fixed on horizontal projection rods of 300 mm long. The nozzles are spaced at 450 mm apart. A reciprocating pump (40 mm × 25 mm) is mounted on the power tiller with the help of a stand. The drive is transmitted from the clutch pulley of the power tiller through 'v' belt. A 25 mm diameter, heavy-duty alkathene suction hose carries the spray chemical from the tank kept in the power tiller trailer to the pump inlet. The delivery line from the outlet of the pump is divided into three lines by means of a three-way cock to the 3 spray lances. The three aluminium sections with spray lances and nozzles are carried by three persons with a "waist belt rest" and "shoulder belt" provisions for easy handling. The unit was evaluated for its performance in terms of the atomization characteristics viz. droplet size and spray spectrum. This was compared with the conventional knapsack motorized mist blower.

Introduction

Chemical crop protection is the most important field operation and will become even more widespread with the demand for better yields to fulfill the need for food for the exponentially growing world population. On an average, about one-third of the potential agricultural production of the world is annually lost to pests. Horticultural crops constitute a significant component of total agricultural production in India. The horticultural crops put together covered nearly 11.6 million ha with a total production of 91 million mt. Although horticultural crops covered 6.7 percent of the gross cropped area in a year, yet they contributed more than 18 percent of the gross values of agricultural output. Similarly, their contribution to the total agricultural export is substantial (52%). The cropped area planted to orchard in India, being about 3 percent, shares about 14 percent of total pesticide consumption. The area planted to orchard crops is growing and causes higher cost requirement in field crops and non-availability of labour. The conventional methods of applying chemicals to orchard crops involves poor distribution of spray, drift and high cost of labour. The existing spray systems have limited height of reach for chemicals. Orchard sprayers have become the felt need of Indian orchard farmers to overcome infections of diseases. Power tillers are visualized as a potential source of power for horticultural farming due to their compact size and easy maneuverability. The development and evaluation of a power tiller-operated tall tree sprayer for orchard trees is the subject of this paper.

Review of Literature

Tajuddin (1978) found that the speed of the plunger pump fitted in a tractor-mounted hydraulic sprayer increased as well as, the uniformity of spray distributor. Mathew (1979) reported that the depth of the chamber could be adjusted during spraying for straight jet or wide cone at fairly short intervals. He also stated that piston pumps are most useful for spraying large or tall trees or widely spaced bushes for high pressures up to 40 bar. ASPEE, Bombay developed a horizontal triplex pump power sprayer for orchard spraying. The sprayer is powered by a 3-hp engine and developed a pressure of 17 to 25 kg cm^2. The spray gun was 56 cm long provided with a swirl chamber in which the swirl plunger was moving to and fro.Two types spray viz. jet spray and cone spray could be obtained with varying discharge rates. Bindra and Singh (1997) developed a hydraulic sprayer and reported that increase in liquid pressure resulted in increased carry of spray droplets, spray angle, liquid flow rate and smaller droplets.

Materials and Methods

The sprayer consists of three aluminum hollow sections (50 × 25 mm) of 4 m length to which three spray lances of 1.8 m long each are fixed. Each lance consists of 5 nozzles fixed on horizontal projection rods of 300 mm long. The nozzles are spaced at 450 mm apart. A reciprocating pump (40 mm × 25 mm) is mounted on the power tiller with the help of a stand (**Fig.1**). The drive is transmitted from the clutch pulley of the power tiller through 'v' belt. A 25-mm diameter heavy-duty alkathene suction hose carries the spray chemical from the tank kept in the power tiller trailer to the pump inlet. The delivery line from the outlet of the pump is divided into three lines by means of a three-way cock to the 3 spray lances. The three aluminium sections with spray lances and three persons with a "waist belt rest" and "shoulder belt" provisions for easy handling carry nozzles. A regulator valve with a by-pass line to the tank is also provided in the delivery line to control excess pressure and discharge rate. The unit costs Rs. 10,000.

The sprayer was evaluated for its performance for its atomization characteristics and the results are compared with the conventional motorized knapsack sprayer. The droplet size is measured by collecting the spray at 6, 7 and 8 m high from ground level and at an axial distance of 1m from the nozzle. The spray is collected on a glass slide coated with magnesium oxide. The glass slide is exposed for a fraction of a second towards the spray. The slides are viewed in the microscope and the average droplet size of the particles is measured. The sprayer is tested in a mango orchard. The geometry of the trees viz., the diameter of canopy, height for 20 trees are measured. The surface area of the tree is computed.

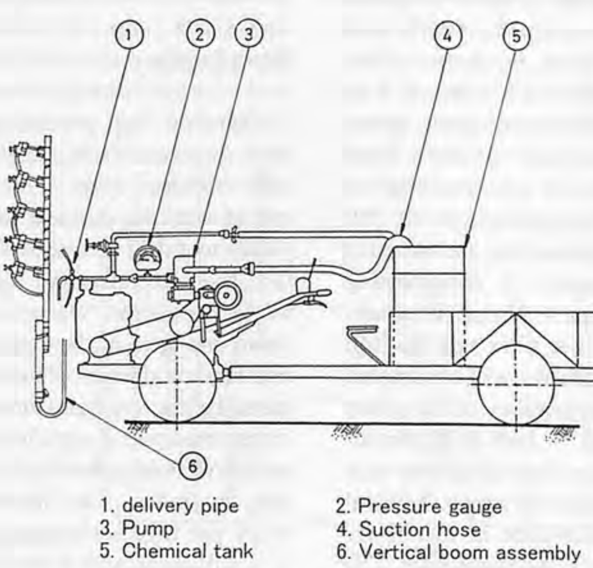
Results and Discussion

The total discharge in 15 nozzles of the tall-tree sprayer attachment to power tiller at different speeds of spray pump and the spray pressure are shown in **Table 1**.

The discharge Vs pressure curve for the orchard sprayer is shown in **Fig. 2**. It is observed that the relationship between the pressure and the discharge of the sprayer is linear. The size of droplets measured in terms of Volume Median Diameter (VMD) and Nominal Median Diameter (NMD) at 6,7 and 8 m

Table 1. Pressure and Discharge Rate of Tall-tree Sprayer

Power tiller engine speed, rpm	Pump speed, rpm	Pump pressure, kg/cm^2	Total discharge, lit/hr
1220	260	144.80	293
1220	260	193.14	323
1220	260	241.40	371
1220	260	289.70	397
1220	260	337.90	417
1220	260	434.60	468
1220	260	482.80	508
1220	260	695.30	565



1. delivery pipe
2. Pressure gauge
3. Pump
4. Suction hose
5. Chemical tank
6. Vertical boom assembly

Fig. 1 Power sprayer sketch for orchard trees.

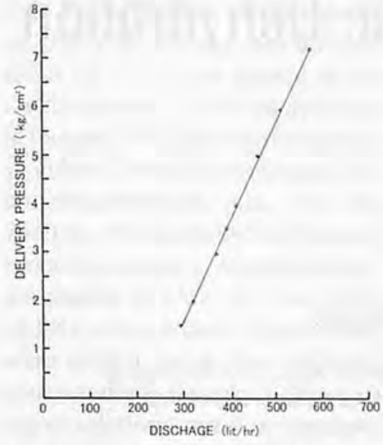


Fig. 2 Pressure vs. Discharge Curve of Tall-tree Sprayer.

Table 2. Comparative Values of VMD/NMD Ratio for Normal Configuration

Distance of nozzle from ground level, m	Axial distance from nozzle, m	NMD	VMD	VMD/NMD
Power tiller operated orchard sprayer				
6	1	16.85	18.65	1.24
7	1	18.64	24.23	1.30
8	1	22.45	27.15	1.22
Motorized knapsack sprayer				
1.0	1.0	17.60	16.76	1.05
2.0	1.0	21.47	23.81	1.10

Table 3. Comparative Field Evaluation Results of the Orchard Sprayer

Tree	Height of the tree, m	Diameter of the tree, m	Surface area of the tree, m^2	Time for spraying one tree, min	Effective time for spraying one tree, min
1	6.0	12	266	3.76	5.37
2	5.5	10	157	2.53	3.73
3	5.0	9	127	2.13	3.02
4	6.5	11	190	3.03	4.32
		Mean			4.11

high for the orchard sprayer and at 1.5 m high for the motorized knapsack sprayer is listed in **Table 2**.

The VMD ranges from 18.65 to 27.15 for the power-tiller orchard sprayer and from 16.76 to 23.81 for the motorized knapsack sprayer. The increase in VMD for the forma is due to the coarser particles generated due to higher spray pressure. However as the spraying applied closer to the foliage and avoidance of drift is also important, the larger droplets produced by the orchard sprayer is advantageous. The VMD/NMD values vary from 1.22 to 1.30 and 1.05 to 1.10 for the orchard sprayer and motorized sprayer, respectively, indicating that both sprayers have very narrow droplet spectrum.

The atomization characteristics of the sprayer is the most important criterion for the performance of sprayer, hence the measurements of particle size distribution for both sprayers in the normal configuration (crop spray arrangement) were made. The relationship between the size of droplets and the percentage of droplets is illustrated in **Fig. 3**. It can be inferred that for the orchard sprayer under normal conditions 100 - 300 m droplets dominate the spray spectrum. accounting for 63 percent. This implies that the droplets are of slightly coarse range whereas for the knapsack sprayer 35 per cent of the droplets are of 100 m and 200 to 800 m size droplets account for 54 per cent. For optimum deposition the droplet size have to be in the range of 100 - 300 m and, hence the power tiller operated orchard sprayer satisfies the above requirement (**Table 3**).

The average time spent by the sprayer for a tree is 4.11 min: as considerable time is devoted to maneuvering the spray lance around the tree canopy.

Conclusions

Based on the results of the investigation the following conclusions are drawn.

a) The relationship between the pressure and the discharge of the sprayer is linear;
b) The orchard sprayer has very narrow droplet spectrum;
c) The droplet size produced by the power tiller-operated orchard sprayer satisfies the requirement for optimum deposition;
d) Best suited for spraying in tall orchard trees like mango, guava and sapota with a maximum height of spray reach is 8.0 m; and
e) About 10 - 15 trees can be covered per hour depending upon the tree density.

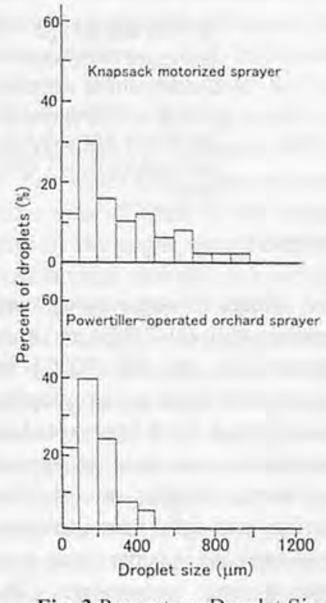


Fig. 3 Percent vs. Droplet Size.

REFERENCES

Bindra, O.S and Harharan Singh, 1997. Psticide application equipments. Fouth Edition.Oxford and IBH publishing Co. New Delhi.

Matthews G.A., 1979. Pesticide application method Longman Group Ltd, London 334 pp.

Tajuddin A. 1995 Investigation on the effect of operational and atomizer parameters an the performance of battery powered spraying systems. Unpublished Ph.D. Thesis work submitted to TNAU, Coimbatore.

Mathematical Modelling of Osmotic Dehydration Kinetics of Papaya

by
S. Kaleemullah
Research Scholar
Department of Agricultural Processing
College of Agricultural Engineering
Tamilnadu Agricultural University
Coimbatore – 641 003
INDIA
E-mail: kaleem_shaik@usa.net)

R. Kailappan
Professor
Department of Agricultural Processing
College of Agricultural Engineering
Tamilnadu Agricultural University
Coimbatore – 641 003
INDIA

N. Varadharaju
Associate Professor
Department of Agricultural Processing
College of Agricultural Engineering
Tamilnadu Agricultural University
Coimbatore – 641 003
INDIA

CT. Devadas
Professor and Head
Department of Agricultural Processing
College of Agricultural Engineering
Tamilnadu Agricultural University
Coimbatore – 641 003
INDIA

Abstract

The effects of sugar syrup concentrations (50, 60, 70°B) and temperatures (32, 50, 60, 70°C) on osmotic dehydration in papaya cubes of 1.5 cm for 4 h were studied at an initial mass ratio of papaya cubes: sugar solution as 1:4. The water loss and solid gain increased with an increase in sugar syrup concentration and temperature. The movement of water and sugar was modelled for water loss and sugar gain by the pappy cubes. The water and sugar transfer coefficients were found to increase with an increase in sugar concentration and temperature. The developed model can be used to predict water loss and sugar gain during osmotic dehydration of papaya cubes within the range of experimental study. It can also be used to determine the osmotic dehydration time in getting the desired level of sugar content in papaya.

Introduction

Osmotic dehydration is used for partial removal of water from materials such as fruits and vegetables (water containing cellular solids) by immersing in a concentrated aqueous solutions such as sugars or salts. The most commonly used osmotic agents are sucrose for fruits and sodium chloride for vegetables. Osmotic dehydration can be conducted at low temperatures and does not involve a phase change of water as in other dehydration processes, such as air drying and freeze drying. The main advantages of osmotic dehydration include minimized heat damage and less discolouration of fruits, improved texture quality of rehydrated products, maintaining the physical and chemical qualities of fruits, increased retention of volatile compounds and pigments, reducing raw material to half by removing moisture and is ready to eat without rehydration.

The Kinetics of dewatering and mass transfer properties during the osmotic process have been investigated for apple (Videv et al., 1990), green beans (Biswal et al., 1991) and banana (Pokharkar and Suresh Prasad, 1998). Papaya (*Carica papaya* L.) is an important fruit in tropical and sub-tropical regions of the world. The major producers of papaya in the world are Brazil, Thailand, Nigeria, Romania, India, Indonesia and Mexico. The world production of papaya was 5.02 million tonnes in 1997 (Vikas Singhal, 1999) and it was reported that its loss was 40-100%. The papaya loss can be minimized to some extent, if the fruit can be processed and stored. One way of processing the fruit is by osmotic dehydration and the osmotically dehydrated papaya can be easily accepted as a snack item as compared to other processed products.

The objective of this study was to use osmotic dehydration technique on papaya cubes and developing a mathematical model of osmotic dehydration kinetics of papaya.

Materials and Methods

Semi-ripened, fresh fruits of papaya (CO-2 variety) used in this study were washed, hand-peeled using a knife. The seeds were seperated. The fruit was cut into uniform cubes of 1.5 cm and dipped in 1% $CaCl_2$ solution for 10 minutes so as to increase the firmness of the papaya cubes. Three different sugar syrup concentrations, viz., 50, 60, 70°Brix, were prepared and the preservatives, namely; potassium metabisulphite (0.1%) and citric acid (0.1%) were added. Experiments were carried out at three different concentrations (50, 60, 70°Brix) of sugar solutions and four temperatures (room temperature – 32, 50, 60, 70°C), maintaining a solid to liquid mass ratio of 1:4. Twenty five grams of papaya cubes were immersed in glass beakers containing different concentrations of sugar syrup. The beakers were kept in a thermostat- controlled oven to maintain the required temperature. The papaya cubes were not agitated during the experiment. The movement of sugar and water was monitored by analyzing the samples of papaya cubes soaked at designated times: 30, 60, 120, 180, 240 minutes. After removing the papaya cubes from the solution, they were immediately placed on tissue paper to remove the sugar solution adhered on its surface. The cubes were weighed and moisture loss was determined by using a vacuum oven (AOAC, 1995).

The water loss and solid gain were calculated by using the following formulae: (**Equation 1**)

where,

WL - Water loss,%

m_o - Mass of papaya cubes at time zero, g

m_θ - Mass of papaya cubes at time θ, g

x_{wo} - Water content as a fraction of the mass of papaya cubes at time zero

$x_{w\theta}$ - Water content as a fraction of the mass of papaya cubes at time θ

The dry matter gain is related to sugar gain and hence, the sugar gain (SG) was the net gain in total solids by the papaya cubes at time, θ on the initial mass basis. The water loss (WL) was the net loss of water from papaya cubes at time, θ on the initial mass basis (**Equation 2**).

where,

SG - Solid gain,%

The osmotic dehydration models were developed by taking the experimental data obtained for water loss and solid gain at 50, 60, 70°Brix sugar solutions and at 32, 50, 60, 70°C syrup temperatures. In order to test the applicability of the models developed, they were verified for 250 g sample of 1.5 cm papaya cubes under 60°Brix sugar solution with 60°C syrup temperature at 1, 2, 3, 4 h.

Results and Discussion

The kinetics of osmosis of the experiments are shown in **Figs. 1-2**. In all experiments, the water loss was very fast at the beginning of the process and decreased gradually with an increase in time and approaching to equilibrium. The same type of results were reported in the case of osmotic concentration of green beans (Biswal et al., 1991) and banana slices (Pokharkar et al., 1997). The water loss at any given temperature was affected greatly by the initial concentration of the sugar syrup. Water loss increased with an increase in syrup concentration. This may be due to the increased osmotic pressure in the sugar syrup at higher concentrations, which increased the driving force available for water transport. This is in agreement with the findings by Heartwin (1997).

The water loss at any concentrations was affected by the temperature of the sugar syrup. The water loss increased with an increase in syrup temperature. This may be due to the changes in semi-permeability of the cell membranes of the fruit, allowing more water to diffuse at a short period. The finding was in confirmation with the results obtained by Ponting et al. (1966) and Heartwin (1997). Besides, at higher temperatures, the viscosity of the syrup decreased, causing convection currents in the syrup which, in turn, eliminated local dilution and favoured osmosis.

The solid gain (**Fig. 2**) was greater during initial stages of osmosis and decreased gradually at later stages and approaching to equillibrium. This is in agreement with the findings of Biswal et al., 1991 and Pokharkar et al., 1997. The solid uptake increased when the concentration of the sugar solution increased. This is because of the high concentration difference between solids in fruit and syrup at high syrup concentrations. The sugar uptake increased with an increase in syrup temperature. This may be due to the collapse of the cell mem-

$$WL = \frac{\text{Initial moisture in fruit} - \text{Moisture in osmotically dehydrated fruit at time, } \theta}{\text{Initial weight of fruit}} \times 100$$

$$= \frac{(m_o x_{wo} - m_\theta x_{w\theta})}{m_o} \times 100$$

Equation 1

$$SG = \frac{\text{Solids in osmotically dehydrated fruit at time, } \theta - \text{Initial solids in fruit}}{\text{Initial weight of fruit}} \times 100$$

$$= \frac{m_\theta (1-x_{w\theta}) - m_o (1-x_{wo})}{m_o} \times 100$$

Equation 2

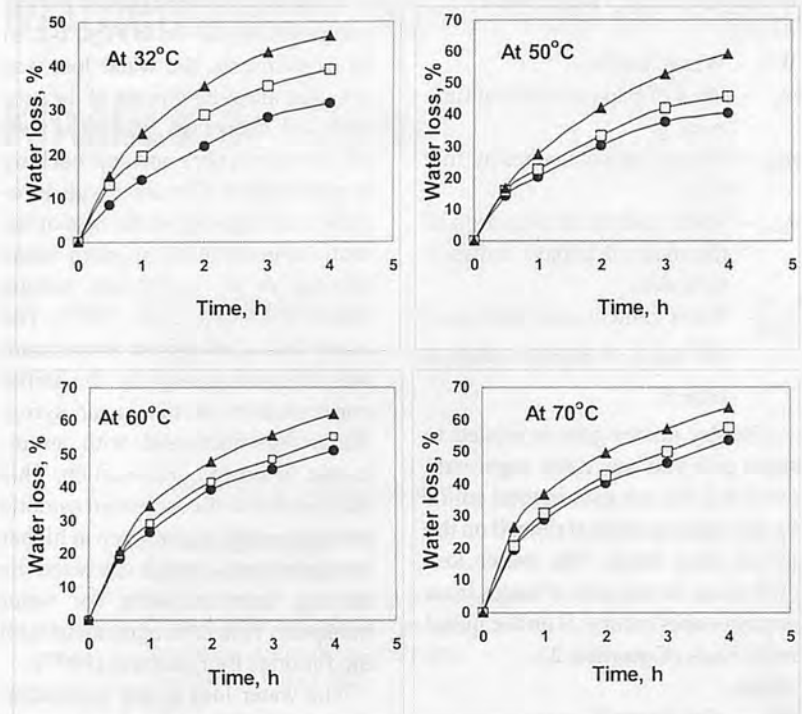


Fig. 1 Effect of osmosis time and syrup concentration on water loss in papaya at different syrup temperatures. (▲--▲ 50°Brix, □--□ 60°Brix, ●--● 50°Brix)

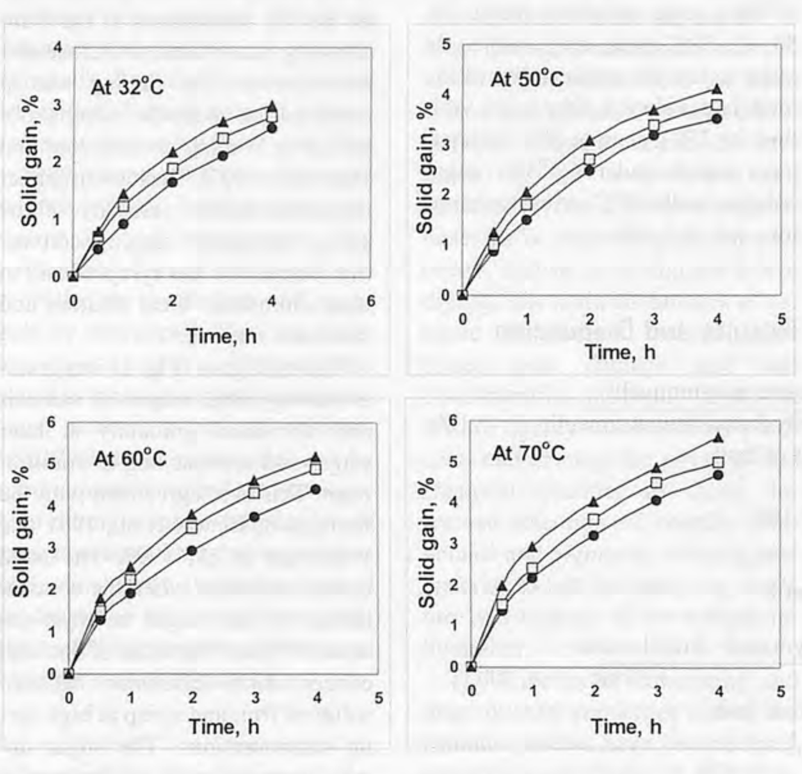


Fig. 2 Effect of osmosis time and syrup concentration on solid gain in papaya at different syrup temperatures. (▲--▲ 50°Brix, □--□ 60°Brix, ●--● 50°Brix)

branes at high temperature. The same type of result was quoted in osmotic dehydration for banana (Heartwin, 1997).

Assuming that the resistance to water movement from papaya cubes to sugar solution lies in the solid, the water loss (WL), was modelled based on the principles of diffusion in solids. Since the solid to liquid ratio was 1:4, it was considered that the papaya cubes were soaked in limited volume of external solution. The water loss (WL), essentially a concentration parameter, was proportional to the square root of the time of contact in minutes (Biswal et al., 1991; Pokharkar and Suresh Prasad, 1998). So, it was written as:

$WL = kw\theta^{0.5}$ .... (3)

Where,

k_w - Water transfer coefficient, $min^{-0.5}$

θ - Time of contact, min

The water transfer coefficient, k_w is a function of starting sugar concentration, c_o and contact temperature, t. The k_w values were determined by noting the slope from linearity plots of the water loss (WL) versus the square root of contact time ($\theta^{0.5}$) (**Fig. 3**). The following model used by Biswal et al., (1991), Pokharkar and Suresh Prasad (1998) was proposed for k_w:

$k_w = A\ C_o^{p}\ t^{q}$ .... (4)

Where,

C_o - Sugar syrup concentration, °Brix

t - Temperature, °C

The parameters A, p and q were unique to the system and were estimated from the experimental data. By feeding the data of k_w, C_o and t in a statistical package (Microstat, 1984), the values of A, x and y were obtained as 0.0145, 0.848 and 0.498, respectively, with multiple R = 0.96. The equations to calculate water transfer coefficient (k_w) and water loss (WL) were obtained as:

$k_w = 0.0145\ C_o^{0.848}\ t^{0.498}$ ...(5)

$WL = 0.0145\ Co^{0.848} t^{0.498}\ \theta^{0.5}$ (6)

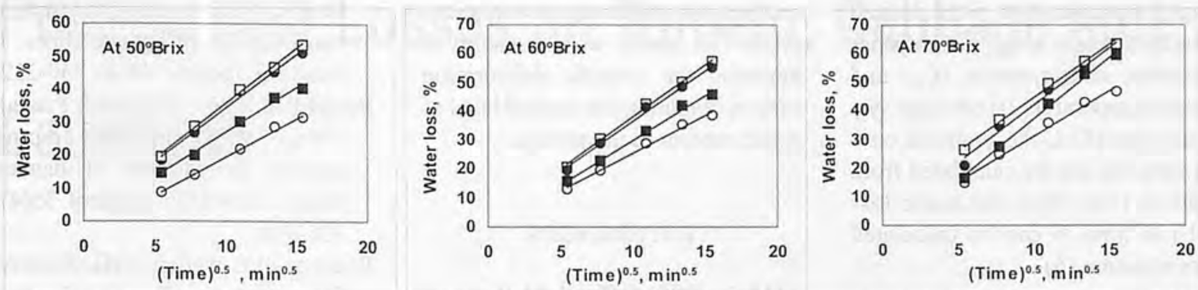


Fig. 3 Plot between percentage water loss of papaya and square root of contact time. (○--○ 32°C, ■--■ 50°C, ●--● 60°C, □--□ 70°C)

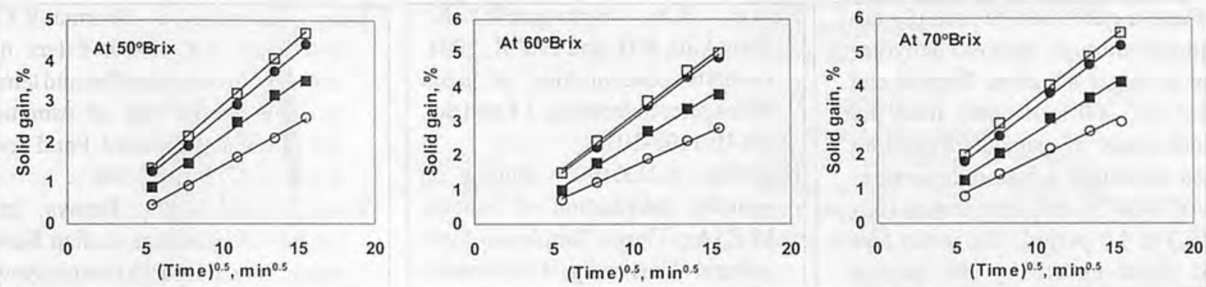


Fig. 4 Plot between percentage solid grain of papaya and square root of contact time. (○--○ 32°C, ■--■ 50°C, ●--● 60°C, □--□ 70°C)

The sugar gain (SG) of the papaya cubes was modelled similar to that of the water loss:

$SG = ks\ \theta^{0.5}$ .... (7)

Where,

k_s - Osmotic agent (sugar) transfer coefficient, $min^{-0.5}$

The sugar transfer coefficients, k_s were determined by noting the slope from linearity plots of the solid gain (SG) versus square root of contact time ($\theta^{0.5}$) (**Fig. 4**). The following model was proposed for k_s:

$k_s = B\ C_o^{\ x}\ t^y$ .... (8)

The parameters B, x and y were estimated from the experimental data and obtained as 0.0019, 0.467 and 0.768, respectively, with multiple R = 0.99. The sugar transfer coefficient (k_s) and the solid gain (SG) were obtained as:

$ks = 0.0019\ Co^{0.467}\ t^{0.768}$ ... (9)

$SG = 0.0019\ Co^{0.467}\ t^{0.768}\ \theta^{0.5}$ .... (10)

The experimental values of water and sugar transfer coefficients and the values calculated by using equations (5) and (9) were tabulated in **Table 1** which shows that both coefficients increased with an increase in sugar syrup concentration and temperature. The experimental values were found to be very close to the predicted values with root mean square deviations of 3.19 and 2.87% in water and sugar transfer coefficients, respectively.

