International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.33, NO.2, SPRING 2002

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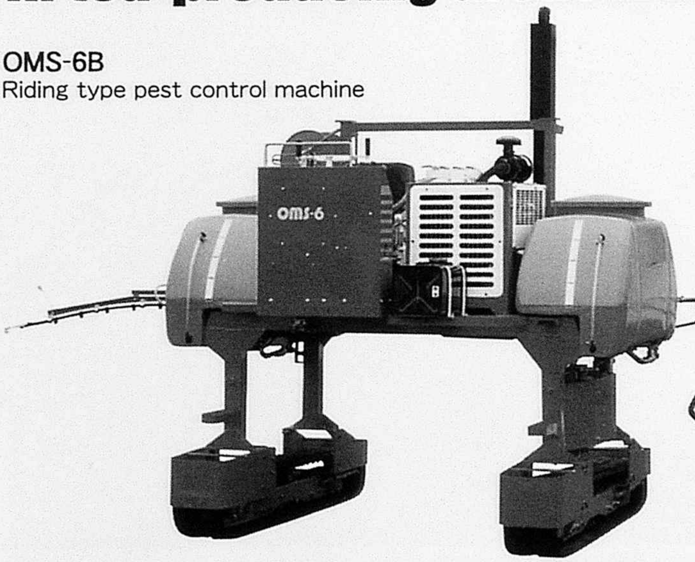

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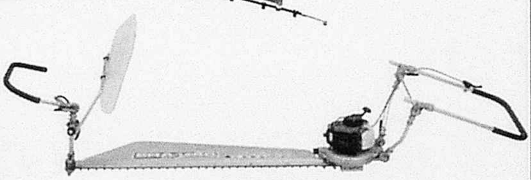

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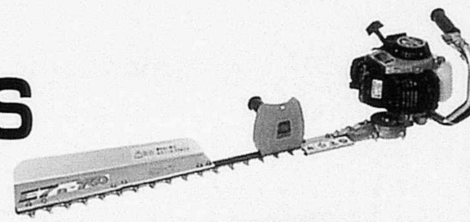

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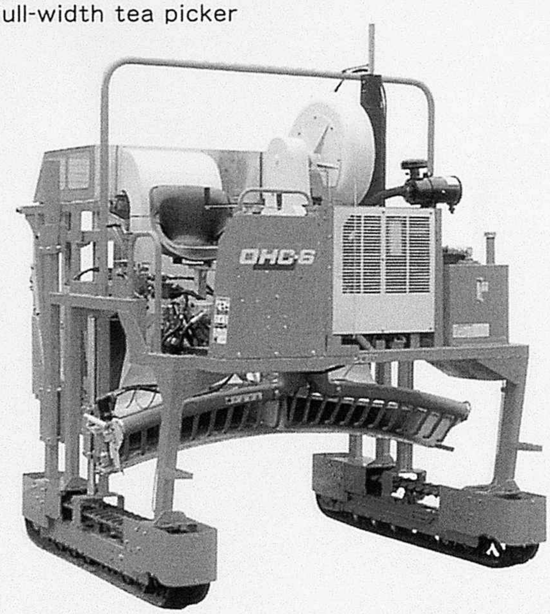

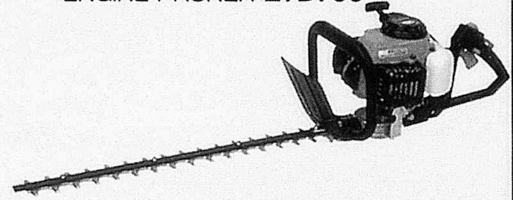

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International specialized medium for agricultural mechanization in developing countries

ISSN 0084-5841

AMA

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

VOL.33, NO.2, SPRING 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

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7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan
URL : http://www.shin-norin.co.jp
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7, 2-chome, Kanda Nishikicho, Chiyoda-ku, Tokyo 101-0054, Japan
Printed in Japan

This is the 115th issue since its maiden issue in the Spring of 1971

EDITORIAL

A New AMA Target

The spate of recent unmistakable signs of the effect of global warming, in all probability, may be equated with global warning actually. Consider some of the unprecedented effects: 2-week earlier blooms of cherry blossoms in both Washington, DC and Japan prior to the onset of Spring this year; a reported 2-week earlier blooms of spring flowers in London, also this year; the almost uncontrolled forest fires (at this writing) in Colorado and Arizona, US burning thousand and thousand acres of forests and threatening hundreds of homes; and about 10 million hectares of forest lost to fires world-wide over the last decade. All this points out to mankind's great concern to maintain a proper balance between global life and man's life in the future.

Global warming was already the raison d'e-tre of the Third Session of the Parties to the United Nation's Framework Convention on Climate Change that was organized in Kyoto, Japan in December 1997. Otherwise known as the Kyoto Protocol, it was the UN's initial step towards the prevention of global warming and an international resolution aimed at reducing greenhouse gases' emission that was adopted. All delegates from developed countries except the US signed the Protocol. The Japanese Diet has since ratified it and is resolved at developing a domestic system to prevent global warming.

The average number of cars possessed by each household and other motorized vehicles in developed countries, Japan included, over the last 10 years and the average mileage of the carbon dioxide emission - the main culprit in global warming.

It cannot be gainsaid that we in the agricultural machinery profession and business, are responsible for undertaking both basic and applied research toward reducing gas emission. It behoves upon us, therefore, to continue and not falter in finding ways of using limited resources efficiently in order to continue our share in the total effort for the sake of our population and those who shall come after us.

In this regard, AMA calls upon all contributing authors, cooperating editors and the readers, in general, to join us in this new AMA target.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
June 2002

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

Vol.33, No.2, Spring 2002

Development and Testing of Low-cost Animal Drawn Minimum Tillage Implements : Experience on Vertisols in Ethiopia

by

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Abstract

In Ethiopia, Vertisols which are affected by water logging during the rainy season due to its physical and chemical characteristics are potential agricultural lands but are prone to soil erosion. The soil erosion rates of the cultivated Vertisols are accelerated due to the traditional practices of planting crops at the tail end of the rainy season exposing the bare land to soil detachment. An animal drawn implement, the Broadbed Makers (BBMs), which facilitates the drainage of the Vertisols is used for attaching other implements for minimum tillage practices. Implements have been designed, prototypes produced and tested both on-station. Labour savings, lowering soil erosion rates, reducing rates of seed and fertilizer use and maintaining productivity were achieved by using minimum tillage package.

Introduction

In Ethiopia , 90 per cent of the land preparations for crop production under the small holder farmers are being carried out with the traditional ëmareshaî implement pulled by a pair of local zebu oxen as shown in Fig 1. Three to five passes, each cultivation pass perpendicular to the previous one, with the maresha are required for all soil types before a field is ready for planting. The first ploughing ranges from 5 to 8 cm soil depth while with the last pass up to 20 cm depth could be attained (Astatke and Ferew, 1993).

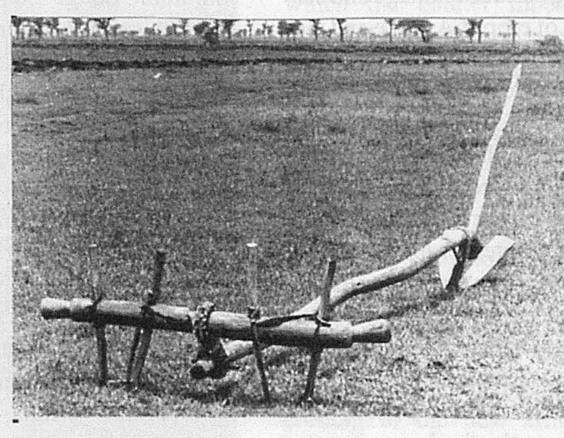

Fig. 1 Traditional Ethiopian plough "maresha"

Vertisols cover 12.6 million ha

Acknowledgement

The authors would like to thank The Netherlands Government for funding this work. The authors are also grateful to all staff members of Highlands-ILRI particularly Aklilu Alemu, Teferi Abegaz and Kahsay Berhe.

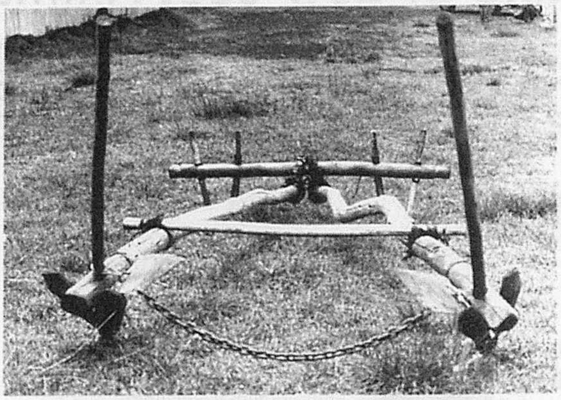

Fig. 2 The broadbed maker developed based on the traditional plough "maresha"

(10.3 per cent) of the total area of Ethiopia, of which 8 million ha are in the Ethiopian Highlands above 1500 m asl (Wakeel and Aastatke, 1996). Despite the fact that they have high agricultural potential, they are generally regarded as marginal soils due to their hydro-physical properties. Due to water logging in the main rainy season (June to September), crops are planted at the tail of the rainy season thus subjecting the already cultivated area to water erosion during the main part of rainy season. The introduction of animal powered broadbed maker (BBM) as shown in **Fig.2** has enabled Vertisols to be shaped into broadbeds and furrows (BBFs), thus facilitating surface drainage and early sowing of crops (Astatke and Gebresenbet,1998; Astatke and Mohamed Saleem,1998; Mohamed Saleem,1995;Tedla et al.,1992). Early planting due to the drainage facilitation created by the BBM are resulting in higher yields than traditional late planted crops which are affected by water stress during the latter stage of the plant growth. It has other advantages as well, eg. the BBM crop is harvested early during the severe food deficit period, so it contributes to the food security.

Up to now broadcasting is the planting method followed for the BBF system. This is similar to the traditional method of planting with no depth control mechanism of the broadcasted seeds. This method of planting has been shown to mix 15.3 % of the broadcasted wheat seed to a depth of 10-20 cm yet leaving 25.3 % within the top (Tinker,1989). Due to this depth variation of wheat seeds at planting, emergence is low and might be the main reason for the use of high seeding rates by farmers (Astatke and Kelemu, 1993).

Currently the BBFs are ploughed and reconstituted if the BBM package is going to be used for the next season. The possibility of retaining the BBFs for repeated use with the minimum tillage could be an option. This will save animal and human labour for various tillage operations. Along with this the possibility of row seeding rather than broadcasting which requires high seed rates as done with the traditional system was considered. The row planting could reduce the required seed rate by improving the crop emergence with the placement of seeds uniformly at the optimum soil depth and also reduce required fertilizer rate by improving nutrient uptake by these plants. Further advantages would be better control of weeds (making weeding easier and less labour demanding) and stubble incorporation into the soil thereby partially filling the cracks thus reducing moisture loss and help the following crop.

The BBM frame could provide a low cost toolbar for attaching tine cultivator units and planters. It is hypothesized that such simple and low cost attachments would have more potential for adoption by farmers than the wheeled tool-carrier frames which have been tested in Africa. Nolleís designs of wheeled tool-carrier was promoted in Senegal and several hundreds were sold at a subsidized price to farmers. But soon it became clear that the farmers wanted cheaper, lighter and simpler implements (Starkey, 1988). Small numbers of Poly-cultures and Tropicultures were tested in several African countries but here also farmers opted for simpler implements when the subsidies were raised. The NIAE tool-carrier was tested in at least eight African countries but found to have very low adoption rates and concluded that simpler implements were more appropriate (Starkey,1988).

Several options to achieve the above goals were considered and modifications of the BBM with additional attachments for the use of minimum tillage and row planting have been designed and on station trials conducted in 1997 and 1998 at the International Livestock Research Institute (ILRI) Debre Zeit station. After the two years of an on station trial investigating of the new attachments to the main frame of the animal drawn Broadbed Maker (BBM) for minimum tillage operations and planter attachment, an on-farm testing was conducted at Chefe Donsa, in one of the Joint Vertisol sites. This paper reports on the development of the implements, the years results found using these implements at ILRI Debre Zeit Research Station .

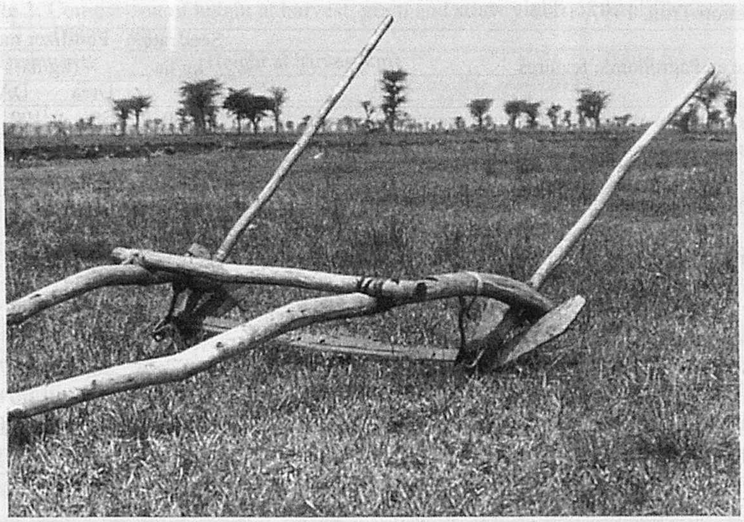

Fig. 3 The blade harrow attachment to the broadbed maker.

Materials and methods

Development of BBM attachments

The attachments for the BBM were designed for reduced tillage and seeding and in establishing semi-permanent BBFs system on Vertisols. To develop the design some basic compromises and features were decided upon:-

- fixed row and tine spacings
- low tine-bar height for reasonable diameter tine legs
- cultivating points forged onto one- piece tines
- tine bar to be lashed on to allow flexibility for steering yet include sufficient adjustment to give universal fitting to all mareshas
- seed and fertilizer to be hand metered
- seed and fertilizer covering to be completed by BBM wings and chain

The design used 40 mm diameter pipe for the main bar with a simple ring and wedge fitting which is lashed to the maresha beams. The tines are made in one piece from 20 mm diameter reinforcing bar and held in place by steel clamps and wedges made from 16 mm reinforcing metal pieces and needing only a hammer to fit or adjust on the main bar. There are nine grooves in the main bar of 93cm length at 8.8cm distances which will allow location of the tines. A blade harrow consisting of a metal blade 4mm thick fixed on both sides of the maresha tines as shown in **Fig.3** was also tried for post harvest cultivations.

The planter attachment to the BBM has been developed for line seeding. This is similar to the traditional planter used by the Afars in the eastern part of Ethiopia, which is a simple hand-metered seeder made of calabash and bamboo that mounts on the maresha. This has been redesigned to be attached to the BBM with a sheet metal funnel and four connecting tubes to cover the bed of the BBFs systems which is 80 cm in width. A set of tines, tines of leading and trailing coulter units (tines with ¾ inch tube welded on), penetrating the horizontal soil surface at 45° angle are used. The funnel consists of a circular hopper 100mm diameter with a disked bottom drilled with four equally spaced 25mm diameter holes to which the coulter tubes are attached. In the hopper, a centre rod supports a double layered cones above the plate with the four holes to provide better uniformity in seed distribution. The space of the lower cone to the plate is 50mm while there is 20mm space between the two cones. The lower cone which is nearer to the plate has a 70mm diameter while the upper cone has a 50mm diameter. The holes inside the hopper could be blocked off according to the new arrangement. The seeder is supported by a bar clamped to the tine bar. The funnel

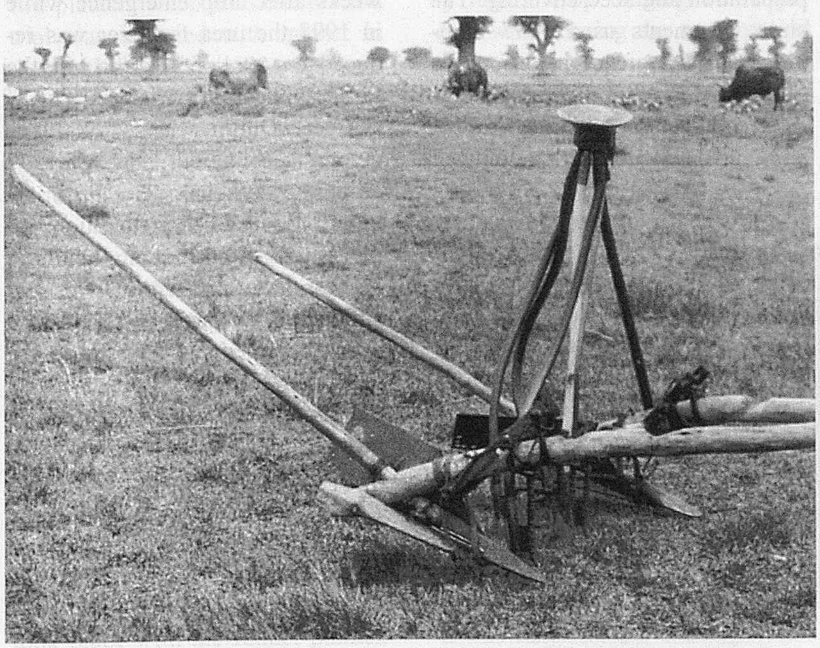

Fig. 4 The funnel planter unit attached to the broadbed maker.

Table 1. Composition of Treatments for on-station Trial, 1997, 1998

Treatment No	Tillage and agronomic features	Seed rate, kg/ha	Fertilizer rate (kg/ha)	
			Urea	DAP
1	Wheat and DAP broadcast and covered with the maresha (traditional practice)	150	50	100
2	Wheat and DAP broadcast on traditionally prepared surface and covered with the BBM to form BBFs at the same time	150	50	100
3	Use of BBM to form BBFs followed by the row placement of wheat seeds mixed with DAP with the planter at 5-7 cm depth	100	50	100(70)
4	Use BBM to form BBFs, row placement of wheat seed at depth of 5-7 cm and followed by DAP at depth of 3-5 cm on the previous rows with the planter	115	50	100(70)
5	Use of BBM to form BBFs and DAP broadcasted on the BBFs followed by row placement of wheat at 5-7 cm depth with the planter	115	50	100(70)
6	Row placement of DAP mixed with wheat, at a depth of 5-7 cm using the planter on reshaped BBFS.	100	50(25)	80 (70)
7	Row placement of wheat seed at a depth of 5-7cm followed with the placement of DAP at 3-5 depth on the previous rows using the planter on reshaped BBFs.	115	50(25)	100(70)
8	First broadcasting DAP on the BBFs followed by row placement of wheat seed at a depth of 5-7 cm using the planter on reshaped BBFs.	115	50(25)	100(70)

Note: Figures in parentheses are fertiliser rates for 1998. See text for reason for change.

planter unit as shown in **Fig. 4** is fitted to the tine bar using the same clamp and wedge system as the tines. When using the funnel planter three people are required, one pouring in the seeds into the funnel and two for handling the BBM as shown in **Fig. 5**. To assess the power developed by the animals engaged, the working speed and pull force of the tine and blade harrows and the planter were taken when the top 5-8 cm of the soil layer was moist which would be the conditions required for these implements to be used.

On-station Trials

Tine and blade harrow attachments to the BBM were used to disturb the top 5-7 cm soil depth, with the maresha pass in the already existing furrows to clean the sediment of the previous year and reshaping the BBFs with the BBM were required for the minimum tillage practice. Each broadbed was 0.2 m high and 0.8 m wide, separated with 0.4 m furrows. Planting of all minimum tillage plots was done with the double layered cone funnel planter. The conventional land preparation involved several pass with the maresha and making new BBFs while for the traditional system the maresha was used for both land preparation and seed covering. The eight treatments used 1997 cropping season were repeated on the same plots in 1998. Each plot measured 50m by 6m, separated by 1m path and laid out in a randomized complete block design with four replications. Due to high crop lodging incidences of wheat planted in rows during 1997 cropping season , seed and dimonium-super phosphate (DAP) were reduced from 150 kg /ha and 100 kg/ha to 125 kg/ha and 70 kg/ ha respectively in 1998 cropping season. Recommended rates of 175 kg/ha of wheat seed and 100 kg/ha of DAP were applied for broadcasted plots. In 1997, urea was applied to all plots at a rate of 100 kg/ha equally split and applied on the third and six weeks after crop emergence while in 1998 the urea fertilizer was reduced to a total of 50 kg/ha with the same application period as that of last year. Durum wheat, Foka variety was used in both 1997 and 1998 cropping seasons. The time required for seed bed preparation and planting, data on lodging, height at harvest, grain and straw yields and 1000 seeds weight were taken from all the treatments. Furthermore, the maneuverability and robustness of the implements were assessed during the two years trial. Treatments characteristics are given in **Table 1**.

Fig. 5 Row placement of seeds with the funnel planter,

Table 2. Comparison of height at harvest, grain and straw yields of the different treatments in the two years of on-station trial at Debre Zeit

Treatments	Height at harvest(cm)		Grain (t/ha)		Straw (t/ha)	
	1997	1998	1997	1998	1997	1998
1	120 b	96 c	1.72 b	0.90 c	3.63 c	2.34 bc
2	116 b	101abc	1.67 bc	0.96 c	3.84 b	2.48 bc
3	120 b	100bc	1.70 b	1.01 c	4.13 ab	2.61 b
4	121 b	107ab	1.57 c	1.03 c	3.50 c	2.52 b
5	117 b	98c	1.67 bc	0.64 d	3.74 b	1.83 c
6	132 a	107ab	1.83 a	1.35 b	4.36 a	3.09 a
7	133 a	111a	1.81 a	1.53 a	4.07 ab	3.42 a
8	129 a	111a	1.94 a	1.41 ab	4.14 ab	3.31 a

Results

Development of BBM Attachments

Tests were carried out in 1996 comparing funnel planters with different cone arrangements in terms of their uniformity in seed distribution. Both the single and double layered cone funnel planters provided uniformity of seed distribution , and ensured better crop inter and intra spacings on the broadbeds compared to the hand-metered planter without the cone arrangement. The wheat seed distributed along a 50 m distance in the dry run averaged 193.5 ± 89.59 g/coulter (row) using a single coned planter while the double coned planter distributed 201.7 ± 60.9 g/ coulter. There was no significant differences in seed weight distributed by the two planters when the same dry run trial was repeated with maize. In the field trial, use of the different planters didi not cause significant yield of wheat, but plots sown with the double cone planter had a more uniform crop stands between rows. There was no change of the coulters by using the different funnel types. The coulter unit tines were used as furrow openers and seeding boots to which the seed tubes are fitted as well as being used as tine cultivators when the planter device was not attached. The blade harrow which cuts the top soil to 4 cm depth was used to smoothen the beds of the BBFs disturbed by the tine harrow and for uprooting weeds before planting took place with the funnel planter. The power developed by a pair of local zebu oxen using the tine and blade harrows and the funnel planter was low and varied from 0.45-0.54 kW which is similar to the power developed on the third pass with the traditional maresha. The power developed during the first pass of the maresha can be as high as 0.95 kW (Astatke and Matthews, 1982).

On station Trials

The time required for the seed preparation and planting for the two years with the minimum tillage systems averaged 21 hrs /ha and was significantly lower than both the traditional and conventional systems which took 78 hrs/ha and 64 hrs/ha respectively. Vigorous crop growth on plots where minimum tillage was followed in 1997 cropping season lead to significantly higher crop lodging of 62 per cent while during the same period the crop lodging in the traditional and conventional systems were 5 and 19 per cent respectively. The height at harvest, grain and straw yields of wheat for the different treatments for the two cropping seasons (1997 and 1998) are shown in Table 2. In 1998 rains extended into early October and coincided with crop flowering period thus lowering the grain produced compared to 1997 production. During the two years trials, the problem encountered with the implements was the clogging of the funnel planter at the seed outlet when used during wet soil conditions and when there was a lot of stubble in the field. As it was easy for the oxen operators to see the seed flow, the cloggings were cleared whenever they happened.

Means in each column with the same letter are not significantly different at 5% level probability.

Conclusion

Since the early 90ís, no till and reduced till (commonly referred to as conservation tillage) have become important soil-crop management systems in the developed countries. Unlike the conventional deep tillage systems, conservation tillage systems are important because they protect soil from erosion, increase soil organic matter, improve precipitation storage efficiency, increase biological yield, provide fuel and tractor-life savings of 25-50 percent and increase the number of crop options for dryland rotations (Vigil et al.., 1995). No till and reduced tillage management also resulted in increased soil organic carbon concentration on top the surface of 0.07m in comparison to more intensive tillage management. Conservation tillage practice will improve the soil organic matter content with less release of carbon dioxide (CO_2) from the soil minimizing the green house gas emission which is adequately understood (Dalal and So, 1998).

In the Ethiopian context land degradation, defined as a reduction in long term productivity, is caused by severe soil erosion which results from intensive cultivations and overuse of land resources. According to Constable and Belshaw (1989), by 1984/85about half of the

Ethiopian highlands were reported to be eroded, of which 14,000 km^2 were seriously eroded. During the same period, some 20,000 km^2 of agricultural land were rendered irreversibly eroded and could not sustain further cropping. If this trends continues, it has been calculated that one- third to a half of the total area of the Ethiopian highlands would be totally unsuitable for crop production within the next two decades.

The most important aspect of soil conservation which has the greatest effect is having plant cover during the rainy season (Hudson, 1975). The importance of a plant cover in reducing erosion is demonstrated by several experiments. At Henderson Research Station in Zimbabwe mean annual soil loss in three years from bare ground averaged 46.3 t/ha compared with 0.4 t/ha from ground with dense vegetative cover (Morgan, 1980). In Ethiopia, soil erosion from Vertisol plots were found to be very high as they are planted late during the main rainy season, leaving the ploughed soil exposed to rains. An incidence of 70.8 mm of rain on 11August 1999, in the middle of the main rainy season, at Chefe Donsa resulted in 18 t/ ha of soil loss in just a day from the bare land prepared for planting (EARO, 2000). Long term studies of soil sediment loss from farmersí fields in Anjeni, Amhara Region (central highlands) where planting is practiced late during the main rainy season was high approximating 60-97 t/ha annually from 100-ha catchment or an equivalent soil depth loss of about 1cm/year (Hurni and Perich, 1992). The role of vegetation is in interception of the raindrops so that the kinetic energy is dissipated by the plants rather than imparted to the soil.

In developing countries like Ethiopia, the practice of no till system which requires high amounts of herbicides will be costly and probably unacceptable to the farmers. Modifying the traditional implements for minimum tillage operations could be much more attractive to farmers. On-farm verification of the animal drawn implements developed and tested on- station for minimum tillage use will be an essential step for disseminating the package to a larger community.

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Combined Implements for Simultaneous Loosening and Levelling of Soil Surface

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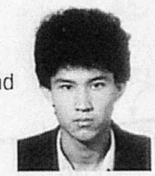

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Abstract

In the present article are given the scheme and description of combined implements for simultaneous loosening and levelling of soil surface.

Results of researches on the study of the optimum form and parameters of a levelling working body for combined implements are presented. It is established that for achievement of the best quality of processing of soil before sowing with minimum costs of energy, the most acceptable working body consist of levelling and condensing soil surfaces. This has the condensing surface located under angle to the horizon 16° to 20° and the levelling surface is located under angle 130° to 140° to a condensing surface. Thus the height of a working body must be within the limits of 150...200 mm and length of a condensing surface at 175 to 200 mm.

Introduction

At present the processing of soil before sowing in a zone of cotton growing is made by various harrow units (ÀÁÍ-8,5; C-11Ó + ÀÇÑÑ-1,0) and levelling implement (ÂÍ-8; ÌÂ-6,0), which work separately. This results in an increase in costs of labour and means for preparation of soil to sowing, condensation and drying it up, as well as in temporary periods of sowing of farm crops.

Materials and Methods

The present study was done at the Uzbek Research Institute of Mechanisation And Electrification of Agriculture (UzMEI) together with a joint-stock company "BMKB-Agromash" on combined implements, ensuring one pass of unit loosening and levelling of soil (**Fig.1**).

The scheme consists of central 1 and lateral 2 and 3 sections connected with the central by joints, and gear 10 for lifting lateral sec-

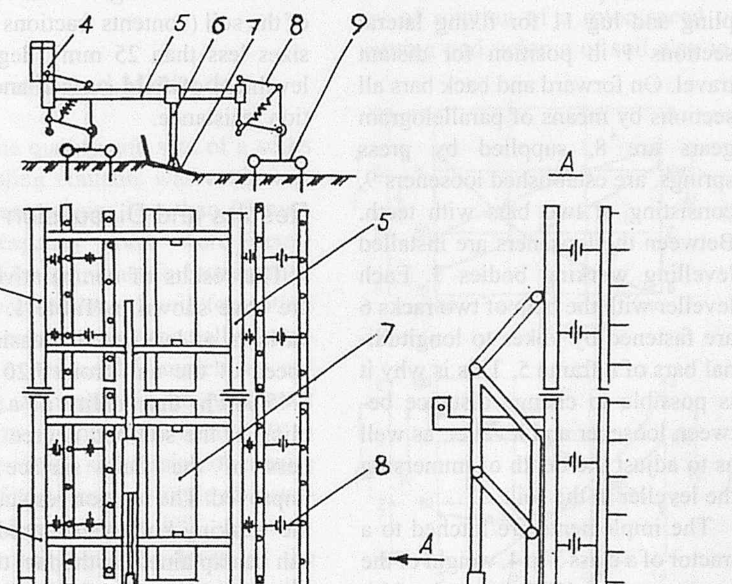

Fig.1 Scheme of the implement for simultaneous loosening and levelling of soil surface before sowing.

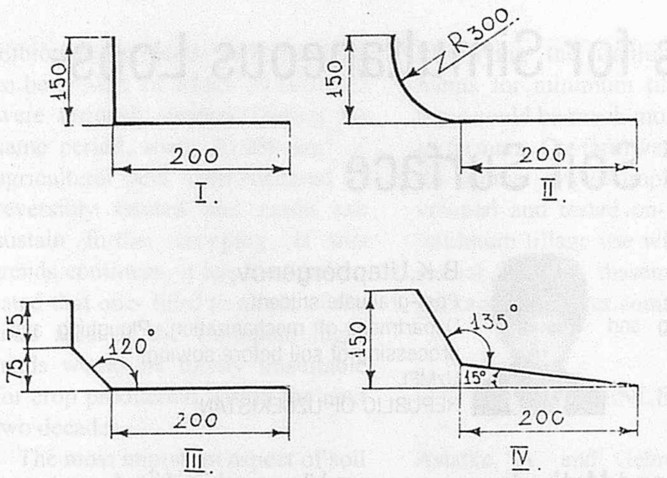

Fig.2. Schematic diagram of the levelling working bodies.

