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EDITORIAL

The impact of the global financial crisis has been enormous and the global economy has not yet rebounded. The depression is obvious, especially in the developed nations. However, countries like India and China have sustained high rates of growth in this severe global slump.

China is home to a population of 1.3 billion people, and this huge number causes a significant economic gap between urban and rural areas. To narrow this, the Chinese government is investing large amounts of money for farms in the rural areas. This year, to stimulate agricultural mechanization, the Chinese government invested more than 3 billion dollars of subsidy with funds from the central government, provincial governments and local governments. Considering the fact that the price per horsepower of tractors in China is only the seventh from that of developed countries, this amount of subsidy is nothing short of extraordinary. Because of this benefit from the government, the Chinese agricultural machinery market is growing and is in excellent condition.

This year in Thailand, over 50,000 new tractors were sold with 40,000 having been made by Kubota, a Japanese company. Two million small cultivators of Thailand are gradually being switched to passenger tractors. This means that, if 5 % of the two wheel tractors in Thailand were replaced by four wheel tractors each year, there would be 100,000 sales in Thailand each year. This would be quite a large number of sales. Thailand is one of the countries where the demand for tractors is increasing rapidly. Moreover, with India becoming the world's most populous country, it is in a smooth progression of agricultural mechanization. They have already produced more than 300,000 tractors. As a result, investment for the mechanization of agricultural in India has been active the this few years.

These countries will gradually be key countries and it is clear that they are on their way to becoming developed countries. The influence of their economic growth is tremendous. Also, the demand for agricultural machinery in heavily- populated countries like China and India is expanding rapidly. This business opportunity may make them the world's leading agricultural machinery countries.

However, agricultural mechanization in other countries, such as some of the African countries, is full of difficulties and, at this time, they have no clue with respect to how to solve the problem. As the developing countries in Asia become affluent, the problems in African countries should come under closer scrutiny.

Africa, as well as Asia is a promising and resource-rich region but efforts are needed, especially for the redesign of machines in a community-based way, to fit into African land and culture. The most important thing in agriculture from now on is to expand the production in a limited farming area. This means to increase the productivity per unit of land and agricultural mechanization is the most important and best way to increase this productivity. To make this a reality, more time must be spent on the fine details than before. Additionally, regions with more sunlight such as Southeast Asia need the technology of multiple cropping. Unfortunately, the mechanization system for multiple cropping has not yet been well defined. The mechanization systems originating in developed countries are all for monocropping, and are not suitable for multiple cropping. Henceforth, to increase the productivity more completely, we need to study more about the technologies needed for multiple cropping. From a simple tool to a complicated machine, agricultural machinery itself is in the age of information. Computer and communication technologies have realized many other new techniques. The internet is one of them, and the age when everyone can easily use this intellectual power will come. Regarding agricultural mechanization, the same power may be the key to develop new technologies.

The world population is still growing rapidly, but the farming land is limited. Various new farming technologies would be the solution to the problem. Agricultural Mechanization would play the main role, and I hope that many funds would be injected to solve the worldwide problem.

Yoshisuke Kishida
Chief Editor

December, 2009

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Soil Response to Tillage Treatments

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Abstract

Soil structure is an important measure of soil quantity that is significantly affected by tillage systems. The investigation was carried out on the suggested system of tillage to get the best soil structure for achieving a high production. To fulfill this aim, five tillage systems were investigated. The combination between the primary tillage, (moldboard plow, 20 cm in depth; chisel plow, 20 cm; disk plow, 10 cm; disk harrow, 10 cm and control without tillage), and two secondary tillages (disk harrow followed with rotary and control) as tillage systems are identified. Clod size distribution, main weight diameter, soil roughness, tillage degree, soil resistance, soil shearing, bulk density, and mechanical measurements such as rolling resistance, slippage, draft and fuel consumption were measured as the independent variable. The results indicated that, the soil surface after using a moldboard plow or disk plow were more responsive to pulverization. The lowest mean weight diameter (34.81 mm) was recorded for "disk harrow" followed with rotary. Increasing the mean weight diameter (MWD) increased the soil roughness. Moreover, decreasing the "MWD" values because of increasing soil pulverization consequently increases the number of impacts and then decreased the penetration values. Bulk density, rolling resistance, slippage, and draft were affected by tillage systems.

Introduction

Tillage operations for seedbed preparation are often classified as primary or secondary tillage operations although the distinction is not always straightforward. It is carried out for many objectives; the most important one is to improve the soil physical properties that are beneficial to the growth of plants. Primary tillage consumes about 50 % of the power used for all production and harvesting operation. Different types of tillage tools are used for preparing the soil such as chisel, moldboard, disk, and rotary plows. In Egypt the chisel plow is locally manufactured and is widely used for preparing the soil for different crops (Korayem *et al.*, 1985). About 5-6 billion tons of soil, covering about 6 million feddans in Egypt are tilled 4-8 times each crop rotation per year. This would in fact turn about 24-48 billion tons of soil and consume 5×10^{12} litters of diesel oil (El-Sheikha, 1989). The land preparation for rice in Egypt is carried out by tillage with a chisel plow twice and wet leveling, which gave low rate of yield/fed compared with other methods used by El-Serafy (1986).

Abo-Habaga (1992) reported that the suitable seedbed for using the drill machine must contain different aggregate size having diameters, not greater than 50 mm. The percentage of greater aggregates (Φ 20-50 mm) and likewise the small aggregates (Φ < 2 m) must be kept to a minimum value of total aggregates. The effect of tillage on surface roughness was studied by Romkens and Wang *et al.*, (1986).

The amount of energy required to produce a given degree of pulverization depends primarily upon the soil strength and the energy utilization efficiency of the implement. Soil strength is related to the nature of the soil and to its physical condition (El-Banna *et al.*, 1987). Clay soils need higher breakup-energy requirements than sandy soils. Loams, climate, cropping practices, cultural practices, and other factors influence the soil physical condition. Depth of cut, width of cut, tool shape, tool arrangement, and travel speed are factors that may affect draft and the energy utilization efficiency for a specific soil condition. Kenneth (1977) reported that the energy requirement is a function of the draft of the implement. The draft of the plow is commonly expressed as units of weight per units of area of furrow cross-section. The draft is extremely variable from one place to another and on a same place from year to year.

The objectives of this study were to evaluate the performance of five methods of primary and two of secondary tillage systems. The evaluation includes tillage quality, some of soil physical properties and mechanical performance for primary tillage implements. Draft force and fuel consumption were conducted as mechanical performance.

Materials and Methods

The experiment was carried out in Sakha research farm (Kafr El-Sheikh Governorate) in the summer season (May, 1990). Clover was the previous crop. The land preparation for clover was done by chisel twice in the two directions and then disked and dry leveled. The strip-split plot design was used to evaluate the factors affecting the different parameters as soil physical properties. The five primary and two secondary tillage operations were first arranged according to a strip plot design. Then each of the 10 plots at three replicates was divided into subplots. The primary tillage operations was the main factor done in one direction for one trip and included five operations in every replicate as main factors. The moldboard plow (20 cm in depth) "M", chisel plow (20 cm) "C", disk plow (20 cm) "dp", disk harrow (10 cm) "dh" and without primary tillage "Non" were considered as primary tillage operation. The secondary tillage operations were done in the perpendicular directions as subplot treatments. The offset disk harrow two trips (10 cm depth) followed with rotary (10 cm depth) "d2-r" were considered as secondary tillage operation.

The penetration (compaction) and shear of soil, and bulk density were measured during harvesting time, after sowing with 6 days for depth (0-10 cm). The measurement after primary tillage was infiltration rate and tillage degree, while the clod size; mean weight diameter and soil roughness was measured after secondary tillage. All experiments were conducted to study the effect of different combinations of secondary and primary tillage factors on the soil mechanical and physical properties.

The clods sizes were measured by traditional methods. The sieves have holes with different diameter (100-75-50-25-19-12.5 mm). The sample were taken from three different locations secondary tillage within 3 days in each tillage system, the mean weight diameter (MWD) of the soil clods was calculated using the following equation:

$$MWD = \frac{W_1 S_1 + W_2 S_2 + ... + W_n S_n}{W_1 + W_2 + ... + W_n} \quad (1)$$

Where:

W_1, W_2, ... W_n = Weight of soil above each sieve.

S_1, S_2, ... S_n = Medium of size range for each sieve.

n = Number of observations.

A reliefmeter apparatus was used to measure the soil surface profile along a line perpendicular to the plowing travel after secondary tillage operations. The reliefmeter was 150 cm in length. Soil profile was measured according to Gaheen *et al.*, (1978). The soil surface roughness (SR %) was measured by the following equation:

$SR = 100 \log \delta$

The standard deviations (δ, cm) were estimated according the following equation:

$$\delta^2 = \frac{\sum (x - \bar{x})^2}{n}$$

Where:

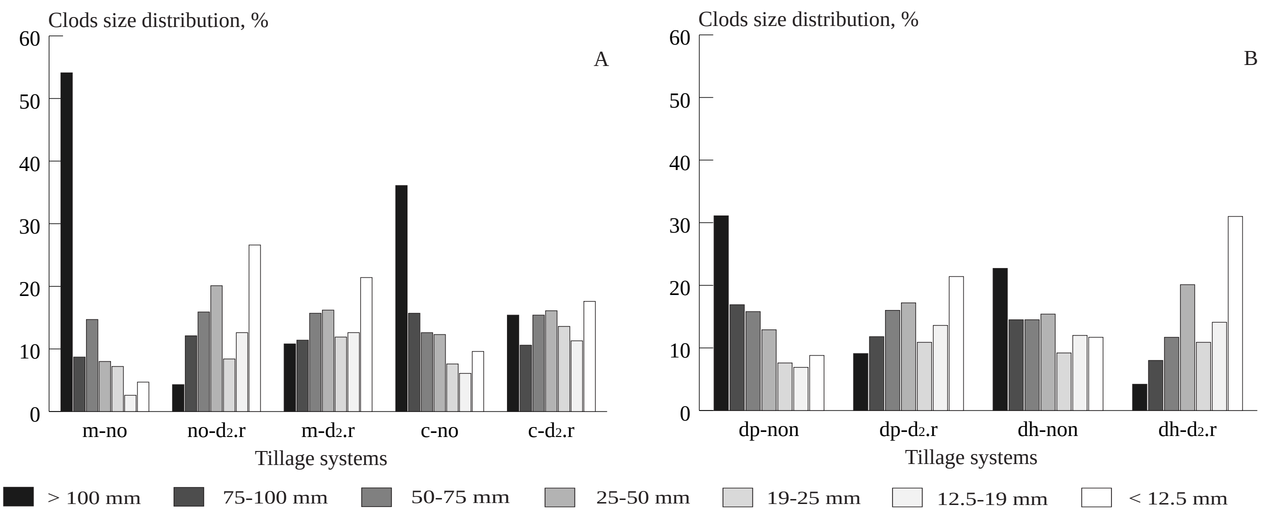
$\bar{x}$ = The average treatment of observation number, cm

x = The value of observation, cm

The compaction was carried out by using an impact type penetrometer (Singh, 1967), before primary tillage and after seeding with 6 days.

A torque wrench and a wing borer according to (Singh, 1967) measured the shearing resistance of the soil. The shear strength of the soil could be determined by using the

Fig. 1 Clods size distribution as affected by different tillage systems (m)



following equation:

$T = \pi\ T_f\ [(d^2\ H / 2) + (d^3 / 6)]$

Where:

T = The torque at failure, kg. cm,

T_f = The unit shear strength of the soil, kg/cm^2,

H = The height of van, cm,

d = Diameter of van, cm.

The bulk density was determined by using the traditional methods, while the percentage of slippage could be determined as follows:

$$S = \frac{(V_1 - V_2)}{V_1} \times 100$$

Where:

S = Slippage percentage, %,

V_1 = Forward speed without load, m/sec,

V_2 = Forward speed with load, m/sec.

The draft force was measured by using two tractors and a calibrated hydraulic force dynamometer (5,000 kg) by (Ismail, 1980). The specific draft was calculated by the following equations:

$$sin\theta = \frac{Y_1 - Y_2}{L}$$

Where:

θ = Angle of inclination of line of pull,

Y_1 = Height of the front tractors drawbar above the soil surface,

Y_2 = Height of the hitching point of the rear tractor above the soil surface,

L = The length of chain and dynamometer.

Then; the draft could be calculated as follows:

$D = P \times cos\theta$

Where:

D = Draft force,

P = Pulling force along the chain, the dynamometer reading.

The fuel consumption per unit time or unit area can be worked out as follows:

$$F.\ C_t = \frac{F}{t} \text{ and } F.\ C_a = \frac{F}{a}$$

Where:

F. C_t = the fuel consumption rate per unit time,

F. C_a = the fuel consumption rate per unit area,

F = the quantity of fuel consumed throughout the work,

t = Time of work,

a = The plowing area.

The data for this paper were provided from the "M. Sc." of "Mechanization of seedbed preparation and planting of rice crop". Whose supervisor is Prof. Dr. Ismail (1994).

Results and Discussion

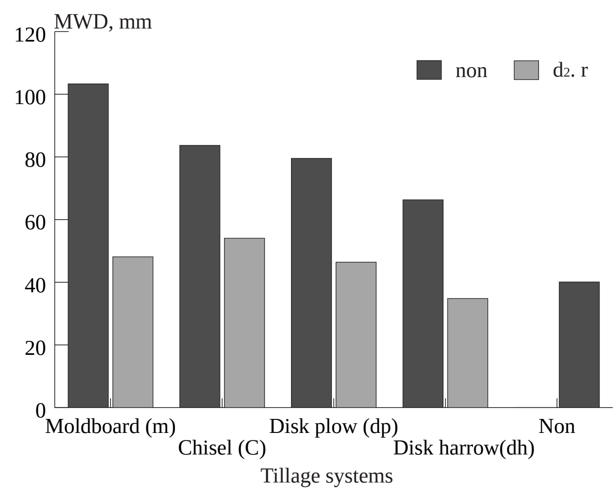
The quality of tillage may be judged by measuring the soil mechanical properties such as clod size distribution (CS %), mean weight diameter (MWD), soil roughness (SR %) and tillage degree.

Clod Size Distribution

The relation between the tillage systems and the distribution of clod sizes were illustrated in **Fig. 1**. Using the moldboard plow (m) as the primary tillage operation, the data indicated that the maximum percentage "54.1 %" of clod size of more than 100 mm was recorded for "m-no" tillage system. But, using disk twice, followed with rotary "dh-d_2r" recorded the best situation for soil pulverization (the distribution tended to normal distribution) because it gave the minimum clod size > 100 mm (9.1 %). It was easy to note that the decrease of percentage of clod size categories > 100 and (75-100 mm) increase of clod size categories < 12.5 and (12.5-19 mm). Generally, the differences between clod size percentages for tillage treatments (m, C and dp) were clearly decreased after using "d_2r" as secondary tillage systems.

It may be concluded that the land, after using moldboard plow or disk plow, was more response to pulverization by different systems of secondary tillage compared with chisel plow (C) (**Fig. 1-A**). The secondary tillage treatments "d_2r" recorded 4.3 % for clod size > 100 mm at using the (dh) as a primary tillage (**Fig.1-B**).

Fig. 2 Mean weight diameter for different tillage systems



Mean Weight Diameters (MWD)

Data in **Fig. 2** showed that the lowest mean weight diameter (34.81 mm) was recorded for "dh-d_2r", while the tillage system "m-non" recorded the maximum of mean weight diameter (103.31 mm) but the "c-d_2r"; "dp-d_2r" and "non-d_2r" tillage systems recorded 54.04, 46.41, and 40.09 mm of mean weight diameter (MWD), respectively.

Generally, using the secondary tillage operations led to a decrease of the "MWD". For example the "MWD" decreased from 103.31 mm to 48.12 mm as a result of using disk harrow two trips followed with rotary "r" instead of "non" with constant primary tillage (moldboard plow). The analysis of variance for data of "MWD" for primary and secondary tillage factors were highly significant. But, the secondary tillage factors were more effective on the "MWD".

Soil Roughness

The effects of tillage systems on the soil surface profile is illustrated in **Fig. 3**. The "m-non" tillage system left the soil surface very rough (SR = 89.8 %) while, soil roughness (SR %) redacted to 80.29 % after "c-non" tillage system. This may be due to fact that the clod size on the soil surface at "m-non" tillage system produced the greatest number of aggregates larger than 100 mm. The effects of using the "d_2r" as secondary tillage on (SR %) are greater at "c" than at "dp".

The relationship between soil

Fig 3 The effect of different tillage systems on the soil surface profile at: A: Non-primary tillage, B: Moldboard plow, C: Chisel plow, D: Disk plow, E: Disk harrow

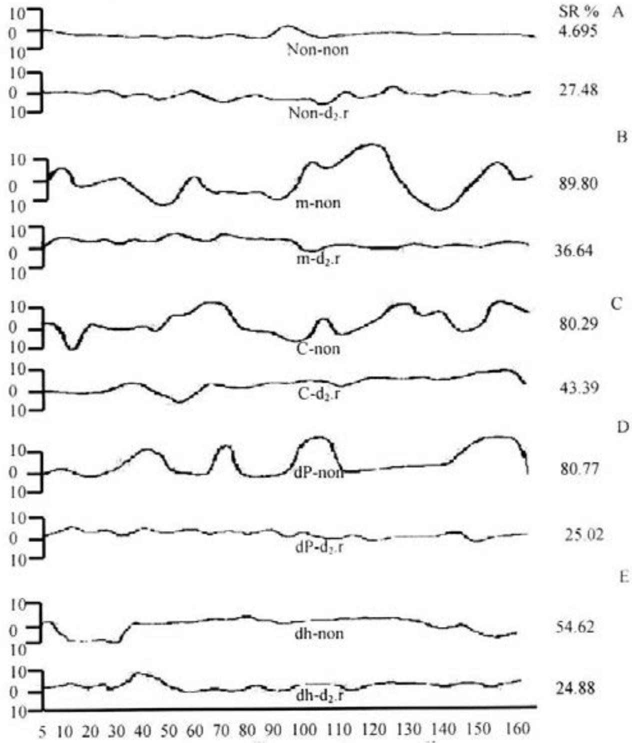


Fig 6 The soil penetration as affected by tillage systems at: A: Non-primary tillage, B: Moldboard plow, C: Chisel plow, D: Disk plow, E: Disk harrow

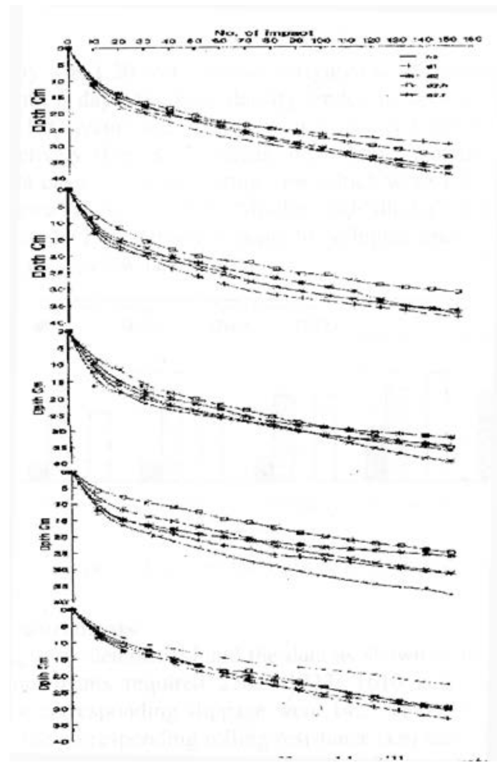


Fig. 4 The effect of mean weight diameter on soil roughness

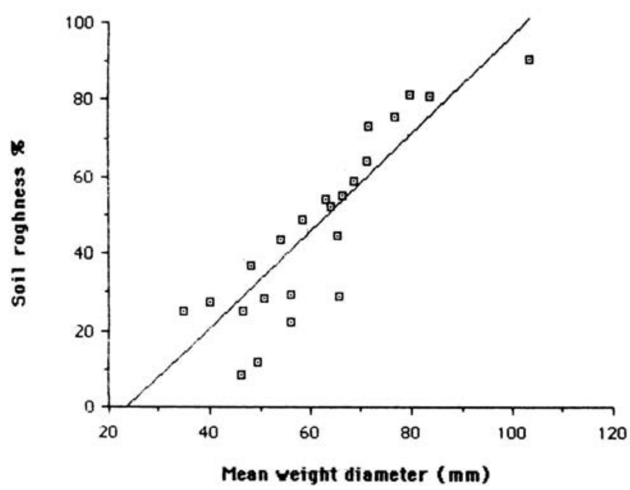
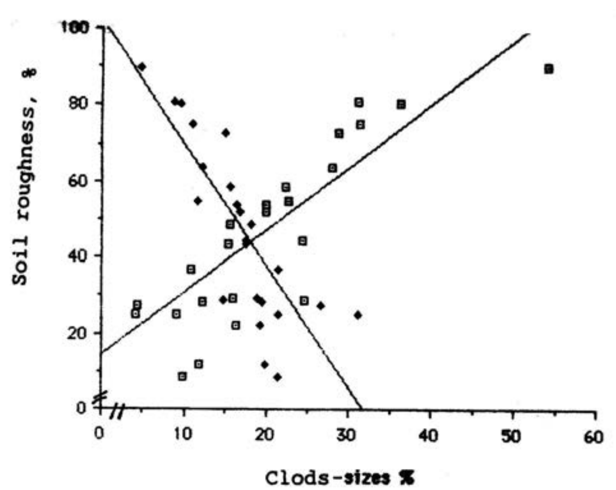


Fig. 5 The effect of mean clods sizes on soil roughness



SR = −29.3878 + 1.2518 MWD, R2 = 0.81, SR = 14.4705 + 1.6386CS, R^2 = 0.78, □ > 100 mm
SR = 101.834 − 3.2178CS, R^2 = 0.78, ♦ < 12.5 mm

surface roughness and mean weight diameter is illustrated in **Fig. 4**. Generally, increasing the mean weight diameter increases the soil roughness. For example increasing the mean weight diameter from 60 to 80 mm increases the soil roughness "SR %" by 1.54 times.

The best fitted curve for the relationship between clod sizes and soil roughness is illustrated in **Fig. 5**. The large size of clod > 100 mm had a bad effect on soil roughness, but the small size < 12.5 mm had the opposite effect on the soil roughness.

Soil Resistance

The term of soil resistance is important for describing their susceptibility to apply pressure from farm machinery and tillage system. It could be divided into soil penetration (compaction) and soil shearing.

The Soil Penetration

The soil resistance is illustrated in **Fig. 6** for all treatments 6 days later from sowing. Generally, the experimental results of all tillage systems showed an increase in the penetration resistance with the increase in soil depth. The soil penetration recorded (14 impacts) the highest values with the "d_2h" of secondary tillage systems. While the lowest values of resistance of penetration recorded 6 impacts at constant, chisel-plow with "non" as secondary tillage system. Moreover, decreasing the "MWD" values because of increasing soil pulverization (non-d_1-d_2-d_2h-d_2r) increases the number of impacts and then decreases the penetration values. These results were in agreement with Chaplin *et al.,* (1986); Abo-Habaga (1992) and Saffan (1975).

Torque Required For Soil Shearing

The values of torque (Nm) required shearing soil at depths (0-10 cm) and at 6 days later from sowing. Moreover, during harvesting time for all the treatments under this study, the soil shearing was recorded as 38.1 Nm, 38.8 Nm, 39.8 Nm, 41.6 Nm and 40.5 Nm for tillage systems "m-d_2r", "c-d_2r", "dp-d_2r", "dh-d_2r" and "Non-d_2r", respectively, 6 days after sowing as indicated in **Fig. 7**. But, the highest values of torque required to shear soil were recorded for non-non (42.4 Nm) during harvesting time and the values of torque increased with increasing the secondary tillage action.

Bulk Density

The bulk density was 1.30 g/cm^3 before carrying out the primary tillage operations but after sowing with 6 days, the bulk density tended to decrease more to reach 1.05 g/cm^3; 1.06 g/cm^3; 1.07 g/cm^3 and 1.15 g/cm^3 with the systems "m-non, c-non, dp-non and dh-non", respectively (**Fig. 8**). Whereas, it was shown that the differences in bulk density values were not clear in the harvesting time which were 1.33; 1.32; 1.34 and 1.34 g/cm^3 with the systems "m-d_2r"; "c-d_2r"; "dp-d_2r" and "dh-d_2r", respectively, as shown in **Fig. 8**. It was clear that the bulk density was going to be higher and it may be related to the system used in irrigation as low land rice.

Mechanical Measurements

The draft (kg_f) was determined and the data as shown in **Table 1** that "m"; "c"; "dp" and "dh" implements required 2,361; 1,723; 1,610 and 1,883 kg to be pulled, respectively, and the corresponding slippages were 14.2 %; 10.3 %; 8.7 % and 11.5 %. On the other hand, the corresponding rolling resistance (kg) was 253; 241; 225 and 298 kg, respectively. The chisel plow recorded the lowest specific draft 0.448 kg/cm^2, whereas the moldboard recorded 0.894 kg/cm^2 as the maximum. On the other hand, "dp" and "dh" recorded 0.719 and 0.553 kg/cm^2, respectively.

Fig. 7 The relationship between the tillage systems and the values of torque to shear soil at 6 days later from sowing and at harvesting time

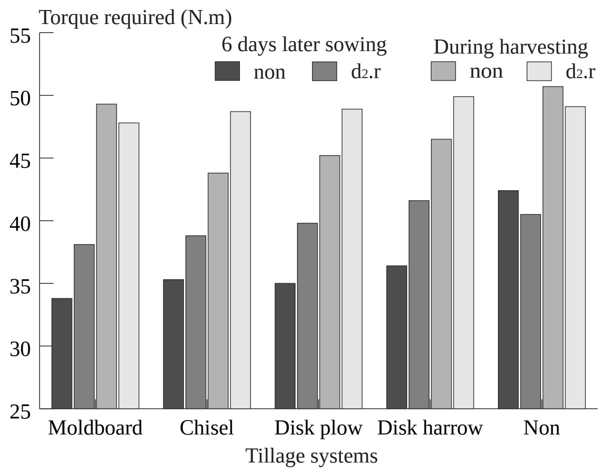


Fig. 8 The effect of tillage systems on the bulk density at 6 days from sowing and at harvesting time.

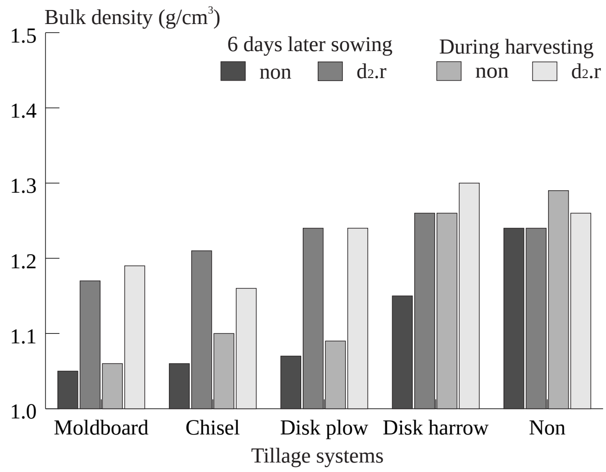


Table 1 Mechanical measurements

Primary tillage implements \ Measurements	Rolling resistance, kg	Slippage, %	Draft, kgf	S. draft, Kg/cm^2	Fuel cons, L/hr	Fuel cons, L/fed.	Field capacity, fed./hr	Width of cut, cm
Moldboard plow “m”	253	14.2	2,361	0.894	19.2	18.28	1.05	132
Chisel plow “c”	241	10.3	1,723	0.448	15.4	9.57	1.61	192
Disk plow “dp”	225	8.7	1,610	0.719	13.7	16.17	0.847	112
Offest disk harrow “dh”	298	11.5	1,883	0.553	18.1	6.41	2.82	340

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■■

Status of Biogas Technology in Akola District of Maharashtra State

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Abstract

The research work was a survey conducted for the identification of the present scenario of biogas systems. In the survey, biogas installation data were collected from the national project on Biogas Development in 1982-83 to December 2006. Nearly 13,136 biogas plants were installed in the district. Two villages from each block of Akola district were selected for collection of information about the biogas system. Nearly 140 biogas plants were installed in the fourteen selected villages of the seven blocks of the district. Out of these, only 30 biogas plants (21 %) were found in working condition and 79 % were in non-working condition. A biogas user in the district faced the problem of dung and water availability for satisfactorily working a system. Users did not have proper awareness of the problems expected during system operation that affected the working of the biogas plant. The majority of operators installed the floating dome type (KVIC) biogas plant.

Introduction

The economy of developing countries grows by using the commercial energy sources. But, the prices of these sources have increased sharply due to the depletion of reservoir resources. Hence, the capital of the nation has been diverted to importing these commercial energy sources and this satisfies the demand of consumers. The diversion of capital affects the development of a nation. In India, almost 75 % of imports were for crude oil. To avoid importing this crude oil and permit the diverting of this capital to socio-economic development, there is a need to exploit alternate energy sources that could help reduce the foreign exchange.

The government of India realized the importance of renewable energy technologies and constituted the separate ministry of New and Renewable Energy (MNRE). This MNRE was devoted to planning and development of renewable energy in India. In this effort, the MNRE started the National Biogas Development Programme in 1982-83. Under this programme, the government assisted people with financial aids/subsidy for the installation of biogas plants. As of today, 38,340 biogas plants of various family sizes of KVIC and fixed dome type have been installed in the country. The potential of biogas plants in India was estimated to be 120,000 (Anon, 2006). The real milestone of the biogas plants has not been reached.

Biogas is one of the good and promising sources of energy. Thus, energy can be harnessed successfully to meet the existing and future need of the rural areas. Biogas is the fourth largest source of energy in the world supplying about 13 % (55 EJ/years), which is equivalent to 25 million barrels of primary energy (Mittal, 1997). India has over 300 million livestock, which produce about 980 million tones of cattle dung. If the entire quantity of available dung was used for biomethation, it could generate nearly 70.22 GJ (195 million kWh) of energy annually (Govil and Gaur, 2002).

Biogas production is based on the anaerobic digestion of organic materials, producing cheap fuel for cooking, lighting and running engines and also resulting in digested slurry, containing major plant nutrients free from weeds, seeds, foul smell and pathogens (Khandelwal & Mohdi, 1990). The working life of a biogas plant depends on the proper selection of the site, capacity of plant, proper maintenance and the availability of the water and dung. It has been reported that some of the working plants are rendered unserviceable every year mainly because feeding is suspended due to scarcity of water. As such, a major fraction of available cattle dung is either being converted to dung cakes for use as fuel or composted for use as organic manure.

An attempt was made to find the present status of biogas plants in the Akola district of Maharashtra state, India. It was intended to identify operating problems related to biogas plants. The users of the biogas systems also interacted and data were collected at the user site for judging the effectiveness of the biogas plants.

Material and Methods

The study was conducted in seven blocks of Akola district *viz.,* Patur, Murtizapur, Balapur, Barshitakali, Akola, Akot and Telhara of Vidarbha region in Maharashtra State, India. The study area lies in the central east side of Maharashtra between 19º 51' and 21º 61' North latitude and 76º 38' and 77º 44' East longitude. The district falls under semi-arid climatic type. The list of villages having more biogas plants was obtained from office of the Panchayat Samities of each block of the district. Out of these, two villages were selected from each block on the basis of more biogas plants installed in the villages. The villages selected were, Nimkarda and Paras in Balapur, Devai and Chohata Bazar from Akot, Kanheri Sarap and Sindkhed from Barshitakli, Nankhed and Bhandaraj Br. were from the Patur, Mhaisang and Kolambi from Akola, Anbhora and Hirpur from Murtizapur and Manabdha and Bhamberi were from Telhara. The villages are shown in **Fig. 1**.

The study was conducted through in depth case studies of the 14 selected villages. A survey sheet was designed to collect the required information. Structured interviews were held for a sample of 140 biogas plant owners to gather information on family size, cattle holding, energy-use pattern, impact of biogas technology, etc. Technical details of biogas plants, problems related to gas availability, installation and maintenance of the biogas plants

Fig. 1 Location of selected villages in Akola district

Table 1 Status of biogas plants in Akola district up to the end of December, 2006

Block	Akola	Barshitakali	Akot	Telhara	Balapur	Patur	Murtizapur	**Total**
Total biogas plant installed	2,199	1,638	2,793	1,922	1,661	1,467	1,456	**13,136**
Percentage (%)	16.74	12.47	21.26	14.63	12.65	11.16	11.09	**100.00**
Average animal availability	5.00	4.00	6.00	5.00	7.00	4.00	6.00	**5.28**

were collected by personal interaction with users. Information was collected relating to the source of information about biogas plants, installation, resources available (water, dung and finance), biogas types, installed capacities and awareness of biogas problems.

Results and Discussion

The data collected from personal interaction with the 140 respondents and the structured questionnaire were analyzed.

The government of India launched a national programme on biogas plants in 1983-84. Many farmers of the district constructed and installed biogas plants under this scheme. In this survey, interacting with Panchayat Samities (block) office, data were collected for the total biogas plants installed in the Akola district up to December 2006 and are presented in **Table 1**.

A total 13,136 of biogas plant were installed in the district. The Akot block had the maximum number of biogas plants in district. The Murtizapur block had the minimum biogas plants, which contributed to about 11.09 % of the total installations. The average animal availability of the 140 selected biogas users of the seven blocks are given in **Table 1**. The average number of animals available for the dung in district was 5.28.

Status of Selected Biogas Users in Akola District

Villages were selected according to the maximum number of biogas plants installed. The information about the present status of selected villages is given in **Table 2**.

In the selected villages only 30 of the 140 biogas plants were in working condition and 110 biogas plants were not working.

Table 2 Status of selected biogas system in villages

Block	Villages	Total No. of Biogas plants	Biogas plants (working)	Biogas plant (non-working)	Percentage of Biogas plant (non-working)
Balapur	Nimkarda	10	2	8	80
	Paras	6	1	5	86
Akot	Devari	8	1	7	86
	Chohhta (Bz)	6	2	4	67
Barshitakali	Kanher Sarap	9	3	6	67
	Sindhkhed	5	1	4	80
Patur	Nandkhed	10	2	8	80
	Bhandaraj (Bk)	10	3	7	70
Akola	Mhaisang	15	6	9	60
	Kolambi	11	2	9	82
Murtizapur	Anbhora	10	2	8	80
	Hirpur	14	2	12	85
Telhara	Manabada	15	2	13	86
	Bhamberi	11	1	10	91
Total		140	30	110	
Percentage (%)		100	21	79	

Source of Information and Biogas Plants Constructed

The details of the biogas plant technology and the information acquired were discussed with the respondents. The information presented in **Table 3** gives the outline of the above parameters of Akola district.

The Panchayat Samities performed the major role for dissemination of information to the users. Nearly 73 % of the respondents were informed about the biogas plants from the Panchayat Samities. The Television and Agricultural Universities contributed 16 and 11 % of the source of information for the beneficiaries, respectively.