Table 1. Experimental and Predicted Values of Water and Sugar Transfer Coefficients at varying Concentrations and Temperatures

Sugar Syrup		Water transfer coefficient (kw), $min^{-0.5}$		Sugar transfer coefficient (ks), $min^{-0.5}$	
Concentration (C_o), °Brix	Temperature (t), °C	Experimental	Predicted	Experimental	Predicted
50	32	2.129	2.247	0.174	0.173
50	50	2.705	2.806	0.241	0.243
50	60	3.367	3.073	0.287	0.280
50	70	3.466	3.318	0.309	0.315
60	32	2.598	2.623	0.187	0.188
60	50	3.049	3.275	0.256	0.265
60	60	3.604	3.587	0.324	0.305
60	70	3.726	3.873	0.334	0.343
70	32	3.157	2.989	0.203	0.202
70	50	3.981	3.733	0.276	0.285
70	60	4.120	4.088	0.342	0.327
70	70	4.112	4.414	0.362	0.369

The experimental values obtained for water loss and solid (sugar) gain in 250 g of osmotically dehydrated papaya cubes (60°Brix and 60°C) and the values predicted by using equations 6 and 10 were found to be very close with root mean square deviations of 3.19 and 4.33%, respectively. The osmotic dehydrated papaya was good in taste than the raw fruit.

A relationship between solid gain (SG) and water loss (WL) can be obtained by combining the equations 3 and 7:

$$SG = \left(\frac{k_s}{k_w}\right) WL \qquad .... (11)$$

From the practical application point of view, WL and SG as cited in equations (6) and (10) respectively were not independent. They were rather related to each other through equation (11). If the desired quantity of sugar gain (SG) in papaya cubes, concentration (C_0) and contact temperature (t) of sugar syrup are specified, the required contact time (θ) can be calculated from equation (10). Then the water loss (WL) at time, θ can be calculated from equation (6).

Conclusions

Papaya cubes can be partially dewattered through osmotic dehydration in sugar solution. Papaya can loose 30 – 60% of water from the initial mass of papaya depending upon the sugar solution concentration (50-70°B) and temperature (32-70°C) in 4 h period. The water loss and sugar uptake by the papaya cubes during osmotic dehydration in sugar solution at different concentrations and temperatures were modelled. The model will be useful in knowing the osmotic dehydration time in obtaining the desired level of sugar content in the papaya.

REFERENCES

AOAC. 1995. Official Methods of Analysis. Association of Official Analytical Chemists, 16 th edn., Arlington, Virginia, USA.

Biswal, R.N., Bozorgmehr, K., Tompkins, F.D. and Liu, X. 1991. Osmotic concentration of green beans prior to freezing. J. Food Sci. 56(4): 1008-1012.

Heartwin, A.D.P.1997. Studies on osmotic dehydration of banana. M.E.(Ag) Thesis. Tamilnadu Agricultural University, Coimbatore, India.

Pokharkar, S.M., Suresh Prasad and Das, H. 1997. A model for Osmotic concentration of banana slices. J. Food Sci. Technol. 34(3): 230-232.

Pokharkar, S.M. and Suresh Prasad. 1998. Mass transfer during osmotic dehydration of banana slices. J. Food Sci. Technol. 35(4): 336-338.

Ponting, J.D., Watters, G.G., Forrery, R.R., Jackson, R. and Stanley, W.L. 1966. Osmotic dehydration of fruits. Food Technol., 20(10): 125-128.

Videv, K.,Tanchev, S., Sharma, R.C. and Joshi, V.K. 1990. Effect of sugar syrup concentration and temperature on the rate of osmotic dehydration of apples. J. Food Sci. Technol. 27(5): 307-308.

Vikas Singhal. 1999. Papaya. In: Indian Agriculture, Indian Economic Data Research Centre, New Delhi, India. 169-170. ■■

(Continued from page 26)

Development and Evaluation of Tractor Operated Coconut Tree Sprayer

a) Reduced initial investment since the spraying unit is operated by tractor;
b) The entire canopy area of the tree is easily sprayed;
c) The total height of spray is 55 feet;
d) For easy transport, the unit can be kept in a horizontal position by folding the frame with telescopic pipes. The same could be erected vertically by winding a cable;
e) The sprayer can be used in orchard trees and for spraying in field crops, by bifurcating the delivery section into spray lines with spray lances and spray guns;
f) The cost of the unit is Rs.35,000; and
g) About 30 - 35 trees can be sprayed per hour.

REFERENCES

Anon (1992) Technical bulletin published by American springs and pressing works Ltd. ASPEE House, Mumbai.

Bindra, O. S. and Harcharan Singh. (1977). Pesticide application equipments 2nd Ed. Oxford and IBH Publishing Co., New Delhi, pp. 464

Gupta, C. P. and E. T. Dante. (1994). Recent developments in pesticide spray application. Agricultural Engineering Today,18(3-4):31-41.

Kathirvel, K. and T. V. Job (1984). Annual report on AICRP on intensive testing of power tillers and research and development of new machines to make them versatile, pp. 63-66

Manian, R. S. Thangavelu and K.Rangasamy (1984). Optimization of orifice diameter and spray angle of high pressure spray guns suitable for orchard spraying.

Mathews, G. A. (1979). Pesticide application methods. Longman Group Limited, London.

Manohar Jesudas, D. (1992). Report published by Dept. of Farm Machinery, Tamil Nadu Agricultural University.

Reichard, D. L., B. R. Tennes, C. L. Burton and G. Brown (1982). Experimental orchard sprayer. TRACTIONS OF ASAE Res. P.33-41.

Smith, D. B. (1992). 'A proposal for the prefield broadcast spray deposit evaluation. TRACTIONS OF ASAE, 35(1): 33-37.

Tajuddin, A., K. R. Swaminathan, K. S., Subramnian and M. Singaravelu (1978). Analysis and testing of spray pattern from power sprayer and other sprayers with reference to related parameters B. E. (Ag.) Project work submitted to Tamil Nadu Agricultural University, Coimbatore.

Thampan, P.K. (1997) Gains from organic farming. The Hindu Survey ofIndian Agriculture. P.89-93. ■■

Post-harvest Losses on Tomato, Cabbage and Cauliflower

by
Uma Sankar Pal
Asst. Process Engineer
AICRP on Post Harvest Technology
College of Agril. Engg. & Technology
OUAT, Bhubaneswar
Orissa, INDIA

Md. K. Khan
Research Engineer
AICRP on Post Harvest Technology
College of Agril. Engg. & Technology
OUAT, Bhubaneswar
Orissa, INDIA

G. R. Sahoo
Asst. Bio-chemist
AICRP on Post Harvest Technology
College of Agril. Engg. & Technology
OUAT, Bhubaneswar
Orissa, INDIA

N. R. Sahoo
Asst. Food microbiologist
AICRP on Post Harvest Technology
College of Agril. Engg. & Technology
OUAT, Bhubaneswar
Orissa, INDIA

Abstract

Experiments were conducted in the state of Orissa, India to determine the extent of post-harvest losses occurring at different stages of handling and transportation of perishable commodities, namely; tomato, cabbage and cauliflower. Total losses on these vegetables during different post-harvest operations were found to be 30.3 to 39.6; 24.9 to 30.4; and 28.6 to 35.1 percent respectively. The maximum quantity of losses occurred during transportation from rural markets to urban markets. Experiments were also conducted to evaluate the qualitative losses such as change in moisture content, pH, total soluble solid, total sugar and ascorbic acid content of these commodities. While storing for 20 days in ambient condition (26 to 32^{0}C, 60 to 80% R.H.) , reduction in moisture content of the cauliflower was found to be highest followed by the cabbage. The loss of water from tomato was less due to its comparatively impermeable outer skin. The pH value remained almost constant in the case of the tomato and cauliflower whereas it decreased slightly in case of the cabbage. Total soluble solids and total sugar content were found to increase with the storage period whereas a decreasing trend was observed in the case of ascorbic acid in all the cases.

Acknowledgement
The authors are grateful to the Indian Council of Agricultural Research, New Delhi for providing financial assistance to undertake this research work.

Introduction

India is the second largest producer of vegetables in the world next only to China. The area planted to vegetables is about 68.7 million hectares with an annual production of 68.7 million tonnes (Ghosh, 1997). A wide range of vegetables are grown under varying India's agro-climatic conditions. Though the country has reached the second position in the production of vegetables, the per capita availability is only 125 to 135 g against the recommended level of 300 g by the Indian Council of Medical Research. The shortfall in per capita availability is due to lack of proper post harvest technology.(Som Dutta, 1996). A recent survey showed that about 50% of the total fruits and vegetables produced in India amounting to Rs. 23,000 crores are being lost due to poor post-harvest practices (Anonymous, 1997). The post harvest losses in vegetables occur in the form of physical, quantitative and qualitative losses.

Tomato, cabbage and cauliflower are major vegetables grown in the state of Orissa with an annual production of 582, 685 and 585 thousand metric tones, respectively, (Anonymous, 1999). Considerable amount of vegetables is lost in the post-harvest chain during its movement from farmers field to consumers due to improper handling and lack of scientific awareness.

Tomatoes are generally harvested from the plant by hand picking at mature greenish yellow/reddish yellow stage and packed in bamboo baskets with a gunny cover at the top and transported through bicycle/ bullock cart to the local market. In the local market tomatoes are packed in bamboo basket or wooden crates and transported to the urban market by trucks. Tomatoes are graded in the go-down, packed in plastic trays and supplied to the market. A serious reduction in quality occurs in the produce displayed for lengthy period in the retail outlets.

Cabbages are harvested from the field manually and the lower unbound leaves with stem are cut by sickle. After harvest the cabbage heads are packed in gunny bags and sent to the local market by bullock cart. From the local market, the cabbages packed in gunny bags are transported to the urban market by trucks. Loss of water from cabbages and rough handling during transportation causes wilting and shriveling of the outer leaves and resist purchasing of such produce by the consumers. The outer leaves of cabbages from a lot were scaled off after being received at urban markets to impart fresh look to the produce.

Cauliflowers are generally harvested manually. Compact flowers having fresh look is highly accepted by the consumer. To maintain the freshness, generally cauliflower with leaves attached are packed in gunny sheets with provision for air circulation. Trucks to urban markets transport the packs. In the retail outlet, during period of abundance, the produce displayed for lengthy period and gradually the freshness/quality decreases reducing its price.

No scientific information is available on the extent of quantitative and qualitative losses of vegetable in the post-harvest chain. Therefore, the present study was undertaken to assess the post-harvest losses in tomato, cabbage and cauliflower at different stages of handling.

Materials and Methods

Quantitative Loss Assessment

The flow network of vegetables from farmer's field to the consumers was studied to identify the unit operations where loss occurs. The nature and extent of loss was assessed using standard methods.

Tomato - The total weight of tomatoes harvested from a field of definite size was recorded. After harvesting, tomatoes were sorted and weight of rejected amount of tomatoes due to crack, cuts, bruising and over-ripening was taken. From these weights harvesting loss was calculated (Anonymous, 1998).

In the market the tomatoes that sustained damage during transportation were sorted out and the weight was taken to estimate the loss. At each stage of unloading, the damaged tomatoes were weighed. From the weight of good tomatoes obtained after sorting the losses in percent due to handling and transportation were estimated as per the equation given below:

Loss in tomato, % =

$$\frac{W_{dt}}{W_{dt} + W_{gt}} X100 \qquad (1)$$

where,

W_{dt} = Weight of discarded and damaged tomatoes sorted out

W_{gt} = Weight of good quality tomatoes obtained after sorting a lot during any stage of handling

Knowing the total weight available for sales and the weight of tomatoes damaged due to handling by the consumers and rejection at the end of sales, the loss in percent at retailer's level was estimated. The experiments were conducted in five replications in different fields and markets.

Cabbage - Since cabbages are harvested manually, there is almost no loss during harvesting. The weight of the outer wilted and shriveled leaves removed by the sellers from a lot was taken. From the weight of cabbages after removal of leaves, the percentage loss was estimated:

Loss in cabbage, % =

$$\frac{W_{dl}}{W_{dl} + W_{gc}} X100 \qquad (2)$$

where,

W_{dl} = Weight of damaged leaves removed from cabbage

W_{gc} = Weight of cabbage after removal of the leaves

The weight of cut leaves obtained from the lot was taken and the loss in percent due to transportation was estimated as above. From the weight of the cabbage heads available at the retail outlet and the weight of outer leaves removed by the salesman everyday during marketing, the percentage loss at retailer point was estimated. The experiment was conducted in five replications in different fields and markets.

Cauliflower - In the case of cauliflower, damaged or discarded ones are not thrown away as in the case of tomatoes but sold at lower price depending on its quality.

Let 'N' number of cauliflowers after harvesting packed in gunny sheets were transported to the market. After the lot is received in the market, the cauliflowers were graded into different fractions based on the extent of damage during transportation and handling. In the market the price of the graded fractions were fixed based on the quality of the buds.

Let the lot was graded into 'k' fractions and 'c_i' was the price fixed per bud for i^{th} fraction having 'n_i' the numbers of cauliflowers. If 'c_g' would be the price of good quality cauliflower per bud that had been received in perfect condition, the percent loss was estimated as per the equation below:

Loss of cauliflower, %

$$= \left(1 - \frac{\sum_{i=1}^{k} c_i n_i}{c_g N}\right) \qquad (3)$$

where $\sum_{i=1}^{k} n_i = N$

The loss at the retailer's end was determined by using the above equation until the whole lot was sold. The experiment was conducted in five replications also.

Qualitative Loss Assessment

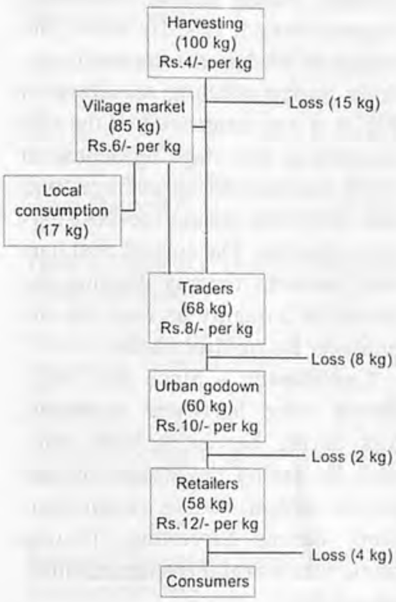


Fig. 1 Flow network of vegetables from farmer's fields to consumer.

Freshly harvested tomatoes, cabbage and cauliflowers were stored in ambient condition(26 to 32^{0}C, 60 to 80% R.H.) and analysed in the laboratory to study the qualitative loss such as change in weight, moisture content. pH, total soluble solid, total sugar and ascorbic acid content during storage in 5 days intervals. Visual changes during storage was also recorded.

Results and Discussions

The flow diagram of vegetable from farmer's field to consumer point is shown in **Fig. 1**. From the diagram it is seen that the price of vegetable is almost three times at the consumer point. In the process, two-thirds of the price goes to the middlemen. When the chain is long, the price goes on increasing due to the transportation cost and loss of vegetable during the process. Improper handling and transportation was observed to be the major source of loss followed by storage due to delay in its consumption.

Quantitative Loss

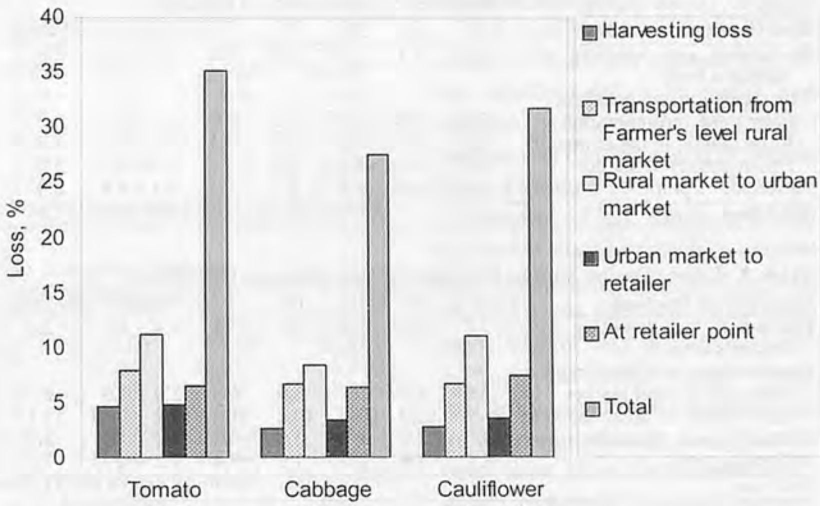


Fig. 2 Post-harvest losses of tomatoes, cabbage and cauliflower at various stages.

The quantitative loss of tomato, cabbage and cauliflower at different post harvest stages is shown in **Fig 2**.

Tomato - Since tomatoes were harvested manually, the loss during harvesting was not siginificant. By taking the weight of cracked, overriped and bruised tomatoes after sorting the harvested lot, it was found that such losses during harvesting amounted to 4.6%.

It was also observed that rough handling and transportation over bumpy roads damaged the produce by mechanical action. Inappropriate packaging caused the physical damage on the produce due to bruising and abrasion as the produce moves about during transportation (**Fig 3**). Dropping tomatoes during handling produced bruises that caused loss of tissue juices and increased enzymatic reactions resulting in darkening and flavour changes. Bruising stimulates the rate of ripening and rotting of tomatoes thereby shortening the holding period. Overriped and bruised tomatoes were sorted out before marketing to prevent damage to other tomatoes in contact with it.

Fig. 3 Damage of tomatoes during transportation and handling.

By taking the weight of damaged, rotten and discarded tomatoes at different stages of handling and transportation, it was found that loss due to transportation from farmers level to rural market was about 8.0%, from rural market to urban market 11.2% and from urban market to retailer point 4.8% (**Table 1**). The loss at the retailer's end was estimated to be 6.5% due to handling of tomatoes

Table 1. Losses During Different Post Harvest Operations of Tomato

Post Harvest Practices	I	II	III	IV	V	Range	Average
Harvesting and handling at farmer's level	4.9	4.3	4.4	5.3	4.1	4.1 – 5.3	4.6
Transportation and handling							
Farm yard to rural market	7.5	8.7	8.2	6.8	8.9	6.8 – 8.9	8.0
Rural market to urban market	11.6	12.0	10.2	11.3	10.8	10.2 – 12.0	11.2
Urban market to retailer	3.9	5.7	5.3	4.5	4.7	3.9 – 5.7	4.8
At retailer's point	5.8	7.7	7.1	6.4	5.3	5.3 – 7.7	6.5
Total loss						30.3 – 39.6	35.1

Table 2. Losses During Various Post-harvest Operations on Cabbage

Post-Harvest Practices	I	II	III	IV	V	Range	Average
Harvesting and handling at farmer's level	2.8	3.1	2.7	2.4	1.9	1.9 – 3.1	2.6
Transportation and handling							
Farm yard to rural market	7.0	6.8	6.2	7.1	6.5	6.2 – 7.1	6.7
Rural market to urban market	8.3	7.8	8.5	9.2	8.1	7.8 – 9.2	8.4
Urban market to retailer	3.4	3.5	4.2	2.9	3.7	2.9 – 4.2	3.5
At Retailer's point	6.1	6.8	6.5	6.1	6.3	6.1 – 6.8	6.4
Total loss						24.9 – 30.4	27.6

Table 3. Losses During Various Post-harvest Operations on Cauliflower

Post-Harvest Practices	I	II	III	IV	V	Range	Average
Harvesting and handling at farmer's level	2.7	2.4	2.4	3.3	3.1	2.4 – 3.1	2.8
Transportation and handling							
Farm yard to rural market	7.6	6.3	7.4	5.9	6.5	5.9 – 7.6	6.7
Rural market to urban market	11.2	12.0	10.7	10.2	11.4	10.2 – 12.0	11.1
Urban market to retailer	3.5	2.9	3.4	3.8	4.3	2.9 – 4.3	3.6
At Retailer point	8.1	7.6	7.2	7.2	7.4	7.2 – 8.1	7.5
Total loss						28.6 – 35.1	31.7

by consumers and delay in selling resulting on an average total loss of 35.1% during the process. The local varieties with thin outer skin sustained to heavy loss during period of abundance amounted to even 50%.

Cabbage - It was found that the loss in cabbages was mainly due to transportation, mechanical injury and loss of moisture. By sorting cabbages after harvesting, it was found that loss due to natural senescence, improper bulb and physiological disorder amounts to around 2.6%. Since cabbages were harvested manually loss during harvesting in the field was minimum.

Transportation over bumpy roads and rough handling during loading and unloading caused bruises and physical damage to the cabbage surface by mechanical action. These mechanical injury caused loss of visual quality with unsightly marks. The leaves at the injury point became yellowish dark in colour which denied consumer acceptability. Transportation on open trucks caused sun scorch on the produce. Severe water loss from cabbage occurred at this condition and the produce wilted and shriveled. Injuries caused due to improper transportation and handling enhanced the loss of water from cabbage as the natural barrier has been damaged. From the weight of the outer wilted and off-coloured leaves cut by the trader during different stages of handling, it was found that loss during transportation from farm yard to rural markets, rural markets to urban markets and urban markets to retailers end amounted to 6.7, 8.4 and 3.5%, respectively, (**Table 2**).

It was found that reduction in quality by wilting and yellowish dark colouring of outer leaves as the cabbages were displayed for lengthy period during marketing caused heavy losses. By taking the weight of the leaves removed by retailer during retailing as shown in **Fig. 4**, it was estimated that the loss incurred at this stage amounted to 6.4% resulting on an average total loss of 27.6% during the post-harvest activities. The current post harvest practices thereby denying the consumer a quality product and the producer his rightful return.

Cauliflower - Since the cauliflower were harvested manually, loss during harvesting was minimal. By taking the weight of bud pieces broken due to rough handling during harvesting, it was found that loss at this stage amounted to 2.8%.

It was observed that bulk handling, long hauling and transportation over bumpy roads caused many bruises by mechanical action and affected the consumer acceptability of the produce. Such bruises after one or two days turned black and the price of such produce was reduced. Loss of water from the produce and sun scorch during transportation on open trucks affected the freshness of the produce and it looked dry and lost visual quality. Leaves attached to the flower protect it from sun light and absorbed external shock during transportation and maintained its freshness. It was found that the loss on cauliflower at various stages of handling amounted to 21.4% and the major loss of 11.1% was sustained during transportation and

Fig. 4 Removing outer leaves on cabbage.

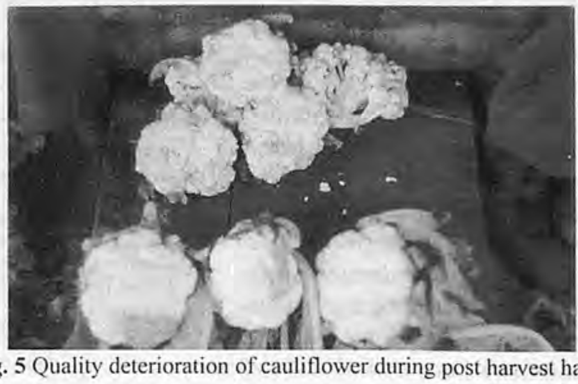


Fig. 5 Quality deterioration of cauliflower during post harvest handling.

Table 4. Changes in Quality Parameters During Storage of Tomatoes

Quality parameters	Storage period, (days)				
	0	5	10	15	20
Moisture content, %(wb)	95.17	95.08	94.98	94.94	94.89
Weight loss, % of initial weight	0	1.74	3.73	4.46	5.16
PH	4.0	4.0	4.0	4.0	4.0
TSS, %	4.0	4.0	4.0	4.5	4.5
Total sugar, g/100g	3.34	3.37	3.38	3.40	3.41
Ascorbic acid, mg/100g	29.6	22.2	19.6	18.4	17.6
Visual observation	No loss	5% rotten	15% rotten	40% rotten	70% rotten

Table 5. Changes in Quality Parameters During Storage of Cabbage

Quality parameters	Storage period, (days)				
	0	5	10	15	20
Moisture content, %(wb)	91.17	89.53	87.60	84.39	80.88
Weight loss, % initial weight	0	14.13	32.06	43.47	53.8
PH	6.5	6.0	6.0	6.0	5.5
TSS, %	5.0	6.0	6.5	7.0	7.0
Total sugar, g/100g	4.71	4.78	4.81	4.83	4.85
Ascorbic acid, mg/100g	121.6	118.7	114.4	109.9	105.3
Visual observation	good	good	One or two leaves dried	dried	Not acceptable

Table 6. Changes in Quality Parameters During Storage of Cauliflower

Quality parameters	Storage period, days			
	0	5	10	15
Moisture content, %(wb)	90.32	86.91	82.86	77.71
Weight loss, % of initial weight	0	23.43	43.49	56.51
PH	6.0	6.0	6.0	6.0
TSS, %	6.0	6.5	7.5	9.0
Total sugar, g/100g	4.21	4.23	4.26	4.29
Ascorbic acid, mg/100g	58.6	56.3	53.9	52.7
Visual observation	fresh	acceptable	dried	Fungus growth/ damaged

handling from rural market to urban market (**Table 3**).

