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EDITORIAL

This year the weather has been so abnormal here in Japan as not experienced before. It was very warm in winter. We had the very hot day like summer in February, and after that, had a snowfall in March. Aftherwards we had little rain until May, though it is a rainy season in a usual year. Then it went on raining almost every day, that caused the severe damage to the rice crop due to the insufficient sunlight. To make matters worse Japan was struck by typhoons almost every week from end August to September, which also damaged many crops. It was reported that the middle-west part of the U.S. was also terribly flooded. The weather has been indeed unstable all over the world. It seems even to take on an aspect of radical change in weather condition on earth. Though we will not be accurate in saying about weather without making close observation for a long time, we have to survive under any weather condition.

To avoid starvation, the speedy and appropriate agricultural operation is required, where agricultural machinery plays a very important role. It is really difficult to promote the mechanization of agriculture with small scale farming in developing countries. The difficulty comes mostly from the weak economical basis of the farmers and increasing price gap between agricultural products and industrial products. This seems to me that mankind, particularly cities is rapidly going to eat up natural eco-system including farmers. The politics benefiting consumers is the world trend. However it is political responsibility to form the firm basis of farmers who are essentially to bear production basis. Agricultural mechanization should be also considered in that political system.

The goals are certaily challenging; our united efforts should be directed towards developing successfull communication through AMA to overcome many difficulties in promoting agricultural mechanization in deeloping countries.

Yoshisuke Kishida
Chief Editor

Tokyo, Japan
October, 1993

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AGRICULTURAL MECHANIZATION IN ASIA, AFRICA AND LATIN AMERICA

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Effects of Disc and Working Parameters on the Performance of a Disc Plough in Clay Soil

by
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Abstract

The effects of soil moisture content, disc and tilt angle, and ploughing speed on the specific draft requirement of a disc plough were studied in Bangkok clay soil. Experiments were conducted at 33.4%, 29.4% and 23.3% (d.b.) average soil moisture content, 40°, 45°, and 50° disc angles, 17°, 20° and 23° tilt angles and 3, 4 and 5 km/h average forward speeds. The depth of ploughing was maintained constant at 25 cm throughout the experiments. Results reveal that an increase in the soil moisture content and tilt angle, and decrease in the forward speed, reduced the specific draft requirements of a disc plough. A 45° disc angle setting showed less specific draft requirement compared to settings of 40° and 50°. Equations showing the effects of soil moisture content, tilt angle and forward speed were developed for different disc angles.

Introduction

Since 1900, the development of the disc plough followed a trend similar to that of the moldboard plough (Smith, 1964). The disc plough consumes much energy and it is widely used for primary tillage. Gordon (1941) conducted experiments in two different soils with variable speeds. He found that there was a 40% increase in draft in clay-loam and 90% in fine-loam soil when speed was increased from 1.34 to 2.68 m/s for a disc plough of 45° disc angle and 18 to 20° tilt angles. He also observed that the draft on the disc was minimum at a disc angle of about 45°. Harrison (1977) observed that the draft of the disc plough was reduced when the disc angle was increased from 35 to 45°. However, Nortov (1972) found an increase in specific draft for the disc angles above and below 25°.

There was a marked decrease in the specific draft requirement, when the tilt angle was increased from 15 to 25° (Gordon, 1941). Hann et al (1989) studied disc configuration and performance and observed that the degree of soil inversion was reduced as the tilt angle was increased. Disc penetration was best at a low tilt angle. Tilting the disc backward reduced penetration but had the advantage of reducing the draft force.

There were very few attempts in the past to develop theories based on the experimental results so that the draught force could be predicted from the knowledge of disc and soil parameters.

Krastin (1973) suggested methods for developing theories based on dimensional analysis. Following his suggestions, Gee-Clough et al (1978) developed an empirical equation for the prediction of draft requirement for ploughing. This generalized equation cannot be used for disc ploughs having different disc and tilt angles nor for different soil moisture contents.

Singh et al (1979) proposed relationships between speed and specific draft of a disc plough in a Bangkok clay soil. However, this relationship also did not consider the tilt and disc angles.

Hunt (1977) proposed an equation for the prediction of unit draft of ploughs in terms of ploughing speed and a constant depending upon soil type. For a 66 cm diameter disc, with 22° tilt and 45° disc angle, he gave the values of constants for Decatur clay and Davidson loam soils. However, he did not consider the soil moisture content in his equation.

The study outlined in this paper investigated the effects of different disc parameters and working conditions on the specific draft of a disc plough in clay soil.

Experimental Procedure

The experiments were conducted in a stubbled paddy field with predominantly clayey soil. The soil contained 5%, 32% and 63%, sand, silt and clay, respectively. The liquid, plastic and sticky limits of the soil were 47.7%, 23.0% and 33.5%, respectively. The specific weight and cone index values of the soil were, respectively, 16.38 kN/m^3 and 1 498 kPa at 23.3% soil moisture content, 17.06 kN/cm^3 and 1 282 kPa at 29.4% soil moisture content and 17.46 kN/m^3 and 707 kPa at 33.4% soil moisture content. The three average soil moisture contents studied (23.3%, 29.4% and 33.4% dry basis) were above the plastic limit, but below the liquid limit of the soil.

A disc plough, with a radius of curvature of 70 cm and diameter 69.3 cm, was selected for this study. This plough had a provision for changing the disc angle from 40° to 50° and tilt angles of 17°, 20° and 23°. A Massey Ferguson 4-cylinder diesel engine tractor (Model MF-165) with rated power of 46 kW at 2 000 rpm was used for testing. A three-point linkage dynamometer was used to sense the draft on the disc plough. Each lower link transducer of the dynamometer had two bridge circuits to detect the horizontal forces or draft and the vertical force. The algebraic sum of the horizontal forces on the lower links and top link gave the total draft. A strain amplifier, equipped with a built-in active low-pass filter was used to amplify the output signals from the bridge circuit of the load cells and to supply excitation voltage in the circuit. An LVDT, mounted on a three point linkage of the tractor, was used for the measurement of ploughing depth. The amplified signals from the transducers were recorded on a data tape recorder. Later on, using an A/D convertor, all the data recorded were transferred to a micro-computer for further analysis.

Results and Discussion

Effect of Soil Moisture Content

Fig. 1 shows the effects of soil moisture content on the specific draft requirements of the disc plough with 45° disc angle, at different tilt angles and ploughing speeds. **Fig. 1(a)** shows that at 17° tilt angle and 45° disc angle, the specific draft decrased with an increase in soil moisture content for all the ploughing speeds. At 3 km/h speed, the specific drafts were 14.1, 13.1 and 12.4 N/cm^2; at 4 km/h speed, they were 15.4, 14.6 and 13.3 N/cm^2; and at 5 km/h, these were 16.1, 15.2 and 13.7 N/cm^2 for average soil moisture contents of 23.3% 29.4% and 33.4%, respectively, **(Fig. 1(a))**. **Figs. 1(b)** and **1(c)** similarly show that an increase in soil moisture content reduced the specific draft requirement at 20 and 23° tilt angles and 3, 4 and 5 km/h ploughing speeds. Similar trends were noted at 40 and 50° disc angles.

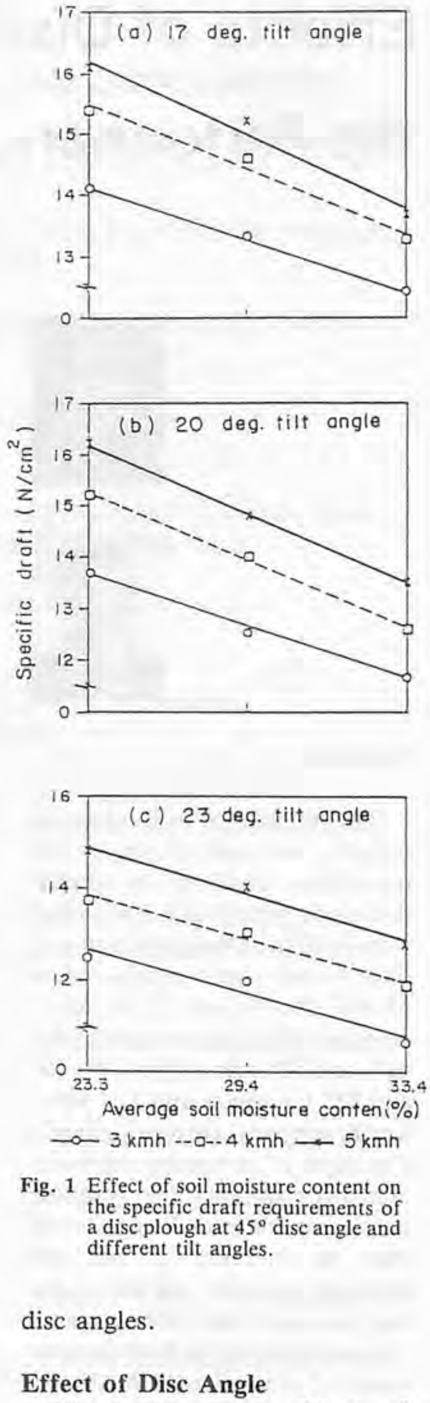

Fig. 1 Effect of soil moisture content on the specific draft requirements of a disc plough at 45° disc angle and different tilt angles.

Effect of Disc Angle

Fig. 2 shows the effects of disc angle at 29.4% soil moisture content, 17, 20 and 23° tilt angle and 3, 4 and 5 km/h speeds. It was found that the draft decreased when disc angle was increased from 40° to 45°; however, it increased sharply when the disc angle was changed from 45° to 50° in all cases. This can be

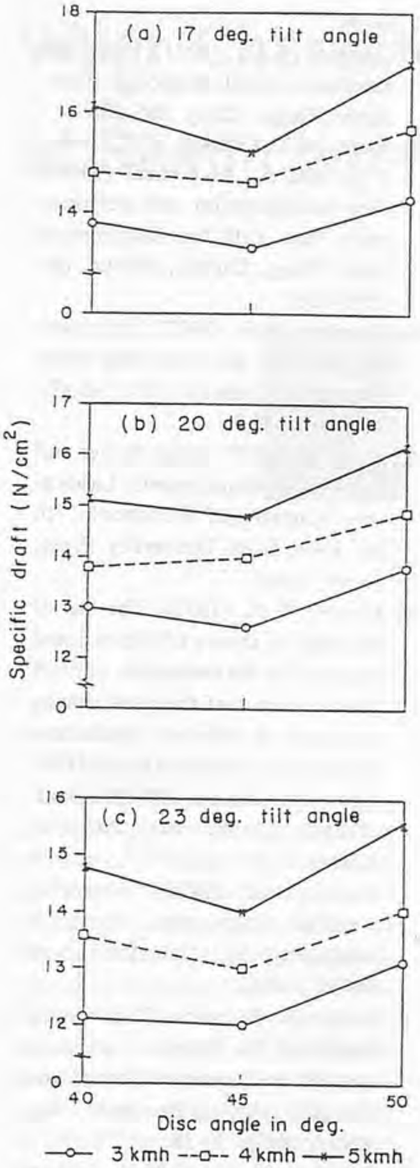

Fig. 2 Effect of disc angle on the specific draft requirements of a disc plough at 29.4% moisture content and different tilt angles.

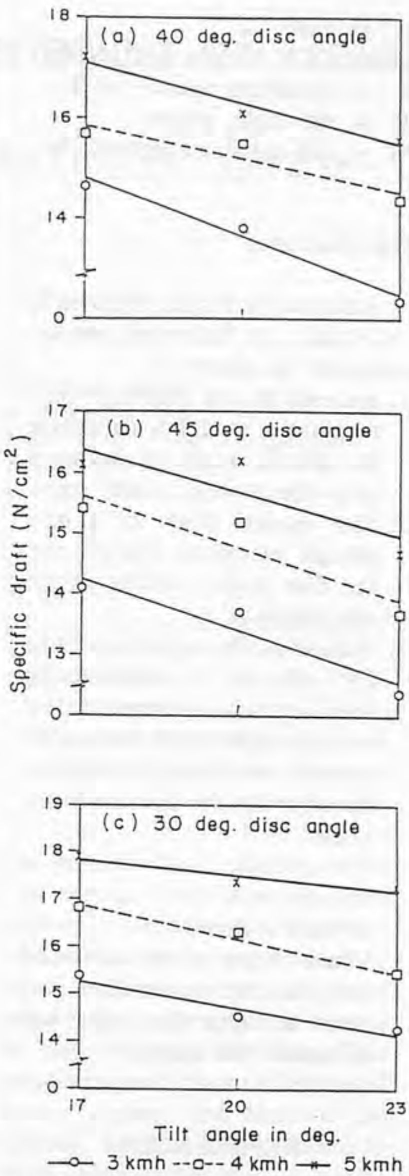

Fig. 3 Effect of tilt angle on the specific draft requirements of a disc plough at 23.3% moisture content and different disc angles.

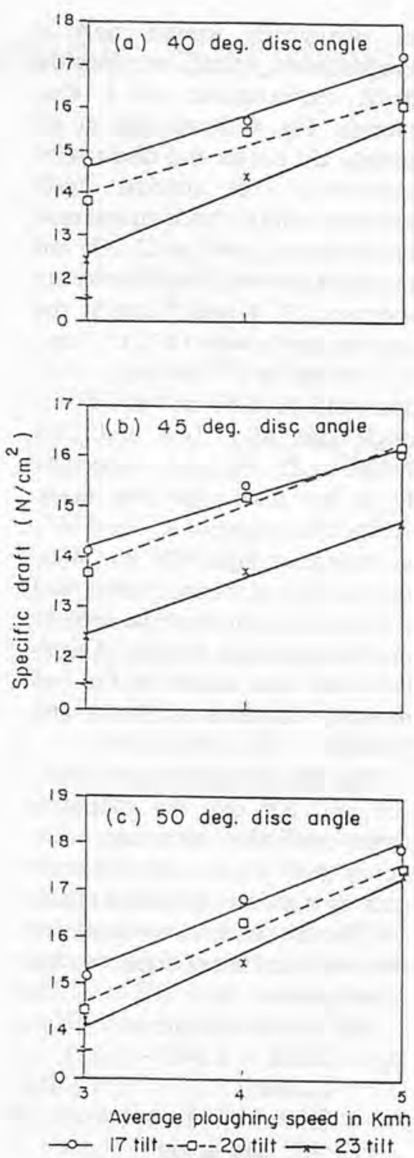

Fig. 4 Effect of ploughing speed on the specific draft requirements of a disc plough at 23.3% moisture content and different disc angles.

attributed to the obstruction in easy flow of soil at the right hand side of the disc at high disc angles. It was observed that as the disc angle increased the disc penetration was better and the width of cut increased.

Effect of Tilt Angle

Fig. 3 shows the effect of tilt angle at 23.3% soil moisture content. It was observed that at all disc angles and speeds, there was a marked decrease in specific draft with an increase in tilt angle. At 23.3% soil moisture content, 40° disc angle and 3 km/h speed, the specific draft requirements were 14.7, 13.8 and 12.4 N/cm^2 at the tilt angles of 17, 20 and 23°, respectively **(Fig. 3(a))**. For the same soil moisture content and disc angle, and at 4 km/h speed, these values were 15.7, 15.5 and 14.4 N/cm^2; and at 5 km/h speed, these were 17.2, 16.1 and 15.6 N/cm^2 at the tilt angles of 17, 20 and 23°, respectively. A similar trend of reduction in specific draft with an increase in tilt angles at 29.4% and 33.4% soil moisture contents was observed. It was observed during the experiments that there was a tendency for reduced penetration of the disc at a greater tilt angle.

Effect of Ploughing Speed

It was observed that increase

in ploughing speed had a predominant effect on specific draft requirements of a disc plough. **Fig. 4** shows that at all speeds, tilt angles and disc angles considered, the specific draft increased sharply with an increase in ploughing speed at 23.3% soil moisture content. For the average speeds of 3, 4 and 5 km/h, the specific drafts were 14.7, 15.7 and 17.2 N/cm^2 at 17° tilt angle, 13.8, 15.5 and 16.1 N/cm^2 at 20° tilt angle and 12.4, 14.4 and 15.6 N/cm^2 at 23° tilt angle, respectively, at 40° disc angle (**Fig. 4(a)**). At the disc angles of 45° and 50°, as shown in **Figs. 4(b)** and **4(c)**, the increase in forward speed had a tendency to increase the specific draft requirement sharply. A similar trend was found at the soil moisture contents of 29.4% and 33.4%.

For three disc angles (40°, 45° and 50° ds), the following three predictive equations were developed using experimental data by multiple regression analysis. These equations are valid for the test conditions used in this investigation.

For 40° disc angle:

$$D_S = 20.68 + 1.04S - 0.25T - 0.20M \quad ...(1)$$

$r = 0.85$

For 45° disc angle:

$$D_S = 18.54 + 1.12S - 0.21T - 0.18M \quad ...(2)$$

$r = 0.91$

For 50° disc angle:

$$D_S = 21.97 + 1.16S - 0.21T - 0.26M \quad ...(3)$$

$r = 0.90$

where, D_S = specific draft, N/cm^2
S = ploughing speed, km/h
T = tilt angle, degree
M = soil moisture content, %

Conclusions

Based on the results obtained in this study, the following conclusions can be drawn:

1. Increase in soil moisture content had a tendency to reduce the specific draft requirements of a disc plough in clay soil.
2. The specific draft of a disc plough increased sharply for the disc angle settings above and below 45°.
3. Incrase in tilt angle from 17 to 23° showed a decrease in specific draft requirement. For this tilt angle range, the specific draft was found to increase linearly with the increase in tilt angle.
4. The specific draft increased linearly with the increase in ploughing speed.
5. Visual observation indicated that the disc penetration was better at higher disc angles but at smaller tilt angles.

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Wear Characteristics of Reversible Shovels of Seed-cum-Fertilizer Drills

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Abstract

Shovels of seed-cum-fertilizers and cultivators wear out very fast because of improper material and hardness of these components resulting in frequent stoppage of work and loss of time during peak season until replacement with new ones. Wear studies have been conducted on shovels of seed-cum-fertilizer drills being the most commonly used component. Wear test on five different samples of shovels, i.e., mild steel, spring steel, high carbon steel, coated mild steel and heat treated mild steel were conducted on the rotary soil bin for 100 h each. Loss in weight for each shovel due to wear was recorded. Three types of soil, i.e., light, medium and heavy soil were used for the wear tests. Based on the comparative analysis, the heat treated mild steel shovel is best suited keeping in view the life of shovels as compared to the normal mild steel shovels.

Introduction

Studies have shown that agricultural machinery components such as shovels of seed-cum-fertilizer drill and cultivator wear out very fast because of use of sub-standard material and improper hardness for those components resulting in stoppage of work and loss of time during peak season. These components have to be replaced with new ones. This results in great inconvenience and loss of money and time to the farmer. Keeping this problem in view, wear studies were conducted on reversible shovels used in seed-cum-fertilizer drill and cultivator.

The shovels used are, in general, made of mild steel (MS) resulting in high degree of wear. The farmer has to replace these shovels very often and thus has to bear high maintenance cost. In view of this aspect, the present study on wear characteristic of shovels has the following objectives:

1. To test the shovels of different materials under laboratory conditions,
2. To compare the life of shovels, and
3. To recommend the suitable shovel based on material strength.

This paper describes the wear behaviour and comparative analysis of five different samples of shovels, namely, mild steel (MS), spring steel (SS) heat treated mild steel (HMTS), high carbon steel (HCS), coated mild steel (CTMS).

Materials and Methods

Wear studies were conducted in the laboratory using rotary soil bin. The bin was fabricated in the Department of Farm Power and Machinery. The schematic diagram of the experimental set up is shown in **Fig. 1**. It has an inner diameter of 305 cm and outer dia of 396.5 cm. The peripheral speed of rotating bin was kept at 56.2 m/min. Five samples of shovels, i.e., MS, SS, HCS, DTMS and HTMS were mounted on the frame as indicated in **Fig. 1**. The depth of penetration of the shovels was kept at 6.0 cm. The basic dimension of the shovel used in the wear study is shown in

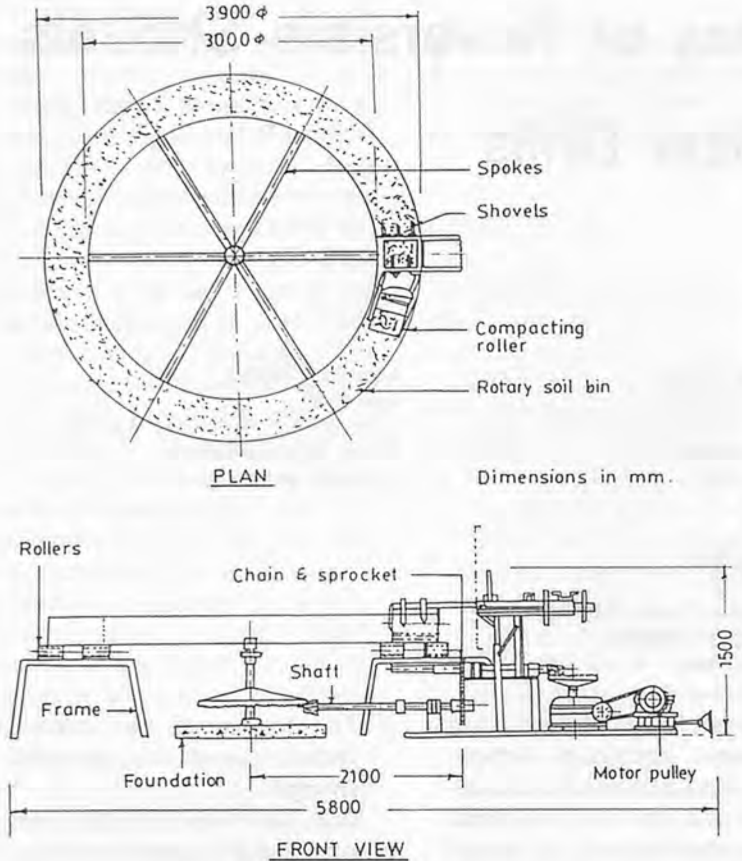

Fig. 1 Rotary soil bin with mounted shovels.

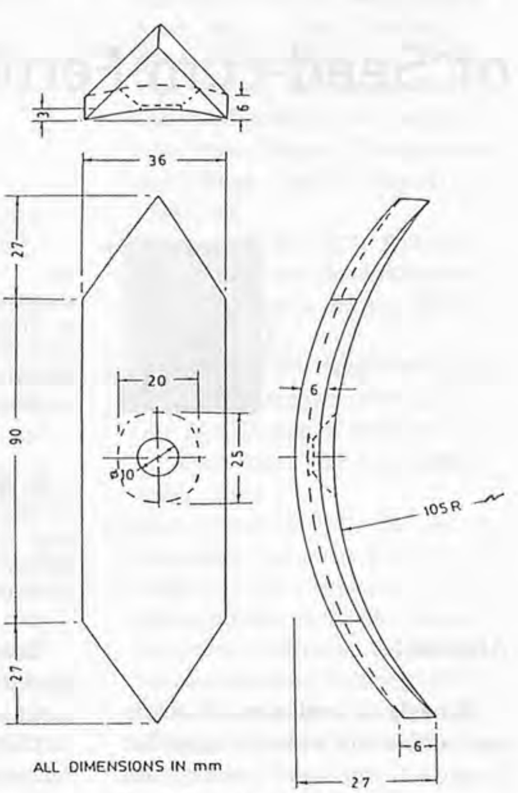

Fig. 2 Experimental shovel.

Fig. 2. The chemical composition of materials of different samples of shovels is shown in **Table 1**. The hardness tests of five samples of shovels were conducted at the Rockwell hardness testing machine. The average values of the hardness for each sample were: MS 30.06 HRC; HCS 45.3 HRC; HTMS 64.7 HRC; CTMS and 31.1 HRC.

The coating of MS shovels was done using the Fontalloy Powder Metal spray torch. The technique of depositing the powdered metal was followed as per the recommended method. The powdered metal used was MP-1 which consists of Ni, Cr, Fe, B, Si, and C.

Three types of soil, i.e., light, medium and heavy were used for the wear tests. The moisture content of soil in all cases was kept about 8.0% (db). The wear test were conducted for 100 h each.

Table 1. Chemical Composition of Different Materials of Shovels

Material of shovels	C%	Mn%	P%	S%	Si%	Cr%
MS	0.175	0.570	0.045	0.027	0.18	Nil
HCS	0.790	0.690	0.050	0.030	0.25	0.55
SS	0.610	0.730	0.020	0.032	1.30	Nil

Table 2. Wear of Shovels

Type of soil	Type of shovel	Initial weight of shovel in g	Weight of shovel after 100 h, g	Wear weight after 100 h g
Sandy soil	MS	219.3	216.5	2.8
	HCS	219.7	215.0	4.7
	SS	189.6	187.3	2.3
	HTMS	216.5	214.6	1.9
	CTMS	202.4	199.0	3.4
Heavy soil	MS	211.0	186.5	24.5
	HCS	272.0	196.8	15.2
	SS	219.0	202.5	16.5
	HTMS	206.8	193.0	13.8
	CTMS	207.0	179.9	27.1
Mixed soil	MS	216.5	177.2	39.3
	HCS	215.0	173.8	41.2
	SS	187.3	156.0	31.3
	HTMS	214.6	192.5	22.1
	CTMS	199.0	160.9	38.1

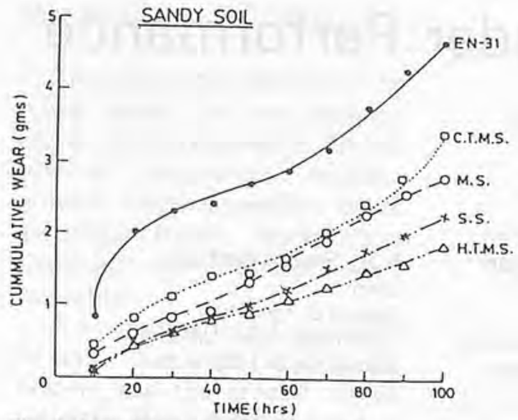

Fig. 3 Cumulative wear vs time graph.