Construction details of the biogas plants were assessed personally by 44 % of the of the biogas users. Local guidance about the biogas construction was received by 35 % of the users. Agencies like Panchayat Samities, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, (Dr. PDKV) MEDA, and NGO, provided construction details to 21 % of the users.

Table 3 Source of information available and plants constructed by users

Particulars	Parameter	Out of 140 users	(%) of users
Source of information	Panchayat Samities	102	73
	Telivision	23	16
	Agril University	15	11
Biogas construction details	Personally	62	44
	Guided by local mason	49	35
	Agency (Panchayat Samiti, Agril University, NGO)	39	21

Table 4 Dung, water and finance resources available to users

Particulars	Parameter	Out of 140 users	(%) of users
Dung	Available	94	67
	Less available	46	33
Water	Bore well	82	59
	Dug well	48	34
	River	10	7
Finance	Loan	58	41
	Subsidy	73	52
	Self	9	7

Resources Available for Users

Dung, water and financial resources available to user were collected. The detailed information about these resources is given in **Table 4**.

Sufficient animal dung was available for 67 % of the respondents for feeding the biogas plants. One third of respondents faced the problem of less dung availability. Adequate water was available for 59 % of the biogas users from bored wells. Dug wells and the river were available for 34 and 7 %, respectively. Financial sources available for the biogas plants installed by the users were also collected. Subsidy from the government was available to 52 % of the users.

Some respondents (41 %) borrowed the money for the construction of the biogas plant. Only a few users used their own capital. Installation cost of the biogas installation for a 2 to 6 m^3 size varied between Rs. 10,000 to Rs. 20,000. Pathaina and Sharma, 1997, made a similar attempt.

Biogas System and Capacity of the Biogas Plants

Table 5 shows the types of biogas plant constructed and capacity of the biogas plants at the user's site.

Floating dome (KVIC type) biogas plants comprised 56 % of the total. Fixed dome biogas plants comprised 44 %.

Table 5 depicts the information about the biogas plant capacities at the user's site. It was found that nearly 43 % of biogas plants had a capacity of 2 m^3. Biogas plants with a capacity of 3 m^3, 4 m^3 and 5 m^3 were also installed in the villages. The percentages were 34, 14 and 9 %, respectively.

Awareness of the Problem

Awareness of the operating problems of biogas plants and water available for the operation was collected with personnel interaction. The information is presented in **Table 6**.

41 % of the users were not aware of the biogas system problems. It meant that the working of the biogas plant was directly affected by the awareness. It was also found that 67 % of the users faced the availability of water for the working of biogas plants.

Problems Faced by the User in the District

Problems faced by the respondents during operation of biogas systems are presented in **Table 7**. The fixed dome biogas plant did not maintain the required pressure while in the cooking operation. The users expressed that, initially, gas obtained was highly pressurized and gradually decreased. The floating dome users found that gas pressure of the plant was being maintained while cooking. The information regarding the burners available at the biogas site was collected from individual biogas users. Seventy four percent of the biogas burners at the user's kitchen were efficient and had no operation problem.

Sixty six percent of biogas users had suggestions for modification in the existing design of the biogas system and its operation.

A digester wall cracking problem in the biogas plants was faced by many users. About 64 % of the biogas plants were cracking and leaking, and the remaining biogas plants were operating satisfactorily.

The study showed that users had inadequate awareness of the operation and maintenance of the plants. The users associated with the problems in existing technology and made suggestions for the modification in design. Malik, 2003 reported improved biogas production technology over traditional. A majority of the biogas systems were not working due to the lack of availability of dung and water. Sources of information about the biogas system was disseminated to the users by Panchayat Samiti/block. It was observed that selection of site and capacity, operation and maintenance were not properly carried out at the user's site.

Conclusions

The present study assessed the biogas technology status across the Akola district. Fourteen villages were selected according to the maximum number of biogas plants installed. These selected villages had 140 installed biogas plants. A total of 140 biogas plants were inspected for information on functional status and reasons for non and suboptimal functionality. Interaction with the each user of biogas was made in an attempt to obtain the exact quantification of the status of biogas plants.

Table 5 Biogas types and capacities at the user's site

Particulars	Parameter	Out of 140 users	(%) of users
Types of Biogas plant	Floating dome	78	56
	Fixed dome	62	44
Capacity of Biogas plants (m^3)	2	60	43
	3	48	34
	4	20	14
	5	12	9

Table 6 Awareness of biogas system problems and water available

Particulars	Parameter	Out of 140 users	(%) of users
Awareness of problem	Yes	82	59
	No	58	41
Water availability	Available	46	33
	Non-available	94	67

About 79 % of the biogas plants were in non-working condition. The reason of the non-working of biogas plants were the proper identification of the biogas operation problems, scarcity of water, change of cattle holding, cracking problem in the installed biogas plants and selection of site and capacities of the biogas plant. The average per cent of biogas plants in working condition in selected villages was found to be 21. Thirty three percent of biogas users faced the problem of dung availability for feeding the plant. Also, the study showed the financing provided for the construction of biogas plants. More than 50 % of biogas plants in the study area were constructed using subsidies provided by the government. The floating dome type biogas plants (KVIC) was 56 %. The selected users have more units with 2 m^3 plant capacity, which accounts for nearly 43 %. The studied area gave a picture of the availability of the water for the biogas production at the user site. Many users suggested modifications in the existing design of biogas plants to run on minimum water.

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Table 7 Nature of problem faced by the biogas users

Particulars	Parameter	Out of 140 users	(%) of users
Modification in existing design	Yes	93	66
	No	47	34
Gas Pressure (low pressure)	Yes	62	44
	No	78	56
Burner problem	Not efficient and Leakages	37	26
	Efficient burner	103	74
Constructional problem like Cracking/leakage etc	Yes	89	64
	No	51	36

Prediction of Surface Area of Garden Egg (*Solanum Aethiopicum L*) from Weight Measurements

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Abstract

Estimation of surface area of various agricultural produce can have a wide range of applications for both producers and processors. The methods available are tedious and in certain cases destructives Studies have been conducted with respect to predicting the surface area of some fruits and vegetables such as apples and tomatoes. Very few, if any, similar attempts have been made to estimate the surface area of indigenous African crops. The objective of this study was to develop a model that will predict the surface area of the garden egg (*Solanum aethiopicum L*) from weight measurements. It is easier to measure the weight of the garden egg than to measure its surface area. Weight and surface area measurements of each garden egg were used to develop equations to predict fruit surface area (cm^2) from the raw weight. The linear-regression model developed showed strong correlation between surface area and weight measurement and can be used to estimate the surface area of garden egg. For a garden egg weighting 47.4 gm, the model predicts its surface area between 96.3 and 118.5 mm^2 with 95 % confidence.

Introduction

Solanum aethiopicum L (garden eggs) can be found in almost every market in West Africa, where it is one of the five most important vegetables, together with tomatoes, onions, peppers and okra. In Ghana, garden eggs occupy second place after tomatoes, where as in Senegal their economic importance equals or possibly surpasses that of tomatoes. Garden eggs are also found in South America and the Caribbean (Schippers, 2002).

The determination of the physical characteristics of fruits and vegetables is very useful in the determination of storage and transport space, as well as rate processes such as respiration, water loss and drying. Surface area in particular is required in estimating the amount of surface coating to be applied to extend storage life (Joseph *et al.*, 2006). Surface area is also important in studies related to spray coverage, colour evaluation and heat transfer analysis (Moshenin 1970). It is also very critical in transport phenomena involving the transfer of heat, water vapour, gases, pesticides and foliar nutrients into or out of fruits and vegetables. Exterior irregularities of many horticultural commodities make estimation of surface area difficult and could cause significant errors in the estimation of various area related measurements.

Various techniques have been applied to determine the surface area of fruits and seeds. Methods that have been used in previous studies of apples include the cutting of apple into slices, peeling and tracing the peels on paper (Frechette and Zahraduik 1966), covering of apples with electrical tape and measuring the surface area of the tapes (Clayton *et al.,* 1995). A structured system for measuring the surface area and volume of soybean seed was developed by Sakai and Yonekane (1991). Other methods that have been developed are the use of atomic force microscopy (Hershko *et al.,* 1998) and digital image analysis system (Wright *et al.,* 1986). Lee *et al.*, (2006) reported a non destructive method to measure the surface area and volume of 3-D objects based on Silhouette information.

Surface area of irregular objects is also estimated by calculating that of a geometric shape, which is considered to be representative of the commodity. Such calculations for apples have commonly been based on perfect spheres (Majness *et al.,* 1926; Hamilton 1929; Gaffrey and Baird 1985, cited by Clayton *et al.,* 1995).

Considered as a perfect sphere, the surface area A of a fruit is given by the formula; $A = 4\pi r^2$; where r is the fruit radius.

However getting an appropriate value of r is difficult because of the non-spherical shape of many fruits. Correlations between surface area and some other easily measured physical characteristic of a commodity such as weight and volume have formed the basis for many predictive models. Clayton *et al.,* (1995) developed non-linear regression models where both fruit mass and volume were used to predict the surface area of apples. Joseph *et al.,* (2005) generated the following equations from regression analysis:

Apple surface area *(Aap)*:

$Aap = 51.5 + 0.785\ Wap$

Where the surface area of apple, *Aap*, is measured in centimetre squared; (cm^2) and the mass of the apple, *Wap*, is measured in grams (g).

Cantaloupe surface area *(Act)*:

$Act = 197.0 + 0.347\ Wct$

where the surface area of apple, A_{ct}, is measured in centimetre squared; (cm^2) and the mass of the apple, *Wct*, is measured in grams (g).

Strawberry surface area, *(Ast)*:

$Ast = 9.4 + 1.58\ Wst$

where the surface area of apple, *Ast*, is measured in centimetre squared (cm^2) and the mass of the apple, *Wst*, is measured in grams (g).

Tomato surface area, *(Ato)*:

$Ato = 69.0 + 0.57\ Wto$

Where the surface area of apple, *Ato*, is measured in centimetre squared; (cm^2) and the mass of the apple, *Wto*, is measured in grams (g).

Objectives of Study

The objective of the study was to develop prediction equations for measuring the surface area of garden eggs (*Solanum aethiopicum L*).

Methodology

The method of Baten and Marshal (1943) was used to determine the surface area of garden eggs. Ninety-eight (98) garden eggs were selected at random from various sizes in the market.

Fig. 1 95% linear regression model of garden eggs surface area vs. weight, with confidence limits (CL) and prediction limits (PL)

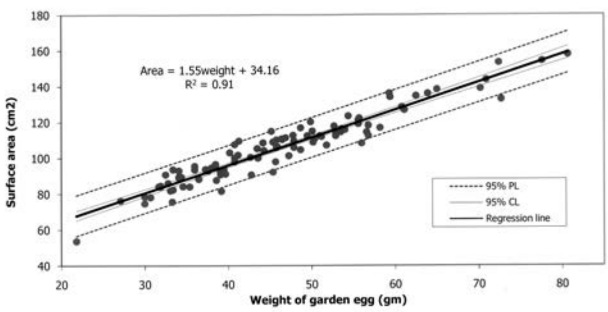


Fig. 2 95 % linear regression model prediction limits vs. weight for garden eggs

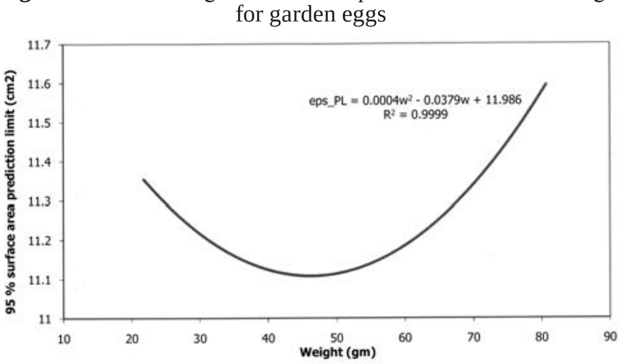
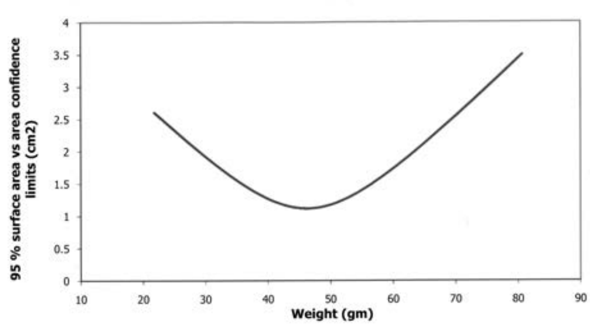


Fig. 3 95 % linear regression model confidence limit vs. weight for garden eggs



The garden eggs were first weighed to the nearest 0.01 g. The garden eggs were then cut into narrow strips and the planimeter sum of the areas of tracings of the strips was taken as the surface area of the garden egg. The use of narrow strips minimized the inaccuracies associated with the flattening for surface measurement. Linear regression was used to obtain the best-fit curve for the data involving the 100 garden eggs. This approach was recommended by Frechette and Zahradnik (1965) when they developed surface area prediction equations from weight measurements for apples (Western McIntosh).

Results

The linear regression model for predicting garden egg surface area, A, from weight measurements was:

$A = 1.55 + 31.16\, w \pm \epsilon\, PL$,

where

W = weight of garden egg and $R^2 = 0.91$, and

$\epsilon\, PL = 0.0004w^2 - 0.0379w + 11.986$,

with $R^2\, \epsilon\, PL = 1$.

A plot of surface area, A, verses weight, w, is shown in **Fig. 1**. The variation of the model prediction limit with garden egg weight is shown in **Fig. 2**. A plot of confidence limits ϵ CL, with weight of garden egg is shown in **Fig. 3**. The minimum prediction limit of the model is

PI = ± 11.1 cm^2 when weight is 47.4 gm. That is, for a garden egg weighting 47.4 gm, the model predicts its surface area between 96.3 and 118.5 mm^2 with 95% confidence.

Conclusion

The measurement of the surface area of garden eggs is tedious, slow and destructive. This information, however, is needed for many rate related processes, applications of surface coatings and pesticides, packaging and storage. The linear regression equation $A = 1.55 + 31.16\, w \pm \epsilon PL$ can be used to obtain the surface areas from weight measurements.

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Farm Mechanization Status and Future Strategies for Major Cereal and Horticultural Crops in Kashmir

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Abstract

Cultural practices and their mechanization level in the production of major cereal and horticultural crops in the Kashmir Valley are presented. Except for ploughing and puddling, all farm operations were done manually using traditional tools and implements. A number of suitable improved tools and implements were identified to bridge the existing mechanization gap for major cereal and horticultural crops of the region. Some of the operations needed immediate attention of researchers for development of new tools/implements or introduction of previously developed implements in the region after feasibility testing. Apart from this, a State Policy for farm mechanization should be made to encourage mechanization on a sound footing.

Introduction

It has been well realized all over the world that in order to meet the food requirements of the rapid growing population and rapid industrialization, the mechanization of agriculture is inescapable. Mechanization in agriculture has enhanced production and productivity of agricultural commodities through timeliness of operation, better management of inputs and reduction of post harvest losses in the country. But the level of adoption of mechanized agricultural practices varies widely across different regions in the country. One of the regions may be attributed to the variation in farm power availability for agricultural operations among different states of India that was found as high as 3.76 kW/ha as compared to only 0.92 kW/ha in Jammu and Kashmir (Anonymous, 2005). The level of adoption of mechanized agricultural practices varies with the cropping pattern followed, agro climatic and soil conditions and socio-economic status of the users. The package of modern technology includes the use of more efficient and economical farm implements and machinery and suitable forms of farm power. Modernization requires appropriate machinery for ensuring timely field operations and effective application of various crop production inputs utilizing human, animal and mechanical power sources. Kashmir, situated in the northern region of the Great Himalayan range, is generally considered as a low mechanized region as compared to other parts of the country. The conservation of natural resources in the region is an issue of utmost concern for sustainable agricultural development and improving livelihood securities of the local inhabitants. Ruthless and unauthorized exploitation of natural resources is affecting long-term sustainability of the agricultural production system, which mainly revolves around crop production, horticulture, livestock, and forestry and to some extent fisheries. Glaciers and glacial melts are steadily declining.

Rice, maize, pulses and oilseed have been cultivated in the region with an objective of attaining self-sufficiency in food. Horticultural crops are well adapted to the region; these include fruits (apple, pear, almond, walnut, plum, peach, cherry and apricots), vegetables (brinjal, chillies, potato, pea, cabbage, cauliflower, knoll khol, turnips, onion, garlic etc.), spices (saffron, kalazeera) and flowers. The crops that are mainly grown under rain-fed conditions in most of the parts though irrigation facilities from canals and rivers are also available in some areas. Hilly and mountainous terrain makes harnessing of river water difficult. Hill ranges are snow covered and provide perennial flow to down plains.

Methodology

The Kashmir region is comprised of 10 districts viz. Anantnag, Budgam, Baramulla, Pulwama, Srinagar, Kupwara, Kulgam, Bandipora, Shopian, Ganderbal with the creation of 4 new districts in the year 2007. Based on the area and production of various crops, district-wise major cereal and horticultural crops have been identified and are presented in **Table 1**. Under this study, one major crop each from cereal, horticultural and vegetables have been taken and their mechanization gaps have been determined.

The information regarding traditional hand tools and equipment used for the cultivation of Rice, Apple and vegetables were collected from local peasants. Information on their use, material of construction, availability, cost, drudgery involved and their satisfaction were also collected from the local people. Various issues on production mechanization were discussed with the state department staff and scientists of KVK and regional stations to have a broader view of the existing mechanization gaps.

The activities studied were land clearing, nursery raising, field preparation, puddling, sowing/planting, transplanting, pit making, weeding, spraying, intercultural operations, harvesting, threshing and storage of produce. The level of mechanization achieved by different categories of farmers was determined on the basis of use of farm tools and machinery. The farm power sources were categorized into human, animal and mechanical. The collected information from local farmers of the region was critically examined and keeping in view the possibilities/suitability of improved farm tools and equipment, a mechanization gap has been determined.

Table 1 District-wise identified major cereal and horticultural crops

District	Major Crops
Anantnag	Rice, oilseed, maize, apple, walnut, vegetables
Pulwama	Rice, maize, apple, walnut, almond, saffron
Srinagar	Rice, maize, apple, walnut, cherries, vegetables
Budgam	Rice, maize, oilseed, walnut, almond, vegetables
Baramulla	Rice, maize, oilseed, apple, walnut, pear, vegetables
Kupwara	Rice, maize, apple, walnut
Kulgam	Rice, maize, apple, walnut
Shopian	Rice, Apple, vegetables
Bandipora	Rice, apple, walnut, almond, vegetables
Ganderbal	Rice, maize, apple, vegetables

Results and Discussion

In this paper, mechanization status of paddy cultivation, horticultural crops (apple, pear) and vegetables are presented.

Paddy: Paddy is the major cereal crop of the region and grown over 70 % of the area with an average yield of 1.8 t/ha (Anon, 2002). The various cultural practices of paddy cultivation are given in **Table 2**. After survey of some selected villages of the region, it was observed that nursery is raised near water source and sprouted seed are sown in puddled field on an area of about 1/20th of total area under paddy cultivation. The nursery of 40 days are uprooted, washed and then transplanted manually in well puddled field. It was observed that farmers transplant 6-7 plants/hill at a spacing of 20 × 20 cm, which is more

Table 2 Various cultural practices followed for paddy cultivation in Kashmir Valley

Operation	Starting time	Ending time	Implement used	Man-power requirement, man-days/ha
Field preparation	15th April	Ending May	Animal drawn Shalimar plough,	20 man-days/ha
Nursery raising	20th April	Ending may	Spade	10 man-days/ha
Puddling	Ending May	10th June	Local wooden plough, *majj*	10 man-days/ha
Transplantation	10th June	Ending June	-	20 man-days/ha
Weeding	Ending June	Mid July	Manually uprooting	10 man-days/ha
Spraying	June	July	Knapsack sprayer	5 man-days/ha
Harvesting	15th October	Ending November	Serrated Sickle	20 man-days/ha
Threshing	15th November	Ending November	Wooden log, empty oil drum	18 man-days/ha

than the recommended level. Harvesting of paddy is done manually with the help of a local sickle. The harvested paddy is then stacked in a heap by making bundles for 15-20 days before threshing. Threshing is done on wooden logs/empty oil drum. In lack of improved tools/equipment, the loss due to untimely rainfall, rats and other animals was reported by the farmers. Cultural operations were manual, using small hand tools/equipment. Mostly family labour and some hired labour did all the operations. The charges for unskilled labour were Rs 120/ day with food two times. There was no mechanized activity in paddy cultivation in the region. The farmers sold their produce (paddy) cheap to urban people. The paddy straw was used as cattle feed. The presently used tools and implements and the mechanization gaps are given in **Table 3**.

Apple/Pear: In Kashmir valley, Apples are grown over more than 9.9×10^4 ha area of which Baramulla and Pulwama districts ranks 1st and 2nd. Apple, particularly the Delicious and Amri varieties grown in Shopian and Sopore belt, are considered the best apple varieties in the world due to sweetness, typical size and shape. The seeds are sown directly in well prepared raised beds during November and December. Generally seeds are sown at a distance of 5-15 cm and row to row distance about 30 cm. Seedlings are planted in 2 × 2 × 2 ft size pits made with the help of shovel at a spacing of 6 × 6 m. Harvesting of apple is done manually with the help of orchard ladder and fruits are collected in a basket. One person climbs up the ladder and picks the ripen fruits manually with a cutter and collects them in the basket. After that, the fruit is collected in a heap and some physical grading is done by engaging 5-6 persons. Fruit is packed in wooden basket (15 kg capacity) and cardboard box (5 kg capacity) for selling to the middle man. Mostly family members and some hired labour do all the operations. The charges for labour used in packing were Rs. 200/ day. There was no processing facility available nearby. The presently used tools and implements and the mechanization gaps identified are given in **Table 4**.

Vegetables: In Kashmir valley, the vegetables are grown as a commercial crop, but the implements used are the same as those used for other agricultural purposes. Since these crops are grown in small, scattered and irregular shaped lands, small hand tools/implements already commercialized in other parts of the country can not be adopted as such. However, some hand tools/implements can be adopted and introduced. The mechanization gaps identified for vegetable crops are given in **Table 5**. All the field operations were manual using small hand tools for cultivation of vegetables crops.

Swat Analysis of Mechanization

Strengths

- Manufacturing of farm tools and implements especially through village artisans, is gaining momentum.
- Tradition of custom servicing and hiring exists in the region.
- Annual sale of tractors, power tillers and their matching equipment, power thresher, pumping sets, etc. are on the rise.

Weakness

- Land holdings are very small, topography is undulating and terraced irregular shape fields makes mechanization difficult with farm equipment available in the market.
- Safety and ergonomic considerations have not adequately permeated in available designs of farm tools/implements.
- Hardly any mechanization has taken place in horticultural/vegetable crop cultivation in the

Table 3 Mechanization gap identified in paddy cultivation in Kashmir region

Operations	Implements being used	Improved implements suggested for introduction	Power source	Developed (D) /New (N)	Status *C/ND
Field preparation	i) Spade, Ramba	Improvement in design	Manual	N	-
	ii) Local plough	Improvement in design, Power tiller, rotavator	Animal, Small engine	D	C (ND)
Puddling	i) local puddler, Majj	Animal drawn puddler, power tiller operated puddler	Animal, Small engine	D	C (ND)
Weeding	Manual, sickle	Cono weeder, self propelled conoweeder	Manual, Small engine	D	ND
Spraying	Knapsack sprayer, foot sprayer	ULV/other air carrier sprayer	Small engine	D	C (ND)
Harvesting	Plain sickle, Punjab sickle	Serrated sickle, self propelled reaper	Manual/ small engine	D	C (ND)
Threshing	Beating on wooden logs/drum	Manual paddy thresher/ motor operated thresher	Manual/ small electric motors	D	ND
Storage	Wood bin, metallic bin	Improved metallic bins	-	D	ND

*C- Commercial, ND- Needs Demonstration/Evaluation and Adoption

valley.
• Weak extension network.

Future Strategy for Farm Mechanization

Farm Power

1. Mechanization is essential for timeliness in field operations and precision in placement of costly inputs to increase productivity, reduce unit cost of production and drudgery in farm operations, as well as conservation of natural resources.
2. For intensification of agriculture farm power availability should be increased from the present level of about 0.92 kW/ha to about 2.0 kW/ha in the region.
3. Equipment and power units suitable for hill agriculture should be identified, tested, adapted and introduced in the region. Power units like the light weight rotary tiller, small tractors, efficient power operated tools and implements for cereal as well as horticultural crops should be evaluated for adoption.

Improved Farm Implements and Machinery

1. There is a need to mechanize puddling, planting/transplanting operations and weeding operation for paddy crop in the region.
2. For timely and efficient plant protection, Aeroblast sprayers, orchard sprayers and electrostatic spraying equipment are required to be introduced.
3. Improved harvesting equipment like serrated sickles, fruit pluckers, vertical conveyor reapers and mini combine harvester should be introduced.
4. Fruit crop mechanization equipment for pit making, transplanting of saplings, pruning, spraying, harvesting of fruits etc. need to be identified/adopted/developed and popularized.
5. For vegetable crop mechanization equipment for seed bed preparation, planting, transplanting of seedlings, intercultural, irrigation, spraying, harvesting, etc. need to be identified/designed and introduced.
6. To overcome drudgery in threshing and cleaning of paddy, maize and pulses appropriate power threshers should be popularized.
7. Simple techniques to increase shelf life like wax coating, polythene, packaging will reduce the losses considerablely, which should be adapted at the farm level.
8. Farm machinery industry needs to be established in the region to modernize farm implements not only in terms of performance characteristics but also for comfort, safety and energy conservation in the region.

Conclusion

The approach to farm mechanization in the hill agriculture is different from that of plain area cultivation. Little farm power availability becomes a constraint for the growth of farm tools and implements. Use of big prime mowers and heavy machinery is limited due to undulated and scattered land holdings in the region (Dixit, Jagvir *et al.,* 2006).

Table 4 Mechanization gap identified in Apple/Pear cultivation in Kashmir valley

Operations	Implements being used	Improved implements suggested for introduction	Power source	Developed (D) /New (N)	Status *C/ND
Field preparation for nursery	i) Spade, shovel	Improvement in design	Manual	N	-
	ii) Local plough	Improvement in design	Animal	D	ND
Transplantation of nursery	Manual	Transplanter which can work in small and irregular fields	Manual/small engine	N	-
Weeding in nursery	Local hoe (Tangroo, Ramba)	Wheel hoe, khurpi, improved weeding device	Manual	D	ND
Pit making	Shovel, spade	Post hole digger	Power tiller/ Tractor	N	ND
Basin preparation	Spade, shovel	Light weight rotary tiller	Small engine	D	ND
Spraying	Knapsack sprayer, foot sprayer	ULV/ other air carrier sprayer, Orchard sprayer	Small engine	N	-
Harvesting of fruits	Local orchard ladder	Light weight ladder, manual fruit harvester, DC power operated fruit harvester, Mechanical Positioner	Manual, tractor	N	-
Pruning	Pruning scateur	Light weight and efficient scateur	Manual	D	C
Storage for off season	Stored in kachha house after packing in wood box	AC cooling chamber	-	D	C (ND)

*C- Commercial, ND- Needs Demonstration/Evaluation and Adoption

Considering all these and the crops grown, four prolonged strategies needs to be taken: (i) Establishing/strengthening the human resource development and R & D programme to develop suitable new implements and modify the existing ones to suit the prevailing topographic conditions of the region. (ii) Organization of training programmes for the entrepreneurs in manufacture/running of custom service centres/Agri-Clinics/repair and maintenance workshop (iii) Encouraging extension agencies for large scale demonstration/popularization of suitable farm tools and implements (iv) Visit of selected groups of progressive farmers and manufacturers to other states/countries where they can see the modern farms, manufacturers and use of improved agricultural machinery. Apart from these, a State policy based on the socio-economic and agro-ecological factors of the region need to be formulated to encourage farm mechanization on a sound footing.

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■■

Table 5 Identified mechanization gap for vegetable crops grown in Kashmir valley

Operations	Implements being used	Improved implements suggested for introduction	Power source	Developed (D) / New (N)	Status *C/ND
Land clearing	i) *Dao*	Light weigh grass/ bush cutter	Small engine	D	C(ND)
Land preparation	i) Spade, shovel	Ridger plough	Animal	D	C (ND)
	ii) Animal drawn Shalimar plough	Light weight rotary tiller	Small engine	D	C (ND)
Ridge formation	Spade, shovel	Animal drawn ridger	Animal	D	ND
		Power tiller operated ridger	Small engine	N	ND
Sowing/ planting	Broadcasting/ manual	Manual seed drill, power tiller drawn planter	Human	Needs improvement for small seed	-
			Small engine		
Fertilizer application	Broadcasting	Fertilizer broadcaster	Manual	D	ND
Earthing-up operation	Spade	Wheel tool carrier	Manual	N	-
Weeding	Local hoe (Tangroo, ramba)	Wheel hoe, khurpi, long handle weeder	Manual	D	C (ND)
Spraying	Knapsack sprayer, foot sprayer	ULV/ other air carrier sprayer	Small engine	N	-
Harvesting	Spade/ sickle/ knife	Digger for tuber crops	Small engine	N	-
		Plucker for some other vegetables	Human	N	-
Short-term Storage	No technology used	Zero energy cool chamber	-	D	ND

*C- Commercial, ND- Needs Demonstration/Evaluation and Adoption

Ergonomics of Self Propelled Power Weeders as Influenced by Forward Speed and Terrain Condition

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Abstract

Hand weeding requires more labour, consumes more time and leads to higher cost. Hence, inter cultivation of weeds using mechanical power was a viable and economical solution for this problem. The TNAU-Varun power weeder, Balram power weeder and Oleo power weeder with 12 male subjects were ergonomically evaluated. The weeding in cotton with the power weeders was performed on 30 and 60 DAS at 1.5, 1.8 and 2.1 km h^{-1} forward speed of operation. Heart rate, energy cost, oxygen consumption rate in terms of VO_2 maximum and work pulse with the TNAU-Varun power weeder was 123.32 beats min^{-1}, 23.00 kJ min^{-1}, 52.34 % of VO_2 maximum and 46.47 beats min^{-1}, respectively. The corresponding values for the Oleo power weeder was 130.19 beats min^{-1}, 23.96 kJ min^{-1}, 57.40 % of VO_2 maximum and 47.82 beats min^{-1}, respectively. For the Balram power weeder, the values were 134.09 beats min^{-1}, 24.45 kJ min^{-1}, 58.59 % of VO_2 maximum and 44.42 beats min^{-1}, respectively. With the increase in forward speed, the mean heart rate and the corresponding oxygen consumption rate increased for all the weeders. The energy cost of the weeding operation was graded as "Heavy" at all levels of forward speed of the three power weeders. The energy cost of weeding was the maximum for the Balram power weeder and minimum for the TNAU Varun power weeder. In general, forty five minutes of work followed by 8-12 minutes of rest was required by the subjects for the power weeder operation. The Oleo power weeder had the highest weeding efficiency of 73.4 %. The savings in cost with TNAU-Varun, Oleo and Balram power weeders was 21.5, 16.2 and 23.1 %, respectively, when compared with manual weeding. The savings in time was 59.8, 58.6 and 59.8 %, respectively, when compared with manual weeding.

Introduction

In developing countries, it was estimated that reduction in yield due to weeds alone was 20 to 30 % depending on the crops, weed infestation, intensity and location, which might be increased up to 50 % if adequate crop management practices were not observed. About 30 to 35 % of the cost of cultivation and 45 to 50 % of total labour requirement was spent on weeding alone when carried out with manual labour. The greatest constraints of crop production were land preparation and weeding. The former constraints were due to the energy requirement and, hence, power demand, as time was usually a limiting factor, and the latter because of the labourious, time-consuming nature of the work. The fact that there was such a strong interaction between the two brought ergonomic considerations to the fore. Power weeders have been developed for the mechanical control of weeds in crops such as cotton, sugarcane and orchard. The ergonomics aspects of the power weeder were of great importance as working with the power weeder involved considerable physical strain to the operator. An operator has to walk behind the weeder for a distance of about 15 to 20 km per hectare. Besides walking, the strains resulting from stress factor due to noise, mechanical vibration, workload and exhaust emission also affected the performance of the operator. In view of the importance of the weeding operation, it was desirable to evaluate the available power weeders that were mechanically efficient and at the same time demanded less human energy expenditure.

Review of Literature

Tiwari and Gite (1998) measured heart rate and oxygen consumption of the power tiller operators during rototilling operations under actual field conditions. The mean values for human energy expenditure during rototilling operations were 10.02, 12.11 and 13.15 kJ min^{-1} at the forward speeds of 1.09, 1.69 and 2.26 km h^{-1}, respectively. Mamansari and Salokhe (1999) assessed the physiological cost of the most commonly used power tiller in Thailand in terms of heart rate of the operator. Primary ploughing required the highest energy, followed by secondary ploughing. Harrowing required least energy. They concluded that the excessive heart rate experienced by power tiller operators came from two sources, environmental and machine. Working with a power tiller in hot and humid environments, which also changed throughout the working day, might be responsible for excessive workload. The surface condition of the agricultural field was another factor contributing to operator workload. Tiwari and Gite (2000) evaluated the physiological cost of a 10.5 kW rotary type power tiller with and without a seating attachment. Mean heart rate and oxygen consumption rates varied from 85.1 to 90.2 beats min^{-1} and 6.68 to 8.98 kJ min^{-1}.

Materials and Methods

Hand weeding requires more labour, consumes more time and leads to higher cost of weeding. An estimate of 400-600 man hours per hectare is the normal man-hour requirement of hand weeding, which amounts to Rs. 2,200 per hectare. This also depends upon weed infestation. Labour is also scarce. Mechanical methods and inter cultivation using agricultural implements are being practiced in many regions. The farmers use a small blade harrow, called "Junior hoe", between the rows of the crop, which is drawn by a pair of bullocks. The time spent in the field, the drudgery of the operator and the requirement of animal power are some of the points of concern in weed control. Hence, inter cultivation of weeds using mechanical power is a viable and economical solution for this problem. The tractor has been in our country for over four decades and, until now, there is no visible change in the scenario of inter cultivation practices in the mechanized farm. The reasons are many, among which are the initial cost of the tractor, the traditional cropping patterns and layout.

Selection of Power Weeders

Mechanization in agriculture has changed the characteristics of labour and it has also influenced the workload. Need for timeliness of operation and increased capacity, has led to higher speeds and bigger and heavier machines. The operation of these machines has increased workload on the operators, as well as occupational hazards and diseases, which impair the performance of the operator. In farm work, fatigue and discomfort to which human beings are subjected are caused by physical labour (Huang and Suggs, 1968). The power weeders are used for uprooting and burying weeds between standing rows of crops. It disturbs the topsoil and increases the aeration.

The power weeders selected for the investigations were the TNAU-Varun power weeder (PW_1 as shown in **Fig. 1**), Oleo power weeder (PW_2 as shown in **Fig. 2**) and Balram power weeder (PW_3 as shown in **Fig. 3**).