The quality of cauliflower deteriorated as the produce was displayed for longer period at the retail store. Dark spot on the flower, mechanical injury due to rough handling and shriveling due to moisture loss during storage affected its freshness (**Fig. 5**). So the price was reduced as consumer denied purchase of such produce. It was estimated that loss at the retailer's end was 7.5% resulting on an average total loss of 31.7%.

From the above study the range of total loss sustained during various post harvest operations of tomato, cabbage and cauliflower were 30.3 - 39.6, 24.9 - 30.4 and 28.6 - 35.1%, respectively. About 70% of the total loss in the postharvest chain was sustained during handling and transportation stage.

Qualitative Loss

The qualitative loss such as change in moisture content, pH, total soluble solid, total sugar and ascorbic acid content of tomato, cabbge and cauliflower is shown in **Figs. 6** through **10**.

Tomato - From **Table 4**, it will be shown that the moisture content of tomatoes decreased from 95.17% to 94.89% wet basis in 20 days. Weight loss in tomatoes was 5.2% of the initial weight. Water loss from tomato was minimal due to its comparatively impermeable outer skin. The pH of tomato was 4 which remained constant throughout the storage period while the total soluble solid and total sugar increased slightly from 4 to 4.5 and 3.34 to to 3.41 g/100g, respectively. Ascorbic acid was reduced from an initial value of 29.6 to 17.6 mg/100g at the end of 20 days. Tomatoes were rotten during storage which amounted to loss of 70% after 20 days.

Cabbage - The moisture content of cabbage decreased from its initial value of 91.17 to 80.88% wet basis (Table 5). The weight loss was 53.8% of the initial weight in 20 days. The pH was initially 6.5, which decreased slightly to 5.5. Total sugar and total soluble solid increased from 4.71 to 4.85 g/100g and 5 to 7%, respectively. Ascorbic acid decreased from 121.6 to 105.3 mg/100g in 20 days period. Up to 10 days of storage, the cabbage

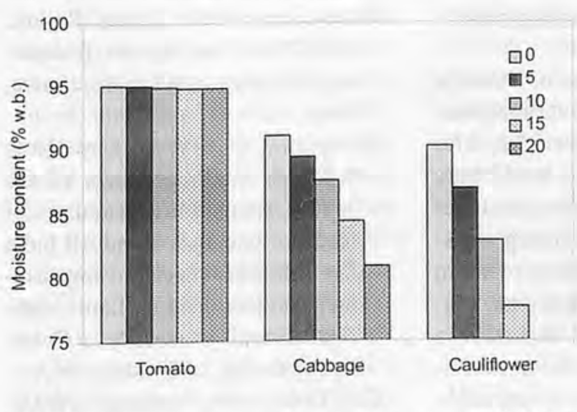


Fig. 6 Changes in moisture content with storage periods in days.

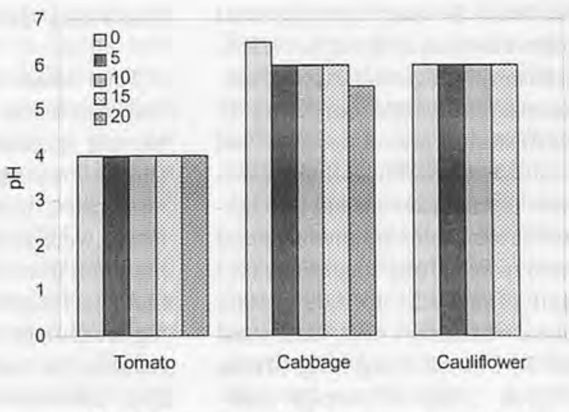


Fig. 7 Changes in pH with storage period in days.

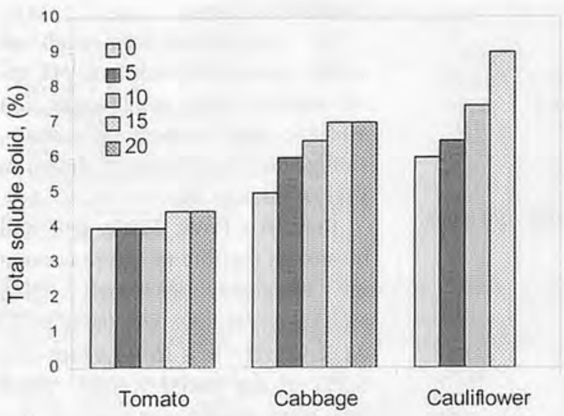


Fig. 8 Changes in of total soluble solid with storage period in days.

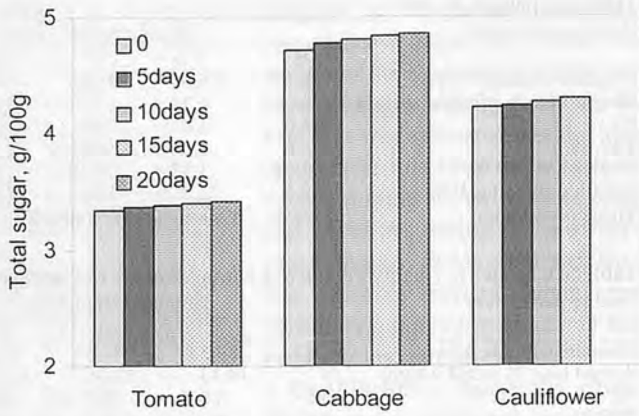


Fig. 9 Changes in total sugar with storage period in days.

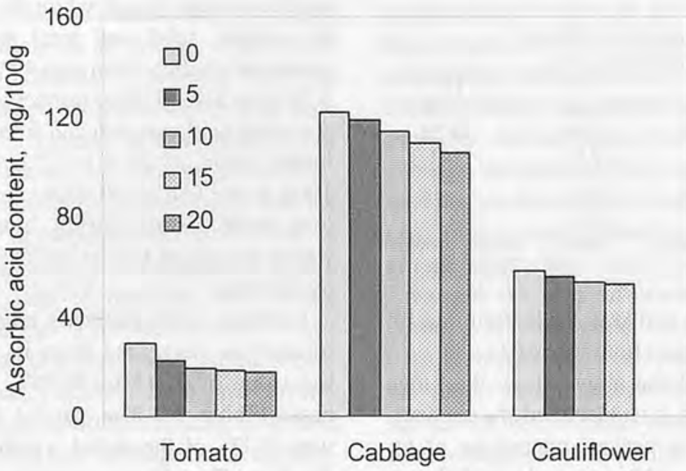


Fig. 10 Changes in ascorbic acid with storage period in days.

head was fresh with one or two outer leaves wilted. After 15 days it looked shriveled/dried with outer leaves turning yellow and after 20 days it was completely damaged.

Cauliflower - Moisture loss was rapid from the cauliflower's initial moisture content of 90.32 to 77.71% wet basis due to greater exposed surface area. The weight loss during 15 days of storage period was 56.5% of the initial weight. The initial pH was 6 which remained constant throughout. The total soluble solid increased from 6 to 9%. Total sugar increased slightly from 4.21 to 4.29 g/100g whereas ascorbic acid decreased from 58.6 to 52.7 mg/100g (**Table 6**). Up to 5 days of storage cauliflower was fresh, whereas after 10 days it looked dried and shriveled. The flower surface was blackened with fungus growth in patches after 15 days of storage.

Summary and Conclusions

Total losses in tomato, cabbage and cauliflower during various post-harvest operations were 35.1, 27.6 and 31.7% respectively. In all these three cases, the maximum amount of losses were sustained during transportation from rural market to urban market. Therefore, proper packaging technology is very important in reducing the losses on these perishable commodities. A co-operative approach like the functioning of milk federation is needed to reduce these losses. The harvested lot should be collected from village level and pre-processing operations such as washing, cooling, grading and packaging should be carried out at the co-operative centres and supplied to the sell centres. Thus farmer will get his rightful return, consumer will get quality product at reasonable price and post-harvest losses will be minimised.

REFERENCES

Anonymous. 1997. Directory of Indian Agriculture. Centre for monitoring Indian Economy Pvt. Ltd., Mumbai, July, 1997, p.80.

Anonymous. 1998. Status report on Post Harvest Manegment of Tomato, AICRP on Post Harvest Technology, Coimbatore Centre, Tamil Nadu, India.

Anonymous. 1999. Annual Report. AICRP on Post Harvest Technology, Bhubaneswar Centre, Orissa, India.

Ghosh, S. P. 1997. Key Note Address. In :Proceedings of the XVI Annual vegetable of research scientists of the All India Co-ordinated vegetable improvement project, held at Tamil Nadu Agricultural University , Coimbatore during 28-31 May 1997.

Som Dutta. 1996. Vision of TIFAC. Rightstep. Indian Hort.,4(2):1. ■■

Planning Variable Tillage Practices Based on Spatial Variation in Soil Physical Conditions and Crop Yield Using DGPS/GIS

by
Qamar-uz-Zaman
Dept. of Farm Machinery and Power
University of Agriculture,
Faisalabad 38040, PAKISTAN
Tel:(041)30281 / 335
Fax:(041)30679
E-mail: zarnab@fsd.paknet.com.pk

Abstract

The conventional tillage practices include use of mouldboard every year for deep ploughing followed by power harrow combined with drill for seedbed preparation and crop sowing. The inefficiency of this method, based on results from Welton Field Nafferton Farm, Newcastle upon Tyne University, UK is demonstrated. Two-thirds of the field area had soil strength less than the critical limit (>1500 kPa) in both seasons after harvesting and would normally receive excess cultivation. Using variable tillage practices there is a reduction in cultivation cost by £25/ha while the cost of the strength measurements was only £4.30 per hectare. With variable rate cultivation 6.7 litre diesel /hr can be saved in low strength areas, so environmental pollution can also be reduced due to a decrease in CO_2 emissions by 39%. It is also very cheap and quick to measure spatial variation of soil physical properties in a field with automated cone penetrometer and time domain reflectrometry, for example, only ~ 0.5 hr/ha is needed to take measurements for soil strength. The Differential Global Positioning System (DGPS) was used to locate the exact position of soil and crop samples within the field. Spatial variation in soil and crop parameters was quantified using the Geographical Information System (GIS). Based on the knowledge of spatial distribution in soil physical properties and crop yield, the division of the field into sub-field regions may be appropriate for developing a differential management strategy for appropriate cultivation for the ensuing crop.

Introduction

Precision farming offers the opportunity to manage inputs and tillage operations within the field in response to measured spatial variation in crop and its environmental conditions. Soil physical conditions are very important for good crop production as they control the root environment and hence moisture and nutrient uptake. Soil physical conditions and crop responses may change considerably with space and time (Boone, 1988). Spatial variation in bulk density, soil strength and soil moisture can all affect crop performance (Voorhees *et al.*, 1975; Kulkarni and Savant, 1977). For a specific moisture content, the soil strength increases with clay content (Ayers and Perumpral, 1982). Roots may penetrate compact soil in wet conditions but growth may be greatly restricted as the soil dries and strength increases (Chaudhary and Sandhu, 1983; Taylor and Arkin, 1981). A negative linear relationship between soil strength and water content has been reported by Douglas (1986); Ghuman and Lal (1984), Hill and Cruse (1985); and Raghvan *et al.* (1979).

Increased soil strength causes a reduction in root growth parameters, such as root number, mean and total root length, rate of root elongation and fresh and dry root mass (Taylor, 1971). The critical soil strength for root growth ranges from 7 MPa in coarse textured to 2.5 MPa in clay soil (Gerard *et al.*, 1982). Soil strength is affected by a number of factors, including bulk density, soil moisture, soil texture and soil organic matter. Soil strength has also a major effect on ease of cultivation (Barley, *et al.*, 1965; Taylor, 1971).

Cultivation practices affect plant growth by reducing the bulk density or loosening the soil. This increases macro-porosity by separating the soil aggregates and affects the aeration, nutrient accessibility, drainage rate and water holding capacity of the soil (Bhushan and Ghildyal, 1972; Lal, 1971). But improperly used, tillage can lead to deterioration of soil structure, reduced infiltration, reduced nutrient uptake, accelerated erosion and runoff, and pollution of water resources.

Materials and Methods

Soil data were collected in 1996 and 1997 from 8.2 ha field at Welton field, Nafferton farm, University of Newcastle upon Tyne, UK (54° 59′ N, 1° 54′ W and at an elevation of 90 m above mean sea level; NZ 091641). 89 sample points were selected for soil physical properties following the tramlines. Soil samples were spaced on approximately a 20 m × 40 m grid to provide relatively uniform coverage over the entire area. The data for spatial analysis of soil physical properties, (soil strength, bulk density and soil moisture) were collected, using automatic devices, Computerized tractor mounted cone penetrometer and a Time Domain Reflectrometry (Hector, 1995). Bulk density measurements were made to calibrate the cone index values. The soil strength measurements were taken up to 30 cm depth due to the limitations of cone penetrometer. The exact locations (x, y co-ordinates) of all the sampling points were obtained using the DGPS.

The crop was harvested using a Deutz Fahr combine harvester equipped with an RDS Ceres yield meter, Hermes data logging system with RDS moisture sensor and Navstar Differential Global Positioning System (DGPS). The ADIS (Agricultural Data Interchange Syntax) format was used (Yule *et al.*, 1995).

Statistical and geostatistical analysis was performed in order to examine the extent of heterogeneity of the soil and crop yield in a field using the Geographical Information System (GIS), UNIMAP (UNIRAS A/S, 1989) and MINITAB. Then the data were converted into a map form using the "fault" procedure in UNIMAP in order to estimate the scale of variability. This has been shown to be the most successful of the map realisation methods for modelling data sets from the fields (Mohamed *et al.*, 1997). The application maps were also produced for appropriate cultivation before sowing the crop.

Results

The crop yield does not vary greatly within two years (**Table 1**). The CVs are moderate and yields are negatively skewed. Soil strength was more variable than other soil properties. Soil texture and moisture did not vary greatly within the field in both years. Yields were positively correlated with clay (r = 0.554, r = 0.520) in 1996 and 1997 respectively. Yield correlated negatively with soil strength in both years.

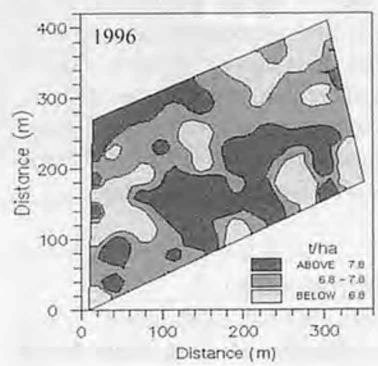
The semivariograms of yield and soil properties attained large range of influence. The sills were larger than the nuggets (**Table 2**) to indicate that the variation of all soil properties and crop yield is non-random, and justify the production of maps by interpolation (Mc Bratney and Pringle, 1995).

There were substantial areas of low yield and high soil strength in both years (**Fig. 1**).

Maps of wheat and barley yield also show gradual and non-random spatial patterns for both seasons (**Fig. 1**). Low yielding areas are located in the SE and NE corners of the field and high yielding areas located in the middle of the field and NW corner of the field.

The contour maps of the soil properties for both years show non-random spatial patterns.

These maps also show gradual progressive change across the field. (**Figs 2** and **3**). A 20 m × 20 m



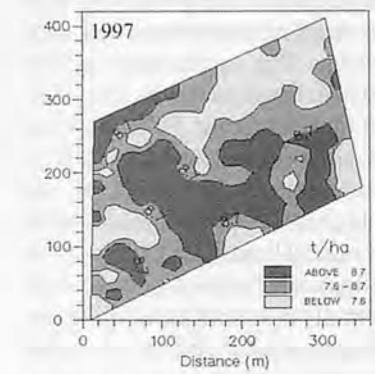


Fig. 1 Contour maps of yield for 1996 and 1997.

Table 1. Univariate Statistics of Crop Yield and Soil Physical Properties

Soil Property	Mean 1996	Mean 1997	CV (%) 1996	CV (%) 1997	Skewness 1996	Skewness 1997
Crop yield (t/ha)	7.30	6.92	20.19	19.96	−0.78	−0.33
Soil strength (kPa)	1459	1497	40.6	29.7	0.62	0.73
Soil moisture (%)	27.5	26.9	11.1	12.7	0.42	1.01
Bulk density (g/cm^3)	1.43	1.44	5.77	4.14	0.14	0.61
Clay (%)	26.2	-	11.0	-	−0.49	-

Clay only measured in 1996.

Table 2. Geostatistical Parameters of Soils and Crops in 1996 and 1997

Soil Property	Sill 1996	Sill 1997	Range (m) 1996	Range (m) 1997	Nugget 1996	Nugget 1997
Crop yield (t/ha)	1.86	2.26	100	105	1.52	1.61
Soil strength (kPa)	347280	195340	120	140	245000	150000
Soil moisture (%)	9.2	11.5	120	100	6.5	8.1
Bulk density (g/cm^3)	0.007	0.003	140	140	0.003	0.002
Clay (%)	8.13	-	100	-	5.70	-

Clay measured only in 1996.

grids of soil properties for both growing seasons were overlaid after interpolation and classification into three groups (Mulla and Bhatti, 1997). Approximately two-thirds of the field area was in the same class for each soil property in both years (P<0.0001***).

Discussion

There are high soil strength areas within the field after harvesting (**Fig. 2**) where intensive cultivation is required to minimize the adverse effects of excessive soil strength and there are also some parts within the field that have low soil strength that need less cultivation.

In spite of spatial variation in soil strength and texture (**Figs 2** and **3**), typical uniform field operations are being applied at the Nafferton Farm. The normal tillage practices are that a mouldboard is used every year for deep ploughing. Power harrow combined with drill is used for seedbed preparation and sowing of crop. However, based on the results there is a need for site-specific tillage within a field for the proper management of soil at each location. This should provide suitable conditions for crop establishment and subsequent crop growth and reducing the costs of crop production and atmospheric pollution. (Kepner *et al.*, 1978).

In present study, only one-third of the field has a soil strength above the critical limit (1500 kPa), at which deep cultivation using mouldboard or chisel plough (**Fig. 2**) following power or tine harrow and drill is required. The use of uniform tillage operations would lead these areas of high soil strength receiving too little cultivation (Taylor, 1971). The remaining two-thirds area of the field will receive more cultivation than is needed and in these parts of the field only the use of the power harrow combined with drill is needed for cultivation and sowing (**Fig. 4**).

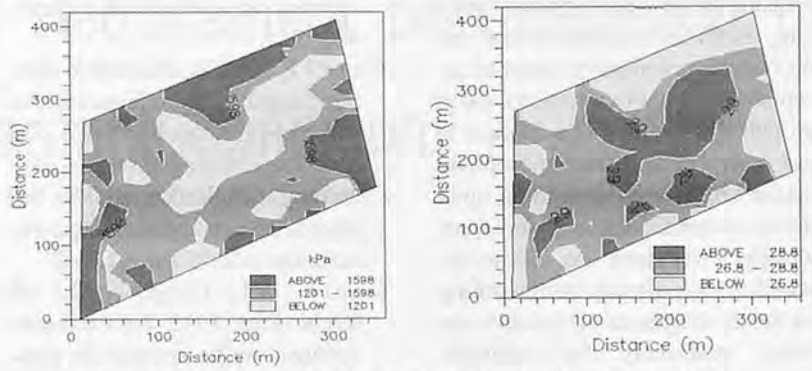


Fig. 2 Contour map of soil strength (left) and soil moisture (right).

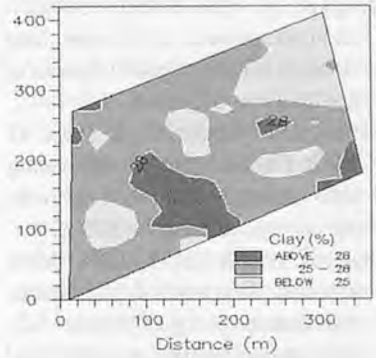


Fig. 3 Contour map of clay content.

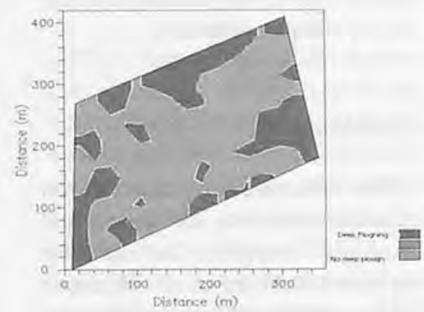


Fig. 4 Areas that require intense cultivation and less intense cultivation.

In addition to improving crop production with variable rate tillage within the field, one-third of the cultivation cost could be reduced by using only power harrow in the areas having soil strength less than the critical limit (**Table 3**). Also, a mouldboard plough should typically achieve a work rate of 0.9 ha/hr, 42% less than power harrow (**Table 3**). Using the power harrow only in the areas of the field with low strength, the driver's costs of £16.00 could also be saved for this field (Nix, 1999).

Atmospheric pollution can also be reduced with less fuel consumption through variable tillage practices, because the cultivation of excessively strong soil requires appreciably more energy than low strength soils. This can lead to extra fuel combustion and also increased CO_2 and NO_x emissions (Voorhees and Hendrick, 1977; Dickson *et al.*, 1992).

This means that soil strength will have a marked effect on the overall contribution of such soils to the increase in atmospheric pollution, cost of cultivation and delay the completion of work. Variable rate tillage avoids these problems and can be applied, for example, only to areas with high soil strength. Therefore, in-

Table 3. Cost and Time Analysis for Cultivation with Conventional and Variable Tillage System

Year	Conventional tillage: Mouldboard+harrow+drill			Variable tillage: Mouldboard+harrow+dril				Variable tillage: Power harrow+drill				Ave. cost/ha (£)
	area (ha)	cost/ ha (£)	ha/ hr	area (ha)	area (%)	cost/ ha (£)	ha/ hr	Area (ha)	area (%)	cost/ ha (£)	ha/ hr	
1996	6.84	71	1.0	2.2	32	71	1.0	4.64	68	34	1.5	46
1997	6.84	71	1.0	2.7	40	71	1.0	4.14	60	34	1.5	49

Source: (Nix, 1999) Farm management pocket book.

creasing the desire to maximize work rate, minimize cultivation cost and fuel consumption and produce an acceptable soil environment for plant growth, has resulted in a demand to use more efficient and appropriate tillage implements depending upon the local conditions, e.g. soil type, weather conditions etc. Some researches have already been working on the development of variable rate tillage machinery. For example, Scarlett *et al.* (1997) developed a tractor-power harrow integrated control system for variable rate secondary tillage operations.

Conclusion

The within-field variation in soil physical properties, soil texture and crop yield supports the need for variable rate tillage as an alternative to the traditional whole-field approach. Soil strength was consistently very high or very low in some parts of the field after harvesting in both seasons. Based on this information, division of field into sub-field regions may be appropriate for developing a differential management strategy for appropriate cultivation for the ensuing crop. The results also indicate that using variable tillage practices, one-third of the cultivation cost can be reduced, atmospheric pollution can be decreased and work rate can be increased.

REFERENCES

Ayers, P.D. & Perumpral, J.V. 1982. Moisture and density effect on cone index. *Tansactions of the ASAE,* **25(5),** 1169-1172.

Barley, K.P., Farrell, D.A. & Greacen, E.L. 1965. The influence of soil strength on the penetration of a loam by plant roots. *Australian Journal of Soil Research,* **3**, 69-79.

Bhushan, L.S. & Ghildyal, B.P. 1972. Influence of radius of curvature of moldboard on soil structure. *Indian Journal of Agricultural Science,* **42**,1-5.

Boone, F.R. 1988. Weather and other environmental factors influencing crop responses to tillage and traffic. *Soil and Tillage Research,* **11**, 283-324.

Chaudhary, A. & Sandhu, M. 1983. Soil physical environment and root growth. *Advances in Soil Sci*ence, **1,** 1-43.

Dickson, W.J., Campbell, D.J. & Ritchie,R.M. 1992. Zero and conventional traffic systems for potatoes in Scotland, 1987-1989. *Soil and Tillage Research*, **24**, 397-419.

Douglas, J.T. 1986. Effects of season and management on the vane shear strength of a clay top soil. *Journal of Soil Science*, **37**, 669-679.

Gerard, C.J., Sexton, P. & Shaw, G. 1982. Physical factors influencing soil strength and root growth. *Agronomy Journal*, **74**, 875-879.

Ghuman, B.S. & Lal, R. 1984. Water percolation in a tropical Alfisol under conventional ploughing and no–tillage systems of management. *Soil and Tillage Research*, **18**, 37-45.

Hector, J.E.M. 1995. *A tractor mounted Cone Penertometer.* M. Phil thesis, University of Newcastle upon Tyne.

Hill, R.L. & Cruse, R.M. 1985. Tillage effects on bulk density and soil strength on two Mollisols. *Soil Science Society of America Journal*, **49**,1270-1273.

Kepner, R.A., Bainer, R. & Barger, E.L. 1978. Principles of farm machinery, 3rd. edn. AVI Publishing Co. West port, Connecticut.

Kulkarni, B.K & Savant, N.K. 1977. Effect of compaction on root-cation exchange capacity of crop plants. *Plant and science*, **48**, 269-278.

Lal, R. 1971. Tillage and agricultural sustainability. *Soil and Tillage Research*, **20**, 135-146.

Mc Bratney, A.B. & Pringle, M.J. 1997. Spatial variability in soil-implication for precision agriculture. In: *Proceedings of Ist European Conference on Precision Agriculture*, Warwick University Conference Park. 8-10 September. pp. 3-33.

Mohamed, S.B. 1997. *Management of spatial patterns in soil acidity and in P and K fertility using geostatistics and mapping techniques to improve crop performance*. PhD thesis, University of Newcastle Upon Tyne.

Mulla, D.J. & Bhatti, A.U. 1997. An evaluation of indicator properties affecting spatial patterns in N and P requirements for winter wheat yield. In: *Proceedings Ist European Conference on Precision Agriculture*, Warwick University Conference Park, 8-10 September. pp. 145-155.