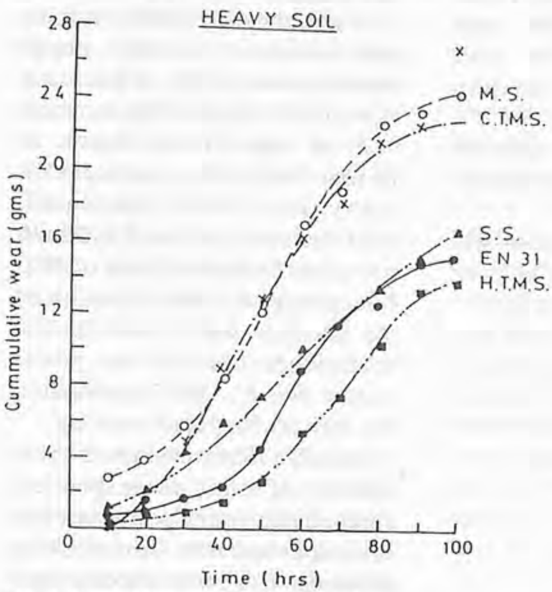

Fig. 4 Cumulative wear vs time graph.

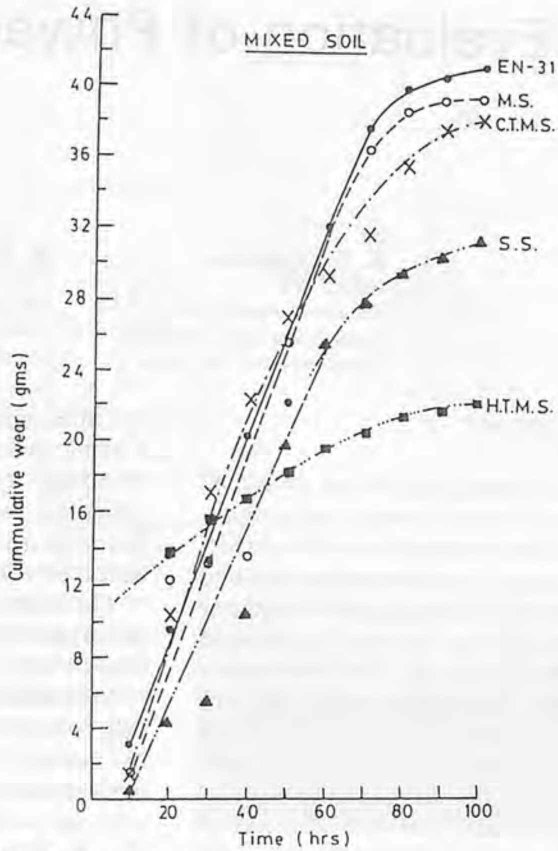

Fig. 5 Cumulative wear vs time graph.

The loss in weight for each shovel due to wear was recorded after an interval of 10 h. The wear data indicating the loss in weight of shovel after 100 h or use in each case is shown in **Table 2**.

Results and Discussion

The wear weight vs time relationship for the sandy soil is shown in **Fig. 3**. For all the samples of shovels, i.e., MS, SS, HCS, CTMS and HTMS it was observed that the wear rate increased with time. Wear rate was minimum for the HTMS shovel whereas for HCS the wear rate was maximum.

Fig. 4 shows the wear weight vs time curve for all the samples of shovels using heavy soil. The graph reveals that wear rate was minimum for the HTMS and maximum for CTMS. It was also observed that the wear rate for the CTMS shovel was minimum up to 50 h, in comparison with the MS shovel. After that it behaved similar to MS shovels. In **Fig. 5** the wear cuves using medium soil are shown. The graph indicates that the wear rate for HTMS shovel was minimum, in this case also. However, wear rate was maximum for the HCS. It also shows that wear rate for the CTMS shovel was minimum up to 60 h in comparison with MS shovel. After that CTMS behaved similar to the MS shovel.

The comparative analysis of wear curve shows that for the MS shovels, cumulative wear is greater for medium soil followed by heavy and sandy soils. A similar trend was observed for HCS, SS, HTMS and CTMS shovels. It is evident that wear was maximum in medium soil. Based on the wear characteristics of these five samples of shovels it is observed that for the HTMS shovels, the wear rate was minimum in all types of soils.

Based on the comparative analysis of wear of the five samples of shovels, the heat treated MS shovel (HTMS) is best suited keeping in view the life of the shovels.

Evaluation of Power Weeder Performance

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Abstract

A power weeder was developed and the performance was evaluated and compared with the performance of the conventional method of manual weeding with hand hoe and using manually-operated dryland weeder. The field capacity of the weeder was 0.04 ha/h with weeding efficiency of 93% for removing shallow-rooted weeds. The performance index of the weeder was 453. The cost of operation with the power weeder amounted to Rs. 250 as against Rs. 490 by dryland weeders and Rs. 720 by manual weeding with hand hoe. The saving in cost and time amounted to be 65% and 93%, respectively.

Introduction

Weed control is one of the most expensive steps in crop production. The high cost of weeding can be understood from a comparative study of the losses in the farm due to various causes. The losses due to soil erosion was assessed to be 13.6% and that due to insects and diseases was 35.8% while the losses due to weeds alone was assessed at 33.8%. In India, about 4.2 billion rupees are lost due to weeds in the production of major crops. The reduction in yield due to weeds alone is estimated at 16% to 42% depending on the crop and location. An analysis reveals that one-third of the cost of cultivation is being spent for weeding alone. Weeding requires 560 man hours/ha whereas 1536 man hours/ha is required for the cultivation of sorghum crop.

The above data clearly show the importance of weeding in the cultivation of crops.

Mechanical weed control will help reduce the drudgery involved in manual hoeing. Moreover, mechanical weed control not only kills the weeds between the crop rows but also keeps the soil surface loose ensuring better soil aeration and water intake capacity.

Review of Literature

Khan and Diesto (1987) report the development of a push type cone weeder which uproots and buries weeds in a single pass without requiring a back and forth movement, especially suitable for paddy. Manual weeding of paddy in one ha requires an average of 120 man-hours. The cono weeder is about twice as fast to operate as conventional rotary weeders.

Mudakavi et al (1987) conducted a field study with different tillage tool treatment combinations and weed control treatment combinations. The results indicate that the primary tillage tools alone for controlling weeds were found ineffective and the treatment combinations of blade harrowing or tilling with hand weeding were found advantageous in effective weed control.

Ambujam et al (1984) designed and developed a rotary paddy weeder powered by a knapsack type, 1 kW engine. The machine had an operational depth of 70 mm with 80% weeding efficiency. The effective field capacity of the machine was 0.022ha/h with a performance index of 587. The average fuel consumption of the machine was 0.86 ℓ/h. The operational cost of the power weeder was Rs. 502.71 compared Rs. 437.50 for hand weeding.

Fanoll (1986) evaluated three models of shoulder-suspended, hand-guided rotary power weeders in comparison with hand slashing of weeds. The power weeders were operated by 1.86; 1.49 and 1.12 kW gasoline engines. The field capacities of the machine were 12 to 131% higher than the hand weeding processes. The carrying weights of these machines ranged from 5.4 to 10 kg with overall lengths, 1600 to 1700 mm. The engine characteristics were 2-stroke, single cylinder 50.2, 35 and 27.2 cc displacements, flywheel, magneto-ignition, petrol operated 8:1 compression ratio and air-cooled. Out of the three models tried, the 1.4 kW machine had better performance in terms of both field capacity and weeding cost.

Materials and Methods

The construction features of the power weeder that was designed and developed consists of the following components: engine, ground wheel assembly, blade assembly, frame, depth wheel assembly and counter shaft assembly.

A supporting frame was made of m.s. 'L' angle and at the bottom end the ground wheels have been fixed. At the top end of the frame the handles are provided. The engine is fixed below the handle. The drive is taken from the engine wheel and given to intermediate shaft drive. From the intermediate shaft, the drive is taken to the rotary blade shaft. The rotary blade consists of 4 blades around the periphery of a drum. A depth wheel assembly was fixed at the backside of the rotary blade. The depth of the blade can be adjusted by the depth controlling shaft.

The weeder is pushed manually and the power to the rotary blade is given from the engine through sprocket and chain drive. A 1.7 hp RT35 engine has been selected for the prime mover (**Fig. 1**).

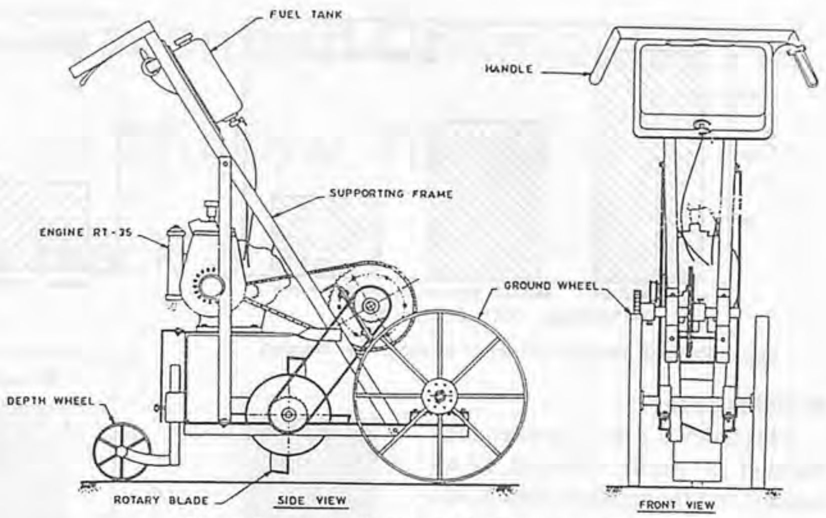


Fig. 1 Schematic diagram of the power weeder.

The power weeder was tested in the field for its performance the following result was analyzed:

The weeding efficiency was calculated by the following expression—

Weeding efficiency =

$$\frac{W_1 - W_2}{W_1} \times 100$$

where,

W_1 = Number of weeds counted before operation and

W_2 = Number of weeds counted after operation.

Fuel consumption test

A measured volume of fuel was put into the fuel tank of the power weeder which was operated in the field for a specified period. After the work was over, the volume of fuel left over in the fuel tank was measured using a measuring jar. From these observations the volume of fuel consumed was determined and the rate of fuel consumption was calculated. The depth and speed of operation were measured.

The operating cost of the weeder for weeding one ha has been compared with manual weeding by hand hoe and with dry land weeder.

Results and Discussion

The actual field capacity of the power weeder was 0.04 ha/h in the black cotton soil. Assuming the area occupied by plants as 30% of the total area, the net field coverage of the machine will be 0.05 ha/h. The rate of fuel consumption of the machine was 0.65 ℓ/h.

Weeding Efficiency

Number of weeds before weeding, $W_1 = 140/m^2$

Number of weeds after weeding, $W_2 = 10/m^2$

$$= \frac{140 - 10}{140} \times 100 = 92.8\%$$

Field capacity

Area covered = 130 m^2


Fig. 2 The power weeder in action.

Time taken = 20 min

$$= \frac{130}{1000} \times \frac{60}{20}$$

$$= \frac{78}{200} = 0.039 \text{ ha/h}$$

Fuel consumption ratio

Time of operation : 30 min

Fuel consumption : 300 mℓ

Fuel consumption rate =

$$\frac{300}{100} \times \frac{60}{30} = 0.6\ \ell/h$$

Performance Index

Field capacity, a = 0.04 ha/h

Weeding efficiency = 93%

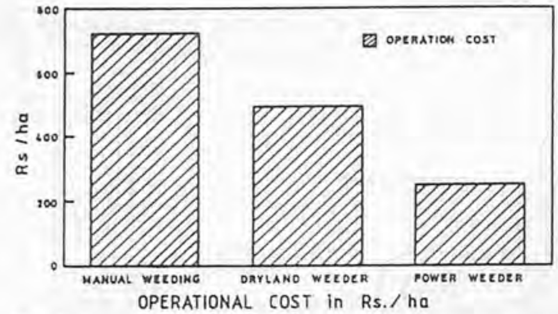
Plant damage = Nil

Power input = 0.82 (at 1.8 km/h speed)

Performance index

$$= \frac{0.04 \times (100\text{-}0) \times 93}{0.82}$$

$$= 453.65$$



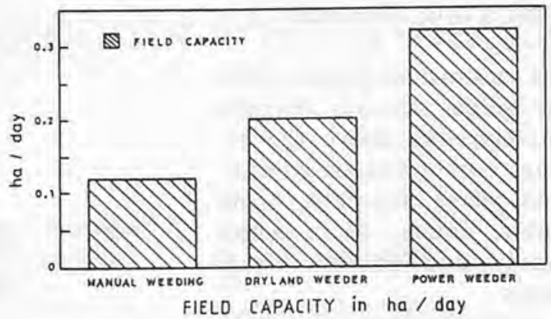
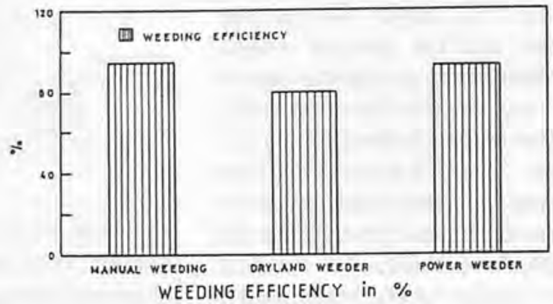


Fig. 3 Percent weeding efficiency of the power weeder.



Weeding Index

This index is a ratio between the number of weeds removed by a weeder and the number present in a unit area and is expressed as a percentage. The spots where such counts were taken were randomly selected and a ring covering an area of 1 m^2 was used for sampling.

$$\text{Weeding index} = \frac{W_1 - W_2}{W_1} \times 100$$

where,

W_1 = weeds before weeding

W_2 = weeds after weeding

$$= \frac{135 - 10}{135} \times 100 = 92.59\%$$

Comparison with Long-handled Weeder

The power weeder performance was compared with that of the long-handled weeder and the results are as follows (**Fig. 3**).

Item	Dryland weeder	Power weeder
Overall length, mm	1200/1500	990
Overall width, mm	590	510
Overall height, mm	220	1020
Width of cut, mm	150	120
Overall weight, kg	4	40
Maximum depth of operation, mm	30	50
Actual field capacity, ha/h	0.015	0.04
Capital cost, Rs.	125	3500
Operating cost, Rs.	490	250

Conclusion

1. The power weeder can work up to depth of operation of 50 mm with field capacity of 0.04 ha/h
2. The weeding efficiency can be obtained up to 93%.
3. The performance index of the power weeder was 453.
4. The fuel consumption rate was 0.6 ℓ/h.
5. Cost of the unit was Rs. 3,500.
6. The operating cost of the unit was Rs. 250 as against the Rs. 450 by the dryland weeders and Rs. 720 by manual weeding with hand hoe.
7. The savings in cost and time were 65% and 93%, respectively.

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Performance Evaluation and Optimization of Straight Blades for Shallow Tillage and Weeding in Black Soils

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Abstract

Straight blades used in mechanical weeders were evaluated in black soils and the critical dimensions were optimised. The draft force per unit working width (Du) was minimum for rake angle of 22°. The value of Du was minimum sharpness angle. Mechanical strength of blade becomes the limiting factor in obtaining the minimum values of these parameters. However, better material, e.g., spring steel, high speed alloy steel, etc. may be used where feasible so as to reduce the values of these critical dimensions.

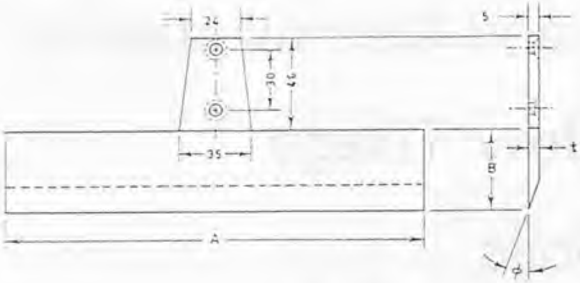
Introduction

Straight blades are widely used in traditional weeding tools as the soil engaging components due to their simplicity in construction. The major dimensions in a straight blade are the working width, blade width, blade thickness and blade sharpness angle. The effect of the major dimensions of a straight blade on the draft force during operation in black soil at different depths and rake angles were studied. Based on the study, optimum dimensions of the straight blade were suggested for design purpose for minimum draft force.

Shallow tillage and weeding operations are practised repeatedly in black soils with animal-drawn straight blade hoes to keep the weeds suppressed during the monsoon season. Manual weeding tools with straight blades are also in use for weeding and interculture. Due to low output, farmers are often unable to complete the weeding operations resulting in yield losses. By using straight blades of optimum dimensions, the output of the weeders with straight blades can be increased significantly.

Materials and Methods

Straight blades of different specifications (**Fig. 1**) were selected for the study. There are four major dimensions in a straight blade—working width (A), blade width (B), blade sharpnes angle (ø) and blade thickness (t). The blades for the study were fabricated from mild steel flat section. For variation of working width (A), blade sizes of 100, 150 and 200 mm were selected. For other blades, a constant working width of 220 mm was kept because this width was most suitable for weeding in most of the Kharif crops. Blade widths (B) of 15, 30, 40 and 50 mm were taken for the study to determine the effect of blade width on draft force. Other blades had constant blade width of 40 mm. The blade thicknesses of 2, 3, 4, 5 and 6 mm were selected for the study. The blade sharpness angles of 5, 10, 15, 20 and 30 degrees were used in the study, whereas the other blades



SL. NO.	A (mm)	B (mm)	t (mm)	φ (Degrees)
1	100	30	3	15
2.	150	30	3	15
3.	200	30	3	15
4.	200	15	3	15
5.	200	40	3	15
6.	200	50	3	15
7.	200	40	2	15
8.	200	40	4	15
9.	200	40	5	15
10.	200	40	6	15
11.	200	40	5	5
12.	200	40	5	10
13.	200	40	5	15
14.	200	40	5	20
15.	200	40	5	30

Fig. 1 Straight blades.

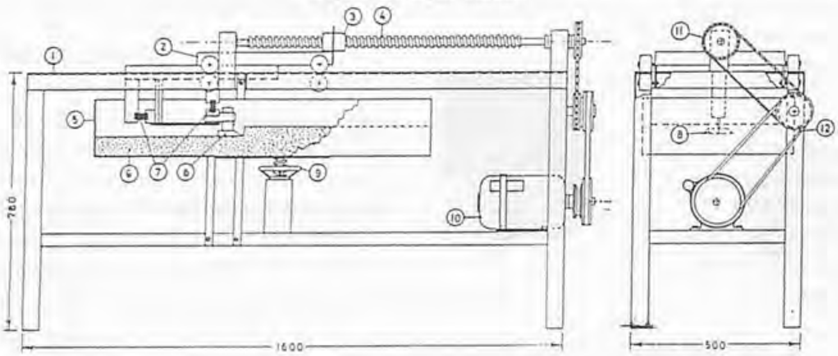


Fig. 2 Laboratory test apparatus for tools.

Fig. 3 Laboratory test set-up.

were provided with a blade sharpness angle of 15°.

A laboratory test apparatus for tools (**Fig. 2**) was developed. The apparatus consisted mainly of a fixed soil tray, a movable tool carrier frame, strain gauge transducers, driving unit and the main frame. The soil tray was provided with vertical adjustments for depth control of the tool. The soil tray had a maximum length of 1000 mm with effective working length of 800 mm. The maximum working width of the soil tray was 430 mm. A manually-pulled compaction roller was provided to compress the soil of the tray each time a tool was operated. As far as possible, the original reading of cone-penetrometers was achieved. The value of cone penetration resistance was reasonably uniform and it ranged from 11.980 to 12.178 N/cm^2. The straight blade under test was mounted to the tool carrier frame with two strain-gauge transducers picking up the horizontal and vertical forces acting on the tool. The forces were recorded on a direct writing 2-channel oscillographic recorder. The strain-gauge system was calibrated by standard weights for horizontal and vertical forces acting on the tool before conducting the tests. The tool carrier frame was run by a lead screw drive unit at a constant speed of 0.155 m/s. After each test, the frame was reversed to its original position by manual cranking of the lead screw. Each test was repeated for three times. The average horizontal and vertical forces were graphically determined from the chart paper. The horizontal force was a measure of the draft force of the tool. Draft force per unit working width of a tool was used as an indicator of performance of a tool. The laboratory test set-up is shown in **Fig. 3**.

Soil samples from the field were collected, sieved through a 25 mm sieve and filled in the soil tray. The physical properties of the soil were as follows:

Soil texture : Clayey
Sand -Fine 1.84%
coarse 12.95%
Silt -30.51%
Clay -54.70%
Structure : Subangular blocky
Liquid limit: 46.62%
Plastic limit: 23.94%

During the tests, soil moisture was kept constant as far as possible and it ranged from 18.12 to 18.84% (db). After each operation of the tool, the soil was manually prepared by a small hand tool and compacted twice by the soil compaction roller. The bulk density of the soil ranged from 0.919 to 0.965 g/cc after compaction. The cone penctration resistance of the soil was reasonably uniform and it ranged from 11.980 to 12.178 N/cm^2.

Results and Discussion

The straight blades were tested at three depths of 5.0, 7.5 and 10.0 cm and at different rake angles. The effect of the independent variables, e.g., rake angle, blade width, blade thickness and blade sharpness angle on the dependent variable draft force per unit working width (Du) were as follows:

Rake Angle

Three straight blades of 10.0, 15.0 and 20.0 cm working widths were tested at 18°, 22°, 27°, 32° and 37° rake angles and at three depths of 5.0, 7.5 and 10.0 cm each. The draft force per unit working width (Du) obtained for these blades at different rake angles (δ) and depths are graphically represented in **Figs .4** to **6**. Polynomial relationship of the third degree was observed between Du and δ. Minimum Du occured for rake angle ranging from 20.6° to 22.5° with average value of 22.01°.

Blade Width

Straight blades of 15, 30, 40, and 50 mm widths were tested at three depths of 5.0, 7.5 and 10.0 cm. The effect of blade width (B) on Du is graphically represented in **Fig. 7**. Polynomial relationship of the third degree was observed between Du and B. No optimum value of blade width (B) could be arrived at for minimum Du. The value of Du increased

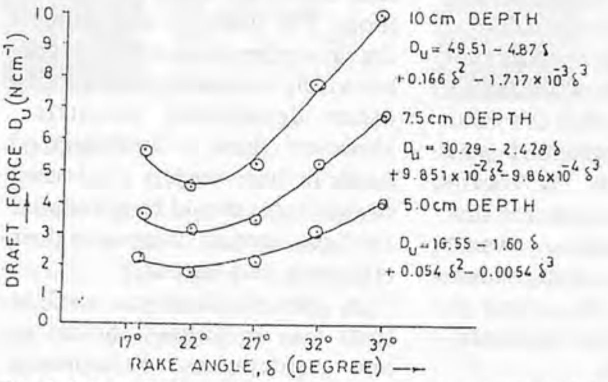


Fig. 4 Effect of rake angle on draft force of 10 cm straight blade at three depths.

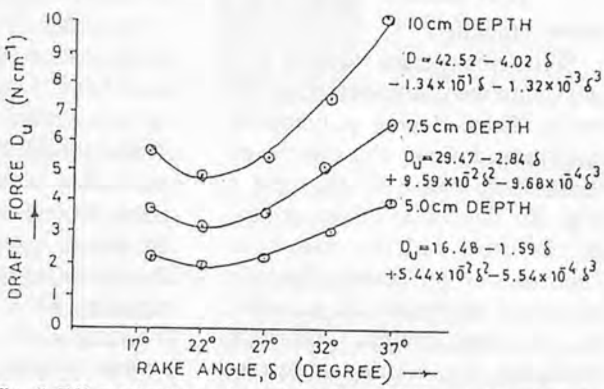


Fig. 5 Effect of rake angle on draft force of 15 cm straight blade at three depths.

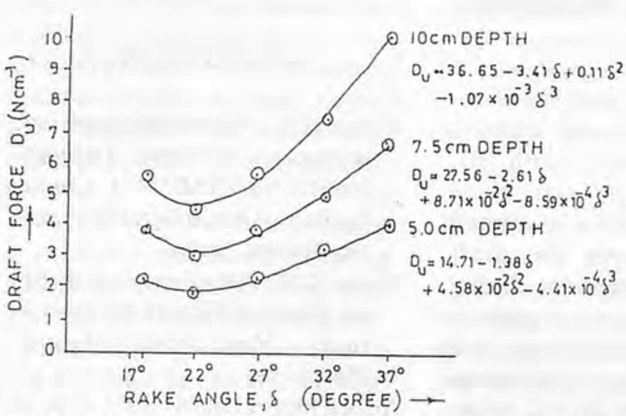


Fig. 6 Effect of rake angle on draft force of 20 cm straight blade at three depths.

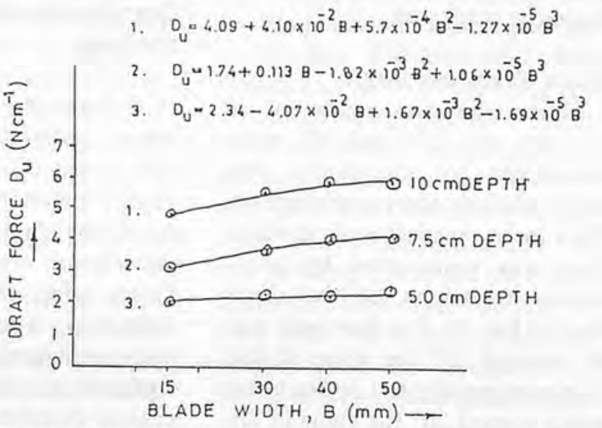


Fig. 7 Effect of blade width on draft force of straight blade at three depths.

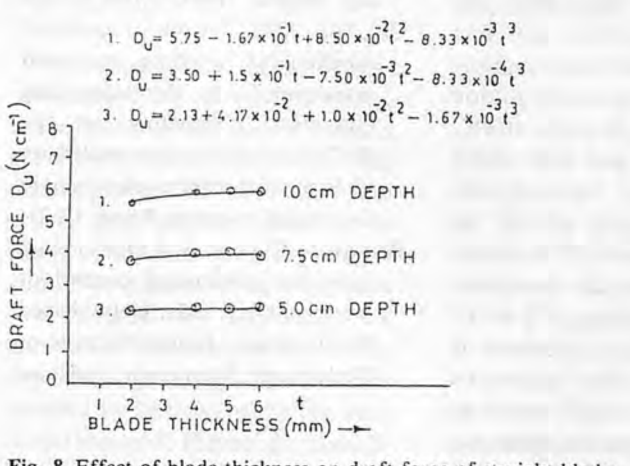


Fig. 8 Effect of blade thickness on draft force of straight blades at three depths.