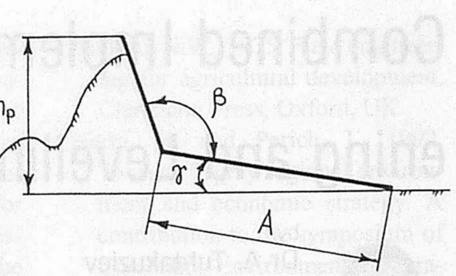

Fig.3. The scheme of a levelling working body of the implement.

tions to transport position. In a forward part of a central section there are present a lock 4 for connection of the implements with a tractor with the help of an automatic coupling and lug 11 for fixing lateral sections 1 in position for distant travel. On forward and back bars all sections by means of parallelogram gears are 8, supplied by press springs, are established looseners 9, consisting of two bars with teeth. Between the looseners are installed levelling working bodies 7. Each leveller with the help of two racks 6 are fastened by yokes to longitudinal bars of a frame 5. This is why it is possible to change distance between loosener and leveller, as well as to adjust the depth of immersing the leveller in the soil.

The implements are hitched to a tractor of a class 3 to 4, weight of the implement of 1320 kg and width grab of 8,5 m and working speed of movement of 7 to 10 km/h.

For attaining optimum form, the parameters of a levelling working body of this implement were developed and made various variants (**Fig.2**). Their comparative tests were conducted.

The tests were conducted at speeds of 5.20 and 8.45 km/h during preparation of the soil for sowing of cotton seeds. The soil was loamy that was ploughed in autumn on a depth 30 to 32 cm. Humidity and hardness of the soil on the horizons 0 to 10 and 10 to 25 cm, accordingly made 15.9; 17.8 % and 0.59; 0.95 MPa. The criteria of valuation were: a degree of crumbling of the soil (contents fractions by the sizes less than 25 mm), degree of levelness of field surface and traction resistance.

Results and Discussion

The results of comparative tests are have shown in **Table 1.** At all variants of levellers increasing the speed of the unit from 5.20 up to 8.45 km/h, the quality of a crumbling of the soil and degree levellness of the field surface were improved. The traction resistance of the working bodies increased. This can be explained by the fact that increasing the speed of movement of a unit force of impact of the working bodies about lumps of soil also increases. As a result lumps are broken into more small-sized particles and are distributed in regular intervals on the surface the soil.

For the variants of levelling working bodies, the best parameters have variant IV which provides 7.10 to 18.90 % large degree of crumbling of soil and on 2.87 to 16.00 % large degree of levelness of field surface and 5.16 to 46.01 % traction resistance. When the degree of crumbling and levelness of soil surface is improved the traction resistance of a working body decreases.

The best degree of levellness of a soilís surface at minimum traction resistance was reached at $\beta = 130^o$ to 140^o, $\gamma = 16^o$ to 20^o. Researches have also shown that for the achievement of required density of a soil (1.1 to 1.3 gram/cm^3) the length of a condensing surface of the leveller should be within the limits of 175 to 200 mm, and height of a levelling working body can be accepted within the limits of 150 to 200 mm. Thus the soil of a drag prism is not poured over the top edge of a leveller and reaches qualitative fulfilment of technological process. ■■

Table 1. Results of Comparative Tests of Various Forms of Levellers

Variants of levellers	Speed of motion,K m/h	Degree of levellness of soil's surface, %		Degree of soil's crumbling, %		Specific traction resistance, N/m	
		M_{av}	±σ	M_{av}	±σ	M_{av}	±σ
I	5.2	62.37	5.68	70	5.38	448	15.28
	8.45	69.8	7.61	75.9	4.3	676	20.15
II	5.2	71.27	7.05	79.9	4.04	329	24.73
	8.45	78.86	7.24	81.1	5.71	514	23.04
II	5.2	70.15	8.02	78.4	5.51	365	21.27
	8.45	78.16	6.42	85.3	5.66	501	25.21
IV	5.2	74.14	5.81	87	4.03	312	19.95
	8.25	85.8	5.57	94.8	2.05	365	22.74

Some Results of Researches of a Rotor with a Vertical Axis of Rotation

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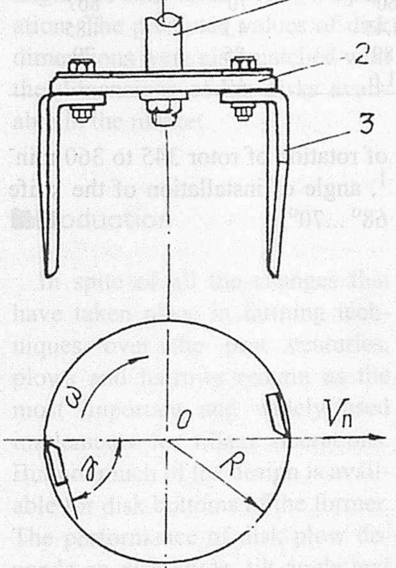
Abstract

In the present article results of researches on the study of influence of frequency of rotation of a rotor harrow, submission on a knife and angle of itís installation are indicated on quality of a soilís crumbling and power, consumed by the rotor.

Introduction

At the Uzbek Research Institute of Mechanization and Electrification of Agriculture (UzMEI) was conducted a research on modes of operations of rotary harrow with a vertical axis of rotation (**Fig.1**) with reference to processing of soil before sowing cotton and other cultures.



1 -Shaft of a rotor;
2 -Disk of a rotor;
3 -Knife of a rotor;
Vn-translational speed;
ω -angular speed;
R -radius of a rotor;
γ -angle of installation of a knife of a rotor.

Fig. 1 A rotor of a rotary harrow with a vertical axis of rotation.

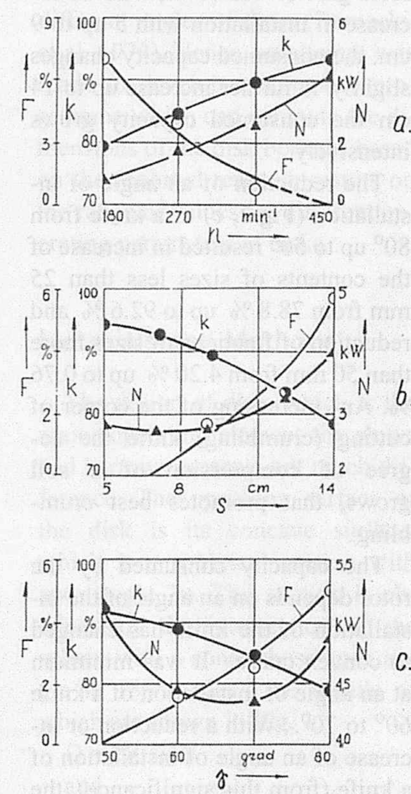
Materials and Methods

The quality and size of a soilís crumbling contents was evaluated. Fractions of size less than 25 mm, and capacity rotor were determined by tenzometric instruments. The preparation of soil for cotton seeds sowing using specially developed experimental implement enabling a change in frequency of rotation of the rotor from 180 to 450 rev/min, submission on a knife from 5 to 14 cm and angle of installation it from 50° to 80°.

Humidity and hardness of the soil of an experimental site in the horizon 0 to 5, 5 to 10 and 10 to 20 cm accordingly made 9.12; 17.1; 17.3 % and 0.26; 0.59; 0.63 MPa. The statistical processing of results of the research has given the opportunity to understand the main laws of process of interaction of the rotary of a harrow body with the soil.

Results and Discussion

The installation of a knife with an increase in the frequency of rotation of the rotor of soilís crumbling, i.e., the contents of fractions of size less than 25 mm increases, fractions by the size more than 50 mm decreases, and capacity, consumed by the rotor, grows in direct proportion. This is explained by the fact that with increasing in frequency of rotation of a rotor speed of cutting and volume of soil also in-



K -fractions by the size less than 25 mm;
F -fractions by the size more than 50 mm;
N -capacity, consumed by rotor.

Fig. 2 Change of a degree of a soilis crumbling and consumed rotor's capacity.

$$Y_C = 88,8588 - 1,8672X_1 + 9,9322X_2 - 2,2733X_3 - 3,0203X_1^2 + 4,8592X_1X_2 - 8,1319X_2^2$$

Where $X_1 = (Vn - 1,5)/0,5$;
$X_2 = (n - 360)/90$;
$X_3 = (\gamma - 65)/10$;
V_N - translational speed, m/s.

Equation (1)

$$Y_N = 3,2936 + 0,1283X_1 + 0,2267X_2 - 0,4467X_3 + 0,3363X_1^2 - 0,2767X_1X_2 \text{ ñ } 0,4567X_1X_3 + 0,8446X_2^2 + 0,1683X_2X_3 + 0,7680X_3^2$$

Where $X_1 = (Vn - 1,5)/0,5$;
$X_2 = (n - 360)/90$;
$X_3 = (\gamma - 65)/10$;
V_N - translational speed, m/s.

Equation (2)

creases.

With an increase in installation (**Fig. 2, b**) of a knife owing to an increase in thickness of the soil, cutting by a knife, the quality of a soilís crumbling becomes worse and the capacity consumed by the rotor grows. However, with an increase in installation with 5 up to 9 cm, the consumed capacity changes slightly. A further increase up to 14 cm the consumed capacity grows intensively.

The reduction of an angle of installation (**Fig.2, c**) of a knife from 80° up to 50° resulted in increase of the contents of sizes less than 25 mm from 78.8 % up to 92.6 % and reduction of fractions of sizes more than 50 mm from 4.20 % up to 0.76 %. An increasing of the corner of cutting (crumbling) knife the degree of compression of a soil grows, that promotes best crumbling.

The capacity consumed by the rotor depends on an angle of the installation of the knife has changed to convex curve. It was minimum at an angle of installation of a knife 60° to 70°. With a reduction or increase of an angle of installation of a knife (from this significance), the consumed capacity grew. The increase in capacity at an angle of installation less than 60 ° is explained by increasing of costs of energy on discarding and compression of soil

Table 1. Data for Graphs (**Fig. 2**)

	a			
n, min^{-1}	180	270	360	450
N, kW	0.8	1.9	2.5	4.1
K, %	80	85	90	83
F, %	7	4	0.75	0
	b			
S, cm	5	8	11	14
N, kW	2.9	2.7	3.1	4
K, %	95	91	86	78
F, %	0	0.6	2.5	5.9
	c			
γ	50°	60°	70°	80?
N, kW	5.15	4.45	4.3	4.85
K, %	93	89	85	79
F, %	0	1.6	2.5	5

by the knife, and at an angle of installation more than 70° at the expense of compression of soil by the back side of the knife.

As a result of processing the experimental data, the **equations (1)** of regressions describe change of quality of the soilís crumbling (%).

And capacity (kW), consumed rotor

Equations (2)

At joint congruence of **equations** (1) and (2) the following rational significance of parameters of the rotor, and ensuring the required degree of the soilís crumbling (not less than 80 %) are at minimum consumed capacity. The frequency of rotation of rotor 345 to 360 min^{-1}, angle of installation of the knife 68°...70°. ■■

Computer-aided Design for Disk Bottoms

by

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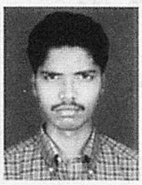

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Abstract

The design of disk bottoms of the plow was made by developing a computer programme. The variation of dimensions of disks bottoms for the plow was computed by using the developed programme for different values of operating parameters such as setting angle, tilt angle and maximum depth of operation. The predicted values of disk dimensions were also matched with the dimensions of the disks available in the market.

Introduction

In spite of all the changes that have taken place in farming techniques over the past centuries, plows and harrows remain as the most important and widely used implements for tillage operations. But not much of the design is available for disk bottoms of the former. The performance of disk plow depends on disk angle, tilt angle and concavity of the disk. Kepner et al (1978) reported that the diameter of the disk for disk plow commonly varies between 61 and 71cm and are operated at a disk angle of 42 to 45°and with a tilt angle of 15 to 25°. Research conducted by Clyde (1939) on a 66-cm disk plow with radius of curvature 56.9cm in heavy clay loam and fine sandy loam soil at a moisture content of 14.9 to 17.6 and 10.7%, respectively, indicated that reduction in tilt angle resulted in reduction of penetration at high speeds. Gordon (1941) indicated that the draft of the disk plow increased with increase in disk angle beyond 45° and was minimum at 45° for the disk. The penetration was also improved by increasing the disk angle. Increasing the angle of tilt within 15 to 25° increased the draft and decreased the side force and improved the penetration at smaller tilt angles. Similar observation was also reported by Taylor (1967). Gordon (1941) also found that increasing the disk concavity (i.e., smaller radius of curvature) increased the vertical upward force and also tended to increase the draft.

Tests conducted for disk harrows by McCreery (1959) in a sandy soil with moisture content of 8.4% and for a constant width and depth of cut indicated that the lateral, side and vertical forces decreased with an increase in disk angle from 10 to 25° and beyond that the decrease is not that significant. Similarly, increasing the radius of curvature from 47.8 to 66 cm also reduced all forces upto 23° disk angle. Beyond that, it has little effect. Based on research activities some design data for disks of plow and harrow are also available on different angles of disks (Bernacki. et al. 1972). Hence, an attempt was made to develop a computer programme which can compute the dimensions of the disk bottoms based on the reported research results on the range of values for different operating parameters of disks.

Materials and Methods

The design of disk, which is the major operating element for plows and harrows presents not much difference. The operating surface of the disk is its concave surface, which is a spherical section with apex angle 2φ. This section is obtained by the intersection of the sphere with a cone whose apex angle is $180° - 2\omega$, the details of which are shown in **Fig. 1**.

$$D = 2R \sin\varphi$$

and

$$D = k\, a/\cos\beta$$

Where

D = Diameter of the disk

R = Radius of curvature of disk

k = Dimensionless coefficient

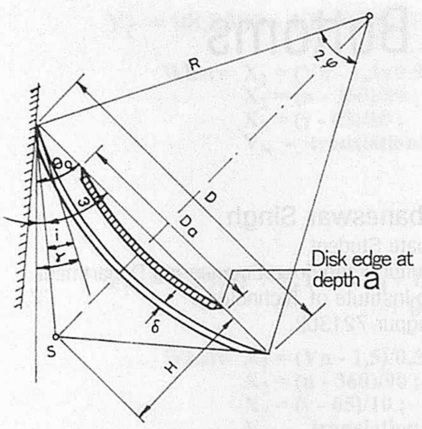
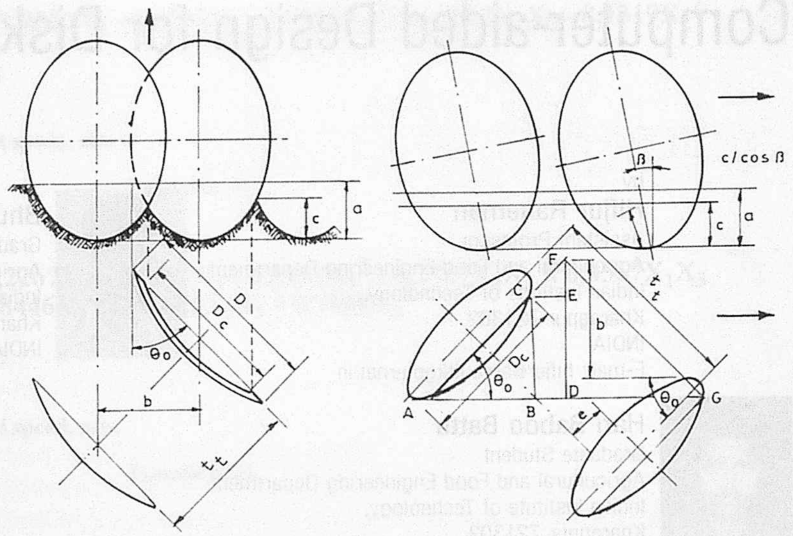


Fig. 1 Cross section of disk showing various parameters.



(a) Spacing of perpendicular disks

(b) Spacing of inclined disks

Fig. 2 Spacing of disks in a multi-disk plow.

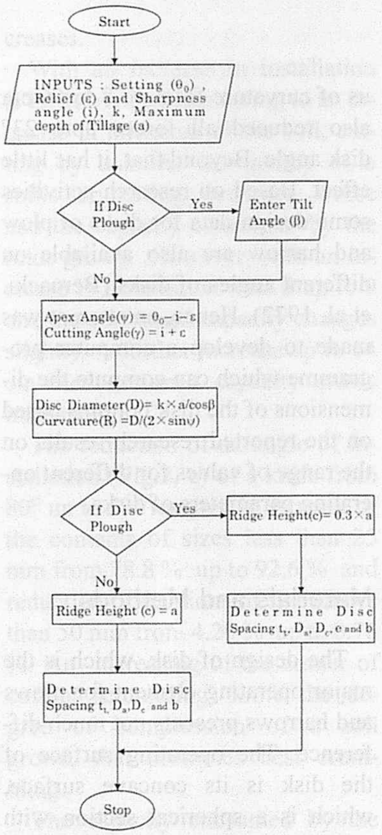


Fig. 3 Flow chart for designing the discs of a plow or harrow.

= 3 to 4 for plows and 3 to 6 for harrows (Bernacki et al. 1972)

a = Maximum depth of plowing or harrowing

β = Tilt angle of the disk = 15 to 25° for plows and 0° for harrows

The apex angle, $2\varphi = 2(\theta_0 - i - \varepsilon_0)$

Where

θ_0 = Setting angle of the disk = 40 to 45° for plows and 15 to 25° for harrows (Kepner et al. 1978).

i = Angle of sharpness of disk = 10 to 15°

ε_0 = Relief angle = 3 to 5° for plows and 3 to 2° for harrows (Bernacki et al., 1972)

The cutting angle, $\gamma = i + \varepsilon_0$ (1)

The ratio D_a/D can be calculated from the relation $(D_a/2)^2 = a(D-a)$

In a multi-disk implement, their spacing should be so calculated that they do not become clogged with soil. The spacing t_t of perpendicular disks depends on the height of ridges formed on the bottom of the furrow (**Fig. 2a**) or on the width of tillage of a single disk.

$D_c \sin\theta_0 = t_t \cos\theta_0$

$D_c = 2\sqrt{c(D-c)}$

Hence $t_t = 2\sqrt{c(D-c)} \tan\theta_0$

Since $b = t_t \cos\theta_0$

Then $b = 2\sqrt{c(D-c)} \sin\theta_0$ (2)

Where

$c \leq 0.3a$ for plows and $\leq a$ for harrows

The spacing of inclined disks of plows is determined by two values: spacing t_t and transposition e.

From **Fig. 2b**, BC = FD-EF (3)

$BC = Dc \sin\theta_0$

$FD = FG \cos\theta_0 = t_t \cos\theta_0$

$EF = CF \sin\theta_0 = e \sin\theta_0$

$Dc \sin\theta_0 = t_t \cos\theta_0 - e \sin\theta_0$

$Dc = t_t \cot\theta_0 - e$

Simultaneously

$Dc = 2\sqrt{c/\cos\beta(D - c/\cos\beta)}$

Then $t_t = [2\sqrt{c/\cos\beta(D - c/\cos\beta)} + e] \tan\theta_0$ (4)

The value of the transposition is such that $t_t > 2a$.

The thickness of the disk depends on the diameter of the disk and amounts to

$\delta = 0.008D + 1$ mm (Bernacki et al., 1972)

Based on the above relationships computer programme was written

Table 1. Variation of Disk Dimensions for Different Values of Tilt Angle for $\theta_0 = 45°$, $i = 15°$, $\varepsilon_0 = 5$, $k = 3$ and $a = 20$ cm

Tilt angle (β, degrees)	Radius of curvature (R, cm)	Diameter (D, cm)	Transposition (e, cm)	Spacing (t_t, cm)	Vertical spacing (b, cm)
15	73	62	3.23	40	26.4
17	74	63	2.86	40	26.6
19	75	63	2.43	40	26.9
21	76	64	1.94	40	27.3
23	77	65	1.39	40	27.7
25	78	66	0.78	40	28.1

Table 2. Variation of Disk Dimensions for Different Values of Setting Angle for $\beta = 15°$, $i = 15°$, $\varepsilon_0 = 5$, $k = 3$ and $a = 20$ cm

Setting angle (θ_0, degrees)	Radius of curvature (R, cm)	Diameter (D, cm)	Transposition (e, cm)	Spacing (t_t, cm)	Vertical spacing (b, cm)
40	91	62	9.23	39	24.0
42	83	62	6.94	40	24.9
44	76	62	4.51	40	25.9
45	73	62	3.23	40	26.4
46	71	62	1.91	41	26.8
50	62	62	0.00	44	28.6

Table 3. Variation of Disk Dimensions for Different Values of Maximum Depth of Operation for $\theta_0 = 45°$, $b = 15°$, $i = 15°$, $\varepsilon_0 = 5$, and $k = 3$

Maximum depth of operation (a, cm)	Radius of curvature (R, cm)	Diameter (D, cm)	Transposition (e, cm)	Spacing (t_t, cm)	Vertical spacing (b, cm)
15	55	47	2.55	30	19.8
17	62	53	2.82	34	22.4
19	70	59	3.09	38	25.0
20	78	62	3.23	40	26.4
23	85	71	3.64	47	30.3
25	92	78	3.91	50	32.9

Table 4. Comparison of Dimensions of Disk Predicted and Available in the Market

Parameters	Predicted	Available(Market)
Radius of curvature, cm	57.2	57
Apex angle, degrees	66	70
Diameter of disk, cm	65.5	66
Thickness of disk, mm	1.5	2
Spacing between disks, cm	40	40

in C language to facilitate computations in determining the dimensions of disk bottoms and their arrangements in a disk plow. The flow chart of the developed programme is given in **Fig. 3**.

Results and Discussions

The dimensions of disk bottoms computed by using the developed programme is reported in **Tables** 1 to 3 for different values of setting angles, tilt angle and maximum depth of operations. The effect of tilt angle on disk diameter while keeping other variables such as setting angle, relief angle, cutting angle, apex angle and dimensionless coefficient ëkí constant for 20 cm maximum depth of operation is presented in **Table 1**. From this table it can be seen that the diameter range of the disk varied from 62 to 66 cm by increasing the tilt angle from 15 to 25° and for multi-disks plow the spacing between disks does not vary even with the variation of disk diameter. The effect of varying the setting of angles on disk dimensions and keeping other variables constant for 20 cm maximum depth of operation is presented in **Table 2**. Which shows that with the variation of setting angle there is variation in radius of curvature of the disk but not in the diameter of the disks. For a multiple disk system, the spacing also increased with the increase in setting angle.

The effect of maximum depth of operation on disk dimensions and on their arrangement in multiple disk systems is presented in **Table** 3 for a constant setting angle, tilt angle and relief angle. It can be seen that with an increase in maximum depth of operation, radius of curvature, diameter and spacing between disks also increased.

The dimensions of disks predicted for a setting angle, angle of sharpness and relief angle as 45, 10 and 3°, respectively, with ëkí as 4 matched with the dimensions of disk available in the market and are given in **Table 4** .

Conclusions

The developed programme was used to determine the dimensions of disks of a disk plow for different combinations of tilt angle, setting angle, and maximum depth of operation. The predicted values of disk dimensions also matched with the values obtained for the available disks in the market. Thus the developed programme can be used as a tool in deciding the dimensions of disk bottoms while designing a disk plow.

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Development and Evaluation of a Mechanical Seed Extractor

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Abstract

Dependence on human labour for seed extraction results in delayed processes, inadequate inconsistent supply and increased production cost. To overcome these difficulties, a mechanical seed extractor was developed. The test results indicate that by adopting a three-pass system, 98.3% seed and 79.4% juice can be recovered with a feed rate of 60-70kg/hr.

The seed extraction cost by mechanical seed extraction is half that of manual seed extraction. If the machine is operated for 100 days annually, the cost of the machine would be recovered within one year. Utilizing the by-product juice can generate additional income.

Introduction

The seed is the carrier and catalyst of agro-technologies. Its production, availability and quality has played a significant role in achieving higher agricultural production. India has a large number of small and marginal farmers who would immensely benefit if good quality seeds are adequately available to them. The seed industry has developed rapidly during the last 20 years. In India, the tomato and lime are popular with consumers as fruits and also as vegetables.

Seeds from fruit/vegetable such as tomato, lime, chilli, brinjal, (eggplant) water melon and cucumber. are extracted manually which is both time-consuming and labour intensive. About 300 - 400 kg of tomato and 160 - 180 kg of lime fruits are required to recover 1 kg of seed. The recovery of seeds from new hybrid varieties is very low (Saxena et. al., 1990).

Dependence on human labour for manual seed extraction results in delayed process, seed loss and increased cost of production. This process is unhygenic, cumbersome and uneconomical. The extraction process is such that, the remaining by-product is of no use and has to be thrown away. In some cases, the hands and feet of the labourers get inflicted with injuries during manual seed extraction. Non-availability of adequate labour for seed extraction is another major problem (Gabani and Siripurapu, 1993).

To overcome these manual seed extraction difficulties and utilization of by-product, a mechanical seed extractor was developed at the Department of Agricultural Product Process Engineering, Gujarat Agricultural University, Anand. Various physical and mechanical properties of tomato and lime were determined, (Mohsenin, 1986) in order to design and optimise the dimensions of the various components of the seed extractor. The prototype model was tested and evaluated for its capacity, seed extracting efficiency, seed germination and cost of operation.

Traditional Seed Extraction

Tomato seed extraction method

There are two traditional methods of seed removal from tomatoes. In the first method, tomatoes are immersed in water and crushed by hand. The skin is thrown away and the material collected in tub is then sieved and the seeds are separated. The remaining material (juice) is

Acknowledgment

All facilities for designing, fabrication and testing the machine provided by the Department of Agricultural Product Process Engineering, Gujarat Agricultural University, Anand are duly acknowledged.

Fig. 1(a) Mechanical seed extractor.

thrown away. The collected seeds are subsequently rubbed by hand using ash to remove the mucus layer and than washed in water to get clean seeds. The cleaned seeds are then sun-dried for preservation and subsequent use.

In the second method tomatoes are taken in a tub and crushed by manual trampling. Water is added to the slurry and fermented for 2 to 3 days. The fermented sludge is then stirred manually. After some time the seeds sink to the bottom and the rest of the material float to the top. The seeds are separated out and washed in clean water and subsequently dried in the sun (Saxena at. al. 1990).

Lime seed extraction

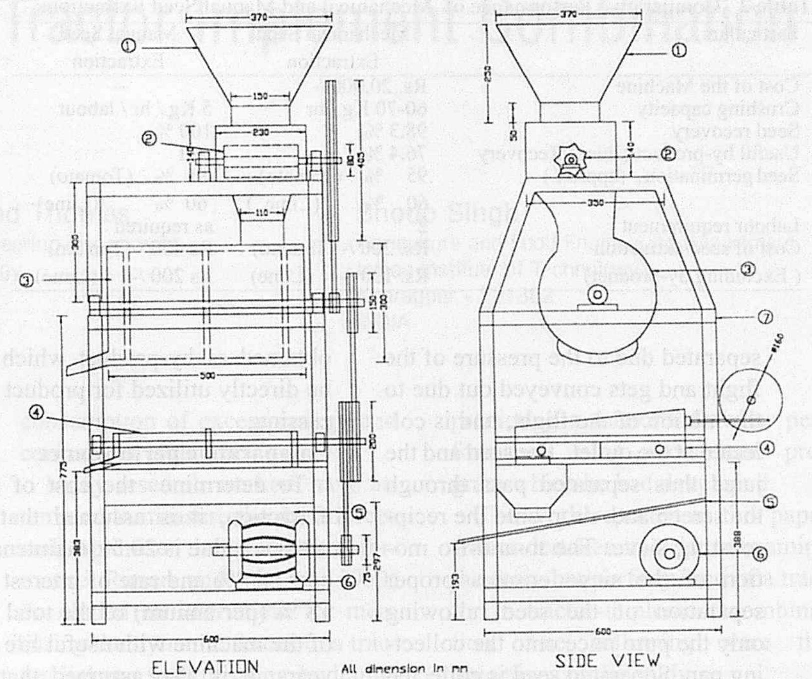
The conventional method of extracting seeds from the lime fruits is by fermenting in water for one week and then crushing them manually. Subsequently the seeds are separated from the crushed materials by hand sieving and the fleshy portion is thrown away.

Description of the Machine

In order to achieve maximum efficiency, the machine was designed after studying the physical and mechanical properties of the fruit and seed of tomato and lime.

The developed mechanical seed extractor consists of a hopper, crushing assembly, drum separator assembly, reciprocating sieve and collecting pan made of stainless steel. A one-hp electric motor is used to drive the machine (Fig. 1).

The crushing assembly consists of a concave and a star roller fitted on a shaft. The clearance between the concave and the star roller is kept such that the material coming from the hopper, fixed on the top of this assembly, gets properly smashed. A drum separator assembly, fitted below the crushing assembly, consists of an interchangeable perforated screen and rotating flight fitted on a shaft. Two sets of perforated screens, one for tomato and one for lime, are used. A reciprocating sieve is provided below the separator assembly, which retains the separated seed. The remaining juice passes through the sieve on to a pan fixed at the bottom of the machine. Provision is made to collect the outputs obtained at the separator assembly, the reciprocating sieve and the bottom pan.



Legend ① Hopper ② Star roller ③ Separating drum ④ Vibrating sieve ⑤ Collecting pan ⑥ Motor ⑦ M.S. frame

Fig. 1(b) Mechanical seed extractor.

Principle of Operation

The fruit is fed into the hopper and passes to the crushing assembly where it is crushed between the rotating star roller and concave. The smashed material now reaches the separator assembly where the rotating flight presses the material on to the perforated screen. The skin gets

Table 1. Effect of Number of Passes on Recovery of Seed and Juice

Particulars	Seed recovery %	Juice recovery %
First pass	80.7	69.2
Second pass	9.5	5.9
Third pass	8.1	1.3
TOTAL	98.3	76.4

Table 2 Comparative Performance of Mechanical and Manual Seed Extractions

Particulars	Mechanical Seed Extraction	Manual Seed Extraction
Cost of the Machine	Rs. 20,000 /-	--
Crushing capacity	60-70 Kg / hr	5 Kg / hr / labour
Seed recovery	98.3 %	100 %
Useful by-product (Juice) Recovery	76.4 %	Nil
Seed germination, (approx.)	95 % (Tomato)	95 % (Tomato)
	60 % (Lime)	60 % (Lime)
Labour requirement	2	as required
Cost of seed extraction	Rs. 200 /- (Tomato)	Rs 400 /-(Tomato)
(Excluding by-product)	Rs. 100 /- (Lime)	Rs 200 /- (Lime)

separated due to the pressure of the flight and gets conveyed out due to the motion of the flight, and is collected at the outlet. The seed and the juice thus separated pass through the screen and drop onto the reciprocating sieve. The to-and-fro motion of the sieve ensures proper separation of the seed, allowing only the pure juice onto the collecting pan. Separated seed is collected from the outlet provided at one end of the reciprocating sieve.