Nix, J. 1999. *Farm management pocketbook. 29th edition.* Wye College, London.

Raghvan, G.S.V., McKyes, E., Taylor, F., Richard, P., Douglas, E., Negi, S. & Watson, A. 1979. Corn yield effected by wheel compaction in a dry year. *Canadian Agricultural Engineering Journal,* **21**,27-29.

Scarlett, A.J., Lowe, J.C. & Semple, D.A. 1997. Precision Tillage: In - field, real-time control of seedbed Quality. In: *Proceedings of Ist European Conference on Precision Agriculture,* Warwick University Conference Park, 8-10 September. pp. 503-510

Taylor, H. M. 1971. Effects of soil strength on seedling emergence root growth and crop yield pp. 292-305. In *compaction of agricultural soils*. American Society of Agricultural Engineers Monograph.

Taylor, H.M. & Arkin, P.S. 1981. Root zone modification: modifying the root environment to reduce crop stress. *ASAE Monograph No.* 4, St. Joseph, MI.

UNIRAS A/S. 1989. *Unimap 2000 Users Manual.* Soborg, Denmark.

Voorhees W.B., Farrel, D.A. & Larson, W.E. 1975. Soil strength and aeration effects on root elongation. *Transactions of the ASAE,* **31,** 948-953.

Voorhees, W.B. and Hendrick, J.G. 1977. Compaction: Good and bad effects on energy needs. *Crops Soils Magangement,* **29,** 11-13.

Yule, I. J., Cain, P. J., Evans, E. J. & Venus, C. 1996. A spatial inventory approach to farm planning. *Computers and Electronics in Agriculture,* **14,** 151-161. ■■

Audit of Energy Requirement on Cultivation of Rice for Small Farming Condition

by
Ajay Kumar Verma
Associate Professor (FIM)
Faculty of Agril. Engineering
I.G. Agricultural University
Raipur, Madhya Pradesh
INDIA

Abstract

Experiments were conducted to study the energy input for growing rainfed paddy by traditional and improved methods under bullock farming condition. Soil parameters such as moisture content bulk density, clod mean weight diameter and soil inversion were compared. The crop parameters such as germination, number of plants per sq. m, tillering, plant height and yield were also studies. The energy inflow comprised of the direct energy for seedbed preparation, fertilizer and sowing application, harvesting, threshing and indirect energy of seed, fertilizer and chemical. The highest energy consuming operation in paddy production were for weeding followed by tillage and threshing. The energy inflow were 1830.12, 1108 and 165.25MJ/ha for, weeding tillage and threshing, respectively. The corresponding values under improved method were 1069.56, 1028.8 and 576.8 MJ/ha respectively. On the basis of output/input ratio, the improved method was more an energy-efficient system than traditional system. The yield on improved method was 3.425 ton/ha, which was significantly higher than traditional method (2.509 ton/ha).

Introduction

The Southeastern part of Madhya Pradesh is called Chhattisgarh which is mainly mono-cropped rice area. However, about 20% of the total area is planted to pulses and oilseed crops, mostly grown under relay cropping condition. The productivity of rice, on the average, is 1.3 ton per ha which is quite low as compared to the national average of 1.8 ton/ha. All kharif crops are sown by broadcast system. About 80% of the rice area is under traditional broadcast "biasi" system of cultivation. The biasi is usually delayed due to erratic distribution of rainfall, frequent dry spells and early withdrawal of monsoon. These have been common occurrence in this region often leading to failure of the rice crop. To overcome the inherent defects of broadcast biasi, line sowing technology was introduced in recent past. The line sowing offers a possible solution to various production constraints imposed by the broadcast biasi system. Biasi is not so dependent on water requirement.

Singh and Chancellor (1975) reported that the total energy used per hectare in growing various crop increased with an increase in mechanization level. They also observed that the average energy consumed by various levels of mechanical technology for rice crop varied from 879 kWh/ha for conventional farms using animal power to 2195 kWh/ha for tractorized farms. Tewari et al., (1987) observed that paddy production operation in the laetrile soil zone of West Bengal was labor intensive as only conventional implements were used. The commercial energy inputs for rice production ranged from 1556 to 2133 MJ/ha, while those of non-commercial energy inputs varied between 4377 and 4801 MJ/ha. The average yield of rice varied from 1.6-2.4t/ha and the output-input ratio for the main product ranged from 4.0 - 5.5. Rutger et al., (1987) reported that US rice production is highly mechanized, with only 20-30 man-h of labor per hectare, compared to 800 or more man-h per hectare in developing countries. They also found that in Philippines fossil fuel inputs in upland rice require minimum mechanization in land preparation. Fertilizer is not generally used, weed control is commonly done by hand with about 300 man h/ha for weeding. Singh G (1996) reported that for rice production/ha bullock-operated farms required 890 man-h and 180 bullock pair-h, while bullock and tractor operated farms require 830 man-h, 60 bullock pair-h and 8-tractor h.

The objective of this study was to determine the actual energy inflows for raising the rice crop on broadcast system (traditional method) and online sowing methods of cultivation from tillage to threshing. The study should provide a basis for identify-ing the suitable machinery management system under given soil condition.

Materials and Methods

The experiment was conducted at the Faculty of Agricultural Engineering Farm, Raipur, in 1996-97 to 1998-99. The soil was loam with 42.4% sand, 35.6%silt and 22% clay. On average, the initial bulk density and cone index for the depth of 0-150 mm was 1.60g/cc. and 8.87 kgf/cm^2, respectively, at average moisture content 14.7%. The experiments used on animal-drawn farming situation traditional method using traditional implements and improved method using of improved implement. There were three replications in completely randomized block design for growing rice. Singh et al., (1988) classified the farmers as marginal small, medium and large on the basis of their land holdings. The same criteria were followed by taking small farmers (1-<2ha) practice of paddy cultivation as traditional method.

The area of each plot was 20 × 40m.

The measurement of draft, speed and operational time for each operation were done separately. The electricity consumption was recorded by using energy meter and time was noted with the help of stopwatch. The recommended doses of fertilizers were applied. The crops were grown under rainfed condition. Observations on germination, tillering and yield were recorded. The quantum of energy consumed in each operation was calculated. The energy equivalence for direct and indirect sources suggested by Mittal et al., (1985) is shown in **Table 2**

Table 1. Details of Operation for Rice Cultivation

Traditional method / farmers' practice	Improved method
(A) Seed bed preparation Primary tillage (i) Country plough × 2	(A) Seed bed preparation Primary tillage (i) MB Plough × 2 (Animal drawn, 15 cm width) Secondary tillage (ii) Disc harrow × 1 (4 disc 80 cm working width)
(B) Sowing / fertilizer application (i) Manual fertilizer broadcasting (ii) Manual seed broadcasting (iii) Country plough × 1 (vi) Planking (to cover seed) by animal drawn plank (2.20m)	(B) Sowing / fertilizer application (i) Manual broadcasting of fertilizer (ii) Sowing by animal drawn seed drill (3 Row, 60 cm) (iii) Planking (to cover seed) by animal
(C) Irrigation -without irrigation but in fields that are bunded to impound rainfall	(C) Irrigation – without irrigation but in fields that are bunded to impound rainfall
(D) Intercultural operation/weed control by traditional biasi system (i) Country ploughing × 1 (ii) Gap filling (iii) Manual hand weeding	(D) Intercultural operation/weed control (i) Mechanical weed control by Manual operation (a) 3- Tine weeder (b) Japanese type paddy weeder
(E) Plant protection (i) Insecticide spraying as per requirement	(E) Plant protection (i) Insecticide spraying as per requirement
(F) Harvesting by traditional sickle, bundling and transportation	(F) Harvesting by improved serrated sickle, bundling and transportation
(G) Threshing by animal treading and winnowing	(G) Threshing by power thresher and winnowing

Table 2. Energy Equivalence for Direct and Indirect Sources

Particulars	Unit	Equivalent Energy (MJ)	Remarks
(1)Human			
Adult-man	Man-h	1.96	
Woman	Woman-h	1.60	
(2)Animals			Weight of bullock 350-450 kg
Medium size bullock	Pair-h	10.1	
(3) Electricity	kWh	11.9	
(4) Agricultural machinery	kg	62.7	Distributing the manufacturing energy uniformly over the life, based on weight
(5)Chemical fertilizer			
(a)Nitrogen	kg	60.1	
(b) P_2O_5	kg	11.1	
© K_2O	kg	6.7	
(6)Seed-cereal paddy	kg	14.7	The main out put product is grain
Straw	kg	12.5	
(7) Superior chemicals	kg	120.0	Needing dilution

Results and Discussion

Seedbed Preparation

The comparative energy requirement for tillage by farmers' practices and tillage operation by improved method is shown in **Table 3**. The quality of seedbed was better for the improved method (with two passes of MB plow and one pass disc harrow) as compared to the traditional method (two passes of country plow). The bulk density, clod mean weight diameter and percentage of soil inversion for final seedbed for improved method were 1.36g/cc, 24.6 mm and 92.1% whereas, they were 1.448/cc, 38.4mm and 68.3%, respectively, for the traditional methods. The quality of tillage was compared with performance index (PI) using equation (1). The PI was 20.86 and 9.91 respectively for improved and traditional method. The energy is calculated by using draft, speed of operation and operation time in hours per hectare. The energy required by improved implements was less (1028.85 MJ/ha) compared with the traditional method (1108.4 MJ/ha).

Energy Requirement for Sowing

The seeds and fertilizers were applied by manual broadcasting system in the traditional method of rice cultivation. Energy consumption was calculated by man-hour requirement per ha. In the improved method, fertilizer was applied by broadcasting and seed drill was used for sowing. In both methods, the standard dose of fertilizer 80:50:30 was applied and animal drawn plank was used to cover the seeds.

Table 3. Soil Parameters and Energy Input for Seedbed Preparation

Operation	Soil moisture content (d.b.) (%)	Bulk density (d.b.) (g/cc)	Clod mean weight diameter (mm)	Soil inversion (%)	Furrow cross section area (cm^2)	Unit draft (kgf/cm^2)	Field capacity (ha/d)	Field efficiency (%)	Direct energy input (MJ/ha)		Total energy (MJ/ha)
									Animal	Human	
(A_1)Traditional Method (Farmers Practice)				Tillage Operation by Country Plough							
First Ploughing	12.87	1.51	60.71	52.4	62.40	0.972	0.1572	66.7	512.79	109.76	622.53
Second Ploughing	11.62	1.44	38.40	68.3	67.48	0.849	0.2044	70.2	395.70	90.16	485.86
				Sub total energy input for seed bed preparation (A_1)					908.47	199.92	1108.39
(B_1) Improved Method		Tillage Operation by Improved implement									
First Ploughing	12.58	1.43	52.6	69.5	94.0	0.677	0.2108	68.6	405.5	88.20	493.71
Second Ploughing	11.36	1.38	31.7	80.7	115.8	0.524	0.2335	65.2	370.2	78.40	448.56
Harrowing	12.15	1.36	24.6	92.1	-	-	0.8775	72.8	70.9	15.68	86.58
				Sub total energy input for seed bed preparation (B_1)					846.6	182.28	1028.85

The farmers in this region use 80 to 120 kg seed per ha, to get high plant population to outgrow the weeds. The average seed rate for the study was 104 kg/ha and 69 kg/ha for traditional and improved method, respectively. The energy consumed for sowing is shown in **Table 4**. On average, 180 MJ/ha and 82 MJ/ha energy input were required for sowing by improved and traditional method, respectively.

Energy Requirement for Weeding

Weeds were controlled by biasi followed by manual weeding and gap filling in traditional method. In this method with the commencement of monsoon when there was an accumulation of 10-15 cm water, the 4-6 weeks old crop were ploughed by country plough followed by manual weeding and gap filling. Energy input for biasi and manual weeding for traditional method and energy input for mechanical weeding in improved method (line sown crop) are give in **Table 5**. Weeding operation was recognized as the highest energy consuming operation. There was significantly difference between the energy consumptions for weeding under these two systems of farming. The weeding operation in improved system consumed about 750 MJ/ha less energy as compared to traditional system.

Effect of Cultivation System of on Crop Parameters

Table 4. Energy Input for Sowing

Operation	Energy input (MJ/ha) Direct energy Human	Animal	Indirect energy	Total Energy (MJ/ha)
(A_2) Traditional Method				
(i)Fertilizer application	9.92	-	-	9.92
(ii) Broadcasting of seed	12.83	-	-	12.83
(iii) Planking	13.72	46.35	-	60.07
Sub-total energy input for sowing (A_2)	36.47	46.35	-	82.82
(B_2) Improved Method				
(i)Fertilizer application	10.04	-	-	10.04
(ii) Sowing of seed by seed drill	24.40	92.05	6.6	123.05
(iii) Planking	7.81	39.45	-	47.26
Sub-total energy input for sowing (B_2)	42.25	131.50	6.6	180.35

Table 5. Energy Input for Interculture Operation

Operation	Direct energy input (MJ/ha) Human	Animal	Total Energy (MJ/ha)
(A_3) Traditional Method			
(i)Biasi by animal drawn country plough	32.88	166.04	198.92
(ii) Gap filling by manual labour	147.20	-	147.20
(iii)Manual hand weeding	1484.00	-	1484.00
Sub-total energy input for interculture operation (A_3)	1664.08	166.04	1830.12
(B_3) Improved Method			
(i)Mechanical weed control by manual operated hand weeding implement (3 tine and Japanese paddy weeder)	1069.58	-	1069.58
Sub-total energy input for interculture operation (B_3)	1069.58	-	1069.58

Table 6. Effect of System of Cultivation on Crop Parameters

Cultivation System	Germination count per m^2	Tillering count per m^2	Average height of plants cm	Average height of penicle cm	Grain yield kg/ha	Straw kg/ha
Traditional	57	181	67	18.3	2509	3488
Improved	85	236	75.8	22.08	3425	3820

The effects of various treatments on germination, tillering and yield on **Table 6** show that the germination rate, tillering and yield were maximum for the improved method which gave an average yield of 3435 kg/ha which was 36.5 greater than that of the traditional method of 2509 kg/ha. The mean yield due to both methods differed significantly at 1% level of significance. The greater yield under improved method was due to better tilth condition, better germination rate, higher numbers of tillers per unit area, and healthy plants. Proper utilization of fertilizer and row-to-row seeding also promoted better sunlight penetration.

Energy Input for Plant Protection, Harvesting and Threshing

The direct and indirect energy

Table 7. Energy Input for Plant Protection, Harvesting and Threshing

Operation	Direct energy input (MJ/ha)				Indirect energy input (MJ/ha)	Total energy (MJ/ha) (Direct+Indirect)
	Human	Animal	Electric	Total Direct		
Traditional Method (A_4)						
(i)Plant protection	-	-	-	-	-	-
(ii)Harvesting	432.30	-	-	432.30	-	432.30
(iii)Bundling and transportation	205.26	85.3	-	290.56	-	290.56
(iv)Threshing and winnowing	84.45	80.8	-	165.25	-	165.25
(iv) Seed energy	-	-	-	-	1528.80	1528.80
(iv) Fertilizer energy	-	-	-	-	5604.00	5604.00
Chemical energy	-	-	-	-	-	-
					Sub Total (A_4)	8010.91
Improved Method (B_4)						
(i)Plant protection	8.55	-	-	8.55	2.50	11.05
(ii)Harvesting	387.91	-	-	387.91	-	387.91
(iii)Bundling and transportation	152.50	89.5	-	242.00	-	242.00
(iv)Threshing	38.00	-	318.0	356.00	220.00	576.80
(vii) Seed energy	-	-	-	-	1293.60	1293.6
(viii) Fertilizer energy	-	-	-	-	5604.00	5604.00
(ix) Chemical energy	-	-	-	-	30.00	30.00
					Sub Total (B_4)	8115.36

Table 8. Output - Input ratio for Traditional and Improved Methods of Rice Cultivation

Cultivation system	Energy output			Energy input		Energy out put – input ratio	
	Grain	Straw	Total	Direct + energy input tillage to threshing	Direct + indirect energy from tillage to threshing	Tillage to threshing	Total (direct + indirect)
Traditional	3.6882	4.360	8.0480	3.908	1.1040	20.63	7.28
Improved	5.0347	4.775	9.8097	3.273	1.0423	29.97	9.41

consumed per hectare for various operations is shown in **Table 7**. Energy consumed in the traditional method for harvesting bundling and transportation and seed energy requirement were greater than that of the improved method. Energy consumption for threshing for the traditional method was less, due to less grain yield in comparison with the improved method. It is interesting to note that the threshing cost for unit weight was much higher for the traditional method because of the use of animal and human energy. The amount of fertilizer for both treatments was similar at 5604 MJ/ha. Under the traditional farming method the energy due to the seeds was 33.6% higher than that for the improved system.

Energy Output- Input Ratios

The energy available from grain and straw represents the energy output whereas that consumed in various operations represent energy input. (Gupta et al., 1994). The energy from grain straw tillage to threshing operation, and total direct and indirect energy, including seeds, fertilizer and chemical energy and energy output input ratio are shown in **Table 8**.

Conclusion

From the above results following conclusions are drawn:

1. The line sowing /improved method of cultivation is most effective in view of energy saving and better yield as compared to the traditional broadcast biasi system of cultivation for rice.
2. Weeding is the highest energy consuming operation in rice production. The direct energy consumed for weeding by mechanical weeder was 1069 MJ/ha and which was 71 percent less than that of the traditional method.
3. The soil parameters such as bulk density and mean weight diameter were minimum for the improved method. They were 1.38 g/cc and 24.6 mm, respectively.
4. Germination and tillering per square meter and yield/ha were maximum in the case of the improved method and were 85/m^2, 236/ m^2 and 3425 kg/ha, respectively.
5. The energy output- input ratio, on the basis of total product, was higher for the improved method 9.41 than the traditional method (7.28).

REFERENCES

Gupta, D.K., Singh, Bachchan and Mishra T. N. (1994) Studies on Different tillage treatment for growing wheat under Paddy-wheat rotation. Journal of Agricultural Engg. 1.5 A.E. vol xxx1 No., 1 to 4 Jan-Dec. 1994. pp 65-80.

Mittal, V.K. Mittal J.P., and Dhawan K.C. Researd (1985) Digest an Energy Requirements in Agricultural sector. All India co-ordinates Research Project Energy Requirements in Argil Sector Punjab Agril. Sector Punjab. Agril University Ludhiana.

Singh, G and Chanceller W.J. 1975 Energy ijnputs and agril production under various regines of mechanization in northern India. Transactions of the ASAE 18(2) pp 252-259.

Singh (1961) Energy input in production Agricultural of India Proceeding of national conservation of Agril Engineers. The Institution of Engineers (India) pp 1-20. ■■

Development of Devices Suitable to Manufacture Paneer at Farm Level

by
Ashok Kumar Agrawal
Associate Professor
College of Dairy Technology
I.G. Agricultural University
Raipur (C.G.) 492 012
INDIA

Hrishikes Das
Professor and Chairman
Post Harvest Technology Center
Indian Institute of Technology
Kharagpur (W.B.) 721 302
INDIA

Abstract

In developing countries like India, milk producers/dairy farmers are always at the receiving end due to the perishable nature of milk which must be sold immediately at whatever prices prevailing at that particular day. Now, however, there is a simple technology available for converting milk into some indigenous milk products like paneer. In India, some devices have been developed which can be employed profitably for manufacturing paneer at the farm level. In this article, information' on the development of such devices have been compiled, the operation of which is discussed.

Introduction

In Europe and America, different types of cheese are consumed widely. "*Paneer*" is synonymous to cheese. It is very popular in some countries in Western and Southern Asia including India. Because of similarities, paneer is also called white cheese or Indian cheese.

Paneer is an important protein-rich dairy product used widely as ingredient in the preparation of various culinary dishes and snacks. It is a highly nutritious food and has great value in the diet as it contains, in concentrated form, almost all proteins and fats of original milk. In India, the annual milk production increased from 21.37 million tons in 1970 to 60.80 million tons in 1994 (Punjrath, 1995), In India, about 5 percent of the total milk produced is converted paneer (Sachdeva, 1985 and Mathur, 1991).

For a farm which is engaged in the production of milk, it will be more profitable when whole or part of milk produced is converted into paneer. A simple technology to manufacture paneer with minimum labour cost shall encourage the farmer to venture in its production. In this paper, an attempt is made to outline the development of devices of small capacity that can be suitably adopted to manufacture paneer at the farm level.

Traditional Method of Paneer Production

Milk (preferably buffalo milk) is heated to near boiling temperature and coagulated at 70°C (Bhattacharya *et al.*, 1971) using mostly citric acid or sour whey as coagulant. Whey is drained through muslin cloth and then the coagulant is filled and pressed in hoops to form blocks. Blocks thus formed are dipped in chilled water for firming their body. The product obtained is paneer.

Present Status of Paneer Production

In India, most of the manufacturers are small traders who purchase milk from dairy farmers. They manufacture paneer in small-scale level of meeting the local demands (Rajorhia *et al.*, 1984). Thus they are earn huge profit which must be earned by the farmers themselves. Indigenous milk products like *paneer* have an excellent market, hence profitability of dairy farmers can be increased by adopting its manufacture at the farm level.

Potentiality of Mechanization of Paneer Production

At the household level, the traditional method of paneer production is quite simple. However, to produce it in small-scale level is urgently required. The pressing of curd and chilling of pressed curd are essential steps in paneer production. Hence, any device capable of pressing and chilling shall prove to be of utmost importance.

The adoption of '*tofu*' (a Japanese product) manufacturing process has been suggested (Mathur, 1991; Mathur *et al.*, 1991). In view of the synergism in unit operations involved in the manufacture of tofu from soymilk, excellent potential exists for the mechanization of paneer production.

Mechanization of Paneer Production

Mechanization for production of

paneer was attempted by many workers (Kumar, 1984; Aheer, 1986; Chatterji and Lobo, 1992; Mudgal, 1993; Agrawal, 1997).

Kumar designed and developed a mechanical press for pressing of curd and whey drainage. This device consisted of a rectangular tapered channel made of perforated stainless steel plate. Curd was fed into the channel through a hopper at specific intervals. Pressing of curd was done by the action of a solid piston driven by a connecting rod and crank pulley. Whey was drained through the perforations and pressed curd was collected in the form of rectangular blocks.

Mudgal developed a paneer press for 20 liters of milk per hour capacity based on the counter rotating twin screws. For continuous feeding, standardized heated milk and coagulant were placed in a curdling bowl. Milk-acid mixture was held for a desired curdling time. The curdled mass was then directed into the twin screw device for whey drainage and curd matting. The system was able to maintain iso-thermal condition at 70 $\pm$ 2°C by providing a hot water- jacket around the barrel in which the twin screw was fixed. The matted curd mass was discharged through a die while the expelled whey was collected separately. Pressed curd was then cooled to room temperature. The texture quality of pressed curd varied considerably.

As shown in **Fig. 1**, a laboratory-scale paneer-making centrifuge (Agrawal, 1997) consisting of two concentric cylinders: inner, (1); and

Fig. 1 Double-wall basket centrifuge.

outer, (2); fixed on a base plate, (3); was fabricated with 1 kg curd handling capacity. Provision was made for filling the curd in the annular space between two cylinders, and outer cylinder was perforated and lined with muslin cloth that acted as a filter screen, (4). After completion of pressing, the inner cylinder was taken out and the centrifuge was rotated for chilling the pressed curd. During chilling, cold water was applied continuously on the base plate. After completion of chilling, paneer was taken out and cut into suitable sizes for consumption.

Conclusion

With huge amount of work related to agriculture and animal husbandry, farmers in the developing countries like India are already overburdened. They will be ready to start a new enterprise only when they are sure that it will not increase their drudgery further. The production of paneer with mechanized method shall fulfill this condition. With the adoption of any one of these paneer production devices, farmers should be able to earn conveniently higher remunerative prices.

REFERENCES

Agrawal, A.K. (1997) Studies on traditional and centrifugal methods of paneer production. Ph.D. Thesis, Indian Institute of Technology, Kharagpur, India.

Aheer, HL. (1986) Development and evaluation of a process for continuous production of chhana and paneer. M. Tech. Thesis, Indian Institute of Technology, Kharagpur, India.

Bhattacharya, D.C.; Mathur, O.N.; Srinivasan.M.R. and Samilk, O. (1971) Studies on the method of production and shelf life of paneer (Cooking type of acid coagulated cottage Cheese). Journal of Food Science and Technology, 8(9):117-120.

Chatterji, B. and Lobo S. R. (1992) Limitations of a conical surface centrifuge and design of cylindrical basket centrifuge for dewatering chhana. B. Tech. Thesis, Indian Institute of Technology, Kharagpur, India.

Kumar, R. (1984) Development of a mechanizes process for continuous drainage and pressing of paneer. M. Sc. Thesis, Kurukshetra University, Kurukshetra, India.

Mathur. B.N. (1991) Indigenous milk products of India: The related research and technological requirements. Indian Dairyman. 43(2): 61-74.

Mathur, B.N.; Hashizuma. K.; Musumi, S.; Nakazuwa, Y. and Watunabe, T. (1986) Traditional paneer in India and soybean food 'tofu' in Japan. Japanese Journal of Dairy Food Science, 35(3):A138-A141.

Mudgal, V.D. (1993) Studies on a whey filtration and matting system for mechanized production of paneer. Ph. D. Thesis, National Dairy Research Institute, Karnal. India.

Punjrath, J. S. (1995) Trends in packaging of milk and milk products. Indian Dairyman, 1 7 (5):29-40.

Rajorhia, G.S.; Dharam Pal and Arora K.L. (1984) Quality of paneer marketed in Karnal and Delhi. Indian Journal of Dairy Science, 37(2):274-276.

Sachdeva, S. Singh, S and Kanawjia, K.L. (1985). Recent development in paneer technology. Indian Dairyman, 37(11):501-505. ■■

The Mechanization of Agriculture in Jordan: Progress and Constraints

by
A. I. Khdair
Assistant Professor
Agricultural Engineering and Technology Department
Jordan University of Science and Technology
P.O. Box: 3030, Irbid,
JORDAN
E-mail: akhdair@just.edu.jo

N. H. Abu-Hamdeh
Assistant Professor
Agricultural Engineering and Technology Department
Jordan University of Science and Technology
P.O. Box: 3030, Irbid,
JORDAN
E-mail: akhdair@just.edu.jo

Abstract

This study analyzed the Jordanian experience in the technology adoption of mechanizing agricultural operations, including the factors that affect adoption rate. Manufacturing of tools and implements, maintenance and extension services to farmers are also addressed. The study indicates that aside from mechanizing a high percentage of land preparation and cereal harvesting, most other agricultural operations are performed manually which is costly, time consuming and results in high food losses. The major constraints to the adoption of technology were lack of education and awareness among farmers, small holdings and lack of alternatives.