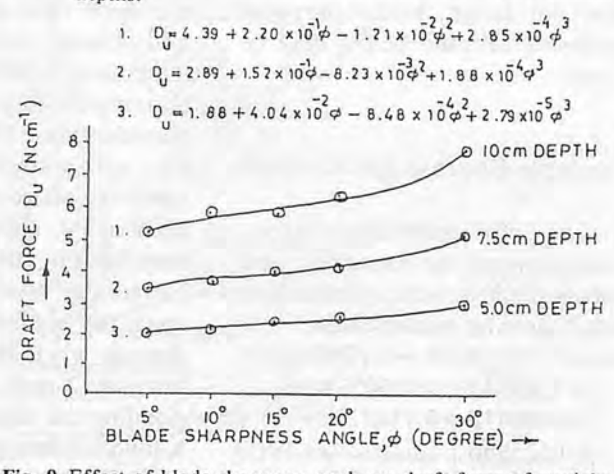


Fig. 9 Effect of blade sharpness angle on draft force of straight blades at three depths.

with the value of B, initially with a faster rate and then at a slow rate. So, for tool design, the value of B may be selected from mechanical strength consideration. However, for small weeding tools, low values of B in the range of 15 to 40 mm may be selected.

Blade Thickness

Blade thicknesses (t) of 2, 4, 5 and 6 mm were considered for the study. Third degree polynomial equations defined the nature of relationship between Du and t (**Fig. 8**). The value of Du gradually increased with the value of t. There was no optimum value of t for which minimum Du occured. So, for tool design, minimum thickness at which adequate mechanical strength of the blade is achieved may be taken as the optimum thickness.

Blade Sharpness Angle

Blade sharpness angles (ø) of 5°, 10°, 15°, 20° and 30° were considered for the study. The effect of blade sharpness angle on draft force per unit working width (Du) was represented by polynomial equations of the third degree (**Fig. 9**). For sharpness angle beyond 15° the value of Du increased rapidly and at sharpness angle beyond 20° the value of Du increased at a very fast rate. So, for tool design, blade sharpness angle of 15° and below may be used.

Multiple Regression Analysis

The linear multivariate regression between the dependent and independent variables resulted into the following relationship:

$$Du = -7.36954 + 0.139008\delta + 0.758357d + 0.005053A + 0.018647B + 0.134717t + 0.052596\phi \qquad (1)$$

Where, dependent variable

Du = draft force per unit working width (N)

And independent variables

δ = rake angle (degree)

d = depth (cm)

A = working width or length of blade (mm)

B = blade width (mm)

t = blade thickness (mm) and

ø = blade sharpness angle (degree)

The value of the co-efficient of determination (R^2) of the equation was 0.866675, which was reasonably high, indicating that the value of Du could be predicted with reasonable accuracy. The coefficients of regression indicate that the major contribution towards Du were due to the independent variables of δ, d, B, t and ø. Working width A had less contribution towards Du.

Comments and Recommendations

1. Four major tool specifications of straight blades namely, rake angle (δ), blade width (B), blade thickness (t) and blade sharpness angle (ø) contributed significantly towards the draft force acting on the tool during operation. There is a scope to reduce the draft force acting on a straight tool by using the optimum critical dimensions as was established for black soils. To achieve minimum value of blade width (B) and blade thickness (t) for minimising the draft force, material strength of the tool is the major consideration. High grade steels, e.g., spring steels and high speed alloy steels that have better mechanical strength should be used for the purpose. It is possible to use low blade sharpness angle (ø) in the range of 5 to 10 degrees when blade thickness is low (say 2 mm), since cutting or grinding the tool edge is easier as it involves less material removal.

2. There is a wider scope of using the optimized straight tools for manual- and animal-drawn weeders where power availability is limnited. Since straight tools are already in use, there may not be much difficulty in introducing the optimized straight tools. Straight tools are easy to fabricate and small fabricators and village artisans can easily make the straight tools. The manual- and animal-drawn weeders with straight tools are widely used in India and many other developing countries. However, there is limitation of power in these weeders. Optimized straight tools should be introduced for these weeders to increase their efficiency and output.

3. The findings on straight tools may be utilized for design and development of improved weeders with straight tools for heavy soils.

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Mechanized Planting and Harvesting of Onion

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Abstract

Onion growing by onion sets is a most widely used method in Turkey. But there are many problems in planting, hoeing and harvesting operations. In this report, the possibilities of mechanization in planting and digging of onion which these operations done by manual labour, was studied in field experiments and laboratory tests. The prototype machines for planting and digging were designed. The results were compared with the conventional method.

Positive results were obtained in the use of machine in planting and harvesting onion using sets. The results of planting and harvesting methods were similar to those of the conventional method.

Introduction

Growing of dry onion by sets considers 3 steps; seed growing, onion set growing and dry onion growing. The parameters for planting were; 200-250 mm row space, 100-160 mm distance in row, 20-40 mm planting depth and 25-45 pieces/m^2 by hand into row opened by cultivator or harrow in February and March for dry onion growing. The sets are covered by harrow in the conventional method. Plants are hoed 2-3 times by hand in May and June. Onions are dug by hand in August and dried approximately 7-10 days in the field.

The aim of this research is to plant onion in crop rotation with wheat-sunflower using mechanization in planting of onion sets and harvesting.

The study was undertaken for 2 years in the laboratory and fields at the Thrace Region. The planting utilized a planting machine with aluminium cast cups and planting by hand. In harvesting an onion harvester machine was used as well as hand hervesting.

Materials and Methods

The materials for the study were a prototype planting machine and an onion digging machine which were developed by the Agricultural Mechanization Department of Takirdağ Agricultural Faculty.

The Planter

The planting machine is a semi-mounted type farm machinery and has 6 independent planting units. Each unit had a parellelogram system. The space between two planting units can be adjusted 220 to 280 mm. The type of furrow openers are shoe coulter (**Fig. 1**).

Each planting unit has a hopper for oinion sets. Cups are connected onto a rubber band. A vibration unit for the cups prevents them from taking more than one set. A wheel drives the cups by a chain that also covers on the sets with soil. The wheel is made of rubber and its diameter is 340 mm. The cups are made from

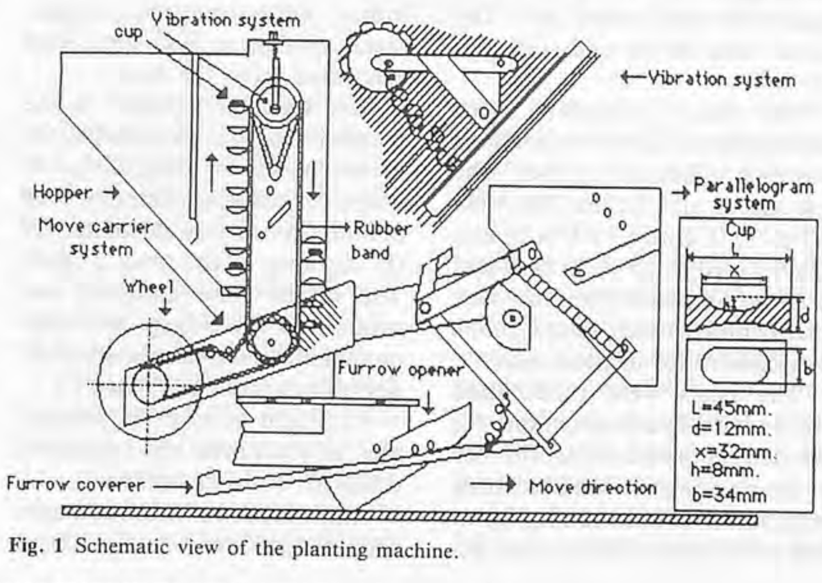

Fig. 1 Schematic view of the planting machine.

alluminim cast and have three different sizes for various sizes of onion sets.

An additional seat was located on the main frame of the planting machine for better control of the cups. The plant distances in row can be varried between 80 and 200 mm.

A rubber band turns the cups that takes the sets and which are connected on the surface of band.

The Harvester

The onion digger machine has a frame digging blades, a separation system, an adjustment system for the digging depth and a carrier system that is a activated by the P.T.O. (**Fig. 2**).

The blades are made of steel, the sizes of which are 25 × 45 × 250 mm. Its angle from the bottom is 15°. The separation band consists of a number of iron bars. The cross section diameter of each bar was 15 mm and is connected to a rubber band from both tips. In the separation band, the onions and impurities (stones, soils, etc.) were separated if their diameter was less than 25 mm.

The separation band's direction of move was towards the back of the machine and driven by the P.T.O. shaft. The move is reduced in the gear box. The speed of the separation band was 1.5 m/s. The blades dug onions and stones in the soil.

The band apparatus with adjustable speeds and inclinations was used in laboratory tests. The test speeds and inclinations were 0.5 m/s, 1.0 m/s, 1.5 m/s and 0%, 5%, 10%, 15%, to back and to front, respectively. The seed distribution between planting units was determined in these tests.

The trials were randomized blocks with four replications for the determination of proficiency of the planting and the harvesting methods. The soil was clay loam. The emergence of the plants, distances of plants in row, distances of plants to the parallel line, planting depth and yield were measured in each plot in order to compare planting results. The planting index, emergence percentage, mean emergence and date were calculated from the data.

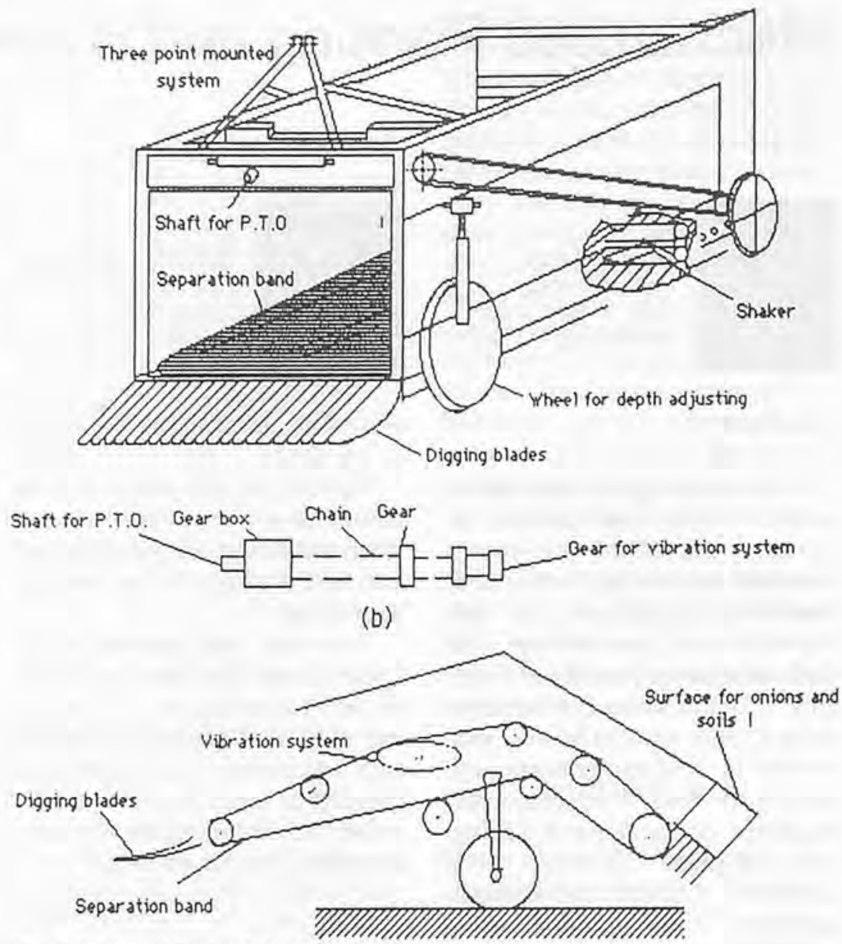

Fig. 2 Schematic view of the digging machine.

The spaces of plants in the parallel line were established for determination of distribution in width for planting methods. The planting index was calculated by the distance of the plant in row. The results were analyzed and evaluated according to minimum/maximum, means, standard deviation and C.V. (**Table 1**).

The ratio of seed distrubition area to total area was calculated using the formula below:

Ratio of seed distribution area with the total area = 2 × S × 100/m ....(2)

where,

S = Standard deviation of seed distrubition width (mm)

m = Row space (mm)

The planting methods were compared according to the percentage of emergence (P.E.), mean emergence date (M.E.D.) and emergence rate index (E.R.I.). The equations are given below for the

Table 1. Analysis of Results in Plant Spacing

Deviation of obtained distance = measured distance	
Deviation of measured distance in row than space (%)	Planting index
0.0-10.00	5
10.1-20.00	4
20.1-30.00	3
30.1-40.00	2
40.1-50.00	1
<50.00	0

calculations of P.E., M.E.D. and E.R.I.

P.E. = Number of emergent plants per meter (3)

$$M.E.D. = n_1d_1 + n_2d_2 + \ldots + n_nd_n / (n_1 + n_2 + \ldots + n_n) \quad (4)$$

E.R.I. = Number of seeds sown per meter/M.E.D. (5)

where,

P.E. = Precentage of emergence sets

M.E.D. = Mean emergence date (days)

E.R.I. = Emergence rate index

n = Number of sets sown previous accout

d = Number of days after planting

The results of P.E., M.E.D. and E.R.I. were evaluated with analysis of variance.

The plots were harvested by hand. Then the onions were dried for 7 days after which their weights were measured.

The harvesting methods include the digging machine and by post-harvest hand. The harvesting methods were compared according to the post-harvest losses. The losses included damaged onions and left in the field after the harvest. The losses were determined as percentage of total yield.

The efficiency (da/h) and manpower requirement of the experimental planting and harvesting methods were compared with that of the conventional method.

Table 2. Distribution of Seeds between Planting Units at Varying Speeds and Inclination of Planter

Speed (m/s)	Inclinations (%)	Planting units					
		1	2	3	4	Mean	CV(%)
1.5						305.7^{B}	
1.5	0	336.4	319.9	319.5	293.9	317.9^{CD}	5.52
1.5	% 5 to front	330.1	356.9	333.8	346.7	341.9^{BCD}	3.59
1.5	%10 to front	358.7	335.5	332.8	355.3	345.6^{BCD}	3.85
1.5	%15 to front	335.6	369.7	343.4	328.5	349.3^{BC}	5.02
1.5	% 5 to back	330.1	303.2	335.1	314.2	320.7^{CD}	4.57
1.5	%10 to back	306.4	308.9	254.1	302.7	293.0^{CDE}	8.90
1.5	%15 to back	152.8	164.1	185.3	187.5	172.5^{E}	9.71
1.0					301.4^{B}		
1.0	0	301.3	322.1	285.7	370.9	320.0^{CD}	11.58
1.0	% 5 to front	325.3	313.0	359.1	256.0	313.4^{CD}	13.69
1.0	%10 to front	350.6	353.9	449.1	398.4	387.9^{ABC}	11.91
1.0	%15 to front	415.3	545.8	445.5	312.9	429.9^{AB}	22.29
1.0	% 5 to back	266.1	223.2	300.9	352.6	285.7^{CDEF}	19.16
1.0	%10 to back	253.6	159.2	204.3	115.0	183.0^{FG}	32.51
1.0	%15 to back	203.4	177.4	154.6	225.4	190.2^{EFG}	16.20
0.7					326.5^{A}		
0.7	0	341.5	342.0	347.4	345.6	344.1^{BCD}	0.82
0.7	% 5 to front	347.0	328.3	387.3	343.3	351.5^{BC}	7.17
0.7	%10 to front	389.4	396.9	428.3	341.5	389.0^{ABC}	9.23
0.7	%15 to front	420.3	504.2	515.2	432.6	468.1^{A}	10.20
0.7	% 5 to back	275.7	313.0	304.7	273.3	291.7^{CDE}	6.91
0.7	%10 to back	238.3	246.2	234.2	243.3	240.5^{DEFG}	2.21
0.7	%15 to back	215.6	204.6	178.2	203.8	200.5^{EFG}	7.91
Mean		310.8^{A}	313.7^{AB}	318.9^{AB}	302.1^{B}	311.2	10.92

	LSD 0.05
Planting units	11.96
Speeds	10.35
Inclinations	15.82
Plant units × inclinations	31.64
Speed × inclinations	27.40
Plant units × speeds × Incl.	54.80

Table 3. Planting Index and Distances of Planting Methods

Year		Distances of sets in row (mm)		Planting index	
		Planting machine	Planting by hand	Planting machine	Planting by hand
1988	Max.	330.00	270.00	5.00	5.00
1988	Min.	40.00	60.00	4.00	2.00
1988	Mean	146.40	135.00	4.17	4.33
1988	CV (%)	42.31	29.29	—	—
1989	Max.	410.00	440.00	5.00	5.00
1989	Min.	50.00	70.00	5.00	5.00
1989	Mean	180.50	172.80	5.00	5.00
1989	CV (%)	48.22	31.49	—	—

Results and Conclusions

Table 2 shows the result of the study. In 1988, the mean distance of sets in rows were 135.1 mm for the hand-planted sets compared with 146.6 mm for the planting machine. In 1989, these figures were 172.8 mm, 180.5 mm, respectively. The planting index of the planting machine and planting by hand calculated from the distance of onion sets in rows were same (**Tables 3** and **4**).

The mean planting depths were 44.5 mm for the hand-planted sets and 44.4 mm for the planting machine. The C.V. were 21.10% for the former and 17.25% for the latter.

The planting methods were compared according to P.E., M.E.D. and E.R.I. (**Table 6**).

The planting efficiency methods were 0.333 da/man-day for the manual planting and 19.44 da/day for the planting machine. The manpower requirements for the planting methods were 32 man work hours/da for the manual planting and 0.823 man working hours/da for the planting machine.

The efficiency of harvesting methods were 0.285 da/day for manual harvesting and 23.133 da/day for the harvesting machine. The requirement of manpower was 24.0 man work hours/da for manual harvesting and 0.691 man work hours/da for the harvesting machine.

The best-harvest losses were 3.2% for manual harvesting and

Table 4. Result of Width Distribution

Year		Planting method	
		Planting machine	Planting by hand
1988	Standard deviation (mm)	18.80	16.43
1988	C.V. (%)	16.56	14.63
1988	Width of distribution (mm)	37.60	32.86
1988	A1/A2 (%)	15.66	13.14
1989	Standard deviation (mm)	15.43	12.25
1989	C.V (%)	12.84	10.29
1989	Width of distribution (mm)	30.86	24.50
1989	A1/A2 (%)	12.85	9.80

Table 5. Planting Depths by Methods (1989)

Planting methods	Mean planting depth (mm)	Standard deviation (mm)	C.V. (%)
Planting by hand	44.50	0.939	21.10
Planting machine	44.40	2.930	17.25

Table 6. Results of P.E., M.E.D. and E.R.I by Planting Method

Item	P.E. (%)		M.E.D. (day)		E.R.I. (number/m.day)	
Planting methods	1988	1989	1988	1989	1988	1989
Planting by hand	81.54	83.17	16.14	19.34	0.55	0.28
Planting machine	88.17	90.89	13.79	20.48	0.57	0.32
l.s.d. (0.05)	0.6406	0.3076	1.7905	—	0.078	0.0715

Table 7. Yield by Planting Method (kg/da)

Year		Planting method	
		Planting by hand	Planting machine
1988	Max.	3866.63	3850.00
1988	Min.	1980.00	333.33
1988	Mean	2712.15	3659.43
1989	Max.	3199.94	3715.26
1989	Min.	2438.63	2719.43
1989	Mean	2836.63	3376.72
Lsd (0.05)		1988 487.10	
		1989 515.14	

3.33% for the harvesting machine.

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(Continued on page 32)

Development of a Mechanical Date Pollinator

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Abstract

A mechanical date pollinator compatible with the common conditions of Iranian date palm groves has been developed and tested. This single-man-operated device eliminates the need for climbing the palms to pollinate them. Date pollen diluted with a carrier powder is pneumatically conveyed and broadcast by a controlled flow of pressurized air accumulated in a knapsack sprayer tank. An extendable aluminium pipe which is carried and controlled by the operator supports the air tube, pollen hopper and broadcasting nozzle. The pollen hopper is equipped with a special metering device for suspending and conveying pollen in a controlled flow of air. The pollinator has been successfully tested on different palm heights ranging between 3 and 15 m in two successive years on an Iranian superior variety. Fruit set and average fruit yield per bunch of the mechanically pollinated palms were comparable and in one experiment significantly better than those of the hand-pollinated palms.

Introduction

The world's production of dates has been estimated to be 2 to 2.5 million tons per year and the number of palms to be 70 000 000 (FAO, 1982). Almost all of this production belongs to the semi-tropical areas of Middle East and Africa. Iran, by producing about 24% of the world production, holds the second rank. The mean yield per fruit bearign palm has been estimated to be about 20 to 25 kg. Since the mean fruit yield per palm for the varieties similar to the Iranian palms grown in California has been reported to be 60 to 120 kg (Nixon, 1950), it could be expected that this national resource might be developed significantly by practicing mechanization projects.

Date palm (*Phoenix dactylifera* L.) that belongs to the family of palmaceae is a dioecious tree bearing male and female inflorescences on separate palms. Artificial pollination for increasing the percentage of pollinated female flowers and development of more fruits is a necessary practice. Natural pollination by wind and insects is not sufficient and artificial pollination by man is a must for producing high fruit yield with desirable quality. Development of small triplet seedless fruits would be the result of avoiding artificial pollination. This kind of fruits which usually shrink before full ripening are mostly found in abandoned palm groves.

Artificial pollination without using mechanical devices which is referred to as "traditional method" must go back to antiquity as even the cuneiform texts of Ur (about 2300 B.C.) made mention of it (Oudejans, 1969). This method which is still widely practised in almost all palm groves in the country is considered to be one of the most costly and difficult parts of the cultivational practices. This method of pollination implies that the labourer has to climb each palm 3 to 6 times during a 30-40 days of flowering period to carry the flowering male spikes for shaking over the mature female inflorescences whose split spathes have been removed. The spikes are subsequently inserted between the branches of the female flower cluster.

This practice, due to its difficult and hazardous nature, is invariably carried out by specialists who have long time experience and skill and their knowledge is usually transmitted from father to son. With regard to the height of the palms and hazardous working condition around the female inflorescences, it could be claimed that hand (traditional) pollination is the most difficult chore in the palm groves and that as long as this method is practised, the hardship also will persist.

In 1966 the first experimental mechanized pollination by aircraft was tried in California (Brown and Perkins, 1966). Twelve one-acre plots were broken into two groups, one to be flown by fixed-wing aircraft with conventional

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dusting gear and the second by a helicopter employing special metering and application equipment developed for pollinating. Various rates and frequencies of application were established for both methods. Flour was used as a carrier in order to achieve uniform distribution of the small amount of pollen being applied. The net rate of pollen used ranged from a low of 1.93 kg/ha applied every 4 days to a high of 5.8 kg/ha applied every 2 days.

When the fruit was harvested in the fall, it was apparent that the helicopter had reduced results superior to that of the fixed-wing aircraft. The helicopter applications had resulted in yields of 70% to 120% of hand pollinated controls. Much of the difference in yield was attributed to the helicopter's higher concentration of pollen in the narrow band of the palms bloom area.

In 1968 the first ground-level application was tested with a trailer-mounted palm duster (Brown et al, 1968). The duster operator stood on a 4-m height platform and directed a delivery pipe at the bloom area of the palm. The dusting nozzle was about 9 m above the ground level, while the palm heights in the experiment varied considerably and the distance from ground level to the bloom area varied from 9.5 m to 15 m.

Results of pollination with the palm duster show that fruit set of the tall palms was much poorer than those of the medium to short palms. This indicated the need for a variable-height platform in order to adjust to varying palm heights.

In 1969, a redesigned palm duster was put in the field employing a variable-height platform (Brown et al, 1970). This was accomplished by mounting a fork-lift mast to a trailer, which gave 4.5 m of vertical travel. The air supply and delivery tube system were similar to those used on the 1968 machine. Results from the two years experiments were similar to those of 1968 on short and medium-height palms. The conclusion was reached that 2.9 kg pollen/ha/season would be a sufficient quantity, and that once a week application would work if clusters were properly thinned.

Using the principles developed in the USA, a mechanical pollinating system was developed in Israel (Sarig et al, 1982). The system consisted of a telescoping mast mounted on the three point linkage of a wheeled tractor, a metering device, a blower and a dispersing unit mounted at the top of the mast. Field capacity was about 500 trees/h. Fruit set in several varieties was comparable to or better than the conventional hand-pollination system.

The application of the preceding mechanized systems are generally feasible in large and leveled palm groves of uniform layout and palm heights. In Iran date palms are usually planted irregulary on unleveled lands and often mixed with citrus trees for the purpose of protecting them against winter frosting as well as burning sunshine. Also, the presence of irrigation basins and canals around the palms has made the implication of mechanical pollinators mounted on ground-level vehicles almost impossible.

Objectives

In this project, design, construction and testing of a mechanical pollinator compatible with the general conditions of Iranian palm groves to meet the following requirements have been limited:

1. Portable and applicable by a single operator.
2. No need for climbing the palms.
3. Ability to pollinate tall palms.
4. No need for leveling and changing the irrigation system or any other modification of the existing conditions in the palm groves for implication of the pollinating device.
5. The rate of pollen broadcasting be easily controlable by the operator.
6. The ease of operation eliminates the need for the skilled labourers currently doing hand pollination.
7. Mass production of the pollinator being possible by utilization of domestic materials and technology.
8. Low production cost enables even the small date growers to purchase one.
9. Reduction of pure pollen consumption by addition of carrier materials.
10. Possibility of improvement in fruit set by more uniform distribution of pollen over female inflorescences and feasibility of multiple pollination due to the ease and speed of operation with respect to hand pollination.