The TNAU-Varun power weeder (PW_1) consisted of a 10 hp diesel engine, power transmission housing, ground wheels, rotary knives, handle and clutch. From the engine, the power was transmitted to the transmission housing and then to the ground wheels and the rotary knives. The knives, when rotating,

Fig. 1 TNAU-Varun power weeder

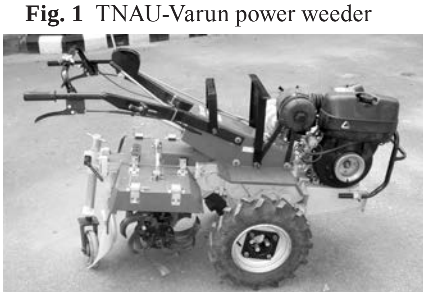

Fig. 2 Oleo power weeder

Fig. 3 Balram power weeder

enabled weeding and mulching of the soil. Width of the rotary was 550 mm and depth of weeding could be adjusted. The Balram power weeder consisted of a petrol start kerosene run engine, power transmission housing, rotary knives, handle and clutch. There was provision to adjust the ground wheel spacing according to the row crop spacing. A clutch with lever provided at the handle actuated the simple idler pulley and disengaged the power transmission from the engine to rotary tynes. These knives, when rotating, enabled weeding and mulching of the soil. Width of the rotary was 350 mm and depth of weeding could be adjusted. The Oleo power weeder was compact and lightweight which was ideal for working with ease even in confined spaces. A front wheel with vertical tip-up mechanism was provided for easy transport and could be lifted to facilitate tillage work. Two-side protection discs ensured that crops remained undamaged while also maximizing operator safety. The transmission guard was reinforced to withstand projected stones and accidental impact.

Ergonomical Evaluation

Twelve male subjects were selected for the investigation based on age and fitness. They were screened for normal health through medical examinations. The age of the workers was 29.9 ± 3.4. The heart rate of the selected subjects was measured using Polar Vantage NV computerized heart rate monitor. All the twelve were calibrated in the laboratory condition by indirect assessment of oxygen uptake. From the downloaded data, the values of heart rate at resting level and the 6th to 15th minute of operation were taken for calculating the physiological responses of the subjects (Tiwari and Gite, 1998). The stabilized values of heart rate for each subject from the 6th to 15th minute of operation were used to calculate the mean value for the operation of the power weeders. To ascertain whether the operation of all the selected weeders were within the acceptable workload (AWL), the VO_2 maximum for each treatment was computed and recorded. The acceptable workload (AWL) for Indian workers was the work consuming 35 % of VO_2 maximum (Saha *et al.,* 1979). To have a meaningful comparison of physiological response, ΔH values (increase over resting values) for heart rate (work pulse) was calculated (Tiwari and Gite, 1998). The calculated values of work pulse for each operation were compared with the acceptable work pulse values of 40 beats min^{-1} as the limit of continuous performance (Brundke, 1984).

The evaluation was conducted in the cotton field of Tamil Nadu Agricultural University Coimbatore.

Fig. 4 Operational view of power weeders in cotton

Table 1 Average physiological response of selected subjects for weeding operation

Weeders	Heart rate, beats min^{-1}	Energy cost of work, kJ min^{-1}	AWL (35 % VO_2 max)	LCP (40 beats min^{-1})
A. TNAU-Varun power weeder (PW_1)				
1.5 km h^{-1} forward speed	120.9	22.3	50.8 (>AWL)	44.1 (>LCP)
1.8 km h^{-1} forward speed	123.3	23.0	52.3 (>AWL)	46.3 (>LCP)
2.1 km h^{-1} forward speed	125.8	23.7	53.9 (>AWL)	49.0 (>LCP)
B. Oleo power weeder (PW_2)				
1.5 km h^{-1} forward speed	127.5	24.4	55.6 (>AWL)	45.9 (>LCP)
1.8 km h^{-1} forward speed	130.0	25.6	58.2 (>AWL)	48.2 (>LCP)
2.1 km h^{-1} forward speed	133.1	25.7	58.4 (>AWL)	49.3 (>LCP)
C. Balram power weeder (PW_3)				
1.5 km h^{-1} forward speed	131.5	25.4	5.7 (>AWL)	46.1 (>LCP)
1.8 km h^{-1} forward speed	134.0	25.9	58.9 (>AWL)	47.2 (>LCP)
2.1 km h^{-1} forward speed	136.8	26.0	59.1 (>AWL)	50.0 (>LCP)

The field experiment was conducted with TNAU-Varun power weeder (PW_1), Balram power weeder (PW_2) and Oleo power weeder (PW_3) during the month of November and December 2006 (**Fig. 4**). The mean and maximum temperatures varied from 27.4 to 30.8 ºC and 34.6 to 38.5 ºC, respectively, during the period of evaluation. The mechanical analysis of the soil was as follows: Clay: 19.64 %, Silt: 9.75 %, Fine sand: 37.11 % and Coarse sand: 33.50 %. The trial with power weeders was performed in cotton for weeding 30 and 60 DAS. The field selected for trial was planted with MCU 12 cotton. The subjects were trained well for the operation of the power weeder. The trial was conducted between 7:30 AM and 5:00 PM and the subjects were asked to report at the field at 7:00 AM. Each trial started with taking five minutes data for physiological responses of the subjects while resting on a stool under shade. After a rest period of half an hour, the selected subjects operated the power weeders. In the trial field, the cotton crop was sown manually in a flat bed at the recommended spacing of 75 × 30 and the performance was compared. The trial field lay out was planned in such a way to operate the power weeder between the rows of crop. The moisture content of the soil during evaluation was 14.48 % on dry basis. The weed species in the trial plot were Crow foot grass *(Dactyloptnium ageuptium), Chloris barabata, Panicum reptens, Parthenium hysteriphorus, Cynodon dactylon, Corchorus capsularis, Cyprus rotundus and Digera arvensis.* Each trial was conducted for a period of 20 minutes. The heart rate was measured with the computerized heart rate monitor. The same procedure was repeated for all the subjects.

Results and Discussion

The physiological response of the subjects for weeding on 30 DAS and 60 DAS with the selected power weeders are furnished in **Table 1**.

The energy cost of weeding was the maximum for the Balram power weeder and minimum for the TNAU Varun power weeder. The subjects expended more energy during the first weeding than the second weeding. The higher energy cost involved in the first weeding might be due to the additional effort required by the subjects in walking in the field with weeds and also guiding the power weeders exactly in between the standing rows of crops. Also the bite of the rotary tynes of the power weeder on the relatively compacted soil induced vibration which might have increased the energy cost of the subjects. The mean values of oxygen consumption rate (OCR) in terms of the per cent maximum aerobic capacity were above the AWL of 35 % VO_2 maximum. Also the work pulse for the TNAU Varun power weeder, Oleo power weeder and Balram power weeder were greater than the LCP value of 40 beats min^{-1}, which showed that the weeders could not be operated continuously for 8 hours without a rest period.

The mean values of the rest period required by the subjects for performing weeding operation are furnished in **Table 2**.

In general forty five minutes of work followed by 8-12 minutes of rest was required for the operation of selected power weeders with the selected subjects. The mean values of Overall Discomfort Rating (ODR) of the power weeders are furnished in **Table 3**.

The mean values of BPDS of selected subjects for first and second weeding are furnished in **Table 4**. It was observed that the pattern of regional discomfort varied with different operating conditions. It was quite evident from the results that as the forward speed increased, the discomfort score increased for all the operations at all levels of forward speed (Pessina, 1986). It was observed that the body part discom-

Table 2 Rest period required by male subjects for operation of power weeders

Forward speed, km h^{-1}	Total working time, min	Rest required, min
A. TNAU - Varun power weeder		
1.5	45	8.51
1.8		8.91
2.1		9.24
B. Oleo power weeder		
1.5	45	8.85
1.8		9.1
2.1		10.51
C. Balram power weeder		
1.5	45	9.01
1.8		10.35
2.1		11.85

Table 3 Overall Discomfort rating of male subjects for weeding in a cotton field

Forward speed, km h^{-1}	Weeding on 30 DAS		Weeding on 60 DAS	
	ODR	Scale	ODR	Scale
A. TNAU-Varun power weeder				
1.5-2.1	5.73	> More than moderate	5.50	> Moderate discomfort
B. Oleo power weeder				
1.5-2.1	5.78	> More than moderate	5.57	> Moderate discomfort
C. Balram power weeder				
1.5-2.1	6.00	> More than moderate	5.77	> More than moderate

fort score (BPDS) of subjects was maximum for the Balram power weeder followed by Oleo power weeder and TNAU Varun power weeder for both the first and second weeding. The maximum number of intensity levels of pain experienced was seven categories (U).

Based on the mean value of overall discomfort score, the discomfort rating was determined at each level of forward speed. The overall discomfort rating for first weeding at selected levels of forward speed of 1.5, 1.8 and 2.1 km h^{-1} varied from 5.73 to 6.00 and scaled as "> more than moderate discomfort" and for second weeding it varied from 5.50 and 5.77 and scaled as "> moderate discomfort".

Ergonomic-Costs-Benefits

The field evaluation results of the selected power weeders are furnished in **Table 5**.

Among the three power weeders, a weeding efficiency of 73.4 % was the highest for with the Oleo power weeder followed by TNAU-Varun and Balram weeders. The cost of operation of the selected three power weeders is furnished in **Table 6**.

The savings in cost with the TNAU-Varun, Oleo and Balram power weeders was 21.5, 16.2 and 23.1 %, respectively, when compared with manual weeding. The savings in time with the TNAU-Varun, Oleo and Balram power weeders was 59.8, 58.6 and 59.8 % respectively when compared with manual weeding.

Table 4 Body part discomfort score of male subjects for weeding in cotton field

Speed	Body part experiencing pain	Score	
		30 DAS	60 DAS
TNAU Varun power weeder			
1.5-2.1	Moderate pain in left shoulder and right shoulder, knees, elbows, palms and mid back, clavicle	28.53	26.06
Oleo power weeder			
1.5-2.1	Moderate pain in left shoulder and right shoulder, knees, elbows, palms and mid back, clavicle	38.42	35.77
Balram power weeder			
1.5-2.1	Moderate pain in left shoulder and right shoulder, knees, elbows, palms and mid back, clavicle	44.46	41.47

Conclusion

The greatest constraint of crop production were land preparation and weeding. The former constraint was due to the energy requirement, and, hence, power demand with time was usually a limiting factor, and the latter because of the labourious, time-consuming nature of the work. The fact that there was such a

Table 5 Results of performance evaluation of power weeders in cotton

Details	TNAU Varun power weeder	Oleo power weeder	Balram power weeder	Manual weeding
Wet weight of weeds collected after weeding operation, gm/m^2	263.9	293.7	324.6	429.9
Wet weight of weeds left in the field after weeding operation, gm/m^2	151.7	106.8	210.6	91.2
Total wet weight of weeds, gm/m^2	415.6	400.5	535.2	520.9
Weeding efficiency, %	63.5	73.4	60.6	82.6
No. of plants for 30 m length	155	155	155	155
Damaged plants	11	4	12	2
Percentage of damage	7.1	2.6	7.7	1.3
Depth of operation, cm	8	6	6	-

Table 6 Economics of power weeders in the cotton crop

Details	TNAU Varun power weeder	Oleo power weeder	Balram power weeder	Manual weeding
Cost of weeding, Rs./hr	126.03	113.37	123.29	15.15
Field capacity, ha/hr	0.06	0.05	0.06	290.0 women hrs/ha
Cost of weeding, Rs./ha	2,100.5	2,267.4	2,054.8	4,393.5
Cost of manual weeding in between plants after power weeder operation, Rs./ha (100 women hr/ha @ Rs.15.15/hr)	1,515	1,515	1,515	-
Total cost of weeding, Rs./ha	3,615.5	3,782.4	3,569.8	4,393.5
Saving in cost when compared to conventional method, %	21.5	16.2	23.1	-
Saving in time when compared to conventional method, %	59.8	58.6	59.8	-

strong interaction between the two brings ergonomic considerations to the fore. Power weeders have been developed for the mechanical control of weeds in crops such as cotton, sugarcane and orchard. The ergonomics aspects of power weeder is of great importance as working with a power weeder involves considerable physical strain to the operator.

The TNAU-Varun power weeder, Balram power weeder and Oleo power weeder with the selected 12 male subjects were ergonomically evaluated. The weeding in the cotton crop with power weeders was performed on 30 and 60 DAS at 1.5, 1.8 and 2.1 km h^{-1} forward speed of operation. The heart rate, energy cost, oxygen consumption rate in terms of VO_2 maximum and work pulse for the weeding operation in cotton crop with TNAU-Varun power weeder was 123.32 beats min^{-1}, 23.00 kJ min^{-1}, 52.34 % of VO_2 maximum and 46.47 beats min^{-1}, respectively. The corresponding values for Oleo power weeder was 130.19 beats min^{-1}, 23.96 kJ min^{-1}, 57.40 % of VO_2 maximum and 47.82 beats min^{-1}, respectively. For Balram power weeder, the values were 134.09 beats min^{-1}, 24.45 kJ min^{-1}, 58.59 % of VO_2 maximum and 44.42 beats min^{-1}, respectively. With the increase in forward speed, the mean heart rate and the corresponding oxygen consumption rate increased for all the selected weeders. The energy cost of weeding was graded as “Heavy” at all selected levels of forward speed of three power weeders. The energy cost of weeding was maximum for the Balram power weeder and minimum for the TNAU Varun power weeder. In general, forty five minutes of work followed by 8-12 minutes of rest was required by the subjects for the operation of selected power weeders. Among the three power weeders, the Oleo power weeder had the highest weeding efficiency of 73.4 %. The saving in cost with TNAU-Varun, Oleo and Balram power weeders was 21.5, 16.2 and 23.1 %, respectively, when compared with manual weeding. The saving in time with the TNAU-Varun, Oleo and Balram power weeders was 59.8, 58.6 and 59.8 %, respectively, when compared with manual weeding.

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A Simple Milk Churner for Ghee-Making

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Abstract

Most smallholder dairy farmers in sub-Saharan Africa do not have access to grid electricity due to their sparse location and, thus, do not have means for cooling their milk. Their evening milk cannot get to markets the next day without spoiling. Where possible, the evening milk is consumed locally. In cases where there is no local market, the milk is either wasted or used to make a ghee-like product. Fermented milk (*makamo*) churning is the most laborious and time consuming component of the ghee-making process. Additionally, the traditional manual process is considered unsatisfactory with respect to meeting acceptable hygiene standards. This report includes the design, construction and testing of a simple milk churner for smallholder dairy farmers that reduces traditional churning process time from 8 to 1 hour, while improving production hygiene.

Introduction

In Uganda, the livestock subsector contributes approximately 20 % of the agricultural GDP and approximately 50 % of this is attributed to the dairy industry. Cattle dominate the livestock species in terms of numbers and monetary value and account for almost 90 % of the domestic animal biomass. It has been estimated that 90 % of the national cattle heard is in the hands of mixed farm smallholders and pastoralists, who are sparsely distributed. Most of these farmers are able to sell their morning milk to cooperatives or middlemen, who then resell the milk, without any processing, to urban retailers with cooling facilities that serve the general public or to the central processing plant. Because of the sparse location, most smallholder farmers do not have, means for cooling their milk, thus, the evening milk cannot get to markets the next day without spoiling. Where possible, the evening milk is consumed locally. In cases where there is no local market, the milk is either wasted or used to make ghee.

Ghee is widely considered as the Indian name for clarified butterfat prepared from cow, buffalo or mixed milk (Rajorhia, 1993). Fat-based products comparable to ghee have been produced for generations by cattle keeping communities of Africa such as *samin* in Sudan (Hamid, 1993) and *mashita* in Uganda (Sserunjogi *et al.*, 1998). *Mashita* is traditionally made by churning of raw fermented milk (*makamo*). *Makamo* is made by fermentation of good quality raw milk in smoked gourds to which a starter from the previous batch has been added. *Makamo* is then churned to *mashita* in a large gourd by rocking back and forth. *Mashita* is washed with water 3-4 times and then ripened in smaller gourds for 2-4 weeks. *Mashita*,

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alternatively referred to as ghee, can be heat clarified to samuli by heating several batches in an open saucepan with constant stirring. The heating is stopped when the product gives off a pleasant characteristic aroma.

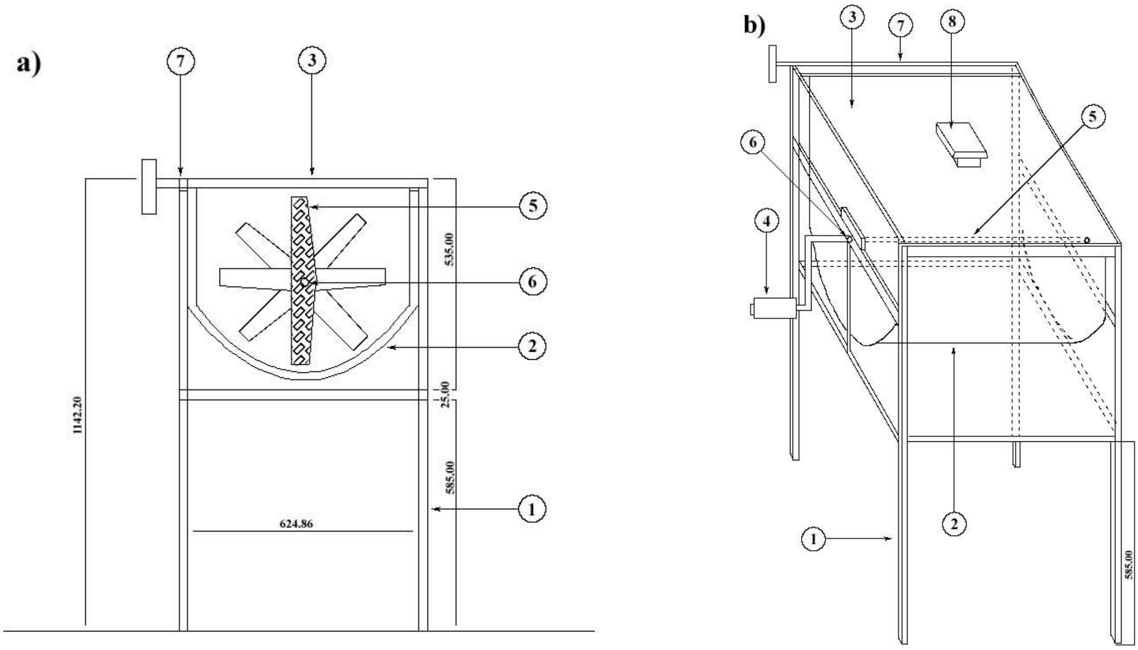
Churning is normally done by women or children and involved rocking the vessel back and forth either suspended from a wooden post or on the ground or on the operator's lap. Churning is the most laborious and time consuming component of the ghee-making process. Additionally, the traditional manual process is considered unsatisfactory with respect to meeting acceptable hygiene standards. The purpose of this project is to enhance the traditional ghee-process productivity while addressing the hygiene issue through a simple churning mechanization.

Solution Concept

Based on experience with ghee-making, the solution sought had to be low cost, simple to use by rural operators, provide easy means to maintain acceptable hygiene standards (e.g., easy to clean) and easy to integrate into current daily activities without major disruption. Mechanizing the churning component of the process with constraints shown in **Table 1** was deemed one of the most viable solutions among several concepts.

The approach adopted was to pattern the design after commercial milk churners used in butter making but at a reduced scale to enable hand operation. A drawing of the churner is shown in **Fig. 1**. It is a semi-cylindrical chamber with a cover and a baffled shaft supported by two bearings at both ends of the chamber. The churner and its cover were made out of wood. The height

Fig. 1 Drawing of the milk churner (all dimensions in mm)



1. support structure, 2. churner chamber, 3. churner chamber cover, 4. handle for hand operation, 5. baffled shaft, 6. bearings, 7. hinge, 8. handle for emptying the chamber cover

Table 1 Constraints

Constraint Description	Comment
To be hand-operated	Most locations do not have grid electricity
To be mainly constructed from locally available materials	Cost of imported materials is usually prohibitive and subject to price fluctuations which increases the economic uncertainty
To be portable	A large percentage of the small holders are nomads that move often in search of grass and water for their animals. Ability to move with the product is likely to substantially expand the customer base
To be robust	This is critical to success of any new product especially give the conditions (rural) and education level of the users (may not be able to follow complicated user instructions)
Maintain acceptable hygiene standards	Parts that get in contact with the ghee need to be easily accessible for cleaning purposes
Pay back period to be less or equal to 12 months	Long payback periods are not popular in a social-political climate with high levels of uncertainty, e.g., political stability, weather patterns, etc.

of the shaft was based on the elbow height of men and women and was 1,035 mm, reduced by 145 mm to enable hand operation in both standing and sitting positions (Kroemer *et al.,* 1997). The churner chamber was fitted with a pivot on the stand, just below its center, to be rotated during draining. A handle was incorporated at one edge of the chamber to facilitate draining (turning the chamber) with one hand.

Design and Construction of the Milk Churner

The following points were considered in the detailed design and construction of the milk churner:

Churner Chamber and Churning Speed

The churner chamber was constructed out of 15 mm thick Cyprus wood with a maximum volume of 92,877 cm^3. For better agitation, the churner should be operated between 1/3 and 1/2 of maximum capacity. A 1/3 capacity translates into 31.9 kg of fermented milk. The minimum acceleration of the shaft together with the baffles should be less than 9.81 m/s^2. Otherwise, the centrifugal force might overcome the force of gravity and the fermented milk (*makamo*)/ cream could follow the motion of the baffles resulting in no churning. Thus, $r\omega^2 < 9.81$, where r and ω are the radius of rotation of the baffles (23 cm) and the angular velocity of baffles in rad/s, respectively. Hence the speed of the baffles should be less than 21.3 rad/s.

Baffled Shaft and Support Structure

Power output at 76 W is a typical peak human performance. However, this output cannot be maintained for a long time. For example, Sentongo-Kibalama (1993, Personal Communication) pointed out that human power (P) varies with time (t) according to $P = 0.139 - 0.0691 \log (t)$ (kW), assuming an average food intake of about 8,300 kJ/day. Applied torque, T_A, came to 3.6 Nm *(90 % × 76 W × 19 rad/s)*.

The four baffles were constructed from Cyprus wood and had a mass of 1.5 kg each and a combined weight of 58.86 kg. The resistive torque, T_R, came to 3.12 Nm (from effective power transferred of 90 % of *76 W = 68.4*) and angular velocity of 19 rad/s. $T_A = 68.4/19 = 3.12$ *Nm*. The 304 annealed stainless steal shaft was sized according to Goodman's equation of fatigue analysis (Shigley and Mischke, 2001) using the above values of T_A, T_R, baffle weight and a factor of safety of 2. A shaft diameter of 12.3 mm was calculated and a standard size of 14.0 mm was selected. Six holes of 20 mm were placed on each side of the baffle as shown in **Fig. 1**, to facilitate better churning and to reduce the weight without affecting the dimensions. Stainless steal bearings were used. Rubber seals were used on the shaft to prevent lubricants from getting in contact with the churner chamber contents. The support was constructed out of 25 mm mild steal square pipes with internal dimensions of 15 mm. All joints were welded using gauge 10 welding rods.

Testing and Economics

The objective of the tests was to estimate the improvement in productivity afforded by the design by determining the time required to separate *mashita* (butter fat) by churning *makamo* (fermented milk). Materials included *makamo*, stop clock, milk churner prototype, and a weigh scale. To determine the time required to separate *mashita*, 10-25 litres of *makamo* were poured into the churner chamber. The *makamo* was churned at 35 rpm and reduced to 10 rpm as the ghee granules coalesced until *mashita* formation was complete. The amount of *mashita* formed was weighed. The tests were replicated four times. The butterfat content of the milk was determined by the Babcock test which involved centrifuging a mixture of equal parts of milk and sulphuric acid. The test was performed at the Dairy Corporation Laboratory in Kampala.

The amount of *mashita* formed from different *makamo* volumes and the associated process times are presented in **Table 2**. The *makamo*

Table 2 Butter fat formation from different milk volumes

Fermented milk (*makamo*) (liters)	Amount of butter fat (*mashita*) (kg) Average (St. Dev.) N = 4	Time (min) Average (St. Dev.) N = 4
10	0.28 (0.01)	31 (1.0)
15	0.45 (0.05)	37 (2.6)
20	0.55 (0.04)	34 (1.7)
25	0.75 (0.08)	35 (2.1)

Table 3 Bill of quantities in US$*

Item	Quantity	Cost
Square steel bars 25 × 25 mm	2 pieces	23.44
Bearings	2 pieces	30.77
Stainless steel shaft	1 piece	12.82
Paint (red oxide)	1 tin	2.56
Cyprus timber	3 pieces	28.21
Vanish	1 tin	2.05
Transportation		10.25
Labor		30.77
TOTAL		**140.87**

*1.00US$ = 1950.00 Uganda Shillings

volume had no effect on the amount of *mashita* formed and the process time. The amount of *mashita* formed compared favorably to the butterfat content of the milk of 3 % (mass/volume). If the churner was operated at full capacity (30 liters) with a process time of 30 min, approximately 2 kg of *mashita* would be produced per hour. It took 8 hours to produce the same quantity while using the traditional gourd churning.

Details of materials and labor costs are presented in **Table 3**. The unit cost was approximately US$ 140.00. The production cost could be halved if batches of 500 or more units were made. Three typical smallholder farmers producing 10 liters of evening milk each can cooperatively use the churner to produce 2 kg of ghee from *mashita* everyday. At a farm gate price of US$ 1.50 /kg of ghee (www.unido-aaitpc.org/unido-aaitpc/new1/uganda/dairy.pdf, accessed on June 18, 2007), the farmers could pay for the milk churner in approximately 50 days *[US$ 140/(2 kg ghee/day × US$ 1.50/kg ghee)]*.

Concluding Remarks

The mechanization of the traditional ghee-making process through improved fermented milk churning for smallholder dairy farmers is technically feasible and economically favorable. Not only does the proposed churner design address the most laborious and time consuming component of traditional ghee-making process, but it also facilitates production under more acceptable hygiene standards. Replacing hand drive with a foot pedal drive could make further improvements in the design.

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Detection of Stress Cracks in Rice Kernels Based on Machine Vision*

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Abstract

A machine vision system was developed to detect different types of stress cracks in rice kernels. An image processing algorithm was used to enhance the object and reduce noise in the acquired image. Rice kernels were classified as those with zero, single, double or multiple stress cracks. Zero and single stress cracks were the easiest to detect. Careful positioning of the kernel over the lighting aperture was necessary for accurate detection of double and multiple stress cracks. This system provided an average accuracy of approximately 96.5 % for no cracks, 93.4 % for a single crack, 84.2 % for double cracks and 83.4 % for multiple cracks compared to human inspection. The processing time was between 0.45 and 0.12 s/kernel.

Introduction

Rice is the leading cereal crop in China. In 2005, the rice production in China was nearly 200 million tons (Department of Agriculture of the People's Republic of China, 2006) which represented about 36 % of the world's rice production. Some properties with low percentages of stress cracks and broken kernels are desirable for food or milling. Physical and mechanical stresses developed in rice kernels as they are harvested, dried, stored and handled induce various quality defects. Defects such as surface splits, starch cracks and chip-offs, caused by mechanical stresses, are external and easily detectable. However, stress cracks, caused by a combination of thermal, moisture and mechanical stresses, are internal and not readily identifiable.

Algorithms were developed based on row gradients and local thresholds to identify areas of surface defects on dried prunes (Delwiche, Tang and Thompson, 1990). Rigney, Brusewitz and Kranzler (1992) inspected asparagus defects with machine vision. Yibin (2000) found that sobel's edge detector was superior to laplacian for background segments and edge detection of fruit image using machine vision. Shahin, Tollner and Gitaitis (2002) studied the classification of sweet onions based on internal defects using image processing and neural network techniques in which Robert's edge detector was used for edge detection from x-ray image. It is more obvious that coarse intensity changes are obtained on a large scale whereas the fine details of intensity changes are obtained on a small scale, so the conflict between restraining noise and extracting details of image was well solved. In recent years, multi-scale wavelet transformation has been widely used in edge detection. Guifang, Ke and Jinwu (2006) detected surface crack defects of medium plates by morphological wavelet. And a method with wavelet demising and multi-scale edge detection was developed to extract defect from ultrasonic images (Yang and Jianzheng, 2003).

This article presents the application of image processing technique based on wavelet transform for accurate detection of stress cracks in rice kernels.

Material and Methods

System Description

A vision system was developed with special hardware to interface with stereo microscope and cameras and with software to implement processing algorithms and drive the

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camera, as shown in **Fig. 1**.

The Nikon SMZ1000 stereo microscope with removable platform was used to acquire the original image of rice kernels with stress cracks, and the Nikon DS-5M-U1 video camera provided maximum resolution of *2560 × 1920* pixels (approximately 4.92 million pixels). A lighting source such as the Schott 1500 LCD fibber optic light source was necessary. The Dell OptiPlexTM GX620 host microcomputer contained a 3.6 GHz CPU, a 1 GBRAM, a 256 MB PCI-Express Graphics Card and a 120 GB hard drive.

Sample Selection

Rice kernels of four varieties namely, Wugeng13, Wuxiangeng14, Eyou512, andyou084 were used in this investigation. These rice genotypes are grown popularly in southern China. The kernels for the experiment were drawn at random from a combine-harvested sample and grouped as those with zero, single, double, and multiple stress cracks, as shown in **Fig. 2**.

Illumination

The need for proper lighting conditions for efficient image processing has been well established. Different lighting modes include front-lighting (illuminating from above the rice kernels), back-lighting (illuminating from below the rice kernels) and side-lighting (illuminating the rice kernels from side with an angle). In this investigation the rice kernels were illuminated by side-lighting from above with 45º angle, which was provided by the Schott, Model 1,500 fibber optic light source. The light source had a maximum of 150 W power rating and provided a maximum light intensity of about 10 Mlx at the fibber optic light guide.

Test Procedure

The rice hulls needed to be removed by handcraft, before the rice kernels were directly placed on the removable platform which was painted black to generate the desired image background. A focusing knob was rotated to adjust the focus of the stereo microscope until the legible image was displayed on the screen (shown in **Fig. 3**).

Stress Cracks Detection

Stress cracks extracted by wavelet transform. According to the Canny rule, a pixel was considered as an edge point in the image when three conditions were met: (1) edge intensity of the pixel was bigger than the adjacent ones along the gradient direction; (2) two adjacent pixels gradient direction had a difference of less than 45 degrees; (3) maximum edge intensity was in the neighborhood of *3 × 3* less than the threshold given before.

When maximum module of wavelet transform coefficient was in the 2^{j+1} scale, named as A. The module of wavelet transform coefficient in the 2^{j+1} scale was determined by signal because the module square of

Fig. 1 Block diagram of the vision system hardware

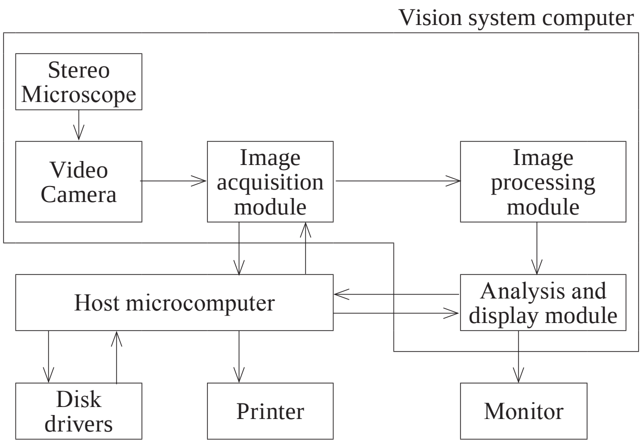
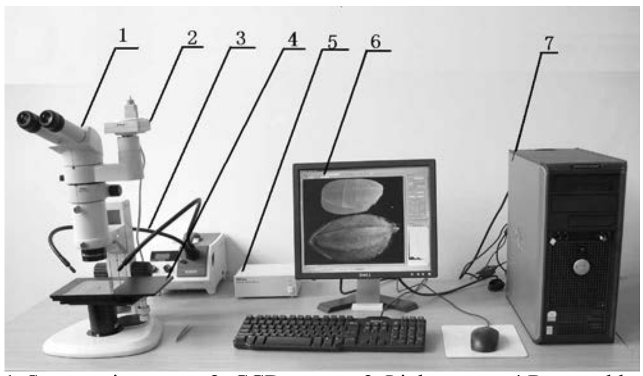
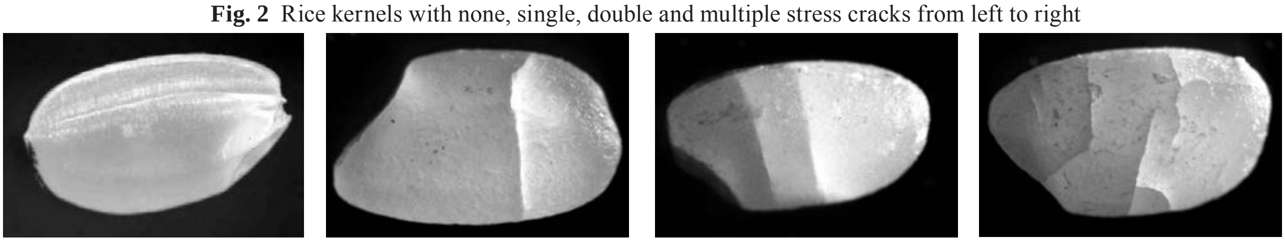


Fig. 3 Computer vision instrument for detecting stress cracks in rice kernels



1. Stereo microscope 2. CCD camera 3. Light source 4.Removable platform 5. Controller 6. LCD screen 7. Computer host

Fig. 2 Rice kernels with none, single, double and multiple stress cracks from left to right



wavelet transform coefficient determined by noise declined with binary velocity while the scale increased. But some smaller modules were likely to be spread by noise in the 2^j scale.

The threshold T was

$$T = \frac{A}{j + c},$$

where c is an integer.

Set modules, less than T, of wavelet transform coefficient was in the 2^j scale zero, because most of them were determined by noise. Pixels that met the 3 conditions above were edges in image.

Stress cracks matching in multi-scales. It was a good method for edge detection from big scale to small scale because noise was restrained in large scale and edge was identified accurately in small scale. Edge displacement was not exceeding one pixel in the adjacent scale, so it just needed to match with the eight neighborhoods in the adjacent scale. According to the signal strangeness, if (x0, y0) was a point and the module of wavelet transform coefficient was not zero at the same time the phase of (x, y) equal to and the module was not less than the one of (x0, y0) in the 2^j scale, where (x, y) was in neighborhood of 3 × 3 of (x0, y0). (x, y) was a pickup point of (x0, y0). If double module square of the pickup point of (x0, y0) equaled the module square of (x0, y0) in the 2^j scale, set the module of (x0, y0) in 2^j scale zero, because it was a noise point.