Results and Discussion

Evaluation of the seed extracting machine

The machine was tested with ripe fruits of tomatoes and lime of different varieties. Three replications of each test were taken with sample weight of 50 kg for each replication. The input capacity, seed recovery and juice recovery of mechanical seed extraction were determined.

The effect of number of passes on the recovery of seed and juice (as by-product) of tomatoes and lime using mechanical seed extractor were studied. Results are given in **Table 1**. It was observed that in the first pass 80.7% seeds and 69.2% juice are recovered. At the end of three passes, the total recovery of 98.3% seeds and 76.4% juice was obtained. The capacity of the extractor was determined to be 60 - 70 kg per hour. As all the parts coming in contact with the processed fruit are made up of stainless steel, good quality juice is obtained as by-product which can be directly utilized for product processing.

Comparative performance

To determine the cost of seed extraction, it is assumed that the salvage value is 20 %, maintenance cost is 5 % and rate of interest was 18 % (per annum) of the total cost of the machine with useful life of 7 years. It is also assumed that the machine works for 100 days annually and the labour charge per day was Rs 40 /- per day per labourer. The comparative performance data of the mechanical and manual seed extractor are given **Table 2**.

Two workers are required to operate the mechanical seed extractor whose crushing capacity is about 60 -70 kg fruits per hour, with total seed and juice recovery of 98.3% and 76.4% respectively. In comparison, by the manual seed extraction method, one worker can extract seeds from about 5 kg fruits per hour with 100% seed recovery. However, the fleshy material of fruits is generally thrown away. Seed germination is around 95% and 60% in tomato and lime seed, respectively, in both mechanical and manual seed extraction method.

The cost of seed extraction using the mechanical seed extractor was about Rs. 200 and Rs.100 per kg seeds of tomato and lime fruits, respectively, whereas in the manual seed extraction the costs were Rs. 400 and Rs. 200 per kg of seed for tomato and lime fruits, respectively. The approximate cost of the machine is Rs. 20,000 which can be recovered, if a total 40 tons of tomato and lime fruits are processed. In other words, if the machine is operated for 100 days (50 days for each tomato and lime fruits) with 8 hr/day operation, the cost of the machine would be recovered within one year. Additional income can be generated through utilizing the by-product, namely, tomato and lime juice.

Conclusions

It is concluded from the above study that the seed extractor is easy to operate, faster and cheaper as compared to traditional seed extraction. The cost of the machine can be recovered in one year of operation. Moreover, the by-product can be utilised for processing purpose thereby generating additional income.

Recommendations

The machine was duly evaluated at the Department of Agricultural Product Process Engineering, Anand and was recommended by the Joint Agricultural Research Committee of Gujarat Agricultural University for commercial production to benefit the farmers.

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Performance of Tractor Implement Combination

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Abstract

Proper matching of implements with tractor and performance evaluation of the combination is important in minimizing the expenditure of energy in the farm. A tractor-cultivator combination was investigated in the present work. Experiments were carried out in order to determine the draft, fuel consumption and slip of the tracotr in the above combination in the field of the Department of Agricultural and Food Engineering. Statistical analysis reveals revealed that the speed and depth of operation have significant effects on the draft. Based on the findings, operating speeds and gears for 10 cm and 12.5 cm depth of operation were selected.

Introduction

The use of improved implements has great importance in increasing agricultural production which allows the utilization of scarce agricultural inputs more effectively and reducing human drudgery and physical exertion. Simple tractor drawn implements for seedbed preparation such as mould ploughs, cultivators and harrows are available in sufficient numbers to meet the current need. However, proper matching of implements become difficult due to lack of information on the performance of tractor-implement combinations leading to consumption of excess energy and consequent high costs.

Many research workers have attempted to measure the draft forces and optimise the tractor performance. Rogers and Johnson (1953) developed an instrument for measuring the dynamic forces in a tractor linkage system using hydraulic cylinders provided on the links. Reece (1961) used instrumented pins at the link points. Scholtz (1966), Johnson and Voorhes(1979), Smith and Barker (1982), Chung, et al (1983), Reid, et al (1983), Kendali, et al (1984), Thompson and Harris (1986), Chaplin, et al (1987), Garners, et al (1988) and Bowers (1989) used a variety of frame and sensor configurations to measure the forces in three point linkages. Nadre (1977) and Palmer (1992) also developed a three-point linkage dynamometers. Fuel consumption and wheel slip are also associated with the draw bar performance. Shyam and Verma (1985) developed a technique for gravimetric measurement of fuel consumption. Watt, et al (1989) used positive displacement type liquid flow meters. Different techniques for measuring the true ground speed and slip of tractor was reviewed by Tompkins, et al (1988). Saleque and Jangiev (1990) utilized a mathematical model developed by Jangiev to determine the optimum operational parameters of a wheeled tractor for its effective use in tillage operations. Zoz (1972) outlined a method of predicting a tractor's drawbar performance using a computer program which he had developed.

The work reported in this paper was undertaken in order to examine the draw bar performance of a tractor in tractor-implement combination. The following were the objectives of the study.

(1) Design and fabrication of a dynamometer for measurement of forces in the three-point-linkage; and
(2) Determination of the draft and fuel consumption of a tractor in tractor-implement combination at different speeds and depths of operation so as to determine the optimum operating point based on draw bar specific fuel consumption.

Methods and Materials

The tractor was equipped with the following instruments:

(1) Transducers to measure the forces in the three-point linkage.
(2) External fuel measuring jar arrangement to measure fuel consumption during field operation.

The geometry of the linkage was noted in order to analyse the link forces. The true ground speed was determined by noting down time taken to travel a known distance. The slip of the rear heels of the tractor was also calculated and recorded.

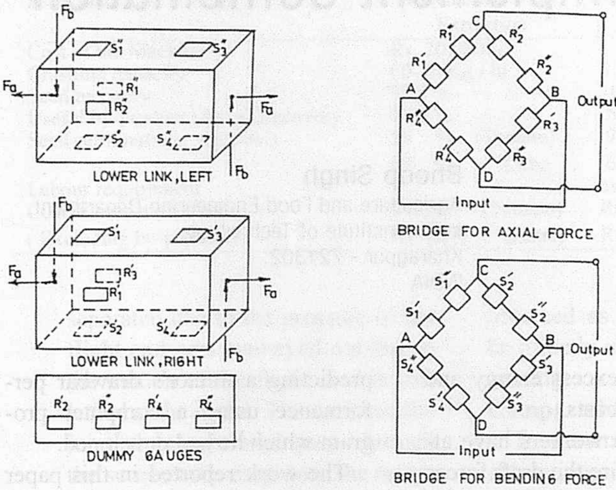

Fig. 1 Strain gauge configuration and bridge circuit on lower links for measurement of axial and bending forces.

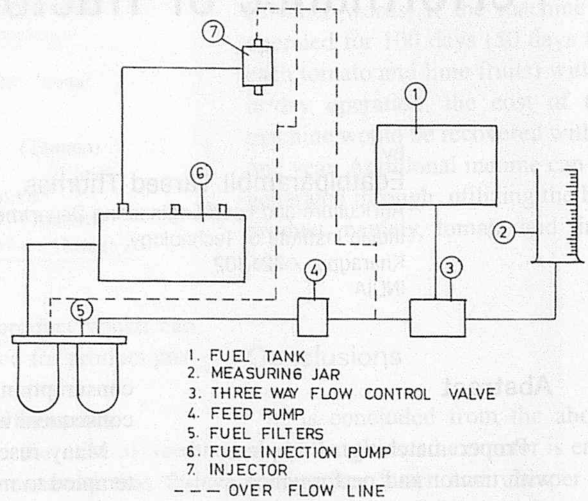

Fig. 2 Schematic diagram of level fuel measurement set up for field us.

Calculation of Draft

The lower links experienced axial force and bending due to a perpendicular force component. Considering that cultivator operation gives symmetrical soil manipulation about the line of travel, the side draft components are neglected. Axial and bending forces are measured separately using strain gauge circuits shown in **Fig 1**. The circuit adds up the individual forces of the two lower links. The axial and bending forces are calibrated in the true geometry. The orientation angles of the links were used along with the forces recorded in the field in order to calculate the vertical and horizontal components of pull.

The forces experienced in the top link is mainly axial with negligible or no bending force. The axial force was measured by incorporating a proving ring in the link itself. The middle was fixed on brackets welded in the middle of the link after cutting out a small portion of the link in order to maintain the original length. The force was then measured using strain gauges mounted on this ring. The strain gauge based circuit was designed to operate on a 9-volt battery supply and the output was read in terms of millivolts. It was calibrated in tension and compression. The angle of the top link with respect to horizontal plane was recorded and the horizontal and vertical components of the force were used. These were summed along with the corresponding components of the lower links.

Measurement of Fuel Consumption

During the experiment fuel was supplied to the engine from an auxiliary jar mounted on the tractor frame. The sketch of the fuel measurement set up is shown in **Fig 2**.

The field was prepared well in advance in order to achieve uniformity in moisture levels along the field and proper level. The trials were carried out over a short period so as to minimise the occurrence of moisture variations from time to time. The soil cone index and moisture content measured randomly

Table 1. Cone Index and Moisture Content of Soil in the Experimental Field

(a) Cone index

Depth (cm)	Cone index (kg/cm^2)								
2.5	3.01	2.45	3.15	3.92	2.80	1.82	2.10	1.96	2.80
5.0	3.15	4.90	3.36	5.04	3.50	3.43	3.36	3.29	3.43
7.5	4.41	3.22	3.64	4.62	4.41	4.13	3.92	3.78	4.76
10.0	4.20	3.99	3.92	4.48	4.83	5.46	5.11	4.83	4.97
12.5	5.53	4.69	3.29	6.16	5.11	6.58	6.16	6.86	7.77
15.0	5.60	2.80	2.80	6.30	5.53	--			

(b) Moisture content

Sample No	Moisture content, per cent (dry basis)
1	11.33
2	10.85
3	12.10
4	12.48
Average	11.69

Table 2. Treatment Combinations in the Experiment

Tractor gear	Depth		
	D1	D2	D3
L3	L3 D1	L3 D2	L3 D3
H1	H1 D1	H1 D2	H1 D3
L4	L4 D1	L4 D2	L4 D3

Table 3. Important Parameters of the Experiment

Parameter	Value
Tractor engine power	35 hp
Throttle position	3/4 th
Rear wheel ballasting	82 kg
Tyre size	13.97-40.69 (front) 31.49-71.12 (rear)
Tyre inflation pressure	1.41 kg/cm2 (front) 0.84 kg/cm2 (rear)
Type of soil	Lateritic sandy clay loam
Soil cone index	As reported in Table 1
Soil moisture content	As reported in Table 1
Implement	21 cm x 11 tine cultivator

from few locations in the field are reported in **Table 1**. The trials were carried out in three different gears and at three different depths as shown in **Table 2**. Parameters listed in **Table 3** were kept constant.

Results and Discussion

The draw bar dynamometer system worked satisfactorily. The draft thus calculated was compared with that measured using a spring dynamometer in the two-tractor system of draft measurement. The results were analysed statistically. It was found that both the speed and depth have significant effect at 1-percent level of significance. The interaction speed x depth was not significant which may be due to the fast that the range of operation was not large enough for that. The relationship between draw bar-specific fuel consumption versus speed is shown in **Fig. 3**. The curves are fitted with polynomial equations of a second degree. It can be seen that they are minimum within the range of experimental values for 10.0 and 12.5 cm of depth whereas the draw bar specific fuel consumption is on a decreasing trend for 7.5 cm depth. However, the energy utilised in tilling on a hectare area basis is minimum at the lowest speed and is on a decreasing trend towards lower speeds (**Fig. 4**). Due to limitations on availability of time during the field preparations, one does not normally go for very low speeds. Regression equations were developed to calculate draft, draw bar specific fuel consumption and wheel slip within the range of speed and depth. The values of coefficient of correlation calculated for **equations (1), (2), (3)** show that the fitted equations are satisfactory.

Conclusions

Based on draw bar specific fuel consumption, speeds of 5.58 and 4.80 km/h at 10 and 12.5 cm depth were optimum for the given tractor-implement combination and field condition. However, the gears L4 and H1 which give slightly different speeds are to be used since the exact speeds are not available.

Empirical equations to predict draft, draw bar specific fuel consumption and wheel slip from the speed and depth of operation are useful in planning the tractor operations.

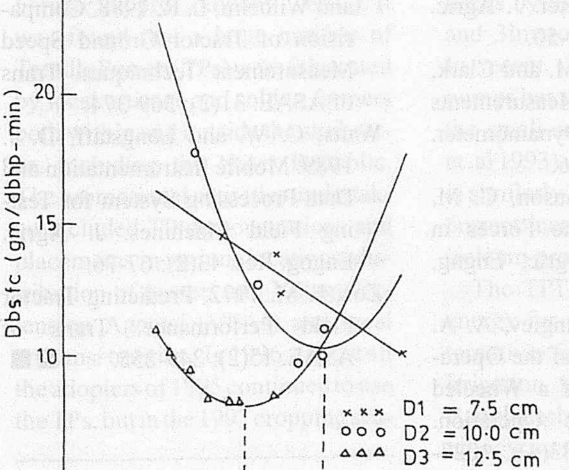

Fig. 3 Draw bar specific fuel consumption versus depth plots at different depths of operation.

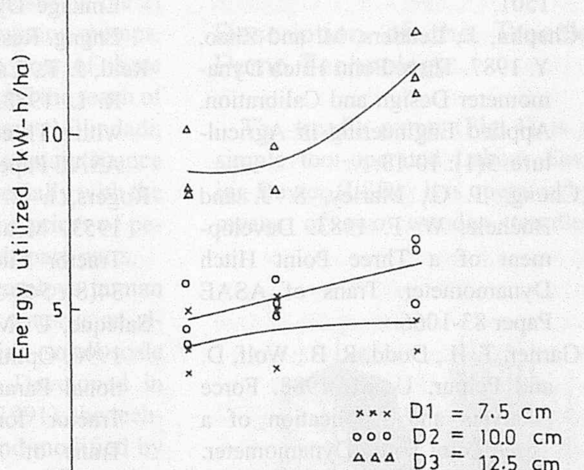

Fig. 4 Energy utilised in tillage versus speed plots at different depths of operation.

$$D = 2693.48 - 618.453d + 29.3784d^2 + 29.2951dv - 17.9824v^2 \quad (R^2 = 0.9418) \qquad (1)$$
$$S = 19.8993 - 2.54225d - 3.68449v + 0.096647d^2 + 0.496747dv \quad (R^2 = 0.9441) \qquad (2)$$
$$Q = 127.755 - 40.7706v - 0.326416d^2 + 1.08500dv + 2.66869v^2 \quad (R^2 = 0.9386) \qquad (3)$$

Where,

D = draft, kg(f)

S = wheel slip, per cent

Q = draw bar specific fuel consumption, g/(dbhp.min)

d = depth of operation, cm, 7.5 to 12.5

v = ground speed, km/h, 3.92 to 7.74

R = coefficient of correlation.

Equations (1), (2), (3)

The instruments developed for measuring the forces on the three point linkage has worked satisfactorily. Electronic instruments for computation and display of the draft and vertical forces can be added to the present instrumentation of the linkage.

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Status of Treadle Pump Technology Production and Adoption in Northern States of Nigeria

by

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Abstract

The treadle Pump Technology (TPT) was introduced in Zamfara and Katsina States during the 1992/93 and 1993/94 dry season farming, respectively. This study examines the status of production and adoption since TPTís inception. Structured questionnaire and a checklist were used. The questionnaire was administered to fabricators, dealers and farmers while the checklist sought information from the Agricultural Development Projects (ADPs), International Fund for Agricultural Development (IFAD) and Zamfara Farmer Supply Company (ZFSC). It was found that a large number of Treadle Pumps (TPs) were fabricated by local artisans and sold to farmers both within and outside the study area, including the Niger Republic. The promotional activities undertaken included TP demonstrations and placements in various locations, distribution of posters and Village Extension Agentsí (VEAs) and local artisansí training. In 1996, almost all the adopters of 1995 continued to use the TPs, but in the 1997 cropping season, there was a fall in the number of adopters. Suggestions for improved production and adoption include training of more local artisans, provision of relevant service infrastructures and credit facilities.

Acknowledgement

The authors wish to acknowledge the financial support of the National Agricultural Research Project (NARP), Federal Department of Agricultural Sciences, without which this study would not have been possible.

Introduction

Dry season farming of vegetables and cereal crops has become an important agricultural activity in Nigeria, especially in the Northern part. Apart from the shadoof irrigation system and hand pumps, most farmers have been able to meet their water needs by investing mostly in the 2î and 3îmotorized irrigation pumps. In recent times, the cost of these pumps has gone beyond the reach of the small-scale farmers (Mijindadi, et. al 1993). The cost of maintenance is similarly high, especially with the current increase in the prices of petroleum products and spare parts.

The TPT which employs human energy for pumping water is an alternative for Nigerian small-scale irrigation farmers. Developed in Bangladesh (BIDS, 1991), the technology was tested and modified by the National Agricultural Extension and Research Liaison Services (NAERLS) of Ahmadu Bello University (ABU), Zaria, to suite the Nigerian farming system (Abubakar and Abubakar, 1996).

The technology enjoyed enthusiastic acceptance everywhere it was demonstrated in Zamfara and Katsina States (Abubakar et al. 1995; Yiljep and Akpoko 1996). Consequently, local artisans from the two States and one from the Niger Republic were trained on the fabrication of the pump for mass production. Similarly, village extension agents were trained on the use and management of the pump. This study is aimed at establishing the current status of the treadle pump production and its adoption in Zamfara and Katsina States.

Description of the Treadle Pump Technology.

The treadle pump (**Fig. 1**) is a simple foot-operated Labour Saving Device (LSD). It is operated by means of two wooden treadles

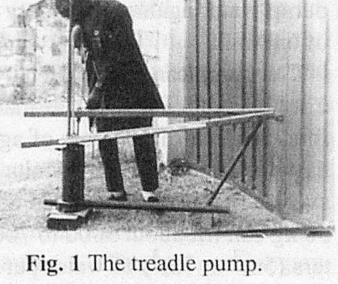

Fig. 1 The treadle pump.

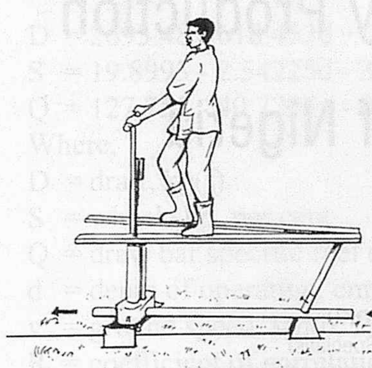

Fig. 2 The treadle pump operation by one adult.

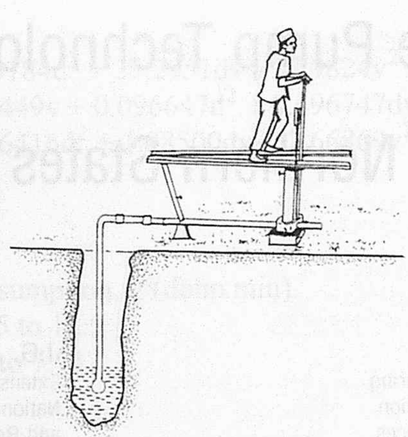

Fig. 3 Pump application in well.

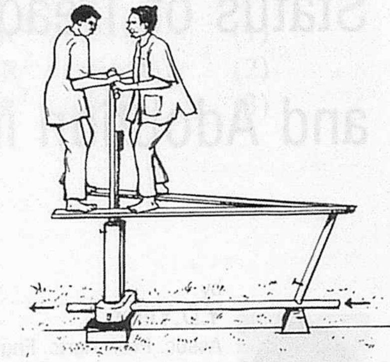

Fig. 5 Pump operation by two adults.

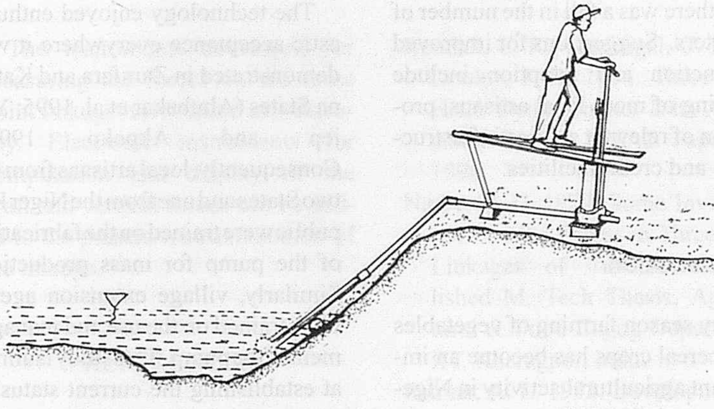

Fig. 4 Pump application in surface water or pond.

hooked to two piston rods that reciprocate inside two metal cylinders moved by human bodyís strongest muscles - the foot (**Fig.2**).

The pump is a device designed to lift water from both underground and surface water sources such as hand-dug wells (**Fig. 3**), tubewells and washbores, streams, ponds, dams, and lakes (**Fig. 4**). The device is capable of lifting water by suction from wells up to 7m or from surface water sources. It can also pump water against a delivery head of 6m high.

The pump can be operated by one or two adults (**Fig. 5**) or as many as four children of 10 years of age. It has been reported that adults with average weights of between 60 and 70 kg can lift about 5000 to 7000 liters ($5m^3$ to $7m^3$) of water per hour from an average dynamic head of 5m (Abubakar, et al. 1996). On the basis of two hours of pumping per operator per day and taking into account soil permeabilities and crop water requirements, the pump can adequately irrigate up to 0.25 hectare of land in a dry season (Bielenberg, 1992; Carruthers and Rodriguez, 1992). These outputs of the pump, make it superior to the hand pump which can deliver only about 20 percent of water from deep wells, and can therefore, irrigate only about 1000 square meters of land which is only about one quarter of the total area that can be irrigated using the treadle pump (Abubakar and Murtala, 1996). The ease of construction, high operating efficiency and versatility of the treadle pump allow it to fit the farmer-managed small-scale irrigation system in Nigeria.

Methodology

This study is based mainly on primary data obtained from a sample of 62 farmers and extension agencies through the use of survey instrument. The survey instrument consisted of two sets of questionnaire and a checklist. The first set of the questionnaire was designed for fabricators and dealers, and provided information on TP fabricated, number sold and constraints encountered. The second set of questionnaire seeking information on sources of information and stages of awareness. The checklist solicited information on promotional activities such as training of farmers from the Katsina Agricultural and Rural Development Authority (KTARDP), Zamfara Agricultural Development Project (ZADP), International Fund for Agricultural Development (IFAD) and Zamfara Farmer Supply Company (ZFSC). It generated information on the technology transfer techniques and provision of credit facilities. Information on training of artisans was provided by the National Agricultural Extension and Research Liaison Services (NAERLS).

In this study, a multi-stage cluster sampling technique was used in the selection of agricultural zones, fadama sites and respondents. The first stage was also the purposive selection of Agricultural Development Zones (ADPs) with high concentration of TPT users. The second stage was also the purposive selection of two Local Government Areas (LGAs). Thirdly, the fadama sites were selected from each of the two sample LGAs. Finally, 5 farmers were randomly selected from each of the six fadama sites, thus, giving a total of 60 farmers, plus two others who were included on special request. The 62 farmers comprised of 31 adopters and 31 non-adopters. The data collected were analysed using descriptive statistics.

Results and Discussions

Promotional Activities by ADPs and Other Extension Agencies

The ADP in each state, namely, Katsina state Agricultural Development Authority and Zamfara State Agricultural Development Project was visited to collect relevant information relating to the promotion of TPT in the States. Similarly, other relevant agencies such as the International Fund for Agricultural Development (IFAD) and Zamfara FarmersíAgric Supply Company were also visited for similar purpose.

From the information gathered, the promotion of the treadle pump technology started in Katsina State in 1993. This activity continued up to 1994 after the funding agency transferred the promotion activity to the IFAD programme. In Zamfara State, the activities started in 1992 when it was under Sokoto State but stopped in 1994. The ZADP did not organize any promotional activities. The reason for the stoppage in both States was due mainly to the termination of the activities of the sponsors (Appropriate Technology International). The major TPT promotional activities adopted in the two States were:

1. Continuous demonstration of the TP in various locations in the States. Placement of the pumps after demonstration in locations for other farmers to see and try their hands on the technology;
2. Distribution of posters published by the NAERLS to extension agents and farmers;
3. Demonstration of the TPT at local agricultural shows and at both international and local trade fares;
4. Training of farmers and frontline extension agents on the use and maintenance of the TPT in the States. While the former was carried out on the farm, the later was on the farm and in the classroom, and
5. Production of Radio and Television programs which are aired throughout the States.

Training of Artisans and Farmers

In Katsina and Zamfara States, nine and six artisans, respectively received training on TP fabrication at NAERLS. An artisan from the Niger Republic was also trained by NAERLS at the same time. The trained artisans, in turn, conducted training for three and one artisan in Katsina and Zamfara States, respectively. It was gathered that the pumps fabricated by these four artisans performed satisfactorily.

Six hundred and sixty farmers were reportedly trained by KTARDA in conjunction with IFAD. No data were provided on farmersí training by Zamfara State but it is evident from the number of adopters that some farmers were trained by IFAD when the State was part of Sokoto State.

Sources of Farmersí Information on TPT

The sources of information on the treadle pump as reported by the farmers were varied. The ADPs were the major source of information about the TP. This was followed by friends and relations

Table 1. Sources of information on TP

Source	No.	%
NAERLS	38	61.3
ADPs	11	17.7
Friends and Relations	4	6.5
Dealers or Fabricators	4	6.5
Others	5	8.0

Table 2. Level of Awareness

Stage	No.	%
Aware but do not adopt	27	43.5
Currently adopting	31	50.0
Had adopted but discontinued	4	6.5

Table 3. Stages of Adoption

Stage	No.	%
Aware	27	43.6
Aware and use	31	50.0
Aware and discontinue use	4	4

(**Table 1**). The NAERLS and dealer/fabricators were other important sources of information on the technology. The most preferred channels of disseminating the TPT as perceived by the ADPs and other extension agencies in the States were: demonstration, radio and television.

Stages of Awareness

The stages of awareness are presented in **Table 3**. As the table shows, 50 percent of the farmers indicated that they were aware and used the technology. Almost seven percent were aware but discontinued the use of the technology.

Location of Artisans and Adopters

Nine trained artisans spread across Katsina State were found to engage in the fabrication of treadle pumps, while seven were reported for Zamfara State. Specifically, they were located in Katsina, Daura, Jibiya, Mashi, Dutsima and Bakori towns in Katsina State, and Gusau and Gumi towns in Zamfara State.

The users were predominantly located in Kankuyawa, Rogogo, Nassarawa, Katsina, Kaura, Girka, Makauraa, Bugaje, Gangara,

Table 4. Rate of Adoption of Treadle Pump

Period after TPT Introduction	Proportion of Adopters No.	%
1993	11	5.0
1994	18	37.8
1995	33	66.7
1996	47	88.9
1997	38	68.9

Daura, Jibiya, Mashi, Bakori and Dutsima in Katsina State, while in Zamfara State, they were found in Furfuri, Falade, and Yankuzo. It can be seen that there is a very good spread of users across the States.

Treadle Pump Fabrication and Sale

The survey showed that a large number of the TP has been fabricated and sold to farmers in the two states as reported by the artisans and dealers. It was gathered that in Katsina State, a total of 176 TPs were fabricated and sold by artisans while 210 were also fabricated and sold in Zamfara State. The breakdown for Katsina State is as follows: Bakori (50), Daura (56) Katsina (55) and Jibiya (15). All the TPs in Zamfara State were in Gusau. Only one dealer, Zamfara Farmersi Supply Company, was reported to have acquired and sold 20 TPs.

The predominant category of customers who patronized the TPs were individual farmers, Local Government Councils (LGCs), Non Governmental Organisations (NGOs), State and Federal Governments, Cooperatives and the IFAD. The Customers were reported to be located both within and outside Nigeria. The major towns from which customers came were: Maiduguri (Borno State), Kano (Kano State), Bakori, Daura, Katsina, Jibiya, Mashi (Katsina State), Dutse (Jigawa State), Gusau (Zamfara State), Sokoto (Sokoto State) and Niger Republic. From the above, it can be seen that the TPT has received wide popularity, suggesting the possibility for its wide acceptance in other

Table 5. Constraints to the Use of Treadle Pump

Period after TPT Introduction	Proportion of Adopters No.	%
Frequent breakdown	6	19.3
No spare parts	12	37.1
Non-availability	6	19.3
High energy requirement	18	59.6
High skill requirement	7	22.6
Difficult to operate	7	22.6
Difficult to maintain	7	22.6
Risky	8	25.8

States of Nigeria.

The major problems reported in the fabrication of TP by the artisans in the States were:

1. Insufficient leather for the making of leather cups (Katsina State);
2. Reluctance by more farmers to acquire the TP due to lack of knowledge and conviction about the performance of the TP;
3. Inadequate tooling sets required for the fabrication of the TP;
4. Limited depth from which water can be lifted using the TP, and
5. Lack of adequate capital to purchase tooling set and materials for TP fabrication.

Adoption of TPT

The rate of adoption of the TPT was measured by the proportion of TPT adopters. The proportion of TPT adopters is presented in **Table 4**. In 1993 only 5 per cent of those aware adopted the technology. In 1994, about 38 percent of those who indicated awareness of the TPT adopted it. Evidently from the table, in the early years of adoption the adopters continued to use TPT in successive years. In 1996, almost all the adopters of 1995 continued to adopt, but in the 1997 cropping season, there was a sudden fall in the number of adopters. This fall in the number of adopters could be attributed to the possibility that some of them have made a substantial amount of money and might have been able to purchase motorised pumps to replace the use of the treadle pump. However, the current enthusiasm of the artisans and farmers attests to the high prospects of the technology in Nigeria. The brief history of the introduction of the innovation in Nigeria dating back to only 1992, but already being fabricated and adopted by many artisans and farmers, may be considered a case of an acceptable technology by Nigerian farmers.