Introduction

The total area of Jordan is 89,213 km^2, with a total population of 4,561,147 and a growth rate of 3.05% (July 1999 est.). Jordan is located in the Middle East with geographic coordinates: 31 00 N, 36 00 E. The percentage usage of land are: 4% arable land, 1% permanent crops, 9% permanent pastures, 1% forests and woodland and the rest are 85% arid desert with annual rainfall rate less than 200 mm. This means that the agricultural lands count for less than 10% of the total area, which was estimated at 0.68 million hectares. The irrigated area is about 63,000 hectares, most of it in the Jordan valley. The rainy season in the Northwest highland (November to April) has an average of 500 mm annual rainfall.

The agriculture sector plays an important role in Jordan's economy. As estimated by the country's Department of Statistics, 6.5% of the total gross domestic product was generated in the agriculture sector in 1981 and jumped to 10% in 1997. The major agricultural products are wheat, barely, citrus, tomatoes, melons, olives, sheep, goats and poultry. The labor force involved in agriculture decreased from 34% of total population in 1970 to 18% in 1980 to less than 10% in 1996, due to rapid transfer of labor from agriculture to other industrial and construction sectors. Some of the other reasons which led to this reduction in labor force are: scarcity of irrigation water which results in low yield, high cost of agriculture inputs, small holdings, lack of grading and transporting systems for agricultural produce, lack of supporting financial and institutional system, and low net incomes from agricultural production due to lack of good marketing system. (Snobar and Arabiat 1984).

In their study on a random sample of 492 legume farmers representing all areas in the Kingdom, Salem and Snobar (1995) found that the major constraints to the adoption of technology were non-availability of most technology components at the proper time, lack of awareness on the part of farmers, small holdings, low yields and the high cost of technology, especially harvesting technology. Although the adoption rate by the traditional farmers was low, there was an adoption of fertilizers, improved seeds, tillage implements such as chisel and sweep plow and seed drill. In the process of overcoming labor shortage in the agriculture sector, there has been a tendency toward mechanizing operations, particularly land preparation, irrigation and spraying.

The objective of this study was to discuss mechanization of agriculture in Jordan, farm machinery manufacturing, operation and maintenance, in addition to the major constrains to agricultural mechanization.

Mechanization in Jordan

The mechanization of agricultural operations would solve many of the problems facing Jordan's farmers. It will lead to increase yield, reduce cost and solution to the hand-labor shortage. Lack of education among farmers could be a reason for the continuing use of primitive tools and methods in cultivation. Other reasons could be that farmers might lack knowledge regarding the new technology, land topography or lack of alternatives. At present, farm mechanization in the rainfed areas of Jordan is limited to plowing, seed covering and grain harvesting. However, in the irrigated areas the operations of tillage, spraying and irrigation are also mechanized.

The government encourages farmers to own and use farm machinery in different ways such as organizing farm machinery show, holding field days, demonstrations, research on farm machinery and renting the farmers seed drills and spraying units with subsidized prices.

Farm mechanization in Jordan gained momentum with the successful implementation of two projects. The first project was called the Zarqa river basin project, which covers an area of 82,500 hectares. This project supplied the farmers since 1988 with suitable machines through project stations. The result now is an increasing use of suitable machines like chisel and sweep plows which replaced moldboards and disk plows that are not suitable to the area of the project. Due to this project, farmers started using spike harrow to destroy the capillary of the soil layer and thus keep the soil moisture down. For harvesting crops, combine harvesters with sacking system are used. Reaper binders are used for small and flat area for harvesting and gathering the crops. Most farmers use threshing machines driven by P.T.O shaft. Knapsack sprayer (manual and motorized types) are used in small areas, other sprayers (trailed and mounted types) are used in large fields. Press wheel rollers are used for soil leveling. Balers, rakes and mowers are used in forage production. Seed drill is used for planting seeds at proper depth. Recently, farmers began to use two-row potato planters, and potato diggers for planting and harvesting potato, respectively.

The second project is called "Increase in food production project". This project supplied the ministry of agriculture with tractors, plows, seed drill for orchard and boom sprayers, combine harvesters and other farm machineries. The government of Japan supported this project with additional $3.9 million in 1995 to buy fertilizers and farm machinery. This support will continue in the future. The equipment will be distributed to the agricultural directorates for renting or selling to farmers with long-term loans. Because of this support, Jordan reached self-sufficiency on tractors and various arm machineries at least to the beginning of the third millennium.

Farm Machineries

Farm machinery operation on large scale is limited to four sectors in Jordan. They own more than 60% of the machines throughout the country. Those owners can be grouped as follows:

Ministry of Agriculture (MOA), Jordan Valley Farmers Association (JVFA), Jordan Cooperative Organization (JCO), Private owners and large agricultural companies such as: Rum, Gramico, Arabic, Wafa and ASTRA company.

Due to small holdings and low yields, very few farmers own tractors. Local agricultural contractors carry out most of the mechanized farming operations. Contractor equipment consists of tractor, plows, a 3-m^3 water tank, trailer, and a thresher driven by P.T.O shaft.

The other source of machinery for agricultural operations is the Jordan Cooperation Organization (JCO) which supplies the farmers with machineries through three stations in the North, in the middle and in the South of the country. These machinery stations are well equipped but with few of them suitable for working in large fields.

Farm Machinery Manufacture

Most farm machineries in Jordan are imported. Little efforts have been done to manufacture heavy machines for agricultural applications. Local manufacturing is limited to assembly of imported components and mold implements. Blacksmiths are the main manufacturers of such implements. Machineries and implements are produced by three different enterprises: medium scale, small scale and artisan shops.

a) The medium-scale enterprise, "Rama" for assembling different types and models of farm machinery in Jordan. The company was established in 1986 to produce traditional equipments like 7-9 tine cultivators, 500-L mounted type boom sprayer, and 2-3 furrows moldboard plows (Fawzi Hamam 1996). In 1996 the factory started manufacturing seed drills, potato planters, potato diggers, chisel plows and post hole diggers. They have supplied 40-50% of the country's needs of the above tools.

b) Small-scale enterprises: There are six of them in the country. Three of them are located in Amman, the capital. These workshops can repair all kinds of implements by using new technology for cutting, shaping and finishing. Their main products are assembling cultivators, moldboard plows, disc plows, threshers P.T.O driven, trailers, water tanks, ridges and potato diggers. The other three workshops are located in Irbid 80 km to the north of Amman. They do similar jobs to those in Amman. Entrepreneurs and workers who run these workshops are not highly educated or trained, but they have long experience in this field.

c) Artisan workshops: The number of these small workshops is 43. They repair farm machineries and build traditional machines like water tank and trailers. The number of workers in each workshop is between 3-7. They are not really qualified workers as they have little experience. These workshops do other basic work like welding, metal hardening, grinding, cutting and drilling. Their basic equipment include mobile welding machines, plate roller and cutters, drills, grinder, air compressor, greasing unit, lathe machine, small crane and oxygen-acetylene torch.

Raw Material

Jordan imports 85% of the raw material used in the manufacturing process. This includes small gas engine, bearing, shanks, discs, blades, shock absorber and vertical springs, water pumps, spraying pumps, pressurized hoses, pressure gages, strainers, sealing, bolts and fasteners.

Different steel alloys with various components from scrap are molded together and used to produce different parts of farm machineries. For example, shock absorbers from trucks, as a durable raw material, are commonly used in workshops to make tines an sweeps furrow for different plows. Used steering axes from old lorries and trucks are used for building axes to water tanks.

Human Resources

There is a clear shortage of agricultural engineers in Jordan. For example, there are 93 agricultural engineers in the country. Some 20 of them are appointed by the Agriculture Ministry. Jordan is also suffering from shortage of extension services and skilled laborers.

Constraints

Beside small-holdings and land topography, the major constraint to mechanizing agricultural operations in Jordan are the local farmers. An extensive extension service is needed to carry out a national program to educate farmers and to explore the advantages of using new machines in their operations. The government should encourage small farmers to own new machines by subsidizing the prices of these machines with low interest rate. The major constraints can be summarized as follow:

a) Extension farm machinery services in the Ministry of Agriculture do not exist. Local farmers perform machine operation and maintenance based on their limited knowledge without any professional supervision. This leads to sudden break downs of machines due to misuse and lack of preventive maintenance.

b) Clear shortage of farm machinery engineers in Jordan. This was the main reason behind the establishment of the Agricultural Engineering and Technology Department in the College of Engineering at Jordan University of Science and Technology (JUST) in 1992.

c) Most dealers are not conversant about the proper and suitable farm machineries needed for the country.

Recommendation

Increasing farmer's awareness of the advantages and benefits of mechanization of agricultural process, which will result in cost and time savings and can increase technology adoption gradually in the agriculture sector. Other factors that can help apply new technology and upgrade the machinery assembly and manufacturing can be summarized as follows:

a) Establish training centers to provide training course related to proper farm machinery operations, maintenance and management. The staff should be well-trained and familiar with farmer's problems.

b) The government should disseminate information on the importance of using farm machineries to the farmers throughout newspaper, radio and TV programs;

c) Establishing research and development center for testing and developing new farm machineries;

d) Financial resources, i.e., loans special interest rate should be available to farmers in order to enable them to own suitable farm machineries; and

e) Encourage technology transfer in the country.

Results and Discussion

The government encourages small farmers to use modern farm machineries with subsidized rental prices. **Table 1** shows the actual operating cost of different machines per hectare. For example, the actual cost of combine harvester is $28 per hectare. The government charges the farmers $14.2/hectare which represents half the actual cost, while the private sector charges $28/hectare which is double the price extended by the government. As a result farmers could start using these machineries without any capital outlay.

The Ministry of Agriculture conducted two surveys on farm machinery in Jordan as shown in **Table 2**. There was a significant increase in the number of farm machineries in 1992 compared to 1983. For example, the number of tractors increased from 2,320 units in 1983 to 3,320 and more than 4,000 in 1992 and in 1995, respectively. The numbers of threshers and orchard and boom sprayers

Table 1. Comparative Rental Charges of Farm Machineries*

Implement	Actual cost $	Ministry of Agr. charge	Private sector charge
Baler	0.34/bale	0.25/bale	0.42/bale
Boom sprayer	-	28	20-30
Chisel plow	7.5	9	15-20
Combine	28	14.2	28
Cultivator	-	9	40-50
Disk plow	10	9	40-50
Fertilizer spreader	-	2.8	Not Provided
Moldboard plow	13	9	40-50
Orchard sprayer	3.0/hr	3.0/hr	4-5/hr
Post hole digger	0.22/hole	1.14/hole	Not N.A.
Potato digger	10	14.2	Not N.A.
Potato planter	15	14.2	Not N.A.
Rake	10	8.5	Not N.A.
Reaper binder	16	17.8	60-70
Rotary tiller	10	9	40-50
Seed drill	13	11.4	28
Stone picker	35	28	Not N.A.
Thresher P.T.O driven	10.8/hr	5.7/hr	8.5-11.5/hr
Tractor (75 hp)	5/hr	3/hr	8/hr
Trailer 3 metric ton	-	4.25/Trip	5-7/trip
Water tank 3 m^3	6/tank	4.5/tank	6-9/tank

*US dollars per ha.

Table 2. Distribution of Farm Machineries in 1983 and 1992*

Machines Types	1983	1992	Estimated 1995
Baler	19	45	85
Boom Sprayer	None	88	150
Chisel Plow	142	557	700
Combine Harvester	37	68	83
Sweep cultivator	None	290	650
Disc Harrow	57	189	220
Disc Plow 2-3 furrows	1359	2,302	2,700
Fertilizer spreader	14	37	45
Knapsack sprayer (Different types)	329	506	700
Leveling machine	42	61	81
Mould board plow	1006	1,357	1,660
Mower	14	30	50
Orchard sprayer unit	None	143	230
Post hole digger	21	17	83
Potato digger (Harvester)	None	9	40
Potato planter	None	10	50
Press wheel roller	None	16	25
Rake	31	15	25
Reaper binder	None	34	50
Rigger	265	286	400
Rotary	139	384	475
Seed Drill	57	124	225
Sprayer units different sizes	148	756	990
Stone picker	None	14	25
Thresher P.T.O driven	None	514	665
Tooth harrow	None	117	130
Tractors	2,320	3,320	4,000
Trailer	1,465	1,686	2,150
Water tank	803	1,382	1,870

*Source: Survey conducted by the Jordanian Ministry of Agriculture.

were not available in 1983, while in 1992 their numbers increased to 514, 88 and 143, respectively. Potato planters and diggers, seed drills, cultivators and combine harvesters are available upon farmer's request for the first time in Jordan. The increase in the number of machineries needs more qualified technicians and engineers to service these machines and keep them working at optimal performance. That will lead to maximizing the machineries output in the fields and minimize major breakdowns.

To protect their crop from pests and diseases, farmers started using boom and orchard sprayers, dust blasting and hand gun sprayers. The quantity of imported spraying chemicals increased from 85,178 kg in 1990 to 180,890 kg in 1993. These chemicals should be used wisely to prevent any environmental pollution, which required professional extension agents to train farmers and applicators on the proper handling, calibration and use of this toxic. The side effect of chemicals is the contamination of soil and the scarce water resources.

Manufacturing of agricultural machineries is limited to the assembly of threshers, trailers and water tanks. The manufacture of plows has saturated the local market needs with the possibility of exporting some if factories work at full production as shown in **Table 3**. Artisan workshop productions are limited to 1.5-3 ton trailers and water tanks.

Conclusion

The study examines the Jordanian experience in the transfer of technology to mechanize agricultural operations. The use of farm machinery increased in land preparation and cereal harvesting operations. Most other agricultural operations are performed manually which is costly and time consuming. The major constraints to the adoption of technology were lack of education and awareness among farmers, small-holdings and lack of alternatives.

In order to increase mechanization use and hence increase the productivity of farmlands in Jordan, an extensive extension program should target the traditional farmers to demonstrate the advantages of mechanizing tillage, spraying, irrigation, harvesting, handling, processing and storage of agricultural products. This lead to a sustainable development in agriculture.

REFERENCES

Agriculture statistical yearbook and agricultural sample survey. 1970. The Hashmite Kingdom of Jordan. Department of statistics. Amman.

Table 3. Distribution of Farm Implements Manufactured Annually by Medium, Small Enterprises and Artisan* Workshops

Implement	Need/yr.	Medium Scale Enterprise			Small Scale Enterprise		
		Full Capacity	Production	Sale	Full Capacity	Production	Sale
Thresher P.T.O driven	50	None	None	None	20	20	20
Moldboard plow	120	90	80	75	50	35	35
Disc plow	60	85	60	45	65	45	35
Chisel plow	40	40	20	15	20	15	10
Rotary	30	20	15	1	10	8	8
Cultivator 7-9 tines	120	80	70	70	40	30	40
Disc harrow	10	10	8	8	5	5	3
Seed drill	10	10	5	3	None	None	None
Sprayer unit-trailed	120	120	115	100	20	20	20
Sprayer unit-mounted	130	130	125	130	None	None	None
Sprayer (Manual)	100	None	None	None	100	90	80
Post hole digger	20	20	15	15	None	None	None
Rigger	50	50	30	30	30	20	20
Potato planter 1 row	10	10	8	5	None	None	None
Potato planter 2 row	10	10	8	5	5	3	2
Trailers 1.5-3.0	200	80	70	65	70	65	55
Water tank 3 m^3	200	150	180	120	50	45	40

*Manufacturing is limited to the assembly of trailers and water tank.

Agriculture statistical yearbook and agricultural sample survey. 1981. The Hashmite Kingdom of Jordan. Department of statistics. Amman.

Agriculture statistical yearbook and agricultural sample survey. 1997. The Hashmite Kingdom of Jordan. Department of statistics. Amman.

Department of farm machinery documents. 1983. Ministry of Agriculture. Amman-Jordan

Department of farm machinery documents. 1992. Ministry of Agriculture. Amman-Jordan

Department of farm machinery documents. 1997. Ministry of Agriculture. Amman-Jordan

Department of statistics. Annual report. 1999. Amman-Jordan

Hamam Fawzi. 1996. Agro-related metal working industry in Jordan. Submitted to United Nations Development Program (UNDP). Casablanca-Morocco 21-24 May.

Monthly statistical Bulletin Center Bank of Jordan. Department of research and studies, Amman vol. 18, No 101, October 1982.

Monthly statistical Bulletin Center Bank of Jordan. Department of research and studies, Amman vol. 20, No 93, November 1998.

Salem, M.A. and B.A. Snobar. 1995. A Socioeconomic Study on Technology Adoption and its Impact on Lentil and Chickpea Production in Jordan. DIRASAT 22B(3): 689-705.

Snobar, B.A. and S.M. Arabiat 1984. The mechanization of agriculture and socioeconomic development in Jordan. DIRAST 11(7): 159-200. ■■

New Co-operating Editor

Saeid Minaei

Nationality: Iran

Birth Date: 1957

Educational Record:

B. S., Univ. of Massachusetts, Mech. Eng., 1981

M. S., Virginia Polytechnic, Agricultural Engineering, 1984

Ph.D., Texas A&M Univ., Agricultural Engineering, 1990

Post, Obihiro Univ.- Japan, Automation of Ag. Machinery, 1996

Research Interests :

1) Measurement and control systems in agriculture
2) Mechanical losses of agricultural products
3) Soil dynamics
4) Design of agricultural machinery

Academic and Research Positions Held :

1- Associate Dean of Agriculture, Tarbiat Modarres Univ.
2- Chairman, Dept. of Agricultural Machinery Eng.
3- Vice president, Iranian Society of Ag. Eng. & Mechanization
4- Managing Editor, Modarres Journal of Agricultural Sci.
5- Member, Res. Council of Parks and Greenery Org. of Tehran Municipality
6- Advisor to the Scholarships Administration, Ministry of Hgher Education

Current Position:

Assist. Professor Since 1991.
Dept. of Ag. Machinery Eng.
Tarbiat Modarres University
P.O.Box. 14115-111 Tehran, Iran
Tel : + 9821 6026522-3
(office Ext. # 2060 ; lab # 2168)
Fax: + 9821 6026524
Email: minaee7@hotmail.com

■■

Trends in Mechanization in Livestock Production in Brazil

by
Nääs, I. A.
Professor.
State University of Campinas.
Agricultural Engineering College.
Campinas, SP.
BRAZIL

Mantovani, E. C.
Senior Researcher.
EMBRAPA Corn and Sorghum Research Center.
Sete Lagoas, MG.
BRAZIL

Introduction

Animal production in Brazil is somewhat divided in two extensive and intensive technological levels according to management and housing: extensive, which is mainly found in Northern, Northeastern and Center West geographical regions, and intensive, mostly in the other regions of the country. Even though this is a simple approach, both production systems can be found all over the country. However, in terms of the use of mechanized processes either to substitute human labor or to optimize operations, animal production in Brazil is practically at the same level in developed countries, and compete in final products price in the worldwide market.

Meat processing is nearly fully mechanized in slaughter houses and inspected by a Federal Agency – SIF (Federal Inspection Service) that analyzes the sanitation quality. The Federal Agency DIPOA establishes the regulations affecting for animal's products. The same procedure is applied in milk production, with agencies for inspecting milk quality. Egg processing is also nearly 80% mechanized within the large production centers. However, both milk and eggs can be bought directly from producers in smaller rural cities where the direct commerce is intense in popular agricultural markets.

For milk production the gap between the highly technical production reaching above 20kg/cow/day, mostly with European cattle breeding, and the extensive production with an average production of 4 kg/cow/day, mostly with Zebu breeding, remain directly associated with the use of mechanized operation and better genetic breeding. The production of beef cattle follows the same pattern. The majority of Brazilian beef cattle herd is of Zebu breeding raised on field which depend mostly on seasonal pasture. There are few intensive production on feedlot, but the use of mechanized operations remains for feed ration distribution by tractors.

Most problems related to livestock housed in tropical climates are caused by high environmental temperatures. Building housing costs represent 50% of the initial investment in a livestock production facility. Structures are necessary for efficient production, because they provide means of modifying the interior environment and also protect against predators and against spread of disease. However, structures can generate thermal problems for the herd or flock when they are not adequately designed. Animal housing must provide an interior environment that meets the animal's thermal comfort needs. The thermoneutral dry bulb temperature for a wide range of small animals lies between 18°C and 20°C, and it extends between 12°C and 18°C, for animals at slaughter age. When the upper critical temperature is reached, the latent heat lost by evaporation is highly affected by environmental relative humidity level.

The upper critical temperature is influenced by the ventilation rate, the presence of cooling devices, and the temperature of drinking water. According to Nääs (1989), the animal's thermoregulation processes in response to heat stressing conditions uses extra energy, leading to losses in productivity. Piglets are more sensible to sudden weather changes up to 6-10 days after birth, when their thermoneutral environmental temperature is 26°C. The pig's thermoneutral environmental temperature drops gradually, for instance, to 18 and to 15°C in the growing and finishing period, while gestating sows have their comfort zone at 24°C. Research indicates that the best feed conversion is found at environmental temperatures ranging from 22 to 24°C for swine weighing 30 to 65 kg, and 17°C, for swine above 65 kg. Environmental temperatures between 16°C and 21°C are adequate for animals housed in group, (Andriguetto et. al., 1988).

Milk yield decreases during the summer months as well as its quality to about 8%. Investment in the use of cooling devices and facilities are necessary to reduce losses. The same pattern is followed by egg production, which decreases in the order of 3-4% due to high temperatures in hot season.

Optimum poultry production requires a housing environment that provides adequate temperature and relative humidity. The combined effects of both variable are critical in determining the bird's ability to dissipate heat and avoid losses caused by heat stress. During the summer months in Southern Brazil, losses reach around 10% of the total production. Environmental control of poultry houses is provided by using fans and evaporative coolers. The controllers used by producers are thermostats that regulate equipment operation based environmental temperature.

Overview on Brazilian Economy

Brazilian economical activities has grown in the last 10 years. In 1980 the gross GNP represented U$173,153 millions and increased 3.5 times throughout the period in 1998 to 775.7 US 10^6dollars. Total South America gross domestic product represents the amount of 1,316.6 US 10^6dollars while Brazilian economy contributes with around 60%, in the year 2000. Dividing this by sector, the GNP in 1970 was 11.55% for agriculture, 35.84% for industrial activities, and 52.61% for services. In 1980, the percentage of the GNP represented by the agriculture sector decreased to 10.2% while the percentage in the industrial activities increased to 40.58%. The services decreased to 49.22%, showing a slightly change in the country's economic profile. In later years the final figures were state such as agriculture representing 6.84% of the GNP, industries 38.43% and services 54.80%, showing a small increase on the industrial business towards a large decrease in the agricultural activities, Alves, E. et al (1999).

In the Southern region the industrial production of both swine and poultry started 20 years ago based on the use of intensive technology, as well as in partnership relation between large slaughter industry and producers. This partnership structure so called integration was a successful business investment that strongly reflected on the social development of this region. The need to supply grain for the animal industry led producers to increase yield not only in the region but investing in new frontier in the Center-West. The main animal production industries such as poultry, swine, beef and layers, moved then to this region Dairy intensive production still remained in the Southeastern states, where investments in adequate environment by the use of climatization equipment as well as processing plants where made in very small scale so far.

According to IBGE (1998) the total Brazilian production of grains reached 82.5 million tons in 1999, increasing 9.83% when comparing to 1998 production. The regions Southeast, South and Center West which participate with 90% of the total presented an increase of 7.18, while the regions North and Northeast, reflecting 10% of national production, increased around 44%. **Table 1** summarizes the total Brazilian grain production in 1999.

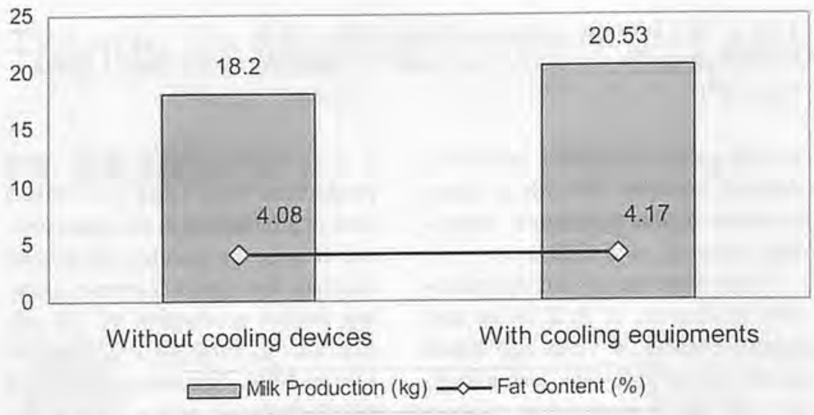
Table 1. Total Brazilian grain production in 1999.

Brazilian production	North	Northeast	Center West	Southeast	South
Tons (10^9)	23.7	5.8	24.1	12.5	37.75

Brazilian Livestock Production Profile

The livestock production area increased significantly over the last 10 years. Swine processed meat went from 980,000 tons in 1980 to 1,12 million in 1990. Beef cattle production went from 2.1 million tons to 2.6 million in the same period. It was the poultry production that had the highest increase, growing from a production of 1.3 million tons in 1980 up to 2.2 million tons in 1990. This sector developed significantly in terms of housing and equipment. For both swine and broiler industry the adopted pattern of organization was vertical integration. Although the cow herd is large, average milk yield and production were low and the increase in production in the last 10 years did not meet the country needs. In 1980 the production was 11,300 million tons, while in 1990 the total country production was 13,000 million tons (Martins, C., 1999).

Vertical integration is a pattern of organization where various stages of the production process - genetics, feed, grow-out, processing, and distribution - are controlled by a single company. The system links farmers, food processors, breeding companies, and other agribusiness and changes the way the industry does business in a fundamental way. As the food marketing system evolves, it is by passing the traditional marketing system and shifting toward contract production and vertical integration. Farmers growing livestock under contract utilize facilities, feeding, and management strategies prescribed in detail by the integrator or contracting firm. The key feature of the new marketing schemes is the establishment of rigid production guidelines to help ensure that raw food products will meet food processors' and ultimately consumers' more stringent demands. In this specific case, applying the precision animal production principles as well as treaceability knowledge may add special value to animal derived products,



Adapted from Arcaro et al (2000)

Fig. 1 Increase in milk yield and quality by the use of cooling equipment

for warranting the product's origin.