Stress cracks connecting. The module value reflected edge intensity. The adjacent pixel, if the module was close, was gonging to be connected together to the same chain. The chain would be eliminated, if its length was less than the threshold given (T = 8). The values were chained up in a definite direction to form the so called chain code.

Results and Discussion

The original image of the rice with single, double and multiple stress cracks and the corresponding processed image was shown in **Figs.4**, **5** and **6**, respectively. In the processed images the outer lines define the rice periphery and the stress cracks were represented by lines inside the rice boundary. The algorithm performed very satisfactorily in extracting the stress crack details in 90 % of the rice examined. The success rate was determined by comparing the visual evaluation of rice for stress cracks with the corresponding evaluation of the vision system using the same set of rice.

Rice kernels of four variety samples were detected by human inspection and the computer algorithm simultaneously. The human inspection was performed by viewing each individual kernel directly. Machine vision classification accuracies compared with human inspection are summarized in **Table 1**.

As shown in **Table 1**, the overall accuracy of the computer algorithm for four rice samples was 96.5 % for no cracks, 93.4 % for single cracks, 84.2 % for double cracks and 83.4 % for multiple cracks. The number of zero crack, single crack, double crack and multiple crack kernels in **Table 1** only reflected the percent-

Fig. 4 Original and processed images of a single stress-cracked rice

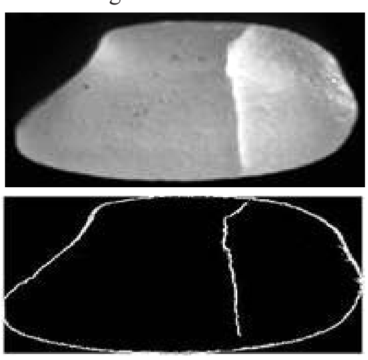


Fig. 5 Original and processed images of a double stress-cracked rice

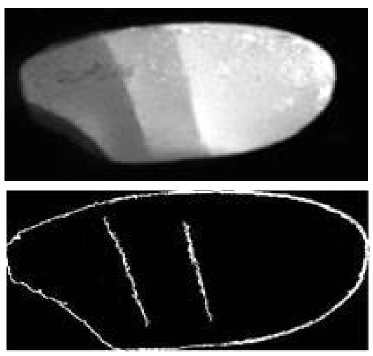


Fig. 6 Original and processed images of a multiple stress-cracked rice

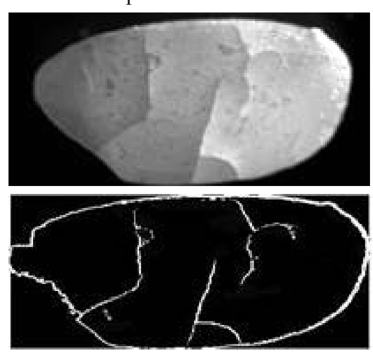


Table 1 Accuracy of the rice kernel with stress cracks classification using machine vision

Variety	Human classified as				Machine classified as				Accuracy/%			
	none crack	single crack	double cracks	multiple cracks	none crack	single crack	double cracks	multiple cracks	none crack	single crack	double cracks	multiple cracks
Wugeng13	438	58	102	28	425	55	85	24	97.0	94.8	83.3	85.7
Wuxiangeng14	426	61	116	32	417	56	93	26	97.9	91.8	80.2	81.3
Eyou512	483	64	123	19	465	60	104	16	96.3	93.7	84.6	84.2
Ⅱ you084	472	76	141	34	447	71	125	28	94.7	93.4	88.7	82.4

ages of different kernel categories in the samples.

Classification error came mainly from kernels that had chalkiness or lines. For those rice kernels, it was difficult to distinguish between chalkiness and stress cracks. Secondly, small unexpected blotches of color that appeared on the surface of the kernel caused mistakes also. Thirdly, the selection of threshold in profile processing was critical, which could cause the loss of meaningful signal components. On the other hand, an under filtered operation could cause the program to over count the zero-crossing number because of the residual noise. The processing time for the rice kernel stress cracks detection program was between 0.45 and 0.12 s from image acquisition to the classification result.

Further improvement in the processing algorithm or illumination condition is required to obtain information of stress cracks with more detail such as length of stress cracks.

Conclusions

1. A hardware system for stress cracks detection in rice kernels based on computer vision was developed.
2. An image processing algorithm by wavelet transform in multiscale was proposed to extract the pixels representing the stress cracks as streaks or lines.
3. Rice kernels were classified as one with none, single, double or multiple stress cracks.
4. This system provided an average accuracy of approximately 96.5 % for zero cracks, 93.4 % for single cracks, 84.2 % for double cracks and 83.4 % for multiple cracks compared to human inspection.
5. The processing time for the rice kernel stress cracks detection program was between 0.45 and 0.12 s from image acquisition to the classification result.

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Economical Evaluation of Mechanization Alternatives for Small Horticulturist in Chillán - Chile

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Abstract

The objective of this work was to perform an economical evaluation of three mechanization alternatives for small horticultural producers. In order to achieve this, data were gathered through surveys of the PRODESAL committee of Chillan Viejo, province of Ñuble, Chile. Data were also gathered about the models of rototillers sold in Chile. The effective work capacity of each rototiller model and horses was calculated. The maximum area that could be worked with one horse was 2.5 hectares.

T maximum with the smallest rototiller was 3.8 hectares and with the largest rototiller was 5.3 hectares. The area worked per year was larger because they obtain 2 or 3 crops per year. The minimum economical use intensity was calculated, as it was the annual equivalent cost for each rototiller model. These indicators showed that they became bigger as the power and the hours of annual use increased. The smallest hourly cost corresponds to the smallest rototiller. However, the smallest cost per unit area corresponded to the larger rototillers. On the other hand, and considering that the maximum area that could be worked with one horse was 2.5 hectare the annual equivalent cost of one traction horse was smaller than any of the rototillers evaluated.

Introduction

The horticultural production in Chile is an increasingly important sector, with a growth of 19 % and 54 %, of area and production, respectively, between 1988 and 1998. In the year 2000 the horticultural area in the Bio - Bio region reached 8,200 ha (ODEPA, 2000). The horticultural orchards in Chile have a very wide set of vegetable species, among which tomatoes, corn, onion, fresh green beans, lettuce, pumpkin and green vetch stand out (FIA, 2000).

Agricultural mechanization fulfills a fundamental role in increasing production. In fact, mechanization permits an increase in the cultivated area, improves the till techniques, decreases costs and dignifies the human work.

In agriculture, a combination of human, animal and mechanical power source is used. This kind of combination determines the mechanization level of manual technology, animal power and motorization. The labor of human workers has a limited performance, compensated by the versatility, ability and judgment capability. So the human worker has a superior capability to do jobs where these capabilities are required, like transplanting, thinning, weeding orchards and fruit or vegetable selective harvest. The human worker is less competitive to

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do jobs that need more power, like water pumping and primary tillage. A farmer that uses only manual technology can cultivate one approximately hectare (Inns, 1992 and Odigboh, 1999).

On the other hand, the use of animal power has great importance, because the small and medium size farmers need power sources that are economical, practical and easy with low level maintenance and operation. Also their work capacity and cost level must be appropriate to the size farm (Hetz and Carrasco, 1987).

Rototillers, called one-axle tractors, are power sources associated, mainly, with rice production in the Asian countries and with horticultural production in temperate climate countries. In Chile, according to the last agricultural census, there are only 73 rototillers, indicating their scarce use (INE, 1997).

Rototillers can be classified, according to their power, in three groups. The first group has the small engine with no power take off axle (PTO) and no rotational equipment can be installed. Groups two and three have larger engines with PTO, and other equipment can be installed, like plows, rakes, rototillers, weed choppers, levelers and sweepers (Cañavate and Hernanz, 1989; Lara and Chancellor, 1999).

Agricultural operations have a time limit for their execution so that yields will not be affected. Generally, the small farmer is limited by this factor since he does not count on the power necessary to fulfill these terms and he is forced to reduce the cultivated area. Therefore, to know the effective work capacity of the equipment, it is very important to determine the area that can be worked with a mechanized system.

In the economic aspects it is important to consider the cost of agricultural machinery utilization, where it is essential to know the operational cost of the machinery used and the cost of agricultural operations (Ibáñez and Rojas, 1994).

The objectives of this research were to establish the mechanized system used by the horticulturists, to compare the effective work capacity (EWC) of each mechanized system, to establish the maximum area that is possible to be worked with each mechanized system, to establish the minimum area that justifies the acquisition of a rototiller, to compare the costs of operation of each model of evaluated rototiller, and to compare the costs of operation of the mechanized systems.

Methodology

General Background

The research was carried out in the Mechanization and Energy Department of the University of Concepción - Chile, at the Chillán Campus, between March 2002 and June 2003. The information was captured through surveys applied to 20 small horticulturists of a committee of 35 producers. The producers belonged to the farmers committee and were supported by the PRODESAL of Chillán Viejo commune, a municipal government institution. Thus, the main vegetables that the farmers cultivate were established in addition to the area that they work and the mechanization degree used.

The information about the rototiller models sold in Chile was requested from the agricultural machinery dealers, with acquisition price of each machine and its respective additional equipment and their technical sheets. The main technical characteristics of each evaluated model are presented in **Table 1**.

Determination of the Ewc and the Maximum Area Possible to Cultivate

Three activities of soil tillage were considered before the planting of the cultures, which are plowing, harrowing and furrow making. In order to establish the EWC of the horse, the results obtained by the surveys and the studies done by Hetz and Carrasco (1987) and Reyes and Hetz (1988) were used.

The EWC (ha h^{-1}) were calculated for the rototiller using equation 1 (Ibáñez and Abarzúa, 1995):

$$EWC = \frac{V \times A \times (1 - t_m)}{10} \text{ .... [1]}$$

Where:

EWC = Effective Work Capacity (ha h^{-1})

V = Working speed (km h^{-1})

A = Work width of the machine

Table 1 Technical characteristics of the evaluated rototillers

Mark	BCS	BCS	BCS	BCS	BCS	BCS
Model	740-A	740-DY	730H	740-D	730A	746D
Fuel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
Power (Hp)	11	10	6.5	7.5	9	13
Speed	4F and 3R	4F and 3R	3A and 2R	3A and 2R	3A and 2R	5A and 2R
PTO (rpm)	965	965	965	965	965	825
Wheel	5 × 12	6.5 × 12	5 × 10	5 × 10	5 × 10	6.5 × 15
Mass (Kg)	103	116	79	95	93	140
Tank capacity (lt)	4	4	3.5	4	4	6

Source: Technical sheets, IMPEX Importer.

(m)

t_m = Idle time of the operation, expressed as a decimal fraction.

A calendar of agricultural operations done in the area was established and the periods of greater demand of soil tillage before sowing or transplant for the vegetable species were identified.

Using the results obtained by Hetz *et al.*, (2003), on the appropriate days to do mechanized agricultural operations in Central Ñuble and the EWC for the work with horse and each model of rototiller, the maximum area possible to work in every climatic biweekly period of 14 days was considered.

The maximum area that can be cultivated with each mechanized system was estimated, using the area possible to work in the two consecutive biweeks, with the smaller number of appropriate days to do mechanized agricultural operations in the period of greater demand. In addition, considering that horticultural production in the Chillán area has a rotation of two or three cultures during the year, the worked maximum area during the year was estimated as 2 or 3 times the maximum area possible to work in the period of greater demand.

Useful Life

In the work done by a horse the useful life considered was 12 years with an annual use of 500 hours (Hetz and Carrasco, 1987). In the work with rototillers a useful life of 4,000 hours (Odigboh, 1999) was considered, with different intensities of annual use that go from 250 to 500 hours. This meant different years of useful life (8, 10, 11 and 16 years).

Determination of Costs

In the work with animal traction four components of the total operational cost were distinguished. They are; the cost of the equipment, the animal (horse) and its feeding, the harness and the operator (Reyes and Hetz, 1988).

For the cost with rototillers, the method developed by Schwartz (1974) and mentioned by Ashburner and Sims (1984) was used. This method considerd the following factors; depreciation, interest on the investment, insurance, repair and maintenance, fuel and lubricants and operator.

Investment

The initial investment corresponds to the payment done at the time of acquiring the machine This cost does not consider the purchase tax (Ibáñez and Rojas, 1994), because the farmers discount this value from their tax payment when they sell their production. The initial investment in the work with animal traction considered the cost of acquisition of the horse, harness, iron plow and spike harrow. In the use of the rototiller the cost of acquisition of the equipment, iron plow, rototiller and furrower were considered.

Operational and Maintenance Cost

The operational costs for each level of mechanization were divided into fixed and variable costs.

Fixed Costs (FC)

The FC considered in the use of animal traction were pasturing, lodging, depreciation and the interest on capital (Reyes and Hetz, 1988). In rototiller utilization depreciation, the interest on capital, the annual payment for insurance (2 % of the average value) and the initial and recovery value of each machine was considered (Benedetti and Gallegos, 1983).

Variable Costs (VC)

The VC were those directly related to the use of each mechanized system.

In the case of the use of the horse the annual costs considered were food concentrate, sanitary attention, shoes, repair and maintenance of the accessories and wages of the operator. These costs were calculated through the methodology proposed by Reyes and Hetz (1988). In the case of the rototiller, the annual costs considered were fuel, repair and maintenance, lubricants, operator and unforeseen expenses. These costs were calculated through the methodology proposed by Ashburner and Sims (1984).

Economic Minimum Intensity of Use (EMIU)

The EMIU is a concept that helps to establish the convenience of buying a machine instead of buying the service when the area or the volume to work justifies it (Ibáñez and Villar, 1994). For the calculation of the EMIU, equation 2 was used.

$$EMIU\ (h\ year^{-1}) = \frac{AFC}{(Tariff - VC)} \quad \text{.......} [2]$$

Where:

AFC = Annual fixed cost of the owned equipment, expressed in \$ $year^{-1}$

Tariff = Tariff that is charged by an equal service, in \$ h^{-1}

VC = Variable costs, including the operator, in \$ h^{-1}

For the calculation of the tariff, equation 3 (Ibáñez and Villar, 1994) was used.

$$Tariff\ (\$\ h^{-1}) = FC + VC + MC + AC + MU \quad \text{.......}[3]$$

Where:

FC = Fixed cost of the equipment (\$ h^{-1})

VC = Variable cost of the equipment (\$ h^{-1})

CMO = Operator cost (\$ h^{-1})

AC = Administration cost (\$ h^{-1}), considered as 10% of the operational cost

$(CF + CV + CMO) \times 0.10$

MU = Minimum profit (\$ h^{-1}), considered as 20 % of the previous values

$(CF + CV + CMO + CA) \times 0.20$

Comparison of Mechanization Alternatives through the Annual Equivalent Cost (Aec)

In this study, the economic calculations were done considering the effective prices of the machines, inputs and operator on March 2002. The prices were surveyed in Chilean pesos and expressed in US dollars without the national purchase tax (Value Added Tax, VAT) (US$1 = Ch$615.66, March 19 of 2002).

The economic evaluation of each one of the alternatives of mechanization was done with the following assumptions:

- The prices do not include VAT.
- The prices considered for the rototiller correspond to values of new machines.
- The alternatives are mutually excluding and offer the same service.
- The interest rate considered was 6.5 % annual over inflation that corresponds to the interest for credits to small farmers by the government service INDAP, a service that supports the small farmers.

The method used to do the economical evaluation was the Annual Equivalent Cost (AEC), defined by Blank and Tarquin (1992). The annual equivalent cost was an annual installment that represents all the ownership, maintenance and operational costs of equipment during every year of its useful life. AEC can be represented by the following equation:

$$AEC = \frac{I_o}{a_i^n} + AOC - \frac{RV}{S_i^n} \text{...........[4]}$$

Where:

AEC = Annual Equivalent Cost (US$ year^{-1})

I_0 = Initial investment (US$)

a_i^n = Present value of an annual rent received by n years considering an annual rate i (decimal fraction)

AOC = Annual operational cost, it represents the operational and maintenance annual cost (US$ year^{-1})

S_i^n = Annual value of a future rent received in the year n considering an annual rate i (decimal fraction)

i = Annual real interest (decimal fraction)

n = Useful life of the machinery (years)

RV = Market or recovery value for the equipment at the end of its useful life

The calculated AEC with the use of a horse was compared with the cost of rototiller use. Then the AEC of each rototiller model was calculated and the hourly cost (US$ h^{-1}) and worked unit area (US$ ha^{-1}) cost were determined in order to compare them establish the most economic advisable alternative.

The maximum area that could be worked with a horse and its AEC was established. Also the AEC to cover the same area with every mechanized system was calculated and they were compared.

Results and Discussion

Vegetable Production Systems in The Chillán Area

Fig. 1 shows the main species of

Fig. 1 Number of farmer that cultivates each vegetable

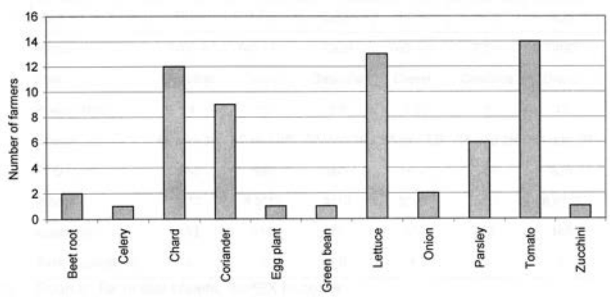

Fig. 2 Cultivated area by each farmer

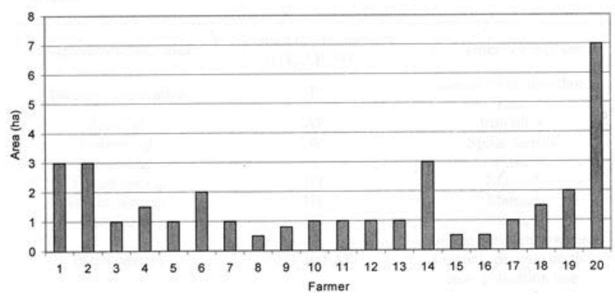

Table 2 Technology applied to field activities and tools used by the farmers surveyed

Agricultural activities	Applied technology (1) (HT, AP, MP)	Equipment or tool used
Seedbed preparation	HT	Shovel, plantation hoe, rake
Plowing	AP	Iron plow
Harrowing	A	Spike harrow
Furrowing	A	Plow
Transplanting	HT	Manual
Direct seeding	HT	Manual
Fertilizing	HT	Manual
Weed control	HT and AP	Tillage between rows and manual spraying on the row, plantation hoe
Harvesting	HT	Manual

HT: Hand technology tools; AP: Animal powered technology; MP: Machine powered technology.

vegetables cultivated by the horticulturists surveyed. They emphasize tomato, lettuce and chard, with a rotation of cultures during the year. The areas planted each time with vegetables vary from 0.5 and 7.0 hectares, with an average of 1.66 ha (**Fig. 2**). **Table 2** shows the main agricultural activities carried out in the culture of vegetables, type of technology applied and tools used by the agriculturists surveyed. It was possible to establish that the mechanized system used is a combination of manual tool technology and horse traction technology, with no utilization of motor machinery.

Ewc and Maximum Area Possible to Work

Table 3 shows the calendar of execution of the agricultural activities for the different species cultivated in the Chillán area. It is possible to appreciate that the period of soil tillage is between August and October. Seeding is done between September and October, because many of these species are sensitive to low temperatures. Thus, they have to be seeded or transplanted after the frost period is finished. Within this group there are tomatoes, chard (spring - summer), lettuce (spring - summer), zucchini, maize, beet root and mature onions. In addition, there is another group of species whose sowing or transplanting period is mainly in May. The reason why the soil tillage is done between March and April is that, in this group, are the cultures of garlic, pea and bean that are re-

Table 3 Scheduling of some agricultural activities for vegetables cultivated in the area studied

Vegetable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tomato	Ha	Ha	Ha					SP	Pl	Hr(2), Fu, Tr		
Chard (spring - summer)									Pl, Hr(2), Se			Ha
Chard (autumn - winter)		Pl, Hr(2), Se			Ha	Ha	Ha					
Lettuce								SP, Pl	Hr(2), Tr			Ha
Corn on the cob	Ha							Pl,Hr(2)	Se			
Zucchini	Ha	Ha	Ha						Pl	Hr(2), Fu, Se		
Beet root		Ha								Pl, Hr(2), Se		
Garlic					Pl, Hr(2), Fu, Se							Ha
Peas			Pl	Hr(2), Fu	Se				Ha			
Mature onion			Ha		SP			Pl, Hr(2)	Fu, Tr			
Lima bean			Pl	Hr(2), Fu	Se					Ha		
Sweet pepper		Ha							SP	Pl, Hr(2), Fu, Tr		
Cabbage	Pl, Hr(2), Fu, Tr				Ha							SP
Carrot							Pl, Hr(2)	Se				Ha

Plowing (Pl), Harrowing (Hr), Furrowing (Fu), Seed (Se), Transplanting (Tr), Harvest (Ha), Seedbed preparation (SP)
Source: Surveys, González (1998) and Velasco *et al.*, (2000)

Table 4 Horse work capacity (h ha^{-1}) for different agricultural activities

Agricultural operation	Survey	Hetz and Carrasco (1987)	Reyes and Hetz (1988)
Plowing	21.9	21	19.7
Harrowing (*)	10.0	6.4	5.2
Furrowing (**)		4.6	
Total	36.5	31.0	29.0

(*) It considers two times. (**) Calculated by equation 1. Source Hetz and Carrasco (1987); Reyes and Hetz (1988) sistant to frost.

Table 4 shows the EWC of the horse obtained by the survey and compared with the ones obtained by Reyes and Hetz (1988) and Hetz and Carrasco (1987). Given the differences among the sources, for calculation affects, the data collected by Hetz and Carrasco (1987) were used.

Table 5 shows the EWC obtained in plowing, harrowing and furrow making operations, for different rototiller models. It is possible to appreciate that as the power increases, its EWC increases. **Table 6** shows the area possible to work in every climatic biweek at a probability level of 0.8. The smallest number of appropriate days to do mechanized agricultural operations corresponds to biweek 12 and 15 with 1.6 days. The period with a greatest number of days corresponds to biweek 4, with 13 days to do these operations. As it was established in **Table 3**, there are two periods of great demand for mechanized operations. The first one corresponds to the months of March and April, whose

Table 5 Effective work capacity of rototillers for different agricultural activities

Fuel	Power (Hp)	Effective work capacity						
		Plow		Furrow		Roto-till		Total
		ha h^{-1}	h ha^{-1}	ha h^{-1}	h ha^{-1}	ha h^{-1}	h ha^{-1}	h ha^{-1}
Gasoline	6.5	0.08	12.6	0.18	5.6	0.17	5.9	24.1
	9.0	0.08	11.9	0.20	4.9	0.22	4.5	21.3
	11.0	0.09	10.6	0.23	4.4	0.26	3.9	18.9
Diesel	7.5	0.08	12.2	0.19	5.2	0.19	5.3	22.7
	10.0	0.09	11.2	0.22	4.6	0.22	4.6	20.4
	13.0	0.10	9.6	0.24	4.2	0.27	3.7	17.5

Table 6 Possible area (ha) to be worked with a horse and rototillers, considering the number of appropriate days for mechanized agricultural activities in Central Ñuble by biweek periods, with a probability level of 0.80

Climatic biweek	Number of days PL 0.8	Area (ha)						
		Horse	Power of rototiller (Hp)					
			6.5	9.0	11.0	7.5	10.0	13.0
1	12.6	2.6	4.2	4.7	5.3	4.4	4.9	5.8
2	12.0	2.5	4.0	4.5	5.1	4.2	4.7	5.5
3	12.0	2.5	4.0	4.5	5.1	4.2	4.7	5.5
4	13.0	2.7	4.3	4.9	5.5	4.6	5.1	6.0
5	12.0	2.5	4.0	4.5	5.1	4.2	4.7	5.5
6	10.0	2.1	3.3	3.8	4.2	3.5	3.9	4.6
7	8.0	1.7	2.7	3.0	3.4	2.8	3.1	3.7
8	8.6	1.8	2.9	3.2	3.6	3.0	3.4	3.9
9	8.2	1.7	2.7	3.1	3.5	2.9	3.2	3.8
10	4.8	1.0	1.6	1.8	2.0	1.7	1.9	2.2
11	2.2	0.5	0.7	0.8	0.9	0.8	0.9	1.0
12	1.6	0.3	0.5	0.6	0.7	0.6	0.6	0.7
13	3.0	0.6	1.0	1.1	1.3	1.1	1.2	1.4
14	2.6	0.5	0.9	1.0	1.1	0.9	1.0	1.2
15	1.6	0.3	0.5	0.6	0.7	0.6	0.6	0.7
16	5.6	1.2	1.9	2.1	2.4	2.0	2.2	2.6
17	7.0	1.5	2.3	2.6	3.0	2.5	2.7	3.2
18	4.6	1.0	1.5	1.7	1.9	1.6	1.8	2.1
19	7.0	1.5	2.3	2.6	3.0	2.5	2.7	3.2
20	9.0	1.9	3.0	3.4	3.8	3.2	3.5	4.1
21	8.0	1.7	2.7	3.0	3.4	2.8	3.1	3.7
22	9.6	2.0	3.2	3.6	4.1	3.4	3.8	4.4
23	11.6	2.4	3.8	4.4	4.9	4.1	4.5	5.3
24	10.6	2.2	3.5	4.0	4.5	3.7	4.2	4.9
25	11.0	2.3	3.7	4.1	4.6	3.9	4.3	5.0
26	12.6	2.6	4.2	4.7	5.3	4.4	4.9	5.8

In bold numbers periods of largest demand climatic biweeks are 6, 7, 8 and 9. The second one corresponds to the months of August, September and October, whose climatic biweeks are from 16 to 21. Within these weeks the one that has the least number of appropriate days to do mechanized agricultural operations corresponds to week 18 with 4.6 days (**Table 6**). With this, the horse can cover 1.0 ha, the smallest power rototiller can cover 1.5 ha, and the most powerful 2.1 ha. The two consecutive biweeks with the smallest number of appropriate days correspond to biweek 18 and 19, with 11.6 days (**Table 6**).

Table 7 shows the maximum area possible to be cultivated in the most critical period (biweek 18 and 19) with different mechanization alternatives With a horse 2.5 ha can be cultivated, the smallest power rototiller (6.5 HP) can work 3.8 ha and the most powerful (13 HP) can cover 5.3 ha. In addition, **Table 7** shows the maximum area possible to cover, considering a rotation of two and three cultures during the year. A horse can cover 7.5 ha, the smallest power rototiller 11.4 ha and the most powerful one 15.9 ha.

EMIU for Rototiller

Table 8 shows the values of EMIU that justify the acquisition for each rototiller model considering different useful lives. It can be appreciated that, as the power increases, the area that can be worked increases with each model. Also, it is possible to see that the models with diesel engines justify their ac-

Table 7 Possible area to be worked in the period of maximum demand and possible area to be worked considering two or three cultures in one year

	Area (ha)						
	Horse	Power of rototiller (Hp)					
		6.5	9.0	11.0	7.5	10.0	13.0
Area possible to be worked in the period of maximum demand (biweek 18 and 19)	2.5	3.8	4.3	4.9	4.1	4.5	5.3
Maximum area possible to be worked considering two cultures in one year	5.0	7.6	8.6	9.8	8.2	9.0	10.6
Maximum area possible to be worked considering three cultures in one year	7.5	11.4	12.9	14.7	12.3	13.5	15.9

Table 8 Economic minimum intensity of annual use (ha year^{-1}), for different useful lifetimes of rototillers

Fuel	Power (Hp)	Useful lifetime (year)			
		Economic minimum intensity of annual use (ha year^{-1})			
		8	10	11	16
Gasoline	6.5	9.8	8.1	7.3	5.4
	9.0	10.3	8.5	7.6	5.7
	11.0	11.4	9.7	8.5	6.4
Diesel	7.5	11.9	9.7	8.6	6.3
	10.0	12.9	10.5	9.4	6.9
	13.0	15.6	12.5	11.1	8.2

Table 9 $AEC_{6.5\%}$ (US$ year^{-1}), estimated for agricultural activities done by a horse

	Time (year)												
Item[1]	0	1	2	3	4	5	6	7	8	9	10	11	12
Investment	380.2												
Capital recovery													-266.6
Fixed cost													
Lodging		7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
Pasturing		182.7	182.7	182.7	182.7	182.7	182.7	182.7	182.7	182.7	182.7	182.7	182.7
Variable cost													
Operator salary		200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
Concentrated food		27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
Veterinary care		76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5	76.5
Horse shoeing		19.7	19.7	19.7	19.7	19.7	19.7	19.7	19.7	19.7	19.7	19.7	19.7
Annual cash flow	380.2	513.5	513.5	513.5	513.5	513.5	513.5	513.5	513.5	513.5	513.5	513.5	246.9
$AEC_{6.5\%}$ (US$ year^{-1})	544.8												

1: Cost (+) and income (−)

quisition because of the greater area than with gasoline engines. Note that the acquisition prices of diesel engine rototillers are greater than those with gasoline engines.

AEC for The Horse Utilization

The calculation of the AEC for the traction horse use is shown in **Table 9** with an annual use of 500 h. doing different agricultural operations like plowing, harrowing and transport. It shows that the greater cost involved is the wage of the operator.

AEC for The Rototiller Utilization

Table 10 shows an example of calculation of AEC (US$ year $^{-1}$) for one rototiller model evaluated. The annual use is the most important variable in the AEC and it is possible to establish that an increase in the annual use produces an increase in the AEC, as shown in **Table 11**, but produces a decline in the hourly cost as well (**Table 12**). **Table 13** shows the cost per unit area and that increasing the annual use reduces the cost per unit area.

The leasing of a tractor to do plowing and harrowing has a cost of 100 US$ ha $^{-1}$ (Casanova, E. 2004. Mechanized Services Inc., Chillán, Personal communication). This value is greater than the cost per unit area of anyone of the evaluated rototillers. In addition, this type of machinery is geared, generally, for wider areas, with no access of this kind of services to the small horticulturists.

Table 10 $AEC_{6.5\%}$ (US$ year $^{-1}$), estimated for agricultural activities done by the rototiller **BCS** model **730A**

	Time (year)										
Item[1]	0	1	2	3	4	5	6	7	8	9	10
Investment	2542.6										
Capital recovery											−506.1
Fixed cost											
Insurance		50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6
Variable cost											
Fuel		403.9	403.9	403.9	403.9	403.9	403.9	403.9	403.9	403.9	403.9
Lubricant		20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2
Maintenance and repairing		4.9	14.6	24.2	34.1	43.7	53.6	63.2	72.8	82.7	92.3
Operator		344.6	344.6	344.6	344.6	344.6	344.6	344.6	344.6	344.6	344.6
Unforeseen expenses		38.8	39.3	39.7	40.2	40.7	41.0	41.5	42.0	42.5	43.0
Annual cash flow	2542.6	862.5	872.9	883.0	893.4	903.5	913.6	924.0	924.0	944.2	449.3
$AEC_{6.5\%}$ (US$ year $^{-1}$)	1218.0										

1: Cost (+) and income (−)

Table 11 $AEC_{6.5\%}$ (US$ year $^{-1}$), for different intensities of annual use

Fuel	Power (Hp)	AEC (US$ year $^{-1}$) Annual use (hour)			
		500	400	350	250
Gasoline	6.5	1,424.4	1,184.9	1,064.0	809.7
	9.0	1,644.1	1,365.1	1,226.9	933.1
	11.0	1,831.7	1,518.2	1,340.4	1,036.8
Diesel	7.5	1,468.8	1,236.8	1,123.2	876.3
	10.0	1,577.4	1,325.6	1,204.7	933.1
	13.0	1,853.9	1,562.6	1,421.9	1,110.9

Table 12 Hourly Cost (US$ h $^{-1}$), for different intensities of annual use

Fuel	Power (Hp)	Hourly cost (US$ hour $^{-1}$) Annual use (hour)			
		500	400	350	250
Gasoline	6.5	2.84	2.96	3.04	3.23
	9.0	3.28	3.41	3.51	3.73
	11.0	3.65	3.80	3.83	4.15
Diesel	7.5	2.94	3.09	3.21	3.51
	10.0	3.16	3.31	3.43	3.73
	13.0	3.70	3.90	4.05	4.44

Comparison of Costs between Alternatives

Table 14 shows AEC of each system for 2.5 ha doing tillage before the establishment of the culture. When 2 and 3 cultures are grown around the year, it is possible to appreciate that the horse has the smallest cost, followed by the smallest power rototiller.

Conclusions

1. Vegetable production in the Chillán area has a very low level of mechanization; no motor machines are used to carry out these operations.
2. The Effective Work Capacity of the rototiller is bigger than that of the horse, and, for the rototiller, this capacity increases as the power increases.
3. A horse can cultivate 2.5 ha, but the rototiller of smallest power can cultivate 3.8 ha and the most powerful rototiller can cultivate 5.3 ha.
4. The smallest power rototiller has the smallest Annual Equivalent Cost and the Economic Minimum Intensity of use. The value of these indicators increases as the power of the rototiller and the hours of annual use increase, with larger values for the rototiller with diesel engine.
5. The smallest hourly cost corresponds to the smallest power rototiller. Nevertheless, the smallest cost per unit area corresponds to the 10 HP tiller.
6. Considering the area that a horse can work (2.5 ha), it is concluded that the Annual Equivalent Cost of animal traction is smaller than the Annual Equivalent Cost of the rototillers considered in this study.

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Table 13 Cost by unit area (US$ ha^{-1}), for different intensities of annual use

Fuel	Power (Hp)	Cost by unit area (US$ ha^{-1}) Annual use (hour) 500	400	350	250
Gasoline	6.5	72.1	75.0	77.0	82.2
	9.0	70.8	73.3	75.3	80.2
	11.0	70.1	72.6	73.3	79.5
Diesel	7.5	68.4	71.8	74.8	81.5
	10.0	64.7	68.1	70.8	76.8
	13.0	67.1	70.8	73.6	80.5

Table 14 Work capacity (h ha^{-1}), required time (hour) and $AEC_{6.5\%}$ (US$ year^{-1}) for two and three cultures per year, doing tillage labor, for 2.5 hectares

Mechanized system	Power, Hp	Work Capacity, h ha^{-1}	Required time, hour: 2 cultures per year	Required time, hour: 3 cultures per year	AEC, US$ year^{-1}: 2 cultures per year	AEC, US$ year^{-1}: 3 cultures per year
Horse		31	155	233	560.4	634.4
Gasoline Engine	6.5	25	127	190	599.9	706.0
	9.0	22	108	161	644.1	750.5
	11.0	19	96	144	688.7	797.4
Diesel Engine	7.5	23	116	174	701.1	775.1
	10.0	21	103	154	725.8	797.4
	13.0	18	91	136	846.7	930.7

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■■

Mechanical Harvesting of Fodder Maize as Influenced by Crop, Machine and Operational Parameters

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Abstract

The efficiency of the reciprocating type cutter bar is influenced by the dynamic cutting force exerted by the cutter bar on the crop. The appropriate crop, machine and operational variables that influence the force required for cutting fodder maize stalks were identified. For recording the dynamic force required for cutting maize stalk, a cutter bar test rig was developed. The investigation was carried out with two levels of stroke length of cutter bar *viz.,* 76.2 and 90.0 mm, three levels of cutter bar speed *viz.,* 1.5, 1.75 and 2.0 ms^{-1}, four levels of diameter *viz.,* 10, 15, 20, and 25 mm and three levels of moisture content of maize stalk (completely dry forage, semi dry and green forage). The peak cutting force requirement was directly proportional to diameter and inversely proportional to moisture content of maize stalk and cutter bar speed. The cutter bar with stroke length of 90.0 mm registered 6.3 to 28.7 % reduction in peak cutting force as compared to 76.2 mm stroke length for the selected levels of cutter bar speed, diameter and moisture content of maize stalk. The peak cutting force of 272.4 N was registered for a combination levels of 71.2 % moisture content, 25 mm stalk diameter, 2.0 ms^{-1} cutter bar speed and 90.0 mm stroke length.