Constraints to the Adoption of Treadle Pump

The major constraints in the adoption of the pump as enumerated by the farmers were high-energy requirement, lack of spare parts and risk during operation, in that order, were considered the most critical problems (**Table 5**). The Nigerian Institution of Agricultural Engineers in collaboration with the Federal Ministry of industry have embarked on setting up of small and medium scale manufacturing industries, the problems of high energy requirement and lack of spare parts are being handled. Lack of funds and credit facilities were also indicated as other factors constraining the acquisition of production tools and materials, and the treadle pump technology. With the current national policy on agriculture, emphasizing formation of cooperatives through which credit facilities can be channelled to fabricators and farmers, the acquisition of fabricating tools and materials, and the treadle pump itself may be enhanced for sustainability.

Conclusions and Recommendations

The study shows that a large number of TPs have been fabricated and sold to farmers both within and outside the States, including the Niger Republic. The extension activities promoted are TPs demonstrations and placement in various locations, distribution of posters, VEAís, farmersí, and artisansí training and production and airing of radio and television programs. However, the major sources of information on TPT were the NAERLS, the ADPs, fabricators and dealers. Individual farmers, LGCs, NGOs, private extension agencies, and State Governments were the predominant categories of buyers of the pumps produced. Based on the results of this study, the following recommendations are drawn:

1. The adoption of TPT in Zamfara and Katsina States has been ensured by local artisans. The need to identify more local promising artisans for further training on the fabrication of TP is recommended. Emphasis in this regard should be given to welders since they have been identified as the most suitable artisans (Yiljep, et al., 1983);
2. For the adoption of TPT to thrive based on local artisans relevant service infrastructures must be put in place;
3. Fadama User Associations (FUAs) already exist in the States. The ADPs should encourage the formation of more FUAs. These groups could be useful as channels in the dissemination of information on TPT;
4. In order to minimize the constraints imposed by high energy requirement of the technology, it is recommended that a gear system be incorporated into its design, and
5. Lack of funds and credit facilities were identified as major factors constraining the adoption of the technology. In this regard, it is hereby recommended that governments should provide a special credit program for fabricators and farmers, backed-up with a working policy that will facilitate accessibility. With adequate supply of credit, the resource capability of small-scale fabricators and farmers would be enhanced, for improved and increased production, acquisition and maintenance.

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Determination of Operating Costs of Some Forage Harvesters

by

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Abstract

The operating costs of six forage harvesters named A, B, C, D, E, F were determined in the present research. Three of them (A,B,C) are of cylinder type, two (E,F) are of fail type and one (B) is of a flywheel type. The operating costs consist of depreciation, interest, shelter, repairs and maintenance, fuel and oil. The average costs were calculated in US dollars as $/h, $/year, $/t-silage and $/ha. Maize, alfalfa and a mixture of barley, vetch were used as silage material. At the end of the research, the lower costs per ton-silage and per hectare were obtained with double-chop flail type forage harvester (machine F) for the harvesting of the mixture of barley and vetch and alfalfa. If flail types were disregarded, the cylinder type forage harvester (machine A) had lower costs as $/t and $/da for the harvesting of maize when compared with other cylinders and flywheel types.

Introduction

Machinery costs (operating costs) are divided into two categories: fixed costs and running (variable) costs (Witney 1988). Fixed costs are dependent on the duration of ownership of a machine and include depreciation, interest, tax and insurance and shelter. Running costs vary in proportion to the utilisation of a machine and comprise fuel and oil, repairs and maintenance and labour. Depreciation is the loss in value of a machine due to time and use. Machines depreciate as a result of age, wear and tear and obsolescence. There are three methods of calculating depreciation: straight-line, declining balance and decremental depreciation. In calculating the cost of owning and operating individual machines, there must be a charge for the interest on the capital which is invested in the equipment. Either the capital is borrowed and interest has to be paid, or the capital is already owned and has an opportunity cost which is the highest return that the capital could earn from an alternative investment. Farm machinery can be taxed in some countries. The shelter charge is between 0,5 percent and 1 percent of the initial purchase price of the machinery. The fuel consumption of a tractor is governed by the amount of energy demanded at the drawbar or through the power take-off. Oil consumption is defined as the volume of engine crankcase oil per hour replaced at the recommended change intervals. The oil consumption is related to the rated engine power. Repairs and maintenance are essential in an effort to guarantee a high standard of machine performance and reliability.

Hunt (1983) described the elements that comprise the cost of machine and guidelines for determining the time of replacement in detail. Sayín and Özgüven (1995) have considered agricultural machines that are widely used and manufactured in Turkey for the determination of their costs. Isík (1998) explained the basic interest factors and thier usage in calculating the time value of money and gave an example. Güner (1996) investigated the cost of which took into consideration the operating costs and the annual equivalent capital cost of belt conveyor for the optimum design. He used the principles of engineering economic analysis.

Audsley and Wheeler (1978) described a procedure to calculate an annual cost for machinery which is directly comparable with other annual items such as crop gross margin or contract hire charges. The purpose of this paper is to determine the operating cost of six types of forage harvesters.

Material and Method

Material

Six different forage harvesters were used for the harvesting of maize, alfalfa and a mixture of barley and vetch. Three of the six forage harvesters named machines A, B, C are of the cylinder type (Kafadar 1997). One of them is of the flywheel type (machine D) and the last two types are of the flail type (machines E, F). Machines A, C, D, E are direct-cut type while the others have conveying fans. Machine E has a cup-shaped hammer which cuts and shreds the grass or hay and immediately impells the material to the wagon. Machine F utilizes a cutting unit to shred and lacerate the material and an auger and fan to convey the material to the wagon. Brief details of the forage harvesters are given in **Table 1**.

Method

The forward speeds were taken as the average of the different speeds. The rates of work are the performance of the harvesters over the complete operational cycle (productive work time plus routine interruptions for turning and product handling). The area rate of work was calculated from the width of cut, forward speed and field efficiency. Field efficiency was taken as 70 percent (Bilgen and Sungur 1992). The crop rate of work is the product of area rate of work and crop yield. To determine the fuel consumption for the different forward speeds, a fuel counter fitted between fuel tank and fuel pump was used.

In this paper, we determined the deprecation, interest, shelter, fuel and oil, repair and maintenance. The operating costs were calculated using American dollars. The equations for operating costs are given in **Table 2**. In the calculations, the salvage values of the machines were assumed to be zero. The average annual use of the machines is 200 h/year and the period of ownership was taken as 8 years (Culpin 1975). The period of ownership is 2000 h(Anonymous 1975). The purchase prices of machines A, B, C, D, E, F are 15000$, 15000$, 15000$, 8000$, 4000$ and 5000$, respectively. Dinçer (1976) reported that the shelter cost should be taken as 0.5 percent of the initial purchase price of the machinery. Culpin (1975) assumed the repairs and maintenance cost as 7 percent of the initial purchase price of the machinery. The price of fuel and oil are 0.46 $/l and 3.23 $/l, respectively. The fuel consumption is the average of fuel consumptions of the different forward speeds.

Results and Discussion

The type of silage material, type of machine, forward speeds, purchase prices, average area and crop rates of work, fuel consumption and total costs are given in **Table 3**.

As shown in **Table 3**, an economic analysis was made for every machine and every silage material. The costs include depreciation, interest, shelter, repairs and maintenance, fuel and oil consumptions. The purchase prices of machine A, B, C are the same. Machines D, E, F have the different purchase prices.

Machine D gives low costs as $/h and $/year but high cost as $/t and $/ha than machines A, B, C for the harvesting of maize. If we take costs as $/t and $/ha into consideration, the least cost is obtained for machine A. Machines A, B, C have cylinder type cutting units and there isn't important difference between their costs. Though the purchase

Table 1. Characteristics of the Forage Harvesters

Technical specifications	Harvesters					
	A	B	C	D	E	F
Width of cut (mm)	1400	1400	1400	700	1100	1500
Type of cutting unit	Cylinder (direct-cut)	Cylinder (conveying fan)	Cylinder (direct cut)	Flywheel (direct cut)	Flail (direct cut)	Flail (conveying fan)
Revolutions of cutting unit at p.t.o speed of 540 (rev/min)	972	565	872	1520	1600	1600
Number of knives at the cutting unit	5 × 3	3	3	10	16	32
Diameter and width of cutting unit (mm)	Diam: 610 Width: 463	Diam: 430 Width: 560	Diam: 630 Width: 420	-	-	-

Table 2. Equations for the Operating Costs

Costs	Equations		Remarks
Depreciation	$a = (A/(T.n_i)$	$n_1 \leq \left(\frac{n}{T}\right)$	a : Depreciation ($/h) A : Purchase price ($) n_1 : Average annual use (200 h/year)
	$a = A/n$	$n1 > (n/T)$	T : Period of ownership (year) n : Period of ownership (h)
Interest	$f = 0{,}5\ A(i/n_1)$		f : Interest cost ($/h) i : Interest rate (=0.08)
Shelter	$m = (0.005\ A) / (n_1.T)$		m : Shelter cost ($/h)
Repairs and maintenance	$TB = (0.07\ A) / (n_1.T)$		TB : Repair and maintenance cost ($/h)
Fuel consumption	$YAK = 0.46\ YT$		YAK : Fuel cost ($/h)
Oil consumption	$YAG = 3.23\ YGT$ $YGT = 0.04\ YT$		YAG : Oil cost($/h)
Total cost	$TG = a + f + m + TB + YAK + YAG$		YT : Fuel consumption (l/h) YGT : Oil consumption (l/h) TG :Total machine cost ($/h)

price of machine D is half of the purchase price of machines A, B, C. its costs as $/t, $/ha are higher.

For the harvesting of alfalfa, the lowest costs as $/h and $/year and the lowest costs as $/t and $/ha were observed for machines E, F, respectively. Due to the fact that machine E has shorter width, the costs as $/h and $/year of machine E are smaller than machine F. High machine widths have positive effects on the costs. Machine E gives the lowest costs as $/h and $/year and machine F gives the lowest costs as $/t and $/ha because of wider machine width for the harvesting of the mixture of barley and vetch. Machine B was used for the harvesting of three silage material and the lowest costs as $/h, $/year and $/t were obtained for maize.

Conclusion

From **Table 3**, it can be seen that the lowest costs as $/t and $/ha for all machines and silage material are obtained for machine F for the harvesting of the mixture of barley and vetch. Between the cylinder type machines (A, B, C) and flywheel type machine (D), machine A gave the lowest cost as $/t and $/ha for the harvesting of maize. The costs as $/t and $/ha of machine F are lower than machine E, which are of flail type, for the harvesting of alfalfa and the mixture of barley and vetch.

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Table 3. Machinery Operating Costs

Variety of crop	Type of machinery	Forward speed (km/h)	Purchase price ($)	Average crop rate of work (t/h)	Average area rate of work (ha/h)	Fuel consumption (l/h)	Total Costs $/h	$/year	$/t	$/ha
Maize	A	2.48	15000	11.84	0.243	7.28	17.40	3480	1.47	71.6
	B	2.50	15000	11.94	0.245	9.26	18.60	3720	1.56	75.9
	C	2.49	15000	11.87	0.244	9.18	18.50	3700	1.56	75.8
	D	2.55	8000	6.08	0.125	5.46	10.20	2040	1.68	81.6
Alfalfa	B	2.20	15000	5.33	0.262	10.00	19.00	3800	3.56	72.5
	E	3.03	4000	4.75	0.233	10.26	9.51	1902	2.00	40.8
	F	3.09	5000	6.60	0.325	11.61	11.2	2240	1.70	34.5
The mixture of barley and vetch	B	3.68	15000	8.52	0.438	10.18	19.10	3820	2.24	43.6
	E	3.22	4000	4.83	0.248	6.01	7.03	1406	1.46	28.3
	F	3.86	5000	7.87	0.405	10.92	10.80	2160	1.37	26.7

Mini Combine: A Relevant Choice for Indian Small Farms

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Abstract

Farm mechanization has been given deserving importance for the last two decades in India. Unfortunately, pragmatic implication is lacking in regards to physical features of the fields. Care should be taken to see that mechanization is a selective one: farmers with small farms landholdings can utilize the appropriate improved farm machines to increase productivity and to reduce the cost of production. Tractorization has been successful in Indian farming, but remained confined to some specific regions and places. Extensive popularization of large machines and bigger implements face the hurdles of small frams in India. Power tiller can be made effective in small sized farms, and can be very efficiently utilized by modifying it to a mini-combine comprising of power tiller matching equipment.

Introduction

In order to increase the productivity of land, investigations are needed on the use of improved agricultural inputs like seed, fertilizer, irrigation and cultivation practices. Efficient application of these inputs requires the use of improved implements and machines operated manually or by some power source to bring about farm mechanization. Therefore, convenient and economic mechanization is a complement to these inputs for tillage, seed sowing, interculture, spraying, harvesting and threshing operations.

A great deal of work has been done in the past on farm mechanization, but thr least attention has been given for appropriate and adoptive mechanization. Some people confused mechanization with tractorization. Proper mechanization should be selected on the basis of farm sizes in the concerned region, socio-economic condition of the farmers and past status of machinery use.

The use of animal power cannot be enhanced as the population of animal cannot be increased in a short span of time to fulfill the agricultural demand of the country. Moreover, efficiency of bullocks is so poor that the agricultural operations cannot be performed within a stipulated time. Therefore, the alternative left is only to harness mechanical power to supplement the immediate demand. But the problem associated with the adoption of mechanical power input in the country is mainly due to availability of small size of plots and poor economic condition of the farmers. The use of tractors and other sophisticated and expensive machineries are beyond their economic threshold. Available standard Indian combines by which mostly all farm operations can be carried out economically and efficiently, which are of 3900 to 4675 mm size, are impractical for small land holdings. Under these circumstances, the power tiller becomes most suitable and economical source of power for small farmers. It is also suitable for farming in hilly regions where big machines are difficult to operate. Hence, the power tiller *vis-à-vis* is a better modification considering the farmers' level problems.

Why Mini–Combine?

Farm Size

Land holding distribution features in India is shown in **Table 1** indicating that the number of farm holdings of less than 2 ha in size was as high as 73.6% of the total holdings in 1980-81. This has been increased to 76.3% and 78.0% in 1985-86 and 1990-91, respectively, while there has not been any change in the net operated area, causing average holding size to decline from 1.84 ha in 1980-81 to 1.60 and 1.57 ha, respectively, in the consecutive next five years. Assuming this trend to prevail, presently, the percentage holding of farms less than 2 ha would not be less than 80%. Unending fragmentation feature of land will cause the average size to decrease further. Also, farm-holding numbers of medium size field has been cut down by

Table 1. Land Holding Distribution Trends in India

Farm size	1980-81 Farm holding,[1]	Operated area,[2]	Average holding size,[3]	1985-86 Farm holding,[1]	Operated area,[2]	Average holding size,[3]	1990-91 Farm holding,[1]	Operated area,[2]	Average holding size,[3]
Marginal, <1 ha	50.12	19.73	0.39	56.15	22.04	0.39	62.11	24.64	0.40
Small, 1-2 ha	16.07	23.17	1.44	17.952	25.71	1.43	19.97	28.71	1.44
Semi-medium, 2-4 ha	12.45	34.65	2.78	13.25	36.62	2.77	13.91	38.35	2.76
Medium, 4-10 ha	8.07	48.54	6.01	7.92	47.14	5.95	7.63	45.05	5.90
Large, >10 ha	2.17	37.71	17.38	1.92	33.00	17.19	1.67	28.89	17.33
Total	88.88	163.8		97.16	164.56		105.29	165.60	
All India Average size holding			1.84			1.60			1.57

Note: 1=million's number; 2=million ha; and 3=ha.

12.5 % over the last 10 years.

These statistics point out the urgent need for farm mechanization with small machines coping with the farm sizes.

Limitations of Animal Power

Indian farmers, mostly of the North Eastern states (West Bengal, Orissa, Bihar, Andhra Pradesh, Tamil Nadu) primarily employ animal power for meeting power requirements because of financial constraints and limited exposure to technology. This is reinforced by the fact that India possesses the largest cattle population in the world. Draft ability of a pair of bullock depends on how they are tamed, trained, harnessed and on their quality. Generally, medium size pair of bullocks in good health develop 0.70 to 0.85 hp with draft ranging between 60 to 80 kg at 1.8 to 2.1 km/hr, which is of low capacity causing high cost of farm operations per horse power per hour. Moreover, bullocks do not exert constant pull; rather it shows a regular pulsating trend (Kumar, 1998). Bullocks work for fewer hours and work needs to be completed before 9-11 a.m. depending upon the sunshine intensity. Variation of animal energy utilization from region to region in **Table 2** shows that the Eastern region comprising the states of Assam, West Bengal, Bihar, Orissa is comparatively more dependant on animal power than other regions. The southern region comprising the states of Andhra Pradesh, Tamil Nadu and Karnataka also show a good account in animal energy utilization. This may be attributed to the socio-economic condition in the region, small land holding capacity, etc. However, it is seen that utilization of draught animal power is continuously decreasing which may be explained by the decreasing population of the draught animals in the country (**Table 3**). Decrease in draught animal population in the last 10 years has been to the level of 7.8% causing 10% reduction in unit power availability from sources.

Problems with Tractor

Four-wheel tractors pose difficulty to operate in small fields, especially in rice growing areas where, in many cases, plots are less than one-tenth of a hectare. Fields are separated by bunds and movement of heavy mounted implements from one field to another becomes difficult. Besides the poor quality of work by tractor drawn cultivators for puddling operations, tractors have tendency to sink in medium heavy and soft soils. The large size and more turning radius of tractors restrict their utility in orchard, hilly areas and forestry. Tractors are under-utilized for light operations like spraying, dusting, interculture operations and threshing with small-sized thresher.

Cost Factor

The price of agricultural products and the cost of farm machinery are important factors affecting development in agricultural mechanization. The bullock has to be fed continuously in off-seasons and now their cost of purchase is also very high. Apart from high capital cost, the hire cost of tractors is also increasing day by day.

Scope and Room for Mini-combine

In the early eighties, just after the emphasis on mechanization, people went for tractorization and the population of tractors has been increased rapidly. It is seen from

Table 2. Animal Energy Utilization in Different Regions of India

Regions	Average draught animal power use, animal-pair-hour/ha. 1981-82	1985-86	1991-92
Eastern	251.2	236.0 (5.97)*	220.6 (6.53)
Western	118.9	107.9 (9.32)	93.9 (12.96)
Southern	129.8	120.9 (6.97)	117.59 (3.33)
North	102.0	81.0 (20.58)	58.0(28.39)

Source:Livestock Census Report. Agricultural Statistics at a Glance, 1995.
*Figures in the parenthesis indicate percentage decrease from the previous season.

Table 3. Population Trend in Draught Animals for Field Operations

Year	Total animal (million)	Animal power (kW)	Unit -power (kW/ha)
1971-72	83.60	20.96	0.12
1976-77	82.50	20.65	0.12
1981-82	71.52	17.68	0.10
1986-87	73.72	18.25	0.10
1991-92	71.54	17.50	0.09
1996-97	67.96	16.80	0.09

Source: Livestock Census Report. Agricultural Statistics at a Glance, 1995.

Table 4. Population Trend in Draught Animals for Field Operations

Power source	Population in million 1981	1986	1991	1996
Tractor	0.518	1.021 (97)	1.318 (29)	1.713 (30)
Power tiller	0.080	0.087 (8.7)	0.095 (9)	0.110 (16)

Table 4 (Singh, 1997) that number of tractor has been increased by 97% in the five years (1981-1986), it declined to 29% for the next five years and remained stable for the next five years. But the increase in population of power tillers in the eighties were only 9%, and went up in the nineties. This may be attributed to the inclination of farmers towards small machines.

In view of small plots and medium-sized holdings, covering a large part of the cultivable land, power-tillers have better maneuverability and low initial cost as compared to four-wheel tractors. Power tillers are multi-purpose machines. When fitted with suitable implements, they can be used for a wide range of farm operations. Broadly power-tillers can be classified into 'tractive' and 'rotary' types. The tractive type tillers are designed primarily for drawing plough, cultivators, seed-drills, trailers, etc.

Power tillers available in sizes ranging from 5-14 hp have proved worth their primarily for rotatilling, puddling and transportation. Engine operated small machines like self-propelled vertical conveyor reaper are used for harvesting of wheat and paddy crops. The tractive type tillers are versatile to drawing plough, cultivators, seed-drills, spraying orchard, threshing and water- pumping. Rotary tillers are more adapted to tilling of soil through a rotavator attachment. Also, rotavators or rotary tillers can be detached for operating them with drawn implements.

Now, if this machine is converted to an integrated mini-combine comprising of tilling, levelling, planting, interculturing, harvesting and threshing attachments in one machine, it will have great demand among farmers of different classes. This multi-use machine will replace bullock power. Seating provision in the mini-combine will lead to comfort compared with the walking type tractor. Because of seating attachment, human energy consumption is reported (Karmakar, 1998) to reduce by 27.43% in rotatilling, 25% in transportation and 21% in rotapuddling. It also increased exposure time by 33% because of higher comfort.

Conclusion

In India, sufficient works have been done on the matching equipment for power tiller through co-ordinated research projects and individual researches. Many of them have not yet reached the production level. Non-availability of the matching equipment and unawareness of them have kept farmers away from the field. But, if an integrated machine exists, mostly all mechanical means will be available to even the marginal and small farmers' level. By doing this, the dependency of the farmers on one another for hiring purpose causing untimely field operations will decrease. Encouraging better management of farm enterprises and facilitating more free time for planning and studying, this will help boost up farmers' standard of living and overall economic and social condition.

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Design and Construction of a Mechanized Fermenter-Drier Prototype for Cocoa

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Abstract

The design and construction of a mechanized fermenter-drier prototype equipped with heated air supply and scrapping mechanisms for cleaning and mixing are described. The objective of this research is to develop a mechanized system capable ofo performing cocoa fermentation and drying in a single unit. The design of the prototype is based on the rotary drier design and consisted of two horizontal, perforated, concentris aluminium cylinders constructed from aluminium plates. The prototype can be loaded with 700 kg of wet cocoa beans and provision for drainage is through the perforated surface of the outer drum.

Introduction

Commercial dried cocoa beans prior to packaging and storage are processed into a two-stage fermentation and drying processes known as curing. These processes are interrelated but they are carried out as separate entities requiring specific equipment at each stage. Conventional methods of cocoa fermentation are performed in a variety of wooden boxes or by heap fermentation ranging from 100-kg to 2-tonne capacity. This process usually requires five to seven days to complete and a series of anaerobic and aerobic reactions take place during this period (1). The beans must be mixed, using wooden shovel, at least once and sometimes daily to obtain a homogenous product. Following fermentation, the beans are either sun dried or artificially dried to a moisture content level of about 7.5 % for safe storage. Sun drying of cocoa beans would take about five to seven days under good weather conditions or 2 weeks under bad weather conditions to dry to this moisture content level while artificial drying, depending on the type of equipments used (flatbed or rotary), would take about 36 to 96 drying hours (2). Beans are mixed manually with wooden paddles to break up and avoid clumping during drying. An attempt was made to design and construct a mechanized fermentation and drying unit in this research project to reduce the laborious activities involved using the traditional methods.

Acknowledgement: This research project is funded by the Ministry of Science, Technology and the Environment under the 7th Malaysian Plan IRPA funding.

Construction of Prototype

The design of the prototype was based on the concept of the rotary drier to mechanize the mixing process during fermentation and drying. The prototype was installed in Tawau at the premises of a cocoa beans trader (Winfield Trading Sdn. Bhd.) and fabricated by a local cocoa dryer specialist (Agromech Technology Sdn. Bhd.). Several modifications following preliminary trials were made which led to the final design of the prototype. The development stages of this drier will be described in more detail in the next section. The final design of the fermenter drier prototype (**Figure 1**) consisted of two horizontal, perforated, concentris aluminium cylinders constructed from aluminium plate, 48 inches in length, the inner being 16 inches and the outer 48 inches in diameter, respectively. A mild steel framework on the concrete floor supported the cylindrical shaped prototype.

The inner drum functioned as a plenum chamber distributing hot air through the cocoa beans loaded into the annulus between the cylinders. About a quarter of the inner drum surface was perforated to ensure that hot air only penetrate the area packed densely with cocoa beans during drying. The circular plates at both ends of the prototype were constructed from mild steel plate of 9 mm thick. The mild steel framework and the circular plates at both ends were painted with heavy duty industrial paint. The prototype was driven by a 0.5 HP three-phase motor and rotated along the horizontal middle axis.

Two chained sprockets (similar in sizes) were responsible for driving the prototype and measured 25 inches in diameter. The revolution of the prototype was adjusted using an electronic inverter (Transicom, model ES400, 0-60 Hz). Hot air ducts were attached to each end (left and right) of the inner drum. Ambient air was drawn and heated indirectly by a wood fueled furnace constructed from mild steel plates. The fan distributing the hot air was driven by a variable speed 1.5 KW motor at approximately 1000 cu.m/hr.

The furnace was fed with 10 kg of wood/hr to maintain the temperature of the hot air between 55°C and 65°C. Wet cocoa beans were loaded into the fermenter drier through windows made at the outer wall and unloading was done through the same windows. Four side scarpers which functions were to lift and mix the beans, were constructed along the inner wall of the bigger diameter (48 inches) outer drum. Four smaller scrappers with hard rubber were constructed near the plenum chamber to scrap away the mucilage deposited on the perforated aluminium wall of the plenum chamber (**Figure 2**). The design capacity of the prototype is one tonne of fresh cocoa beans but the working capacity was between 700 to 800 kg of fresh cocoa beans.

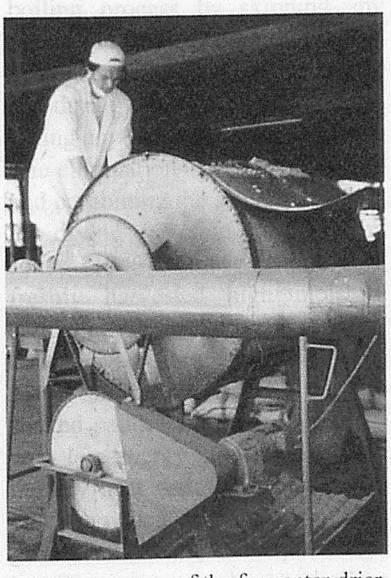

Fig. 1 prototype of the fermenter-drier.

Preliminary Trials and Modifications

The initial design of the prototype was not constructed with the inner scrappers near the plenum chamber and the surface area of the plenum chamber was totally perforated and co-rotating with the outer drum. Several preliminary trials were conducted to observe and determine the areas for modifications when cocoa beans are subject to fermentation and drying in the prototype and flavour development was not the main interest in these trials. Preliminary trials were conducted using one tonne of wet cocoa beans to ensure the cocoa beans still occupy about half of the prototype's volume towards the end of drying. Initially, the beans were let fermented in the prototype and sweating was able to drain through the perforated holes easily and temperature was able to build up during the course of fermentation.

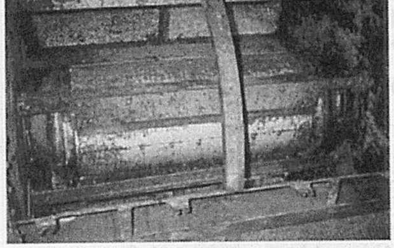

Fig. 2 The inner scraper for cleaning of mucilage.

The beans were left undisturbed inside the drier until the pH value of the nibs reached between 4.9 and 5.1. Drying was started (from 8 am to 5 pm) when this pH was reached and usually occurs in the morning of the 3rd day if the beans were loaded in the late afternoon on the 1st day. The drier was covered with gunny canvas and left to ferment at night. This procedure was repeated until the beans reached the desired moisture content level. During the onset of drying, the vigorous mixing of the beans against the perforated surfaces and the metallic components such as bolts and nuts resulted in the depositing of the slimy mucilage on the perforated surface of the plenum chamber.

During drying, the deposited mucilage dried and formed a hard layer of crust on the perforated surface and blocked the passage of the hot air. Hence, drying was hindered and the cocoa beans had to be unloaded in order to clear the crust. Localized drying was observed at the cocoa beans situated near to the plenum chamber due to inefficient mixing of the cocoa beans at the loading of one tonne that is considered overload. Several modifications were made following these observations as already described in the previous section. In the final design, four inner scrappers with hard rubber were constructed, only a quarter of the total surface area of the plenum chamber was perforated and the plenum chamber was made stationary. Upon completion of the modifications, two trials were conducted using trial masses of about 1000 kg (high loading) and 700 kg (intermediate loading) of wet cocoa beans. The formation of crust was not observed in both trials but mixing during drying was not uniform due to the high loading of cocoa beans (1000 kg) which resulted in uneven drying. The loading capacity of 700 kg seems to be the optimum volume for the prototype. The detached mucilage merely dried and fell off through the perforated surface of the outer drum. It was noted that final drying at moisture content less than 10% was not efficient and drying was terminated at this stage (usually at the 5th or 6th day). The great reduction in volume caused the final loading reduced from 700 kg to nearly 300 kg of dried cocoa beans. Heat was wasted and escaped to the surroundings during the final drying and mixing was not efficient at this condition. The final dried beans produced have the usual polished shell surface as in most rotary driers. Bean breakage was quite high and measured between 1.0% and 4.4% based on final dried beans weight (**Table 1**).

Table 2 shows the results from the sensory evaluation of cocoa liquor samples obtained from the trials using the Ghanaian liquor as the reference. Results show that both samples are inferior in cocoa flavour although sample from trial 700 Kg shows lower score in bitterness, astringency and acidity. The scores for fruity and raw are quite low (<1) in both samples. The lack in cocoa flavour was due to insufficient fermentation in both trials.

Recommendations

Due to limited funding, major modifications could not be done to further improve the prototype. The following are few of the major modifications that could be done to the prototype in the future:

1. Enclose the fermenter drier in an insulated and external non-perforated drum with moisture extractor to minimize the heat loss to the surroundings during fermentation and drying. The design is similar to that of a roaster to conserve heat and to ensure uniform heat mixing with the cocoa beans even towards the end of cocoa drying.
2. The heated air is supplied externally outside the perforated drum and not internally from the inner plenum chamber. This is to prevent the possible crust formation by the mucilages on the surface of the plenum chamber and also to reduce the number of metallic parts inside the fermenter drier which could cause bean breakage and contaminations. Elimination of the inner parts would also increase the capacity of the fermenter drier due to additional volume of the beans.

Conclusions

A prototype of the mechanized fermenter drier was constructed. It was capable of performing cocoa fermentation and drying. Difficulty in drying due to decreasing dried beans volume was observed and heated air was wasted to the surroundings. The prototype has been preliminary tested and few suggestions were made for future modifications of the prototype. These include enclosing the fermenter drier with an insulated drum, as found in most roaster design, to reduce conserve heat and elimination of the inner drum to increase the volume and reduce the number of parts inside the prototype. Flavour analysis showed that the beans lacked in cocoa flavour due to insufficient fermentation.