Materials and Methods

Construction of Pollinator

The main components of the date palm pollinator are depicted in a schematic diagram (**Fig. 1**). A brief description of each part follows:

Pressurized air accumulator — The cylindrical reservoir and hand pump of a knapsack sprayer is used as an accumulator to provide pressurized air for conveying and dispersing pollen grains from pollen hopper over the female inflorescences. The choice of a sprayer reservoir was considered suitable mainly due to its availability in any small scale farmstead in addition to its low weight and ease of transport. Hence, there

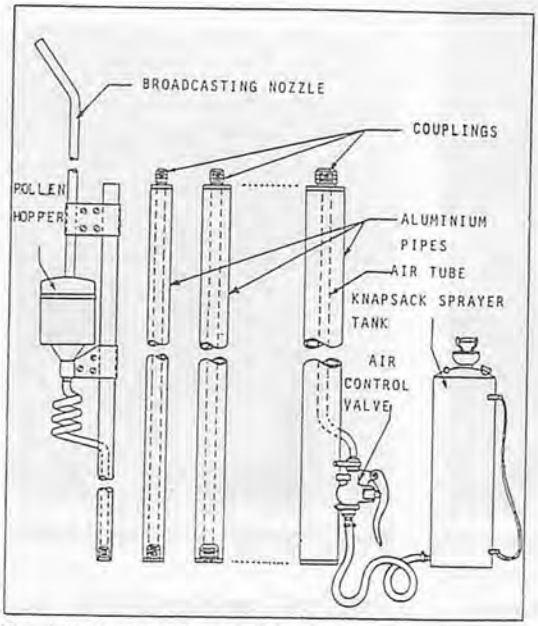

Fig. 1 Main components of the date pollinator.

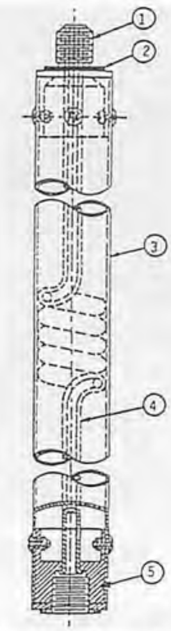

Fig. 2 Details of the aluminium pipe and accessories: 1. coupling screw; 2. rubber seal; 3. aluminium pipe; 4. air tube; 5. coupling nut.

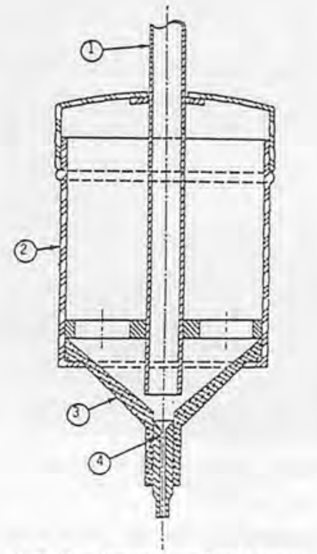

Fig. 3 Pollen hopper sectional view: 1. pollen dispersing tube; 2. hopper wall; 3. conic base; 4. air orifice.

would be no need to supply the air cylinder with the pollinator. Also, due to the simplicity of the hand pump and no need for fuel and maintenance, utilization of knapsack sprayer instead of engine-powered blowers or dusters could be considered an advantage in rural areas.

Air-control valve — This valve controls the flow of air from the pressurized reservoir to the pollen hopper and from there through the dispersing nozzle over the female inflorescences. The valve is mounted on the lower part of the largest aluminium pipe which is held by the operator during pollen application.

Aluminium pipes — Depending on the palm height, several aluminium pipes of 2 m long and diameters ranging from 20 to 50 mm are joined together by male and female screw couplings to form a single boom as tall as the height of bloom area from ground level. This boom is used to hold the air tube, the pollen hopper and the dispersing nozzle. By choosing aluminium pipes, gradual reduction of pipe diameter from bottom to top and making the steel couplings as light as possible, the total weight of the boom was minimized with no incidence of excessive bending or buckling down.

Inside each of the 2 m pipes a 6 mm dia. plastic tube is inseted which conducts pressurized air to the pollen hopper. This tube is coiled in the middle to have sufficient longitudinal flexibility for installing the end couplings. Both ends of each air tube are connected and sealed to the end couplings, so as the pipes are joined to each other, the tubes would be connected too. Rubber gaskets between the male and female couplings make the air gallories air tight. Construction details of an aluminium pipe and its accessories are shown in the sectional view of **Fig. 2**.

Pollen hopper — The pollen hopper is a cylindrical container with an inverted conical base as shown in **Fig. 3**. Its wall is made of a 70 mm transparent plastic tubing so the operator is able to see the pollen level and refills the hopper as needed. The conical base is made of aluminium to make the hopper as light as possible. The air tube is connected to the hopper through a 1.5 mm dia. orifice at the apex of the conical base. This orifice develops an air jet to enhance suspension and conveying of pollen grains by the air stream. A pollen dispersing hose which is made of 12 mm dia. aluminium tubing enters the hopper through its lid and is held over the air orifice to receive the air borne pollen.

Operation

The first step in preparing and setting up the pollinator is to choose the proper length of boom with regard to the average palm height, by joining required number of the 2 m aluminium pipes. Then the operator charges the air cylinder by a hand pump to a pressure level of 2-3 bars depending on the height of the palms. Finally, by filling up the pollen hopper with the mixture of pure pollen and a carrier powder, the pollinator would be ready for application. Then the operator carries the air cylinder on his shoulder, erects and holds the pollinator boom by hands, while aiming the dispersing nozzle at the partly or fully opened female inflorescences (Spaths). Now, by

Fig. 4 Formation of halo of pollen grains at the nozzle point.

Fig. 5 The first trial of the mechanical pollinator in Firozabad.

Fig. 6 Mechanical pollination of a short date palm.

depressing the air valve a pressurized flow of air which is conducted to the pollen hopper, conveyes the air borne pollen mixture to the dispersing nozzle. At this moment the formation of the halo of pollen mixture could be seen at the nozzle point (**Fig. 4**).

A few quick and short depressions of the air valve would apply sufficient pollen on each spath and this usually does not take more than a few seconds. The operator should constantly change his position and the tilt angle of the pollinator boom to adjust for varying palm heights.

Pollen Extraction and Preparation

For testing the pollinator, preparation of some pure date pollen and some carrier powder were needed. In Iran, so far, no attempt has been made to mechanize the extraction of date pollen from male inflorescences because in conventional pollination, mostly freshly cut flowering male spikes are shaken over and then inserted inside the female flower clusters. Rarely is pure dried pollen used.

Since only a small amount of pollen was needed for testing the pollinator, no attempt was made to develop a mechanized system of pollen extraction, and a simple procedure similar to the methods normally presented in extension bulletins was used as follows:

Male mature blooms with open or cracked spaths were cut at the base of the stalks and transported to the laboratory for drying and pollen extraction. The spaths were first removed and bloom clusters were gently shaken over a large tray to collect a part of the pollen already released from the open flowers. The collected pollen usually had a high moisture content to be used or stored. Hence, it was air-dried on absorbent sheets of paper for about 48 h.

The bloom clusters were then air-dried for 48 h to let the male flowers to open completely and release their pollen. The semi-dried clusters were then shaken and beaten by a stick to extract their pollen. With this action the remaining pollen was released along with the flower parts which were separated from the cluster strands. Later, pure pollen was screened from the flower parts.

Inspection of the flower parts revealed that there was a little amount of pollen left inside them which was not easily extractable. For preparing the carrier powder and making use of the remaining pollen, the flower parts were spread over a sheet of absorbent paper to dry up completely and then were ground and screened through a fine sieve (mesh No. = 100). The resulting powder was later mixed with pure pollen in a ratio of 2 to 1 in order to increase the volume of the broadcasting powder. The utilization of dried flower parts as a carrier material not reported before, and was considered to be an original work on this subject.

During the pollination season the extracted pollen was kept in air-tight container and stored in a refrigerator. A small linen bag containing calcium chloride was inserted in the pollen container and also one in the pollen hopper to keep the pollen dry during storage and application. Different sources, including Nixon, 1969, have reported that dry date pollen could be kept in moderate temperature for 2 to 3 months without significant reduction in its viability.

Pollination Tests

In the spring of 1985 the first trial of the pollinator was conducted on three tall (14-15 m) Shahani date palms in Firozabad, a town in Fars province of Iran (**Fig. 5**). The resulting fruit set and total yield of those three palms were comparable or even better than those of the similar neighbouring palms pollinated by hand.

The promising results of the first trial indicated the need for more extensive tests. Hence, in the spring of 1986 two series of pollination tests were conducted on two different palm groves in Jahrom, one of the major date growing regions in Fars province.

In one of the pollination tests using a CRD experiment, three pollination treatments (mechanical, traditional and no pollination) with five replications were conducted on 15 relatively tall (12-14 m) Shahani date palms. In mechanical pollination treatments, each female flower cluster was pollinated twice on a 6-day interval.

In the other experiment, 10 young and short (4-6 m) Shahani date palms were randomly selected among 40 palms (all nearly having the same age and growing conditions) to be pollinated by the mechanical pollinator. The remaining palms were hand pollinated. The mechanical pollination of these short palms is shown in **Fig. 6**.

Both mechanical and hand pollinations were started on April, 5 with opening of the first bloom spaths and lasted for 25 days. In mechanical pollination treatment, each female inflorescence was pollinated twice on a 6-day interval schedule, while in hand pollinated treatment each inflorescence was pollinated once by the traditional method. No artificial pollination was done on the five palms selected as control.

Results and Discussion

Progressive stages of fruit set and development were observed during regular inspections of both experimental date palms. Developments of many triplet fruits along with few pollinated ones (**Fig. 7**) was an outstanding phenomenon which distinguished the unpollinated palms from the other two treatments.

Inspection of the fruit clusters on machine and hand-pollinated palms 3 weeks after the last pollination showed a good fruit set and very rare occurence of triplet fruits in both treatments. **Fig. 8** shows three typical strands of a mechanically-pollinated cluster three weeks after the second (last) pollination.

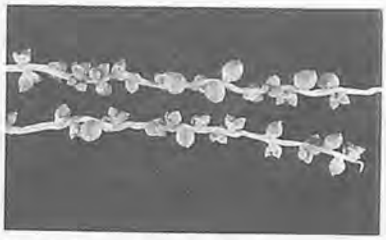

Fig. 7 Development of triplet seedless fruits on unpollinated date palms.

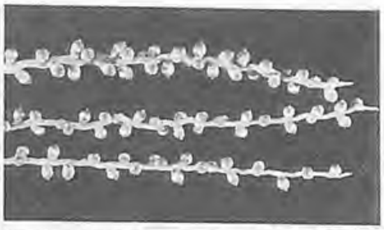

Fig. 8 Development of pollinated fruits on three strands of a mechanically pollinated cluster 3 weeks after pollination.

Observations of equal and, in some cases, better fruit set in the mechanically-pollinated palms vis-à-vis the hand-pollinated treatments was considered a sign of the successful performance of the mechanical pollinator. Urgent and panic harvesting of the tall experimental palms by the owner following an unpredictable rainfall prevented the possibility of data aquisition from fruit yield and quality for reaching a statistical analysis.

Results of the pollination test on short palms show that mechanically pollinated palms had a mean fruit yield per bunch of 10.25 kg, while that of the hand pollinated palms was only 4.9 kg—an increase of over 200% which is a highly significant difference. This increase in fruit yield could be attributed mainly to the more uniform distribution of pollen over the female flowers.

The average rate of pure pollen used in the mechanical pollination was about 2 g per cluster per application, which sums up to 4 g per cluster since each flower cluster was pollinated twice. This pollen consumption rate is comparable with the reported rate of 2.3-5.8 g per cluster in the aerial application (Brown and Perkins, 1966) and 1.5-3.7 g per cluster with the ground level dusters (Brown et al 1968). It should be noted that in the pollinator tests the ratio of pure pollen to the carrier powder was 1 to 2, while in the above mentioned mechanized pollination experiments the ratio of 1 to 6 and 1 to 11 have been used, respectively. Therefore, it could be expected to reduce the pure pollen consumption rate by diluting the pollen mixture with the addition of a larger volumetric ratio of carrier powder to pure pollen. Also, double application of pollen on each flower bunch has been done only to ensure complete pollination of the whole female flowers, while probably a single application and, consequently, reducing the needed pollen to one half of the present rate could have been sufficient.

Higher speed and ease of operation with respect to the traditional hand pollination was also a considerable point in the pollination experiment. In this regard, the total time required for pollinating a female inflorescence with the mechanical pollinator ranged from 1 to 3 min depending on the height of the palm. While pollinating by traditional method which includes climbing the palm, taking a proper position, removing the splitted spath sheath, inserting a few strands of male flowers, tying down the flower cluster with slip knot and finally descending the palm which takes about 10-15 min depending on the palm height.

Suggestions for Future Studies

Now that a mechanical pollinator compatible with the special conditions of Iranian palm groves has been developed and tested, the following suggestions are advanced for obtaining further information necessary to improve the performance of the new device and to prepare operational procedures for more effective application of the pollinator.

1. Conduct mechanical pollination tests on relatively large date growing areas to study its economic appraisal in comparison with traditional hand pollination methods.
2. Conduct experiments to find the most favorable time and the optimum number of pollen application by the mechanical pollinator.
3. Investigate carrier powders compatible with date pollen and determine the optimum pollen concentration to minimize pollen consumption rate.
4. Develop and evaluate the mechanized pollen extraction devices and techniques.

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(Continued from page 26)

(Mechanized Planting and Harvesting of Onion)

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Combine Harvester Reel Stagger — II

Empirical Study on Crop Stem Deflection and Application of the Results for Reel Stagger Determination

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Abstract

Experiments were performed in the field, on standing crop, in order to determine crop stem deflection characteristics. A mathematical relationship involving an angular parameter of the deflected stem, $\varnothing_m$, the actual deflection, ΔX_m, and the perpendicular height, Y_m, from the ground to the point of application of the deflecting force, was established. By combining the empirical results of this study with a model of stem deflection by the reel, and the principle of reel stagger determination, which were proposed in the first part of this paper, an algorithm for the determination of the reel stagger was obtained. Further, it was possible to investigate the significance of viscoelasticity in crop stem deflection through statistical analyses of the acquired data. It is necessary to consider the significance of viscoelasticity if a theoretical model of crop stem deflection is to be constructed.

[Keywords] Reel Stagger, Crop Stem Deflection, Combine Harvester

Introduction

In the first part of this paper (Sakai et al., 1993), a model of the loading condition in the deflection of crop stems by the combine harvester reel (**Fig. 1**), and a principle of determination of reel stagger (**Figs. 2 and 3**) based on crop stem deflection and reel kinematics were proposed. As a result the mathematical relationships summarized below were obtained;

$$Y_r = Y_c + AR_o;\ 1 \leqq A < \frac{R}{R_o} \qquad (1)$$

where

Y_r is the height of the reels axis of rotation above the ground, in metres

Y_c is the nominal height of the crop in meters

A is a dimensionless number

R_o is the rate of header advance in metres per radian of reel rotation

R is the radius of the reel in metres

$$\omega t_2 = \pi - cos^{-1}\left[\frac{AR_o}{R}\right] \qquad (2)$$

where

ωt_2 is an angle measured in radians. Thus the value of the arccosine term must be in radians, too.

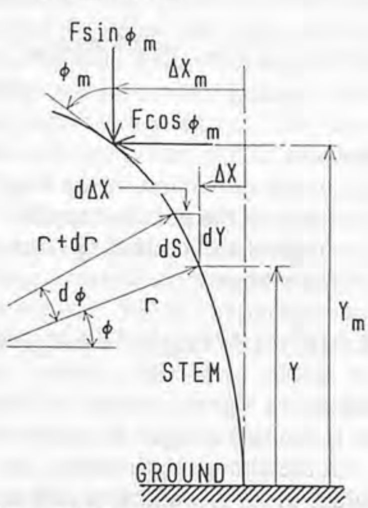

Fig. 1 Model of stem deflection.

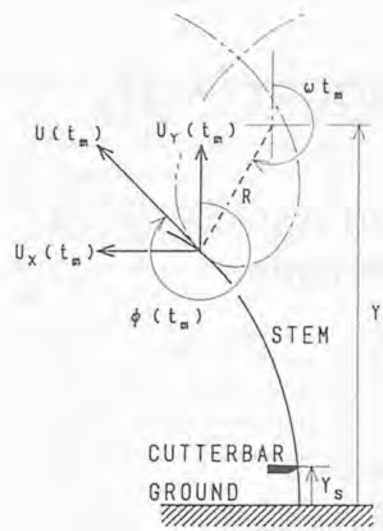

Fig. 2 Timing of stem cutting.

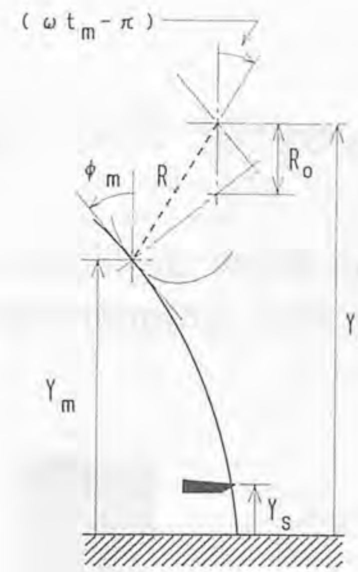

Fig. 3 Relationship between ωt_m and $\varnothing_m$.

π is the ratio of a circles circumference to its diameter (3.14159)

$$\omega t_m = cos^{-1}[\frac{R_o}{R} cos\varnothing_M] + \pi + \varnothing_m \quad (3)$$

where

ωt_m is an angle measured in radians. Thus the value of the arccosine term must be in radians, too.

$\varnothing_m$ is an angle measured in radians.

$$Y_m - Y_r = RCOS\omega t_m \quad (4)$$

where

Y_m is the height from the ground to the point of application of the deflecting force, in metres.

$$\Delta X_m = R[\frac{R_o}{R}(\omega t_m - \omega t_2) + sin\omega t_m - sin\omega t_2] \quad (5)$$

where

ΔX_m is the deflection of the crop stem at the point of application of the deflecting force, in metres.

$$X_r = [R^2 - (Y_r - Y_m)^2]^{1/2} + \Delta X_m \quad (6)$$

where

X_r is the reel stagger in metres.

In the above relationships, the values of A, R_o, and R would be determined from other reel design considerations, including minimization of grain losses and vehicle (combine harvester) locomotion. Y_c is a crop property that is not in the control of the engineer. The four equations (3), (4), (5), and (6) contain five unknowns, (namely ωt_m, $\varnothing_m$, Y_m, ΔX_m, and X_r) and therefore, cannot have a unique solution. It is, therefore, necessary to obtain additional information before these equations can be of practical use. In this paper, an empirical study carried out in order to determine the relationship involving the quantities, $\varnothing_m$, Y_m, and ΔX_m, is reported. Further, a discussion of the significance of viscoelasticity in the deflection of crop stems is discussed through statistical analyses of the data acquired in the study.

Empirical Study on Crop Stem Deflection

In order to understand the mechanical phenomenon of crop stem deflection, an empirical study was carried out. Although field measurements are subject to many uncontrollable factors, it was felt that the conditions prevailing when such measurements were taken would most closely approximate the conditions prevailing when crop stems are deflected during actual harvesting. Thus measurements were taken, in the field, on ready-to-harvest Japonica variety of rice grown at the Kyushu University Farm in Fukuoka, Japan, during October, 1991.

The specific objectives of the empirical study were as follows:

(1) To determine the functional relationship.
$\varnothing_m = \varnothing(\Delta X_m, Y_m)$

(2) To determine the functional relationship
$F = F(\Delta X_m, Y_m)$

(3) To study the effect of loading rate, and by extension, the viscoelastic effect.

(4) To obtain any other information that might be helpful in understanding the problem of crop stem deflection.

It will be seen that the second objective above has no direct relevance to the determination of reel stagger. However, an understanding of the variation of the applied force as the stem is deflected should facilitate an evaluation of the significance of viscoelasticity, which should be useful in the construction of a theoretical model of crop stem deflection.

Equipment Used in the Empirical Study

The equipment used in the empirical study is illustrated in **Fig. 4**and **Fig. 5**. It consisted of a commercial motor, rack gear, and rack rod assembly such that switching on the motor set the rack rod into linear motion. The speed of the rack rod was controllable and the direction of its motion reversible. This assembly was mounted onto a commercial tripod stand normally used with photographic equipment. As usual, the stand had facility for leveling and height adjustment.

To one end of the rack rod was fastened an L-shaped force sensor capable of sensing two mutually perpendicular force components

Fig. 4 Stem deflection apparatus.

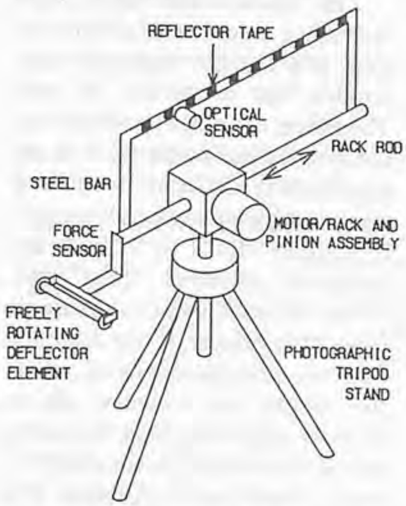

Fig. 5 Essential features and configuration of the deflection apparatus.

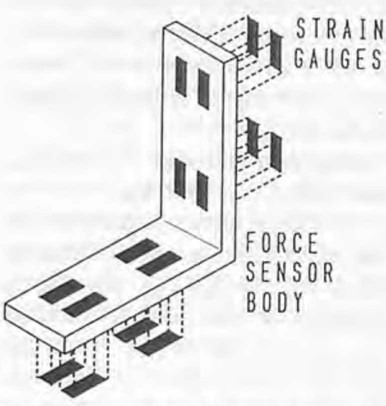

Fig. 6 Arrangement of strain guages on the force sensor.

regardless of the location of the actual point of action of the resultant force. This was achieved through an arrangement of four sets of electrical resistance strain guages bonded to the main body of the sensor as illustrated in **Fig. 6**. Each set of four strain gauges comprised a full-bridge bridge circuit to increase the sensitivity of the sensor, due to the small magnitudes of the forces to be measured. The force-application end of the L-shaped sensor was fitted with a rotating element mounted on ball bearings to ensure that the force between the sensor and the stems would always be approximately normal to the curvature of the stems being deflected.

Also fastened to the rack rod was a bent L-section steel bar with a straight portion of it running parallel to and above the whole length of the rack rod. Uniformly spaced pieces of reflector tape were fastened to this portion of the bar. A stationary ultra-violet sensor and pulse generator used in conjunction with the reflector tapes generated pulse signals which provided a means for monitoring the speed of the rack rod.

Table 1. The Complete Block Design of Measurement Procedure

Replicate	Height Y_m (m)	Deflection speed U_D (m/s)		
		0.005	0.010	0.015
First	0.35	TAKE11	TAKE12	TAKE13
	0.45	TAKE14	TAKE15	TAKE16
	0.40	TAKE17	TAKE18	TAKE19
Second	0.40	TAKE21	TAKE22	TAKE23
	0.35	TAKE24	TAKE25	TAKE26
	0.45	TAKE27	TAKE28	TAKE29
Third	0.45	TAKE31	TAKE32	TAKE33
	0.40	TAKE34	TAKE35	TAKE36
	0.35	TAKE37	TAKE38	TAKE39

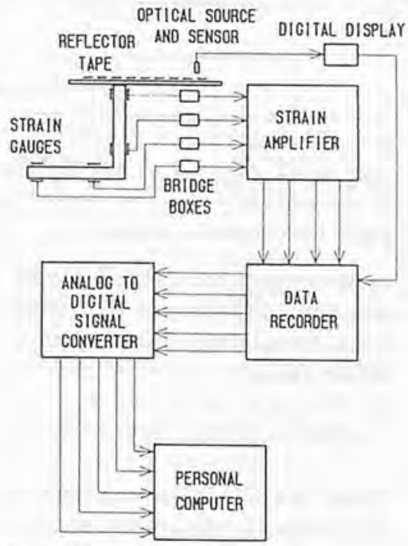

Fig. 7 Data acquisition system.

Method of Measurement

The equipment described in the above section was used to deflect crop stems and to obtain measurements of the horizontal component of force, F_X, the vertical component of force F_Y, and the speed of deflection, $d(\Delta X_m)/dt$ (hereafter denoted U_D). Before actual measurement, a bunch of crop would be selected more or less randomly and isolated by cutting the crop in its immediate vicinity. The only criterion applied was that the isolated bunch should be reasonably upright. The number of stems in the bunch was counted and recorded. The height of the force application unit above the ground was set to a predetermined value. The speed of deflection was also set to a predetermined value by use of a graduated knob on the motor control unit.

The motor was then switched on and as the crop was deflected, the data were recorded on video tape using a TEAC XR-50 cassette data recorder. As the crop was deflected the speed of deflection could be monitored on a digital display unit. The power supply for the equipment was obtained from a portable generator. The data acquisition system is illustrated in **Fig. 7**.

Three replicates of the measurements for each combination of settings (treatments) were taken. The complete block experimental design was adopted and is shown in **Table 1**. The word *TAKE* is used to denote a single measurement run.

Data Processing

As described in the preceding

section, the data recorded in the field were in analogue form on video cassette tape. Subsequent to taking the measurements in the field, the data were input into a personal computer (NEC PC-9801 Series) with the aid of the CANOPUS analogue-to-digital converter interface and software. Once the data were input into the computer desired mathematical processing routines could be executed easily. First a smoothing routine was executed using a program written in N88 BASIC and then other necessary routines were executed using both the LOTUS 123 shoftware and programs written in N88 BASIC on the NEC PC, and the Kaleidagraph and StatView softwares on the Apple Macintosh IIsi PC. The basic data processing procedure is illustrated in **Fig. 8**.