Introduction

Harvesting forage at optimum stage of maturity is crucial for ensuring quality and productivity of fodder crops. Standing crops of cereals, oilseeds, fodder, fibre and other similar vegetative crops are cut mechanically by reciprocating cutter bar. The efficiency of the reciprocating type cutter bar is influenced by the dynamic cutting force exerted by the cutter bar. The quality of cutting the stalk is highly influenced by speed of the cutter bar. The most significant features of the reciprocating cutter bar are stroke length and operational speed of the cutter bar knife. Other than the stroke length of the cutter bar knife and operational speed, the most important factor affecting dynamic force required for cutting crop stalk is the diameter of crop stalk and moisture content of the crop.

In the present investigation, the effect of machine and crop variables *viz.,* stroke length of cutter bar, cutter bar speed, diameter and moisture content of the maize stalk on peak cutting force was analyzed.

Review of Literature

The resistance of the crushed and cut plants depends on rigidity of stalks, diameter of crop, moisture content of stalk and density of growing plants (Czeslaw Kanafojski, 1972). The force required for shearing forage is affected by forage species, maturity and moisture content (Ige and Finner, 1976). Mohsenin (1986) investigated the physical properties of plant materials and reported that ultimate shear strength is found to be inversely proportional to dry matter density.

The moisture content, stem diameter and shear strength are relevant properties to cutting (Jekendra, 1999). With increase in cutting speed, stalks are cut without flattening and the resistive force decreases (Prasad and Gupta, 1975; Das, 1998; Devnani, 1998 and Pandey, 1998). The cutting process is greatly influenced by physical and rheological properties of crops in harvesters. The increased speed also resulted in high inertia force of cutter bar and vibration of machine, which limits the speed of cutter bar (Devnani, 1998).

Methods and Materials

Uniformity of cut and cutting efficiency depends upon the stroke length of the cutter bar knife. The stroke length for a given cutter bar knife determines the amount of space between the knife for the stalk to flow in during the operation. The quality of the cut stalk and power required for the cutting operation are highly influenced by the speed of the cutter bar. The most important crop factor affecting dynamic cutting force required for cutting crop stalk is the diameter of crop stalk. The moisture content of the stem has a direct correlation with the force required for cutting, in addition to the diameter of the crop. Hence, the following variables are selected for investigating the dynamic force required for cutting maize fodder crop using a cutter bar test rig.

1. Stroke Length of cutter bar (L) = 2 levels
   i. 76.2 mm = (L_1)
   ii. 90.0 mm = (L_2)
2. Cutter bar speed (S) = 3 levels
   i. 1.50 ms^{-1} = (S_1)
   ii. 1.75 ms^{-1} = (S_2)
   iii. 2.00 ms^{-1} = (S_3)
3. Stalk diameter (D) = 4 levels
   i. 10 mm = (D_1)
   ii. 15 mm = (D_2)
   iii. 20 mm = (D_3)
   `iv. 25 mm = (D_4)
4. Moisture content in wet basis (M) = 3 levels
   i. Completely dried crop = (M_1)
   ii. Semi-dry crop = (M_2)
   iii. Green crop = (M_3)

For recording the dynamic force required for cutting fodder maize crop stalks, a cutter bar test rig was developed (**Fig. 1**). The test rig consisted of a main frame, cutter bar assembly, power transmission, variable speed drive, load cell and high speed data acquisition system. A total of 216 randomly replicated experiments were conducted using the test rig with selected levels of variables. The data acquired during the cut was displayed as a force-time curve on a personal computer (McRandal and McNulty, 1978). The dynamic force sensed by the load cell was exported to an Excel spread sheet. Here, the force-time curve was converted into the force-distance curve. The number of readings obtained in one revolution of the crankshaft (N) was calculated from the curve obtained from the PICOLOG software. The rotation angle between successive readings (Δ) was calculated using the following expression,

$\Delta = 360/N$ ....(1)

where

Δ = Rotational angle between successive readings, degrees and

N = Number of data obtained for one revolution of crankshaft.

The movement of cutter bar between successive readings was calculated using the following expression.

Movement of cutter bar =

$r - r \times \cos [\Delta \times (\pi / 180)]$ ....(2)

where

r = Radius of the crankshaft, mm and

Δ = Rotational angle between successive readings, degrees.

The force-distance curve for the portion of interest (i.e. cycle at which cutting of stalk was carried out) was compared with the reference cycle (idle stroke) to calculate the force required for cutting the stalk. The typical comparison curve is shown in **Fig. 2.** From the curve, the force required for cutting was

Fig. 1 Cutter bar test rig

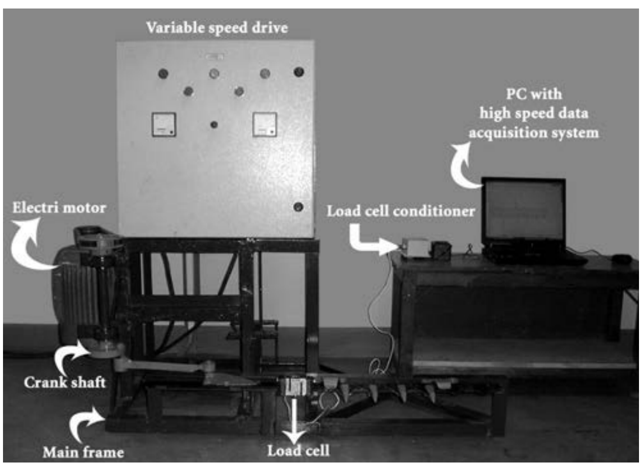
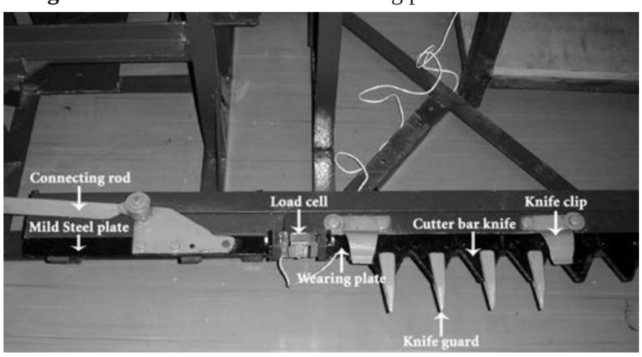


Fig. 2 Load cell connected to wearing plate of the cutter bar



obtained by subtracting the inertial forces and frictional force of idle reciprocation from the gross dynamic cutting force. The force calculated for each position of the cutter bar was plotted as a force - distance curve as shown in **Fig. 3**. The peak cutting force (PFc) required for harvesting the selected maize fodder crops was recorded for all treatments.

Results and Discussion

For 76.2 mm stroke length cutter bar (L_1), the relationship between peak cutting force and cutter bar speed is shown in **Fig. 5**. Increase in cutter bar speed from 1.5 (S_1) to 2.0 ms^{-1} (S_3) resulted in 20.8 to 29.6 percent reduction in peak cutting force. This might have been due to the fact that, at low cutter bar speed, the stalks become flattened and crushed and the cutting process was accompanied by large resistive forces. With increase in cutter bar speed, the stalks were cut without flattening or crushing and the resistive forces decreased. The peak cutting force required for harvesting maize stalk increased by 15.5 to 41.1 % with increase in diameter from 10 (D_1) to 25 mm (D_4). Increase in moisture content from 71.2 (M_1) to 83.5 % (M_3) resulted in 15.0 to 44.9 % reduction of peak cutting force required for the selected levels of diameter of maize stalk and cutter bar speed. This might be attributed to the fact that as the moisture content of stalk reduced, the cells dried out and the stem shrunk. For a given sectional area, the cutting resistance was more when the moisture content was less. Hence, the peak cutting force decreased with increase in moisture content. The minimum value of peak cutting force was 212.42 N at 2.0 ms^{-1} cutter bar speed (S_3) with 10 mm diameter stalk and 83.5 % moisture content (M_3). The maximum value of peak cutting force was 455.11 N at 1.5 ms^{-1} cutter bar speed for 25 mm diameter (D_4) with 71.2 % moisture content (M_1).

For 90.0 mm stroke length (L_2) the relationship between peak cutting force and cutter bar speed is illustrated in **Fig. 6**. Increased cutter bar speed from 1.5 ms^{-1} (S_1) to 2.0 ms^{-1} (S_3) led to 30.9 to 42.1 % reduction in peak cutting force for the selected levels of diameter of stalk and moisture content of crop. The minimum cutting force of 168.59 N was at 2.0 ms^{-1} (S_3) for cutting 10 mm diameter with 83.5 % moisture content. Increased moisture content from 71.2 (M_1) to 83.5 (M_3) % resulted in 17.4 to 50.4 % reduction in peak cutting force for the selected levels of diameter of stalk and cutter bar speed. The peak cutting force was higher for stalks with lower moisture content because the strength of the outer stem layer (stem wall) increased with reduction in moisture content which increased the stiffness of the stem wall.

Effect of Stroke Length

Fig. 5 and **Fig. 6**, show that the cutter bar with stroke length of 90.0 mm (L_2) registered lower values of cutting force than that of 76.2 mm stroke length (L_1) at all levels of cutter bar speed, diameter and moisture content of stalk. The over all reduction in peak cutting force varied from 6.3 to 28.7 % with 90.0 mm stroke length of cutter bar (L_2) when compared to 76.2 mm stroke length (L_1).

The resistance offered by the crop stalk to cutting is the sum of the edge resistance and shearing resistance. The edge resistance is constant and due to the pressure exerted on the edge area. The frictional resistance due to sliding of crop against the edge chamfer depends upon the angle of chamfer, angle of friction between knife and chamfer and the normal force acting on the tapered cutting edge (Bosai *et al.*, 1990). It can be expressed as:

$P = P_0 + N \sin (\gamma + 2\varphi)/\cos^2 \gamma$

Where,

P = Resistance to cutting

P_0 = Resistance offered by the stalk for knife penetration

N = Normal pressure force due to cut stalk fibers acting on the face of wedge

γ = Wedge angle

φ = Angle of friction

Cutting force normal to the knife edge is constant for a given knife

Fig. 3 Typical force-time curve

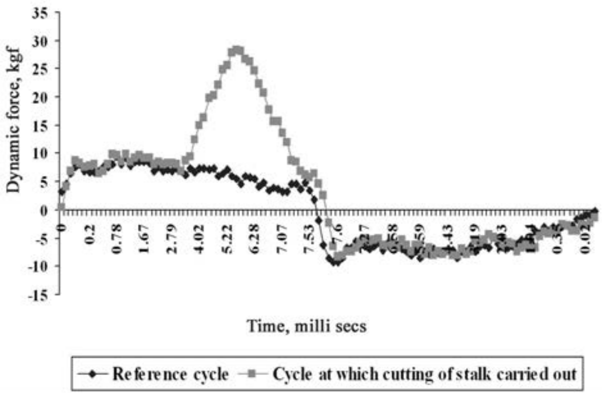
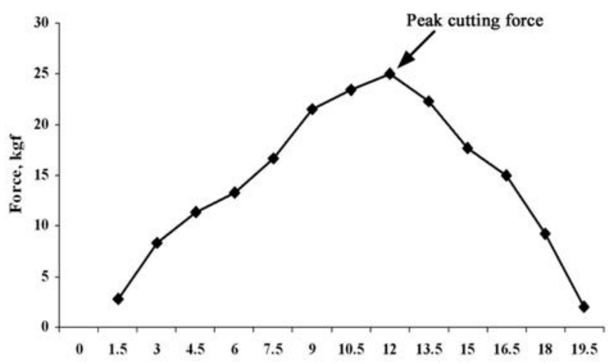


Fig. 4 Typical force-distance curve



and stem. When the cutting edge is perpendicular to direction of travel, force of cutting is equal to the force exerted on the cutting edge. However, when the cutting edge is inclined to the direction of travel by knife edge angle (α), only the component of cutting resistance along the direction travel will constitute the cutting force encountered by the knife.

i. e. cutting force

$P^1 = P \sin \alpha$

i. When $\alpha = 90^o$

$P^1 = P \sin 90^o = P$

ii. When $\alpha = 59^o$ *(value of knife edge angle for 76.2 mm stroke length of knife)*

$P^1 = P \sin 59^o = 0.857 P$

iii. When $\alpha = 54^o$ *(value of knife edge angle for 90.0 mm stroke length of knife)*

$P^1 = P \sin 54^o = 0.809 P$

The cutting force P^1 would be reduced by 5.6 % for the 90.0 mm stroke length as compared to 76.2 mm stroke length of the cutter bar.

For a given value of normal cutting resistance P, the cutting force required to overcome the resistance of the crop dependes on knife edge angle (α) of cutter bar. Since cutting force required is 5.6 % lower for 90.0 mm stroke length (L_2) than that of 76.2 mm stroke length of cutter bar (L_1), the peak cutting force required for harvesting the maize stalk with similar conditions was lower.

In order to confirm the results obtained as discussed above, statistical analysis of the data was performed to assess the significance of the variables *viz.,* moisture content (M), cutter bar speed (S), stroke length (L) and diameter of maize stalk (D)

Fig. 5 Effect of cutter bar speed on peak cutting force at selected levels of diameter and moisture content of maize stalk for 76.2 mm stroke length of cutter bar (L_1)

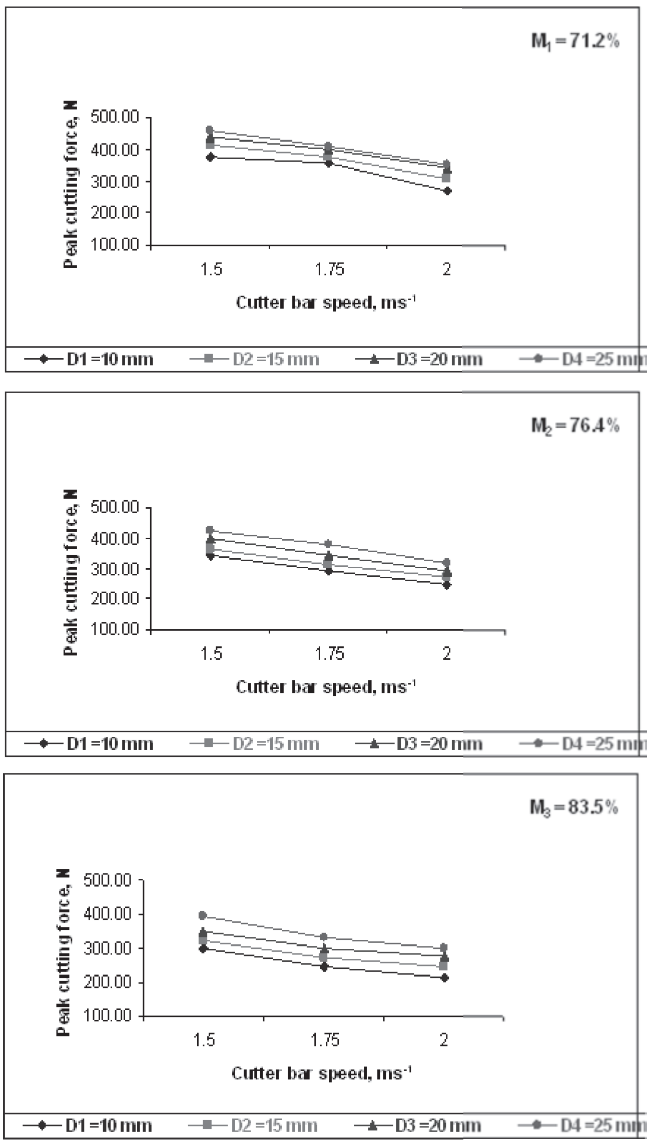
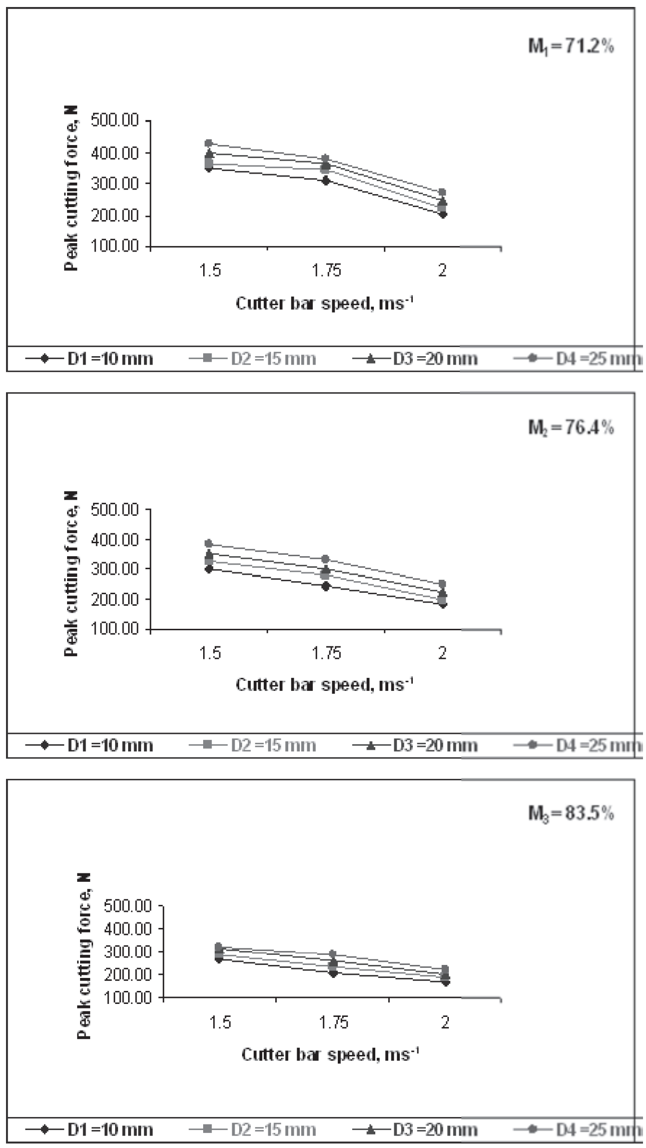


Fig. 6 Effect of cutter bar speed on peak cutting force at selected levels of diameter and moisture content of maize stalk for 90.0 mm stroke length of cutter bar (L_2)



on peak cutting force. There was significant difference among the treatments. The individual effect of the variables *viz.*, moisture content of stalk (M), cutter bar speed (S), stroke length (L) and diameter of stalk (D) were significant at the 1 percent level of probability. In the treatment effect, the order of significance was highest for cutter bar speed (S) followed by stroke length (L), moisture content (M) and diameter of stalk (D) on peak cutting force. This confirmed the earlier discussion that the cutter bar speed (S) had a significant effect on peak cutting force.

Conclusions

Increase in cutter bar speed from 1.5 to 2.0 ms^{-1} resulted in 20.8 to 29.6 % reduction in peak cutting force for a cutter bar with 76.2 mm stroke length,. The peak cutting force required for harvesting maize stalk increased by 15.5 to 41.1 % with increase in diameter from 10 to 25 mm. Increase in moisture content of maize stalk from 71.2 to 83.5 % resulted in 15.0 to 44.9 % reduction of peak cutting force for the selected levels of diameter of stalk and cutter bar speed. For a cutter bar with 90 mm stroke length, reduction of 30.9 to 42.1 % in peak cutting force was observed with increase in cutter bar speed from 1.5 to 2.0 ms^{-1} for the selected levels of diameter and moisture content of maize stalk. Increase in moisture content from 71.2 to 83.5 % resulted in 17.4 to 50.4 % reduction of peak cutting force required for the selected levels of diameter of stalk and cutter bar speed. The cutter bar with stroke length of 90.0 mm registered 6.3 to 28.7 % reduction in peak cutting force as compared to that of 76.2 mm stroke length for the selected levels of cutter bar speed, diameter and moisture content of maize stalk.

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A Hand Operated White Pepper Peeling Machine

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Abstract

White pepper is preferred over black pepper by the people of certain countries as the color matches with light colored food preparations, sauces and soups. White pepper, that gives modified natural flavour to the foodstuff and imparts pungency, is prepared from ripe pepper berries by removing the outer skin by rubbing with hands or trampling after the retting process.

A hand operated pepper peeling machine was developed and its performance evaluated to overcome this unhygienic method. The machine consisted of a blade and brush assembly mounted on a shaft. The whole assembly was enclosed by a perforated cylinder. A pinion (21 teeth) was mounted on the rotor shaft and a gear wheel (110 teeth). A handle was used to mesh with the pinion for manual operation of the peeler. Panniyur1 variety was used for evaluation. The unit was evaluated for its performance by varying clearance between the blade and outer perforated cylinder (4, 6, 8 and 10 mm). Pretreatments included retting, blanching and no treatment at a constant peripheral blade speed 14 m/min. Maximum peeling efficiency was 82.2 % at 4 mm clearance. Minimum breakage was 10.6 % at 10 mm clearance.

Introduction

Black pepper (*Piper nigrum. L*) is known as "king of spices" and is the most important spice of the world, including India. Pepper is widely used for its characteristic aroma and pungent taste. White pepper is used where the white is required (Lewis and Krishnamurthy, 1980).

The total world production of pepper is about 75,000 MT per annum, out of which 25 % is white pepper. During 1997-98, India exported 35,226 MT of pepper for Rs.488 crores of which white pepper contributed 1,634 MT with a value of Rs.12.94 crores (Singal, 1999). Indonesia, Malaysia and Brazil have shared the major part of the white pepper market with India's contribution being very insignificant. Since white pepper has export potential, the required quality must be upgraded for higher earning potential.

Materials and Methods

The mechanical peeler consisted of a feed hopper, rotor shaft, perforated cylinder, mild steel blade with a nylon brush, water tank and discharge outlet. The mild steel blade and nylon brushes were mounted on the shaft to avoid clogging of the 2 × 20 mm perforated screen. A perforated cylinder was placed over a bottom trough. The outlet for white pepper was provided in the cover plate to the thick flange of the perforated cylinder.

The ripe berries were fed into the peeler where they were subjected to a rubbing action between the perforated peeling drum and the rotor. The skin passed through the perforations and reached the skin outlet. The pepper, after skin removal, reached the pepper outlet. The water was fed manually inside the peeling chamber, which helped in washing and cleaning the product and allowed easy peeling and removal of skin after peeling. The peeler was operated manually. A pinion (21 teeth) was mounted on the rotor shaft. A gear wheel (110 teeth) with a handle meshed with the pinion. When the handle was turned at 8 rpm, a normal manual operation speed, peeling took place at 9 to 19 m/min peripheral speed. The schematic diagram of the unit is given in **Fig. 1**.

Performance Evaluation of Pepper Peeler

The pepper peeler was evaluated at different clearance values between the blade and perforated cylinder for various pretreatments. Fresh or pretreated samples of known weight were fed into the feed hopper. Due to impact force, the outer skin of the ripe berries was peeled off. Nylon brushes helped in peeling by providing a frictional force over the berries and helped to prevent clogging of the screen. Water was poured over the berries for washing the skin. Washed skin was carried along with water and separated in a perforated bottom trough. White pepper, obtained after peeling and washing, was collected in a separate outlet.

Independent Variables

The independent variables selected for testing were various pretreatments and the clearance between the blade and the perforated cylinder. Feed rate was an interdependent variable since the residence time of feed in the pepper peeler varied with peripheral speed and clearance.

- ***Pretreatments:*** Retting, blanching and untreated samples.
- ***Clearance:*** The average size of berries varied from 3.25 mm to 4.25 mm (Gopalam *et al.,* 1991). Hence, the clearance was selected as 4, 6, 8 and 10 mm.

Dependent Variables

The dependent variables were peeling efficiency and the percentage of brokens. They were determined as follows (Chandrasekar and Viswanathan, 2002)

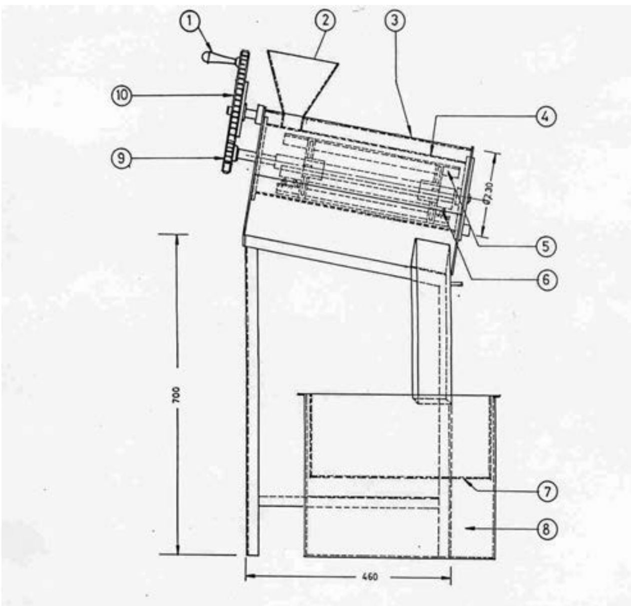
Peeling efficiency (%) = [Weight of feed (g) − Weight of unpeeled pepper (g)] / Weight of feed × 100 ....(1)

Brokens (%) = [Weight of broken in white pepper (g) / Weight of white pepper (g)] × 100 .... (2)

Results and Discussion

Effect of Process Parameters on

Fig. 1 Schematic diagram of the hand operated pepper peeler



Dimenshions in mm

Particulars	Diniensions (mm)	Materials
Handle	25 ø; 100 length	wood
Feed Hopper	350 × 350 × 140	m. s. sheet
Outer Cover	200 ø; 405 length	m. s. sheet
Perforated Cylinder	150 ø; 405 length	m. s. perforated sheet
Blade	395 × 22 × 5	m. s. flatt
Nylon Brush	395 × 35 × 35	Nylon bristles
Perforated Seive	455 × 170 × 170	m. s. sheet
Water Storage Tank	455 × 455 × 370	m. s. sheet
Pinion	65 ø; 21 teeth	casting
Gear Wheel	315 ø; 110 teeth	casting

Fig. 2 Effect of clearance and pretreatments on peeling efficiency and breakage for the hand operated peeler

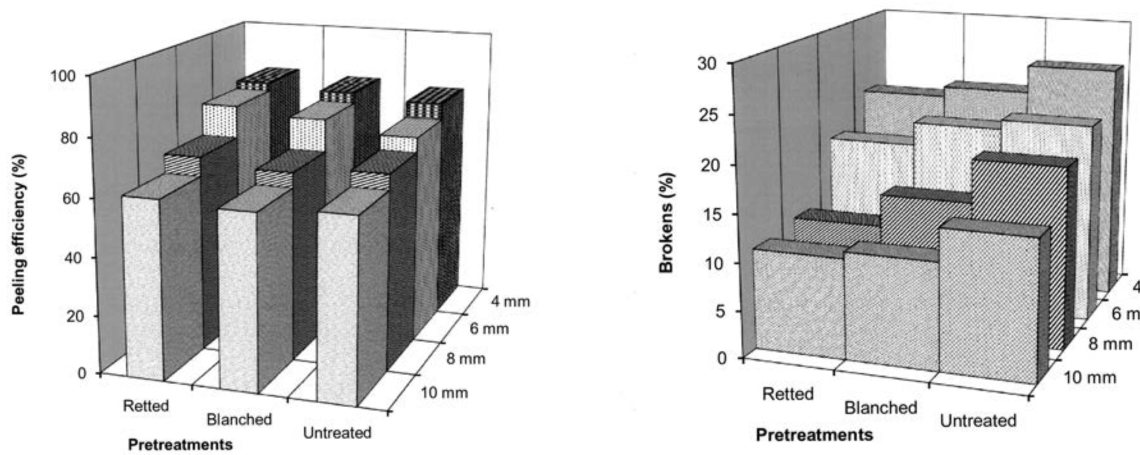


Table 1 Volatile oil and Piperine content of white pepper samples

Treatment	Volatile oil content (%)	Piperine content (%)
Retted	2.4	3.4
Blanched	2.5	3.6
Untreated	2.5	3.8

Peeling Efficiency and Brokens

The effect of pretreatments; namely retting, blanching and untreated ripe berries, and clearance on peeling efficiency and brokens are presented in **Fig. 2**. The maximum peeling efficiency was 82.2 % at 4 mm clearance for retted pepper and minimum peeling efficiency was 60.2 % at 10 mm clearance for blanched samples.

The percentage of brokens varied with pretreatments and clearance. It was found that minimum breakage was 10.6 % at 10 mm clearance for retted pepper and the maximum breakage was 25.5 % at 4 mm clearance for untreated ripe berries. In general, since the peripheral speed was less for a hand operated mechanism, the impact force was less and, hence, pretreatment was necessary to soften the skin, which helped in easy peeling. The quality parameters, namely volatile oil content and piperine content are presented in **Table 1**. The quality parameters of retted and blanched pepper were on par with untreated pepper.

Conclusion

The optimum values of peeling efficiency and brokens for the hand operated peeler, were 79.4 and 17.8 %, respectively, at 6 mm clearance for retted pepper. The quality parameters of retted and blanched pepper were on par with untreated pepper.

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Performance Evaluation of a Divergent Roller Grader for Selected Vegetables

by

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Abstract

Grading of fruits and vegetables is one of the most important operations since it adds value to the product and gives better economic gain to the producer. Grading done on the basis of size and shape is important for marketing uniform high quality produce.

A divergent type roller grader was developed and tested for size grading of tomato, potato and onion. Provision was made for slope and clearance adjustment. Effectiveness of grading and skinning damage of vegetables was estimated by varying feed rate and slope of the unit. The effectiveness of the grader was maximum (84.47 %) and skinning damage was minimum (1.5 %) at a feed rate of 480 kg/h and seven degrees slope.

Introduction

India has been exporting fresh fruits for several decades. However, export promotional activities have received more attention in the recent past. Tamil Nadu is one of the leading horticulture states in India contributing about 8 % to the National Horticultural production. A group of unit operations like washing, drying, grading, waxing, packaging and pre-cooling are performed after harvesting the fruits and vegetables before they reach the ultimate users. In this group of unit operations, grading is one of the most important operation (Mangaraj *et al.,* 2006) since it adds value to the product and gives higher economic gain to the producer. A produce may be separated into size groups according to different physical parameters like size, diameter, length, combination of length and diameter, circumference, projected volume and weight. Grading of fruits and vegetables on the basis of size and shape is important for marketing uniform high quality produce (Varshney *et al.,* 2002). Vegetables like potato, tomato, and onion account for around 60 % of the total vegetables produced in the country. Hence, there is a vast scope for the processing and export of vegetables from Tamil Nadu to other countries.

Grading plays a major role in the food processing industries. Grading is done to standardize a product, to facilitate marketing, for sales appeal, for ease in quantifying, for ease in price fixing of uniform sized lot and for compliance of international or national grading standards. Grading of potatoes has been proposed as a step to improve the overall quality of potatoes delivered to packing companies and to reduce on-farm storage space requirements (Misener and McLeod, 1989). The purpose of grading is to improve potato uniformity and enhance potato appearance to suit market requirement (McRae, 1985).

Grading by human eye judgment is quite difficult. It takes a long time to do the grading process and hence labour charges will be more. Moreover, there are chances of mixing of other sizes of fruits. The manual grading is labour intensive, time consuming and not standardized. The quality perception varies from person to person; hence, the uniformity of graded material becomes doubtful. In view of the above considerations, the mechanical fruit grader is a useful option that maintains uniformity of product and adds value to the final product (Kachru *et al.,* 1986). Mechanical grading of the fruits and vegetables is done based on weight, shape and size.

Considering the above facts, a low cost grader was developed to improve grading efficiency. A divergent roller grader was developed and its capacity and effectiveness in grading tomato, potato, onion and lime were tested.

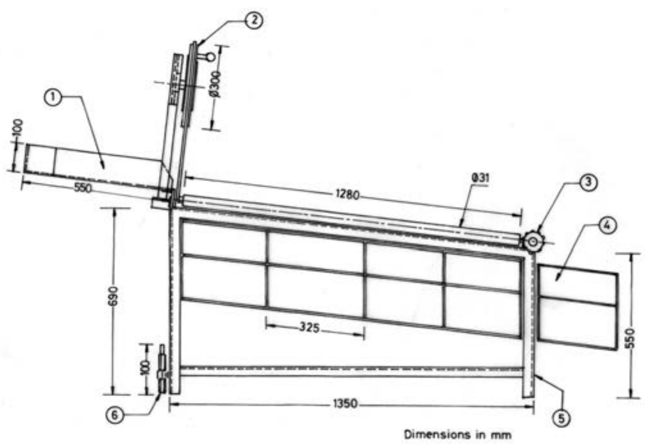
Materials and Methods

The grader consisted of two diverging counter-rotating rollers capable of classifying vegetables according to their major and minor diameters. The rollers were made of mild steel with an outside diameter of 3.1 cm and a length of 128 cm. and were mounted to provide an adjustable slope towards the wide opening end. These roller beds were fixed on a box like frame. A tray was fixed at the feeding end of the machine for feeding the vegetables. A provision was given to adjust the clearance from minimum to maximum level (from 3.5 to 7.0 cm). A pulley was attached to the frame that connects the roller by means of a round belt.

The slope and counter-rotating action of the rollers encouraged the vegetables to continue moving toward the end where the gap between the rollers was widest. The hopper was flat and accommodated approximately 5 kg of vegetables and allowed the vegetables to enter the roller chute as the rollers were rotated. Rotation was accomplished by hand crank.

Slope could be varied depending on the shape of the vegetables. Several compartments were made beneath the rollers for collecting the graded vegetables and a separate outlet was provided for collecting the overflow. A schematic view of the unit is given in **Fig. 1**.

Fig. 1 Schematic diagram of vegetable grader



1. Feed hopper 2. Hand wheel 3. Clearness adjustment 4. Over flow
5. Frame 6. Height adjustment

Performance Evaluation

The performance evaluation of the unit was carried out for different feed rates (480, 580, and 680 kg/) and slopes (5, 7, and 9).

Capacity

A known quantity of fruit was fed into the machine. The machine was manually operated and the time taken for complete sorting of the sample was noted. The capacity of the machine was the ratio of the quantity of the sample sorted and time taken.