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Table 1. Results from Trial Masses of 1000 kg and 700 kg Loads

Trial mass (kg)	Dried beans collected (kg)	Waste produced from breakage (kg)	% Breakage	Moisture content (%)
1000	411	18.0	4.4	9.3
700	313	3.1	1.0	9.8

Table 2. Results of Sensory Evaluation from Trial Masses 1000 kg and 700 kg

Sample	Cocoa	Bitter	Astringent	Acids	Fruity	Raw
Trial 1000 kg	3.6	3.6	3.3	3.9	0.1	0.1
Trial 700 kg	3.5	2.6	2.8	2.5	0.3	0.0
Ghana*	7.0	2.5	2.5	1.5	1.5	0.0

*Reference score as agreed upon by the sensory panelists.

Developement of an Energy-efficient Continuous Conduction Parboiling Process

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Abstract

A continuous conduction parboiling unit using industrial oil as an indirect heat transfer medium was designed and developed. The optimum parboiling conditions like initial moisture content (IMC) and contact time for three varieties of paddy (ADT 36, IR 20 and CO 45) were determined, including the energy required for soaking,parboiling and drying of paddy. Conduction parboiling needed only 49 to 59 per cent of the heat utilized in conventional process depending on variety.

Introduction

Energy can be saved in the parboiling process by skipping any one of the three distinct unit operations, namely; soaking, steaming and drying or, in other words, combining any two operations at a time. The elimination of soaking in water and combining the steaming and final drying was first suggested by Jones (1946). Direct steaming of freshly harvested high moisture paddy improves the head rice recovery but with inferior quality (Tiwary, 1980). Parboiling of the soaked paddy could be carried out with less energy input by applying the dry heat instead of moist heat (steam) which takes care of both gelatinization and subsequent drying. The various dry heat parboiling methods for paddy developed so far have been mostly on laboratory experimental basis. No successful commercial unit is available in India or else where.

In view of the drawbacks associated with the modern parboiling process, one of the possible methods for energy saving for parboiling of paddy is the continuous dry-heat parboiling. This method has the unique feature of parboiling and drying of paddy simultaneously. Therefore, it was believed that the development of a continuous dry heat parboiling system with industrial oil as an indirect heat transfer medium, would most effectively parboil paddy with less energy consumption. Further, no attempt has been reported so far on the use of industrial oil as a heat transfer medium.

Review of Literature

Many investigations have been carried out on the conduction parboiling (Iengar *et al.*, 1971; IRRI, 1970; Arboleda, 1973; Khan 1973; Khan *et al.*, 1974; Ali and Bhattacharya, 1980 b; Srinivas *et al.*, 1981). Iengar *et al.*, (1971) have reported that sand-paddy mixture of 2:1 was the best combination for parboiling whereas Shukla and Khan (1984) advocated the ratio of 15:1 to obtain maximum head rice recovery of about 98%. Paddy with high initial moisture (> 22 per cent) is better suited for parboiling by this method (Srinivas *et al.*, 1981).Various temperature ranges have been used for the parboiling studies, starting from 120 °C (Iengar *et al.*, 1971) to as high as 250 °C (Pillaiyar *et al.*, 1994). Exposture time of 1 to 1.5 minute was sufficient to parboil at low temperature of 95 to 155°C (Srinivas et.al., 1981).Pillaiyar et.al.,(1994) found that 47 seconds was enough to parboil CR 1009 paddy in the temperature range of 125 to150 °C. So far the temperature of the sand had been maintained in the experimental set up by using the LPG or agricultural waste as fuel. Obtaining the uniform temperature of sand throughout the heating portion of the unit is a difficult job if the above fuels are used. Alternatively, industrial oils with high fire point could be used with electrical heaters as indirect heating medium for maintaining the desired temperature of sand.

Materials and Methods

The experimental set up for parboiling of paddy consisted mainly of a rotating annular drum with sieve, oil circulating system, feed hopper, temperature controlling arrangements, reduction gear box and a motor as shown in **Fig 1**. An annular drum with inner and outer diameters as 160 mm and 220 mm,

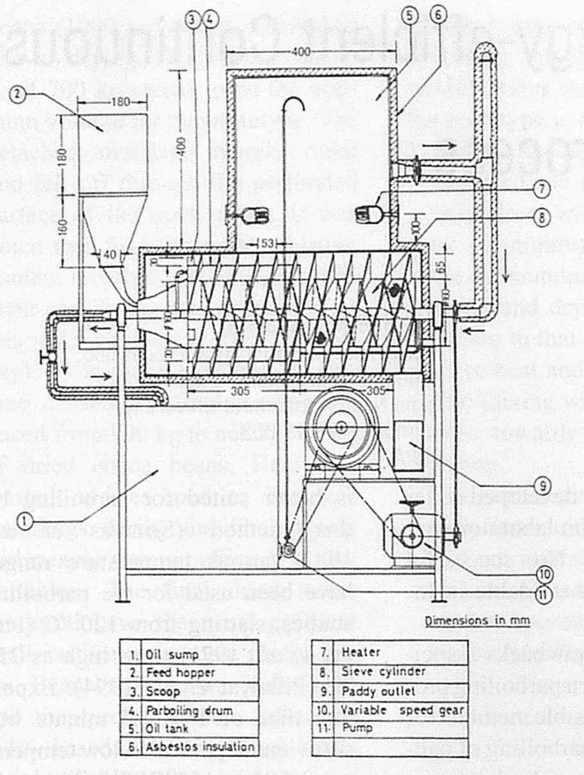

Fig. 1 Conduction parboiling Unit.

Table 1. Moisture Content Of Paddy After Parboiling

Initial moisture content % (w.b.)	Contact time (s)	Moisture content after parboiling, % (w.b.)		
		ADT 36	IR 20	Co 45
28	30	23.26	23.20	23.31
28	45	22.57	21.91	22.12
28	60	21.05	20.42	20.66
28	75	20.27	19.41	19.52
30	30	25.19	24.69	24.58
30	45	23.57	23.09	22.81
30	60	22.25	21.78	21.46
30	75	20.88	20.39	20.05
32	30	26.93	26.28	26.72
32	45	25.29	24.63	24.88
32	60	24.32	23.23	23.51
32	75	23.07	22.42	21.58

Table 2 .Drying Time of Dry Heat Parboiled Paddy

Initial moisture content % (w.b.)	Contact time (s)	Drying time, min		
		ADT 36	IR 20	Co 45
28	30	43	36	39
28	45	45	42	42
28	60	50	46	47
28	75	53	50	52
30	30	45	38	43
30	45	50	42	46
30	60	57	48	51
30	75	62	53	54
32	30	52	45	46
32	45	55	52	50
32	60	63	54	53
32	75	67	58	59

respectively, was improvised cylinder with 160 mm diameter made of ISS-120 sieve was fixed to the drum. In the inner surface of the drum and sieve cylinder, a right-handed screw auger was welded to convey the sand and paddy mixture. In the outer surface of the drum, a left-handed screw auger was welded. At the end of the annular drum four square scoops were fabricated to facilitate the entry of sand in to the drum. A hollow cylinder of 300 mm diameter was made and the drum and sieve assembly was inserted in to it. A one h.p. motor with variable speed gear box was connected to the shaft of the drum assembly using suitable chain and sprockets.

Two square tanks one at the bottom and the other at the top of the unit, were fixed to function as sump and overhead tank for the oil (thermic fluid) circulation. A fractional horse power centrifugal pump was attached to recirculate the oil. Four immersion heaters of 1.5 k.W. were fixed in the overhead tank to heat the oil. A thermostat was connected to maintain the required sand temperature. The entire unit was insulated with 10 mm asbestos rope. The sand of 0.46mm was used for the study to have better heat transfer coefficient(Richard, 1981).

The experiments were conducted for the paddy varieties of ADT 36, IR 20 and CO 45 at a constant temperature of 140^0 C with different initial moisture contents of 28,30 and 32 %(w.b.) for an exposure time of 30, 45, 60 and 75 seconds. The parboiled paddy was dried in a mechanical drier at a temperature of 70^0C with an air flow rate of $0.45m^3$/min.

The parboiled paddy was shelled in the laboratory model McGill sheller and polished in the McGill miller No.2 to 6% level. Head rice recovery and the percent brokens were expressed as percent of total rice obtained. (BIS 9049, 1989). Alkali expansion value is a measure of degree of parboiling and was determined as per Mohandoss and Pillaiyar (1980). The gelatinization percentage (translucence index) was determined as per Bandopadhyay and Roy (1977). The energy utilized for the parboiling process was determined using the procedure followed by Tiwary (1980).

Results and Discussions

The moisture content of paddy after parboiling is presented in the **Table** 1. The moisture evaporated increased with both the initial moisture content and contact time for all three varieties tested. This may be due to the fact that the heat conduction into the paddy at higher moisture contents with greater contact time is relatively at a faster rate which enhanced the moisture migration from the paddy to the atmosphere.

It is observed in the **Table 1** that the reduction in the moisture content increased with all contact times for three varieties. When the initial moisture content was 28 per cent the reduction in the moisture content ranged between 4.69 and 4.8

per cent (w.b.) at 30 s contact time.

The moisture content reduction at 75 s contact time for all the varieties at 28 per cent initial moisture level was 7.73 to 8.59 per cent (w.b.). These results compared very favourably with those reported by Pannu and Raghavan (1986). The moisture content reduction at 30 per cent initial moisture content ranged between 4.81 and 9.95 per cent (w.b.) and that of 32 per cent initial moisture content was between 5.07 and 10.42 per cent (w.b.). Shukla and Khan (1984) reported 10 to 13 per cent (w.b.) reduction in moisture content for IR 36 variety exposed for 10 s at the sand temperature of 200°C. The variation in the moisture content reduction of 30 per cent reported by them may be due to the higher sand temperature and different variety of the paddy used.

The drying time of the parboiled paddy in mechanical drying is presented in **Table 2**. The drying time of parboiled paddy at the initial moisture content of 28 per cent ranged between 36 and 53 minute and for 30 and 32 per cent initial moisture contents, it ranged from 38 to 62 minutes and 45 to 67 minutes, respectively, for all the three varieties tested for attaining the final moisture content of 14 per cent at a drying air temperature of 70 °C. Vasan *et al.*, (1980) reported that the parboiled paddy (CO 25) at 25.6 per cent (w.b.) required 11 min to obtain the moisture content of 14.4 per cent (w.b.) when the drying air temperature was 130°C. The variation in the drying time in the present study could be due to difference in the temperature of hot air and varieties used.

Among the varieties tested ADT 36 took more time to attain the moisture level of 14 per cent (w.b.) at all initial moisture contents and contact times followed by IR 20 and CO 45. This may be due to genetic characteristics of the varieties.The reduction in drying time at 75 s contact time for parboiling compared with that of 30 s was ranging between 10 and 17 minutes for ADT 36 and for IR 20 and CO 45 it was 11 to 13 min and 13 to 15 min respectively for different initial moisture contents tested.

The head rice recovery,gelatinization percentage and alkali expansion value of dry heat parboiled paddy is presented in **Table 3**. From the Table 3 it is seen that the ADT 36 variety gave maximum head rice recovery which was on par in the following treatment combination of 28 per cent IMC and 75 s, 30 per cent IMC and 75 s, 32 per cent IMC and 75 s, 30 per cent IMC and 60 s and 32 per cent IMC and 60 s. The same combination holds good for achieving maximum gelatinization percentage also. Alkali expansion value was comparable with control only at 30 per cent IMC and 75 s and 32 per cent IMC and 45 s. Considering all the three essential parameters for parboiling of paddy it may be concluded that 30 per cent IMC and 60 s contact time is the best combination for the ADT 36 with mechanical drying.

In the case of IR 20 and CO 45 the following combination of treatments gave maximum head rice percentage. 28 per cent IMC and 60 s, 30 per cent IMC and 60 s, 32 per cent IMC and 60 s , 28 per cent IMC and 75 s , 30 per cent IMC and 75 s and 32 per cent IMC and 75 s. The maximum gelatinization percentage (100 per cent) was obtained in addition to the above treatments in 32 per cent IMC and 45 s . The alkali expansion values for both varieties were on par with the treatments of 28 percent IMC and 60 s and 32 percent IMC and 45 s and was comparable with control. From the above results it may be concluded that the combination of

Table 3. Effect Of Initial Moisture Content and Contact Time on Head Rice Yield, Gelatinization and Alkali Expansion Value of Conduction Parboiled Paddy

Initial moisture content (%w.b)	Contact time (s)	Head rice recovery				Alkali Expansion value				Gelatinization percentage			
		ADT 36	IR 20	CO 45	T Mean	ADT 36	IR 20	CO 45	T Mean	ADT 36	IR 20	CO 45	T Mean
28	30	78.37d	81.43c	81.17c	80.32	33.67d	44.67d	40.67d	93.67	18.83d	26.67c	26.83c	24.11
	45	87.32c	88.73b	86.80b	87.62	85.83c	103.83c	91.50c	93.72	56.00c	65.50d	70.33b	63.94
	60	95.92b	99.47a	99.08a	98.16	164.00b	182.83b	196.83b	181.22	79.00b	100.00a	100.00a	93.00
	75	99.68a	99.76a	99.47a	99.63	271.17a	289.00a	279.33a	279.83	100.00a	100.00a	100.00a	100.00
30	30	82.20d	85.46d	83.07d	83.58	44.50d	66.33d	69.00d	59.94	30.67c	37.83c	39.67c	36.06
	45	90.91c	93.93b	94.60c	93.14	129.67c	141.33c	154.17c	141.72	76.33b	88.33b	92.33b	86.67
	60	99.97a	99.63a	99.43b	99.28	187.50b	241.17b	252.67b	227.11	100.00a	100.00a	100.00a	100.00
	75	100.00a	100.00a	100.00a	100.00	306.83a	329.00a	331.50a	322.44	100.00a	100.00a	100.00a	100.00
32	30	85.03c	86.73c	83.98c	85.25	62.33d	74.33d	79.83d	72.17	36.33c	45.33b	50.50b	44.06
	45	94.42b	98.65b	98.80b	97.28	177.17c	167.67c	174.67c	173.17	91.17b	100.00a	100.00a	97.06
	60	99.51a	99.61a	99.66a	99.59	230.67b	312.00b	314.83b	285.83	100.00a	100.00a	100.00a	100.00
	75	100.00a	100.00a	100.00a	100.00	348.50a	413.33a	394.50a	385.44	100.00a	100.00a	100.00a	100.00
Mean		92.67	94.45	93.83		170.15	197.13	198.29		74.03	80.31	81.64	
		SEd	LSD (5%)	LSD (1%)		SEd	LSD (5%)	LSD (1%)		SEd	LSD (5%)	LSD (1%)	
t × M × v means		0.82	1.63	2.15		7.63	15.08	19.91		0.82	1.63	2.15	

Table 4 Heat Utilization Efficiency Of Conduction Parboiling System At Optimum Condition

Process	ADT 36			IR 20			CO 45		
	Heat supplied kJ/kg	Heat utilized kJ/kg	Heat utilization efficiency	Heat supplied kJ/kg	Heat utilized kJ/kg	Heat utilization efficiency	Heat supplied kJ/kg	Heat utilized KJ/kg	Heat utilization efficiency
Soaking	118.80	92.78	78.09	115.20	89.24	77.46	115.20	89.57	77.75
Parboiling	712.89	423.46	59.40	691.00	402.71	58.27	676.98	396.55	58.57
Drying	1069.20	255.60	23.90	716.40	178.78	24.95	759.60	186.18	24.51
Total	1900.89	771.84	40.60	1522.60	670.73	44.06	1551.78	672.30	43.32

28 per cent initial moisture content and the contact time of 60 s with mechanical drying is the best one among the treatments tested for the varieties IR 20 and CO 45.

Energy Requirement for Optimum Parboiling.

Heat utilized in conduction parboiling system is presented in Table 4. The heat utilized for ADT 36 variety at 30 per cent initial moisture level with 45 s contact time under mechanical drying was 771.84 kJ/kg. For the IR 20 and CO 45 varieties optimum combination for parboiling was 28 per cent initial moisture content at 45 s contact time with mechanical drying. The heat utilized at that combination were 670.73 and 672.30 kJ/kg for IR 20 and CO 45 varieties, respectively.

The total energy required (supplied) to parboil 1kg of ADT 36, IR 20 and CO45 paddy in the present study was 1900.89, 1522.6 and 1551.78 kJ/kg. Narasimha *et al.*, (1984) reported that 3751 kJ/kg of heat energy was required for parboiling in CFTRI method (soaking, parboiling and drying). The saving in energy in the present study compared to the CFTRI method ranged between 49 and 59 per cent. This may be due to the fact that about 50 percent of the moisture content evaporated during the conduction parboiling process. **Table 4** shows that the overall efficiency of the system ranged from 40.6 to 44.06 percent. Tiwary (1980) reported that 36.9 percent of the total energy supplied was utilized in the CFTRI method of parboiling. The increased overall heat utilization efficiency in the present study is due to the elimination of steam for parboiling, as to the low amount of energy involved in drying.

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Technical and Economic Analysis on Adaptability of the Typical Grain Drying Patterns in South China*

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Abstract

Grain losses are considerable due to delayed drying because of unfavorable natural effects. The agricultural economy and rural enterprise in South China are relatively developed. Individual small parcels of land are merged into bigger farms run by some skillful and specialized farmer household. Hence mechanization of grain post-production operation becomes possible and urgent needs. In recent years, all kinds of drying equipment rapidly increased especially. The typical drying patterns in South China, taking Zhejiang province as an example, were investigated and the performance data were tested. A method was developed in order to evaluate the economic adaptability of grain post-production drying patterns for different regions with various technical and economic background, farm scale and natural conditions. It was applied to analyze three grain dryers used in some farms in South China, NEW-PRO-60 (made in Taiwan TYPE I for short), YSLG-6 (made in China, TYPE II), and SSA160 (made in Japan, TYPE III). The analysis results indicate that the TYPE III is adaptable for regions where the technical and economic conditions are better and the volumes are over 341 ton/year; TYPE II is suitable for the regions where the technical and economic conditions are low and year operation volumes are 150 to 250 ton/year, or the TYPE I can be considered; In the same year operation volume, TYPE III is suggested to be used only in the regions with high labor value and grain price, but it has high reliability and advanced automatic control skills. The study results can be used to instruct the farmers to choose the best economic drying patterns based on the local comprehensive technical and economic conditions.

In the regions with the value of labor is 25 yuan/day (in most parts of south China), the necessary economic operation volume of the three dryers should be higher than 279.1, 189.4, 341 ton/year respectively. In the regions with the value of labor is over 50 yuan/day, the necessary economic operation volume is only higher than 176.5 ton/year. According to the year operation volume of 240 ton/year, the average maximum of a 6t-dryer, the necessary economic labor value should be over 43.58 yuan/year. The necessary economic year operation volume of the three dryers should be over 277.7, 188.5, 339.2 ton/year, respectively, according to the grain price of 1.5 yuan/kg, purchasing price of government. The necessary economic grain price should reach 9.65 yuan/kg calculated according to the year operation volume of 240 ton/year for all three dryers.*1

Introduction

People always pay more attention to pre-production and production systems and post-production process is easily ignored. In fact, the grain post-production losses are serious. The average loss rate of grain post-production in south China is about 15% and the loss during the drying process is about 3.5%[1]. The grain drying process is one of the important processes of the grain post-production system. About 5-10 billion kg of grain is lost yearly in China due to delayed drying and deterioration[2]. The trial was implemented through a survey of 27 farmer households in 9 villages, respectively, in Jinhua, Jiaxing and Ninbo in Zhejiang province. The measurement results of grain quantity losses during drying treatment process are shown in **Table 1**. The losses are caused by bad drying methods of manual sun drying

The delayed grain drying lead not only to quantity losses, but also to grain quality losses. The results of comparison trial between the timely and delayed drying in the same surveyed area are showed in

1. The study is part of the program funded by National Fund of Natural Science.

Table 1. Grain Quantity Losses in Drying Process

Test area	Loss rate		
	Range of loss rate%	Average loss rate%	Percent in total losses (%)
Jinhua	0.89 ~ 3.15	2.16	10.53
Jiaxung		1.01	
Ninbo		1.53	

Table 2. Influence on Grain Quality Due to the Delayed Drying

Quality indexes	Paddy type		Average
	Early variety	Late variety	
Weight per 1000 grainsg	-0.19	-0.45	-0.32
Germination rate%	-7.45	-4.27	-5.86
Broken rate%	+7.37	+4.54	+5.96
Yellow kernel rate%	+2.28	+0.38	+1.33

Table 3. Productivity and Drying Ability

Items	Type		
	I	II	III
Productivity (kg/per batch)	Paddy:2500-6000 Wheat:3035-7285	paddy: 6000Max wheat: 7280Max	paddy: 1610-5850 wheat:1960-7100
Drying ability (% t water/hour)	6.36	1.5	4.6
Water loss rate per hour(%)	0.91	1.11	0.77

Table 4. Uneven Rate and Drying Quality of Grain

Index	Type		
	I	II	III
Uneven rate(%)	0.3	1.1	0.6
Broken rate(%)	0.1	0.12	0.1
Crack rate(%)	≤0.6	≤1.3	≤3.0

Table 5. Oil Consumption and Electricity Consumption

Items	Type		
	I	II	III
Oil consumption (kg/kg grain)	0.027	0.018	0.026
Electricity consumption (kwh/kg grain)	0.027	0.011	0.024

Table 2. Hence the drying treatment process of the post-production should be improved and advanced drying technology and equipment should be adopted.

In recent years, with the development of social economy and town-owned enterprises in the vast countryside in South China, a great deal of labor force was transferred from planting into other industries where people could earn more money. In the meantime the individual small parcels of land were merged into small- and middle-scale farms run by some skillful and specialized farmers. Taking Shaoxing region as an example, according to statistics in 1998, there were 1,600 farms of over 3.3 ha each and 21,600 farms over 0.67 ha each. The traditional sun heat drying cannot be satisfied any longer, so the modern drying patterns have to be applied instead of the low-efficient ones. The technical and economic analysis on the adaptability of three typical grain drying machines were undertaken in comparison with the traditional manual operation method, in order to provide theoretical base and practical instructions for farmers in selecting the best drying machines and methods.

Analysis on the Technical Adaptability

There are lots of kinds of dryers now in market. Three types of dryers were chosen to be tested and be analyzed, which are popularly used in some farms of South China. The dried cereal was paddy of early variety. The moisture content rate of pre-drying paddy was 31% and the moisture content rate of post-drying paddy was 11.5%. All related data in the following tables were measured under such conditions.

Productivity and Drying Ability

Productivity is mainly determined by the dryers own performance, but it is also related to the operators skills, the grain clean rate and grain variety. The index of drying ability showing the ability to loss water of grain can be substituted by the index of water loss rate per hour. It is mainly determined by the dryers own performance and related to the water content rate of grain water loss scope. The productivities of the three dryers are identical. The drying ability of TYPE II is lower than TYPEs I and III (details in **Table 3**).

Uneven Rate and Drying Quality

The uneven rate of grain drying directly effects the drying quality. The drying quality of grains can be evaluated by indexes: broken rate and crack rate of grain. The uneven rate of TYPE I is lower than TYPE II. TYPE II is lower than TYPE III. The broken rates of the three dryers are similar, all about 1%. The crack rate of TYPE I is the lowest (details in **Table 4**).

Oil and Electricity Consumption

The indices of oil consumption and electricity consumption are important in evaluating the energy consumption of the dryer. They are determined by the dryers own performance and affected by the initial conditions of grain and the required dry rate of grain. The details are showed in **Table 5**.

Method of Analysis on the Economic Adaptability

Multi-effects prompt farmers to choose the kind of drying model, traditional sun-drying, or modern machine drying, and type of dryers. These effects include farmer's idea technical level, local natural conditions, production scale and model, technical and economic adaptability. Economic adaptability is critical as it is closely relevant to farmers economy, especially in the present marketing background.

At present, the farmers running bigger farms urgently need the drying machinery, so the economic analysis was based on their viewpoint and conditions. The economic effectiveness can be quantitatively measured by using three components, according to the economic theory of agricultural mechanization, i.e., labor cost-saving effects (S_1); benefits from increasing production and reducing the losses (S_2); and the interests from saved labor (S_3). These three components are expressed in detail as follows:

Labor Cost Saving Effects (S_1)

Mechanization can improve productivity and save labor. The interests saved in the mechanical operation as compared with manual operation can be expressed in the following equation:

$S_1=(a_1-a_2)LW+(b_1-b_2)W-(c_1-c_2)$ (1)

where,

S_1=labor cost saved from using machines (yuan).

L =average value of manual labor (yuan/day).

W=operation volumes in a year (ton/year).

a_1, a_2=working days by manual and mechanical operation, respectively (day/ton).

b_1, b_2=variable costs of operation by manual and mechanical operation, respectively (yuan/kg).

c_1, c_2=annual depreciation of mechanical equipment and farm tools operated manually, respectively (yuan/year).

Benefits from Increased Production or Reduced Losses (S_2)

The conditions for agricultural production can be improved if farming operation are mechanized. Mechanization plays an important role in the timely operations of farm work and securing the productivity of the corps under unfavorable weather conditions. Increasing productivity and reducing losses can be expressed in the following equation:

$S_2=(R_1-R_2)IW+(r_2-r_1)IW$ (2)

where,

I=grain price .

R_1, R_2=increasing yield with the manual and mechanical operation, respectively.

r_1,r_2=reducing losses with the manual and mechanical operation, respectively.

Benefits from Saved Labor (S_3)

The labor saved after adopting mechanical operation can be utilized in other occupations. The produced effect (S_3) can be expressed by the following equation:

$S_3=S_{31}+S_{32}+S_{33}+S_{34}+S_{35}+S_{36}$ (3)

where,

S_{31}, S_{32}, S_{33}, S_{34}, S_{35}, S_{36}=benefits from the saved labor which was transferred to other occupations instead of farming.

Comprehensive Benefits (S)

For the farmers who run bigger farms, they decide if using the machine depend on directly the plus (S) of S_1 and S_2. They can't directly benefit from S_3 hence farmers pay less attention to it. The comprehensive benefits (S) can be expressed as following equation:

$S=S_1+S_2$ (4)

$S=(a_1-a_2)LW+(b_1-b_2)W-(c_1-c_2)+(R_1-R_2)IW+(r_1-r_2)IW$ (5)

If S>0, it is favorable; S<0, unfavorable; S=0, cost is equal to benefits.

Assuming S=0, the critical equation of the economic effects is available as following:

$$W=\frac{(c_1-c_2)}{(a_1-a_2)L+(b_1-b_2)+(r_1-r_2)I}$$

Equation (6)

When paying more attention to labor saving effects, the index I can be assumed be constant for simplifying the solution, then this critical curve shows:

(1)If the coordinate cross of the index L and W is over the critical curve, then S>0,favorable. On the contrary, S<0, unfavorable.

(2)The value of the index L can be lowered by increasing of the operation volumes W.

(3)The economic benefits can be increased when either the value of the index L or W goes up.

When paying more attention to benefits from increased production or reduced losses, the index L can be assumed to be constant, then this critical curve shows:

(1) If the coordinate cross of the index I and W is over the critical curve, then S>0,favorable. On the contrary, S<0, unfavorable.

(2)The value of the index I can be lowered by increasing the operation volumes W.

(3)The economic benefits can be increased when either the value of the index L or W goes up.

Table 6. Variables of Four Drying Patterns

Items	Type			
	I	II	III	Manual
Labor expense (day/ton)	0.31	0.32	0.3	1.5
Grain loss rate (%)	0.1	0.1	0.1	1.6
Machine price (yuan)	97000	68000	115000	3000
Depreciation (yuan/year)	9700	6800	11500	
Cost of oil and electricity (yuan/kg)	0.067	0.036	0.059	
Cost of maintenance (yuan/kg)	0.023	0.029	0.037	
Cost of management (yuan/kg)	0.01	0.01	0.01	
Variable costs (yuan/kg)	0.10	0.065	0.106	800

Application of Analysis Method in South China

Based on the method above, several drying patterns in south China were evaluated as follows:

There co-exists the manual sun-drying and machine drying models in south China. The advanced dryers were used more and more in recent years. Through the survey and practice in Shaoxing and Shengzhou regions in Zhejiang province, the relavant data are measured (**Table 6**).

Substituting these data in formula (4) respectively, the economic benefits equations of types II and III and dryers are available as follows:

$S^{(1)}$=1.19LW-0.1W-8900+1.6WI (7)

$S^{(2)}$=1.18LW-0.065W-600+1.6WI (8)

$S^{(3)}$=1.17LW-0.106W-10700+1.6WI (9)

According to the equations (7) to (9), the economic benefits of dryers can be calculated when the data I, L, W are given. If the value of local grain price is 1.4 yuan/kg (average price by government), and $S^{(1)}$, $S^{(2)}$, $S^{(3)}$=0, the economic critical curve can be attained on the basis of the relation between the indices W and L, as follows:

$$W^{(1)} = \frac{8900}{2.14 + 1.19L} \quad (10)$$

$$W^{(2)} = \frac{6000}{2.175 + 1.18L} \quad (11)$$

$$W^{(3)} = \frac{10700}{2.134 + 1.17L} \quad (12)$$

According to the equations (10) to (12), the critical curve of types , I,II and III dryers are shown in **Fig. 1**.

In the same way, if assuming the local labor value is 25 yuan/day (standard in much of the regions), the economic critical equations can be attained as follows:

$$W^{(1)} = \frac{8900}{29.65 + 1.6I} \quad (13)$$

$$W^{(2)} = \frac{6000}{29.435 + 1.6I} \quad (14)$$

$$W^{(3)} = \frac{10700}{29.144 + 1.6I} \quad (15)$$

According to the equations (13) to (15), the critical curves of types I, II and III dryers are shown in **Fig. 2**.

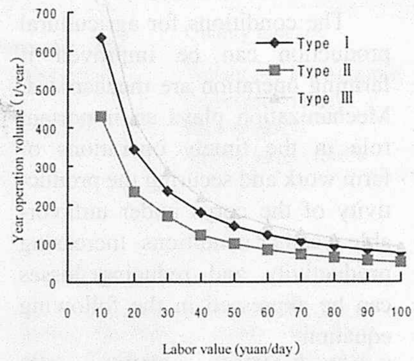

Fig. 1 Economic critical curves based on the relations between the indices W and L.