Results and Discussion

The Relationship Involving $\varnothing_m$, ΔX_m, and Y_m

Figs.9a, 9b and **9c** are examples of the graphs of $\varnothing_m$ against $\Delta X_m / Y_m$ for various values of U_D and Y_m. The values plotted in these graphs are the means of the data obtained in the three replicates of each combination of treatments U_D and Y_m. By using the least-

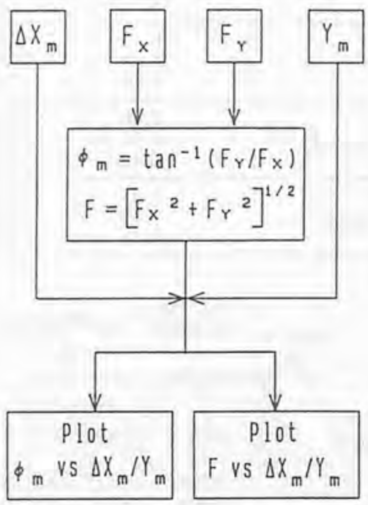

Fig. 8 Data processing system.

squares regression method (Stoodley, 1984; Stoodley et al., 1980), it was found that a linear equation of the form:

$$\varnothing_m = \alpha + \beta(\Delta X_m / Y_m) \qquad (7)$$

fitted well to the plotted data as can be seen in the graphs. A summary of the regression coefficients as well as the correlation coefficients, denoted γ, is given in **Table 2**.

The question arises as to whether the observed mean value of α, is significantly different from the theoretical value which is zero. Another question of interest is whether the observed values of β are significantly correlated with either Y_m or U_D or both.

To answer these questions, statistical inference tests were performed the results of which are given below:

Hypothesis Test on the Population Means of α

The theoretical crop stem deflection model assumes that the stem is a vertical cantilever; this implies that α should be zero. Therefore, the null hypothesis that the population mean of A is not significantly different from zero was tested against the alternative hypothesis that it is, in fact, significantly different from zero. Given the small size of the sample (only nine values), it was assumed that the population from which this sample was drawn would be at least approximately normally distributed. Thus a two-tailed Student's **t**-test was performed. The sample t-statistic of -3.5347 for eight degrees of freedom indicated the population mean was not significantly different from zero, at 95% confidence level. Therefore, the value of α shall be taken to be zero.

Correlation between β and U_D, and between β and Y_m

It is necessary to determine the degree to which the rate of change of $\varnothing_m$ with $(\Delta X_m / Y_m)$, denoted β, depends on the speed of loading, U_D, or on the height from the

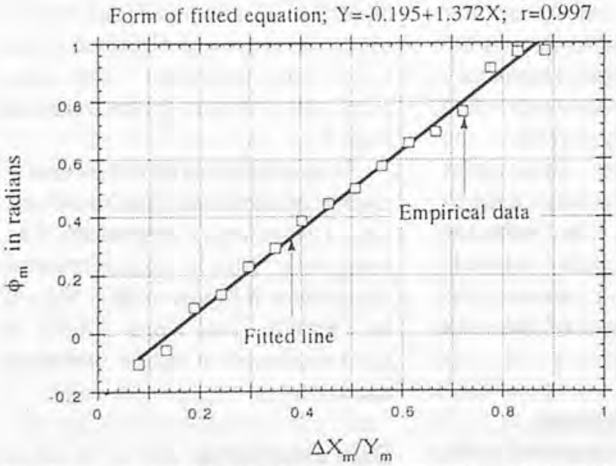

Fig. 9a $\varnothing_m$ against $\Delta X_m/Y_m$ for $Y_m = 0.35$ m and $U_D = 0.015$m/s.

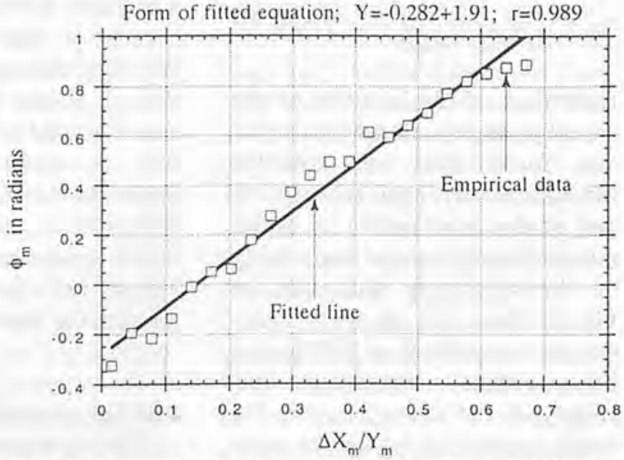

Fig. 9b $\varnothing_m$ against $\Delta X_m/Y_m$ for $Y_m = 0.4$ m and $U_D = 0.005$m/s.

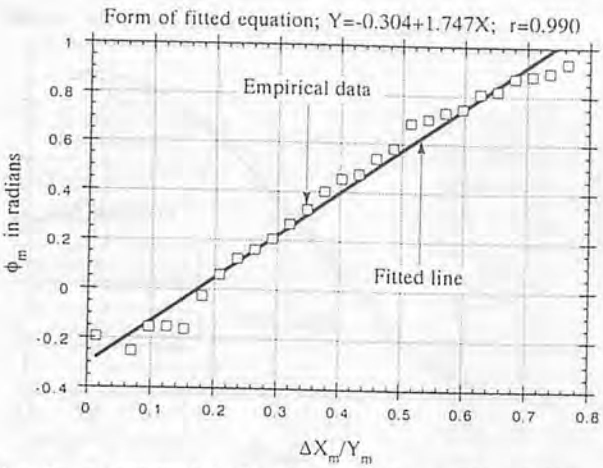

Fig. 9c $ø_m$ against $\Delta X_m/Y_m$ for $Y_m=0.45$ m and $U_D=0.01$m/s.

Table 2. The Linear Regression of $ø_m$ on $\Delta X_m/Y_m$

Y_m (m)	U_D (m/s)	Regression results		
		α	β	γ
0.35	0.005	−0.036	1.211	0.985
	0.010	−0.023	1.003	0.991
	0.015	−0.195	1.372	0.997
0.40	0.005	−0.282	1.910	0.989
	0.010	−0.084	1.419	0.982
	0.015	−0.108	1.610	0.996
0.45	0.005	0.009	1.425	0.985
	0.010	−0.304	1.747	0.990
	0.015	−0.285	1.666	0.993

Table 3. Correlation Between β and U_D, and β and Y_m

Independent variables	Dependent variable, β		
	Covariance	Correlation	γ−Squared
Y_m	0.1565	0.6461	0.4175
U_D	0.0128	0.0526	0.0028

Table 4. One-way ANOVA for the Effect of Y_m on β

Source of variation	Degreese of freedom	Sum of squares	Mean Squares	F-statistic
Y_m	2	0.3787	0.1894	4.5982
Residual	6	0.2471	0.0412	
Total	8	0.6258		

ground to the point of application of the load, Y_m, or on both. For this purpose, a correlation analysis was performed the results of which are given in **Table 3**.

From the statistics in **Table 3** there appears to be a fair degree of correlation between β and Y_m, but there seems to be almost no correlation between β and U_D. This result shall be taken to be adequate ground for the dismissal of any apparent correlation between β and U_D as merely the result of the natural variation exhibited in biological matter and, therefore, insignificant.

Analysis of Variance (ANOVA)

It remains to be ascertained whether the apparent correlation between β and Y_m is, in fact, greater than what could be expected from natural chance variation. Having found that the effect of U_D on β could be dismissed, a one-way analysis of variance (ANOVA) was performed to determine whether the effect of Y_m on β is significant. The results are given in **Table 4**.

The results in **Table 4** indicate that the variance due to Y_m is not significantly greater than what should be expected from natural chance variation, at 95% confidence level. It may, therefore, be assumed that Y_m does not significantly affect the value of β.

On the basis of the above statistical tests, it was concluded that, for practical purposes, the relationship between $ø_m$ and $\Delta X_m/Y_m$ could be taken to be the following;

$$ø_m = 1.4848\ (\Delta X_m/Y_m)$$

where 1.4848 is the mean value of β, obtained from **Table 2** and $ø_m$ is measured in radians.

Relationship Involving the Resultant Deflecting Force, F, ΔX_m, and Y_m

Figs. 10a, 10b, and **10c** are examples of the graphs of F against $\Delta X_m/Y_m$ for various values of U_D and Y_m. The values plotted in these graphs are the means of the data obtained in the three replicates of each combination of treatments U_D and Y_m. By using the least-squares regression method, an equation of the form:

$$F=F_o[1-COS[\Omega\pi(\Delta X_m/Y_m)]\ ] \tag{8}$$

which was inspired by a consideration of the fundamental harmonic of a half-range Fourier Series of general period for an even function (Heading, 1963; Greenberg, 1978), was found to fit well to the plotted data as can be seen in the graphs. A summary of the regression coefficients, F_o and Ω ($\pi=3.14159$), as well as the correlation coefficients, denoted r, is given in **Table 5**.

Statistical Analyses

Statistical analyses, including tests on hypotheses concerning population means, correlation analyses, and analyses of variance were performed on the data acquired in the experiment and the values of the regression coefficients obtained from the regression of F on $\Delta X_m/Y_m$ (see **Table 5**). As a result, Ω was found to be weakly correlated to Y_m ($\gamma=0.33$) but considerably negatively correlated to U_D ($\gamma=0.73$). However, on performing an ANOVA, it was found that the effect of U_D on Ω was not significant at 95% confidence level.

Further, F_o was found to be almost uncorrelated to U/D ($\gamma=0.022$) but strongly and negatively correlated to Y_m ($\gamma=0.91$), which is to be expected from the well known fact that it is easier to

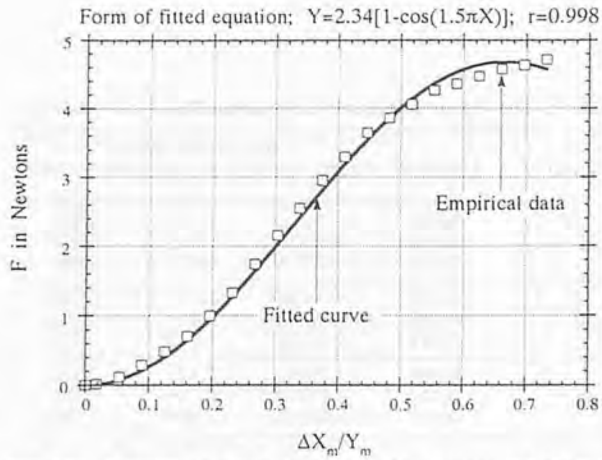

Fig. 10a F against $\Delta X_m/Y_m$ for $Y_m = 0.35$ m and $U_D = 0.005$m/s.

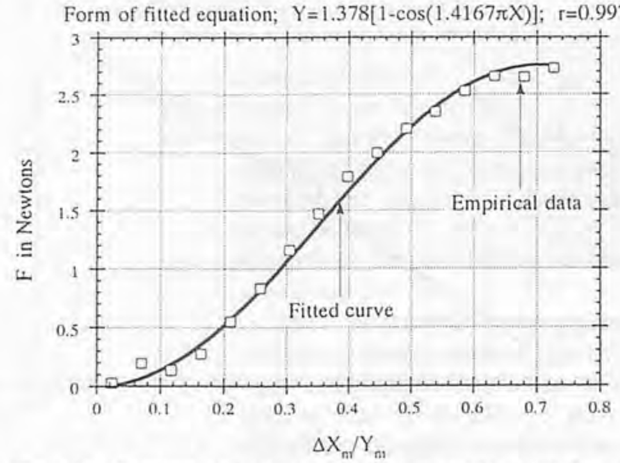

Fig. 10b F against $\Delta X_m/Y_m$ for $Y_m = 0.4$ m and $U_D = 0.015$m/s.

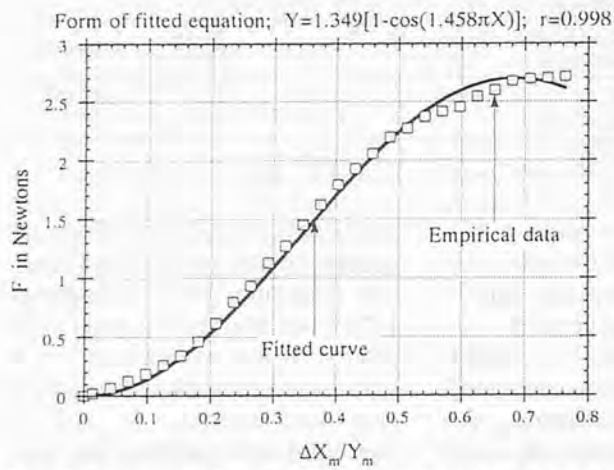

Fig. 10c F against $\Delta X_m/Y_m$ for $Y_m = 0.45$ m and $U_D = 0.01$m/s.

Table 5. The Regression of F on $\Delta X_m/Y_m$

Y_m (m)	U_D (m/s)	Regression Results		
		F_o	Ω	r
0.35	0.005	2.340	1.500	0.998
	0.010	2.390	1.250	0.998
	0.015	2.880	1.375	0.995
0.40	0.005	2.100	1.708	0.999
	0.010	1.790	1.540	0.998
	0.015	1.378	1.417	0.997
0.45	0.005	1.092	1.729	0.998
	0.010	1.349	1.458	0.998
	0.015	1.367	1.313	0.996
Mean values		1.854	1.477	

bend a longer beam. On performing an ANOVA, it was almost conclusively evident that the effect of Y_m on F_o was significant. The result that the force required to deflect the stems does not appear to depend on the rate of loading (*F_o was found to be almost uncorrelated to* U_D) implies that the deflected stems can be considered to be elastic rather than viscoelastic, at least for the range of loading speeds used in this study. This should be an important consideration in the theoretical modelling of crop stem deflection but does not directly concern the problem of reel stagger determination. Efforts by the authors to construct such a theoretical model shall be reported subsequently.

Experimental Methodology

Though it was necessary to determine the actual deflection of the stems, denoted ΔX_m, the apparatus used in this study was equipped to directly measure this deflection, but rather to measure the time rate of deflection. Thus, in order to determine the actual deflection, it was necessary to determine the moment in time at which the deflection of the stem commenced. This was done by looking at the time histories of the output voltages from the force sensor, on a personal computer visual display unit. It is thought that this method led to some loss in precision and can be improved.

Application of Results for Reel Stagger Determination

Fig. 11 illustrates the procedure for the determination of reel stagger using the results of this study. The equations necessary for the calculations in this procedure are the following:

$$Y_r = Y_c + AR_o;\ 1 \leqq A < \frac{R}{R_o} \quad (9)$$

where

Y_r is the height of the reels axis of rotation above the ground, in meters.

Y_c is the nominal height of the crop in meters

A is a dimensionless number

R_o is the rate of header advance in meters per radian of reel rotation.

R is the radius of the reel in meters

$$\omega t_2 = \pi - cos^{-1}[\frac{AR_o}{R}] \quad (10)$$

where

ωt_2 is an angle measured in radians. Thus the value of the arccosine term must be in radians too.

π is the ratio of a circles circum-

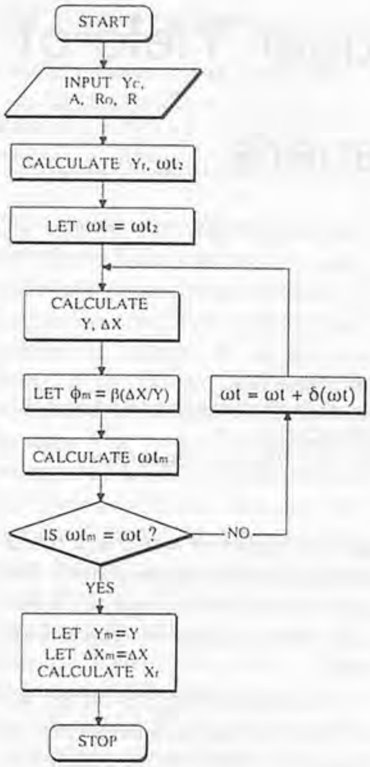

Fig. 11 Determination of reel stagger.

ference to its diameter (3.14159)

$$Y = Y_r + R cos\omega t \quad (11)$$

$$\Delta X = R[\frac{R_o}{R}(\omega t - \omega t_2) + sin\omega t - sin\omega t_2] \quad (12)$$

$$\omega t_m = cos^{-1}[\frac{R_o}{R} cos\o_m] + \pi + \o_m \quad (13)$$

where

ωt_m is an angle measured in radians. Thus the value of the arc-cosine term must be in radians too.

$\o_m$ is an angle measured in radians.

$$X_r = [R^2 - (Y_r - Y_m)^2]^{1/2} + \Delta X_m \quad (14)$$

where

X_r is the reel stagger, in meters.

In using the above equations, it should be noted that, in accordance with the definition of the coordinate reference frame, and the various quantities involved in the calculations, the calculated value of ΔX_m, and by extension, that of $\o_m$ would be expected to be less than zero. The quantity denoted β is an empirical coefficient which may vary with the type and condition of crop being harvested. For the *Japonica* rice variety, which was studied in this work, the numberical value of this quantity has been found to be 1.4848, and may be estimated to be 1.5.

Conclusions

1. An empirical study on crop stem deflection due to the action of the combine harvester reel was carried out and, as a result, a mathematical relationship involving the crop stem deflection, denoted ΔX_m, the perpendicular height, denoted Y_m, from the ground to the point of application of the deflecting force, and an angular parameter of stem deflection, denoted $\o_m$, was established.
2. By combining the results of the empirical study presented in this paper and the principle of determination of reel stagger, which was presented earlier in the first part of this paper, it was possible to construct an algorithm for the determination of reel stagger. However, the results of this method of reel stagger determination still need to be tested on actual reels fitted to operating combine harvester.
3. Through statistical analyses of the data acquired in this empirical study, it was found that, for the range of loading speeds used in this study, the force required to deflect the stems was not significantly affected by the rate of deflection. This implies that, for practical purposes, the stems could be considered to behave elastically rather than visco-elastically. This information should be useful in the theoretical modelling of crop stem deflection under the action of reel. This aspect of the problem is still being studied by the authors.

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Optimizing Harvest Time and Sugar Yield of Sugarcane Using Chemical Ripeners

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Abstract

Two chemical ripeners, Ethrel (ethephon as active ingredient) and Round Up (glyphosate as active ingredient), were applied under rainfed conditions in order to optimize the harvest time of sugarcane. The level of extractible sugar and sucrose increased to over 13% in 360 days and over 20% in 360 days, respectively, in the presence of Round Up during the period of study. The harvest time of sugarcane, in order to optimize the sugar yield, depends on the age of the sugarcane, the soil type as well as the length of application of the ripener. Ethrel plays the role of a growing chemical thereby increasing the tonnage of sugarcane.

Introduction

In the past sugarcane producers often assessed their crop in terms of cane production per hectare, rather than tons sucrose produced per hectare per unit time. This is however, changing rapidly, particularly because of the inverse relationship that has been observed between sugarcane production and sucrose content. This is mainly attributed to seasonal variations. In the present study, sugarcane was produced in a region which exhibits two dry seasons and two rainy seasons. Cultivation starts during the rains which last for 4 months (August-November) and followed by a dry period lasting 4 months (December-March) and finally returns to the rains which last for about 3 months (April-June).

The first rains are generally responsible for rapid growth with significant utilisation of the sucrose produced. During the first dry period, growth is retarded with subsequent storage of sugar. As the second rains begin there is a resumption of rapid growth leading to high levels of nitrogen and water in the soil. During this time the sucrose content begins to decrease while there is an increase in the production of sugarcane. At the beginning of the second rains an attempt has to be made, therefore, to improve or at least maintain gains made earlier in the sucrose content. A control experiment permits a study of the influence of soil type on the level of sucrose. For a chosen variety and age of sugar cane, type of soil, it is mainly the climate, minerals and the supply of water and nitrogen that determine the growth rate and the level of storage of sugarcane (Fauconnier et Bassereau, 1970).

A number of studies on the use of chemical ripeners of sugarcane (Rostrom 1985, Soopranarien et al, 1982) and the control of its growth through the supply of water and fertilizers have been carried out in the hope of determining a suitable time for harvest in terms of sucrose content. Such studies became even more important in the present situation because of the two periods of rains that intervene before harvest.

The present study concentrates on the use of two chemical ripeners with commercial names Ethrel (ethephon as active ingredient) and Round Up (glyphosate as active ingredient) hereafter referred to simply as Ethrel and Round Up.

Materials and Methods

The details of the experiment are shown in **Table 1**.

Two sites (B14 and D10) were chosen for the trials. Site B14 was treated with Round Up and this was accompanied by a control experiment without the application of the ripener. Site D10 was

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Table 1. Experiment Details

Variety	Site	Last harvest date	Application date		Harvest date (age in days)
			Ethrel	Round up	
B46364	B14	7/6/1990		24/4/1991	31/5/1991 (357)
B46364	D10	30/6/1990	12/10/1990	23/4/1991	4/6/1991 (370)

first treated with Ethrel and later with Round Up and has as a control experiment the application of Round Up only. The ripeners were sprayed by means of an aircraft fitted with boom and nozzles calibrated to apply 40 litres per hectare. The rate of spray application was 0.75 litre per hectare for Round Up and 1 litre per hectare for Ethrel. The layout of the plots followed standard management practice. Randomized block designs with six replicates were adopted for all the trials. Plots B14 and D10 had surfaces of 61.2 m^2 and 100 m^2, respectively.

Samples were taken from the plots just before spraying and at intervals thereafter to assess treatment effects. The period of sampling was 36 days for plot B14 and 42 days for plot D10. Cane samples were analysed in the factory laboratory using the standard methods (Meade, 1977 and IRIS, 1984). The extractible sugar (E.S. % cane) was determined from the following formula:

$$E.S. = sucrose \times (1 - 2 \times 10^{-3} \times \text{weight of cake})$$ (Rostrom, 1985).

Results and Discussion

Effect of Round Up

The effect of Round Up on the level of extractible sugar as well as that of sucrose is shown, respectively, in **Figs. 1** and **2**. This study was carried out on plot B14. The results in **Fig. 1** show that during this rainy period, the influence of Round Up was to increase the level of extractible sugar (defined as E.S. % cane), which otherwise as seen in the control experiment stays virtually constant. It is seen from the graph that at 350 days the control treatment shows 10.6% E.S. while the Round Up treatment shows 12.4% E.S. The application of Round Up, therefore, increased the level of sugar during this period leading to higher production rates, provided the harvest time coincided with the period when the Round Up has a positive effect. Calculations based on this findings show that an increase in sugar production of one ton per hectare was achieved during the period of study. This result is similar to that observed by Rostron, 1985, using the chemical ripener Polado having the same active ingredient. **Fig. 2** also shows that the level of sucrose increased in the presence of Round Up. The control exhibited 17% sucrose at 355 days while the Round Up treatment exhibits 20%, for example.

Effect of Ethrel

This experiment was carried out on plot D10. The analysis just before the application of Round Up shows that the level of extractible sugar with and without the application of Ethrel was virtually the same (**Fig. 3**). There was an increase in the level of sugar after the application of Round Up in both cases with similar profiles. This shows that Ethrel plays only the role of a growing chemical, and, therefore, leads mainly to an increase in the tonnage of sugarcane.

Influence of Soil Type

Fig. 4 shows the effect of Round Up when applied to the two different soil types. The soil

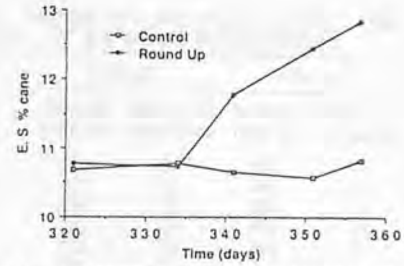

Fig. 1 Extractible sugar as a function of age (site B14).

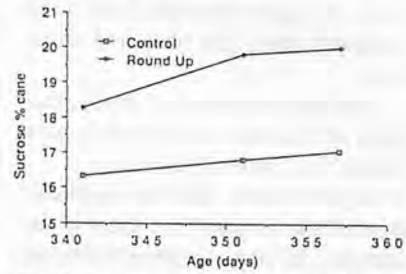

Fig. 2 Sucrose content as a function of age (site B14).

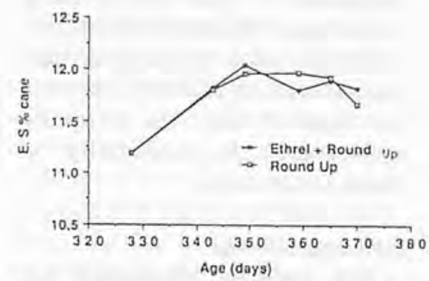

Fig. 3 Extractible sugar as a function of age (site D10).

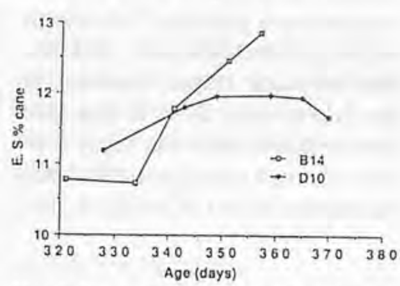

Fig. 4 Extractible sugar as a function of age.

type found in Plot D10 is more sandy than that of Plot B14. This implies that the soil of Plot D10 retains less water than that of B14. Since a high retention of water does not favour the storage of sugar, it is seen from the figure that before the application of the chemical ripener at the beginning

Table 2 Rainfall on the Two Sites after the Application of Round Up

Site B14		Site D10	
Days after application	Rainfall (in mm)	Days after application	Rainfall (in mm)
0	200	0	167
13	294	15	306
20	400	21	369
30	457	31	445
36	480	37	467
		42	482

of the second rainy season, the level of sugar obtained from D10 is higher than that obtained from B14.

During the period of study, the level of rainfall on both plots was about the same (**Table 2**).

Fig. 4 shows that on application of the Round Up, there is an increase in sugar content in both plots. It must be remarked, however, that plot B14 which absorbs more water tends to have a more rapid increase in sugar content. This probably implies that there is some relationship between the type of soil, the chemical ripener and the availability of water at the roots.

Influence of Age

The response of Round Up (**Fig. 4**) is seen to be rather spontaneous in the case of plot D10 contrary to a period of 14 days in which it was observed that the level of sugar stayed constant in the case of plot B14. It was also observed that while the sugar content was on a continuous increase during the period of study on plot B14, it began to decrease after 42 days in the case of plot D10 (**Fig. 3**). This difference in the level of sugar at the early stages of application of Round Up and the results in **Fig. 4**, indicate that the influence of Round Up could have four possible effects on the level of sugar stored which may depend on the age of the crop at the time of application and the duration of application before harvest. These will be periods of no response (e.g., B14, age 321-335 days), a period of increase (e.g., B14, age 335-357 days and D10, age 328-340 days), a constant period (e.g., D10, age 340-365 days) and a decreasing period (e.g., D10, age from 365 days). A mastery of these various stage of response to Round Up enables the sugar producer to determine the appropriate time for applying the chemical ripener as well as the harvest period. This combined response will certainly lead to higher yields of sugar at the factory.