Capacity = Weight of sample taken (kg) / Time taken (h)....(1)

Effectiveness of the Grader

The effectiveness of the grader was determined by the equation developed by Macabe and Smith (1976) as shown in Equation 2.

$$E = [X_D (X_F - X_B) (X_D - X_F) (1 - X_B)] / [X_F (X_D - X_B) (1 - X_F)], \quad (2)$$

where,
E = effectiveness
X_F = mass fraction of desired vegetables in the feed
X_D = mass fraction of desired vegetables in the desired outlet
X_B = mass fraction of vegetables other than the desired vegetables in the desired outlet.

Skinning Damage

Skin damage of potato, onion and tomato received from the grader outlet was observed and separated. The skinning damage was calculated as follows.

$$\text{Skinning damage (\%)} = (M_s / M) \times 100 \quad (3)$$

M_s = Mass of the sample with damaged skin (kg)
M = Mass of the sample taken (kg)

Table 1 Effect of feed rate and slope on efficiency and skinning damage

Feed Rate	Slope	Onion η %	Onion Skinning damage, %	Potato η %	Potato Skinning damage, %	Tomato η %	Tomato Skinning damage, %
480	5	80.0	1.6	77.0	2.0	75.0	2.5
	7	86.7	1.0	84.3	1.6	82.4	2.0
	9	82.0	2.2	80.0	2.5	79.0	2.9
580	5	77.8	1.8	75.0	2.1	73.5	3.0
	7	85.3	1.0	83.5	1.8	81.6	2.4
	9	80.1	2.5	70.5	2.7	77.4	3.0
680	5	76.2	2.0	74.0	2.4	72.5	3.5
	7	85.0	1.5	83.0	2.0	80.4	2.5
	9	78.0	2.6	74.0	3.0	76.0	3.5

Results and Discussion

The effect of feed rate and slope are presented in **Table 1**.

Effect of Feed Rate on the Efficiency

It is observed from **Table 1** that as the feed rate of the vegetable increased, the effectiveness of the grading decreased. The effectiveness of the grade at a feed rate of 480, 580 and 680 kg/h for onion was 86.7, 85.3 and 85 %, respectively.

The above feed rate effectiveness for potato was 84.3, 83.5 and 83 %, respectively. For tomato, it was 82.4, 81.6 and 80.4 %, respectively. Higher feed rate caused less registration of material on the divergent roller, which resulted in reduced grading efficiency.

Effect of Slope

When the slope was increased from an optimum level of seven degrees, the grading efficiency decreased. For onion, the effectiveness at a slope of 5, 7 and 9 degrees was 78.0, 85.6 and 80.0 %, respectively. For potato, the effectiveness at a slope of 5, 7 and 9 degrees was 75.3, 83.6 and 74.8 %, respectively. For tomato, the effectiveness at a slope of 5, 7 and 9 degrees was 73.6, 81.5 and 77.5 %, respectively. The effectiveness was maximum at a slope of seven degrees for all three vegetables.

Higher slope resulted in fast rolling of vegetables, where as lower slope resisted the free flowing of vegetables. Hence, the maximum efficiency was observed at an optimum slope of seven degrees.

Conclusion

1. At a slope of seven degrees the maximum separation was 86.7 % for onion, 84.3 % for potato and for 82.4 % tomato.
2. At a feed rate of 480 kg/h, maximum effectiveness was achieved. (86.7 % for onion, 84.3 % for potato, and 82.4 % for tomato)
3. The maximum effectiveness was obtained at a clearance of 3.5 to 7.
4. The minimum skinning damage was 1.5 percent at a feed rate of 480 kg/h and seven degrees slope.

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Development of Low Cost, Bullock Drawn, Multi-Purpose Implement for Sandy Loam Soil

by

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Abstract

A multipurpose G. I. pipe frame implement was developed for tillage, sowing, interculturing and digging operations in sandy loam deep soils. The implement consisted of a main frame as head piece, beam, and handle with different attachments like cultivator tine, seed drill furrow opener, interculturing prongs and digger curved tine. In this implement, row to row distance could be adjusted as per crop requirement. During field testing, cost of cultivation was $64.5 per hectare for local implements, and $46.0 per hectare for the multipurpose implement. Thus, the multipurpose implement saved $18.5 per hectare in addition to time. Also, the investment was 52.19 % less than the traditional implement. The hourly cost of a pair of bullocks was $ 1.24.

Introduction

About 33 % of the total operational holdings were less than 0.5 hectares. Only 10 % of Indian farms use tractor operated implements. About 21 % of the operational holdings are medium size and include 51 % of the cultivated area.

The geographical area of Gujarat state is 19.6 million hectares, out of which 9.6 million hectares (49 %) are cultivated. The total cropped area is 12.4 million hectares (63 %). There are 3.0 million operational farm holdings with more than 70 % being less than 2 hectares. Only 3 % of the holdings are 10 hectares and above and the remaining are medium size. One of the major factors affecting crop yield is timeliness of operation. To overcome the problem of timeliness with conventional implements and also to provide a common frame for different implements, multipurpose tool carriers were introduced during the sixties (Anonymous, 1972). A study of farming systems conducted at CIAE-Bhopal (India) during 1982-85 in deep black soils revealed that present levels of agricultural production are one ton per hectare per year and could be enhanced to more than 2.5 tons per hectare per year. Use of a bullock drawn multipurpose wheeled tool carrier was found to be encouraging. Broad bed and furrow systems for farming yielded 228 kg per hectare per year more grain in comparison to the flat system of farming. Intercropping systems showed greater stability and less risk than the sequence cropping system.

In central Gujarat, cereal crops like paddy, bajara, maize, wheat and oilseed crops like castor, ground nut (summer), mustard and intercropping of pigeon pea with maize, paddy (drilled), bajra and urid are grown on a large scale. Misra (1981) reported that, in Sauratra, the bullock drawn multipurpose implement known as "Samrat Santi" is very popular. It is useful for field operations in groundnut, cotton, wheat, bajara, sorghum and pulse crops. Dimensions of the main part head piece is 5.0 to 7.5 cm diameter and 90 to 120 cm length. It is made of galvanized iron pipe, on which square holes of 18 mm are provided at certain places. Sowing spacing for most of the crops vary from 22.5 cm to 120 cm and require 2 to 4 interculturing operations. To fulfill the above requirements, the bullock drawn multipurpose implement (pipe frame) was developed and is still popular among the farmers of Saurastra region.

Naravani (1982) determined the effect of bullock operated tillage tools on the energy required for seed bed preparation in sandy loam soils under dry conditions of Delhi. The maximum draft range was 142.82 to 170.05 kg for M.B. plough, whereas for the Bakhar disc harrow, Sweep-I, Sweep-II and Plank, the draft range was, 14.3 to 60.26, 102.48 to 142.05, 67.51 to 77.66, 98.60 to 129.91 and 38.22 to 122.98 kg, respectively.

Devnani (1981) reported the work of Mason Vaugh (1947) who found that bullocks developed draft equivalent to 1/5 to 1/6 of their body weight. The maximum draft that the bullocks could exert varied from 49.6 to 60.5 % of body weight.

Dave (1975) reported the physical data regarding bullock's length, height and weight of Kankrej breed as 160 cm, 140 cm and 500-800 kg, and for Gir breed as 152.7 cm, 136 cm and 500-540 kg, respectively.

With the problems faced by the farmers of central Gujarat with sandy loam deep soil when using the Saurastra multipurpose implement, it was important to design a bullock drawn multipurpose implement that was suitable for changing agro-climatic conditions of central Gujarat.

Methodology

An area of 1.72 million hectare is sandy loam type deep soil out of total area (2.4 million hectare) of central Gujarat, particularly, Panchmahals, Vadodara and Kaira districts (Middle Gujarat Agro-climatic Zone-III). Farmers grow crops like maize, drilled paddy, pigeon pea, bajra, tobacco, gram, wheat and groundnut in different seasons. Cultivation of the different crops requires different wooden implements. The wooden plough is preferred, for sowing "Tarfen*" (three row) or "Faidko*" (two row), for interculturing "Karabadi*" (with two persons) and digging of crop "Karab*" or "Karvan*". The wooden implements have no adjustment for row to row distance and, thus, a specific wooden implement is required for a specific distance for various crops, which leads to more investment and larger space. Also, in running condition, the implement parts break at the joints and require more repair time. Farmers have a long felt need for such an implement that is light weight, low cost, durable and labour saving.

With these physical and economic constraints, a bullock drawn, multipurpose implement was designed which could be used as a cultivator, seed drill, interculturing unit and ground nut digger. Row to row distance could be adjusted according to crop requirements in all operations and a single person could operate two interculturing units.

Performance of the multipurpose implement was evaluated for ploughing, sowing, bed shaping, interrow cultivation and groundnut digging. Observations of pull, operating time and turning time in each bed were recorded for all operations. Pull was measured with a spring type dynamometer attached to the beam. The field performance of the multipurpose implement was compared on the basis of draft requirement, actual field capacity, field efficiency and travel speed of the bullock.

* Local names used by the people of the region.

Design Considerations

The following factors were considered in the design of the multipurpose implement.

1. Suitability for deep sandy loam type soil.
2. Adaptability to land holding size, bullock size and farmer's habit.
3. Light in weight, low cost, durable and labour saving.
4. Ability to perform all operations like seed bed preparation, sowing, interculturing and digging under varying crop and climatic conditions.
5. Farmers with available tools should be able to assemble and disassemble easily. It should be easily repairable by local artisans.

The area under central Gujarat Agro-climatic Zone (2.4 million hectare) is sandy loam type deep soil. The soil has a property to become hard after moisture depletion and hold moisture at lower layers (Payne, 1956). The furrow opener is designed in such a way that it could penetrate the required depth. The furrow opener cuts the soil to a uniform depth and, thus, the bottom part of furrow opener slides parallel to the bottom part of the furrow. The bottom part of the furrow opener has more surface area, which limits the penetration depth. Also, the implement must be light weight, which is an advantage to farmers with small land holdings who must

Fig. 1a Cultivator attachment

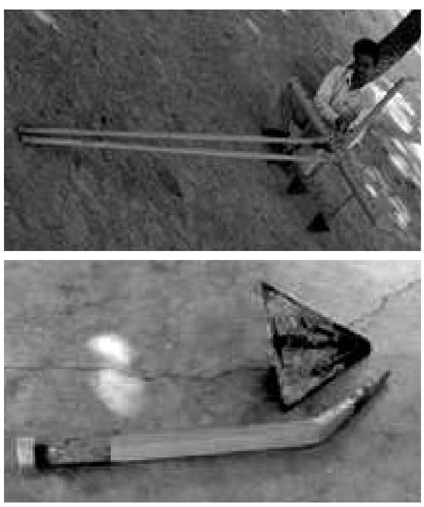


Fig. 2a Seed drill attachment

lift the implement more frequently.

Savani (1987) suggested that the length and diameter of pipe used as head piece be 150 cm and 7.5 cm, respectively, and the number of holes be reduced to 11 from 17 by giving a bend of 10º at 22 cm height from the end of the tine. This reduced cost and improved strength and life of the implement. The angle of pull affected the efficiency and pull of bullock. The optimum range of pull angle as 18.3º to 22.7º, availing good speed. An angle of penetration of 24º to 30º gave better depth at reasonable pull.

Richey (1981) stated that tubes or closed box sections are the strongest for their weight. Welding of connecting members made it possible take full advantage of their strength in both torsion and bending. Standard pipe rather than tubing was commonly used in farm machinery.

Construction Details

The implement consisted of main frame as headpiece, beam, clamps, handle and different attachments. On the headpiece, at specific distances, holes were made to insert different attachments according to crop requirements. The upper holes were round while lower ones were square to grip the attachments firmly. A beam was joined to the headpiece with round clamps to adjust rake angles as per requirements (Payne *et al*., 1959). The yoke could be hitched at 210, 225, 240, 255 and 270 cm distances on the beam. The implement could be used for different operations with different attachments.

Cultivating Attachments:

For using this implement as a cultivator, three tines of square bar, angled at one end, were attached where the triangular sweeps were fitted. The other end was joined to the headpiece with a nut. Three, four or five tines could be used for more coverage depending on the field moisture.

Sowing Attachments:

Three furrow openers were especially designed for sandy loam deep soil. The furrow openers were about 5 cm wide. Two welded angle iron pieces 25 × 25 × 3 mm and 22.5 cm long formed a channel type structure. An oblong shaped hole approximately 30 mm, 18 cm away from the furrow point with an 84 cm radius of curvature were fitted on the headpiece. A bolt and funnel were mounted on three seeding tubes. This attachment could be adjusted for 22.5, 30, 37.5 and 45 cm (three row) and 60, 75 and 90 cm (two row) distance for sowing of different crops.

Interculturing Unit:

During interculturing operation, two blades were worked simultaneously by one person. Blades were fitted on 1500 angled prongs. The other threaded end of the prongs were bolted on the headpiece. This attachment could be used for 15, 22.5 and 30 cm blades as per row to row distance. Since the prongs are angled, the height between head piece and soil could be increased and damage to the crop, up to 22 cm height, ccould be minimized.

Digging Attachments:

For groundnut digging, the two tines were curved at a specific radius of curvature. The blade could be at one end with the other threaded end of the tine bolted to the headpiece. Due to the curved tines, blockage of plants below the headpiece was minimum, which led to minimum jerks and less draft. The implement can also be used as “Karab” for ploughing and tobacco stubble digging.

Field Evaluation

The implement was tested for its performance for sowing of gram and interculturing with a local wooden

Fig. 3a Interculturing unit

Fig. 4a Groundnut digger attachment

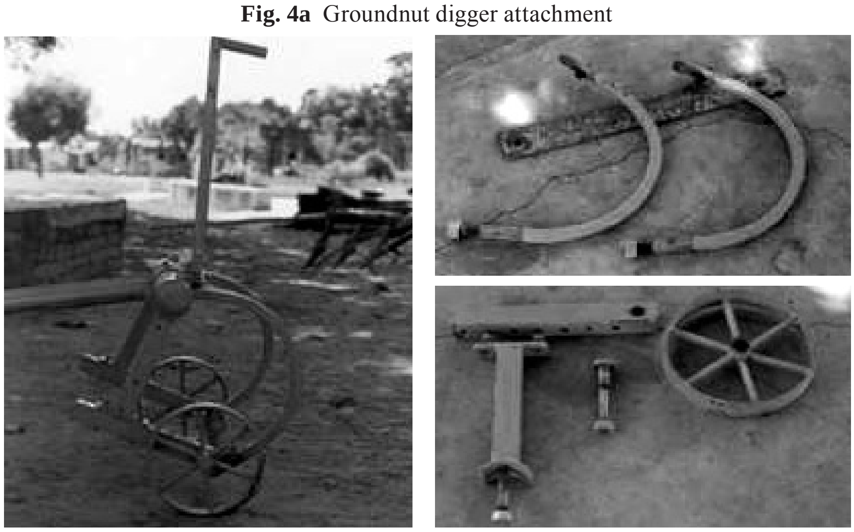


Fig. 1b Cultivator attachment

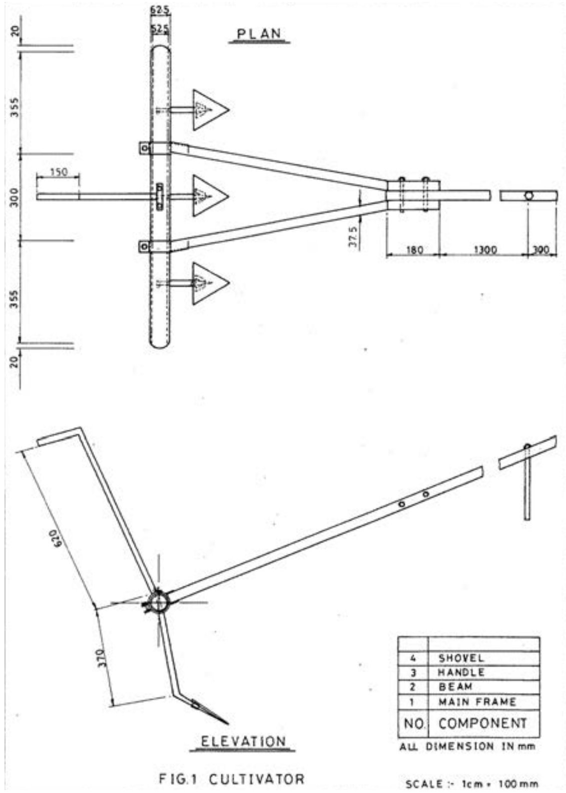


Fig. 2b Seed drill attachment

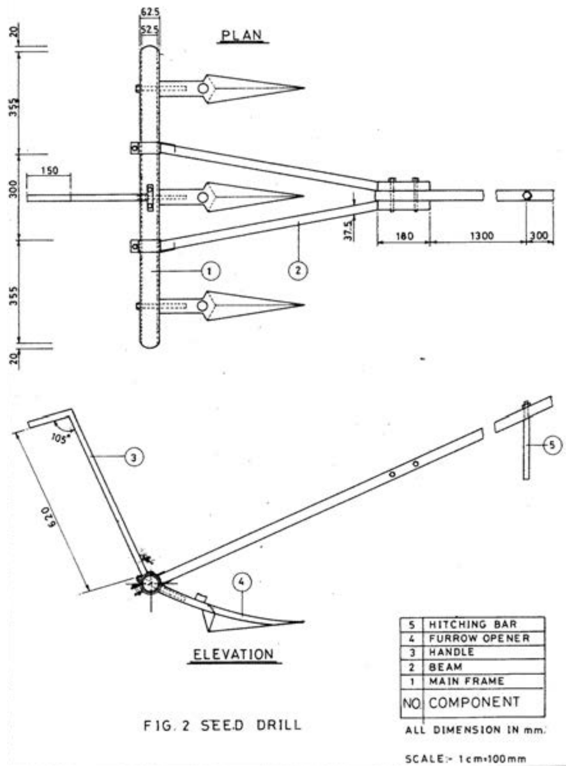


Fig. 3b Interculturing unit

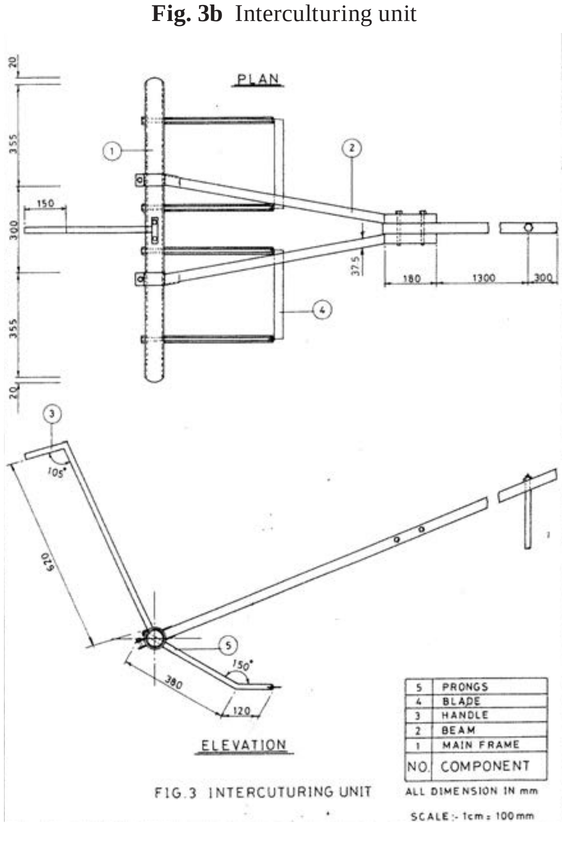
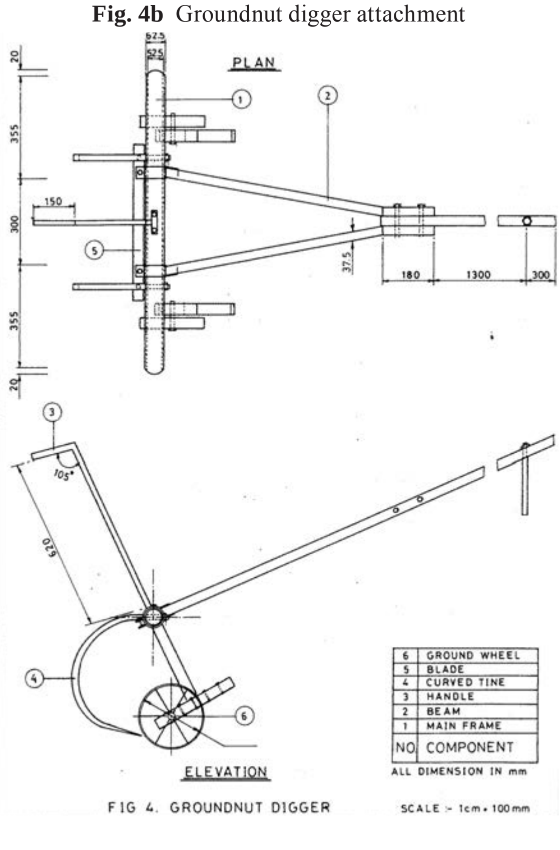


Fig. 4b Groundnut digger attachment



implement. For digging of groundnut, a field trial was conducted in comparison to local implements which showed encouraging results. Three tine cultivator attachments were also tested, which indicated that, when moisture was sufficient, it worked very efficiently in place of the local plough. Also, at the farmer's fields in different villages, live demonstrations were carried out and modifications were made according to the opinion of the farmers.

Results and Discussion

Field trials of the multipurpose implement were conducted for two years at the Agriculture Research Station, Gujarat Agricultural University, Derol, for seedbed preparation, sowing, interculturing and groundnut digging operations. Observations were recorded and presented in **Table 2**. The multipurpose implement was more efficient as compared to local wooden implements.

Economic analysis showed that the multipurpose bullock drawn implement provided an effective low cost alternative machinery system, especially when high initial investment in machinery was a major constraint in the adoption of the improved technology. The multipurpose implement cost less than the local ones.

Mayande *et al*., (1985) reported that a pair of 500 kg bullocks could consistently generate power in the range of 1.4-1.8 kW at a walking

Table 1 Specifications of main component of the multipurpose implement

Component	Specifications		
Overall dimensions of implement			
Length	2,880 mm		
Width	1,050 mm		
	Weight	**Beam angle**	**Angle of penetration**
Seed drill	18.12 kg	24º	25º
Interculturing unit	17.36	24º	30º
Cultivator	19.10	22º	45º
Digger	25.66	22º	24º
Main Frame	G.I. pipe of 62.5 mm diameter with hole at specific distance, upper one round and lower one square		
Beam	Y-section, 37.5 mm diameter G.I. pipe of 2,850 mm length		
Handle	24 mm angle section of 620 mm length.		
Furrow opener (Seed drill)	Pointed hoe type with 840 mm radius of curvature.		
Tine (Cultivator)	18 mm thick square bar, 140º angled at one end		
Prongs (interculturing unit)	15 mm square bar, 150º angled at one end and the end threaded for nut bolting		
Tine (Digger)	Square bar of 18 mm, curved and threaded at one end for nut bolting		
Hitch point	At 2,100, 2,250, 2,400, 2,550 and 2,700 mm adjustable on beam		
Depth control	By vertically sliding implements in clamps		

Table 2 Field performance of the multipurpose implement in deep sandy loam soil

Particulars	Ploughing		Sowing Chickpea		Interculturing Chickpea		Digging Groundnut	
	Local	Improved	Local	Improved	Local	Improved	Local	Improved
Moisture content, %	17.00	17.00	23.00	23.00	20.87	20.87	18.04	18.04
Size of implement, cm	15.00	60.00	60.00	60.00	2 × 30	2 × 30	45.00	45.00
Average depth of operation, cm	15.40	13.30	8.30	9.10	4.00	5.00	14.30	16.50
Travel speed of bullock, km/hr	3.46	2.77	3.53	3.67	3.83	3.75	2.25	2.53
Effective field capacity, ha/hr	0.0400	0.0667	0.1841	0.1975	0.1728	0.1800	0.0630	0.0867
Theoretical field capacity, ha/hr	0.0519	0.0831	0.2118	0.2202	0.2298	0.2250	0.1012	0.1138
Field efficiency, %	77.07	80.26	86.92	89.69	75.19	80.00	62.25	76.00
Draft requirement, kg	70.70	90.70	37.00	35.00	32.50	30.00	106.00	79.50
Power requirement, hp	0.906	0.930	0.480	0.470	0.460	0.420	0.880	0.740
Cost of cultivation, Rs/ha	990.5	594.0	215.2	200.6	229.3	220.1	628.9	456.9

Cost of operation for a pair of bullocks 39.62 Rs/hr: ($ 1.24/hr)
Total cost of operation for traditional implements 2,063.88 Rs/ha: ($ 64.5/hr)
Total cost of operation for multipurpose implement 1.471.17 Rs/ha: ($ 46.0/hr)

speed of 3.1-3.8 km per hour when used for ploughing and ridging operations with wheeled tool carriers.

For the sowing operation of chick pea, 7.28 % more area was covered with 89.69 % field efficiency as compared to traditional implements. Also in ploughing, 6.75 % more area was covered in unit time over the local plough. In interculturing operations, the area covered was as at par but one person could operate the two blades, which reduced labour cost. In the traditional method, two persons operate the separate blades for the same operation. The results of groundnut digging were encouraging as there was 33.3 % reduction in draft requirement and 37.6 % more area covered by the multipurpose implement over the local wooden implement ("Karab*).

As shown in appendix "A", the hourly cost of operation with a pair of bullocks was $1.24. The total cost of all four operations was $64.50 per hectare for the local implement, while for the multipurpose implement, it was $46.0 per hectare. Thus, the multipurpose implement can save the farmer $18.5 per hectare for the same operations in addition to the time savings.

As shown in appendix, "B" this implement required 57.07 % less investment over traditional implements. The implement was released by Agricultural Research Council (Gujarat Agricultural University) of Agricultural Engineering discipline in 1998 and named as the "G.A.U. Derol multipurpose implement" for farmer's use and commercial exploitation.

Conclusion

It was concluded that the G.A.U. Derol multipurpose implement could successfully replace the traditional wooden implements for farming due to following reasons;

a. Faster operations
b. Low cost of operations
c. Attachments for different operations in a single implement which led to low investment and less space in storage.
d. Light in weight, low cost and durable with minimum repairs, which saved time during operations.
e. All cultural operations (seed bed preparation, fertilizing, seeding, interculturing, digging of crops) for year round cultivation could be effectively done with the help of the bullock drawn multipurpose implement.
f. Field capacity in different operations was high and it helped in achieving greater timeliness.

APPENDIX-"A"

Economics of bullock drawn implements.

Data regarding a pair of bullock:

1. Purchase price of bullock: Rs.12,000
2. Bulockshed and foddershed cost: Rs.12,000
3. Cost of feeding:

Item	Quintal Per day	Quintal Per year	Price Rs/qtl	Cost Rs
Crops fodder	0.8	292.0	50	14,600
Dry fodder	0.2	73.0	60	4,380
Oil	-	0.1	4000	400
Cotton seed	-	0.2	800	160
Gur	-	0.1	600	60
Total cost of feeding, Rs				19,600

4. Average annual working hours: 800 hours
5. Medical aids: 300 Rs/year
6. Wages of ploughman: 600 Rs/month
   (Day and night job of looking after pair of bullock for feeding, cleaning, operating time)
7. Price of bullock carts and set of implements: Rs.20,000
8. Return from manures (24 carts × 200 Rs/carts): Rs. 4,800

Hourly cost of operation with a pair of bullock:

1. Interest on initial investment: *(12000 × 15) /100* = *1800 Rs/year*
2. Cost of construction of bullockshed and foddershed: *(12000) / 20* = *600 Rs/year*
3. Cost of feeding: = *19600 Rs/year*
4. Medical aids: = *300 Rs/year*
5. Operators wages: *12 × 600* = *7200 Rs/year*
6. Cost of repairs and maintenance, depreciation, interest on investment on bullock cart and implement (35 % purchase value): *(20000 × 35) / 100* = *7000 Rs/year*

Total annual cost = *36500 Rs/year*

Net annual return from manure = *− 4800 Rs/year*

Net annual cost of pair of bullock = *31700 Rs/year*

Hourly cost of operation with a pair of bullocks,: *31700 / 800* = *39.62 Rs/hour*

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APPENDIX-“B”

Comparative investment on implements:

Operation	Traditional wooden implements				Multipurpose implement (Estimated cost (Rs.) in 1996-97)	
	Local name	Price Rs.	No.	Amount Rs.	Implement Frame	900
Ploughing	Hal*	400	1	400	Cultivator attachments	315
Sowing	Tarfen* (22.5, 30.0, 37,5 and 45.0 cm)	475	4	1,900	Sowing attachments	475
	Faidko (60.0 and 90.0 cm)	400	2	800		
Interculturing	Karabadi* (15.0, 22.5 and 30.0 cm)	225	6	1,350	Interculturing unit	160
Digging	Karab*	675	1	675	Digging Attachments	550
	Total cost of implements			5,125		2,450

***Local named used by people of the region**
Total cost of traditional wooden implements: Rs. 5125 = 00 ($160.0)
Total cost of Multipurpose implements: Rs. 2450 =00 ($76.6)

Development and Evaluation of a Tractor-Operated Sugarcane Cleaner

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Abstract

A tractor operated sugarcane cleaner was developed. The machine consisted of an inclined chute, a series of rollers and a blower fitted on a rigid frame. The upper roller, which has 12 M.S. flats around the periphery of the rings, was covered with spongy rubber and synthetic material. The lower and side rollers were made of M.S. pipe of 270 mm diameter. The blower consisted of four blades and was made with an upper casing 360 mm diameter. The flap roller had six rows of flaps and was made of M.S. sheet with angle iron support from the inside. There were 19-20 flaps per row (alternate rows). The length of each roller and blower was 600 mm. Combinations of independent variables that resulted in mill trash up to 3 % and a cane loss of less than 2 % were (1) a flap roller speed of 16.46 m/s and a cane feed rate of 4 for COJ-64 variety and (2) a flap roller speed of 16.46 m/s and a cane feed rate of for CO-1148 sugarcane variety.

Introduction

Sugarcane (*Saccharim officinarum L.*) is the main source of sugar in India and holds a prominent position as a cash crop. Sugarcane is mostly grown in the tropical and sub-tropical climatic regions of the world. In India, sugarcane production uses 3.99 million hectare with a production of 236.1 million tones and a productivity of 59.1 tones per hectare (Anonymous, 2005). In India and many other developing countries, sugarcane harvesting is by manual labour. Studies have indicated that the labour requirement for manual cutting and cleaning in India requires 158 and 395 man-h/ha, respectively (Shukla and Sandhar, 1985 and Shukla et. al., 1991). The sugarcane must be cut, cleaned and stacked prior to the mill delivery. Barnes (1974) reported that the sugarcane stalk must be processed within 48 hours or less of cutting; otherwise, it results in the decline of sugar recovery. The detrasting operation involves topping and stripping of harvested cane stalks. It consumes about 70 % of total man-hours required for manual harvesting (Miyable *et al.,* 1978; Shukla and Sandhar 1985). Srivastava and Singh (1990) made efforts to establish the mechanism suitable for detrashing the whole cane. However, at present an appropriate machine for successful mechanization of this operation is not available.

In order to overcome these problems, a tractor-operated sugarcane cleaner was developed to suit Indian conditions and make use of available tractor power.

Machine Development

The machine was of the snapping roll type. The basic principle on which the snapping roll type sugarcane cleaner functioned was based on the natural weak point at the joint of the immature top with mature cane stalks. The sugarcane cleaner used for the study made use of this principle to remove the bulk of the top and green leaves from the sugarcane stalks. The constructional details (**Fig. 1** and **Fig. 2**) are discussed below.

Main Frame

The main frame of the sugarcane cleaner was made of 62.5 × 62.5 × 6 mm M.S. angle. The main frame was supported by four 770 mm high columns. The overall size of the frame was 1100 × 1100 × 770 mm. The three point hitch system was provided on the main frame to attach the cleaner to the tractor. All other components were fixed to the main frame. An intermediate shaft used for transmitting power from the p.t.o. of the tractor to the cleaner was attached to the frame. Two additional 62.5 × 62.5 × 6 mm angle irons were welded to the frame. The inclined platform was welded to these angle irons.

Feeding Chute

The throat width of the feeding chute was adequate for uninterrupted flow of the plant material into the cleaner. The canopy width of the sugarcane affected the width of the feeding chute and, hence, the width of the sugarcane cleaner. The canopy width of the sugarcane plant had to be compressed to a reasonable size during the feeding so that the flow of sugar cane was smooth through the cleaner. The width of the front end of the feeding chute was made equal to the length of rollers of the cleaner.

The stalk length must be considered in the design length of the feeding chute with respect to the difficulty of feeding. Lengthy sugarcane is difficult to handle. The portion of the sugarcane where the top leaf joins the stalk is relatively stiff as compared the leave and does not deflect during feeding. When the leaves spread out they must be supported by the feeding chute.

Using the above facts, along with the recommendations by Shukla *et al*. (1991), a feeding chute with a length 1000 mm and a width of 820 mm at the rear and 640 mm at the front was attached to the cleaner. It had an angle of 25º with the horizontal (Khar and Shukla, 2003) with provision for changing the angle.

Upper Roller

The upper roller (**Fig. 3**) consisted of two rings mounted on the shaft. Twelve M.S. flats 25 mm wide and 0.5 mm thick were bolted around the periphery of the rings at equal spacing. The function of the upper roller and the lower roller was to grip the stalks and push them forward as they rotated. A vertical clearance of 10 mm was provided between upper and lower rollers that allowed the cane to pass without damage. The surface of each flat of the upper roller was covered with spongy rubber and synthetic material. The synthetic material came in contact with the cane. The synthetic material was used to protect the rubber sponge that was more elastic. The spongy rubber changed the clearance between the upper and lower rollers and minimized the damage in large stalks.

Lower Roller and Side Rollers

The lower and side rollers were made of M.S. pipe 270 mm in diameter, 600 mm long and 12 mm thick. The outer surfaces had groves that increased the surface roughness and allowed more holding force. A total of 144 threads were cut along the length of the 600 mm long high pressure pipe. A total of 120 grooves, cut with 18 D. P. No.5 cutters on a milling machine, were made along the periphery of the rollers. The axis of the side roller was fixed 25 mm below the axis of the lower roller. Both the shafts of the lower and side rollers were mounted on a bearing having an inner bore of 25 mm.