Conclusion

(1) In regions with the value of labor at 25 yuan/day (in most parts of South China), the necessary economic operation volume of three dryers should be higher than 279.1, 189.4 and 341 ton/year, respectively. In regions with the value of labor at over 50 yuan/day, the necessary economic operation volume is only higher than 176.5 ton/year. According to the year's operation volume of 240 ton/year, the usual average operation volume of a 6-t-dryer, the necessary economic labor value should be over 43.58 yuan/year.

(2) The necessary economic year operation volume of the three dryers should be over 277.7, 188.5 and 339.2 ton/year, respectively, according to the government's grain price of 1.5 yuan/kg. The necessary economic grain price should reach 9.65 yuan/kg calculated according to the year operation volume of 240 ton/year for all three dryers.

(3) The TYPE III machine is adaptable in the regions where the technical and economic conditions are better and the year operation volumes are over 341 ton/year; TYPE II is suitable in the regions where the technical and economic conditions are lower and the year operation volumes are 150 to 250 ton/year. Under the same year operation volume, TYPE I is suggested to be used only in regions with high labor value and grain price, but with high reliability and advanced automatic control skills.

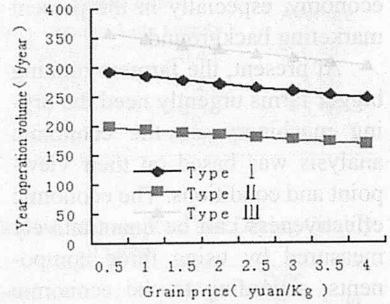

Fig. 2 Economic critical curves based on the relations between the indices W and I.

(4) The results can be used to instruct the farmers to chose the best economic drying pattern based on the local comprehensive technical and economic conditions. But the technical and economic adaptability of post-production machinery is a dynamic process. It needs to be considered based on the dynamic and comprehensive local conditions.

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Design of a Machine for Separating Lemon Seed and Pomace

by

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Abstract

A seed-separating machine was designed for separating lemon seed and pomace. The mixture of seed and pomace, containing 84% humidity, was obtained as by-product after removing the lemonís shell and juice. The complete shell is used as ice cream cups. The material used in this study is the mixture of seed and pomace which is obtained after removing the complete shell and the juice of the lemons. The necessary motor power to drive this system was approximately 1.2 kW.

Introduction

The Cukurova Region is the largest producer of lemon in Turkey. Lemons are consumed in inner and outer markets. There is a firm in the Cukurova that exports lemon shells which are used as ice-cream cups to European countries. Complete shell is obtained by extracting the lemon contents using semi-automated machines. The contents consist of two parts as lemon juice and mixture of seed and pomace. The juice is separated from the mixture of seed and pomace by means of the ipulperî machine. When the separation of pomace and seed is carried out, the products find different areas of use: the pomace may be used as dietary fibres in the food industry, especially in pastry- cooks and cakes while the seed can be used in cosmetics for making perfume, cream and soap; in food indutry as oil; and in textile as protective agent.

Materials and Methods

The material used in this study is the mixture of seed and pomace, with 84% (w.b.) humidity.

The designed machine consists of a feeder which sends the material coming from pulp to the separating unit, a stationary cylindrical screen with round holes, a helical conveyor located in the screen, an electrical motor that drives the conveyor shaft, a gear box for reducing the speed of the electrical motor and two containers for gathering pomace and seed. The helical conveyor made from plastic pallets pressurizes the material towards the screen walls. The pomace under pressure is removed from the screen by means of round holes while the seeds are towards the end of the conveyor. For enhancing the working time of the material moving in the cylindrical screen, an inclination (γ) is given to the screen (**Fig.1**).

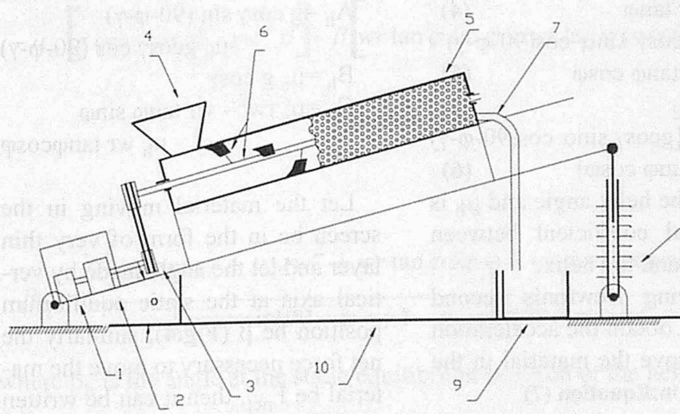

Fig. 1 The separating machine.

Table 1. Components of the Separating Machine

Components	Part No.
Electrical motor	1
Gear box	2
V- belt drive	3
Feeding unit	4
Cylindrical screen with round holes	5
Conveyor shaft and pallets	6
Seed packing unit	7
Inclination adjusting paddle	8
Seed container	9
Pomace container	10

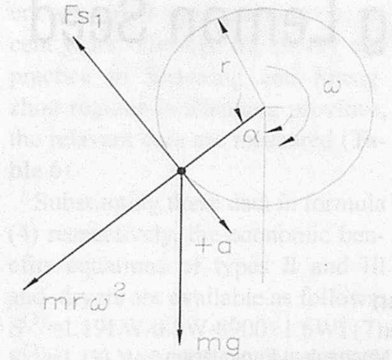

Fig. 2 The forces acting on the material moving in the cylindrical screen.

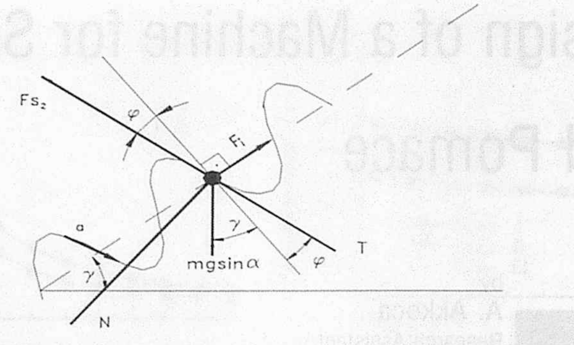

Fig. 3 The forces acting on the material moving along the helix.

$$a_c(\alpha) = g \sin\alpha \cos\gamma - \mu_e g \cos\alpha \cos\gamma - \mu_e r w^2$$

Equation (3)

$$a_h(\alpha) = g \cos\gamma \sin\alpha \sin(90 - \varphi - \gamma) + wr \tan\varphi \sin\varphi$$
$$- \mu_h g \cos\gamma \sin\alpha \cos(90 - \varphi - \gamma) + \mu_h wr \tan\varphi \cos\varphi$$
$$- \mu_e g \cos\alpha \cos\gamma - \mu_e r w^2$$

Equation (7)

$$\alpha = 2 \tan^{-1}\left[\frac{-A + \sqrt{A^2 + B^2 - C^2}}{B - C}\right]$$

Equation (8)

Four forces acting on the material moving in the cylindrical screen are; centrifugal force, translating force, gravitational force and friction force. Both centrifugal force and translating force result from the rotation of the conveyor, gravitational force comes from gravity and friction force is caused by friction between the material, the cylindrical screen and the pallets.

The motion of the material moving in the mentioned media will be either a cylindrical motion or a helical motion or a combination of these two motions.

If the friction force between the screen and the material is denoted as F_{s1} and normal force between the same surfaces is denoted as F_{n1}, (**Fig.2**) then F_{s1} becomes:

$F_{n1} = mg \cos\alpha \cos\gamma + mrw^2$ (1)

$F_{s1} = \mu_e F_{n1} = \mu_e m(g\cos\alpha \cos\gamma + rw^2)$ (2)

where m is the mass per unit time, g is the gravitational acceleration, α denotes the location of the material measured from vertical axis, r is the radius of the cylindrical screen, w denotes the revolution per minute of the conveyor and μ_e is the frictional coefficient between the material and screen (Akcali, 1995).

By applying Newtonís second law, one can obtain the acceleration which causes the material to make a circular motion as **Equation (3)**

If the translating force is F_t, friction force betweeen the material and the helix is F_{s2} and the normal force between the same surfaces is F_{n2}, then:

$F_t = mwr \tan\varphi$ (4)

$F_{n2} = mg \cos\gamma \sin\alpha \cos(90-\varphi-\gamma) - mwr\tan\varphi \cos\varphi$ (5)

$F_{s2} = \mu_h F_{n2} = \mu_h m[g\cos\gamma \sin\alpha \cos(90-\varphi-\gamma) - wr\tan\varphi \cos\varphi]$ (6)

where φ is the helix angle and μ_h is the frictional coefficient between the material and the helix.

By applying Newtonís second law, one can obtain the acceleration needed to move the material in the helix direction:**Equation (7)**

Let α be the angle at the beginning of the motion. Then by substituting sinα and cosα by their tanα equivalents in the equations (3) and (7) and making the necessary calculations, one can obtain the accelerations needed to move the material in circular direction (α_c) and in helical direction (α_h) , respectively (**Equation (8)**).

In the case of circular motion the coeficients in **equation (8)** will be as follows (Akcali and Mutlu, 1990):

$A_c = g \cos\gamma$

$B_c = \mu_e g \cos\gamma$

$C_c = \mu_e rw^2$

In the case of helical motion the same coefficients in **equation (8)** will become

$A_h = g \cos\gamma \sin(90-\varphi-\gamma) - \mu_h g\cos\gamma \cos(90-\varphi-\gamma)$

$B_h = \mu_e g \cos\gamma$

$C_h = \mu_e rw^2 - wr \tan\varphi \sin\varphi - \mu_h wr \tan\varphi\cos\varphi$

Let the material moving in the screen be in the form of very thin layer and let the angle made by vertical axis at the static equilibrium position be β (**Fig.4**), similarly the net force necessary to move the material be F_{net}, then it can be written that:

$$g(1-\cos\beta)\cos\gamma - \mu_e g\sin\beta\cos\gamma - \mu_e r w^2 \beta = 0$$

Equation (11)

$$F_{net} = \int_0^{\beta} a\,dm = 0 \qquad (9)$$

where β is the angle at the static equilibrium position (Akcali, 1995). We can write the mass of the material per unit length (m_r) as:

$$\int dm = \int \rho dV = \int_0^{\beta} \rho r e\, d\alpha \qquad (10)$$

$m_r = \rho r e \beta$

where ρ is the density of the material and e is the thickness of the thin layer.

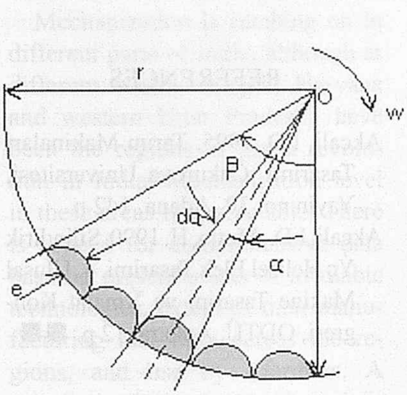

Fig. 4. Motion of the material in the cylindrical screen.

If equations (3) and (10) are substituted in equation (9) and the integral is computed, the following equation can be obtained:**Equation** (11).

For the solution of the above equation, sinβ and cosβ are expanded to Taylor series and large terms are ignored. Then β could be found for circular motion as:**Equation (12)**.

If the same procedures are carried out for equations (7), (10) and (9), the **equations** (13) and (14) are obtained.

The velocity necessary to move the material in the axial direction, in terms of angular velocity, becomes (Akcali, 1995)

$V_z = wr\tan\varphi$ (15)

The mass of the material per unit time becomes (Akcali, 1995)

$Q_t = \rho r e \beta V_z$ (16)

The moment per unit length created by the material around the center of rotation will become (Akcali, 1995)

$M_d = \rho r^2 e (1-\cos\beta) g$ (17)

Necessary Calculations

The helical conveyor was decided to be made from plastic pallets

$$g\cos\gamma(1-\cos\beta)\left[\sin(90-\varphi-\gamma) - \mu_h\cos(90-\varphi-\gamma)\right] - \mu_e\left[g\cos\gamma\sin\beta + rw^2\beta\right] + \beta\left[wr\tan\varphi\sin\varphi + wr\tan\varphi\cos\varphi\mu_h\right] = 0$$

Equation (13)

$$\beta_h = \frac{2\left(\mu_e g\cos\gamma + \mu_e r w^2 + wr\tan\varphi\sin\varphi + wr\tan\varphi\cos\varphi\mu_h\right)}{g\cos\gamma\sin(90-\varphi-\gamma) - \mu_h\cos(90-\varphi-\gamma)}$$

where β_h is the angle at the static equilibrium position of the helical motion.

Equation (14)

$$\beta_c = \frac{2\mu_e(g\cos\gamma + rw^2)}{g\cos\gamma}$$

Equation (12)

in order to avoid the crushing of seeds when squeezing the material towards the screen walls. It was decided that the conveyor length (L) be 2000 mm, outer diameter (d_d) be 300 mm, inner diameter (shaft diameter, d_i) be 90 mm and pitch (h) be 300 mm.

It was also decided that the pallets would be located on the shaft by 90° intervals. Then in one pitch there would be four pallets, hence number of pallets (n) was calculated by dividing the total length to the pitch length times four. The result is 28.

$$n = \frac{L}{h} x4 = 28 \text{ pallets}$$

The width of one pallet was calculated by dividing the length of the conveyor by the number of pallets (n) and was found as 71 mm.

The length of the sheet metal that will form the main helix (conveyor) was calculated as 6945 mm. The mass of this sheet would be 17.19 kg.

The total mass of the pallets was calculated as 1.79 kg.

The mass of the conveyor shaft was calculated as 45 kg.

The helix angle would be

$$\varphi = \tan^{-1}\frac{h}{\pi d_d} = 17.6°$$

The diameters of the round holes were decided to be 4 mm and the holes be located at the corners and in the center of a hexagon so that the seeds do not leave the screen. The screen was decided to be made from stainless steel with 2 mm thickness. Screen efficiency was found by dividing effective screen area by total screen area, assuming there were 2 mm intervals between the holes, which was found as 40.4%.

Appropriate rotation speed of the conveyor was decided to be 105 rpm (or 11 r/s) that was found from conveyor tables.

The angles at the beginning of the motion in circular and helical motions respectively were found from equation (8) as α_c= 31.69° and α_h= 36.47°, respectively.

The angle at the static equilibrium position for circular and helical cases respectively were calculated from equations (12) and (14) as β_c=1.15 rad= 65.89° and β_h= 1.6 rad= 91.67°, respectively.

The mass of the material per unit length was calculated from equation (10) as m_r= 7.76 kg/m.

The velocity of the material in the axial direction was calculated from equation (15) as 0.52 m/s. The same result was obtained by using the equation hw/60= 0.52 m/s.

From equation (16), the mass of the material per unit time would become Q_t=4.11 kg/s.

The total mass of the material in the screen was calculated for most critical position as 116 kg when the screen was full of material.

The frictional forces were calculated from equations (2) and (6) as Fs_1=577.7 N and Fs_2=37 N. The total frictional force was calculated as $F_s=F_{s1}+F_{s2}\cos\varphi$ =614.7 N.

The necessary power to drive this system will be equal to four power requirements. These are: the power required when the system is empty, when the system is full of material, to rotate the product and to give an axial motion to the product.

When the system is empty, the rotating shaft, the helical conveyor and the pallets must overcome the friction force created on the bearings. The total force that must be overcome was calculated as 320 N and the corresponding frictional moment was calculated as 0.96 Nm, and the power corresponding to this moment must be 22 W.

When the system was full of material, the necessary moment to rotate the product was calculated as 11.3 Nm and the corresponding power as 125 W. For the same case the necessary power to overcome the friction of the system was calculated as 1015 W.

The net power was calculated by summing up three powers mentioned above: P_n= 1162 W. The motor power was calculated by dividing the net power to the theoretical efficiency which was calculated by multiplying mechanical efficiencies of the gear box and V- belt drive and calculated as P_m=1236 W.

Conclusions

The separating machine was designed in this study. The material mass per unit time was found as 4.11 kg/s. This means the capacity of the machine is equal to approximately 15 ton/h, which is a sufficient value for the purpose of separating. The highest power overcame the friction force, as expected. The motor power was found approximately as 1.2 kW, which means that power consumption is very low. The same system can be used for separating similar materials. If the prototype of this system was carried out, the necessary arrangements in the way of increasing the efficiency of the system would be accomplished.

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Pattern of Agricultural Mechanization in Sugar-cane Belt of Western Uttar Pradesh

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Abstract

Mechanization is catching on in different parts of India, although at different scales. Punjab, Haryana and western Uttar Pradesh have been the regions of green revolution in India. Mechanization level in these areas is appreciable. There is a need for comprehensive data base on present status of available technologies, extent of their manufacturing and flow across the regions, and use by farmers. A survey study was conducted in sugarcane growing area of western Uttar Pradesh to generate the above information to determine existing gaps, bottlenecks in mechanization process and immediate priorities to achieve optimum level of mechanization in the region under study. Farm implement industry had played an important role in farm mechanization in this region. Due to intensive and profitable agriculture, tractor ownership is high. In few villages, every alternate farmer owned a tractor. Farmers having small land holding are engaged in custom-hiring with their tractor. In spite of a high population of tractors, mechanization is yet to pick up in real terms in this region. Farm operations like tillage, threshing and irrigation are fully mechanized. But farm machines are not used even for critical operations like sowing, transplanting, and harvesting. Seed-drills are not in use for sowing as the farmers are not convinced with its advantages. Regarding planting and harvesting of sugarcane crop, farmers are generally not aware of availability of such machines There is need to popularize these machines which are available in the world market as well as in India

Introduction

One of the major problems in the mechanization process of Indian agriculture is lack of proper information on present status of available technologies, extent of their manufacturing and flow across the regions, and use by farmers. In the absence of such information base, it is extremely difficult to determine technological gaps, to make proper planning, priorities immediately to be taken to achieve optimum level of mechanization. The present study forms part of an AP Cess Funded Project on Mechanization Studies in the Selected Parts of Northern India. The specific objective of this survey study are:

1) To identify successful machinery for variouse on-farm operations being manufactured and marketed in this region.
2) To study the level of farm mechanization both crop-wise and operation wise and associated problems and prospects.
3) To analyse and collate the above information to determine existing gaps, bottlenecks in mechanization process and immediate priorities in order to achieve optimum level of mechanization in the region under study.

Materials and Methods

Acquisition of Information From Manufacturers

A schedule was designed to collect the required information through personal interviews and visits during the survey. It aimed at collecting data on the infrastructural component like production facility, personnel employment, marketing networks and sources of raw materials and components. It also included information on product range, production status and its variation, sources of technical know-how and industry-institution linkages. The information was collected through discussion with the proprietor/ manager of the firm. The production facilities and process were seen in each case to assess the infrastructure. Each centers had manufacturers of different strata in terms of production output and related aspects. Efforts were made to visit most of the manufacturers at each centers. However, at big centers selection of manufactures for visit was done randomly in each strata. A list of FI industrial units was first prepared with the assistance of few manufacturers at each center and a tentative classification was done. A minimum of 50% manufacturers of each category were visited. Based on the infrastructure and volume, the firms were classified in either of the three categories named as A, B, and C. For purposes of classification, each firm was evaluated for infrastructural components, namely; production infrastructure (machinery and personnel), production volume and marketing network with assigned weightage.

The category "A" firms had adequate production facilities operated by sufficiently skilled man-power to maintain a uniform and high quality of the products. These firms also had a wide network of sales outlet through dealers. The other two categories were accordingly in descending order.

Acquisition of iNformation From Farmers

In selecting villages, two things were kept in mind: good representation of the zone and a wide range distribution of the farm sizes in the sample. The farmers from all different holdings categories, i.e., marginal, small, medium and big were randomly selected. Many of the selected farmers assembled at one place and gave their views. The study was conducted in six villages of Baghpat and Muzaffarnagar districts of western U.P. (**Table 1**). This area has comparatively well-to-do peasantry with high productive irrigated loams of Ganga-Yamuna Doaba. The whole area is endowed with canal and groundwater for irrigation, which is a major factor responsible for high agricultural productivity. Shamli and Baraut are two major towns located in this region where from the farmers purchase their farm inputs, including farm machines. These two towns are also major centers of manufacturing of animal drawn vehicles and their rims and axles.

Results and Discussion

Comparative Profile of Farm Implement Manufacturing at Different Centers

The farm implement industry plays an important role in farm mechanization in this region. Here, implement manufacturing is unique; varying from age-old traditional method to well established assembly line. The farm implement industry came into this region out of necessity and flourished along with the progress in agriculture. For example, Baraut and Shamli came up as two major centers of ADV rims and axles. The necessity of this cart was envisaged for this area due to the large scale transportations of sugarcane from villages to the collection centers of sugarcane mills during six months of the year. It is said that the Dunlop company, in order to promote its animal drawn vehicles tyres, provided the basic design of the cart to a carpenter of Baraut to make the carts for the company to market them. Since then the town had become a major center for the manufacture of carts and their components like rim, axle, and chassis. Likewise, the FI industry at other centers in this region came with advent of tractors in western U.P. This necessitated the availability of tractor drawn tillage implements and PTO pulley, specially for lifting water. As a result, the Meerut and Khatauli centers came into prominence as main centers of tillage implements and PTO pulley, respectively. As implement manufacturing was reserved for small scale sector, it had its own problems. Nevertheless, FI manufacturing was prosperous at a few centers. **Table 2** provides a comparative profile on status of FI industry at different centers in this region. A brief description about these centers is given below

Meerut

The farm implement industry in this town is perhaps the oldest, established in the region around Delhi. The first manufacturing unit was set up in 1948. Since then a number of units have come up manufacturing a wide range of implements. The early establishment of the FI industry in Meerut was out of necessity in northern India, after Punjab, western U.P. has been

Table 1. Survey Area

Village	Tehsil/District	No. of Farmers
Mawikalan	Baghpat/Baghpat	1500
Bawli	Baraut	600
Mahatpatpur	Baraut	700
Rustampur	Baraut	600
Elam	M. nagar	2000
Melehandi	Karana/M.nagar	500

Table 2. Status of Manufacturing Centers, Western Uttar Pradesh

Center	No. of manufactures	Main product	Other products	Category A/B/C
Merrut	14	DH, CL	RD, DP, MB, LB, D, PCM	4/6/4
Muzaffarnagar	4	DH, CL	TR, BM, LB	0/2/2
Khatauli	60	PTO pulley, SH	DH, CL	0/20/40
Shamli	20	Rim, Axle	ADV carts	6/10/4
Baraut	13	Rim, Axle	ADV carts, SH	4/6/3

agriculturally most progressive and intensive and tractor came into use very early. This town being centrally located in western U.P., was logical choice of entrepreneurs to set up FI industry. At present, about 15 manufacturers are engaged in the production of farm implements. All the 14 manufacturers, except one, were confined to making a range of tractor-drawn tillage implements like, disk harrow, cultivators, ridgers, levelling blades, etc. One manufacturers was making complete range of potato cultivation machinery, including graders.

Shamli and Baraut

These towns are located in north-east of Delhi in the fertile and sugarcane growing region of western Uttar Pradesh. The progressive and intensive state of agriculture necessitated the introduction of tractors in this area during the fifties. The need for hauling large volumes of sugarcane from the fields' mill and also required efficient carriages both of the animal-drawn and tractor-drawn types. Consequently, pneumatic-wheeled animal cart were developed in Shamli during early fifties. The carts became so popular that both of these towns have now more than 30 small industries manufacturing parts of carts and tractor trailers. At present, these two centres meet the country-wide requirement of rims, axles and hubs of ADV and tractor trailers. A few industries have grown to become original equipment suppliers of rims of tractors and earthmovers.

Muzaffarnagar

Like Shamli and Baraut, this town is also situated in the sugarcane belt of western U.P. Asia's largest 'gur' mandi (whole sale market of jaggery) is located here. It has sufficiently strong base of farm implement manufacturing industry. The main products are cultivator, disk harrow, ridger, plainer, trailer etc. Even though sugarcane is a major cash crop, sugarcane planters and harvesters are neither being used nor manufactured.

Khatauli

Khatauli is major centre of manufacturing PTO drive pulley for all makes of tractors. There are more than 50 small scale manufacturers making about one lakh units of this item. In addition, there are eight manufacturers of cultivator shovels. Manufacturing of other farm implements like disc harrow and cultivators is at limited scale and a recent activity.

Pattern of Mechanization

Cropping System

Sugarcane crop covers about 80 percent the total farm lands in this area (**Figure 1**). The balance is planted to wheat and fodder in Rabi season and paddy, sorghum and green gram in Kharif season. Few farmers also grow onion and some vegetable. About 80 percent of the-farmers are practising mixed farming with dairy as their second job. This adds to their income besides providing milk and milk products for their own use alongwith cow-dung as farmyard manure. Most of the farmers fall under marginal and small category. However, a few sugarcane growers had land 20 acres or more. Sugarcane in this region is a cash crop by supplying the canes directly to the mills.

Farm Power Use Pattern

Due to intensive and profitable agriculture, tractor ownership is high. In a few villages, every other farmer owned a tractor. Farmers with small land holdings are engaged in custom-hiring with their tractor. Custom-hiring rates varied. The prevailing custom-hiring rates are given in **Table 3**. For cultivator, harrowing, planking and for furrow making for sugarcane plantation, the rates are per unit area basis whereas for threshing the rare given is per quintal basis. In the case of threshing of wheat, charges are also entertained in the form of wheat grain and bhusa (chaff). Tractor ownership and use pattern is presented in **Table 3**. Farmers with land holding less than 1 acre had negligible tractor ownership. Similarly, almost all farmers having land more than 10 acre had their own tractor. The use of tractor per annum depended on custom-hiring practice. Farmers with less land holdings spared their tractor more for custom-hiring. Tractors were also used for non-agricultural works to the extent of about 15 percent. However, a typical case was noticed where an entrepreneur owned 20 tractors, all engaged in non-agricultural operations.

Table 3. Tractor Density and Use Pattern

Farm size (ha)	Percent	Use (hrs/annu)	Self (%)	Custom hiring (%)
750	100 %	2500	100	
20-50	75 %	3000	50	50
10-20	50 %	3000	20	80
5-10	10 %	3000	10	90
<5	negligible	-	-	-

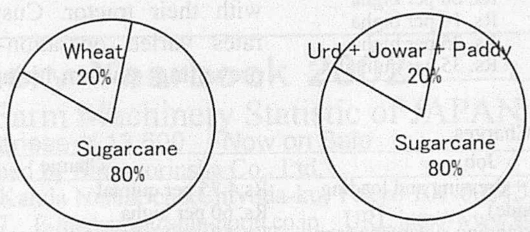

Fig. 1 Prevailing cropping pattern.

Table 4. Machinery Ownership Pattern

Machine/Implement	Ownership pattern
Cultivator (9 tyne)	With every tractor owner
Tiller (9 tyne)	With every tractor owner
Ridger (4 furrow)	With every tractor owner
Ridger (1 furrow)	With every tractor owner
Leveller	With every tractor owner
Disc harrow	One out of 10 tractor owner
Sprayer	One out of 30 farmers, rest of loan at the rate of Rs 5/ day
Thresher	One out of 10 tractor owners, rest on custom hiring
Seed drill	Negligible
ADV	Every farmer
Tractor trolley	Every tractor owner
Tube well (motorized)	Every farmer owns one's own tube well

tions mainly transportation of sand, bricks and agricultural commodities. Animal power is out of scene as such, but the buffaloes are used for off–the-road transportation by all farmers. Marginal farmers use the buffaloes for tillage and other agricultural works. Of late, a new trend had emerged wherein farmers were using bullocks for interculture operation in sugarcane field for their obvious advantages.

Cultural Practices and Mechanization Level

Cultivator, tiller, ridger, planker, leveller, trolley and PTO pulley were common with every tractor owner, whereas disk harrow, sprayer and thresher were owned by selected farmers only (**Table 4**). Every farmer owned an animal-drawn vehicle pulled by buffaloes. Male buffaloes were extensively used pairing with an ox for interculture operations.

Despite intensive cultivation of sugarcane, tractors were extensively used for tillage, interculture and transportation. However, for interculture and transportation animal power was also used. Sugarcane planting, plant protection and harvesting were all labour-intensive operations. Sugarcane planting was done manually by first making ridges with a tractor operated ridger. Harvesting was totally manual operation. In the case of wheat, sowing, plant protection and harvesting were done manually. Wheat is still sown by manual broadcasting. Farmers are not convinced with obvious advantages of sowing by seed drill, primarily because wheat is not a major crop in this region. Farmers want to devote their time, resources and attention to sugarcane crop only. As in other regions, threshing of wheat is 100 percent mechanized in this belt also. Threshing was done by tractor PTO operated and electric motor driven power threshers. Similarly, in paddy cultivation transplanting, interculture, plant protection, harvesting and threshing were mostly done manually. Mechanization scenario is not satisfactory even in this high tractor density region. The above stated facts also revalidated the observation which goes like "Tractorisation does not mean mechanization"

Custom Hiring

Farmers with small land holdoings are engaged in custom-hiring with their tractor. Custom hiring rates varied operation-wise. The prevailing custom-hiring rates of 1997-98 are given in **Table 5**.

For cultivator, harrowing, planking and for furrow making for sugarcane plantation, the rates are per unit area basis whereas for threshing the rate given is per quintal basis. In the case of threshing of wheat, charges are also entertained in form of wheat grain and bhusa (chaff).

Table 5. Custom Hiring Charges

Operation	Charges
Cultivator	Rs. 50 per bigha
Harrow	Rs. 60 per bigha
Planking	Rs. 10 per bigha
Furrow making	Rs. 25 per bigha
Threshing	Rs. 35 per quintal

Table 6. Labour Charges

Job	Charge
Sugarcane cutting + dressing and loading	Rs.4.75 per quintal
Interculture (by spade)	Rs. 60 per bigha
Tying bunches of standing sugarcane crop	Rs. 60 per bigha
Harvesting + threshing (wheat)	25 kg wheat + 25 kg straw

Labour Problem and Contractual Labour System

The availability of labourers for agricultural operations is not secure. The practice of getting local labourers on per head charge basis per day is uncommon. In this region, contractual labour system has become common for certain critical operations. Harvesting of sugarcane, wheat and paddy, interculture of different crops, tying bunches of standing sugarcane crop to prevent lodging were done on contract basis. The contract rates varied from operation to operation and crop to crop. For example, the rates in sugarcane harvesting which include cutting of crop, dressing it and finally loading the cleaned sugarcane in tractor trolley, was Rs. 47.50 per tonne. Likewise, interculture of sugarcane by spade was at the rate of Rs. 300 per acre. The charge of harvesting of one acre wheat crop was in the form of 125 kg of wheat and 125 kg of straw (**Table 6**). Farmers found contractual system more effective, economical and timely. In the days to come the contractual system would extend to many other agricultural operations. Timeliness in accomplishing different agricultural manual operations would be a prime reason.