Conclusion

This study reveals that the chemical ripener, Round Up, when applied at the beginning of the second rains leads to a net increase in the level of extractible sugar. There is, in general, an increase in the level of extractible sugar which attains a maximum that stays constant over a certain period before experiencing a decrease. In order to take advantage of the positive effects of Round Up, it is recommended that harvest should take place during the period at which the level of extractible sugar stays constant. This increase in the level of sugar is seen to be related also to the type of soil and the age of the sugarcane crop. The chemical ripener, Ethrel, appears to have as main function to increase the tonnage of sugarcane.

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Mechanization of Sugarcane Production in Pakistan

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Introduction

Sugarcane is the 4th major crop in Pakistan. It is planted on about 4% of the cultivated land in the country. Since 1947, there has been an annual increase of 3.79 and 4.53% in acreage and production of sugarcane, respectively. However, its yield, 35-37 tons/ha, has been virtually static since 1970 with marginal improvement in some years. Compared with other sugarcane producing countries, Pakistan ranks 5th in acreage and 18th in yield per unit area. Obviously, the pattern of the growth of sugarcane is associated with area expansion. This trend cannot be continued because of limited water and land resources required for other important crops. The emphasis should, therefore, be given to increasing sugarcane yield per unit area.

Enhanced yield of crops can be obtained by optimising physical inputs through bio-hydro-chemical technologies. The degree of effectiveness of these technologies is closely related with mechanization. Mechanization not only reduces the cost of production but also increases crop yields and helps in land forming and preparation, planting, interculturing fertilizer and pesticide application, harvesting and handling.

No doubt, farm mechanization has an edge over traditional methods of operations. Equally important is its efficient use and management which directly influence the cost of sugarcane production. If efficiency is low then profits will be low. Ineffective methods and management will push production costs up which stands to reason that when production costs go up, profits come down.

Fig. 1 shows a schematic layout of mechanized sugarcane production.

Land forming

Sugarcane crop needs almost one ton of water to make 0.5 kg sugar. Even application of irrigation water in the field is also utmost necessary for uniform moisture and nutrients up-take by plants. Uniform germination and growth of plants, increased fertilizer use efficiency and increased farm machinery efficiency, proper land forming viz; precisely levelled bigger and longer reshaped field are required. The traditional method of dividing land into small pieces, mostly 1/8 of an acre, for efficient use of irrigation water is not necessarily advantageous. At the present time, the field can be formed, levelled and graded in such a way that the quantity of available water could spread evenly and, consequently, all plants receive moisture and nutrients uniformly. The adoption of modem irrigation technology through land forming also paves the way for efficient mechanization. The use of levelling equipment to determine cuts and fills and that of scraper and leveller is required to carry out land forming. The use of tractor-mounted automatic laser levelling equipment is most efficient alternative in land forming.

Green manuring—Green manuring replenishes soil fertility. Crop residues can be crushed and mixed with soil using rotavator or disc harrow.

Land Preparation

Free draining soil to the depth of 60 cm is necessary in obtaining reasonably satisfactory cane yields.

Primary tillage—The conventional shovel type cultivator commonly used with tractor by farmers as primary and secondary tillage normally operates to the depth of 8-10 cm. Also, 5-7 passes

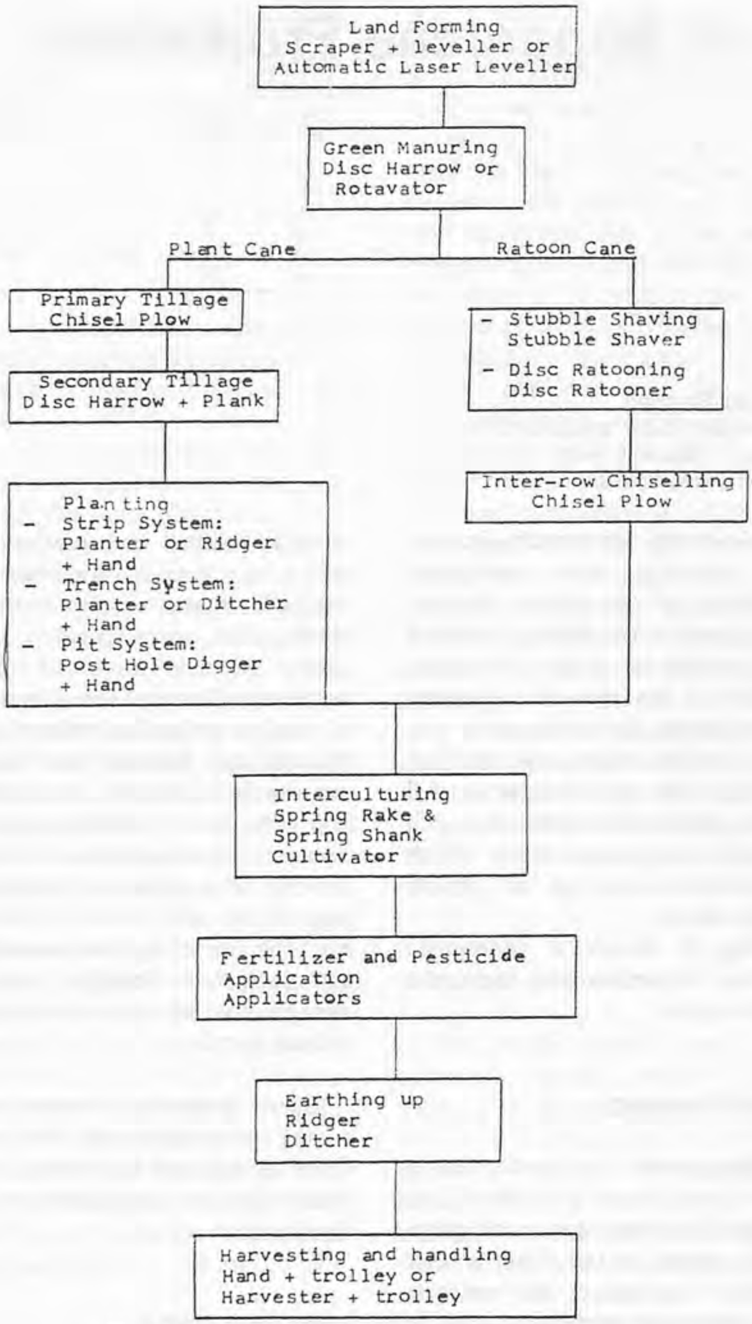

Fig. 1 Flow-chart of mechanized sugarcane production.

of this cultivator with tractor is common in preparing the land for sugarcane crop which severely compacts the soil below the operating depth. The primary tillage with 3-tined chisel plow operated twice bi-directionally followed by ridge and furrow configuration can provide the required depth of free draining soil for sugarcane crop.

Secondary tillage—In the preparation of a seedbed with the use of secondary tillage implements, the objectives are as follows:

a) The promotion of a crumb structure for:
   i. the infilteration and retention of water,
   ii. aeration of soil and uptake of nutrients.
   iii. easy root penetration, and
   iv. resistance to erosion.
b) The incorporation of residue and weeds for unchecked growth.

Equally important is the number of implement operations which should be minimized to the possible extent in order to avoid undesirable soil compaction. On the other hand, the use of cultivator 3-4 times as secondary tillage implement followed by planking in preparing seedbed for sugarcane is very common. A single pass of disc harrow followed by planking once can prepare seedbed to the required standard for sugarcane crop with minimum possible soil compaction. Tractor-mounted offset disc harrow with 14-16 discs is easily available.

Planting

In order to suit subsequent mechanical operations, sugarcane planting in strip and trench systems is recommended. For both of these systems, the population of sets recommended for optimum cane yield is about 98000 pieces/ha each with minimum two "eyes."

Strip planting—In strip planting system, 90 cm distance is maintained between strip to strip. Two lines of sets, 30 cm apart, are planted manually on each strip in furrows made with tractor mounted ridger (**Fig. 2**).

Locally made tractor-mounted planter makes furrows, cuts and places sets in two lines and covers with soil as per above layout quite efficiently. Thus, the use of planter, therefore, eliminates the use of ridger for furrowing and labour required for making and planting of cane sets. Some planters have fertilizer attachment for applying its basal dose along with planting. Provision can be

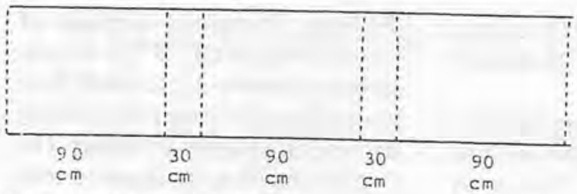

Fig. 2 Layout of strip planting.

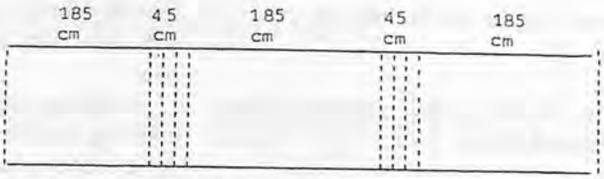

Fig. 3 Layout of trench planting.

made for a positive non-return spray system to treat sets with fungicidal solution.

In this system, tractor over-ridges strip. While carrying out subsequent mechanical operations like weeding, earthing up etc. tractor wheels come on inter-strip spaces.

Trench planting—Trenches of about 23 cm deep and 45 cm wide were made at 185 cm apart with the help of tractor-mounted adjustable ditcher or big-size ridger and four lines of sets are planted manually (**Fig. 3**). However, the use of mechanical planter may perform the function of trench making and sets cutting and placement more efficiently. Also, basal fertilizer application and fungicidal treatment of sets may be carried out with the planter simultaneously if provisions exist.

The system permits inter-row running of tractor without any obstruction for the accomplishment of subsequent operations. It also enhances water application efficiency significantly and depresses inter-row weed growth by restricting irrigation in trenches. Preferably, primary tillage with chisel plow should also be confined in the planting row space. This practice will save energy bill. However, sufficient soil depth free of objectionable constituents is a pre-requisite for the implementation of this system.

Pit planting—This system of sugarcane planting is recommended by the University of Agriculture, Faisalabad. As per recommendation, 4940 pits per hectare each of 100 × 100 × 75 cm (length × breadth × depth) size are dug manually. Thirty sets of cane are placed in each pit in order to increase set population to about 148,200 pieces/ha. Manual digging of pits is very laborious, time consuming and also costly. Distance between pit to pit in manual system is so close that it does not allow subsequent mechanical operations.

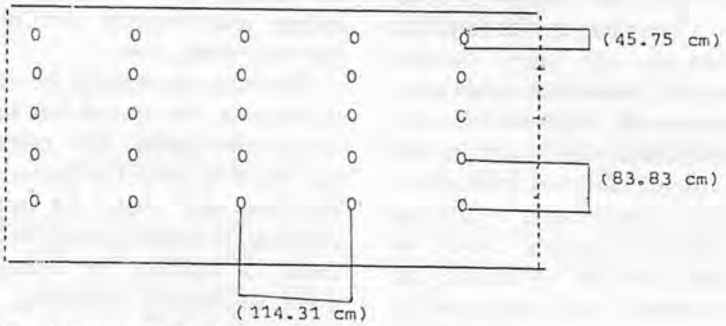

Fig. 4 Layout of pit planting.

A tractor-mounted PTO-driven post hole digger able to dig hole of 45.75 cm diameter was used. A pit of 45.75 cm diameter and 100 cm deep accommodating about 15 sets can be dug in half minute with this digger. However, adding time for pit marking and tractor shifting, one minute per pit will be required.

In order to achieve the required set population with this system, a total of 9994 pits/ha will easily be dug mechanically with centre to centre distance of 114.31 and 83.83 cm on the direction of length and breadth, respectively (**Fig. 4**). Mechanical pit cultivation of cane facilitates subsequent operations with tractor-mounted equipments in the crop.

Interculturing

It is generally recommended that touching the soil should be kept minimal and mainly to control weeds and to break the crust by rain drops or irrigation water as excessive soil disturbance and pruning is not conducive to vigorous root growth. If proper land preparation is initially performed, deep inter-row cultivation is not necessary to further improve the soil tilth at the root zone level. In fact, constant tractor and cultivator points passages cause soil compaction, let alone excess fuel and machine use.

It is also best to control annuals or biennials and seedlings of perennials with shallow working of the soil than with deeper tillage as soon as the weed seedlings appear. If allowed to develop further or to reproduce, weeds become more difficult to eradicate. In addition, they use up soil nutrients and moisture.

A light spring rake, called a multi-weeder or cleaner, uproots weeds in the plant row without harming the emerging cane shoots. Narrow versions are also used to run over the row with discs and coil or spring shank cultivators working in the interspace.

Fertilizer and Insecticide Application

Green manuring can be accomplished with disc harrow or rotavator. Cane planter with fertilizer attachment can carry outside dressing of basal dose while placing sets in soil. Otherwise, fertilizers and insecticides can be applied with tractor mounted applicators. Fertilizer side dressing is essential and its broadcasting should be avoided. Fertilizer applicators can be combined with post-planting cultivation at the appropriate stage of plant growth.

Earthing up—This operation is carried out in order to:

i. Support stalks against strong winds and avoid lodging,
ii. Kill emerging water shoots as they do not have much sugar at harvest time and consume plant nutrients,
iii. Kill weeds in the rows, and
iv. Improve drainage and provide furrows for irrigation to enhance water application efficiency.

In strip and pit planting, tracor with two-bottomed ridger runs over plant row. Ridger bottoms follow tractor wheels and throw loose excavated soil right and left. Thus, a complete ridge or the plant row under the tractor body and two half ridges on the right and left rows are formed along with two furrows behind the wheels. In this system, the tractor will take turn on the third plant row.

A ditcher with adjustable wings can very well be used for earthing up in trench planting. The tractor will pull the ditcher in all the interrow spaces. The trenches become ridges and furrows are made between plant rows.

Earthing up should be done when cane root system has sufficiently developed. For earthing up, April is ideal for September planting and June for spring planting. Irrigation should be confined in furrows for increased water application efficiency.

Harvesting and Handling

Manual harvesting and handling of sugarcane is practised in the country compared with mechanical harvesters in some countries. As industrialization grows, mechanical harvesting of sugarcane will become a necessity. Stripped cane is transported to mills or their depots on trolley pulled by tractor. Utmost care is exercised in processing harvested cane within 24 h as after this chemical inversion of sugar contents start.

Ratooning—Harvesting of sugarcane for ratoon crop is recommended 3-4 cm below ground surface in order to kill hibernating larvae of borers. In manual harvesting, the achievement of this recommendation is difficult. Therefore, the use of tractor-mounted PTO-driven stubble shaver to cut the stalk bottoms left on the cane roots during harvesting becomes essential. The stubble shaver is designed to trim the top of the cane stool to give better and more uniform regrowth. The shaving process also destroys unwanted cane stubble so that ratoon growth can develop from the cane stool. In the case of mechanical harvesting, the cane is cut at or below ground level and stubble shaving is seldom practised.

When there is no need for stubble shaving, the disc ratooner should be operated to prune the side of the stools and cultivate the interrow space. The next operation on ratoons is ripping the inter-row space to cut old roots, correct the effects of compaction and encourage deep water percolation and root system. Conventional chisel plow of 3 tines can very easily be operated with a tractor under trench planting system. However, a ripper of 2 tines will have to be designed for strip and pit planting.

A light rake over the row uproots weeds and loosens the soil over the stool to encourage emergence of new tillers. The ratoon is side-dressed with fertilizer together with subsequent, but early, cultivations. Weeder rakes are used as a fast means of uprooting weed seedlings as these emerge in the row and between rows. Earthing up is carried out at the appropriate stage. ■■

Performance of Draught Animals on Sugarcane Crushing in Bangladesh

by
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Abstract

In this study the performance of draft animals used for crushing sugarcane by traditional three-roller crusher in the "gur" (brown sugar) industry is described. Gur is produced from the juice extracted from sugarcane. Eighteen crushers powered with different pairs of animals were used for data collection. The tests were conducted in order to determine the pulling force, pulling speed, crusher axle torque, crushing capacity and efficiency of crushing by animals. It was recorded that swamp buffalo-powered crushers provided 9% higher and 7% more juice than bullock-powered ones. The efficiency of the buffalo powered crusher was 3% more than the bullock one. The overall performance of buffaloes was found to be better than bullocks during sugarcane crushing.

Introduction

Bangladesh is an agricultural country with almost 61.3% of the labour force directly engaged in agriculture, which contributes around 46% to the gross domestic product (Anon, 1991). More than 0.16 million ha of land in the country is under sugarcane cultivation producing about 40 t/ha of sugarcane (Anon, 1991). More than 60% of the total cane production is utilized for making "gur" (brown sugar) of which 30% goes to the sugar manufacturing factories and the remainder is used for seed or for raw eating. Per capita gur and sugar consumption is 4.41 kg and 3.01 kg, respectively. Gur is about 35% less expensive than sugar and thus it is affordable by village people. Gur making is one of the most important cottage industries for unemployed rural people in Bangladesh. Jabber and Sarker (1987) reported that about six family labours are used in various operations of gur processing in non-sugar mill zones. This gur making technology is considered an employment generating technology rather than a labour displacement one.

The increase in extraction of juice from sugarcane to the factory level is not practically possible with animal powered crushers because of lack of finance and shortage of power for the equipment. The adjustment and modification of existing animal-drawn crushers may significantly improve the efficiency of the juice extraction as well as reduce present power shortage. This paper presents the effect of different parameters to improve crushing efficiency and suggests modifications to the hitching system to increase the crushing efficiency. The crushing capacity for the best utilization of animal power is discussed.

Materials and Methods

Gur is produced from cane juice. The juice is extracted from fresh cane by using a cane crushing unit. Miah and Sarker (1990) found that 8-9% of solid gur is obtained from the fresh cane. The traditional crushing unit consists of two vertical cast-iron rollers, usually 20-23 cm in diameter, grooved vertically, with a third feeder roller set in a wooden frame (**Fig. 1**). Normally the cane growers use a pair of bullocks/buffaloes for crushing sugarcane. Work animals in Bangladesh are very weak and weigh about 225 kg to 270 kg, on average. The pulling force of the animal corresponds roughly to one-tenth of its weight. Each work animal thus produces about 0.24 kW compared with about 0.37 kW by cattle in other South Asian Countries (Mettrick, 1976). But for a very short period, it can exert much more than the average. Hussain and Sarker (1978) found that the draft of work animals in Bangladesh ranged from 35 to 60 kg force, and 0.22 to 0.40 kW power, for 3 to 4 hours of continuous work.

The experiments were carried out for six months in Mowna

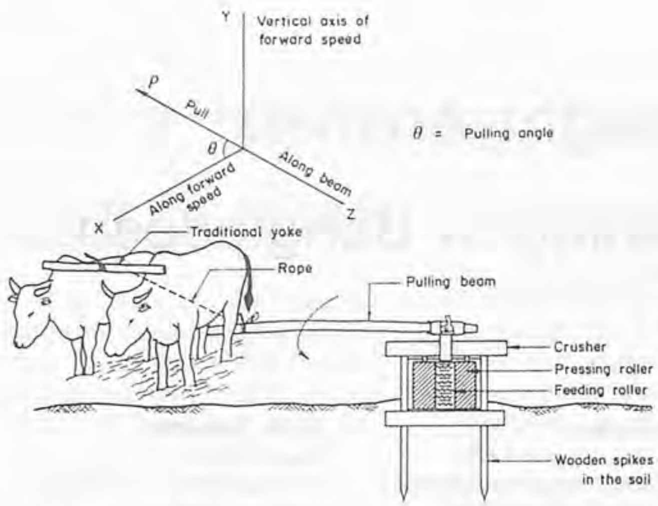

Fig. 1 Traditional sugarcane crushing method on level ground.

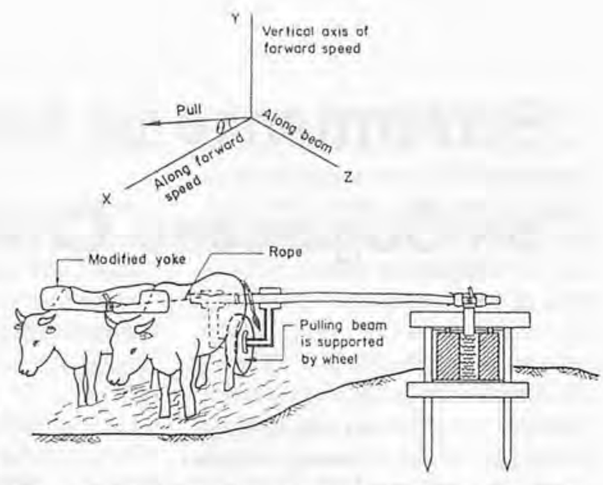

Fig. 2 Modified mounting of sugarcane crusher on a raised ground while the animal moving on a lowered ground and yoke supported by a wheel.

Bazar and Hobir Bari of Mymensingh district and the Seed Store of Ghazipur district. Six bullock-powered and 12 swamp buffalo-powered crushers were selected for investigation. The performance parameters: pulling speed, pulling force, crusher axle torque, crusher capacity were studied during the investigation. Available pull was measured using a hydraulic dynamometer. The pulling radius, cane feeding rate and juice production rate and the necessary dimensions of the hitching system were also recorded.

Crushing Principle of Sugarcane

A sugarcane crusher is powered by a pair of work animals walking along the periphery of a circle (**Fig. 1**). The power available from the animals is calculated as follows:

$$N = \frac{(PCos\Theta)(\pi nR)}{30} \quad (1)$$

Where,

N = power take off from animal neck

Θ = angle between the direction of pull and actual travel

P = pulling force

n = rotational speed of animal

R = radius of pull

The feeding rate can be increased by increasing the crusher axle torque. The crusher torque can be increased either by increasing the pull or by increasing the pulling radius. However, increasing the pull is restricted. The only possible way to increase the crusher axle torque is by increasing the pulling radius. The torque (T) can be calculated by:

$$T = \mathrm{PRCos}\Theta \quad (2)$$

The choice of pulling radius, R

The rotational speed of the crusher axle is related to the motion radius and rotational speed of walking animals (V):

$$V = \frac{\pi nR}{30} \quad (3)$$

Lower pulling radius will decrease both torque and crushing capacity. A smaller value of n will be obtained when R is longer. But when R is increased, the available torque will be higher resulting in increased capacity. If R is increased, i.e., a longer circular lentgh, n will be reduced automatically because of the constant walking speed of animal. Hence the construction of the exact relationship of rotational speed with rotating radius is difficult. The suitable pulling radius and number of turns per minute should be adjusted by experiment to achieve high crusher output.

Choice of yoke and pulling angle

Fig. 1 shows the pulling and walking path of the animal. During pulling, two components $F_H = PCos\Theta$ and $F_V = PSin\Theta$ are acting. F_V is undesirable as it would not only reduce the walking speed of the animal but would also vibrate the unit or even break the hitching beam. Therefore, it should be as small as possible. F_H, called the draft force, is useful for torque required for crushing. higher F_H shows more effective use of animal power. The best way to enlarge F_H and reduce F_V is to reduce the pulling angle. Lower pulling angle can be achieved by following the hitching system shown in **Fig. 2**. If the pulling angle is very low, the yoke might come over the neck to the back. The relasionship between F_H, height of animal neck and other hitching and power transmission components are required to be determined by experiment.

Results and Discussion

Table 1 shows the data about circular radius of pulling, angle of pulling, pulling speed, torque required for crusher, crushing capacity and efficiency during sugarcane crushing with different pairs of bullocks and buffaloes. It is clear that the pulling radius of the crushers for both bullocks and

Table 1. Comparison of Sugarcane Crushers Powered by Different Work Animals

Pulling radius (m)	Average rpm	Pull (kN)	Torque (kN-m)	Speed (km/h)	Capacity (kg/h)	Efficiency (%)
Pair of buffaloes						
3.94	2.22	1.47	5.80	3.31	203	44
3.77	2.19	1.47	5.55	3.12	196	43
3.06	1.57	1.37	4.20	2.93	177	44
3.56	1.83	1.28	4.54	2.75	187	46
3.44	2.27	1.42	4.89	2.60	175	43
3.48	3.25	1.18	4.10	3.61	185	46
3.92	2.89	1.77	6.92	3.08	242	45
3.80	2.14	1.37	5.22	3.40	191	47
3.10	2.22	1.42	4.41	3.26	200	49
4.03	1.64	1.47	5.93	2.50	168	47
3.69	2.16	1.37	5.07	3.01	199	44
4.06	1.90	1.28	5.18	2.91	187	43
Pair of bullocks						
3.71	2.17	0.88	3.28	2.04	155	43
3.64	2.00	1.08	3.93	2.74	156	42
3.62	3.00	0.98	3.55	2.11	184	43
4.25	3.75	0.98	4.17	2.21	182	43
3.92	1.69	0.93	3.65	2.30	151	42
3.77	1.55	0.98	3.70	2.96	144	43
F-value		*47.33*	*15.13*	*14.30*	*11.13*	*8.85*
Significance level		*0.00*	*0.002*	*0.002*	*0.004*	*0.009*

buffaloes were almost the same but the pulling force obtained was different. The pulling force ranged from 880N to 1080 N and 1180 N to 1470 N for a pair of bullocks and buffaloes, respectively. Higher available torque will help to crush more sugarcane. Reduced amount of feeding resulted in inadequate pressing while more feeding resulted in more roller pressure on the cane and required higher torque. The variation of speed and torque exerted depended on various factors like type of animal, animal health, duration of operation, and hitching system of power transmission. Among these the hitching system played an important role. It was found that buffaloes exerted more power than bullocks as they were healthier than bullocks. A statistical analysis by 'F' - test showed that the type of work animal used had a significant effect on pull.