Blower

The blower consisted of four blades 600 mm long and 90 mm wide mounted on a shaft. The blow-

Fig. 1 Schematic view of sugarcane cleaner (side view)

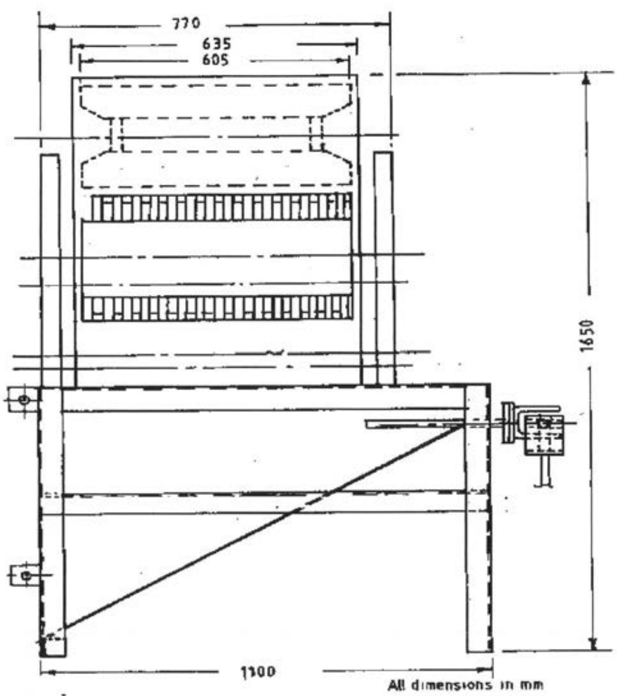


Fig. 2 Schematic view of sugarcane cleaner (front view)

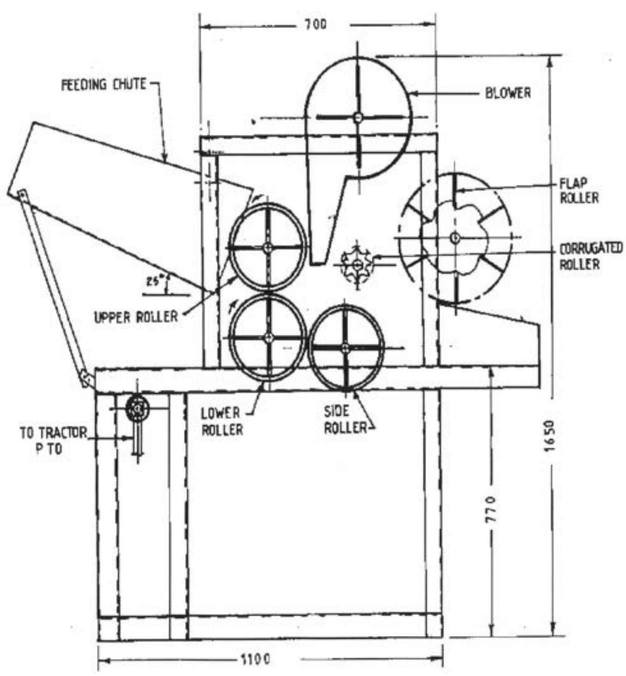


Fig. 3 Upper roller of tractor-operated sugarcane cleaner

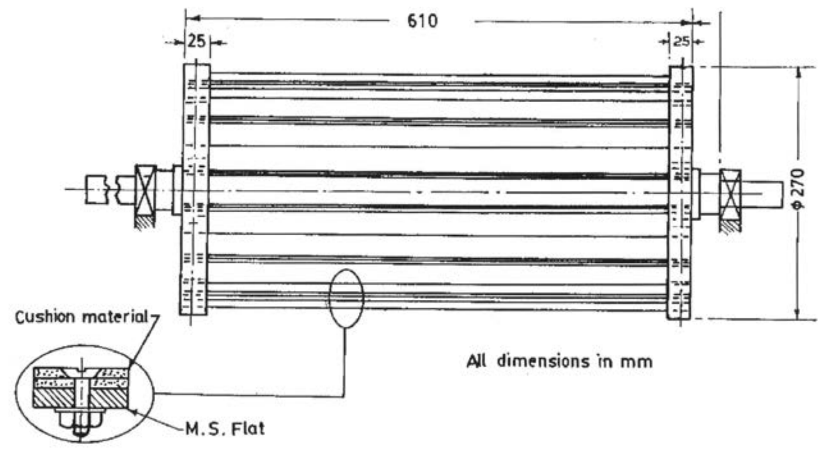


Fig. 4 Blower of tractor-operated sugarcane cleaner

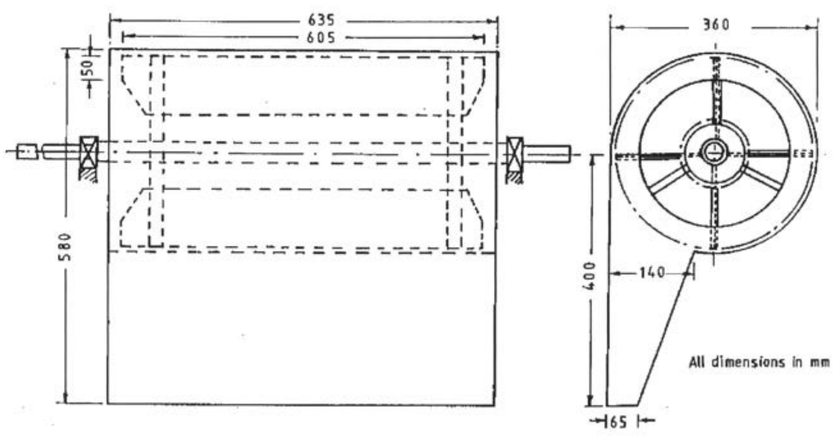
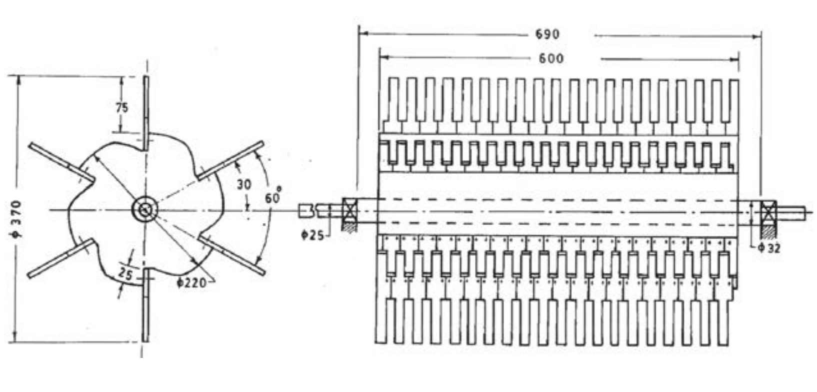


Fig. 5 Flap roller of tractor-operated sugarcane cleaner



er was made with an upper casing 360 mm in diameter (**Fig. 4**) with the air flow directed between the lower and side rollers.

Flap Roller

The flap roller was 600 mm long and made of M. S. sheet with an angle iron support from the inside and had six rows of flaps (**Fig. 5**). The flaps were made from synthetic material and were 15 mm wide, 75 mm long and 10 mm thick and were 60 degrees apart. The flap roller was mounted on the frame with a clearance of 130 mm from the base of the outlet. There were 19-20 flaps per row (alternate rows) arranged in such a way that the flaps did not overlap.

Corrugated Roller

Two feed rollers of the chaff-cutter were welded together and used as the corrugated roller that guided and pushed the cane forward, thus, preventing upper movement. This corrugated roller was 600 mm long and fitted between the upper roller and the flap roller.

Overall Dimensions

The overall dimensions were 1,930 mm long, 1,100 mm wide and 1,650 mm high. The speed of the upper, lower and side rollers was fixed at 300 rpm (4.24 m/s) and that of blower was 1,400 rpm as recommended by Sandhar (1995). The clearance between the upper and lower roller was fixed at 10 mm and no clearance was provided between the side and lower rollers. Similar values were recommended by Shukla and Sandhar (1985) and Sandhar (1995). The angle of the feeding chute was as 25º as recommended by Khar and Shukla (2003). The levels of the independent variables, namely, number of stalks fed at one time, crop variety and flap roller speed are given in **Table 1**.

Field Testing

A crop sample weighing 24 kilograms was fed to the sugarcane cleaner at the desired settings of different components of the machine as per experimental requirement. The crop was fed 4 stalks, 6 stalks and 8 stalks at a time. Four persons were required for smooth operation of the machine. The time required for cleaning the 24 kg of crop at a particular setting of the machine and number of canes fed at a time was measured with a stopwatch. After the cleaning process, the trash left on the ground, over the inclined platform and falling along the canes were collected and weighed separately. The trash remaining on the cane stalks was removed manually and weighed. The numbers of untopped cane stalks were counted and trash removed and weighed. The test procedure was again repeated for other replications.

Results and Discussion

The field performance data of the tractor-operated sugarcane cleaner are shown in **Table 2**. The topping efficiency increased with the increase in the flap roller speed from 6.78 to 16.46 m/s for both the varieties, and decreased with the increase in the number of canes fed from 4 to 8 canes at a time for both the varieties. A maximum topping efficiency of 89.18 % and 93.98 % was achieved for the COJ-64 and CO-1148 varieties, respectively, whereas there was a minimum mill trash of 3.62 % and 2.26 % for COJ-64 and CO-1148 variety. The cane loss percentage decreased and cane damage increased with the increase in the number of canes fed at a time. A minimum cane loss of 0.18 % and 0.87 % was observed for the COJ-64 and CO-1148 varieties, whereas minimum cane damage of 0.61 % and 0.87 % was reported for COJ-64 and CO-1148 varieties. The cane loss percentage and cane damage increased with the increase in the flap roller speed for both varieties.

The criteria for optimization of the independent variables was mainly low mill trash and low cane loss. Sandhar (1995) had assumed that, for optimization of the variables of the mechanical cleaner, the mill trash should not exceed 3 % and maximum acceptable cane loss should be 2 %. This was based on the fact that, even in the manual cleaning of sugarcane, the trash percentage was more than 2 %. The same was accepted by the mills in the country. Similar values for optimization were taken for the present study. A combination of the independent variables that resulted in mill trash of up to 3 % and cane loss

Table 1 Levels of independent variables studied

Sugarcane Variety	No. of canes fed at a time	Flap roller speed rpm, m/s
V_1 = COJ − 64	N_1 = 4 canes	S_1 = 350 (6.78)
V_2 = CO − 1148	N_2 = 6 canes	S_2 =600 (11.62)
	N_3 = 8 canes	S_3 = 850 (16.46)

Table 2 Experimental data of performance of sugarcane cleaner

Treatment		Topping Efficiency, %	Mill Trash, %	Stripping Efficiency, %	Cane Loss, %	Cane Damage, %
For COJ-64 Variety						
S_1	N_1	71.79	5.01	82.44	0.53	0.61
	N_2	67.52	5.83	78.14	0.34	0.81
	N_3	64.10	6.28	74.82	0.18	0.91
S_2	N_1	78.82	3.94	85.69	0.93	0.80
	N_2	73.89	5.05	83.73	0.54	0.99
	N_3	68.63	5.30	79.03	0.29	1.16
S_3	N_1	89.18	3.02	89.37	1.21	0.99
	N_2	80.70	3.86	85.71	0.78	1.24
	N_3	74.34	4.08	81.55	0.45	1.41
For CO-1148 Variety:						
S_1	N_1	75.70	4.21	86.50	1.89	0.87
	N_2	71.29	4.83	81.56	1.44	1.09
	N_3	68.83	5.10	77.91	0.87	1.54
S_2	N_1	83.61	3.47	89.19	2.31	1.10
	N_2	77.79	3.63	85.81	1.70	1.35
	N_3	73.60	4.07	80.81	1.35	1.93
S_3	N_1	93.98	2.26	94.47	2.74	1.36
	N_2	85.40	2.79	89.82	1.98	1.82
	N_3	78.71	3.27	83.57	1.67	2.21

of less than 2 % were a flap roller speed of 16.46 m/s and four cane feed rates for COJ-64 variety and a flap roller speed of 16.46 m/s and six cane feed rates for CO-1148 variety, respectively.

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Design and Development of Compact Desiccant Seed Dryer

by

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Abstract

A dryer was developed to dry seed at safe temperatures that used a silica-gel bed and an electric heater. The air was re-circulated in the dryer for energy conservation. The dryer was tested with brinjal and carrot seeds. Drying temperature was 40 ºC. Carrot seed were dried from an initial moisture content of 8.8 to 4.9 % (wb) while farm fresh brinjal seed were dried to a final moisture content of 5.7 % (wb). Silica-gel was regenerated with hot air supplied by an electric heater at 90 ºC.

Introduction

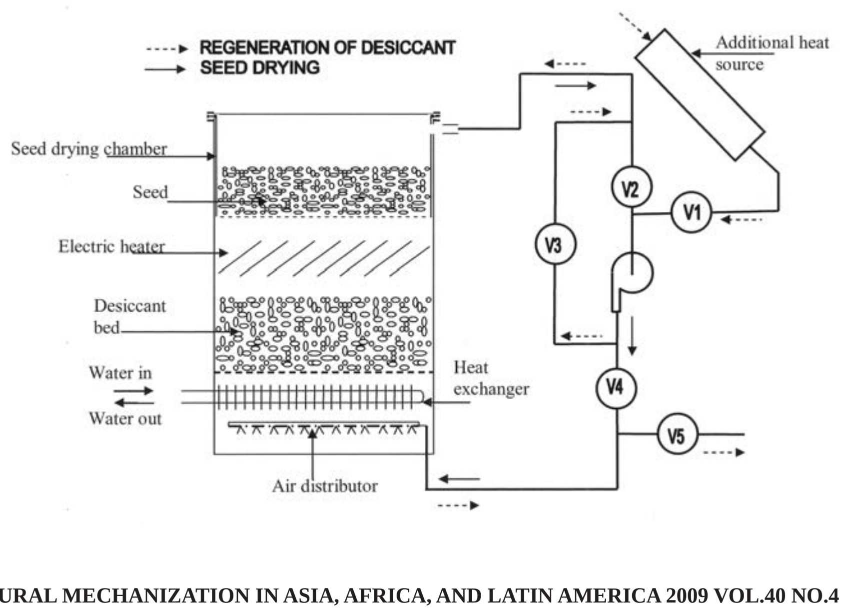
Hot air at 55-60 ºC is normally used for drying purposes to give sufficiently long shelf life for the dried product. However, at these temperatures, seed will have good shelf life but its germination level will fall. For safe drying of seeds, air should not be heated beyond 40 ºC but with this temperature shelf life of seeds is short. Therefore, it is necessary to first dry air before heating so that it will dry seed to lower moisture content for good shelf life along with higher germination level.

Seeds have been dried in thin layer to carry out investigations regarding EMC, drying rates, germination. Experiments were conducted to determine equilibrium moisture content of winged bean seed at temperatures of 40, 50, 60 and 70 ºC (Ajibola, 1986) with relative humidity varying from 11.1 to 82 %. Coefficients for five desorption isotherm models (Henderson, Chung-Pfrost, Modified Halsey, Chen-Clayton and Henderson-Thompson models) were evaluated. The lowest standard errors for estimates of equilibrium relative humidity and equilibrium moisture content were 4.5 and 0.9 %, respectively, for the modified Halsey model. Rapeseed were dried in a thin layer (Correa *et al.*, 1999) to generate data for EMC, drying coefficients and seed quality. The experiment had a four factorial scheme, with temperature levels at 30, 40, 50 and 60 ºC and relative humidity levels at 30, 40, 50 and 60 %. The modified Henderson equation was used to predict the EMC with coefficient of determination of 0.9859. The Page drying equation was found to be quite accurate to predict the moisture ratio. The seed vigor and germination were also correlated with temperature and humidity of drying air in the form of an empirical equation. The coefficients of determination for these two were 0.8553 and 0.9643, respectively. Both these parameters increased with increase in humidity or decrease in temperature. Fresh laird lentils were dried (Tang and Sokhansanj, 1993) with initial moisture contents of 16 to 20 % (wb) in a thin layer for periods up to 24 h at temperatures from 40 to 80 ºC and relative humidities from 5 to 70 %. The germination rates of the samples were evaluated four months after drying. Seed dried at temperatures up to 66 ºC had germination rates above 93 % that decreased significantly between 66 and 80 ºC. The loss in germination between 66 to 80 ºC was positively correlated to air temperature, seed initial moisture content and exposure time, and negatively correlated to relative humidity. Lentils dried at 80 ºC lost all their viability.

Different drying methods have been for drying seeds. In one of the drying studies, tomato seed were dried to evaluate sun, shade, sun and shade and mechanical drying at different air temperatures (Gowda *et al.,* 1990). Among the traditional methods, sun and shade drying and mechanical drying at 40 ºC were found to be best suited for commercial scale drying. The final equilibrium moisture content and germination were nearly 9 % and 90 %, respectively, in both cases. However, the drying period in mechanical drying was just 8 h in comparison to 30 h in sun and shade drying for a sample of 100 g. The effect of stage of harvest and drying methods were studied on storability of maize inbred, CM 201 seed (Sarada *et al.,* 1994). Seed were dried to 8-9 % moisture content in shade, sun and shade and artificially in the Thermax batch type seed dryer at 30, 35, 40 and 45 ºC. Seed dried at 40 and 45 ºC in shade, sun or artificial could maintain germination above certification standards (80 %) up to 12 months. The storability was markedly less when artificially dried at 30 and 35 ºC. Peroba-rosa (a forest species known for its wood) seed was dried naturally in the shade and artificially in a dryer at 35 and 45 ºC (Valentini *et al.,* 1999). The final moisture content for drying temperatures of 35 and 45 ºC were 10 and 5 %, respectively, in comparison to 6 % for drying in the shade. Seed germination was highest when seed were dried to 5 % moisture content by artificial means. Patra *et al*., (2000) studied the effects of drying and storage methods on summer groundnut variety JL-24. They were dried by (1) heaping plants left in the field with pod intact, (2) shade drying of pods with pods intact and separation of pods thereafter, (3) stripping of pods after harvest and exposing them to direct sunlight in a single layer and (4) stripping of pods after harvest and shade drying in a single layer. The pods were then stored separately in (1) an air tight plastic silo, (2) a gunny bag and (3) a polythene lined gunny bag with a centrally placed plastic container containing 25 g anhydrous $CaCl_2$. It was concluded that groundnut pods harvested in April/May could well be used as seed in October if pods were dried in the shade in a single layer and then stored in a polythene lined gunny bag containing $CaCl_2$.

Desiccants have been used to dry seeds. Soybean seeds were dried with silica gel (Zhanyong *et al.,* 2002). The seed were mixed directly with silica gel in different mass ratios. Soybeans and RD type silica gel (Fuji Silysia Co., 10-20 mesh) were put into a container of 100 mI and placed in a temperature-controlled chamber. A diffusion-type model representing the moisture exchanging in a mixed system of soybeans and silica gel (adsorbent) by analogy with “diffusion from a well-stirred solution” was applied. The drying kinetics were compared and analyzed. The diffusion-type model well represented the moisture exchange in a mixed system of soybeans and silica gel. At a moisture ratio (mass ratio of silica gel to soybean) of 0.5 and temperature of 303 K, soybean seed were dried to a moisture content of 0.13 (db) from 0.22 in 12 h. Higher temperature resulted in lower moisture content of soybean in a given time. Kundu *et al*., (2001) investigated different parameters for fluidization of a bed of soybean seeds and silica gel for sorption drying. The characteristic fluidization velocities, mixing mechanisms and fluidization quality were studied in a 180 mm inside diameter fluidized bed. Two sizes of silica gel particles were selected with the mass fractions in the range of 0.33-0.75 to form a static bed with heights from 100 to 280 mm (H/D = 0.56-1.56). The dispersion rate of soybean seed increased with addition of either of the two sizes and the frequency and span of pressure fluctuations within the bed were increased. It was inferred that the gas-solids contact was improved with addition of small particles in

Fig. 1 Schematic arrangement of different components in the compact desiccant seed dryer



the bed of large particles. Empirical correlations for characteristic fluidization velocities were developed.

Adapa (2002) used a cabinet dryer that employed recirculation of air to conserve energy, vapor compression dehumidifiers to dehumidify drying air and a moving tray arrangement to achieve uniform and faster drying for alfalfa. Chopped alfalfa, initially at 70 % moisture content, was dried to 10 % moisture content. Two dryer setups were used. The dryer in each case had a partitioned cabinet with trays of material on one side and a stack of one or two small household dehumidifiers on the other side. Air was recirculated through the material from bottom to top and back through the dehumidifiers. In one, the material was left on the trays until drying was complete (batch or fixed tray drying). In the other configuration, the trays were moved from top to bottom, introducing a new tray at the top while removing an old tray from bottom. Drying air temperature ranged from 25 to 45 °C. The average air velocity through the material was 0.38 m/s. Alfalfa chops dried in 5 h in the fixed tray drying and in 4 h in the moving tray drying. The specific moisture extraction rate ranged from 0.35 to 1.02 kg/kWh for batch drying and stayed at an average value of 0.50 kg/kWh for continuous/moving tray drying. The flip side of the dryer was use of high grade energy in the form of electricity and manual opening and closing of butterfly valves to maintain the drying air temperature at the desired level. It resulted in loss of dehumidified air to the environment. Dhaliwal *et al.*, (2006) dried onion seed from 8 % to 4.5 % with 40 ºC drying air. The air was recirculated through a desiccant bed of silica gel to dehumidify the drying air. The drying air could be supplied at any temperature by adjusting the setting of a thermostat and the desiccant could be regenerated by any source of heat including solar energy. The draw back of this dryer was that its components were spread out to occupy more space.

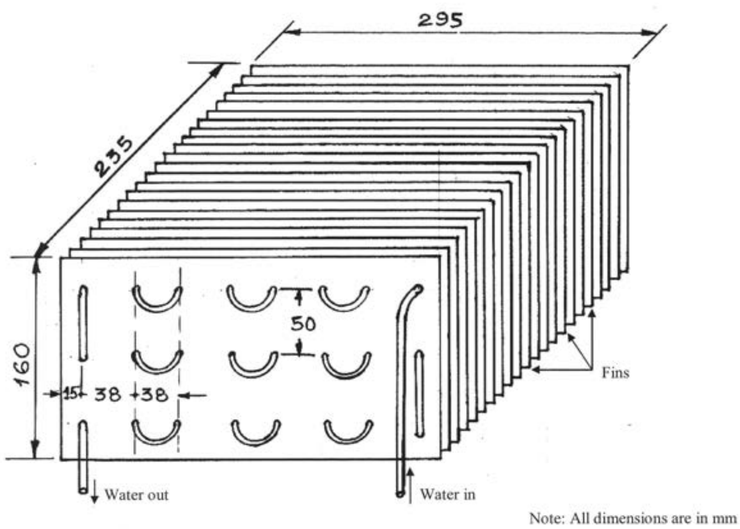
The present work was about the development of a seed dryer called Compact Desiccant Seed Dryer, which was principally the same in operation. However, all components but the blower were integrated into one unit making it small in size. This study used carrot and brinjal seeds.

Description of Dryer

The schematic of the compact desiccant seed dryer is shown in **Fig. 1**. The drying air was dehumidified in the desiccant bed and passed through an electric heater and thence through the seed in the drying chamber. The hot air leaving the drying chamber was cooled in the heat exchanger before reentering the desiccant bed to start a new cycle. Cooling in the heat exchanger enhanced the absorption capacity of the desiccant. Since the air was being re-circulated in the dryer, the desiccant removed moisture picked up by the air from the seeds only. The air distributor ensured uniform distribution of the air. The desiccant became saturated and was regenerated with hot air supplied by electric heater. There was a provision for an optional additional heat source. During regeneration, the seed-drying chamber was empty and the system worked in an open loop. **Fig. 1**. shows the path of air during drying and regeneration by firm and dotted arrows, respectively.

The components of the dryer, viz. desiccant bed, 200 W electric heater, seed drying chamber, air distributor and heat exchanger, were housed inside an air-tight, G. I. sheet, rectangular chamber 35 × 31 cm and 55 cm high (**Fig. 1**). The electric blower, heating source and piping network was outside the rectangular chamber. The desiccant bed of silica gel crystals was 35 × 31 cm and 11.5 cm high and was supported over a wire mesh base. The 200 W electric heater consisted of 10 heating strips, each 7 cm wide and 30 cm long. These strips were inclined at 45º with the horizontal so that air by-pass was minimum. The seed-drying chamber was 35 × 31 cm and 15 cm high made of G. I. sheet with a wire mesh base. It had a 3.5 cm wide flange at the top that rested on the flange of the rectangular chamber. The air distributor had three pipes 1.25 cm diameter and 28 cm long. Each pipe had 13 holes 3 mm diameter on the lower side for proper distribution of air. The heat exchanger was a fin and tube

Fig. 2 Heat exchanger



type (**Fig. 2**) and had 16 identical parallel copper fins 29.5 × 16 cm. Each fin had 24 holes of 1.6 cm diameter arranged in 8 columns and 3 rows The distance between any two consecutive fins was 1.5 cm. Centre to centre distance between any two consecutive columns and rows was 4 cm and 5 cm, respectively. Twenty-four pieces of pipe of 1.6 cm diameter and 26.5 cm length were passed through the holes in each fin. These pieces of pipe were brazed to the fins for good thermal contact. Any two consecutive pieces of pipes in a row were joined at the ends by copper U-bends so that one row became one pipe with 7 bends. Pipes of any two consecutive rows were also joined at the ends by U-bends so that water had a single entry and exit point.

Design of Desiccant Bed

The design steps and criteria for the desiccant bed were:

Amount of seeds to be dried
= 1 kg
Initial moisture content of seeds
= 40 % (assumed)
Final moisture content of seeds
= 5 % (assumed)
Drying time for seeds
= 6 h (assumed)
Moisture required to be removed from
1 kg of seeds
= 1 × (0.040 − 0.005) × 1000
= 350 g
Moisture removal rate from the seeds
= 350/6
= 58.3 g/h
Average rate of heat release in desiccant bed
= [(58.3 / 1000) × 2400] / 3600
= 0.0388 kW
Maximum heat release rate in desiccant bed using factor of safety 2
= 2 × 0.0388
= 0.0776 kW (say 77.6 W)

It was determined through experimentation on an adiabatic bed that 1 kg of silica-gel adsorbed 70 g of moisture which was similar to the results of (Singh and Singh, 1997)

Amount of silica-gel required to adsorb 350 g moisture
= 350 / 70 kg
= 5 kg
Density of silica-gel bed (measured)
= 667 kg/m^3 of bed volume
Volume of 5 kg of silica-gel bed
= 5/667 = 0.0075 m^3
Volume of silica-gel bed using factor of safety 1.5
= 0.0075 × 1.5
= 0.01125 m^3
Silica-gel bed cross-section
= 35 × 31 cm (Assumed)
Therefore, silica-gel bed height
= 0.01125 / (35 × 31)
= 10.3 cm
Actual silica-gel bed height
= 11.5 cm

Design of Heat Exchanger

The design steps for the heat exchanger (cooling coils with fins) were:

Heat transfer coefficient between air and fins (h)
= 25 $W/m^2 {}^oC$ *(assumed)*
Cooling water temperature
= 25 ºC (assumed)
Air temperature
= 35 ºC (assumed)
Approximate fin temperature
= 30 ºC
Temperature difference between air and fins (dT)
= 35 − 30
= 5 ºC
Applying
$Q = h \times A \times dT$
$77.6 = 25 \times A \times 5$
Required surface area of fins (A)
= 77.6 / (25 × 5) = 0.624 m^2
= 6240 cm^2
Where;
Q: heat transfer rate (W)
h: heat transfer coefficient (W/m^2 ºC)
A: surface area of fins (m^2)
Assume the following arrangement to satisfy the required surface area of fins:
Number of copper fin plates *(29.5 × 16 cm)*
= 16
Number of holes in each fin to pass a piece of pipe of 16 mm diameter (8 columns, 3 rows)
= 24
Number of pieces of pipe
= 24
Centre to centre distance in consecutive pieces of pipe in a row
= 4 cm (fixed by copper bends available in the market)
Centre to centre distance in consecutive pieces of pipe in a column
= 5 cm
Fin area available for heat transfer
$= 32 \times 29.5 \times 16 - 384 \times 3.14 \times (1.6)^2 / 4$
$= 14332\ cm^2$ *(required 12480* cm^2*)*

The heat exchanger based on this design is shown in **Fig. 2**.

Experimentation

The Compact Desiccant Seed Dryer was tested both in the laboratory and in an industry (M/s Plantsmans Landscapes and Seeds, Patiala, Punjab, India). The experiments consisted of seed drying and regeneration of desiccant.

During drying in the laboratory, the valves v1, v3 and v5 were closed and valves v2 and v4 were opened. Farm fresh brinjal seed weighing 250 g were loaded for drying. The flow rate of air was measured with an orifice meter by measuring the pressure drop across it with a U-tube manometer with water as the manometric fluid. The flow rate was $8.55 \times 10^{-4}\ m^3/s$. Ground water was circulated through the heat exchanger. A thermocouple sensed the temperature at the inlet of seed bed and its output was used in the controller to maintain it close to 40 ºC by switching the electric heater on and off. Ambient temperature, temperature of air at the outlet of heat exchanger, outlet of desiccant bed and inlet of seed drying chamber were sensed by thermocouples and recorded every half an hour. Moisture contents of seeds at the beginning and end of drying were measured by oven drying. Germination of the seed were determined by sprouting a given number of seeds at specified conditions in the germinator.

During drying in industry, all the parameters except ambient temperature and temperature at the outlet of the desiccant bed were measured. Carrot seed (100 g) with initial moisture content of 8.8 % (wb) were loaded for drying.

During regeneration, valves v2 and v4 were closed and valves v1, v3 and v5 were opened. The seed were taken out of drying chamber and the cooling water supply to the heat exchanger was shut off. The air flow rate (8.55×10^{-4} m^3/s) was measured with an orifice meter and a U-tube manometer.

A temperature of 90 ºC was maintained at the inlet of the desiccant bed. A controller used the input from a thermocouple at the inlet of the desiccant bed and controlled an electric heater. The temperatures at the inlet and outlet of desiccant bed were measured every half an hour with mercury-in-glass thermometers.

Results and Discussion

Fig. 3 shows the temperatures of air at the inlet and outlet of the desiccant bed, inlet of the seed drying chamber and ambient temperature as a function of time during drying of brinjal seed in the lab. On a given day, the temperature of drying air was maintained close to 40 ºC (38 ± 2 ºC). The temperature of air at the outlet of the desiccant bed was higher than that at the inlet showing adsorption of moisture in the desiccant bed. The difference in these temperatures decreased as drying progressed showing decrease in drying rate of seed and, hence, lesser adsorption and lower temperature of air at the outlet of the desiccant bed. The temperature of air at the outlet of desiccant bed was lower than the desired temperature for drying air, signifying the need for heating the air before it entered the seed. The air temperature at the outlet of the desiccant bed was lowered between 5 and 6 hours of drying. This was attributed to low temperature of desiccant bed due to overnight halt in the experiment. However, this did not affect the drying of seed because the heater raised the temperature of drying air to the desired level before it entered the drying chamber. The seed was dried to 5.7 % (wb) moisture content in 8.25 h. Germination of the dried seed was 70 %.

During drying in the industry, carrot seed were dried from the initial moisture content of 8.8 to 4.9 % (wb) in 5 h. Germination of the loaded and dried seed was 75 %.

Fig. 4 shows regeneration of air temperatures at the inlet and outlet of the desiccant bed as a function of regeneration time. The temperature of hot air for regeneration was about 90 ºC. The temperature at the outlet of the desiccant bed continued to rise as regeneration progressed showing that evaporation rate of moisture from the desiccant decreased with time as less moisture was available for evaporation. Regeneration was completed in 7 h.

Fig. 3 Variation of air temperature with drying time in the compact desiccant seed dryer and ambient temperatures during drying of brinjal seed

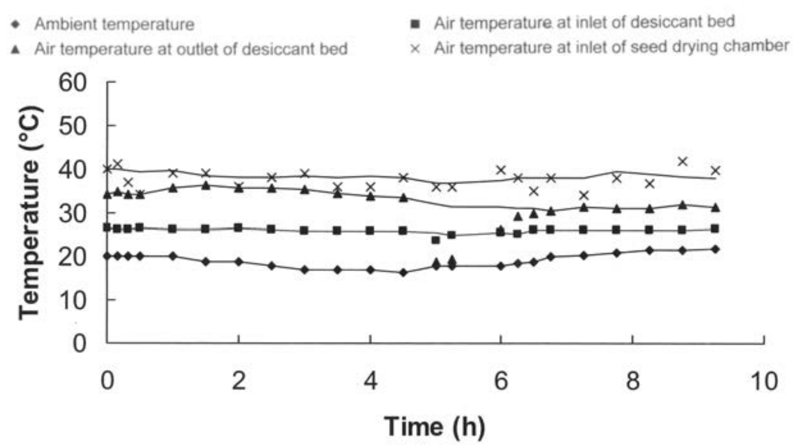
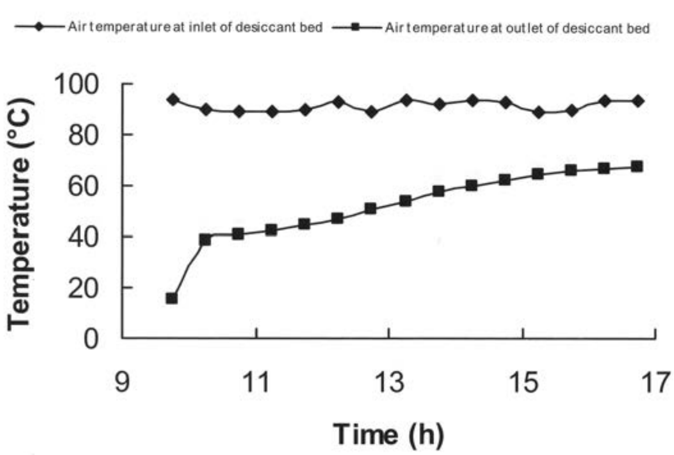


Fig. 4 Temperature of air at inlet and outlet of desiccant bed as a function of time during regeneration of desiccant



Conclusions

The Compact Desiccant Seed Dryer was able to dry brinjal and carrot seed to the desired moisture content. By using the Compact Desiccant Seed Dryer, it was possible to dry the seed at lower drying air temperature (40 ºC) to ensure higher viability and germination. At the same time, seed moisture content below 5 % could be obtained for good shelf life.

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■■

Test Results of “Aquasearch Pm-600” Moistur Meter of “Kett Electric Laboratory” (Japan)

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The laboratory of the All-Russia Research Institute of Agricultural Mechanization (ВИМ (VIM), Moscow) has been conducting laboratory and field tests for 15 years on a moisture meter “Aquasearch PM-600” that came to our country for the first time in 1989. This device appears to be the best modern electric grain moisture meter in production. In addition to moisture, the device can measure grain-unit, temperature, weight and electric capacity of a controlled sample of material.

The principle operation is that of the dielcometer with an operating frequency is 50 MHz. The primary transducer is coaxial-type. Dosing of a controlled sample is volumetric (240 cm^3) with free loading. Self-diagnosis of the device operability allows excluding instrument error. The instrument provided an opportunity for indication correction by a shift of the calibration curve by ±5.9 % (in devices of last years’ release, by ±9.9 %). Fifty six calibration curves for grain, leguminous, oil-bearing, vegetable and flower crops were embedded in the device. The moisture measurement range is: 4 to 20 % for vegetable and flower crops; 6 to 30 % for oil-bearing and legume crops and 6 to 40 % for wheat, barley and corn.