Existing Gaps and Bottlenecks in Mechanization

In spite of a high population of tractors, mechanization is yet to pick up in real terms in this region. Farm operations like tillage, threshing and irrigation are fully mechanized. But farm machines are not used even for critical operations like sowing, transplanting and harvesting. Seed-drills are not in use for sowing as the farmers are not convinced with its advantages. Regarding planting and harvesting of sugarcane crop, farmers are generally not aware of availability of such machines. This state of affairs in the sugar bowl region shows very poor extension services existing in the system. Media programs like Krishi Darshan and others are not effective for one or other regions. A new trend noticed in this region is that the farmers, owning tractors, use a pair of bullocks to perform interculture operations in their fields, because interculture by tractor-tiller system caused harmful compaction of soil, which adversely affected the soil-plant-environment and damage to the plants. Compaction has been researched extensively by the tillage scientists, however their recommendations have not reached to the farm level in India. Sooner the better one must understand that the modus operandi of farm machinery popularization is different from the popularization of other agriculture inputs like seed fertilizer or other packages and practices. The extension may be more effective if trio: agriculture engineering institutions, farm implement manufacturers and farmers are engaged in this process.

Conclusions

On the basis of the study the following conclusions are drawn:

1. There is wide variation in the industrial infrastructure of the farm implement industry. The centers like Meerut, Baraut, and Shamli have a fairly strong agro-industrial complex in terms of production, personnel and machinery whereas centers like Muzaffarnagar and Khatauli are not strong enough.
2. Manufacturers have been facing certain technical and non-technical problems. Industry-institution linkages are almost absent or very weak and need to be built up to solve technical problems. There are institutions around these centers and the linkages would help both the industry and the institutions in their respective mandates of manufacturing and research with new ideas and insights into the entire spectrum of activities.
3. The quality of component manufacturing has to be raised. The small-scale sector is, probably not equipped to meet the quality targets.
4. A significant use of tractors for commercial purposes was observed. A seemingly unusual case of an entrepreneur, owning 20 tractors for commercial purposes was noticed in the study area.
5. In spite of high tractor density mechanization is yet to pick up in real terms in sugarcane growing area of western Uttar Pradesh. Farm machines are not being used for critical operation like sowing, transplanting and harvesting. Wheat is sown by broadcasting. Sugarcane planting and harvesting are not mechanized. Farmers are not aware of availability of machines like sugarcane planter. A strong extension service system capable of disseminating technical know-how, both hardware and software are needed.
6. Crop harvesting was found to be the most critical operation requiring the introduction of machinery urgently. The existing practice of contractual harvesting is expensive and represents a large portion of cost of crop production.

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Anonymous 1999 Annual report of AP Cess funded Project on Mechanization Studies in selected regions of Northern India ,Division of Agricultural Engineering, IARI, New Delhi, India. ■■

An Automatic Stirring Mechanism for Starch Settling Tanks of Sago Industries

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Abstract

Starch settling is one of the important processes in the manufacture of starch and sago. At present settling is done normally by 3 or 4 human labourers continuously trampling in the tank for 8 to 10 hours, thus making the process labour intensive, time consuming and most unhygienic. Therefore, a prototype mechanical stirrer was fabricated and field trials were conducted at Sago Industries. This mechanism has resulted in getting an efficient and faster settling of starch granules free from dust particles. The purity of starch was superior when compared to the manual method.

Introduction

Cassava (*manihot esculenta crantz*) also known as tapioca is one of the major tuber crops grown in more than 80 countries in the humid tropics. Much of the world production of cassava is used for human consumption in tropical countries. Another main use is for animal feed and starch industry. (Raja *et al*. 1979). Dry cassava consists of 80 to 90 per cent carbohydrate of which starch content ranges from 78.1 to 90.1 percent on dry basis.

At present starch sedimentation is done manually in settling tanks to remove the free dust particles from starch which is most unhygienic (Sreenarayanan *et al*. 1991). Also, a faster rate of sedimentation is highly desirable in order to prevent the formation of alcohol and organic acids, particularly butyric acid (Radley, 1976). Centrifuging of starch milk is an alternate method of starch settling to separate water from starch milk (Dersell, 1950).

In order to quicken the settling process and to increase the final quality of sago, the process has to be mechanized (Odigbo, 1980). Therefore, a stirring mechanism for starch settling in tanks was developed and evaluated in the sago industries of Tamil Nadu, India.

Materials and Methods

The mechanical stirring mechanism was designed for efficient starch settling and quality starch production. The primary components of the mechanical stirrer are: a rectangular frame, a wooden paddle stirrer, power transmission system, rails, control panel and prime mover.

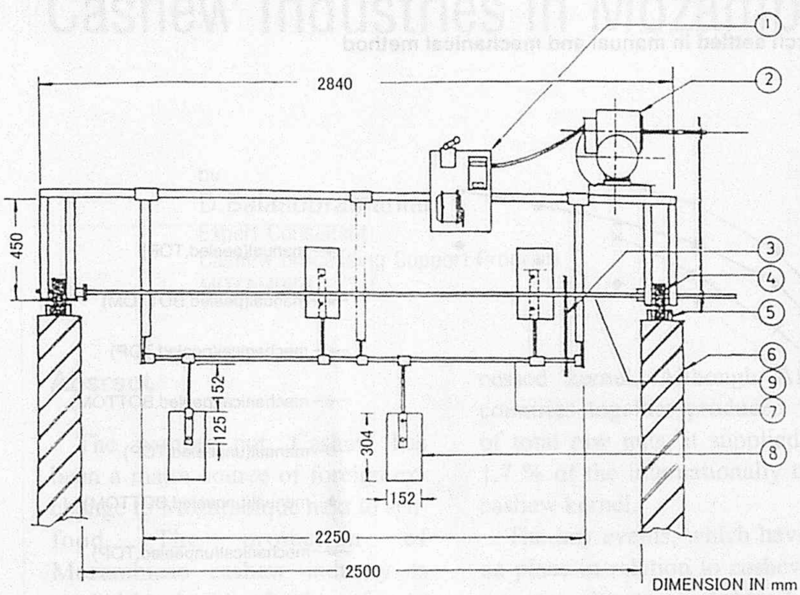
Wooden Paddle Stirrer

A mild steel flat of size 122.5 mm long was welded to the rod of a 6.35 mm diameter and 152.5 mm in length. The rod was welded with a collar. The wooden paddle of size 304 × 152 × 6.35 mm was fixed on mild steel flat by bolts. Four such wooden paddles were fixed on the galvanized iron hollow shaft of 31.75 mm diameter and 2250 mm in length at 180^{o} intervals and at equal distance leaving 160 mm for both sides of the wall. Eighteen teeth are fixed on the hollow shaft to get the power from the main shaft, by chain drive.

The hollow shaft with wooden paddles for stirring is fixed with rectangular frame assembly, by welding a suitable height of channel section with mild steel flats and collar bolted to the section. The vertical channel holds the shaft with wooden paddles and the depth of paddles can be adjusted depending on the bed thickness of starch settling tank.

Four limit switches are provided at the four ends of the channel. The drive for 1.25 hp motor is given through a control panel. By this mechanism, stirring is made automatic and only one person is required at the beginning and at the end of the operation. The sectional view of the mechanical stirrer is shown in **Fig. 1**.

The mechanical stirrer was tested for performance in a sago factory at



1. Panel board
2. Motor with reduction gear box
3. Chain drive
4. Wheel
5. Rails
6. Setting tank
7. G. I hollow shaft
8. Wooden paddels
9. Polished solid shaft

Fig. 1 Sectional view of automati stirring mechanism.

Salem District of Tamil Nadu. The size of the tank used was 8000 × 2500 mm. Trials were conducted with starch milk obtained from both peeled and unpeeled cassava roots.

During the operation of the stirrer, samples were collected at every hour interval from the top and bottom layers for analysis. The stirrer was operated until complete settling of the starch. After complete settling the used water was drained and the pure starch was taken for further experiments. The pH of the starch milk was determined by using a standard digital pH water. The percentage of starch settled was calculated using the formula:

$$\text{Percentage of starch settled} = \frac{\text{Volume of the starch} \times 100}{\text{Volume of the starch milk sample taken}}$$

Results and Discussion

pH Value of Starch Milk

The pH value of the starch milk obtained from peeled and unpeeled roots at different time intervals is presented in **Table 1** which shows that the starch milk was acidic in both top and bottom layers at the beginning of the settling process. The pH value increased gradually with the time of settling in both layers. At the end of 8 hours of settling by manual method, the starch milk had pH values of 5.3 at the top layers and 5.6 at the bottom layer for the peeled roots. In the mechanical method at the end of 6 hours of settling the pH value of starch milk at the top and bottom layers was 5.2 and 5.1, respectively. The change in the pH value could be due to the biochemical and enzymatic reactions taking place during the sedimentation process.

It was also observed that the drained water in the manual and mechanical methods had a pH value of 5.3 and 5.0, respectively, when the starch mild form peeled roots was used for starch settling.

The percentage of starch settled in the starch milk obtained from the peeled and unpeeled cassava roots at different time intervals is shown in **Table 2** showing that the percentage of starch in the top and bottom layers are almost equal at the beginning of the settling process in both methods. As the settling proceeded, the percentage of the settled starch increased significantly up to the fifth hour at the bottom layer due to the fast settlement of the large-sized starch particles.

The percentage of the settled starch at the bottom layer after 8 hours in the manual method was 70 and 63 percent for the peeled and unpeeled root, respectively. The per-

Table 1. pH Value of Starch Milk at Different Time Intervels (Unit: pH value)

Time (hours)	Manual (Peeled) Top	Manual (Peeled) Bottom	Mechanical (Peeled) Top	Mechanical (Peeled) Bottom	Manual (Unpeeled) Top	Manual (Unpeeled) Bottom	Mechanical (Unpeeled) Top	Mechanical (Unpeeled) Bottom
0	3.6	3.6	3.8	3.8	4.0	4.0	3.8	3.8
1	3.7	3.9	4.0	4.1	4.1	4.2	3.9	4.0
2	3.8	4.1	4.1	4.3	4.3	4.3	4.1	4.2
3	4.0	4.3	4.3	4.5	4.5	4.6	4.3	4.5
4	4.2	4.5	4.4	4.7	4.6	4.7	4.5	4.6
5	4.4	4.6	4.7	5.1	4.8	5.0-	4.7	4.9
6	4.8	4.9	5.2	5.3	5.2	5.3	4.9	5.1
7	5.0	5.2	-	-	5.4	5.5	-	-
8	5.3	5.6	-	-	5.6	5.8	-	-
Drain	5.3	-	5.0	-	5.6	-	4.8	-

Table 2. Percent Distributon of Settled Starch by Manual and Mechanical Methods for Peeled and Unpeeled Cassava Roots

Time (hours)	Manual (Peeled) Top	Manual (Peeled) Bottom	Mechanical (Peeled) Top	Mechanical (Peeled) Bottom	Manual (Unpeeled) Top	Manual (Unpeeled) Bottom	Mechanical (Unpeeled) Top	Mechanical (Unpeeled) Bottom
0	25	27	24	28	21	23	21	24
1	21	34	20	36	20	26	19	29
2	19	40	17	43	18	30	16	34
3	15	47	13	51	16	39	13	43
4	12	58	10	62	14	47	9	52
5	10	63	5	68	11	56	6	59
6	7	66	2	71	8	58	3	64
7	5	68	-	-	6	61	-	-
8	3	70	-	-	4	63	-	-
Drain	3	-	2	-	4	-	3	-

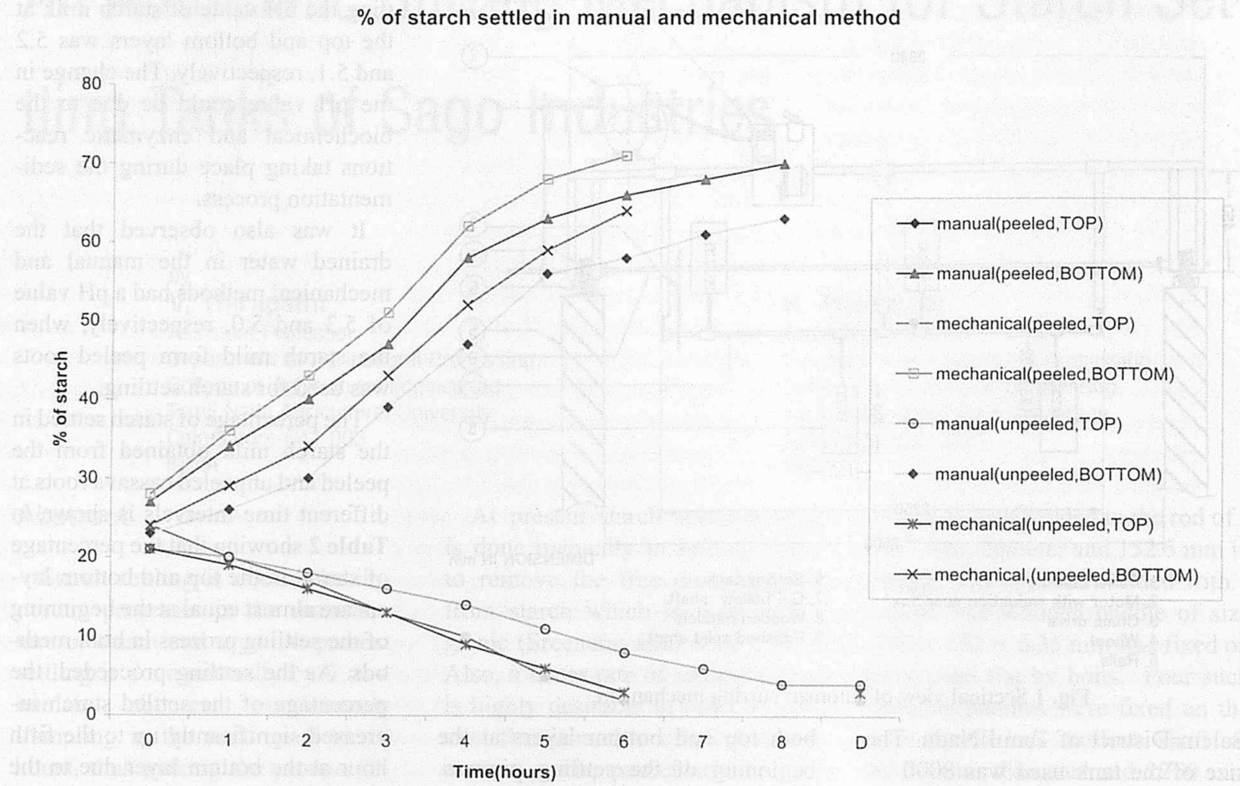


Fig. 2 Graph of table 2.

centage of the settled starch after 6 hours of mechanical stirring for the peeled and unpeeled roots were 71 and 64 percent, respectively.

The drained water in the mechanical method had a starch content of 2 percent against 3 percent in the manual method for the peeled roots. The time required for complete settling of starch is 8 hours in the manual method, whereas the mechanical stirrer took only 6 hours for complete settling.

Quality of the Settled Starch

In the manual method of settling, the starch cubes had a dusty layer sandwiched in the top portion of the cubes due to improper and discontinuous agitation of human labour. The mechanical method yielded starch without any dusty layer and had more whiteness than the manual method due to continuous and proper agitation of the mechanical stirrer. The study revealed that the developed mechanical stirrer took only 6 hours for complete settling of starch against 8 hours in the manual method. Apart from faster settling of starch, the mechanical stirrer could eliminate the human labour in the starch settling tanks of cassava and could yield a whiter starch without any dust particles.

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Cashew Industries in Mozambique - An Overview

by
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Absract

The wonder nut, Cashew has been a major source of foreign exchange to Mozambique next to seafood. The protection of Mozambican cashew industry is eroded by the introduction of market liberalization. In this paper the present status of cashew processing sector particularly, the industry, the systems and their efficiencies, competitiveness on a world scale and the likely future assuming the current policies in Mozambique are discussed.

Introduction

In Mozambique, cashew is consistently considered as the most lucrative crop. It is highly vulnerable to pests and least important as a domestic food source. Worldwide demand for cashew kernel at current price is about 181,440 mt was valued at more than $ 2 billion (1999). Consumption has been increasing at an average rate of 10 % per annum over the last five years. About 110,000 mt are traded internationally and the rest is consumed domestically. India, in particular, has a thriving domestic market consuming 46 % of domestically processed kernel. Although African countries together produced 15 % of total raw nuts, it supplied only 1.7 % of the internationally traded cashew kernel.

The key events, which have taken place in relation to cashew sector, are shown in **Table 1**. The permitted deregulation of the raw nut procurement trade allowed unconstrained entry of traders into the sector, culminating in reduction of barriers to export as exercised by a tariff.

Liberalization has also nudged the processing industry towards a less capital, more labour intensive shelling system, which is more appropriate to the economic conditions in Mozambique. The export tariff currently is 18 - 21% and paved the way for better economic performance of the country. Based on a survey report the status of Mozambique cashew processing industries is discussed.

Table 1. Key Events in Mozambican Cashew Sector

YEAR	EVENT
1975	Mozambique produced 1,60,000 MT of raw nut and exported about 21, 200 MT of kernels
1992	A longstanding ban on the export of raw nuts was lifted.
1995	Privatization of the cashew processing industry was initiated
1996	The export tax on raw nuts was set at 20 percent
1997	The export tax on raw nut was lowered to 14 percent. A large part of the processing sector began to collapse. The processors approached the "Inspection panel" of the world bank with a complaint demanding reimbursement of losses allegedly caused by lowering of the export tax.
1998	A large number of processors did not operate at all and shut down before the end of the season.
1999	The export tariff is increased from 14 percentages to 18-21 percentages, favouring the processing sector.

Cashew in Mozambique

In Mozambique, cashew has been a major source of foreign exchange but the production of raw nut has fallen from a peak of 216,000 mt in 1970 to 48,000 mt in 1999. **Table 2** shows the trend in cashew production in Mozambique since 1988. The declining production was due to aging of trees, diseases and the effects of war as well as apathy among the growers. Although Mozambique plants have the installed capacity up to 65,000 mt per annum, only 44 percent of the total production was made available for processing in the 1998 -99 season.

Table 3 shows the merits and demerits of cashew nut processing in Mozambique and India. The flourishing cashew industries in India are due to production subsidy policy, labour endowment, export promotion and premium prices in

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Table 2. Year-Wise Production of Raw Nuts in Mozambique (Unit:mt)

Province	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99
Cabo Delgado	1200	2971	494	1386	2330	573	984	702	2087	990	1554	1450
Nampula	23653	38529	1513	17411	33922		27132	16500	36650	28000	35601	35000
Zambezia	1860	2014	1839	1932	7272	2125	1442	1213	3988	1709	3865	4978
Total North	26713	43514	17467	20729	43524	21013	18315	18415	42725	30699	41020	41428
Manica/Sofala	140	13	30	26	100	300	267	400	4592	210	119	61
Inhambane	8000	2500	1968	3283	3206	915	38	5710	8912	2790	4569	3443
Gaza	9300	4161	2541	7065	7184	1707	124	8365	10231	2111	5966	3000
Maputo	300	38	0	19	0	0	0	0	50	0	42	0
Total South	17740	6712	4539	10393	10490	2922	429	14475	23785	5111	10696	6504
Grand Total	44453	50226	22006	31122	54014	23935	29987	32890	66510	35810	51716	47932

Table 3. Relative Merits and Demerits Have Cashew Industries in Mozambique and India

Merits	Demerits
MOZAMBIQUE	
• Climatic suitability • Abundant labour force • Investment incentives • Close to market and seaports • Long tradition in cashews and experienced management at all levels of industry • Favourable terms of agreement with South Africa and preferential terms with Europe	• War damage to settlements, infrastructure and trees • Poor state of trees due to age, neglect and disease leading to poor quality nuts • Unreliable and costly power supply • Poor worker training and education levels • Poor worker motivation, ease of subsistence, easy access to land and dependency syndrome • Dispersed crop relative to factories combined with expensive transport
INDIA	
• Stable workforce with long tradition and experience in cashew • Limited options for income generations due to landlessness of peasants • High literacy rate affords better communications • Government subsidy on tree propagation • Export incentives effectively subsidize imports • Strong domestic market for kernel • Preferential trade agreements with Russia	• Poor quality of working conditions leading to criticism by the market

domestic market. Besides, the lower grades are also absorbed at competitive prices, thus improving the total income to the processors by approximately 15 % without additional export costs. Indian export incentives allow for access to import licenses free of the normal 27 % duty of the value of the exports. This right can be sold at 15 % effectively giving tax relief on imports to the full value of the exports.

Raw Nut Procurement

The shelf life of raw cashew nut is up to two years the is allowed for processing i.e. recovery of commercial grade kernels and cashew nut shell liquid (Ohler, 1979). The cashew-harvesting period in northern Mozambique extends from late October to early February and in Southern Mozambique from late January to early May, providing a staggered schedule for the country as a whole.

The initial transaction takes place between the producer/gatherer and the first trader. One or several tiers of retailers and wholesalers with their own warehouses and trucks are engaged in consolidating the purchases of raw nuts into commercial lots. The whole sales deal with local industrial users and exporters. Apparently, a considerable amount of size and quality grading of raw nuts goes on at the medium and large traders, with the bigger sized nuts going for export at a better price, while local industry is getting the rest based on their financial capacity. Normally, export demand rises in September when Indian buyers look for raw nut from South of Equator after the end of harvest season at home. The ensuing price surge generally subsides in February when prospects for the Indian crop due to start in May are out. Beneficiaries of this fluctuation are South hemisphere exporters with an early harvest date.

The cashew nut price at factory gate is derived from the export parity price, i.e., Indian price, while the wholesale price is influenced by the producer price. The gap between the export parity and wholesale price is made up of the direct export costs and the margin to the trader. When

Table 4. Raw Nut Price Derivation

	S/T	Total		
Indian price	858	858	Upper limit	
Shipping loss	18	840		
Sea freight	70	770		
Broker's commission	15	755	Foreign exchange revenue	
L/C negotiation	4	751		
Export tax (14 %)	76	675		FOB
Port handling charges	10	665		540
Ware housing	3	662		530
Transport to Mozambique	30	632		527
Financial charge	19	613		497
Storage and handling	4	609	Export parity price	478
Exporter's margin	135			
Whole seller margin	32	474	Whole sale price	474
Finance charge	12	442		442
Transport to factory or export	9	430		430
Grading and moisture loss	10	421		421
Bags and packing	15	411		411
District trader margin	28	396		396
Finance charge	5	368		368
Weight loss (1.5 %)	5	363		363
District transport	9	358		358
Producer price		349		349

Note: All data with respect to 1998 season.

export opportunities are reduced, the price structure becomes more viable economically (**Table 4**).

The Processing Sector

As Mozambique's cashew production grew in the late 1960s and early 1970s to be the largest producer of raw cashew nuts, the facilities to process the raw nut evolved. There was a change from the simple, small-hand opening facilities for raw nuts to factories with large mechanized, high-capacity processing units. Mozambique was the first African country to initiate processing on an industrial scale.

The first industrial plant was installed in 1960 and grew to five plants following the manual shelling of the raw cashew nuts in 1962. Most of the industries the followed impact technology. There were 14 large capacity factories with a processing capacity of 1,47,000 mt raw nuts by the end of 1970. Since then, the production of raw nut quality has been, in serious decline and shortage of raw material led to the closure of many industries facilities.

Currently, there are five general cashew nut processing systems in operation. All have advantages and disadvantages under different situations. Variations in the basic systems are due to different manufacturers and fabricators around the world but **Table 5** describes at a glance the basics and their general description. All of these systems exist in Mozambique.

The village-hand system is the start off for small volumes of production with the lowest capital cost and lowest operating cost. The raw nuts are burnt in direct heat as a batch process and followed by shelling using a small wooden baton or lengthy steel pipe. All subsequent operations are done manually in the same way as other systems. Thus given some training, the local people can produce finished kernels with minimal technical input, power requirement and technical management.

The mechanical hand system is most common which was developed in India in the 1950s (Ohler 1979). Following either steaming or hot oil bath operation, shelling is done using a mechanical device in which nuts are fed by hand and cut individually. A pedal is used to clamp the nut between blades and the shell of which is cut and ply open as the handle is lifted. In some models the shell and the kernel fall through the hole and passes down through a spout to a basin. The kernels are then extracted and separated by a second worker from the opened shells. It has been recently improved with a low cost steaming system replacing the hot oil bath-roasting drum in preparing the raw nuts for shelling. This resulted in much less kernels being damaged or scorched and higher white wholes recovery than the mechanical systems. There are concerns regarding the health and safety of the workers and it is yet to be addressed.

The modular impact type was incorporated in the cashew processing system by a natural resource institute, Italy. It can achieve similar outturns to hand-shelling, particularly poor quality raw nuts with which other mechanized or hand-processing systems suffer limitations. The mass decorticator is a mechanized system that can successfully open small cashew nuts below 19 mm in width. However, its high capital cost necessitates large volumes of raw nut through put and good quality raw nuts to support economic viability.

Table 5. Basic Types of Processing Systems

Type of cashew processing systems	Processing capacity (mt)	Employment	KPR	Cost of machinery/unit (Rupees × 10^5)
Village hand	300	35 - 100	60 - 65	0.2
Mechanical/ hand	600 - 1000	250 - 500	60 - 70	0.8
Modular impact	600 - 1200	150 - 250	55 - 65	3.5
Mass impact	2500 - 5000	400 - 700	50 - 55	7.0*
Automated cutter	3500 - 10,000	450 - 750	50 - 60	7.5*

* Values per 1000 mt processing capacity
KPR - Kernel percentage recovery with fair quality raw nuts
mt - metric tonnes

Conclusions

1 It is anticipated that the cashew processing facilities will find it increasingly difficult to secure good quality raw nuts. It is unlikely to increase significantly over the next 5-year period due to the time lag from any new planti

ngs. Production will continue to be erratic in the short term. The tonnage available is not sufficient to supply all the potential interested parties. The smaller, low cost rural factories will be the most profitable in short term.

2 Many of the larger mechanical factories are poorly located to procure sufficient quantity raw nuts at reasonable prices. The full potential of the mechanized factories is unlikely to be realized without significant levels of investment and upgrading to more modern equipment combined with the provision of higher quality raw material

3 Increase in producers price are beneficial to the long term development of the industry since it is mainly through this channel that more planting, better tree management and correct harvesting methods will be induced. It also allows for exercising demands on grading for quality at farmers level. which helps to improve turn out percentages.

4 The failures of processing systems in Mozambique are mainly due to shortfalls in management, incorrect technical configuration and insufficient skill in procuring raw nuts.

5 All the factories have not met the international standards on health, safety, social and food hygiene. This will become an increasingly serious problem as cashew nuts are traded internationally and as outside inspection becomes a pre-requisite in many overseas retailers. There will be an increasing need for training and expertise to assist the industry to adopt better practices.

6 Kernel outturn is primarily an indicator of the raw nut quality and secondarily an indicator of the efficiency of the processing systems. Therefore, 1000 TPA capacity units are the most suitable and cost effective for this country. This helps in improving foreign exchange and drive out rural poor to the greater extent.

7 In addition to improved outturns and white whole composition, the industry has the opportunity to gain increased revenue from marketing higher ups in the cashew kernel marketing chain through retain packing and sales to the end users directly.

8 Adoption of protection mechanism would also preserve the opportunities for Mozambique's re-emergence as a world force in cashew and enhance the reputation of the country as an investment arena.

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Performance of Cashew Nut Processing in Mozambique

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Abstract

The cashew-processing sector in Mozambique has undergone many changes over the last few years as the economic development of the country has also changed. The new private plants are able to get higher revenue per unit of raw nut processed than privatized former state and old private plants. Kernel yield is primarily a function of raw material. But there is concern at procurement level irrespective of the type of the industries. The kernel price index varied between 0.726 and 0.851 showing less difference between the types of technologies adopted. Non-availability of skilled labourers is the bottleneck in the efficiency of operation. For profitable processing, norms are fixed for wages based on the output quality. The unstable condition of industry and alternative source of income prevent labor to continue with the industry.

Introduction

Ever since the early days of the Mozambican cashew industry, export of raw nuts have been under Government control in order to capture the added foreign exchange value by the processing industry. In the early 1990s, due to the collapse of the processing industry the export of raw nuts increased, although under licensing system combined with tariff. This situation persisted until the new liberalization policy was introduced in 1995. When the processing industry began to be privatized and raw nut exports were subjected to tax of 14 %. This stands at 18 - 21% for the current year. Based on the diagnostic study conducted, an attempt has been made to identify certain industry performance on the basis of plant characteristics such as adopted technology, size, processing efficiency, finished product marketing and management issues

Cashew Processing Industries

The processing sector of the Mozambican cashew industries ranges from simple artisan workshop to the highly sophisticated industrial complex. The variation in age and size reflect the contrasting conditions under which the sector developed (**Table 1**).

In the eighties, the industry contended with all types of disruptions and risks inherent in the civil war. At this juncture, the private entrepreneurs were able to choose cashew processing as a normal business venture and this resulted in new set of entrants. The Mozambican cashew processing plants can be broadly be grouped into three clusters as follows:

Privatized former state plants - These are state-owned cashew processing enterprise transferred to new private owners by the privatization process of 1995 (Ango caju Pro caju-Inhambane, Pro caju-Manzacaze, Mocaju and Poly caju),

Old private plants - These are state owned cashew processing en-

Table 1. Basic Information on Cashew Processing Industries in Mozambique

Name of the industry	Location	Year of start	Installed capacity (TPA)	Processing technology	Shelling method
Privatised former state plants					
Ango caju	Angoche	1971	10500	Oil bath	Mec- Impact
Pro caju- In	Inhambane	1966	3750	Oil bath	Mec- Impact
Procaju - Ga	Manjacaza	1965	3750	Oil bath	Mec- Impact
Mocaju	Machava	1965	12500	Oil bath	Mec- Impact
Polycaju	Maputo	1950	3750	Oil bath	Mec- Impact
Old private plants					
CCM	Monapo	1971	9000	Oil bath	Mec- Cutting
CCN	Angoche	1969	9375	Oil bath	Mec- Cutting
Inducaju	Lumbo	1973	2500	Steam	Mec- Cutting
Mocita	Xaixai	1965	8750	Oil bath	Mec- Cutting
New private plants					
Cabocaju	Pemba	1995	625	Steam	Semi-Mec
JFS	Geba	1995	3500	Steam	Semi-Mec
Adil	Maxixie	1995	3000	Oil bath	Mec- Impact
Socaju	Jangama	1995	1250	Oil bath	Semi-Mec
Invape	Manjacaza	1998	375	Steam	Semi-Mec
Madecaju	Maputo	1998	200	Steam	Semi-Mec

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terprise continued with private entrepreneurs. (Companhia de caju de monapo, Companhia de caju de nacala, Indu caju and Mocita) ; and

New private plants - These are constituted by start up enterprises (Cabo caju, Geba, Adil, Socaju, Invape and Madecaju).