Industrialization refers to the movement toward more direct production and marketing relationships between producers and processing. This trend is most fully advanced in the broiler industry. Under industrialization, processors attempt to secure a stable supply of a consistent product while exploiting the economies of scale in new production and processing methods. As production shifts to bigger firms and clusters around processing plants, the result is a further concentration of production.

From 1974 to 1992, the broiler sector experienced a steady increase in consolidation. During this period, sales attributable to operations in the largest category (500,000 or more broilers sold) increased from about 70 percent of national sales in 1974 to about 97 percent in 1992. The number of operations in the largest size category increased by nearly 67 percent, while the total number of operations (of all sizes) decreased by about 24 percent (CartaApinco, 1998). Now the trend leads the production to the Center West region where the grain is produced and the business profile has changed again to large operations, mainly in the last 3 years, when the 5 leading processing industries moved towards the central part of Brazil and directed their production to the export market.

Regarding the world's meat consumption which animal protein is the main source, according to FAO (1994), summary : 44% are pork, 29% are beef, 23% are poultry and 4% are represented by others. In Brazil beef represents 52% of the total meat consumption, poultry 34% and the pork consumption is only 15%, there is then room for increasing production as internal consumption tends to increase.

The success in Brazilian poultry and swine production is linked to variables such as economical feasibility, specialized labor force, productive and reproductive swine characteristics and adequate management, CartaApinco (1999). Each one has its own importance and it needs to be evaluated in an interdisciplinary way. This labor intensive activity mainly in the South and Southeastern regions is in the hands of Europeans immigrants descendent families. They are efficient in growing swine and poultry associated to integration systems. With the grain production moving towards the Center-West region, this kind of farming activity is condemned to disappear soon.

The use of mechanized operations for animal production is mainly divided in three segments: industry of animal feeding and processing; environmental and climatization and meat or dairy processing (Martins, C. 1999).

Within the intensive animal production systems the major gap in mechanization remains in the area of climatization. In poultry production, for instance where nearly 60% of the operations are mechanized, feeding and drinking systems are automated, as well as the ration feeding processing and distribution. While for swine production the level of mechanization is smaller, there are larger producers that use automatic feeding and drinking facilities. Depending on the size of the production, the level of mechanization varies from literally nothing to highly mechanized farms. For both broilers and swine production Brazil competes in the international market in terms of quality and price.

The breeding used for industrial herd and flock production is mostly imported and hardly adapted to tropical climate conditions. Due to large hot season, industrial animal production in Brazil is quite dependent on the use of climatization equipment in order to improve the animal's performance. **Figure 1** shows the increase in milk yield and fat content when Holstein cows in semi-confinement were exposed to cooling devices (Arcaro et al, 2000).

Another weak point in production, wherein the losses are high specially in the broiler industry, is the waiting zone at the slaughter houses. Studies have shown that the use of cooling equipment such as fans associated to fogging system, in the area where the loaded trucks wait with the caged birds, reduce the heat stress and, consequently, the bird mortality, Nääs et al (1998). **Figure 2** illustrates the change in the environmental conditions with the use of cooling equipments

The Brazilian dairy and meat industry is based upon three different segments: cooperatives, integration and independent producers. The in-

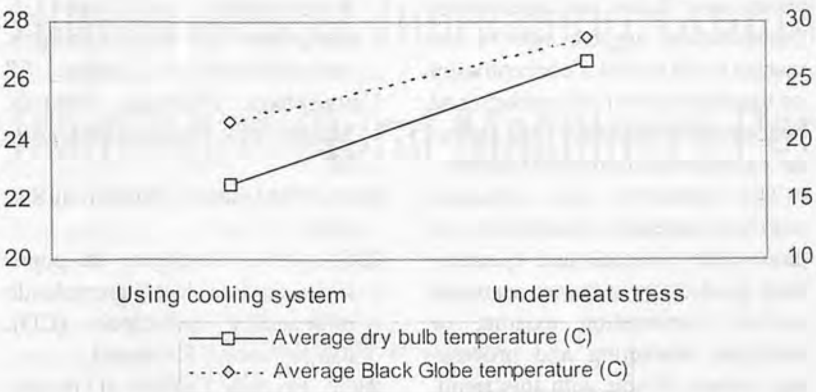


Fig. 2 Environmental response in poultry slaughter house waiting zone when using cooling devices

tegration in the Brazilian way, is a production system wherein the producer is interactive with the industry demand. It involves two stages: first the main sector provides the animal or bird reproduction with the newly born production, and the second is related to the growing and finishing for both pigs and broilers.

The evolution of mechanization of animal production operation, such as feeding, handling and environmental control is shown in **Fig. 3**. It is clear that broiler production is the most mechanized activity while swine and dairy production still has room to apply some mechanized operations.

The Role of Government

Livestock production in Brazil is regulated in terms of sanitary control of the final product and herd or flock, by Federal agencies connected to the Ministry of Agriculture. The States have control division of zoonoses, however, just mainly based on vaccination control of international regulated diseases.

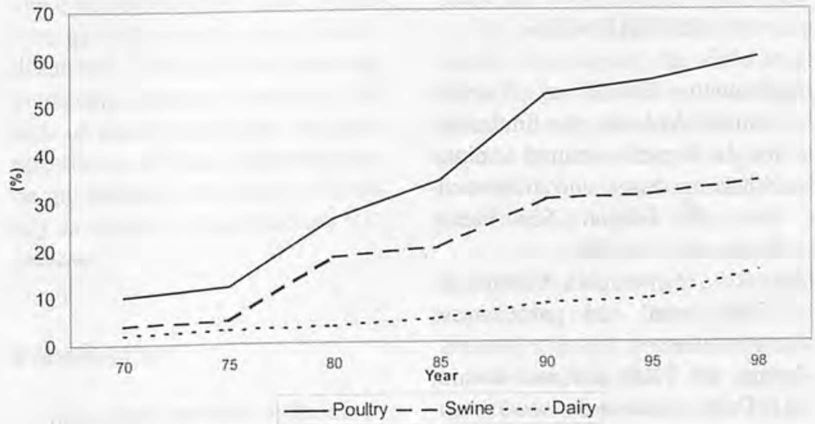
In the last five years the government has been reducing significantly subsidies for animal production which is nearly none nowadays implying that the producers have to search for funding in private banks. On the other hand, the federal extension service is very limited, and the extension service in the highly mechanized operations is provided by large chemical and nutrition companies that offer this fringe benefit to their clients.

The Brazilian investments in research and development for agricultural development are mainly distributed in the chain of educational system as well as in research institutes and the Embrapa Research Centers. In an overall figure the numbers barely average up to 0.2% of the total country's GNP, for all areas of knowledge.

The Brazilian education system is composed of federal, state and private universities, according to the funding support. The Agrarian Sciences related courses formally train professionals graduated in Agronomy, Forest Engineering and Agricultural Engineering. Graduate courses are also offered by the same education system at the levels of Masters and Doctoral degrees. Even though there are courses available in all regions of the countries the major concentration of both courses and students rely in both South Eastern and Southern regions.

The most well-trained professionals in the research system in both Embrapa and the universities, in the areas of animal production formed groups that have reached a high level in the mainstream of their specific fields of knowledge. They prefer to cooperate with groups in developed countries in specific research networks, following up an international tendency of using the communication facilities to interact. However, there is need to identify the specific demand of the country in technological cooperation, and both incentive and fund institutional initiatives. The association between academic initiatives and private enterprises is also desirable, specially for training of undergraduate scholars (Mantovani, E.C. et al, 2000).

The private sector has also an important role in transferring technology for both genetic and equip-



Adapted from CartaApinco, 1999 and Martins, C., 1999.

Fig. 3 Use of mechanization in the process of animal production ment used in animal production. Most multinational corporations dealing with livestock production equipment have their design departments in their original countries with engineering concepts certainly unadapted to Brazilian climate, needs and demand. It is not uncommon to find that machinery work research are carried on at certain testing condition, both in research institution fields and in commercial operations, while management, maintenance and its overall use are adapted to some specific condition. This process usually takes time and investment and is mainly funded by the companies themselves but, in the longer run the inefficiency of results are reflected in the producers budget.

Conclusions

Larger livestock production companies/farms are the most likely to benefit from contractual arrangements to produce specialized products for food processing companies. The industry's new structure will link these farms more closely to the growing market for value-added food products. On the other hand, smaller farms may face a declining market for their generic production. At best, they may become residual suppliers to the specialty product market. Thus, a more industrialized agriculture promises to add momentum to the long-standing shift toward fewer, larger farms.

The forces and trends fueling concentration, industrialization, and vertical integration have created a fertile breeding ground for distrust and suspicion mainly in Southern Brazil. Distrust is fueled by the great and increasing concentration of the remaining livestock industries. Every major anti-trust law has been the result of packer concentration, and previous levels of concentration that spawned governmental action were much lower than those which now exist. Left unchecked, concentration on one side of the market tends to foster concentration on the other side of the market. And concentration also may tend to foster adverse environmental impacts.

The industry's new structure points to increased concentration of large-scale livestock and specialty crop production in fewer, scattered pockets surrounding existing or emerging marketing and processing centers. Along with this trend, special value added products require specific quality control and special mechanization policies in order to reach the markets demand. To meet the new demand, specially in the fields of animal welfare policy and to minimize losses, the use of equipment for climatization will surely be needed.

The potential of the low technological level farmers (specially in milk and beef cattle production) lays on the use of simple improvements in the production process, such as the use of silage and breeding for herd improvement. The consciousness towards this changing pattern would promote the demand for mechanization process implementation which, by the natural consequent increase in production would lead to higher income and ability for supporting and funding further investments.

REFERENCES

Andriguetto, J.M. et. al. Nutrição Animal: As bases e os fundamentos da Nutrição Animal (Animal Nutrition: bases and fundamentals), 4th Edition. São Paulo: Parma ed. v.2, 1988.

Alves, E., Lopes, M., Contini, E. 1999. Como está pobre nossa agricultura.

Arcaro, I.J., Nääs, I.A. and Arcaro, J. Dairy response for shade associated to cooling equipment. ASAE Paper # 004100. ASAE International Conference. Millwakee. 2000.

CartaApinco. Electronic Bulletin. July 1999. FACTA. Campinas. SP

CartaApinco. Electronic Bulletin. March 1998. FACTA. Campinas. SP

FAO. 1994.Quaterly Bulletin of Statistic. v. 7, n. 1.

IBGE. 1996. Contagem da população, sistema de recuperação de informações municipais (CD). Rio de Janeiro. RJ. Brazil.

IBGE. Brazilian Institute of Geography and Statistics. 1998. FAO (ONU). (site IBGE)

Martins, C. Palestra no IV encontro Sul-Americano de Suinocultores. Vitória-ES, Abril 1999.

Nääs, I.A. Princípios de comforto térmico na produção animal (Principle of thermal comfort in animal production) . São Paulo: Ícone. 1989.

Nääs, I. A , R. P. Gouveia, and Silva, I.J. Evaluating the environmental temperature behavior in poultry transportation cages. AgEng 98. Oslo. 1998.

Mantovani, E.C., Nääs, I. A. and Hermmann, P. R. The future of mechanization: trends and requirements for the Latin-American countries: Brazil case. Club of Bologna paper, presented at the First Latin American Meeting. Fortaleza. 2000. Umpublished.

Hindrances of Increasing Cropping Intensity: from Agricultural Machinery Perspective

by
Kshirode C Roy
Principal Scientific Officer and Head
WM Division,
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur 1701
Bangladesh

Abstract

In Bangladesh, almost all of the cultivable lands have been brought under cultivation. Any increase in crop production can be done either by increasing the yield or increasing the cropping intensity. In order to increase the latter, the turn-around time between two successive crops need to be reduced. Also, other agricultural operations need to be completed within a short period. To do that, energy per unit land has to be increased. Introducing appropriate agricultural machinery can increase energy input. At the present techno-socio-economic condition of Bangladesh, it is necessary to mechanize land preparation, sowing, irrigation, harvesting and threshing. In this paper, the importance of mechanizing these operations as well as the ways to do so are discussed. The main hindrance in increasing cropping intensity is the lack of use of machinery for these operations. If these operations can be mechanized, the cropping intensity as well as crop production will increase.

Introduction

Bangladesh has been a chronically food deficit country. Food production has increased in the past, but the rate of increase could not surpass the rate of population growth. It was only in 2000, that the country has attained self-sufficiency in cereal production. Since almost all the cultivated land area has been brought under cultivation, it is not possible to increase the production by horizontal expansion. Additional food required for the increasing population needs to be met by vertical expansion, i.e., by increasing cropping intensity which depends on many factors like crop, variety, water availability and input power for different agricultural operations. Food production from the same land can be increased by either variety improvement or by better crop management. After the Green Revolution of the sixties and seventies, the yield of modern varieties could not be increased significantly. The present modern varieties are merely maintaining the yield level almost at par. Therefore, total agricultural production needs to be increased by better crop management in order to can increase the cropping intensity significantly.

In view of the techno-socio-economic condition, farm size and population of Bangladesh at present, it is not possible or desirable to mechanize all the agricultural operations. But some of the operations definitely need to be mechanized gradually. Otherwise crop production cannot be increased commensurate with the population growth. Definitely selective mechanization will not create wide-scale unemployment. Rather it will generate employment in the farm sector as well as off-farm sector. The use of machinery enhances timeliness of operation, reduces drudgery of the farmers and gives some leisure time to them, thereby improving their quality of life. Some educated people are entering into farming because of the availability of modern technologies which give the dignity of work in agriculture and help them to engage in business.

It has been observed in different countries that agricultural mechanization starts from the most labour-intensive operation. Gradually less labour-intensive operations are mechanized (Khan, 1996). If the economy is good, mechanization process moves at a faster rate. In Bangladesh, pumping water for irrigation, plant protection and milling grains were first mechanized.

The use of machinery and equipment for land preparation and harvesting has made it possible for farmers in the Punjab provinces of India and Pakistan to practice wheat-rice crop rotation, whereas before introducing machinery only one crop could be grown. Farm machineries have made it possible also for farmers of some water available areas in the Philippines to grow up to three crops of rice in a year (Rahman, 1993).

Irrigation pumping has been mechanized to a great extent. **Figure 1** shows the area irrigated by different methods. Data up to 1994-95 were plotted as data for current and later years are not available. Irrigation by deep tubewells (DTW), canals and traditional methods are stagnant. The number of shallow tubewells (STW) is increasing rapidly. The area served by irrigation is about 39 percent of total cultivable land. About 483 thousand shallow tubewells, 24 thousand deep tubewells and 54 thousand power pumps are currently in use throughout the country apart from a few large-scale canal irrigation projects. Irrigation allowed double or triple cropping which has increased the cropping intensity to 177 percent in 1997-98 (Bangladesh Bureau of Statistics, 2000). Pesticides application is done widely throughout the country, mostly by locally made hand sprayers. A few hundred thousands of this type of sprayers are now used for plant protection. As pumping for irrigation, plant protection and milling have been mechanized to a great extent, they are not discussed here.

The objective of the present paper is to identify different agricultural operations which are presently considered to be impediments in increasing the cropping intensity and to suggest the ways and means to increase it.

Land Preparation

Land preparation is one of the most labour-intensive agricultural operations. Without the use of machinery, it is very difficult to prepare land for sowing the seeds at the right time. During the devastating flood of 1988 in the country, thousands of animals were killed. As a result, land preparation became a serious problem and in many areas of the country, land preparation could not be done properly.

Table 1 shows the livestock population of Bangladesh. The cattle population has increased by 8.6 percent between 1960 and 1977, 4.81 percent between 1977 and 1983-84 and only 0.36 percent between 1983-84 and 1996. The same is true for the swamp buffalo which are 3.08, 2.58 and 27.51 percent, respectively. On the other hand, Human population has increased by 102 percent between 1961 to 1991. In 1983-84, work animals in Bangladesh numbered 10.2 million. Therefore, the increase in cattle population between 1983-84 to 1996 was only 0.36 percent. Again in 1998, there was a devastating flood, which claimed innumerable cattle deaths. The current cattle population may be less than that of 1996. The total cultivable land of the country is 9.6 million ha. If all the lands were cultivated by animals, additional 8 million drought animals would be required to maintain the present cropping intensity. It is not possible or desirable to increase the animal population of the country since men and animals depend on the same land for food. Therefore, power tillers (PT) were imported at an increasing rate and dependence on it for land preparation and other farm activities need to be continued.

One of the most important factors for good crop production is the timeliness of sowing. If sowing is delayed, the yield loss becomes substantial. For instance, if wheat is sown after the optimum date of sowing, the yield is reduced by 44.50 kg/ha/day of late sowing (Anonymous, 1990). A similar trend is seen for paddy. Delayed sowing not only yields low, but also requires more seeds.

Farm size and land distribution in

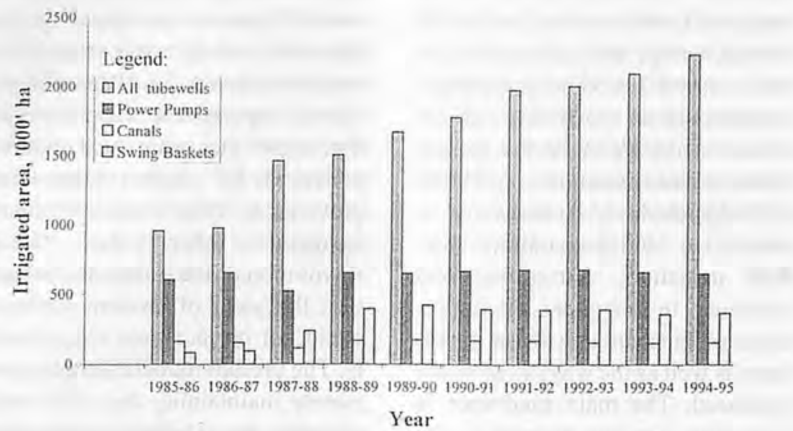


Fig. 1 Area irrigated by different method in Bangladesh.

Table 1. Distribution of Livestock Population in Bangladesh (Unit:1000 head)

Category	Agril. Census 1960	Agril. Census 1977	Agril. Census 1983-84
Cattle	18,961	20,509	21,495
Adult male	N.A.	7,610	7,688
Adult female	N.A.	6,712	6,953
Young stock	N.A.	6,712	6,854
Cows used for work	N.A.	3,315	2,131
Buffalo	455	469	567
Adult male	N.A.	235	338
Adult female	N.A.	50	60
Young stock	N.A.	141	129
Female swamp buffalo used for work	N.A.	N.A.	60

Source: Bangladesh Bureau of Statistics (1999).

Bangladesh are shown in **Table 2**. Eighty percent farms are less than 1.01 ha and only 2 percent are above 3.03 ha (Bangladesh Bureau of Statistics, 2000). This is an indication of uneven distribution of land. Moreover, this small area of farm is fragmented in such a way that the use of big machineries is not appropriate. Small ones such as power tillers and small tractors are suitable for land preparation.

The use of power-operated machinery for land preparation, i.e., tractors and power tillers not only saves time, but also saves money. The initial cost of a 35-hp or big tractors is beyond the reach of most farmers. Moreover, they are not appropriate considering the size of land holdings. When the cost of land preparation by PTs and bullocks is compared, the former have an edge over the bullock-drawn ploughs (Sarker, 1997). The cost of rearing bullocks is becoming expensive due to the increased price of animal feeds. Also, when cropping intensity is increased, the turn around time between two successive crops is so tight that land preparation cannot be done efficiently by country ploughs. On the other hand, after the withdrawal of taxes on agricultural machineries, the Chinese-made PTs became very cheap, though it has had a negative impact on the local manufacturing of PTs (Khan, 1996). Farmers are buying PTs for themselves as well as for renting. When PTs are used intensively, the pay back period becomes only 2-3 years. Poor and marginal farmers find it cheaper to hire PTs than to hire bullocks or to have their own bullocks.

At present, there are about 150 thousand PTs in operation in the country. Some 15 thousand units are imported annually. The problem of land preparation in many areas of the country has been solved through this technology.

Sowing/Transplanting

Another operation that needs immediate attention is sowing and transplanting of paddy. In Bangladesh, broadcasting of paddy and wheat are done manually. The process is quick, but line sowing is better than broadcasting. The former reduces seed requirement and increases aeration. Also, the cost of weeding and thinning is less in line sowing than in broadcasting. For example, in the case of jute, the cost of seed is reduced by 50 percent and that of weeding by 45 percent (Wohab *et al.*, 1996). It has been established that line sowing gives better crop yield than broadcasting. But farmers are not well aware of this fact. Also, due to their non-availability good seeders and transplanters, are not used in Bangladesh. Line sowing by hand is very slow and tedious. Therefore, seeders are required for sowing various crops. Only a few government farms in the country use seeders for sowing a limited number of crops.

When more than two crops are grown on a piece of land, the turn around time becomes low. Sowing/transplanting need to be done very quickly which is not possible without machinery. When wheat is sown after the aman harvest, land preparation may take up to 25 days with traditional bullock-drawn ploughs. This is one of the main hindrances of the wheat expansion program. If sowing could be done immediately after the aman harvest, wheat yield could be increased substantially. A few Chinese PT-operated minimum tillage seeders have been imported in the recent years that enable sowing wheat immediately after aman harvest (Meisner *et al.*, 1997). The seeder does not require tilled land and can be used for paddy also. Wide use of this machine for sowing wheat and paddy will increase the cropping intensity and thereby cereal production.

In Bangladesh, the entire transplanting of paddy seedlings is done manually which is a very time consuming work. The labour demand during transplanting period becomes so high that many farmers cannot transplant seedlings on time, thereby resulting low yields. Due to high labour demand, wages becomes as high as Tk. 100 per day (1 US $ = Tk 54.00 in 2000) in some areas of the country. With this high labour wage, the cost of production becomes naturally high. As a result, the crop price may not be competitive in the international market in a free market economy. Instead of paying so much for labour wage, if machinery were used, the cost of transplanting would definitely be less.

In 1990, rice transplanters units used in the Republic of Korea, People's Republic of China and India were 112 thousand, 15 thousand and 1200, respectively, (Rahman, 1993). Those countries use a lot of seeders also. In Bangladesh, research and development work on seeders for different crops are in progress and it is expected that within a few years, seeders will be available for farmers' use and should make a positive impact on increasing cropping intensity.

Table 2. Farm Size and Land Distribution of Bangladesh

Farm Size	Number of farms ('000')	Area ('000' ha)	Average Size (ha)
Small (0.02-1.01 ha)	9,423	3,326	0.35
percent	80	41	
Medium (1.02-3.03 ha)	2,078	3,352	1.61
percent	18	42	
Large (>3.03 ha)	298	1,399	4.69
percent	2	17	
Total	11,799	8,077	0.68
percent	100	100	

Paddy Reapers

Another labour-intensive agricultural operation is the harvesting of crops. As all the wheat varieties and many rice varieties are photo-and thermo-sensitive, almost all of the crops in a season become ready for harvesting almost at the same time. Matured crops must be harvested quickly. Otherwise, due to shattering, many grains are lost in the fields as well as in transportation. It is estimated that 2.2 percent of paddy and 0.8 percent of wheat are lost during harvesting. Similarly, during transportation 0.5 percent of paddy and 0.38 percent of wheat are lost (Haque *et al.*, 1997 and Bangladesh Agricultural Research Institute, 1992). The total food grain loss in Bangladesh is estimated to be 2.6 million tonnes. If this loss could be avoided, the country could save a substantial amount of money.

As all the crops in a season need to be harvested almost at the same time, labour demand becomes very high. Consequently, labour wages become high but if mechanized reapers were used, the cost of harvesting would definitely be cheaper than manual harvesting. Meisner *et al.* (1997) reported that the savings in cost by a PT-operated reaper is 60 percent in Nepal over the traditional method of harvesting. Both paddy and wheat can be harvested by the same reapers. Their use will make the use of PT reapers more versatile. Therefore, the pay back period of a PT would be less. If harvesting can be done quickly, turn around time could be reduced which will allow sowing the next crop on time.

Threshing/Shelling

Another labour-intensive agricultural operation that needs to be mechanized is threshing/shelling of paddy. Traditionally, paddy is threshed by cattle treading and by manual beating. When thousands of draught animals were killed in the devastating flood of 1988, shortage of animals compelled farmers to find alternate means of threshing. Many farmers have adopted pedal threshers for paddy threshing. Also, in some areas of the country, power-operated threshers for both paddy and wheat are used to a limited scale.

As a result of adopting modern varieties, crop production has increased significantly. If farmers have to thresh paddy and wheat manually, it needs so much time that they cannot prepare lands for the ensuing crop on time. Therefore, in order to raise the cropping intensity, threshing must be completed very quickly. Otherwise, losses in terms of both quantity and quality may occur. The average threshing losses for paddy and wheat are 2.97 and 4.83 percent, respectively, (Haque *et al.*, "opus citatus"). When pedal or power threshers are used instead of traditional threshing method, the threshing losses are reduced substantially.

Both the manual- and power-operated threshers for paddy and wheat are manufactured in the country. The capacity of the pedal-operated thresher for paddy and wheat are 138 and 37 kg/hr grain, respectively, (Anonymous, 1993). This low capacity may be enough for small farmers, but not for medium and large farmers. Therefore, small power-operated threshers requiring 4.5 to 6.5 kw are appropriate for the latter category of farmers. The capacity of this thresher for paddy and wheat are 250 to 350 and 180 to 220 kg/hr, respectively. The rapid introduction of PTs can play a big role in the mechanization of different agricultural operations. Power threshers can be operated by PTs. Power-operated threshers can be used on custom hiring basis just like land preparation. Even small farmers can benefit by this type of threshers. These are used on custom hiring basis in India, the Philippines and Pakistan. Therefore, there is a good potential for this kind of threshers in Bangladesh. A few private manufacturers are already fabricating and marketing power threshers in the country.

Though maize covers less than 0.2 percent of the country's total cultivated area, its production is increasing every year. Its production in 1997-98 was 75 thousand tonnes. Saleh *et al.* (1998) compared the average net returns of potato with wheat, boro, mustard, pulses and maize in 1978-91 and found to be Tk 37,294.00, Tk 8,820.00, Tk 16,311.00, Tk 9989.00, Tk 8,015.00 and Tk 13,123.00 per hectare, respectively. It can be seen that the net return per hectare of maize is more than that of wheat, mustard and pulses but less those that of paddy and potato. That is why farmers are becoming interested in maize cultivation. Good quality manual-and power-operated shellers have been developed in the Bangladesh Agricultural Research Institute, which has become very popular among maize growers. The capacity of manual thresher is 25 to 30 kg/hr and that of power thresher is 2500 kg/hr (Anonymous, 1993).