Laboratory tests of the device were being conducted under laboratory conditions at the VIM laboratory. Field tests for natural moisture conditions at the elite-seed-production collective farm “Borets” of Ramenskoye District of the Moscow Region during the harvest seasons of 1989-2002 for wheat, rye, barley, oats, peas, corn, sunflower, rape and radish.

Metrological parameters of the device were being estimated during tests. These included range, error, convergence and reproducibility of moisture measurements. A check of operability by measurement channels of grain-unit, temperature and weight of an analyzed sample was also being conducted. Effect of grain-unit and crop variety differences, as well as personal operator features on accuracy of moisture measurements was being estimated. Operating parameters (convenience of operation and reliability) were being estimated.

A drying cabinet was used as a reference facility for moisture measurement (W) СЭШ-3М (SASH-3M) that was certified by the metrological service of the GosStandart. The measurements were conducted according to GOST 13586.5-93 (1993) and GOST 12041-82 (1982).

Estimation of a moisture meter range was conducted for grain and seeds of eared, leguminous and oil-bearing crops. For this purpose, samples were used that corresponded to moisture of lower (4 to 6 %) and upper (30 to 40 %) limits of the range given in technical documentation for the device.

The test results identified that the ranges of moisture measurements for grain of wheat, barley, oats, peas, sunflower and rape correspond to data given in the operation instructions. For rye, the upper limit of measurements was limited to 25.5 %.

Estimation of absolute error of moisture measurements (Δ_{abs}) was determined from results of device field tests for grain and seeds of natural moisture using five varieties of wheat, three varieties of rye, four varieties of barley and two varieties of oats peas, rape and radish of crops of 1990-2000. A value of the (Δ_{abs}) error was calculated on the basis of comparison with material moisture measurement from the device and standardized tool - a drying cabinet СЭШ-3М:

$\Delta_{abs} = \bar{\alpha} - \bar{w}$,

where $\bar{\alpha}$ and $\bar{w}$ are mean values of moisture of three material samples obtained with the testing device and a reference facility of measurements, respectively. Estimation of Δ_{abs} was conducted in moisture ranges up to 20 % and above 20 %. Results of statistical analysis in specified ranges are shown in **Table 1**.

It can be seen from the table that, in a range of grain moisture up to 20 %, a mean value of the measurement error for specified crops mainly corresponds to the value given in the operation instructions (0.5 %).

In a range of moisture above 20 % the value of moisture measurement error increased in 1.5 to 2 times.

Histograms of distribution (**Figs. 1a** and **b**) of measurement of absolute error values for wheat grain in ranges of moisture up to 20 % (a) and above 20 % (b) are shown as an example.

Calculations showed that 74 % of all measurements for wheat and 50 % for barley gave an error value not exceeding 0.5 % in a moisture range of 8 to 20 %. Thirty five percent of the total number of measurements for wheat and 32 % for barley were within a rated error limit at a grain moisture of more than 20 %.

Convergence of moisture measurements was estimated by a difference (R) between maximum and minimum values of device readings for five consecutive measurements of samples taken from one specimen of grain. Results of statistical processing of moisture measurements for grain of some agricultural crops are given in **Table 2**.

It can be seen from the table that convergence of moisture readings, depending on the crop and personal operator features, varied from 0 to 1.0 %. Maximum values of this parameter were: 0.6 to 1.0 % for the basic eared crops and peas; and 0.4 % for rape seeds. Mean values of moisture measurement convergence ($\bar{R}$, %) in specified ranges were 0.18 to 0.25 % for rye, wheat, barley and peas; 0.33 % for oats; 0.11 % for rape.

Histograms of distribution of values of moisture measurement convergence are shown in **Fig. 2**.

Calculations showed that, among 600 values of convergence of measurement results for grain of eared crops and peas, the largest part (82 %) was within limits of 0.2 to 0.3 %. Greater values of measurements convergence were observed at grain moisture above 20 %.

Estimation of moisture measurement reproducibility was conducted with devices with serial numbers 8900062 and 8900070 for three moisture conditions (dry, damp, wet). A reproducibility value was estimated by a difference between mean values of measurement results from five controlled samples of grain. Results of the measurements are presented in **Table 3**.

The reproducibility of moisture measurements was 0.4 to 0.5 % for

Fig. 1 Histograms of distribution of moisture measurement error values for wheat grain in ranges: a) 8 to 20 %; b) 20.1 to 30 %; n-number of measurements

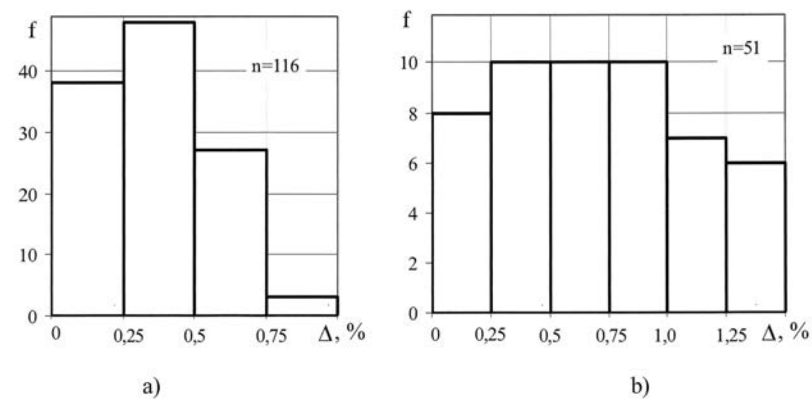

Table 1 Statistical estimation of absolute error of moisture measurements with the "Aquasearch PM-600"

Crop	Moisture range, %	Values of moisture measurement errors (Δ_{abs}, %) in ranges					
		up to 20 %			above 20 %		
		variation limits Δ_{abs}, %	$\bar{\Delta}_{abs}$, %	$\bar{\Delta}_{abs} \pm t_{05} \cdot s_{\bar{\Delta}}$, at 5% significance level	variation limits Δ_{abs}, %	$\bar{\Delta}_{abs}$, %	$\bar{\Delta}_{abs} \pm t_{05} \cdot s_{\bar{\Delta}}$, at 5% significance level
Wheat	7.0-35.0	0.1-1.0	0.34	0.34±0.03	0.1-1.5	0.71	0.71±0.11
Rye	7.5-26.7	0.1-0.7	0.24	0.24±0.04	0.1-2.2	1.0	1.0±0.36
Barley	7.6-37.0	0.1-1.7	0.52	0.52±0.06	0.1-2.1	0.91	0.91±0.17
Oats	6.5-30.0	0-1.25	0.56	0.56±0.1	0.1-2.6	0.89	0.89±0.37
Peas	6.5-30.0	0-1.0	0.32	0.32±0.06	0.35-2.2	0.63	0.63±0.29
Rape	6.6-28.0	0.1-0.6	0.24	0.24±0.06	0.1-2.0	1.0	1.0±0.17
Radish	3.3-18.4	0.1-1.0	0.15	0.15±0.28	-	-	-

eared crops with grain moisture in a range of 13 to 17 %, for wetter grain the specified values were 0.7 % for wheat and rye, 13 % for grain of barley, and 0.3 to 0.4 % for oats and rape.

One of the features of the "Aquasearch PM-600" device is an opportunity to make measurement of grain-unit, which is its most important qualitative indicator.

On the basis of long-term observations it was identified that grain-unit measurements with the device were underestimated in comparison with the standard method (GOST 10840-64, 1986): for wheat and barley on the average by 16 to 17 g/l, of rye, 11 to 12 g/l, of oats, 19 g/l at standard moisture of controlled samples connected with various methods of material sample formation in volumes of a measuring glass of the device and capacity of a standardized facility for grain-unit determination.

Estimation of a method of automatic compensation of grain-unit effect on moisture measurement was conducted for wheat grain samples with identical moisture and different natural weight. Results of tests are presented in **Table 4**.

It can be seen from the **Table** that for wheat with moisture of 13.6 % and 16.0 % that significant effect of grain-unit on moisture measurement results was not found. For damp grain (W=24 %) a difference between device readings amounted to 1.5 % at ΔN = 47 g/l.

Test results showed that a method of compensation of grain-unit effect on moisture measurements with the device acts most effectively for grain of standard moisture. For greater values of grain moisture the efficiency becomes lower. This is relater to the change of mechanical-and-physical properties of grain.

During device tests under field conditions estimation of the effect of variety differences of a crop on its readings was conducted. For this purpose, wheat, rye, barley and oats of different varieties grown in the same farm were used.

Fig. 3 (a, b, c, d) shows the graphic representations of the relationship between device readings (α) and grain moisture (W) and their analytical expressions for grain of two varieties of wheat ("Moskovskaya 39", "Lada"), rye ("Purga", "Krona"), barley ("Moskovsky-3", "Risk") and oats ("Skakoon", "Ulov").

The figures show that variety differences of a crop grown in the same climatic conditions do not significantly affect device readings. For wheat and rye differences between device readings in the examined range did not exceed 0.5 %. For barley and oats, values were within the value of measurement convergence (0.1 to 0.2 %).

The difference related to the personal operator and the material sample formation in the measuring

Fig. 2 Histograms of distribution of convergence values of moisture measurement with the device for grain of various crops

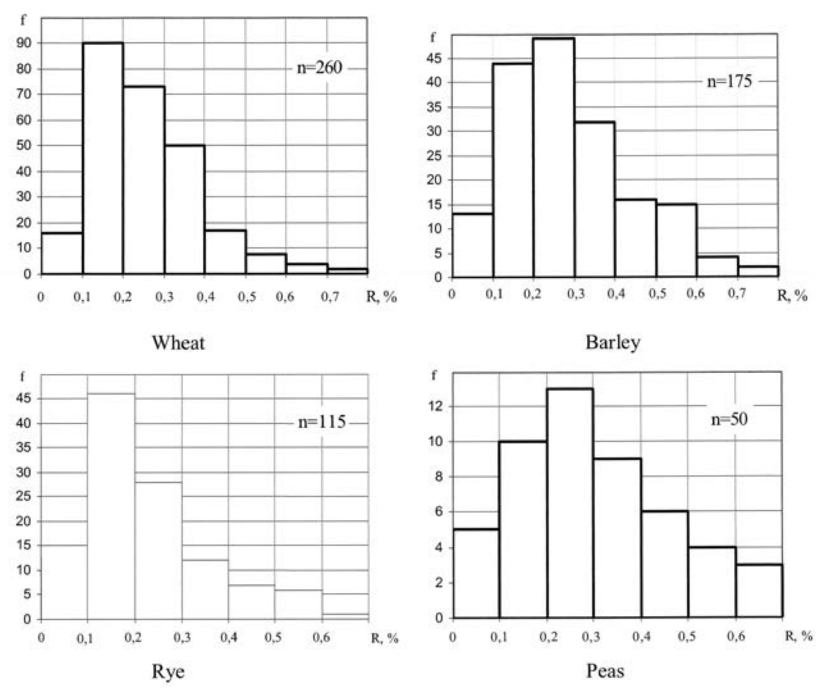

Table 2 Estimation of convergence of moisture meter measurements for grain of eared and leguminous crops

Crop	Number of measurements, n	Range of grain moisture, %	Range of value variations R, %	Mean value $\bar{R}$, %	Standard deviation S, %	Confidence interval for $\bar{R}$, %
Wheat	260	7.0-35.0	0-0.9	0.21	0.13	0.21±0.02
Rye	115	7.5-26.7	0-0.6	0.18	0.14	0.18±0.03
Barley	175	7.6-37.0	0-0.7	0.24	0.15	0.24±0.02
Peas	50	6.5-30.0	0-0.6	0.25	0.17	0.25±0.05
Oats	60	6.5-30.0	0-1.0	0.33	0.17	0.33±0.04
Rape	65	6.6-28.0	0-0.4	0.11	0.02	0.11±0.01

Fig. 3 Relationships α = *f* (W) for grain of the main eared crops of different varieties

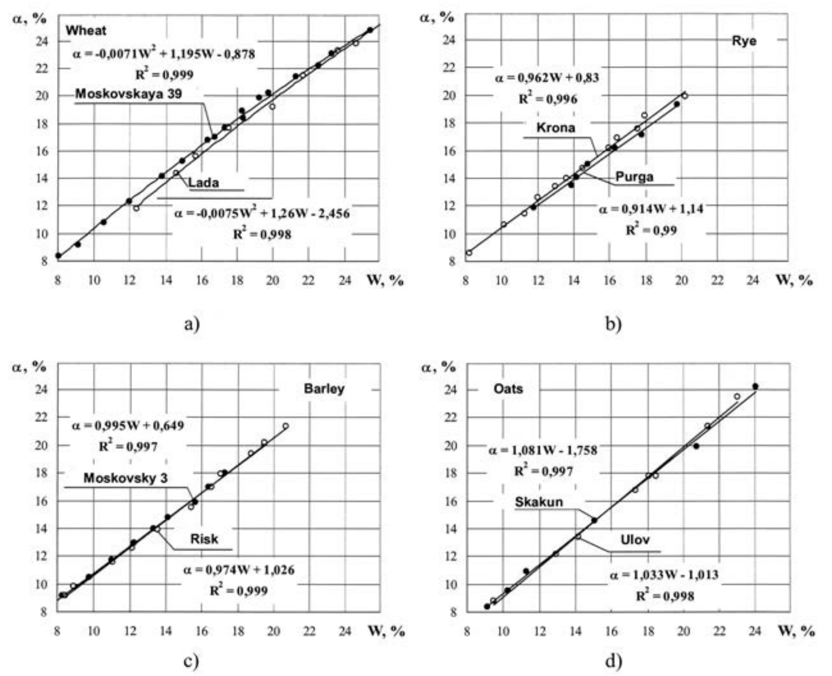

Table 3 Estimation of results reproducibility for grain moisture measurements made by specified devices

Crop	Moisture of grain, (W, %)	Device serial number: 8900062	8900070	Measurement results reproducibility, (B, %)
		средние значения результатов измерений влажности, ($\bar{\alpha}$, %)		
Wheat	13.2	13.8	13.3	0.5
	17.5	18.2	17.8	0.4
	27.6	28.9	28.2	0.7
Rye	13.5	13.7	13.2	0.5
	17.0	16.8	16.4	0.4
	20.2	20.0	19.3	0.7
Barley	13.0	13.3	12.8	0.5
	17.8	18.0	17.5	0.5
	26.9	27.0	25.7	1.3
Oats	12.0	11.5	11.0	0.5
	17.0	16.9	16.4	0.5
	20.2	20.8	20.5	0.3
Rape	7.8	7.4	7.1	0.3
	14.1	14.2	13.7	0.5
	21.2	20.2	19.8	0.4

sleeve, speed and heights of filling of the transducer is an important factor affecting results of moisture measurements with the "Aquasearch PM-600" device. Estimation of the effect of this factor on moisture measurement was conducted for dry wheat. Thirteen operators five measurements each with the device. Results are given in **Table 5**.

It can be seen from the table that a difference among results of moisture measurements by operators with the device was 0.4 %. Convergence of measurements of the same grain sample depending on an operator varied from 0 to 0.8 %. Values of measurement convergence did not exceed 0/3 % for nine operators out of thirteen. The results indicate a low effect of an operator on results of measurement.

In 2005 comparative tests of "Aquasearch PM-600" and PM-600 devices produced in 1989 and 2004, with the purpose of comparison of their metrological characteristics, were conducted. The wheat crop of 2005 with natural moisture was used. Results of the tests are presented in **Table 6**.

Results of tests showed that appreciable changes in metrological parameters of these devices were not observed. The maximum value reproducibility for the two devices did not exceed 0.13 %.

The "Aquasearch PM-600" moisture meter found wide application in the elite-seed-production collective farm "Borets" which is a base farm of the Moscow Region for in-

Table 4 Estimation of grain-unit effect on moisture measurement

Grain moisture under GOST 13586.5-93 (W, %)	Grain-unit under GOST 10840-64 (N, g/l)	Δ N, (g/l)	Results of grain moisture measurements with the device (α, %)	Difference between moisture measurement results, %
13.6	749	47	13.4	0.4
	796		13.8	
16.0	727	27	16.4	0.1
	754		16.5	
24.0	615	47	24.8	1.5
	662		23.3	

troduction of domestic and foreign moisture meters to agricultural industry. For after-harvest processing of seeds the collective farm "Borets" has a large mechanized seed-cleaning-drying complex including 48 hoppers of active aeration and a significant park of floor dryers (14 pieces). During 15 harvest seasons, using this device they determined ripeness of grain in the field, terms and methods of harvesting, controlled moisture and temperature of grain at its reception and distribution on open storage grounds of a thrashing-floor determined a period of safe storage and modes of drying and the controlled moisture of final products.

For observance of technology of after-harvest seed material processing using this device, more than 100 measurements of moisture were made every day that corresponded to more than 3,000 measurements at harvest season.

The "Aquasearch PM-600" moisture meter was noted for high reliability and high operational advantages. For the period of its heavy use during harvest seasons from 1990 till 2005 more than 75 thousand measurements were made with it. Failures of both separate units and the device as a whole were not observed. For all periods of device operation, its metrological parameters did not change. However, it was necessary to exclude the influence of technological equipment vibrations on the device when carrying out measurements.

Thus, results of long-term laboratory and field tests of the "Aquasearch PM-600" moisture meter showed that the device meets modern requirements of agricultural production by its metrological and operational parameters, for a wide range of measuring crops. Scientific and industrial activities of the laboratory connected with tests and use of the device during harvesting, processing and storage of grain and seeds assisted in its promotion to the Russian market.

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GOST 10840-64. 1986. Grain. Methods of Natural Weight Determination. Moscow: Publishing House of Standards. 3 pages.

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Table 5 Effect of personal operator features on results of grain moisture measurements with the "Aquasearch PM-600" moisture meter

Moisture meter readings α, %:						R, %
α_1	α_2	α_3	α_4	α_5	$\bar{\alpha}$, %	
9.4	9.4	9.5	9.4	9.5	9.4	0.1
9.5	9.7	9.4	9.3	9.6	9.5	0.4
9.8	9.7	9.8	9.8	9.6	9.7	0.2
9.7	9.6	9.5	9.7	9.5	9.6	0.2
9.7	9.8	9.6	9.7	9.6	9.7	0.2
9.6	9.1	9.5	9.5	9.4	9.4	0.5
9.2	9.4	9.8	9.0	9.1	9.3	0.8
9.6	9.0	9.3	9.3	9.3	9.3	0.6
9.6	9.7	9.6	9.6	9.6	9.6	0.1
9.7	9.7	9.6	9.5	9.7	9.6	0.2
9.7	9.6	9.4	9.5	9.7	9.6	0.3
9.7	9.7	9.7	9.7	9.7	9.7	0
9.6	9.6	9.5	9.6	9.7	9.6	0.2

Table 6 Estimation of metrological parameters of PM-600 devices for wheat

Moisture of grain, W, %	Grain-unit, g/l	Years of device production:						Reproducibility B, %
		1989			2004			
		$\bar{\alpha}$, %	R, %	Δ_{abs}, %	$\bar{\alpha}$, %	R, %	Δ_{abs}, %	
11.88	813	11.7	0.2	-0.18	11.77	0.1	-0.11	0.07
12.62	802	12.57	0.1	-0.05	12.67	0.1	0.05	0.10
13.50	797	13.63	0.1	0.13	13.70	0.2	0.20	0.07
14.89	726	14.32	0.1	-0.57	14.43	0.1	-0.46	0.11
16.85	729	16.87	0.1	0.02	17.00	0.1	0.15	0.13

ABSTRACTS

The ABSTRACTS 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.

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Ergonomic Evaluation of Male and Female Operators during Weeding Operation: **R. Yadav**, Professor (FMP), CAET, Junagadh Agril. University, Junagadh; **S. Pund**, Dy Manager, Mahindra & Mahindra (R & D) Nashik; **L.P. Gite**, Project Coodinator (ESA), CIAE, Nabi Bagh, Bhopal, College of Agril. Engg. & Technology, Junagadh Agril. University, Junagadh.

All the agricultural equipment are either operated or controlled by human workers and these equipments require skill, effort and correct speed. The estimated energy expended values can be used to define limits of human efforts for various agricultural operations. The operator's performance in different field operations can be assessed on the basis of the physiological responses. The estimation of energy expenditure rate (EER) by measuring the OCR is fairly accurate and acceptable method. Using Morgan Oxylog II Apparatus recorded OCR during filed operations. Oxylog can be easily mounted on the operator back and the oxygen consumed by operator during particular operation in the field can be recorded and data can be downloaded on PC for analysis and calculation.

In Saurashtra region weeding by sickle and with manual weeder is a common practice used by the farmers. In view of this 4 male and 4 female workers took part in this study. Subjects were acclimatized for the experimental protocol. Heart rate and oxygen consumption rate of male workers were measured. The physiological cost of male and female subjects was worked out on the basis of OCR and it was found to be 15.87, 15.87, 16.08 and 15.87 kJ min^{-1} and 8.14, 8.35, 8.35 and 8.35 kJ min^{-1} for subjects 1, 2, 3 and 4 respectively. Similarly physiological cost was worked out for female workers during weeding by manual weeder and it was found to be 13.57, 14.41, 14.20 and 14.41 kJ min^{-1} for subjects 1, 2, 3 and 4 respectively.

727

Prospectus of Paddy Cultivation Mechanization in Kashmir Valley; **Jagvir Dixit**, Assistant Professor (Agril. Engg.) Division of Agricultural Engineering, SKUAST-K, Shalimar, Srinagar. -191121 (J&K), India, **J. N. Khan**, Assistant Professor (Agril. Engg.) Division of Agricultural Engineering, SKUAST-K, Srinagar. -191121 (J&K) India

This paper describes the prospectus of paddy cultivation mechanization in Kashmir valley based on research findings during the recent past. The paddy cultivation mechanization is very poor in terms of mechanical power, matching and efficient implements and equipment drawn by draft animal power, power tiller and tractor. Recent work in the development and dissemination of engineering technologies carried out to mechanize the paddy cultivation for the region can play Adominant role in augmenting and sustaining the paddy production. Seed bed preparation with a light weight power tiller has saved about 50 % cost of operation in comparison to bullock ploughing and practice of rotatilling for paddy cultivation is becoming popular among the farmers of this region. The puddling by lugged wheel puddler ensured better puddling index and gave 11 % increased yield compared to conventional puddling by plough. Mechanical transplanting and weeding helped in reducing labour requirement to a great extent. Similarly, other operations needed for increasing paddy yield and reducing cost of operation need to be mechanized, not necessarily with the costly equipment, but with suitable improved implements suited to local conditions.

748

Simulation of Solar Radiation Incident on Horizontal and Inclined Surfaces: **M. A. Basunia**, Department of Soils, Water & Agricultural Engineering, Sultan Qaboos University, P. O. Box 34, A1-Khou 123, Muscat, Sultanate of Oman; **T. Abe**, Retired Professor, Department of Biomechanical Systems, Ehime University, Matsuyama, 790-8566, Japan.

A computer model was developed to simulate the horuly, daily and monthly average daily solar radiation on horizontal and inclined surfaces. The measured hourly and daily solar radiations were compared with the simulated radeation, and a good agreement was observed for the measured and predicted values on clear days. The measured and simulated monthly averages of totas (diffuse and beam) daily solar radiatin were compared and a reasonable agreement was observed for a number of stations in Japan. Simulation showed that during the rice harvesting season, September to October, there is a daily average of 14.7 Mj/m^2 of solar irradiation on a horizontal surface during the major rice harvesting season, November to December, in Bangladesh that can be effectively utilized for drying rough rice and other farm crops.

751

Ergonomics of Finger Type Rotary Weeders Interms of Physiological Stresses and Work Output: **K. Kathirvel**, Professor; **S. Thambidurai**, Ph. D scholar; **D. Ramesh**, Asst. Professor; **D. Manohar Jesudas**, Professor and Head/Department of Farm Machinery Agriclutural Engineering College & Research Institute Tamil Nadu Agricultural University, Coimbatore-641003

Traditional weeders are used in undesirable postures according to ergonomic criteria; involve repetitive movement of body parts which may lead to musculoskeletal disorders. In these postures, the energy consumption for a given load is 30 to 50 % more when compared with standing and sitting posture. The long handled weeders are slowly becoming pupular among paddy cultivars. The available finger type rotary weeders (single row and two row) were evaluated ergonomically with selected 12 male and female subjects to assess their suitability for men and women farm workers for reduced drudgery and adequate comfort. Ergo refinements *viz*., a telescopic adjustable handle for comfortable work posture, a flat type refined float in the front portion of the weeding roller frame with adjustable inclination to avoid excessive sinkage of weeding rollers in the paddy field and a plastic handle for firm grip were incorporated. The mean value of heart rate, energy cost, oxygen consumption rate interms of per cent VO_2 max and work pulse of male subjects for weeding operation with ergo refined single row finger type rotary weeder (EFW_1) was 127.76 beats min^{-1}, 24.85 kJ min^{-1}, 56.53 % of VO_2 max and 45.63 beats min^{-1} respectively. The corresponding values for female subjects are 121.71 beats min^{-1}, 24.55 kJ min^{-1}, 69.59 % of VO_2 max and 42.31 beats min^{-1} respectively. The mean value of heart rate, energy cost, oxygen consumption rate interms of per cent VO_2 max and work pulse of male subjects for weeding operation with ergo refined two row finger type rotary weeder (EFW_2) was 126.31 beats min^{-1}, 24.22 kJ min^{-1}, 55.11 % of VO_2 max and 43.29 beats min^{-1} respectively. For male workers, the maximum weed control efficiency of 83.4 and 89.1 % was observed with single and two row finger type rotary weeders respectively. The corresponding value for female workers was 79.4 % for single row weeder. Force required for push-pull operation of single row and two row weeders was 89.3-76.0 N and 149.9-114.6 N respectively. Ergo refined single and two row finger type rotary weeders resulted in 11.8-16.3 and 6.4 % reduction in cost and 11.8-16.3 and 12.0 % saving in time of weeding respectively when compared to weeders without ergo refinements.

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Status of Women Friendly Farm Tools and Equipment: Need and Prospectus in Indian Agriculture: **Shiv Pratap Singh**, Senior Scientist (FMP), NRCWA (Bhopal Sub-centre), CIAE, Bhopal, Presently, Research Scholar, Dept. of FMP Engg., CTAE, Udaipur- 313001. India; **Pratap Singh**, Director Research, MPUAT, Udaipur- 313001, Rajasthan, India; **Surendra Singh**, Project Coordinator (FIM), CIAE, Bhopal- 426 038, M. P., India

In Indian agricultural system, men and women are having equal role to play and both are a main stay in terms of power and source for the system. Most of the equipment was developed keeping male as main worker while ergonomical characteristics of women are different. Of human (men and women) power, female workers constitute about 39 % of total agricultural workforce in the country, their population being 91.2 million which is around 11% hike in comparison to 1991 census of the country. By 2025, women participation in agriculture is estimated to be around 133 million, i.e., 55 % of total agricultural workforce, as more men are migrating to urban areas in search of alternative source of livelihood, leaving their female partners to take charge of agriculture in addition to children and regular housework. In the light of above facts, ergonomics play major role which deals with anthropometry, assessment of workload, working environment and safety features/ mechanism to optimise man-machine environment system by matching the capabilities and limit of human operators/ workers. Presently the population statistics indicates about fast growth of female workforce in agriculture as compared to men. The present paper aims to acquaint about women friendly farm tools and equipment based on ergonomical studies conducted at different parts of the country and focus the need to enhance the pace of gender friendly studies with aim to make women as operators.

810

Ergonomic Assessment of Sugarcane Harvesting Knives; **K.Kathirvel,** Professor; **R.Thiyagarajan**, Ph.D scholar; **D.Ramesh**, Asst. Professor; **D. Manohar Jesudas**, Professor and Head, Department of Farm Machinery Agricultural Engineering College & Research Institute Tamil Nadu Agricultural University, Coimbatore-641003

Harvesting is one of the most labour consuming operation in sugarcane cultivation. In spite of improved farm mechanization, the use of the hand tools is inevitable in certain agricultural operations. Traditional manual sugarcane harvesting requires skilled cutters and demands enormous effort and energy. Commonly used and high energy demanding sugarcane harvesting knives were selected to assess the ergonomic suitability. A total number of ten harvesting knives were collected from various regions of South India and four harvesting knives were screened for ergonomic evaluation owing to their suitability, increased comfort, user friendly, damage caused to the stem while harvesting, versatility and field capacity. Twelve male subjects were selected for the investigation based on the age and fitness. The harvesting of sugarcane crop with selected harvesting knives was performed after 306 DAP. Out of the four screened sugarcane harvesting knives, the model which registered lowest value of ergonomic evaluational parameters, highest harvesting capacity with minimum damage to sugarcane root stalks was chosen and necessary ergo refinements viz. reduction of weight, thickness and width, redefined C_G for reduced torsional moment and modified handle configuration were incorporated. The mean value of heart rate, energy cost, oxygen consumption rate interms of per cent VO_2 max and work pulse of male subjects for cane harvesting operation with ergo refined sugarcane harvesting knife was 115.08 beats min^{-1}, 19.90 kJ min^{-1}, 47.08 % of VO_2 max and 40.90 beats min^{-1} respectively. The effectiveness of ergo refinements carried out in sugarcane harvesting knives is reflected with 4.3 % increase in harvesting capacity when compared to existing model. The effectiveness of ergo refinements carried out in sugarcane harvesting knife was reflected with 11.4 and 11.3 % saving in cost and time of harvesting respectively when compared to existing model of Dharmapuri sugarcane harvesting knife.

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Effects of Compaction on Sunflower Silage Quality; **Fulya Toruk**, Asst. Prof.; **Erkan Gönülol**, Asst. Prof.; **Birol Kayisoglu**, Prof. Namık Kemal University, Faculty of Agriculture, Dept. of Farm Machinery, 59030, Tekirdag, Turkey

The aim of this investigation was to determine sunflower silage quality under different compaction conditions. Whole-plant sunflower (Helianthus annuus L.) was harvested at three different maturity stages: BA; beginning of anthesis, ML; one-third milkline, and BL; blackline. Five compaction applications were carried out in the study. These were control (N), vacuum (WV) and compaction with 150 kPa (C1), 248 kPa (C2) and 498 kPa (C3). An experiment was organized in a 2-year x 3-stage (BA, ML, BL) × 5 compaction (N, WV, C1, C2 and C3) × 4 (replication) factorial arrangement of treatments to elucidate the relative effects of these factors on the conservation characteristics of ensiled sunflower. For this purpose, cylindrical plastic mini-silos (5.2 L) were used. The chopped forages were compacted in mini-silos at five pressure levels. Compaction had significant effects on silage quality, increasing the density of sunflower ($p < 0.05$). The dry-matter (DM) content and density increased in the silages with maturity. Crude protein level at BA stage ($p < 0.05$) was higher than that of ML stage and BL stage. Acetic acid values at the BA stages ranged from 0.30 and 0.53 while at the ML and BL stages they ranged from 0.40 and 0.92.

NEWS

Organic Agriculture Limitations and Future

Cairo, Egypt, October 2010

Organized by Egyptian Society of Organic Agriculture and Environmental Protection (OESOAEP)

In Collaboration with IFOAM, IUSS, UNEP

The objectives of the first ELOAEP Conformance are to:

Identify and evaluate organic agriculture problems in differnt areas.

Report on previous and current research as well as future work needed.

Establishing set of practices and technique to maintain high productivity.

Discussing the possibility of researchers with common interest and problems to work together in cooperative project programs.

The conference will deal with different aspects concerning organic agriculture

Future of organic agriculture in different countries and the market

The healthy soil and how to improve soil productivity.

Composting and methods to enhance the process and improve the compost quality.

Control of pests (diseases and insects) in organic agriculture

Organic crop production and standards

Principals and role in organic agriculture

The program consists of:

Plenary sessions for key not addresses, given by distinct and international specialists

Research papers for oral or poster presentation

Round table discussions

Call of papers:

Papers are accepted in all topics mentioned in the program. They should be written in English as camera ready copies for publications in the conference proceedings. An abstract in English (one-two pages single space) should be submitted with preliminary registration

Participation time table:

March 2010 dead time of receipt of abstracts

April 2010 author informed of paper acceptance

July 2010 dead time of receipt of complete paper

All Corresondence should be addressed to Prof. Dr. A. M. Elgala, Chairman of the Organizing Committee Department of Soil Science, Faculty of Agriculture, Ain Shams University. P. O. Box. 68 Hadayek Shobara, 11241, Cairo, Egypt.

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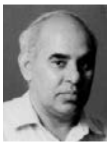
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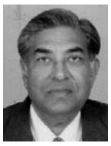
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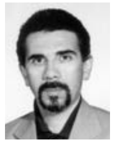
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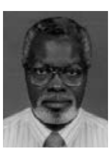
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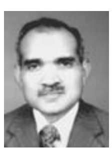
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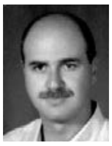
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Back Issues

AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Vol.39, No.4, Autumn, 2008

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Priority in the selection of article for publication is given to those that –

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c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission;
d. deal with practical and adoptable innovations by, small farmers with a minimum of complicated formulas, theories and schematic diagrams;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article;
f. are printed, double-spaced, under 3,000 words (approximately equivalent to 6 pages of AMA-size paper) ; and those that
g. art: supported by authentic sources, reference or bibliography.
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Format/Style Guidance

a. Article must be sent on 3.5 inch floppy disk or CD-R with MS DOS format (e.g. Word Perfect, Word for DOS, Word for Windows... **Absolutely necessary TEXT FORMAT**) along with two printed copy (A4).
b. The data for graphs and the black & white photographs must be enclosed with the article.
c. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features:
(i) brief and appropriate title;
(ii) the writer(s) name, designation/title, office/organization; and mailing address;
(iii) an abstract following ii) above;
(iv) body proper (text/discussion);
(v) conclusion/recommendation; and a
(vi) bibliography
d. The printed copy must be numbered (Arabic numeral) successively at the top center whereas the disc copy pages should not be number. Tables, graphs and diagrams must likewise be numbered. Table numbers must precede table titles, e.g., "Table 1. Rate of Seeding per Hectare". Such table number and title must be typed at the top center of the table. On the other hand, graphs, diagrams, maps and photographs are considered figures in which case the captions must be indicated below the figure and preceded by number, e.g., "Figure 1. View of the Farm Buildings".
e. **The data for the graph must also be included. (e.g. EXCEL for Windows)**
f. Tables and figures must be preceded by texts or discussions. Inclusion of such tables and figures not otherwise referred to in the text/discussion must be avoided.
g. Tables must be typed clearly without vertical lines or partitions. Horizontal lines must be drawn only to contain the sub-title heads of columns and at the bottom of the table.
h. Express measurements in the metric system and crop yields in metric tons per hectare (t/ha) and smaller units in kilogram or gram (kg/plot or g/row).
i. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
j. Convert national currencies in US dollars and use the later consistently.
k. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
l. When numbers must start a sentence, such numbers must be written in words, e.g., Forty-five workers..., or Five tractors..."instead of 45 workers..., or, 5 tractors.

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