All the former state plants professed to have problems with their raw materials supply. Many successful plants are dedicating a considerable amount of time and money in cultivating their procurement network. The companies of these cluster are unanimous in blaming the reduced raw nut export tax for high raw material costs and thus for their suspended operations. With respect to the technology, this cluster shows the least satisfactory results regarding yield and product quality. Rehabilitating the plants is not in the best state of repair but would entail a change of the entire technology. During operation, the finished product of these plants had been exported.

The second cluster employed the technology based on mechanical cutting. This technology demands more capital investment and maintenance but yield a better product quality. The technical installations of these plants are reasonably well maintained and in all of the plants the beginning of the next season depend on the export market for end product.

The third cluster units are located in cashew producing areas of the country with no geographical concentration. Indian technology[1] is employed in shelling operation. The basic concept of these plants is to maximize the returns from all inputs. A common pattern in this cluster is the prospective founder/owner has knowledge of technology, marketing, finance, organizing infrastructure and procuring raw nuts. Most of these plants sell their product in special niches in the domestic market. The most prominent problem for all of them is the adequate access to working capital.

The sales revenue are constrained by output quality in the case of privatized and old industrial plants, which is a function of the technology used and by operating cost. The new private plants established with more quality oriented technology and with a larger fraction variable costs do not have these constraints. They are able to get higher revenue per unit of raw material processed and they can operate more cost effectively.

Processing Efficiency

Cashew processing is essentially an operation of materials separation, designed to recover from the raw nuts the edible kernel and CNSL (Cashew Nut Shell Liquid) contained in the tissues of the middle shell layer. In its natural state, the shell is pliable and unsuitable for any type of manual or mechanical opening. Heating, however, will harden and make brittle, susceptible for cracking or splitting. Opening the nuts has traditionally been achieved by an impact on the brittle shell, which ideally will split into two halves, setting free the kernel. The impact approach was mechanized during the fifties through the use centrifugal impeller, running within and hurling the nuts against the inside wall of a metal cylinder. To control momentum and thus minimize kernel breakage, the impeller has to be adjusted to nut size, which led to the use of size grading of raw nuts prior to processing.

The alternative to open the brittle nut is to, clamp it between two converging blades along its seam and ply open by lifting one of the blades. Later a mechanical system for extracting kernels was developed.

An increasing concern with uniform product appearance, occasionally jeopardized by kernels scorched in oil bath as well as declining price of CNSL, conveniently recovered at roasting led to the introduction of raw nut heating by steam in Mozambique. This method is being used as a batch process in plants employing pedal cutter.

After separating the kernel from the shell, it still has to be separated from surrounding skin, the testa. Oven drying and subsequent cooling either at ambient or controlled conditions cause the testa to loosen from the cotyledon and become amenable to mechanical or hand removal. Manual size and quality sorting into more than 20 commercial grades is the last operation before packing the kernels into 50-pound cardboard containing two vacuum packed PVC bags each.

At each of these steps, quantity and quality losses can occur, the avoidance or control of which decisively influences revenue per unit raw material. Quantitative efficiency is captured in the yield of packaged kernels per unit of raw nuts. Qualitative efficiency is harder to measure as it has several criteria like size, shape, colour and wholesomeness.

The main distinctions in kernel grading are related to wholesomeness and its colour. Whole kernels are further segregated based on size and relates to the number of whole nuts per pound. Therefore, WW 320 has 320 whole white kernels to the pound. Thus, the lower the number, bigger the size and higher the price per unit weight. White kernels are valued more than scorched and discolored ones. Pieces are either butts or splits depending on whether they are broken across or along the cleavage and they are also graded according to colour and size.

The kernelsí yield is primarily a function of raw material, control over which is not so much exerted prior to processing, i.e., in raw nut procurement. It costs as much to process a ton of good nuts as a ton of poor ones. Therefore, a keen perception on quality of input is paramount.

Qualitative Efficiency

Quality indicators on raw nut procurement are moisture content, fractions of defective nuts, size and extraneous matter. A size distribution of nuts to be processed is a reasonable indicator of final yield. The efficiencies of individual processing steps and their contribution to overall efficiency are monitored by material balance in shelling, peeling and grading.

The qualitative efficiency is predominantly a function of processing and the plant management most decisively influences financial results. The potential quality loses are due to :

- Excessive moisture in raw nut storage
- Inappropriate size graded nuts
- Scorching during roasting
- Excessive recycling in mechanical shelling device
- Excessive time between shelling and drying
- Improper heat treatment in drying oven and
- Careless manual operations and handling

Kernel Price Index (KPI)

The arithmetic averages of grade prices for specific periods is standardized to the average price of W 320. Multiplying these standard prices by the output distribution of any plant and then taking the geometric average yield, a single value between 0 and 1 which allows comparisons of quality in certain periods irrespective of actual prices obtained (**Table 2**). The Kernel Price Index varied between 0.726 and 0.851 showing less difference with respect to type of technology. The quality of nuts and dexterity of labour in operation at various stages of processing are the key factors that decide the KPI.

Marketing

Consumer demand for cashew kernels in the USA and Europe drives various tiers of intermediate markets, the most significant of which in terms of the Mozambican processors is made up of clients of the international brokers and large individual final distributors. Local consumers, in this context include South Africa, which satisfies its demand in the less structured domestic market.

The factors influencing price in the export market is lot size. Cashew kernels are normally shipped in containers holding either 700 or 750 cardboard boxes of 50 pounds, i.e., 15.9 or 17.1 mt. As long as no more than 3 grades are included per container the standard price is paid. If the number of grade exceeds three, the buyer recovers the extra distribution cost at the other end by a price discount. It is estimated that between 2 and 5 percent of the total output of the industry goes to the local buyers for value addition

Type of Labour Force

It requires a minimum of three months to train workers in the cashew industry to take up common tasks. The workers take time to acquire skills needed to make their work efficient. Therefore, if sufficient raw material is available so that the throughput is constant, retaining a staff of trained personals and running factory throughout the year except for a month of collective vocation and maintenance lead to better results regardless of the type of technology used.

For capital-intensive highly mechanized factories, a high level of throughput is imperative for a financially viable operation in which a high percentage of skilled workers are necessary. Employing permanent rather than temporary workers appears to be the best approach.

Social Security Contributions

The social security systems unlike pension funds are transferable. Each worker has a unique identification number for the system and has access to health care, retirement benefits and funeral subsidies based on his/her and the employers contribution into the system. Employer's contribution is 4 % of workersí sal-

Table 2. Processing Performance of Cashew Industries in Mozambique

Name of the plant	Latest operational year	Quantity processed (TPA*)	Capacity utilization	Shelling %	Wholes % (at packing)	Kernel outturn %	KPI*
Ango caju	1996	2253	21.46	NA	40.53	18.76	0.770
Pro caju- In	1997	1157	30.85	NA	51.20	18.47	0.787
Procaju - Ga	1997	1168	31.15	NA	51.71	18.47	0.775
Mocaju	1998	3718	29.74	25.89	56.20	19.37	0.763
Polycaju	1998	1020	27.20	24.31	47.37	17.75	0.743
CCM	1998	5848	64.98	NA	56.27	20.74	0.847
CCN	1998	1783	19.02	24.01	44.47	20.62	0.768
Inducaju	1998	2315	94.00	NA	NA	NA	0.839
Mocita	1998	3087	35.28	24.32	51.81	16.62	0.726
Cabocaju	1999	7	1.12	27.12	NA	18.98	NA
JFS	1999	1484	42.40	25.32	66.41	19.91	0.851
Adil	NA	NA	NA	NA	NA	NA	NA
Socaju	1998	422	33.76	NA	NA	NA	0.745
Invape	1999	25	6.69	29.54	40.55	22.38	0.778
Madecaju	1999	NA	NA	NA	NA	NA	NA

KPI - Kenel Price Index. TPA -Tonnes Per Annum. NA - Not Available.

ary and the workers contribute 3 %. The workersí contribution is deducted from his salary and paid to the fund by the employer. Nevertheless, the concern for adequate health care is a valid consideration needs to be addressed.

Price Rates

Price rates are applied in different stages of processing. The norms and the rates set for various operations are usually related to the wholes or brokens produced. A kilo of raw cashews has more nuts in it than a kilo of large nuts. So appropriate adjustment has to be made in the piece rate depending on the size of the nuts. The link between the earnings and productivity is necessary for profitable operations. The link is often made by quality and payment with norms being calculated on the percentage of high quality kernels achieved. Proper levels for task norms need to be set and incentives favouring productivity and high quality has to be implemented. Workers can achieve norms similar to India once they have learned the task.

Labour Discipline and Absenteeism

At the present stage of the development of the industry, most of the labour force is composed of rural people whose principal occupation has been and often subsistence farming supplemented by their earning from their processing industry. Workers cannot be expected to behave like disciplined labour force of other countries such as Republic of South Africa and Zimbabwe, when their income from factory work is sporadic and uncertain.

Family survival requires foods security during the closure of many cashew factories. When the wages on due is not paid, workers have to depend on agriculture in their piece of land or earn in petty commerce. Mostly workers do not turn up during cashew harvest seasons. In coastal communities fishing represents financially attractive and alternative to factory employment. Therefore, workers have to be trained in a variety of tasks to switch over to the most urgent at any time. Once the industry stabilizes and begins providing workers with stable employment and a regular salary, workers will be able to concentrate on their role as cashew processing. Harmonious relation between managers and workers is also a key element in speeding up this process of change.

Non-salary Incentives

The major sources of losses in the plant output are due to pitfalls in the management. The policy of one or two warnings before dismissal deters theft or eating of kernels by the workers. Some of the facilities provided to have control are 1) providing tea and bread; 2) providing lunch and tea break; 3) Allowing the workers to go outside for lunch; 4) providing medical care: 5) providing crèches for children up to 5 years age. ■■

New Co-operating Editor

Jan Pawlak

Nationality: Poland
Birth Date: September 30, 1937
Qualifications:

In 1959 B.Sc. in Agronomy, after completing studies at the Faculty of Agriculture of Agricultural University (SGGW) in Warsaw; in 1963 M. Sc. in Agricultural Economics at the Faculty of Agricultural Economics of the same University; Ph. D. in farm mechanization: 1976, habilitation in 1982; title of full professor of agricultural sciences in 1991.

Experience:

From 1959 working at the Institute for Building, Mechanization and Electrification of Agriculture (IBMER) in Warsaw; from 1995 - also at the Warmia & Mazury University in Olsztyn.

1969-1970 - one year study program at the Department of Agricultural Engineering of Michigan State University (USA), 1972 scholarship in Italy (Universities of Milan, Padua, Bologna, Florence and Bari.

Member of several professional bodies, ea.: EurAgEng and CIGR, Club of Bologna, European Society of Agricultural Economists (EAAE), CIOSTA, Committee of Agricultural Economics at the Polish Academy of Sciences, as well as of editorial boards of scientific periodicals in Poland.

Professional qualifications: agricultural engineering, economics in agricultural mechanization, farm machines utilization.

1985 - 1991: Head of Division of Agricultural Engineering, IARI.

Current Position:

full professor, head of the Department of Economics and Utilization of Farm Machines at IBMER and professor at the University of Warmia and Mazury in Olsztyn, Faculty of Technological Sciences ■■

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.

009

Availability of Farm Tractors in Borno State, Nigeria. **Dr. M.A. Haque**, Associate Professor and Head of Department of Agricultural Engineering, University of Maiduguri, Maiduguri, NIGERIA. **Dr. B. Umar**, lecturer ,of the same Department. **Mr. B. Zamdai**, graduate of the same Department.

This paper presents the findings of a survey of farm tractors in Borno State of Nigeria. It was found that there were 610 tractors of 16 makes and 61 models in the state as at 30th September 1998. Of the total number, about 65% were functional and 52% privately owned. The tractor power available for the present level of cultivated area was only 12 W/ha, which was too low for the state. Considering the vast arable land area of more than five million hectares, the state needs to make serious efforts towards tractorisation of its agriculture.

011

Pasteurization of Apple Juice By Using Microwaves. **J.A. Canumir**, Faculty of Agricultural Engineering, Universidad de Concepcion, P.O.Box 537, Chillan, CHILE. **J.E. Celis**, same. **J. de Bruijn**, same. **L.V. Vidal**, same.

The main objective of this research was to evaluate the effect of the application of microwaves on apple juice cv. Royal Gala, to control the microbial population present in the juice. Juice pasteurization was done in a Samsung microwave, model CE945G, at several doses of energy exposition, using different power levels (270-900 W) and times (40-90 s). These results were compared with a control pasteurization of 83 Åé for 3 minutes. From these results it can be concluded that:

1. Pasteurization of apple juice cv. Royal Gala using microwave, with a power between 900-720 W and time between 50-90 s, was able to control microbial population, and to get juice that satisfies the standards the Chilean regulations for non-alcoholic and non-carbonated drinks;
2. Pasteurization of the apple juice with a power of 900 W and 720 W, decreases the final plate count of 4 and 2 orders of magnitude, respectively;
3. In the apple juice pasteurization, by microwaves, the microbial results show a similar control of microbial growth present in the juice compared with a conventional pasteurization;
4. It is possible to pasteurise apple juice at a low power of 450 W and 270 W, but applying increased intervals of time of exposition (over 90 s); and
5. There is no significant difference between conventional pasteurization (83 Åé, 3 min) and the microwave pasteurization (900-720 W, 60-90 s).

013

Performance Indices of Some Commonly Used Puddling Implements in Orissa, India **H. Raheman**, Assistant professor, Agricultural & Food Engg. Department, Indian Institute of Technology, Kharagpur, INDIA. E-mail: hifjur@agfe.iitkgp.ernet.in . **S. K. Sahoo**, Former Graduate Student, College of Agricultural Engineering & Technology, O.U.A.T., Bhubaneswar, INDIA.

The puddling implements commonly used in Orissa are power tiller-operated riding type puddlers, bullock-drawn riding type zigzag puddler and local plough. However, with the increasing trend towards power tiller farming and the need for reduction in the operator's fatigue, a power tiller-operated riding type puddler was developed. Its performance, together with the commonly used puddling implements, was evaluated and compared by a suitable parameter developed called the performance index. It was highest, i.e., 1469 for the powertiller-operated riding type puddler as compared to 1103 and 47 for bullock-drawn puddler and local plough respectively. There was not much difference in the performance between power tiller operated walking type and riding type puddler.

019

Failure Patterns of Clutch System of Tractors. **Pawan K Tuteja**, Asstt Manager (AE), Sabarmati Ashram Gaushala, Bidaj Farm,Post:Lali, Kheda-387120, INDIA. **A K Verma**, Executive (PEB), N D D B, Anand 388 001, INDIA. **B J Singh**, Dy. Manager (FO), ABC, Salon, Rai Baraeli, INDIA. **D S Rathore**, Asstt Manager (FO), Sabarmati Ashram Gaushala, Bidaj Farm,Post:Lali, Kheda-387120, INDIA.

The field data regarding the number of breakdowns in different time-between-failure of the clutch-system for five tractors (HMT-5911) was recorded at Sabarmati Ashram Gaushala,Bidaj farm (India), and analysed.

It was observed that the mean-to-down-time of the clutch-system was 18.52 hours and the active mean-time-to-repair was 3.43 hours. The MTBF was 761.96 hours. The nuts/bolts followed by travelling-clutch-plate, travel-release-lever and pto-clutch-plate of the clutch-system were most failure prone. The reliability and failure rate at MTBF was 0.46 and 0.581, respectively. The maximum chance of failure of clutch-system was in the range of 400-800 hours.

020

Farmers' perceptions about Vertical Conveyor Reapers in Haryana. **Er. Pawan Kr. Tuteja**, Department of Farm Power and Machinery, CCS Haryana Agricultural University Hisar-125004, INDIA. **Er.S.C.L.Premi**, same. **Er.V.P.Behl**, same.

Abstract

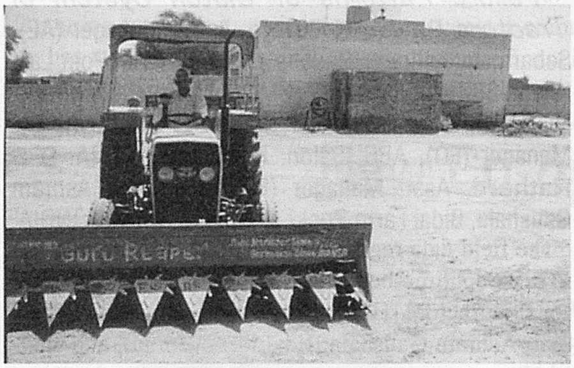
The studies were conducted by interviewing 51 respondents in each of the three categories, viz. machine-owners, custom-hirers and other farmers in more than 37 villages in Hisar and Sirsa districts of Haryana, India.

Summary And Conclusions

The studies were conducted in Hisar and Sirsa districts of Haryana in order to identify perceptions of farmers regarding the adoption of the machines, vertical Conveyor Reaper (VCR).

More than 75 percent of the 153 farmers had the perceptions that: a)fuel consumption was not too high; b)saves straw unlike the combine-harvester; c)increases tractor power utility; d)provides additional income through custom-hire-work and e)field capacity is reasonably good.

Between 50 and 75 percent of the farmers had the perception that a)the VCR requires less labour as compared to the manual operations; b)eliminates the peak demand of labour during harvesting season; c)collection and binding not too difficult after harvesting; d)breakdowns not too many, e)harvest losses not too high; and f)performance of the machine is satisfactory.



Ptate-A fornt view of tractor drawn vertical conveyor reaper

023

Extent of Adoption of Available Labour Saving Devices for Agricultural Production in Nigeria. **J.G. Akpoko,** Agric. Extension Specialist, National Agricultural Extension and Research Liaison Service, Ahmadu Bello University, PMB 1067, Zaria, NIGERIA. **Y.D. Yiljep,** Assoc. Prof., Agric.Engineering, same.

This study was conducted to investigate the extent of adoption of agricultural Labour Saving Devices (LSDs) and factors influencing their adoption in Nigeria. The study was carried out in Bauchi, Enugu, Kaduna, Niger, and Oyo States representing the five farming systems zones of Nigeria. A structured questionnaire was used to gather information from a total of 1500 farmers in the study area. Data were analyzed using frequency counts and percentages. The study shows that more than 50 percent of the 39 LSDs examined were adopted by farmers with the ox-drawn ridger, improved hand hoe, manual grinder and the wheelbarrows as the most widely adopted devices and equipment. Ease with which it was possible to acquire, hire, or maintain an LSD was the reasons for the majority of farmers adopting the devices and equipment. Scarcity, high cost, distant market and unawareness were the major factors hindering the adoption by the farmers in all the States studied.

025

FAILURE PATTERNS OF the HYDRAULIC SYSTEM OF TRACTORS. **Pawan K Tuteja,** Asstt Manager (AE), Sabarmati Ashram Gaushala, Bidaj Farm,Post:Lali, Kheda-387120, INDIA. **A K Verma,** Executive (PEB), N D D B, Anand 388 001, INDIA. **B J Singh,** Dy. Manager (FO), ABC, Salon, Rai Baraeli, INDIA. **D S Rathore,** Asstt Manager (FO), Sabarmati Ashram Gaushala, Bidaj Farm,Post:Lali, Kheda-387120, INDIA.

The field data regarding the number of breakdowns in different time-between-failure of hydraulic-system for five tractors (HMT-5911) was recorded at Sabarmati Ashram Gaushala,Bidaj farm (India), and analysed.

It was observed that the mean-to-down-time of the hydraulic-system was 38.52 hours. The active mean-time-to-repair for the hydraulic-system was 7.68 hours. Its MTBF was 2057.79 hrs. O-rings followed by nuts/bolts and hydraulic lift pump of the system were the most failure-prone. The reliability and failure rate at MTBF was 0.105 and 0.005, respectively. The maximum chances of failure of hydraulic-system was in the range of 1000-2000 hours. However, the frequency of failure was more in the range of 0 to 1000 hours. ■■

AAAE International Agricultural Engineering Conference (IAEC)

November 28-30, 2002
Shanghai, China

In December 1990, 1992 and 1994, International Agricultural Engineering Conference (IAEC) were held in Bangkok, Thailand. In 1996, this bi-annual conference was held in India. Subsequent conferences in 1998 and 2000 were again held in Bangkok, Thailand.

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Abstract and completed information form should be sent to:

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School of Food Science & Technology
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For further information contact: Brenda West, Director, ASAE Meetings & Conferences, 2950 Niles Road, St. Joseph, MI 49085-9659. Voice: (616) 428-6327 (Eastern Time Zone) FAX: (616) 429-3852 Internet: west@asae.org

☆ ★ ☆

NEWS

EIMA 2002

November 16-19, 2002
Bologna, Italiy
http://www.eima.it

There were a record number of applications to take part and the whole exhibition area was booked in less than a week after the invitations were sent out: this is the lead-up to the EIMA 2002, now in its thirty-third year, running from 16th to 19th November in Bologna. It is organised by UNACOMA Service srl in collaboration with Fiere Internazionali di Bologna-Ente Autonomo and even at this early stage it seems that the show will equal last year's results with a list of 1,728 participating businesses (403 of them foreign), 22,000 models of machines on display to a public of more than 114,000, with more than 8,000 visitors from 102 different countries.

It is being held at the provincial capital of Emilia-Romagna, at the Showground which is currently undergoing extensive work to extend and upgrade the structures and services provided for exhibitors and visitors. EIMA will, as always, be divided into 14 specialist sectors and accommodated in the 150 thousand square metres of the 20 permanent pavilions with the addition of 4 temporary pavilions to satisfy the demand for space by the manufacturing companies. These 4 temporary pavilions (30bis, 44, 48 and 49) will have a total surface area of 170,000 square metres and special trains will run from the towns of Cesena, Forli, Modena, Parma, Piacenza, Reggio Emilia and Rimini, stopping at the exhibition site.

EIMA Garden, in which 287 companies, Italian and foreign, participated in 2001, will again be exhibiting in sector XIII - gardening machines, public parks and gardens, small power tools and hand tools - everything that's new in outdoor care, providing an update for both amateurs and professionals on the special technologies available.

innovation and safety remain the main elements in this roundup of-mechanisation offered by EIMA, and the place to find out about these will once again be the Centro Servizi Bologna Fiere Court.

This is where the machines which won the UNACOMA Competition for technical innovation (established in 1986 and restricted to companies present at EIMA; to date it has made 242 awards), machines certified for performance and safety by ENAMA (National farm Mechanisation Body)together with innovative machines produced with assistance from the Ministry of Agricultural and Forestry Policies. The Court will also be the venue for the magic of the Modafralemacchine show, returning for its third consecutive year, with fashion models, dancers and acrobats putting across the message of the importance of safety at work and the use of personal protective equipment.

During the four days of the show (16/17 November open to the public and 18/19 November by invitation), there will be numerous opportunities for information and clarification on agricultural, technical and financial matters with press conferences and meetings organised by companies, associations, bodies and universities. Organisation of the thirteenth meeting of the Club of Bologna on Strategies for the development of agricultural mechanisation is in its final stages of organisation and the meeting will deal with the subject of "Mechanisation and traceability in agriculturalproduction: a challenge for the future". It will be split into two parts: the first will take place on 27th and 28th July in Chicago ~USA), on the occasion of the XV Cigr World congress, which will examine the institutional and regulatory aspects of the matter; the second will take place in Bologna on 16th and 17th November and will analyse the technical content and expectations of the market in relation to the proposed theme.

EIMA is one of the largest shows in the world with manufacturers from 40 countries and the presence of numerous foreign delegations (23 in 2001), and it is promoted by the Italian association for agricultural, gardening and earth moving machinery as an opportunity to promote this machinery sector and to compare supply and demand in the various production segments.

In relation to development of the Italian market for agricultural machinery, Prometeia studies forecast that in 2002 a new phase of growth will begin which will be consolidated in 2003.Registration data Csupplied by the Ministry of Transport and processed by UNACOMA) for the first quarter of this year in comparison with the same period last year show increases of 4.7% for tractors, 23.4% for combine harvesters, 12.7% for agricultural implements and 6.2% for trailers. There should also be positive effects in this sector from government measures for replacement of agro-mechanical stock, providing for the two-year period 2001/2002 financing of around 46.5 million Euros (19.3 of which were paid out last year and 12.8 in the first four months of 2002), a significant contribution to continuing modernisation and updating of machines and equipment for agriculture in operation in Italy. ■■

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BOOK REVIEW

Application of Distinct Element Method to Analyze Machine-soil Interaction

(Japan)

by Akira Oida

Introduction

Remarks on current project

It is clear that there are many reports on tractive performance and running resistance oloff-road vehicles ,cb as a farm tractor and construction machinery, on cutting performance of rotary blade, and on power requirement of. subsoiler. However, the interactions between these machines and ground surface or soil conditions are not completely darified, though the interactions are the decisive factor to the machine performance It is due to the complexity, non-uniformity and variety of soil propertles. In the field of civil engineering soil has been treated ,.mechanical material in order to solve the safe load problem at the collapse of retaining wall or building foundation. Such large-scale and low speed phenomena ,,,,ther different from those of soil-machine interaction, which is a high-speed dynamic phenomenon in a very thin layer of ground. A systematic research on this kind of topic has started in 1960's and is called "Terramechanics".

Final Report on Research Project (Number: 09660273) under Grant-in-Aid for Scientific Research (C) for 1997 to 2000 from Ministry of Education, Culture, Sports, Science and Technology.

Professor, Dr.Akira Oida

Lab. Agricultural Systems Engineering, Graduate School of Agriculture, Kyoto University

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Postharvest Technology : Cereals, Pulses, Fruits and Vegetables

(USA)

by Amalendu Chakraverty and Paul S.R.

This book originates from its predecessor--Post Harvest Technology (PHT) of Cereals and Pulses, a book published in 1981 which was considered to be the first of its kind. Since then consistent interest of the students as well as professionals of PHT and Food Technology in subsequent revised editions of the book PHT of Cereals, Pulses and Oilseeds is the real source of inspiration for publication of this enlarged volume. This comprehensive book dealing with engineering principles, problems, designs, testing and other practical aspects of various grain dryers, milling machines, furnaces and utilization of by-products /biomass for production of energy, chemicals and other value-added products including Postharvest Management of fruits and vegetables should receive attention of a wide range of international audience.

The major aim of this volume is to serve as an introductory text or reference book for the students, professionals and others engaged in Agricultural Science and Engineering and Food Science and Technology in the field of primary processing of cereals, pulses, fruits and vegetables. Prof. Chakraverty, the senior author wishes to record his sincere appreciation to the co-author Professor Paul S.R. for his contribution of the Chapter 17 titled "Postharvest Management of Fruits and Vegetables". He is indebted to his wife Mrs. Sushmita Chakravorty, and sons Soumendu and Krishnendu for their painstaking assistance in the preparation of the manuscript and conversion of units of some tables. Thanks are due to the desk editor, Science Publishers, Inc. and the members of PHTC, IIT, Kharagpur, India who were involved in the preparation of the manuscript.

A. Chakraverty Indian Institute of Technology, Kharagpur, India

Paul S.R. University of California, Davis, U.S.A.

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BOOK REVIEW

CRC DICTIONARY OF AGRICUTURAL SCIENCES

(USA)

by Robert A. Lewis

- Bridges the gap among diverse branches of the agricultural sciences
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- Discusses terminology for a broad range of areas in agriculture from production agriculture to biotechnology

Contemporary agriculture is a wide-ranging field with its own unique language. As an aid for improving scientific communication for everyone from students to public decision-makers, the CRC Dictionary of Agricultural Sciences provides a comprehensive guide to the terminology of agriculture. It includes every area of agriculture, from traditional farming to environmental sciences to the latest developments in biotechnology and genetics.

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More than just a compendium of terms, this dictionary presents clear, concise definitions in traditional dictionary entry format. From agroecology to wildlife biology, the ***CRC Dictionary of Agricultural Sciences*** establishes common ground between the various practitioners involved in agriculture, making interdisciplinary communications easier and more precise.

About The Author

Robert A. Lewis, Ph.D., is the author or editor of numerous scientific papers and books written in English and German. Contributions include basic research in physiology. endocrinology, and animal behavior; applied research on air pollution and toxic chemicals: and chemical, biological, find environmental monitoring and specimen banking as applied to human health and environmental effects.

In addition to a long record of basic and applied research, the author has made contributions to contemporary society through outstanding national and international achievements as an inventor and as an academic and government administrator in both the U.S. and Germany. He developed and coordinated several programs of research that were national or international in scope, and he has served as an administrator of governmental organizations and national programs in the U.S. Although an American, he has also served as an academic administrator, director of a research institute, and leader of national programs of research in the Federal Republic of Germany.

Dr. Lewis led a team that selected the National Environmental Research and Assessment Parks of the Federal Republic of Germany and later developed sampling designs and protocols for chemical and biological monitoring and specimen banking to be conducted on a continuing basis.

The author has made a number of technological innovations including invention and codesign of the Zonal Air Pollution System (ZAPS), a research tool that is able to continuously deliver and monitor the direct and other ecosystems throughout entire growing seasons. Since introduction, this pioneer system (in its original form or with design modifications) has been used in various programs in the U.S., Canaida, and Europe to assess the impacts of sulfur dioxide, ozone, arid carbon dioxide on various crops including, for example, grasses, broccoli, clover, cotton, tobacco, peas, soybeans, wheat, and even trees. It has also been employed in the National Crop Loss Assessment Program sponsored by the EPA.

Other technological innovations include the design, construction. and application of an air quality monitoring and micrometeorological network in Montana to help assess the effects of air pollution on the range resources of the state.

The author successfully standardized and applied remote sensing to the assessment of chronic pollution effects on ponderosa pine forests and grasslands in the north-central Great Plains.

Among many other contributions to agriculture, Dr. Lewis served as a rapporteur at the White House Conference on Technology for a Sustainable Future; The President's Task Force on Water Quality; the American-German Specimen Banking Program; and the Health, Safety and Environmental Task Force for the U.S. Strategic Petroleum Reserve.

Dr. Lewis holds degrees from Ohio State University, Rutgers University, and the University of Washington. His biography appears in various editions of *Who's Who in America, Who's Who in Science and Technology*, and various other biographic sources.

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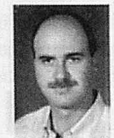
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d. deal with practical and adoptable innovations by, small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
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g. Tables must be typed clearly without vertical lines 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.

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