Conclusion

The food production in Bangladesh needs to be increased significantly in order to raise the per capita availability of calorie. As most of the cultivable land has been brought under cultivation and no horizontal expansion is possible, increase in food production has to be made through vertical expansion. With the current available crop varieties, significant increase in crop production is possible through better management of available resources. The current cropping intensity of 177 percent must be increased to above 200 percent to increase crop production.

(Continued on page 72)

Agricultural Tractor Ownership and Off-season Utilisation in the Kgatleng District of Botswana

by
Cecil Patrick
Dept. of Agric. Engineering and Land Planning
Botswana College of Agriculture
P / Bag 0027
Gaborone
BOTSWANA

Mataba Tapela
Dept. of Agric. Engineering and Land Planning
Botswana College of Agriculture
P / Bag 0027
Gaborone
BOTSWANA

Edward A. Baryeh
Africa University
P.O. Box 1320
Mutare
ZIMBABWE

Abstract

In recent years tractor power usage has increased among smallholder farmers in Botswana. This is mainly due to the influence of available government loans, subsidies and grants on draft power financing. A study on tractor owners and tractors was conducted in the Kgatleng Agricultural District. Questionnaires asked owners about the tractor's usage, serviceability, operation and maintenance costs. It was found that 37% of the tractor owners were illiterate, 42% had primary education and 21% had secondary education. Forty-two percent were over 60 years old and 41% were between 41 and 60 years. Mainly their owners and sons operated the tractors. The tractors, largely Massey-Ferguson make, were used mainly for ploughing. The average ploughing done by each tractor was 106.7 ha/year, and they were parked most of the time during off-season. More than half of the tractors were over 15 years old, and they were poorly serviced and maintained. Service records for tractors were non-existent and their current owners overhauled 68% of the tractors. Tractors experienced frequent problems with hydraulics, power loss, engine oil leakage, front wheel bearings and the electric system. Tractor owners were reluctant to use their tractors for non-ploughing activities. They used them sparingly during off-season in order not to risk damage. Regarding farming as a business, farmers could engage their tractors in all year activities, such as threshing, forage baling, operating mills, water pumping and transportation. These show potential for making ownership cost effective, but it is advisable to do a cost analysis of farm operations for farmers to realise the profit.

Introduction

Botswana's agriculture has been dominated by animal draft power for many years. The introduction of animal draft power into smallholder farming systems dates back to a century ago (Baker, 1988). Animal draft power is well established and is the common form of power used by traditional farmers (Panin *et al.*, 1995). The animals used include oxen, donkeys, horses and mules. They are used during most of the primary and secondary tillage operations. The animals are also a source of meat, milk, transportation, and a trade resource. They are also prominent in a lot of social ceremonies.

However, in recent years, tractor power has emerged to rival the use of animals for draft. In the early 1970s only four percent of the total smallholder farming households used a tractor for ploughing and this figure rose dramatically to 17% and 39%, respectively, by 1980 and 1987 (Poulsen and Purcell, 1989). It is possible that in some parts of Botswana the figure could even be more than 80%.

The use of tractor draft power has increased among smallholder farmers, in spite of the on-going debate on the sustainability and profitability of mechanising smallholder crop production systems (Litschaner and Kelly, 1981). Several factors though could be responsible for the increase; the primary reason could be the influence of government loans, subsidies and grants on draft power financing. Farmers were able to get financial assistance through schemes such as Arable Land Development Program (ALDEP) and low-interest loans through National Development Bank (NDB). Periodic occurrence of droughts often led to such loans being either written-off or interest waived. High purchase prices for cattle offered by Botswana Meat Commission (BMC), structural transformation in the Botswana economy, increased earnings through non-formal income such as remittances, and various other favourable agricultural mechanisation policies also made it easier for farmers to acquire tractors (Panin *et al.*, 1995).

The Kgatleng agricultural district is one of the districts where the use of tractor draft power is predominant. During the 1998/99 cropping season, 183 tractors were registered with the Ministry of Agriculture for ploughing. Registration was done so that tractor owners could benefit through the Ministry's Accelerated Rain-fed Arable Program (ARAP) which paid out cash incentives to farmers (or hired services) for ploughing and tendering their own fields. The profitability of tractor use therefore was linked to the amount of utilisation during ploughing operations. But ploughing operations take place during the months of October to February, which is only a small fraction of the whole year. Off-season use of tractors in the district has not been studied before and so the associated costs and profit can not be determined. In some parts of Botswana tractor usage has been found to be as low as 200 hours per year (Tapela and Nlisi, 1997), instead of the optimal 1000 hours per year (Lonnemark, 1967). Given the absence of previous studies on tractor use in the district and the low levels of tractor usage in other parts of the country, it was found necessary to carry out a study with the following objectives:

1) To determine the average hours of tractor usage per year in the Kgatleng agricultural district;

2) To identify activities other than ploughing and the proportions of tractor usage in the Kgatleng agricultural district; and

3) To determine the cost of owning and operating a tractor in the Kgatleng agricultural district.

Survey Method

A questionnaire was prepared to ask farmers who owned and operated tractors about the tractor's use, serviceability, and operation and maintenance costs. Other information asked was personal information that could help the researchers understand the ability of the farmer to effectively operate the tractor and keep records. A random (pathfinder) survey was carried out to administer the questionnaire to tractor farmers during the 1997-1998 ploughing season. In total, 19 farmers were interviewed, translating to about 10 % of the total registered fleet of tractors for the agricultural district. The farmers interviewed were the owners who knew or had information on the performance of their tractors. During the interview, the researchers also made physical assessment of the tractors and noted their condition. In cases where a farmer owned more than one tractor, each tractor was treated as a separate unit and information about its use was collected independently.

Results and Discussion

A total of 19 farmers were interviewed in the study, making 10% of the registered tractors in the district. The respondents in the study were the owners except in one case where the respondent was the owner's son. Therefore, each respondent had first-hand information about the use, operation and record keeping of the tractor. In all cases, the owners were married and were full-time farmers. In cases where wives were respondents, they demonstrated comparable knowledge about the tractor as their male counterparts.

The information was important to know since it reflected the ability of the farmer to comprehend the operator's manuals and other written instructions as well as record keeping abilities. It was not surprising that majority of them had no education at all, or have been educated only up to primary school level. This observation was made because 42% were an older generation with over 60 years old, 41% were between 41 and 60 years old and the rest were younger. Lack of education may have been the reason why only 58% of the operators were licensed and the rest not. Despite the education level, the farmers showed reasonable knowledge about tractor operation systems and adjustments; knowledge possibly acquired through experience and interaction with peers.

The age distribution of farmers indicated a similar range observed by Baryeh (1982) among West African countries. Investiga-

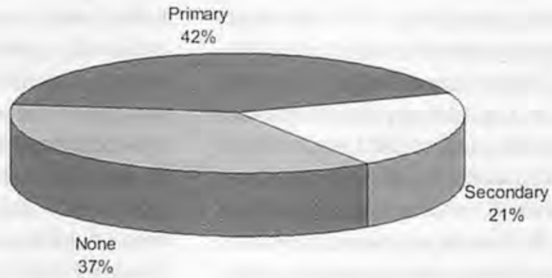


Fig. 1 Education levels of the farmers in the Kgatleng District.

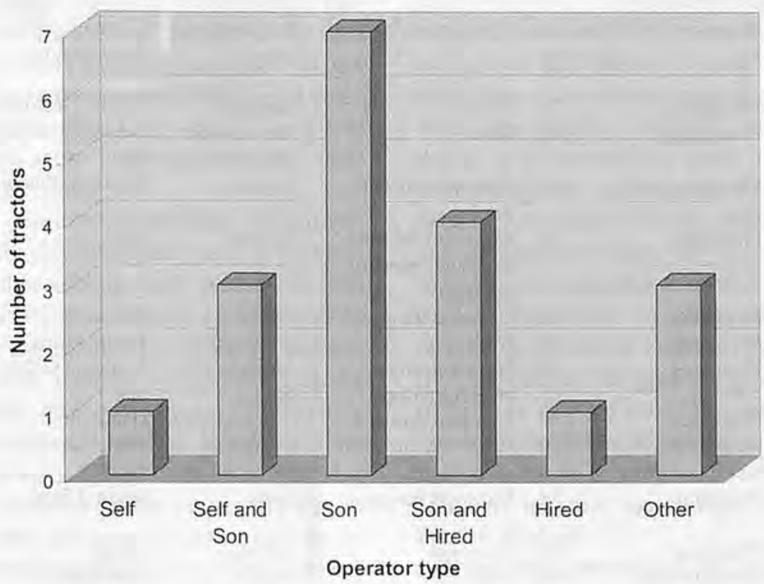


Fig. 2 Operator description for tractors in the Kgatleng District.

tions on why young people tended to stay away from farming may be necessary to undertake. Their apparent disinterest in farming may lead to abandoned fields in the future or even result in the more expensive mechanised farming.

It was evident that in most cases the owner's sons were the primary operators of the tractors. They were the sole operators or at least worked alternately with their fathers or hired labour. The reasons for this arrangement may be that the sons are younger and so tended to be fit to withstand the demands of ploughing. They may also be more conversant and comfortable with modern technology than their fathers. Hired labour tended to be expensive and so to cut down on costs, it was better to use unpaid family labour. In fact, most of the families visited had over seven children and thus had a lot of labour reserve. Customarily, children especially sons, are expected to help with farming activities. The other operators used were a nephew, brother to the owner as well as a brother-in-law. This practice has a downside when the operators are not knowledgeable of the proper settings and adjustments.

The Kgatleng district is within 50 km from the capital city, Gaborone, where there is a Massey-Ferguson dealer. This fact accounted for the high number of the Massey Ferguson tractors encountered during the survey (**Table 1**). Another Massey Ferguson dealer was in Pilane, within the district. Farmers normally buy models which they are certain to easily find spare parts. Other tractor makes were available from neighbouring South Africa, requiring a long process with the Customs Department to import them.

The tractors were generally over 15 years old and were bought second hand. The conditions of the tractors varied widely. The authors could not establish how much of the damage on the tractors was acquired from the previous owner(s). The service records were not available. But it could be deduced that the tractors were bought in poor condition as 68% had to be overhauled by the current owner. Even with overhauling, some tractors experienced frequent problems with hydraulics, power loss, engine oil leakage, front wheel bearings and the electrical system. The farmers could only mention these problems from memory and had no record of how frequent they occurred and the cost to fix them. That being the case, it was impossible to accurately perform any cost analysis for the tractors. Only theoretical values and experience from other districts and countries may offer a simple and easy way of gaining information on costs and how they are influenced by different factors (Lonnemark, 1967). The farmers relied on local mechanics, dealers and auto garages in Gaborone for repairs and servicing.

As previously stated, the tractors were pre-owned and 10.5% were bought between 1970-1975; 10.5% between 1976–1980; 42%, between 1981-1985; and 21% between 1991-1995. One farmer was not sure of the year of purchase. The period when most tractors were bought, that is between 1980 and 1995, coincided with when the ARAP program was operational. Since ARAP paid cash incentives for ploughing, it was not surprising that most farmers said their primary use of the tractors was for ploughing. The Government paid farmers up to P120.00 (US$24.00)/ha for ploughing. They ploughed their own fields and thereafter hired out the tractors to other farmers. Despite their own ploughing and hiring-out, the total area done remained very low (**Table 1**). On average, the tractors ploughed only 106.7 ha per year. Taking an average operation speed of 4km/hr and a plough width of 1.8m, this comes to 148 hrs per year. A number of factors could have resulted in the low hectarages, the main factor being the down-time of the tractors. It took some time for the tractors to get fixed once they were unserviceable. Correct parts were also expensive and not easily available. Sometimes the mechanics used were not qualified and not reliable. Also the fields were relatively

Table 1. Information about Tractor Type, Uses and Service

Tractor Model	Year of manufacture	Year of purchase	Engine Overhauling?	Purpose of buying	Hectares per year	Other activities	Frequent problems	Location of service provider
MF 135	1970s	1993	No	Ploughing	25	None	Bearings	Local / Gaborone
MF 178	NA	1989	Yes	Ploughing	165	None	Air lock and punctures	Dealer in Gaborone
Ford 5000	1986	1994	Yes	Ploughing and hire	162	Kraal manure and water	Engine	Dealer in Pilane
MF 178	NA	1994	Yes	Ploughing	63	Water, animal feed, threshing, livestock transport	Engine	Self
MF 135	1976	1981	Yes	Ploughing	14	Firewood transport	Engine	Gaborone
Landini 6000	1971	1985	Yes	Ploughing	84	Water	Wrong parts	South Africa
MF/ Landini engine	1971	1985	Yes	Ploughing	70	Firewood, water, funeral transport	Air lock, oil leaks	Dealer in Gaborone
MF 165	1977	1983	No	Ploughing	75	Transport produce	Poor operation	Gaborone
MF 240	1978	1979	NA	Ploughing	120	Firewood, diesel for water engine	Hydraulics	South Africa
Landini / MF engine	1980	1991	Yes	Ploughing	30	Transport people	None	South Africa
Deere 1120	1972	1972	Yes	Ploughing	140	Firewood	Bearings	Local
MF 135	1974	1984	Yes	Ploughing and hire	160	None	Engine	Gaborone
MF 135	NA	NA	NA	Ploughing	160	Firewood	Starting and loss of power	Gaborone
MF 135	NA	1978	Yes	Ploughing,livestock transport	45	Sand, livestock transport	Bearings	Gaborone
MF 135	1974	1974	Yes	Ploughing	40	Water and sand	Engine and oil leaks	Dealers in Gaborone and Pilane
MF 285	1978	1982	Yes	ploughing	175	Firewood, water, funeral transport	None	South Africa
MF 185	1972	1985	Yes	ploughing, planting and hire	320	None	Tyres	Gaborone
MF 265	1980	1983	No	ploughing	100	Farm duties	Lights	Dealer in Gaborone
MF 265	1983	1983	No	ploughing	80	None	None	Local

small, about 5 ha each. So, it took some moving about from field to field in order to plough a sizeable total area. Low rainfall and a short rainy season would also contribute to the low hectarages. It should be noted that the figures given were from the past season (1996-1997). Long-term averages could not be determined as farmers did not keep any written records.

Besides ploughing, planting and other on-field activities, tractor owners were generally reluctant to use them for anything else. Thus the tractor lay idle for most part of the off-season period. The reluctance stems from the fact that the farmers did not want to risk damaging the tractor and not having an operational machine at the beginning of the next season. Only occasionally did they use the tractors for transporting firewood, water, livestock and other farm produce, sand for building, and people during funerals (**Table 1**). In one case a farmer used his tractor for threshing sorghum. By using the tractor for stationary jobs such as threshing or water pumping the number of working hours per year can be increased and the average cost per hour reduced. Lonnemark (1967) notes that the cost are high up to 500 hours' annual use, but reduce very rapidly up to 1000 hours. It is important, therefore, to try to ensure that tractors are used for about 1000 hours annually.

Farming for most Batswana farmers is a lifestyle and not necessarily a business. As a result, the activities done were solely to sustain their lives. But if farming were to be taken as a business, then the farmers would appreciate the need to keep proper records and engage in income generating projects. From the listed activities above, it appears there was potential for engaging the tractor all year round and make ownership cost effective. A well maintained tractor that is hired-out will be able to bring income to help pay for the loan acquired to buy it. At present, the farmers use non-arable income or sold cattle to buy the tractors.

On the other hand, the authors acknowledge that the tractor is just a power source and works attached to implements. Therefore, engaging the tractor in other activities takes more than just the decision to do so. It requires acquiring the necessary implements such as threshers, balers, trailers and hammer mills. But if farmers were motivated to get into agro-business, they could build upon what they already have and get more implements to vary their activities.

Pre-owned machines though relatively affordable pose a problem of assessing their useful life and worth. It is a challenge to try and do a cost analysis of a tractor that has been reduced to salvage value by the previous owner. Depreciation rate is difficult to determine. Lonnemark (1967) recommends that when the tractor is used for a short time per year, depreciation should be considered as a fixed cost and calculated from the amount to be written off; which is the price of the machine, or the investment needed for its acquirement. We suggest that a thorough study be done into cost analysis of pre-owned farm tractors. The available methods mostly deal with new machinery and where records are properly kept. As noted by Chen and Bateman (1988), there is no prevailing standard among the several alternatives. The lack of consistency lead to budget differences that may not be due to technology or productive capability. Other methods such as one by Ward (1990) are complicated and only understandable by scholars and researchers. This factor together with the absence of written records by the farmers made it impossible for the authors to determine the cost of owning and operating a tractor in the Kgatleng agriculture district.

Conclusion

he study surveyed tractor use and maintenance as well as characteristics of tractor owners. The use of tractors by farmers in the Kgatleng district has grown over the years. Research aimed at optimal use of the tractors should also be stepped up. Presently, farmers have no means of knowing if it is cost effective to own and operate a tractor or not. Farm accounts are mixed up with other family activities such that it is impossible to know the contribution of each entity. They need to be trained to keep proper and simple records that can be used in tractor management decisions. If tractor ownership by individual farmers prove not to be cost effective, machinery circles by a group of farmers may be tried. However, since this would be a new venture, the farmers will need assistance from government agricultural extension workers.

It has also been found that tractors are old and not well maintained. They are not fully utilised especially during off-season. It could be profitable for farmers to use their tractors for off-season activities such as threshing, transportation, water pumping, and hay baling for a fee. Tractor owners were found to be mostly over 60 years old. Most of them had no formal education or had only primary education. Mainly the owners and sons operated the tractors.

It is imperative that the appropriate tractor is selected to suit particular farm size and operational requirements. But that option is not necessarily available for Kgatleng farmers. They often buy whatever tractor is available and affordable at the time. To address this problem, one way would be to establish a national farm machinery/equipment evaluation and testing centre that can help with documenting tractor condition at the time of purchase. The centre would evaluate and run tests on tractors at farmer's request and give its report for farmers to make informed decisions

REFERENCES

Baker, D.1988 Draft arrangement in Shoshong and Makwate. Agricultural Technology Improvement Project (ATIP) Working Paper 16. Department of Agricultural Research, Ministry of Agriculture. Gaborone Botswana.

Baryeh,E.A. 1982 Mechanizing West African Agriculture. APROTECH Vol. 5 No 4 pp 79-85.

Chen L. H. and W. L. Bateman 1988 A comparison of machinery cost evaluation methods. A paper presented at the winter meeting of ASAE. December 13-16, 1988. Chicago. Illinois.

Litschaner, J.G and W. Kelly 1981. Traditional versus Commercial Agriculture in Botswana Ministry of Agriculture, Gaborone, Botswana.

Lonnemark H. 1967 Multifarm Use of Agricultural Machinery. FAO Agricultural Development Paper No. 85. Rome. Italy.

Panin, A., M. Mrema and M. Mahabile 1995. Government financial assistance to improve the profitability of animal traction in Botswana. In Starkey, P, Mwenya, E. and J. Stares (Ed), Improving Animal Traction Technology. Proceedings of the first workshop of Animal Traction Network of Eastern and Southern Africa (ATNESA). 18-23 January, 1992. Lusaka, Zambia.

Poulsen, E and R. A. Purcel 1989. Relative economics of different draft power applications in Botswana. Ministry of Agriculture. Botswana.

Tapela M. and Nlisi V. 1997 Optimum use and care of tractors. Agrinews. Ministry of Agriculture. Botswana . Vol. 28 No. 7:12.

Ward S. M. 1990 Tractor Ownership Costs. AMA Vol. 21 (1):21-23.

■■

Development and Promotion of Vegetable Auto-grafting Robot Technology in China*

by
Zhang Tiezhong
Professor
Machinery Engineering College, CAU
Haidian, Beijing. 100083
CHINA
E-mail: zhangtz@bjaeu.edu.cn

Xu Liming
Lecturer
Machinery Engineering College, CAU
Haidian, Beijing. 100083
CHINA
E-mail: xlmoffice@yahoo.com.cn

Abstract

The development of vegetable auto-grafting robot technology for use in domestic and overseas need is presented in this paper. Along with the expansion of equipped vegetable production, it is trendy to promote vegetable auto-grafting robot technology all over the world.

Introduction

In recent years, with the adjustment in agricultural production, the planting areas for vegetables, melon and fruits in China has been increasing rapidly in a large scale to 1.229 million hectares in 1998(**Table 1**). China now has a area of more than 1.5 million hectares for machinery cultivation, becoming the largest area in the world. At present, the heliogreenhouse and plastic shed have increased in rapid speed and reached 1,000,000 ha. The equipped vegetable cultivation has solved the contradiction between supply and demand in busy and weak season of vegetable. Meanwhile, vegetable production has been becoming a major source of farm income. However, continuous cropping diseases and low-temperature are always the problem that influenced the equipped vegetable cultivation from the beginning. The statistics show that the rate of withered disease for cucumber in new plastic shed is 12%. If this shed plants cucumber in the second year continuously, the rate will exceed 50%. In equipped vegetable cultivation, the continuous cropping causes disease for eggplant by more than 60%, and for green pepper by 100%. However, China still has not yet made good progress breeding anti-disease vegetables and using farm chemicals to solve the problem.

The beginning of 1980 experienced a new method of way to graft was cucumber or watermelon on Yunnan black-seed pumpkin. The pumpkin roots are strong to build up the resistance and ability against diseases and low temperature, bringing the yield to go up from 30% to 50%. The practices proved that grafting is a more effective way to combat disease and low temperature in vegetable cultivation. Thus, the grafting technology has been applied extensively in the heliogreenhouse and plastic shed.

Besides cucumber and watermelon, grafting is also able to propagate eggplant, green pepper and tomato and to prevent infectious diseases, such as withered disease and verticillium wilt. Therefore, grafting technology has played an important role in developing vegetable cultivation in China.

However, the seedling has small diameter, for the stock 3-4mm,for scion 1-2mm, adding crisp and tender, making graft by hand very difficult, causing low graft quality and low survival rate. Due to this, some area replace graft by using lots of farm chemicals, as a result, financial loss, vegetable pollution and environment pollution are produced. In other words, because of low efficiency and strong intensity, graft by hand can not meet the demand of vegetable production. It is time to develop mechanizing and automatic grafting technology.

Vegetable Auto-grafting Robot Technology Abroad

Vegetable grafting robot technology is a new technology using machinery, auto-controlling and horticulture technology. It can put the seedling cut of stock and scion into together in several seconds, avoiding the cut to be oxidized and the seedling liquid to be lost, and increasing grafting speed and get a survival rate by a big margin.

Japan has 100% success for watermelon, 90% for cucumber and 96% for eggplant in grafting. Every year Japan has 100 milion seedlings needing to be grafted. From 1986, the Institute of Agricultural Machine leading some agricultural

*This project is supported by the 863 Plan and National Natural Science Foundation of China.

Table 1. Vegetable and Melon Planting Area in China (unit10,000 ha)

	1998	1997	1996	1995	1994	1993	1992	1991
Vegetable	1229.12	1128.82	1049.04	951.47	892.07	813.83	703.04	654.65
Melon kind	160.82	130.27	120.30	110.12	112.14	112.39	95.09	76.42
Watermelon	131.48	105.44	96.07	86.48	86.71	85.81		
Melon	19.99	15.89	15.14	14.85	16.85	25.91		

Selected from 《China agriculture yearbook》

machine manufacturers carried out the research on vegetable grafting robot , some achievement has been applied in production. Presently, some fully reinforced industries, such as YANMA,MITSUBISHI, have opened grafting robot referring to watermelon, cucumber and tomato. Generally speaking, these grafting robots have arrived at high automatic level, but structure is complicated and price is expensive.

In 1990, Korea began to undertake research on grafting robot. The products are small in volume, light in weight and low in price, but they only implement some operations and have high requirement for the seedling shape, so they have low automatic level and low speed.

In addition, Japan and Korea have produced nursery plates in conveyance technology for vegetable grafting, Japan also has opened some special equipment for nursing seedling after grafting.

Development and industrialization of Vegetable Grafting Robot Technology in China

The China Agricultural University was first to conduct vegetable auto-grafting technology in China, and has gained a set of breakthroughs and some achievements. The technology of automatic peg grafting method and auto-rotate cutting method has been developed successfully, gaining the national patents. The vegetable auto-grafting robot is being applied in greenhouses, achieving good results.

Controlled by computer, the robot has the ability to go through the whole auto-grafting process, such as picking up seedling, cutting, joining, fixing by clip and discharging seedlings. The operators just put the seedling on the seedling platform so that the grafting speed is raised and the labor intensity is reduced. The robot is capable grafting cucumber, watermelon and muskmelon. Both structure design and grafting performance have reached international advanced level. The robot supplies reliable condition to realize industrialization of vegetable auto-grafting technology.

Like other new technologies, the spread and application of auto-grafting technology depends on social demand and basic technology. According to statistics, China has more than equipped 100,000 agricultural technological plantations recently. Even in the suburbs of Beijing they have opened 13,000 ha equipped vegetable cultivation for the last two years. There are several large-scale equipped vegetable cultivation bases in the Northern area, such as Jilin, Liaoning, Shandong, Henan, and Northwest area, such as Ningxia, Gansu and Xinjiang. By now, the equipped vegetable cultivation is entering the southern area, such as Anhui, Jiangxi, Guangxi, Hainan, and developing very rapidly. All these areas own grafting technology in cucumber, watermelon, muskmelon, as eggplant and tomato, urgently needing automatic production of grafted seedling or are supplied commodity seedlings. Taking Hebei for example, a consumer ordered 160 thousand grafted seedlings, the nursery plantation only supplied 20 thousand due to grafting by hand.

At present, China is adjusting agricultural plant structures and developing moderate scale production. The consciousness of using advanced technology to increase market competition ability has gone up. Beijing, Shanghai, Guangzhou, Shenyang and Hangzhou etc. have built industrial agricultural high-efficient exemplary plantations. Shandong, Anhui,Zhejiang, Hainan are building million of stock for no-seed watermelon grafting nursing plantations. These plantations need high-speed, high-quality, automation grafting robot to supply suffi-

Fig. 1 A Chinese farmer grafting cucumber seedlings

cient commodity seedlings. To sum up, China has owned ripe condition of equipped agricultural base to develop auto-grafting robot technology. To bring about the industrialization of vegetable auto-grafting technology, and change high-speed technology into productivity will be of important significance to promote agricultural production to develop rapidly.