The average pulling speeds during crushing were 2.68 km/h and 3.04 km/h using a pair of bullocks and buffaloes, respectively. Buffaloes walk faster than bullocks. The reason might be the height of the animal and the longer step of buffaloes. The average torques required at the crusher axle were 4.73 kN-m for bullocks and 5.16 kN-m for buffaloes. An average of about 10% higher torque was recorded by buffaloes. The statistical analysis showed that the type of animal had a significant effect on the axle torque when subjected to 'F' - test at 95% level of significance. It was also observed that the buffalo gave 17% higher draft and about 10% higher power than bullocks. The average crushing capacity was 180 kg/h and 193 kg/h (fresh cane) during use of a pair of bullocks and buffaloes, respectively. It was also found that about 7% more juice was produced by the buffalo-pulled crushers than by those pulled by bullocks. The efficiency of buffalo-powered crushers was 3% more than bullock-powered crushers. The reason for the better performance of buffalo powered crushers was that the feeding rate was more compared to bullock-powered crushers which helped the roller pressing and resulting in greater juice extraction.

Relationship between Torque and Draft

The maximum torques developed for crushing were 6.92 kN-m by buffaloes and 4.17 kN-m by bullocks at pulling speeds of 3.08 and 2.21 km/h, respectively.

The regression analysis shows that both draft and torque were affected by the pulling speed. The following relationship could be fitted to the data:

$$D = aS - bS^2 \quad (4)$$

and

$$T = aS - bS^2 \quad (5)$$

where,

D = draft

T = axle torque

a and b = regression coefficients

The values of regression coefficients a and b are given in **Table 2**. The correlation coefficient $r \geq 0.98$ and overall significance of $p \leq 0.01$ indicates the adequacy of regression analysis.

Figs. 3 and **4** show the effect of animal speed on draft and torque

Table 2. Values of Coefficients for Eqs. (4) and (5)

Item	Regression coefficients a	Regression coefficients b	r^2*
Pair of bullock			
Draft	80.30	−16.92	0.98
Torque	2.80	− 0.51	0.98
Pair of Buffalo			
Draft	81.73	−12.10	0.98
Torque	3.87	− 0.71	0.97

*Significance level at $p \leq 0.01$

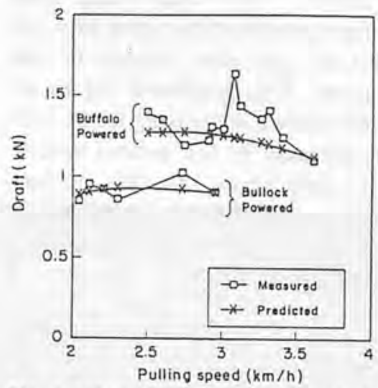

Fig. 3 Effect of forward speed on draft.

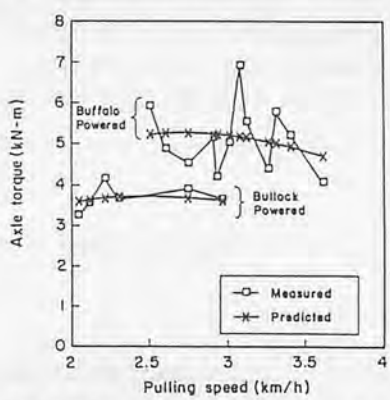

Fig. 4 Effect of forward speed on crusher axle torque.

produced during crushing. It is clear that available draft from a pair of bullocks is lower than the pair of buffaloes. Similarly, the available torque at the crusher axle is higher for buffalo-powered crushers than for bullock-powered crushers. The draft and axle torque predicted by using Eqs. (4) and (5) are also plotted in the figures. The predicted values of draft show a decreasing trend with an increase in the animal speed. The data show that the performance of buffalo-powered crushers was better than bullock-powered crushers.

Conclusion

Crushing of sugarcane is a heavy draft operations. Buffaloes produced more torque for crushing than bullocks, hence it is recommended that buffaloes be used for crushing sugarcane. The crushing capacity of buffalo-powered crushers was higher than bullock-powered crushing because of higher walking speed and higher rotation of the crusher rollers. Draft available for buffalo-powered crushers was higher than for bullocks. Modification and improving of the harnessing system and adjusting the pulling angle and turning will increase the crusher output. Further studies with the proposed improved hitching system (**Fig. 2**) is recommended.

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Effect of Speed and Shape of Shares on Performance of Oscillatory Sieve Potato Digger

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Abstract

An experimental oscillatory sieve potato digger was designed and developed. Its performance was evaluated on Kufri-Chandramukhi variety of potato after removing haulm prior to 25 days of harvesting. The data in respect of recovery, tubers covered with soil and damage tubers were collected at different combinations of forward speeds of 0.29, 0.44, 0.58 and 0.84m/s and sieve oscillations of 2 and 4Hz for four different shapes of digging shares, i.e., rectangular, convex, triangular and V-scoop types. The maximum recovery of potato was obtained at a velocity ratio (the ratio between peripheral speed of separating unit and forward speed of travel) of 1.38 at which the recovery of potatoes for different shares was obtained between 60.02% to 91.73% at 2Hz sieve oscillation and 82.47% to 99.23% for 4Hz sieve oscillation. The percentage cut and bruised potatoes were less than 2.40% and 0.75%, respectively. The V-scoop share gave maximum recovery of 99.23% and minimum damage of 0.65% cut and zero percent bruised tubers.

* Research Paper No. 5731

Introduction

Potato is an important cash crop covering an area of about 0.85 million ha in India. The two main labour intensive operations of potato cultivation are planting and harvesting which utilize about 50% and 33% of the total labour requirement of the crop, respectively, (Singh and Pandey, 1981). At present, the mechanization of potato cultivation in India is partial and selective. Traditionally, the harvesting of potato is carried out manually by digging the ridges with a spade and simultaneously picking the potatoes which employs a huge labour of about 900 man-h/ha (Singh et al., 1981). In addition to this, the manual method of digging has two other shortcomings. Firstly, while digging the ridges about 5 to 7% tubers are cut and, secondly, some tubers are left over in the field. A few harvesting equipment are now commercially available in India which, by and large, incorporate digging blade and one of the four devices which includes use of rods/chains extended over the digging blade, double mouldboard plough of a suitable curvature, elevator chain provided with suitable agitator or a spinner for separating potato and soil. The cut damage by these machines has been reported to be less than 3%.

During the past one decade in India, the emphasis has been given to the mechanical as well as elevator type diggers. In a comparative study on potato harvesting systems, Shyam (1979) quoted maximum exposure of tubers by elevator digger (85.6%) followed by spinner digger (83.3%). tractor-mounted two-rows mechanical digger (74.8%) and animal-drawn digger (52.5%). The performance of the elevator digger is satisfactory but owing to high initial cost, frequent need for maintenance, complex mechanism and irregular row to row spacing, it has not become popular with the farmers. It was, therefore, thought imperative to conduct studies on a low-cost and efficient tractor-drawn digger with improved soil separating mechanism for maximum exposure of potatoes. This paper deals with studies carried out on an oscillatory sieve digger using different combinations of forward speed of travel and sieve oscillation in conjunction with four shapes of digging shares.

Materials and Methods

Construction of Experimental Digger

An experimental oscillatory sieve potato digger was designed and developed (Vatsa, 1988) as shown in **Fig. 1**. The digger consisted of a digging, separating and power transmission units mounted on a rectangular frame of 900 × 10 mm size.

The digging unit consisted of a pair of standards and provision for changing the depth of cut and rake angle of digging shares. The rake angle of share can be adjusted between 10° and 45° with the horizontal. Four different shape of digging shares, i.e., rectangular, convex, triangular fork and V-scoop type of 300 × 500 × 8 mm size were selected for the test (**Fig. 2**). The tip angle of all the shares was kept at 16°. The soil-potato separating unit consisted of a rectangular sieve measuring 1100 × 700 mm. The separating sieve was fabricated using 10 mm m.s. rods spaced at a centre to centre distance of 25 mm. The separating unit is hinged at four positions with the main frame using suitable hangers (**Fig. 1**). The slope of the sieve can be varied from 0° to ±3° towards the exit end. The separating unit is mounted on the frame such that it could oscillate perpendicular to the direction of travel and deliver exposed potatoes to one side of the power unit in a windrow which are later on picked up manually.

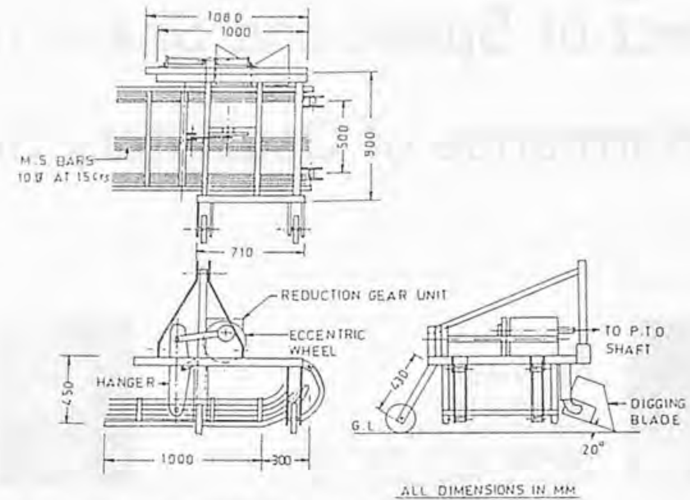

Fig. 1 Details of experimental oscillatory sieve potato digger.

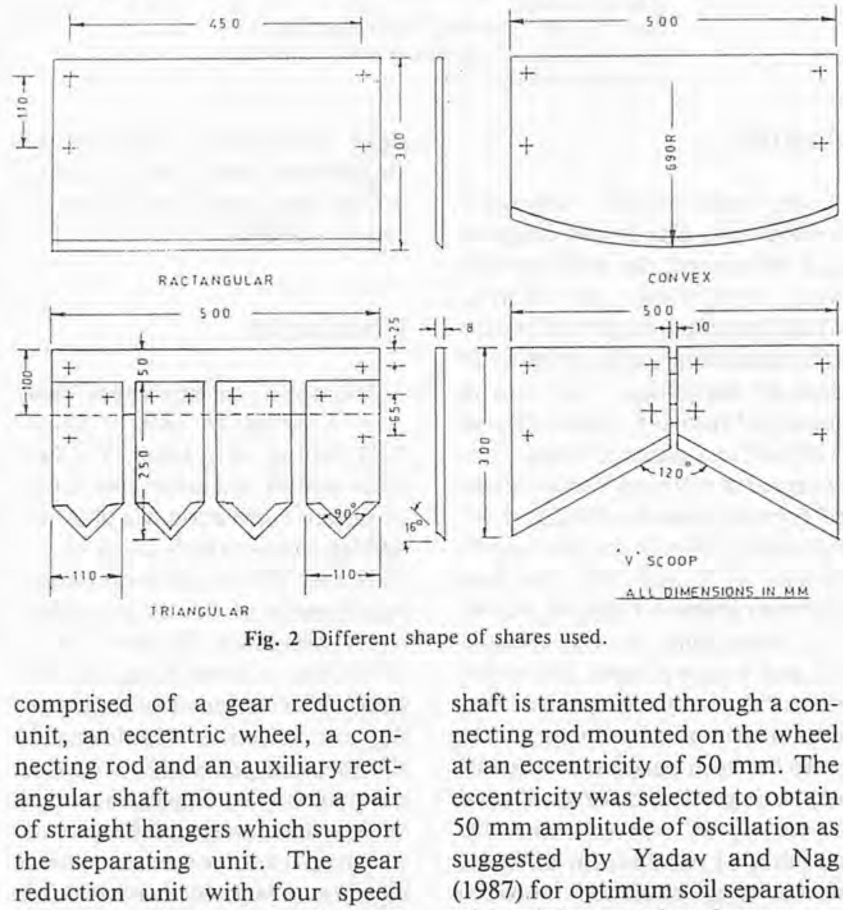

Fig. 2 Different shape of shares used.

The power transmission unit is comprised of a gear reduction unit, an eccentric wheel, a connecting rod and an auxiliary rectangular shaft mounted on a pair of straight hangers which support the separating unit. The gear reduction unit with four speed reductions of 1:1. 1:1.5, 1:3.5 and 1:7.5 was used for obtaining different speeds of oscillation. The output shaft of the gear reduction unit was provided with an eccentric wheel weighing approximately 13 kg. The power from the eccentric wheel to the auxiliary shaft is transmitted through a connecting rod mounted on the wheel at an eccentricity of 50 mm. The eccentricity was selected to obtain 50 mm amplitude of oscillation as suggested by Yadav and Nag (1987) for optimum soil separation with minimum tuber damage.

Experimental Procedure

The performance evaluation of the digger was carried out under actual field condition at the University farm in the months of February-March (1988) of Kufri-

Table 1. Crop Parameters of Test Plot

Iten	Description
Variety	Kufri-Chandramukhi
Date of planting	24 to 30 September, 1987
Date of haulm defoliage	20 to 25 January, 1988
Date of harvesting	13 to 29 February, 1988
Height of ridge, mm	180
Width of ridge, mm	500
Row to row spacing, mm	700
Plant to plant spacing, mm	250
Potato distribution in vertical plane, %	
upto 50 mm depth	40
upto 100 mm depth	90
upto 130 mm depth	99

Table 2. Soil-potato ratio of the potato ridge

Weight of soil (W_s) kg	Weight of potatoes (W_p) kg	Soil-potato ratio (W_s/W_p) %
30.5	1.25	24.4
27.25	1.60	17.03
29.50	1.45	20.34
28.00	1.55	18.06
31.50	1.35	23.33

Length of ridge observed: 1 m and depth of cut: 140 mm.

Table 3. Test Parameters Selected for Evaluation of Oscillatory Digger

Digging shares	Rectangular, convex, triangular fork and V-scoop
Forward speed	0.29, 0.44, 0.58 and 0.84 m/s
Sieve oscillation	2 and 4 Hz

Chandramukhi variety of potato. The type of soil in the test plot was silty clay loam with a mechanical composition of 61.42% silt, 29.74% clay and 8.84% sand. The average bulk density, moisture content and cone index for a depth range of 0 to 150 mm of the test plot were 1.4 g/cc, 11.08% and 1 kg/cm^2, respectively. Various crop parameters of the test plot are shown in **Table 1**. The average soil-potato ratio on the ridge was 20.63 (**Table 2**). The variation in size of potatoes was approximately 20 to 118 mm.

Prior to the experiment various adjustments were made on the digger based on preliminary investigations. The distribution of potato on the ridge showed that 99% potatoes were located down to a depth of 130 mm. Therefore, a depth of 140 mm was selected for the operation of the digger. The rake angle of the share was selected at 20° for maximum upward force and minimum draft as suggested by Payne and Tanner (1959) and Osman (1964). The slope of the separating sieve has definite effects on the separation of materials. Preliminary trials conducted by keeping the slope of the sieve from 0° to ±3° from horizontal showed that a downward slope could give better results by delivering the material quickly towards the exit end. Therefore, a downward slope of 3° was selected for the separating unit. The operation of separating unit at 1:1 gear reduction (6.67 Hz oscillation) produced excessive vibration of the digger wheras a reduction of 1:7.5 (0.67 Hz oscillation) caused frequent chocking of the sieve. Therefore, these oscillatory speeds were omitted from the test.

The digger was mounted on a 18.65 kW tractor and the throttle lever was set at its three-fourth position. Experiments were planned over an area of 50 × 75 m in a completely randomized design with three replications each. For conducting the test, the forward speed of tractor and oscillatory speed of separating unit were fixed and the test run was performed at various combinations of parameters shown in **Table 3**. The initial and last five meter length of the ridge was discarded and over the remaining length of the ridge a strip of one meter was marked randomly at three locations. The area so marked was gleaned thoroughly and the weight of exposed, covered with soil, cut and bruised potato tubers were noted and the results were presented on percentage basis. Different types of potato damage occuring during digging are shown in **Fig. 3**. However, in the present study the cut, sliced and tubers with hole or indentation by sieve were grouped in one and expressed on percentage basis.

Fig. 3 Different types of potato damage.

Results and Discussion

Digger Performance at 2 Hz Sieve Oscillation

The performance results of the experimental digger are presented graphically in **Figs. 4 through 9. Fig. 4** shows the relationship in respect of potato recovery and cut damage with forward speed at 2 Hz oscillation of the sieve. It is evident from the figure that, in general, with the increase in forward speed, the recovery of potato decreases steeply for all the digging shares. This may be due to a large volume of soil-potato passing over the separating unit, but the sieve speed of 2 Hz was not sufficient for proper separation of potato. Therefore, a lower speed of separation in comparison to

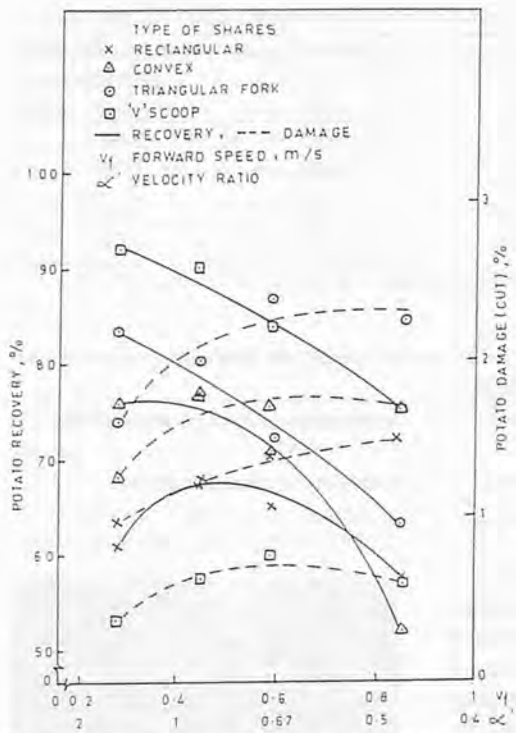

Fig. 4 Variation in potato recovery and damage with forward speed at 2 Hz sieve oscillation.

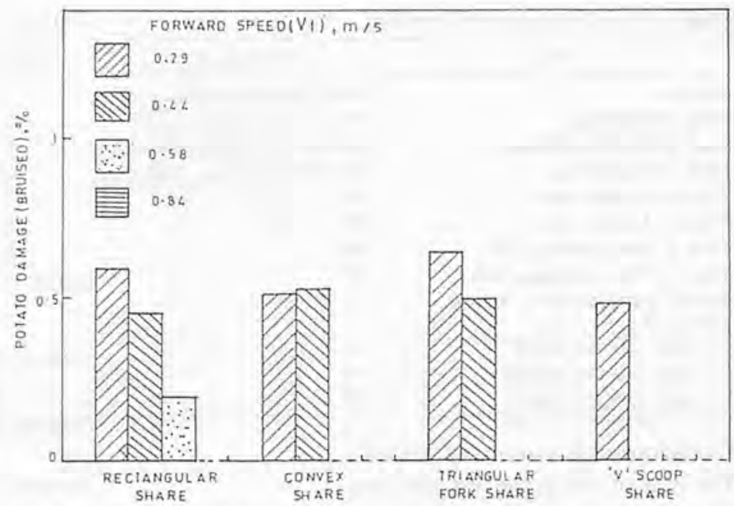

Fig. 5 Effect of forward speed of digging shares on percentage potato damage (bruised) at 2 Hz sieve oscillation.

forward speed of travel chocked the "throat" of the digging unit which resulted in an increase in spillage of potatoes to the sides of the digging shares. This indicates that the maximum recovery of potato could only be obtained at a particular combination of forward and oscillatory speeds. The relationship between these speeds was termed as velocity ratio (α') which is defined below:

$$\alpha' = \frac{2\,L\,n}{V_f}$$

where,

L = length of sieve stroke, m

n = revolution of eccentric wheel, rev/s

V_f = forward speed of travel, m/s

The critical examination of **Fig. 4** reveals that at the forward speed of 0.29 m/s ($\alpha' = 1.38$), the V-scoop share gave the maximum recovery of 91.73% followed in order by triangular fork (83.13%), convex (75.63%) and rectangular (60.03%) shares. However, as the speed increased to 0.84 m/s ($\alpha' = 0.48$), the recovery was 74.94, 62.34, 57.89 and 51.98% for V-scoop, triangular fork, convex and rectangular shares, respectively. It is, therefore, clear that the shape of share has a profound effect on the recovery of potato which is related to the soil-failure regime by the share. The rectangular share gave the lowest recovery because of the soil-failure regime along the ridge that was observed to be largest from the tip of the share and which contributed to the spillage of potatoes from the sides of share. In the case of the V-scoop share, the soil failure regime was minimum within the V-shape, thus, all the loosened materials were scooped by the share before being spilled to the sides. The performance of the other two types of shares was in between these two extreme limits.

The variation in percentage of cut tubers at different forward speed shown in **Fig. 4** reveals that with the increase in forward speed, the cut percentage increases to peak value and, thereafter, decreases slightly. At the lowest speed of 0.29 m/s ($\alpha' = 1.38$) the maximum cut damage was in the case of the triangular share (1.6%) followed by the convex (1.27%), rectangular (0.9%) and V-scoop (0.40%) shares. However, for an increased forward speed of 0.58 m/s, the damage increased slightly to approximately 2.40, 1.75, 1.35 and 0.79% for the above shares, respectively. Further, increase in speed reduced the damage slightly. The reason for this nature of variation in damaged potato may be due to larger volume of soil-potato handled by the separating unit with the increase in forward speed. At a lower forward speed the separation of soil was higher and potatoes were dropped away from the exit. Therefore, the damage on potato due to indentation of sieve into tubers was minimum. With an increase in forward speed, potatoes were dropped close to the exit end of the separating unit because of poor soil separation which resulted in maximum damage of potatoes. Further increases in forward speed gave poor separation and greater quantity of unexposed potatoes which reduced the damage.

The variation in bruised potato

at different forward speeds and sieve speed of 2 Hz is illustrated in **Fig. 5**. The figure reveals that at the minimum forward speed of 0.29 m/s ($\alpha' = 1.38$) the maximum bruising was for the triangular fork share (0.65%) followed by the rectangular (0.60%), convex (0.49%) and V-scoop (0.48%) shares. It is also clear that with an increase in forward speed the brusing of potato was reduced but beyond a speed of 0.58 m/s there was no bruising of potato because of the continuous flow of potatoes over the soil which gives a 'cushioning effect'.

Digger Performance at 4 Hz Sieve Oscillation

Fig. 6 shows the performance of the digger at different forward speeds of travel for a constant sieve oscillation of 4 Hz. In general, the figure reveals that with the increase in forward speed the recovery of potato increases substantially to a peak value and thereafter, declines. It is clear that at the forward speed of 0.58 m/s ($\alpha' = 1.38$), the percentage recovery was maximum in the order of 99.23, 89.80, 88.01 and 82.48% for V-scoop, triangular, rectangular and convex shares, respectively. The variation in potato recovery with the velocity ratio may be due to the fact that for $\alpha' < 1.38$, the flow of material onto the separating unit was comparatively low which resulted in proper separation of soil. However, the potatoes were tossed upwards due to less 'cushioning effect' of soil which increased the spillage of tubers from the separating unit. Similarly, for $\alpha' < 1.38$, a large volume of materials passed over the separating unit but because of lower oscillatory speed, the throat of the digger was chocked which resulted in greater spillage and poor recovery of potato. The statistical analysis of data showed significant effect in the forward speed, sieve oscillations and shape of shares on recovery of tubers at 5% level of significance.

A general nature of variation in damaged potato with forward speed at constant oscillatory speed of 4 Hz was noticed similar to the lower sieve speed. At the lowest forward speed of 0.29 m/s, the minimum and maximum variations in cut damage were 0.25% and 0.90% for V-scoop and rectangular shres, respectively. At maximum forward speed of 0.84 m/s the variation in cut damage was between 0.60 and 1.80% among the different shares. The effect of different speeds on cut damage was insignificant. However, the shape of shares affected the cut damage significantly.

The percentage bruising of potato for the different combinations of forward speed and shape of shares at 4 Hz sieve oscillation is shown in **Fig. 7**. The maximum recovery of potato was at the forward speed of 0.58 m/s ($\alpha' = 1.38$) because of the effective separation of soil. However, at this speed the convex share gave a maximum bruising of 0.61% followed by rectangular (0.48%), triangular fork (0.00%) and V-scoop (0.00%) shares. For the maximum speed of 0.84 m/s all the three

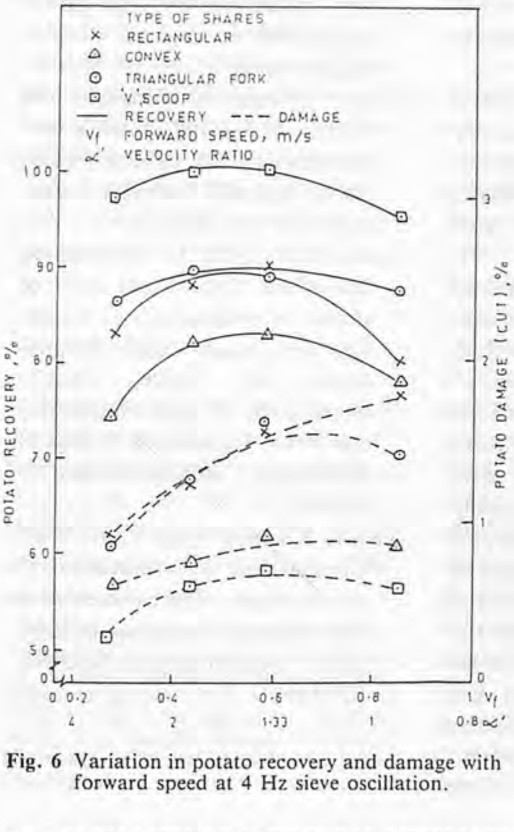

Fig. 6 Variation in potato recovery and damage with forward speed at 4 Hz sieve oscillation.