REFERENCE

Zhang Tiezhong . Study on Vegetable Auto-grafting Technology(1) Test of Seedling Character and Choice of machine design plans. Journal of China Agricultural University , Vol.1, No.6, 1996, 27-29

Zhang Tiezhong . Study on Vegetable Auto-grafting Technology(2)Test and Structure Design of Grafting Equipment.. ol.1,No.6,1996,30-33

Xu Liming, Zhang Tiezhong.Study on Robot System for Vegetable Auto-Grafting Design of the Rotary Cutting Mechanism. Journal of China Agricultural University , Vol.5, No.2,2000,34-36

Akihiko Onoda,Ken Kobayasi,Study of Mechanization of grafting, Japanese Society of Agricultural Machinery 51th Annual Meeting, 241, 1992

Hisaya Yamada, Full Automatic Grafting Robot, Journal of the Japanese Society of Agricultural Machinery Vol.58,No4; 137-138,1996

W.Simonton.Automatic Geranium Stock Processing in Robotic Workcell.Transactions of the ASAE,33(6):2074-2080 ■■

(Continued from page 64)

Hindrances of Increasing Cropping Intensity: from Agricultural Machinery Perspective

Different agricultural operations like land preparation, sowing, harvesting and threshing are the most important operations that need to be mechanized to such an extent that it would not displace the present agricultural labour significantly. Technologies to introduce selective mechanization in those operations are already available in the country and are being used in selective areas. Therefore, the introduction of these technologies on a wider scale is of utmost importance.

REFERENCES

Anonymous. 1990. A profitable method of wheat production, Wheat Research Centre, Bangladesh Agricultural Research Institute, Nashipur.

Anonymous. 1993. The Division of FMPE-developed Agricultural Machinery, Farm Machinery and Postharvest Process Engineering Division, Bangladesh Agricultural Research Institute, Joydebpur.

Bangladesh Agricultural Research Institute. 1992. Annual Report (1992-93), BARI, Joydebpur.

Bangladesh Bureau of Statistics. 1999. Census of Agriculture -- 1996 National Series -- Volume I, Statistical Division, Ministry of Planning, Govt. of People's Republic of Bangladesh, Dhaka.

Bangladesh Bureau of Statistics. 2000. Yearbook of Agricultural Statistics of Bangladesh, Statistical Division, Ministry of Planning, Govt. of People's Republic of Bangladesh, Dhaka.

Haque, A K M A, N H Choudhury, M A Quasem and J R Arboleda. 1997. Rice post-harvest practices and loss estimates in Bangladesh, AMA, vol. 28 No. 3, pp. 51-55.

Khan, A U. 1996. Agricultural mechanization and machinery production in Bangladesh, Agro-based Industries and Technology Development Project, Dhaka.

Meisner, C A, P. Hobbs, M Badaruddin, M A Razzaque, G S Giri and S Justice. 1997. Mechanical revolution among small landholders of South Asia, Proceedings of the Joint International Conference on Agricultural Engineering & Technology, Bangladesh Society of Agricultural Engineers, Dhaka, December 15-18, vol. III, pp. 781-787.

Rahman, Z U. 1993. Agricultural mechanization in Asia - Present status and future prospects, World Agriculture 1993, Alan Cartwright Ed., Sterling Publications Ltd., London, pp. 129-133.

Sarker, R I. 1997. Agricultural mechanization in Bangladesh: Selection of technology, Proceedings of the Joint International Conference on Agricultural Engineering & Technology, Bangladesh Society of Agricultural Engineers, Dhaka, December 15-18, vol. I, pp. 1-12.

Saleh, A N M, S C Das, M H Rahman, M A Baset and A K M Haque. 1998. Economic potential of potato production: An overview, Bangladesh J. Agril. Res., 23(2): 315-323.

Wohab M A, M A Mazed, M A Satter and M F R Khan. 1999. Design and development of a multi-crop multi-row seed-drill, Agricultural Mechanization in Asia, Africa and Latin America, 30(4): 30-33. ■■

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.

050

The Ostwald Chart for Jute Stick. **K. Kumar,** Plant Engineer/Professor, N.D. University of Agri. & Tech., Kumarganj, Faizabad, U.P., INDIA. **S. Bal,** Prof. & head, Deptt. of Agriculture & Food Engineering, I.I.T., Kharagpur, W.B., INDIA. **T.P. Ojha,** Ex. D.D.G (Eng.), I.C.A.R., New Delhi, INDIA.

Combustion of hydrocarbons for production of energy requires controlled air-fuel ratio for maximizing energy output from the reaction. The Ostwald chart for any fuel combustion helps in determining the percentage of excess or deficiency of air and thus in determining optimum combustion conditions for the fuel. This paper deals with the construction of Ostwald chart for jute stick and its use in actual practice.

051

Direct Determination of Fuel Value of Agricultural Wastes. **K. Kumar,** Plant Engineer/Professor, N.D. University of Agri. & Tech., Kumarganj, Faizabad, U.P., INDIA. **S. Bal,** Prof. & head, Deptt. of Agriculture & Food Engineering, I.I.T., Kharagpur, W.B., INDIA.

The Bomb Calorimeter Method for determining the calorific value of jute stick and paddy straw is discussed in this paper, including petroleum and coal equivalence of the above two fuels.

052

Computer Modeling for Selective Agricultural Mechanization in Bangladesh. **T. Ahamed,** Graduate student of Farm Power and Machinery, Faculty of Agricultural Engineering, Bangladesh Agricultural University, Mymensingh-2202, BANGLADESH. **Dr. M. M. Hossain,** Professor of the same. **M. M. Huq,** Professor of the same.

The sustainability of agriculture depends on selective mechanization. This study reviews the concept of selective mechanization for the optimization of cost and power in Bangladesh. The mathematical model is developed by L.U. Opara for the Northern Nigeria which is modified for the Bangladesh context to determine optimistic cost and power requirement for the each selective levels of agricultural mechanization based on human muscle, animal and power tiller as primary sources of farm power. The objective function was to minimize total annual costs made up of fixed cost, operating cost and timeliness cost. Both fixed and operating costs were determined using market price and historical operation data. A relationship was developed to calculate timeliness charge based on crop yield data to account for losses due to delay in performing field preparations for mono-cropping pattern. A computer simulation model written in Microsoft TURBO C ++ language is implemented to enhance a broad-based solution.

053

Mechanical Characterization of o Loam Soil Using o Direct Shear Equipment. **H. M. Duran Garcia,** Researcher Professor, Facultad de Ingenieria. Universidad Autonoma de San Luis Potosi. Av. Dr. Manuel Nava . Zona Universitaria, C.P. 78290. San Luis Potosi, S.L.P. MEXICO.

The mechanical characterization of a loam soil was determined according to its condition, and with the help of a direct shear device. The Determinations were made on cohesion, adherence, soil-soil and soil-metal internal friction angle and soil-soil and soil-metal maximum shear resistance. The Deformation tension and soil-soil and soil-metal deformation trends (K) were determined through the Janosi and Hanamoto (1961) equation according to moisture content of the soil. ■■

NEWS

VIV Asia
March 5 - 7, 2003
Bangkok, Thailand

Location

Queen Sirikit National Convention Center, Bangkok - Thailand

Show dates

March 5 - 7, 2003

Opening hours

10:00 am to 6:00 pm

Information

For more information on visiting VIV Asia mail to N.C.C. Management & Development in Thailand: viv@qsncc.co.th

Organisation

Jaarbeurs Exhibitions & Media

P.O.Box 8800

3503 RV Utrecht

The Netherlands

Telephone: +31 (0)30 295 2772

Fax: +31 (0)30 295 2809

E-mail: viv.asia@jem.nl

N.C.C. Management & Development Co., Ltd.

60 New Rachadapisek Rd, Klongtoey

Bangkok 10110 Thailand

Telephone: +66 2 229 3000

Fax: +66 2 229 3191

E-mail: viv@qsncc.co.th

Internet: www.qsncc.co.th

VIV Poultry Istanbul
June 5 - 7, 2003
World Trade Center Yesilkoy
Istanbul, Turkey

VIV Poultry Yutav is the annual exhibition for intensive poultry production and processing in Eastern Europe/Middle East. This international exhibition of 7,000 square meters covers all aspects of poultry production, including feed, processing and packaging. It is the only event of its kind in the region in an market where the poultry industry is still growing and expending. This is the place where poultry professionals from Turkey and surrounding areas come to learn about the latest products and services.

Contact Information

Jaarbeurs Exhibition & Media

P.O.Box

8800

3503 RV Utrecht, The Netherlands

Tel:+31-30-295-2772/2754

Fax:+31-30-295-2809

E-mail: viv.yutav@jem.nl

Check www.viv.net for information on all our world wide VIV-activities.

Press Communique - CEMA Assembly

The general assembly of CEMA, the European committee which groups the associations of agricultural machinery makers from thirteen countries, met in Rome on June 6-7 to wind up Italy's stint as duty president of the body. The meeting was attended by 53 delegates from Austria, Belgium, Denmark, Finland, France, Germany, Greece, Holland, Portugal, Britain, Spain, Switzerland and a guest delegation from the United States.

The closing session was addressed by Minister for Agricultural Policies Giovanni Alemanno who discussed the main points in current EU agricultural policy.

The agricultural machine industry is important in France, Germany and Britain, but above all in Italy, the leading European producer with about 900,000 tons of machinery a year (excluding earth moving machinery) worth about 6,300 million euros. The turnover of Italian manufacturers accounts for about 3O% of the total turnover of the countries represented on the committee.

In 2001, EU agricultural machine production fell by 2% in real terms compared to 2000, and tractors lost 3.4%. Forecasts for this year estimate a further 2% fall for tractors and a fall for some types of operating machine. Combined harvesters are expected to rise by 2%, and bailers by 4%.

The assembly's various work sessions discussed organisational issues linked to coordination of the activity of the individual associations and the management of joint projects, as well as economic and political questions concerning agricultural mechanisation and its role in developing agriculture while safeguarding the territory and the environment.

Outgoing CEMA President Apronian Tassinari reminded the assembly that one major project now in the works is a European statistics data base with uniform criteria for counting production and sales. He also cited study and training projects, and lobbying to achieve greater cooperation with EU institutions in defining regulations applicable to agricultural machines.

On policy issues, Alemanno stressed that agricultural mechanisation improves efficiency and quality, making it a tool for achieving EU policies in a complex scenario in which the EU is working to enlarge its frontiers to the east while also seeking to compete with the US economic and commercial system.

At the end of the Italian mandate, the duty presidency passed from Tassinari to Savvas

Balouktsis of Greece, who will head the CEMA until the nest assembly, to be held in

Thessaloniki on May 29-31 next year.

UNACOMA General Assembly press release
Italy

Despite an unfavourable economic climate, Italy's agricultural and earth-moving machinery industry maintained high sales in 2001 and expects further increases this year and next, according to definitive figures for 2001 released when UNACOMA, the Italian manufacturers' association for this specialised sector, held its annual general assembly at San Lazzaro di Savena near Bologna on June 18.

The figures showed that a total of 899,251 tons of tractors, tractor parts, agricultural operating machines and gardening machines was produced, worth 6.338 billion euros. The total for earth-moving machinery - diggers, mechanical shovels, backhoe loaders, mini-excavators, skidsteer loaders and the like - was 569,060 tons, worth 2.960 billion euros.

Agricultural machines were down in weight by 1.23% on the total of 910,454 tons in 2000, and down by 0.66% on the year 2000's 6.380 billion euros. Earth moving machinery was little changed: 0.17% down from 570,030 tons in weight, and-3.13% up on 2,870 billion euros in value.

Overall, the sectors represented by UNACOMA recorded production of 1,468,311 tons (down by 0.82%), worth 9,298 million euros (up 0.52%). This confirms Italy's as Europe's largest producer and the world's second after the United States.

Exports came to 555,569 tons for agricultural machines and 468,961 for earth-moving machinery, up 0.35% and 2.07% in value for farm machines, and down 2.88% and down 2.37% in value for earth moving. In their traditional strength in exports, the trade surplus produced by the two types of machinery came to 3,300 million euros and alone accounted for 34.9% of a total Italian trade surplus, including petroleum products, of 9,522 million euros.

Looking at the various types of machine, tractors were down by 6.15%, with production falling by 84,458 units, which was partially offset by a rise of 1.82% in other types of farm machine. The domestic market absorbed about 32,000 tractors, over 10% lower than in 2000, but still keeping between 32,000 and 34,000 units which, in the medium term, is thought to about what the Italian market can handle. Losses on other farm machines were more contained, and came to just 1% overall, with gains for operating machines and losses for motors and parts.

Lower tractor sales at home and in Europe probably reflect lower farm incomes due to bad weather and health crises in animal husbandry, but also exacerbated by the trade reductions following the September 11 attacks. But the losses were offset by the good international performance registered by operating machines on international markets, which led the way and were decisive in the overall gain in exports at the end of the year.

At the end of 2002, the European tractor market is expected to rise by 0.5% and by a further 1.7% in 2003, Growth in other agricultural machines is forecast at 1.6% this year and 2.1% next. Increase in value will be 1.2% this year and 5.5% next.

The Italian market is expected to grow by 2% this year with sales of over 33,000 tractors, also thanks to a measure to encourage demolition of out-dated models. Similar growth is also expected next year.

Expansion is expected to continue outside Europe, especially in the United States, with increases this year, but then an acceleration to 5% in 2003. One result will be to stimulate tractor production to over 85,000 this year and almost 90,000 in 2003, the highest in the last two decades.

2nd Forest Engineering Conference
12-15 May 2003, Växjö, Sweden

About the conference

Awareness of the relationship between operational efficiency and business success has grown rapidly. Cost efficient forest operations are recognized worldwide to be one of the major prerequisites for the forest industry to stay in business. At the same time, safeguarding biodiversity and regenerating new healthy, valuable forests is a must.

We have to continuously adjust our operational methods and systems to changing forest management practices. We also need to apply the latest technology to perform and support the chain of activities from the forests to the end users of our products. Furthermore the technical and organisational development in the forestry sector must go hand-in-hand.

The growing interest in forest engineering was successfully demonstrated at the 1st FEC in Scotland in 1999. SkogForsk has proudly accepted the responsibility for the 2nd FEC to be held in Sweden in 2003.

The objective of the FEC is to present and discuss the state-of-the-art both in practice and R&D within a variety of disciplines related to forest operations. The FEC also offers a great opportunity for you to meet colleagues and to help create a global network for forest engineering.

More information

M. Iwarsson, Manager Training

SkogForsk

Uppsala Science Park, SE-751 83

UPPSALA Fax+46 18 188600 ■■

BOOK REVIEW

The Mechanics and Physics of Modern Grain Aeration Management

(USA)

by Shlomo Navarro, Ronald Noyes

Preface

The preparation and release of this publication is timely because it details the most practical available technology that is designed to cope with environmental pollution resulting from historic and traditional conservation practices in grain storage facilities. Its release at the beginning of the 21st century coincides with the preferences of many consumers for grains and seeds that are free of pesticide residue.

This handbook focuses on the protection of grain and other bulk products from deterioration by insects and molds through diligent sanitation and temperature management practices. It includes contributions by distinguished researchers currently active in the field of grain storage with particular expertise in aeration and cooling technologies of grain stored in bulk. Their joint experience is derived from research work on four continents and from travels and field experience throughout the world.

The original impetus for the preparation of this volume was a modest, state-of-the-art publication prepared for the FAO (Food and Agriculture Organization) of the United Nations entitled Aeration of Grain in Subtropical Climates, FAO Agricultural Services Bulletin No. 52 (Navarro and Calderon, 1982). This FAO publication documented the current information on aeration technology available at that time. Particular emphasis was placed on the inherent advantages of using aeration in subtropical climates.

The outline of the 1982 publication was prepared during an FAO mission by Shlomo Navarro to Cyprus to assist the Cyprus Grain Commission and the Cyprus Ministry of Agriculture. The objective of the mission was to disseminate the grain storage management technology to strengthen the existing infrastructure in Cyprus in the use of aeration and chilling of grain by refrigerated air. Dr. Navarro remains indebted to the late Geoff G. Corbett, senior officer, Storage of Food Crops and Inputs, FAO Agricultural Research Service, for his encouragement in the preparation of the FAO publication. Geoff Corbett will always be remembered for his contribution to disseminating advanced grain storage technologies throughout the world, particularly in developing countries.

CRC PRESS

http://www.crcpress.com

■■

Co-operating Editors


M F Fonteh


A A K El Behery


A M El Hossary


B S Pathak


R J Bani


I K Djokoto


D K Some


K Houmy


J C Igbeka


E U-Odigboh


K C Oni


N G Kuyembeh


A H Abdoun


A B Saeed


A I Khatibu


E A Baryeh


S Tembo


H A Centrángolo


I de A Nääs


A E Ghaly


E J Hetz


A A Valenzuela


R Aguirre


O Ulloa-Torres


S G C Magana


H Ortiz-Laurel


W J Chancellor


M R Goyal


A K Mahapatra


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


S Illangantileke


Soedjatmiko


M Behroozi-Lar


Saeid Minaei


J Sakai


B A Snorbar


C J Chung


C C Lee


M Z Bardaie


M P Pariyar


D B Ampratwum


E S Eldin

Graeme R. Quick
Leader, Power & Machinery Section, 200 Davidson Hall, Agricultural and Biosystems Engineering Dept., Iowa State University, Ames, Iowa, 50011-3080 U.S.A.

-ASIA and OCEANIA-

Shah M. Farouk
Professor(Retd.),Farm Power & Machinery Dept., Bangladesh Agricultural University, Mymensingh 2200, BANGLADESH TEL+880-91-5695ext.2596, FAX+880-91-55810,E-mail:smf@bdcom.com

Mohammed A. Mazed
Member-Director, Bangladesh Agri. Res. Council, Farmgate, Dhaka, BANGLADESH
E-mail:mamazed@barcbgd.org

Manbahadur Gurung
Store Officer, Bhutan Fruit Products Limited, Samtse, BHUTAN TEL+975-65369

Wang Wanjun
Past Vice Director and Chief Engineer/Chinese Academy of Agricultural Mechanization Sciences, 1 Beishatan, Beijing, 100083, CHINA TEL+86-(0)83-001-6488-2710,FAX+86-(0)83-001-6488-2710,E-mail:wwj@isp.caams.org.cn

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

T.P. Ojha
Director General(Engg.) Retd., ICAR, 110, Vineet Kung Akbarpur, Kolar Road, Bhopal, 462 023, INDIA TEL+91-755-290045

S.R. Verma
Prof. of Agr. Eng. & Dean Eng.(Retd), 14, Good Friends Colony, Barewal Road , Via Ayoli Kalan, Ludhiana 142027 Punjab, INDIA TEL+91-(0)161-463096 E-mail:srverma@hotmail.com

Sarath Illangantileke
Regional Representative for South and West Asia, International Potato Center(CIP), Regional Office for CIP-South & West Asia, IARI(Indian Agric. Res. Institute) Campus, Pusa, New Delhe-12, 110002, INDIA TEL+91-11-5719601/5731481,FAX+91-11-5731481,E-mail:cip-delhi@cgiar.org

Soedjatmiko
President, MMAI(Indonesian Soc. of Agric. Eng. & Agroindustry), Menara Kadin Indonesia Lt.29 Jl. HR. Rasuna Said X-5/2-3 Jakarta, 12940, INDONESIA TEL+62-(0)21-9168137,7560544,FAX+-62-(0)21-5274485,5274486,7561109

Mansoor Behroozi-Lar
Professor, Agr. Machinery, Ph.D, Tehran University Faculty of Agriculture, Karaj, IRAN TEL+98-21-8259240,E-mail:mblar@chmran.ut.ac.ir

Saeid Minaei
Assistant Professor, Dept. of Agr. Machinery Eng., Tarbiat Modarres Univ., P.O.Box 14115-111, Tehran, IRAN TEL+9821-6026522-3(office ext.2060, lab ext. 2168) FAX+9821-6026524, E-mail:minaee7@hotmail.com

Jun Sakai
Professor Emeritus, Kyushu University, 2-31-1 Chihaya, Higashi-ku, Fukuoka city, 813, JAPAN TEL+81-92-672-2929,FAX+81-92-672-2929,E-mail:junsakai@mtj.biglobe.ne.jp

Bassam A. Snobar
Professor and Vice President, Jordan University of Science and Technology, P.O.Box 3030 Irbid, 22110, JORDAN
TEL+962-2-295111,FAX+962-2-295123,E-mail:snobar@just.edu.jo

Chang Joo Chung
Emeritus Professor, Seoul National University, Agricultural Engineering Department, College of Agriculture and Life Sciences, Suwon, 441-744, KOREA
TEL+82-(0)331-291-8131,FAX+82-(0)331-297-7478,E-mail:chchung@hanmail.net

Chul Choo Lee
Mailing Address: Rm. 514 Hyundate Goldentel Bld. 76-3 Kwang Jin Ku,Seoul, KOREA TEL+82-(0)2-446-3473,FAX+82-(0)2-446-3473,E-mail:ccsslee@chollian.net

Muhamad Zohadie Bardaie
Professor and Deputy Vice Chancellor (Development Affairs), Chancellory, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Darul Ehsan, MALAYSIA
TEL+60-39486053,FAX+60-3-9426471,
E-mail:mzbd@admin.upm.edu.my

Madan P. Pariyar
Consultant, Rural Development through Selfhelp Promotion Lamjung Project, German Technical Cooperation, P.O. Box 1457, Kathmandu, NEPAL

David Boakye Ampratwum
Associate Professor, Dept.of Bioresource and Agricultural Engineering, College of Agriculture, Sultan Qaboos University, P.O. Box 34, Post Code 123, Muscat, Sultanate of Oman, OMAN TEL+968-513866,FAX+968-513866,E-mail:davidamp@squ.edu.om

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, OMAN

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

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

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

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

Bherulal T. Devrajani
Professor and Chairman, Faculty of Agricultural Engineering, Sindh Agriculture University, Tandojam, Sindh, PAKISTAN TEL+92-2233-5594

Umar B. Bindir
Lecturer and Team Leader of Engineering Section, Dept. of Agriculture, The University of Technology, P.M.B. Lae, PAPUA NEW GUINEA

Surya Nath
Visiting Scientist, Dept. of Agriculture, Papua New Guinea University of Technology, Private Mail Basg, Lae, PAPUA NEW GUINEA TEL(675)473-4451,FAX(675)473-4477

Reynaldo M. Lantin
Professor, College of Engineering and Agro-Industrial Technology University of the Philippines Los Baños, Laguna 4031, PHILIPPINES TEL+63-(0)49-536-2792,FAX+63-(0)49-536-2873, E-mail:rmlantin@mudspring.uplb.edu.ph

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

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


N A Abu-Khalaf


A D Chaudhry


A Q Mughal


R ur Rehman


B T Devrajani


U B Bindir


Surya Nath


R M Lantin


R P Venturina


S A Al-suhaibani

REMINDER

The reminder might run something like this:

THE AMA EDITORIAL STAFF WILL APPRECIATE RECEIVING ARTICLES FOR PUBLICATION TYPED DOUBLE-SPACE AND NOT REDUCED IN SIZE.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.
7-2Kanda Nishikicho,Chiyoda-ku,Tokyo,Japan(Tel.81-(0)3-3291-5718,3671~4)
E-mail:ama@shin-norin.co.jp URL:http://www.shin-norin.co.jp

INSTRUCTIONS TO AMA CONTRIBUTORS

The Editorial Staff of the AMA requests contributors of articles for publication to observe the following editorial policy and guidelines in order to improve communication and to facilitate the editorial process :

Criteria for Article Selection

Priority in the selection of articles for publication is given to those that -

a. are written in the English language ;
b. are relevant: to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by, small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are printed, double-spaced, under 3,000 words (approximately equivalent to 6 pages of AMA-size paper) ; and those that
g. art: 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, a single writer is given 25 offprints of the article and plural writers are given 35 offprints (also sent by surface/sea mail)"
d. Complimentary copies: Following the publishing, three successive issue 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... **Absolutely necessary TEXT FORMAT**) along with two printed copy(A4).
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) 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.(e.g. EXCEL for Windows)**
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.

BACK ISSUES

(Vol. 30, No. 1, Winter, 1999 ~)

INQUIRY and REQUEST to AMA

Please let us know your need. We shall promptly reply them. Inquire on any catalog listed in the advertisement in this issue. We shall try our best to serve you. We welcome articles of interest to agricultural mechanization.

Fill in the reverse side of this card and send us by sealed letter.

FARM MACHINERY INDUSTRIAL RESEARCH CORP.
7-2, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan

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 101-0054, Japan
Tel. (03)－3291－3671～4, 5718

STAMP

FARM MACHINERY INDUSTRIAL RESEARCH CORP.

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

TOKYO 101-0054, JAPAN

1st FOLD HERE

2nd FOLD HERE

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 31, No. 1 Winter, 2000)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 31, No. 2 Spring, 2000)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 31, No. 3 Summer, 2000)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 31, No. 4 Autumn, 2000)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

(Vol. 32, No. 1 Winter, 2001)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

(Vol. 32, No. 2 Spring, 2001)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

(Vol. 32, No. 3 Summer, 2001)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 32, No. 4 Autumn, 2001)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 33, No.1, Winter, 2002)

◇ ◇ ◇

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA
(Vol. 33, No. 2, Spring, 2002)

■■

NEW TECHNOLOGY IN GRAIN POSTHARVESTING

by Ritsuya Yamashita
Professor emeritus of Kyoto University

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

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

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

TWO-WHEEL TRACTOR ENGINEERING
for Asian Wet Land Farming

by Jun Sakai
Professor emeritus of Kyushu University , Co-operating Editors of AMA

A present to the students who dream to be an international-minded specialist in farm machinery science&technology
Intoduction of new "Tractor-Tillage Engineering" based on a global view of agricultural civilizations in the world
Two-wheel tractors contribute to the industrial promotion of agri-countries consisting of small-scale family farms.
The textbook with new guidelines for international technical cooperation with a better mutual understanding.

CONTENTS

Difference between Euro-American and Asian farming civilizations
New wheel dynamics and tractor-vehicle engineering in the 21th Century
New plowing science of walk-behind tractors originated from Asian paddy farming
Scientific creation and systematization of rotary tillage engineering in Asia

English-Japanese Version