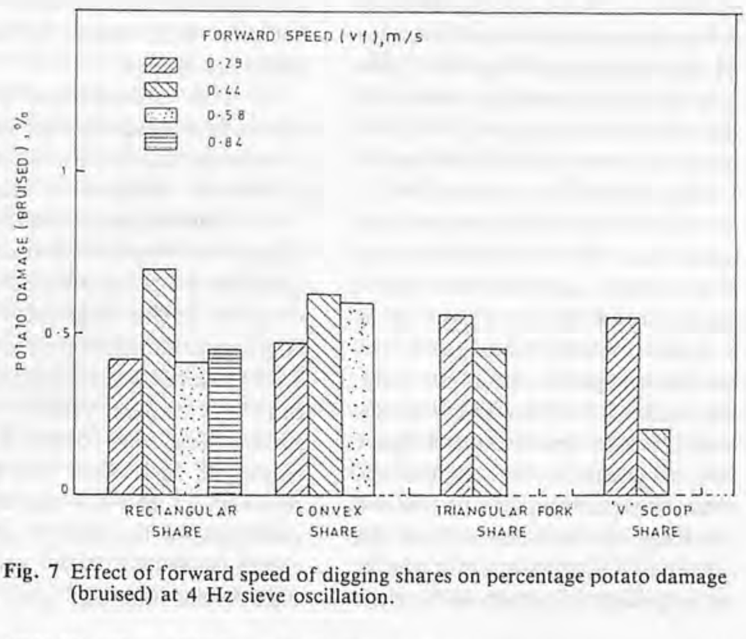

Fig. 7 Effect of forward speed of digging shares on percentage potato damage (bruised) at 4 Hz sieve oscillation.

Fig. 8 Losses of potatoes due to improper velocity ratio (0.47) of the digger.

Fig. 9 Maximum recovery of potatoes at best velocity ratio (1.38) for V-scoop share.

shares, except the rectangular share, did not give any bruising. The variation in bruising with forward speed is attributed to the 'cushioning effect' of the soil because of a large volume of material flow over the sieve. But in any case, the bruising was less than 0.75% for both speeds of oscillation. The negligible amount of bruising was obtained because of the hardening of potato skin due to haulm cutting about 25 days prior to harvesting which is in agreement with the findings of Dhingra and Srivastava (1973).

The effect of forward speed of travel and sieve oscillation was also studied qualitatively. **Fig. 8** shows the exposure of potatoes at a high forward speed and low oscillatory speed, i.e., a low velocity ratio of 0.47 for the V-scoop share. It is evident from the figure that an excessive flow of the soil over the separating unit has caused choking of the "throat" of the digger which, consequently, resulted in spillage of potato to the sides of the shares. Similarly, **Fig. 9** shows the qualitative performance of the digger at the optimum velocity ratio of 1.38 for 4 Hz sieve oscillation. The figure clearly shows that maximum exposure of tubers in the field resulted in the highest recovery of potatoes.

Conclusions

On the basis of the present study the following conclusions may be drawn:

1. For a constant sieve oscillation, an increase in forward speed of the digger increased the recovery of potato to a peak value and, thereafter, decreased for all types of shares. This shows that there is a definite velocity ratio (the ratio between peripheral speed of the separating unit and forward speed of travel) at which the maximum recovery could be obtained. At the best velocity ratio of 1.38, the recovery of potatoes for the different shares varied between 60.02 to 91.73% and 82.47 to 99.23% for 2 and 4 Hz sieve oscillations, respectively.
2. An increase in forward speed at a constant oscillatory speed of the sieve increased the cut damage of tubers which varied between 0.25 and 2.4% with different shares.
3. The precentage bruised tubers increased with an increase in velocity ratio but was less than 0.75% for all types of shares.
4. The best performance of the digger was obtained at oscillatory speed of 4 Hz for a velocity ratio of 1.38. At this ratio the V-scoop share gave maximum recovery of 99.23% and minimum damage of 0.65% cut and 0.00% bruised tubers. This was followed by the triangular fork share with 89.80% recovery, 1.6% cut damage and zero percent bruised, rectangular share with 88.01% recovery, 1.52% cut damage and 0.42% bruised and convex share with 82.48% recovery, 0.83% cut damage and 0.60% bruised tubers.
5. The capacity of the digger for a forward speed of 0.58 m/s at a field efficiency of 85% was 0.124 ha/h.

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Knowledge Engineering-Based Studies on Solar Energy Utilization in Kenya—Part I

by

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Abstract

This research work focused on the engineering aspect of solar energy utilization using solar cell modules in Kenya. For the first step of this research work, a knowledge-based software system using three layered neutral network model as the kernel module was developed in order to predict meteorological parameters such as insolution, temperature, rainfall and wind run. The software developed here is capable of providing the updated prediction by use of the knowledge-based function for meteorological parameters necessary to evaluate the efficiency of solar cell generation system for any part of the country.

Introduction

Kenya has been relying, and continues to rely, on imports for much of her energy requirements. According to the government statistics, the country's total spending on oil imports in 1983 was 214 million kenya pounds, and in 1986 it was 375 million. Today the demand on energy has tremendously increased and the oil imports takes about 30% of the national budget. The nation has been forced to think of alternative source of energy, since the spending on energy imports has continued to rise. Other problems with the conventional source of energy are the threat of exhaustion and the dangers to the environment.

Alternative sources of energy, which are renewable and clean are solar, wind, tidal, geothermal and so on. Among those alternatives solar energy has great potential in Kenya, both in terms of availability and exploitation. Most areas of the country are far from the country's electricity grid and it will take quite some time before these areas can be served with electricity supply. There are many areas that are not currently agriculturally used, for instance, just because of inadequate rainfall and lack of artificial irrigation water. These are areas where solar energy could provide solutions, i.e., provision of electricity and power for pumping water for irrigation. Hankins (1987) reported that about 30 solar powered pumps were already installed in the country as of January 1987. A study undertaken by Kenya's Ministry of Energy and Regional Development and Beijer Institute of Sweden, 1980, revealed that rural household used about 53% of total energy in Kenya.

It is anticipated that the demand for solar electricity will increase in Kenya as the price of solar cells continues to decrease and efficiency to improve. Currently the price of solar cell is about Ksh 400/watt (US$7/watt) (Hankins, 1991). The efficiency of solar cells has been improved significantly over the last decade, (Japanese figures show efficiency of 12-18%) (Kyocera Corporation, 1992).

For the development of solar energy throughout the country, it is essential to grasp the availability of solar insolation and related meteorological data at every spot in the country. Unfortunately, such meteorological information is limited geographically in Kenya. Hardware efficiency is influened by environmental conditions, and maximum efficiency will be obtained when the hardware is used under adequate conditions of the surrounding. However, no studies have been conducted on the influence of Kenya's extreme surrounding conditions such as high temperature and thick dust, which have tremendous negative

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effect on solar cell efficiency in solar energy generation.

This research work focused on the engineering aspect of solar energy utilization using solar cells. The efficiency of solar cell generation as affected by physical factors of specific environment in Kenya was analyzed. An attempt has been made to obtain engineering solutions to maximize the efficiency of solar cell generation. The system consisting of the solar cell and environmental factors was treated as a large scale non-linear multi-input multi-output system. The knowledge engineering approach was extensively applied to deal with this complex problem.

In Part 1, the neural network was used to develop a software system that provides meteorological information necessary to evaluate the efficiency of solar cell generation system for any part of the country. In the next parts of this report, the effects of high temperature and dust effects on the efficiency of solar cell generation will be discussed and a unique engineering solution to the dust problem will be introduced.

Meteorological Information Available in Kenya

There are nearly 100 meteorological stations in Kenya today. The available meteorological data which have been monitored by those stations include parameters such as atmospheric pressure, temperature, humidity, rainfall, sunshine, solar radiation, evaporation, cloud amount, wind, etc. Especially, radiation and temperature are essential parameters that affect directly the efficiency of solar cell. Rainfall and wind are also considered as important parameters that relate to the contamination of face of solar cell by the fine dust found throughout Kenya. Fig. 1 shows the most

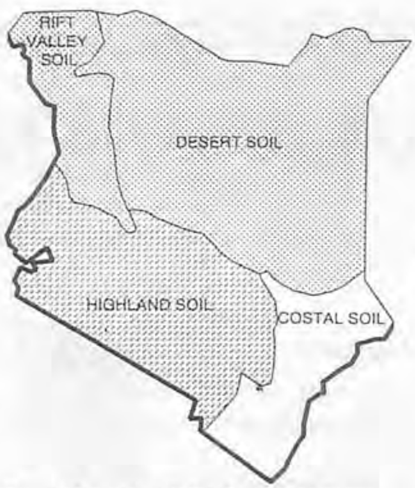

Fig. 1 General soil distribution of Kenya.

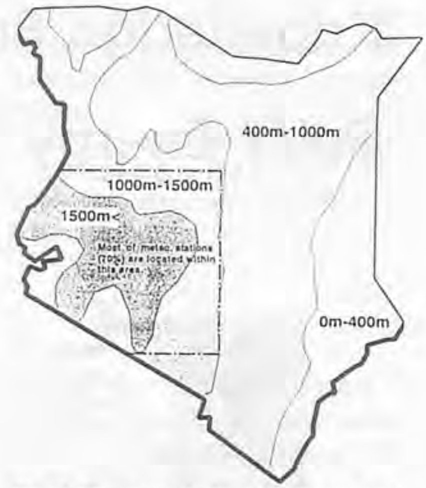

Fig. 2 Topographical map of Kenya and the area where meteo stations are densely located.

generalized soil distribution that can be obtained. Kenya consists of a complex soil combinations, with almost all types of soils distributed all over the country. However, clays and sands sub-types are dominant. As indicated in **Fig. 1**, the country can be divided into four major soil regions; namely: rift valley soils which consist chiefly of unweathered or partially weathered thin rocks; desert soils which are mainly alluvium and sands; the highland soils which are chiefly clays with high humic content, 8-30%; and the coastal soils which are mainly sands.

The important parameters can be extracted from the compiled data published by the National Meteorological Department. Those official meteorological data have been compiled in a condensed form on ten-year basis. The weather review for the 10th decade for each year is also issued by the Kenya meteorological department every month. The original latest data from each meteo station are always available to the public. However, as indicated in **Fig. 2**, those stations are not evenly distributed geographically, as some areas have many of these stations located within short distances, and, on the other hand, some areas have no meteo station. This situation makes it difficult to have meteorological information for as many spots in the country as would be necessary for local solar energy generation, development or installation and assessment.

Neural Network Application

It is impractical to go for collecting meteorological data for a number of days and months at a location where no meteorological data has been available before making assessment for solar installation. The country's part where a very few meteo stations are situated appears topographically simple and relatively flat. Those characteristics also make the meteorological pattern over the area relatively flat. Such a condition allows us to have more possibility to make acceptable estimation for missing data based on other available data.

A knowledge engineering approach can provide a means of solving this problem. A system identification technique using neural metworks can be applied to this problem. **Fig. 3** illustrates that meteorological parameters can be considered as outputs of a multi-input and multi-output system of

Fig. 3 System model for meteorological parameters as a function of geographical point.

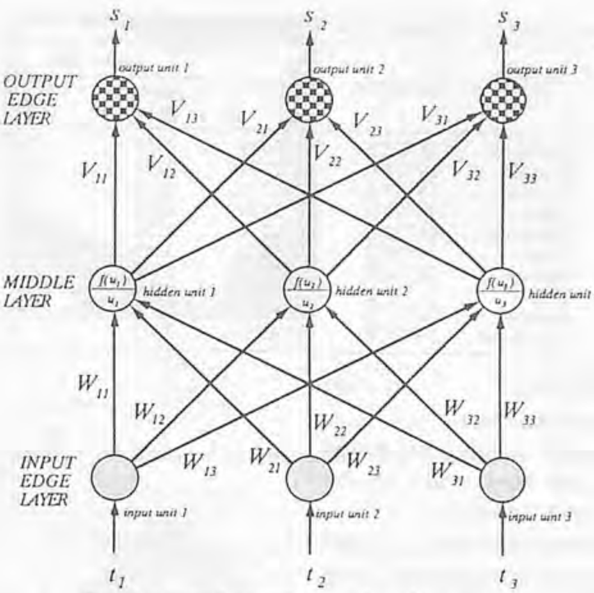

Fig. 4 Layered neural network architecture.

which inputs are longitude and latitude that specify the location where the meteorological data are needed. Let us call this system as Kenya's Geographic Meteorological System (KGM system in short). There is obviously no known theoretical relation between inputs and outputs of KGM system. However, the discrete data that have been made available by meteo stations could describe the behavior of KGM system with the help of neural network system modeling.

Three-Layered Neural Network

Fig. 4 illustrates an example of a three-layered neural network structure. The mathematical explanation for the process of signal transfer in the network may help understand the mechanism of layered neural networks.

The input T can be expressed in a vector form as $T=\{t_1, t_2, ...t_n\}$. In **Fig. 4**, n is equal to 3.I-th component of the inputs T, i.e., t_i that comes out from the input unit is transferred to a hidden unit j through the synapse weight W_{ij}.Since each hidden unit has a summation function operating on input, the total input u_j received by the hidden unit becomes

$$u_j = \sum_{i=1}^{n} W_{ij} t_i \qquad (1)$$

The hidden unit i has also a transfer function that performs nonlinear transformation on the total input u_i and then gives an output which becomes the next input fed into the output unit i, which has also a summation function, through another synapse weight V_{ij}. The total input received by the output unit j becomes directly its output s_j expressed as

$$s_j = \sum_{i=1}^{n} V_{ij} f(u_i) \qquad (2)$$

The outputs can be given in a vector form as $S=\{S_1, S_2, ..., S_m\}$. After all, what this neural network does is to perform a non-linear transformation on T as expressed in the following equation.

$$S=F(T) \qquad (3)$$

Once those non-linear functions (transfer functions) of hidden units are specified, the behavior of the network can be identified by determining all synapse weights contained in the network. The sigmoid function is often employed for the transfer function. The learning of neural network is a procedure to determine optimal values of synapse weights by adjusting them step by step using known input data and their associated output data called training data. The most common algorithm for this learning procedure is the back propagation. The Kalman filter can be also used as a training algorithm.

Kalman Filter Learning Algorithm

In this study, the Kalman filter algorithm was employed due to its quicker converging characteristics than any other algorithm (Murase, 1991).

The state equation and the observation equation for the neural network can be described by the following forms:

1) State equation

$$\{x\}_{k+1} = [I]\{x\}_k \qquad (4)$$

$\{x\}$: synapse weights to be determined

$[I]$: unit matrix

k: discrete time

2) Observation equation

$$\{y\}_k = \{h(\{x\})\}_k \qquad (5)$$

$\{y\}$: unit values

$[h]$: observation matrix

The discrete time can be taken as the iterative step, e.g., learning iteration. [I] in Eq. 4 is due to that synapse weight in this problem are independent upon time. Equation 5 is considered as a non-linear observation equation that can be expressed in simpler form using the sensitivity matrix [H] as given by Eqs. 6, 7, and 8.

$$\{p\}_k = [H]_k \{x\}_k \qquad (6)$$

where,

$$\{p\}_k = \{q\} - \{F(\chi,t)_k + [H(\chi,t)]_k \{\chi\}_k \qquad (7)$$

Table 1. Data Used for Training of the Proposed Neural Network

Station ID	Station Name	Longitude	Latitude	Input data		Output data			
				Longitude (min)	Latitude (min)	Insolation (W/m^2)	Temperature (°C)	Rainfall (mm)	Wind run (km)
1	Mandela	41°52'E	03°56'N	2512	478	221	34.5	255	187.8
2	Moyale	39°03'E	03°32'N	2343	454	185	27.2	705	249.6
3	Lodwar	35°37'E	03°07'N	2137	429	259	34.8	193	203.1
4	Alupe	34°07'E	00°28'N	2047	280	273	28.6	1674	122.8
5	Runuruir	36°32'E	00°32'N	2192	274	266	25.7	7331	155.4
6	Meru	37°39'E	00°05'N	2259	247	186	23.4	1259	103.1
7	Garissa	39°38'E	00°28'S	2378	214	232	34.4	352	187.3
8	Kisii	34°47'E	00°41'S	2087	201	234	26.2	1998	97.3
9	Nairobi	36°45'E	01°18'S	2205	164	220	23.4	1049	134.5
10	Mombasa	39°37'E	04°02'S	2377	0	224	30.2	1049	239.4

$$[H_{ij}] = \partial F_i / \partial x_j \qquad (8)$$

$\{q\}$: training data

χ: synapse weights estimated at one step prior to the present iteration.

The observation vector $\{p\}$ and matrix $[H]$ can be evaluated using *a priori* information.

Model Description and Training Data

Fig. 5 illustrates the three-layered neural network structure to model the KGM system. Two input units are needed to carry designated input parameters, i.e., longitude and latitude that specify the location where the meteorological data are needed. The 4-output parameters, i.e., annual averages of insolation, temperature, rainfall and wind run also require to fit the neural network with 4 output units. Twenty units were employed in the hidden layer. Both hidden unit and output unit have a sigmoid non-linearity in this model.

Ten meteo stations (No. 1 ~ No. 10) indicated in **Fig 6** were chosen as key stations from which meteo data were extracted for training of the neural network. The training data with meteo station names are indicated in **Table 1** which shows that latitude and longitude are measured in minutes. The datum of latitude was fixed at Mombasa meteo station which locates southernmost in the map.

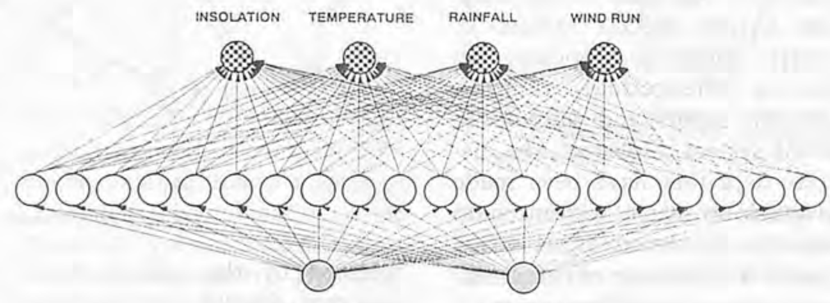

Fig. 5 Neural network model for KGM system.

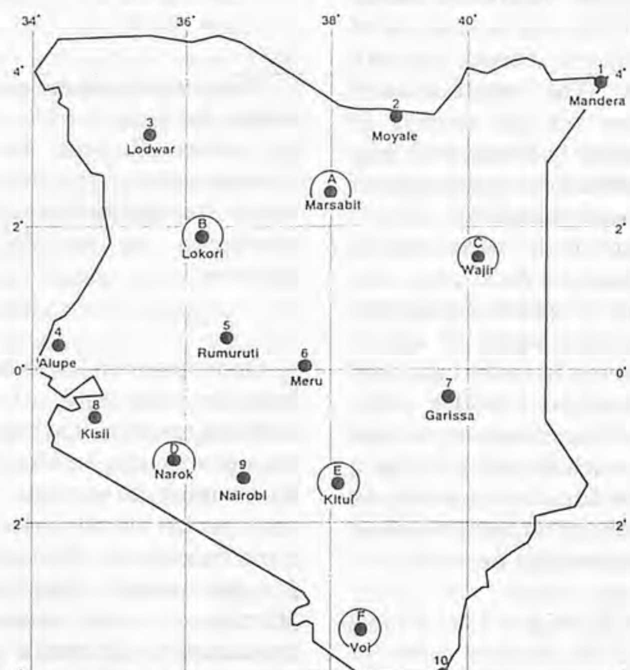

Fig. 6 Data provided by meteo stations (1-10) and meteo stations (A-F) were used for training data and checking data, respectively.

Software System

The software system developed in this research consists of 4 modules; 1. training data management module; 2. neural network training module; 3. simulation module; and 4. distribution chart module. The first module manages training data. The functions of module 1 are renewal of the training data with updated data provided by meteo stations and correction of miss input data. The second module is a kernel module that performs the neuron training with update training data to keep up with the latest meteorological trend. The third module implements the trained neural network to estimate values of the four meteorological parameters at any prescribed location within the country. The forth module produces intensity distribution chart for each of the four meteorological parameters. Data entry and output capabilities of all modules are enhanced by the elaborate graphics. **Fig. 7** shows examples of screen view generated by this software.

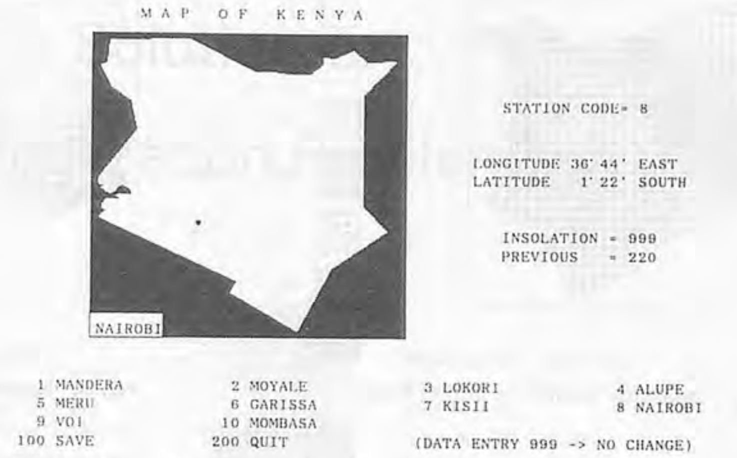

Fig. 7a Screen view generated by the training data management module.

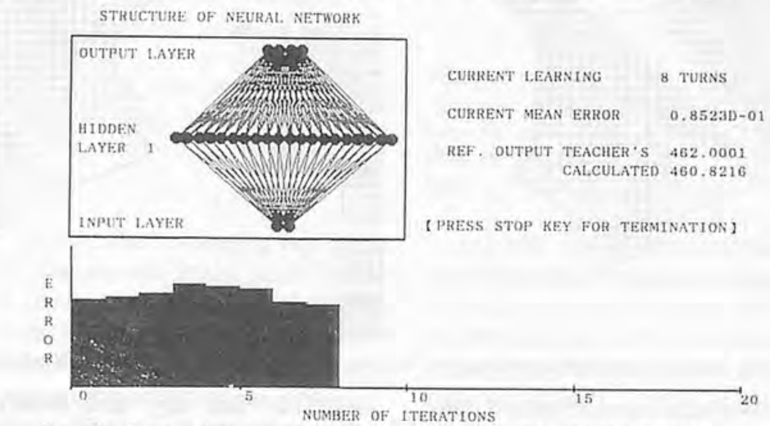

Fig. 7b Screen view generated by the neural network training module.

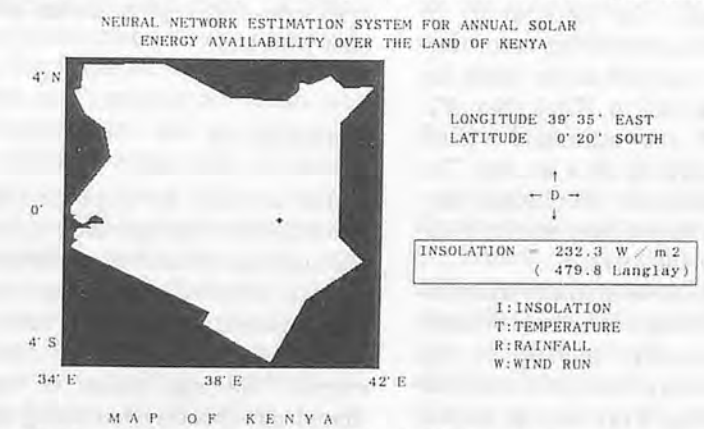

Fig. 7c Screen generated by the simulation module.

Results and Discussion

After 3500 iterative calculations, the mean absolute error of outputs reached 2.28×10^{-2} (within the range of about ±2.3% deviation from each of the target value of training output data). The learning process was terminated at this point by assuming acceptable convergence. The trained neural network was tested by using input data which were not included in the training data. The test results are capsulized in **Table 2**. Six stations (No. A ~ No. F) as shown in **Fig. 6** were selected to compare

Table 2. Results of Performance Test of the Trained Neural Network

Station ID	Station name	Longitude	Latitude	Insolation (W/m^2)		Temperature (°C)		Rainfall (mm)		Wind run (km)	
				Actual	Calculated	Actual	Calculated	Actual	Calculated	Actual	Calculated
A	Marsabit	37°59'E	02°19'N	246	236	24.7	23.9	693	786+	*	217.8
B	Lokori	36°02'E	01°57'N	313	299	36.2	34.3	399	426	174.1	190.8
C	Wajir	40°04'E	01°45'N	*	230	33.7	35.4	283	297	379.9	355.9
D	Narok	35°50'E	01°08'S	231	220	24.6	26.6	1743	1685	*	136.8
E	Kitui	38°00'E	01°22'S	251	242	26.9	24.4	1034	1103	127.6	106.7++
F	Voi	38°34'E	03°24'S	216	203	30.6	28.8	555	538	207.6	231.0+

* Indicates that no actual data are available. + Indicates errors more than 10%. ++ Indicates the largest error resulted (16%).

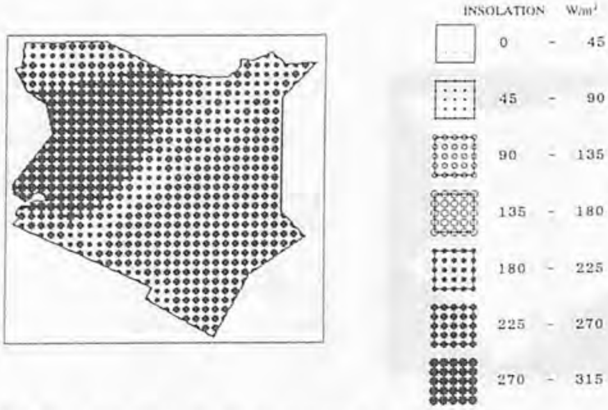

Fig. 8a Insolation distribution map of Kenya.

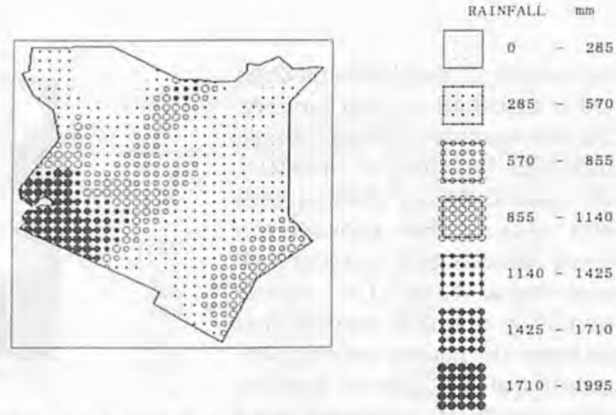

Fig. 8c Rainfall distribution map of Kenya.

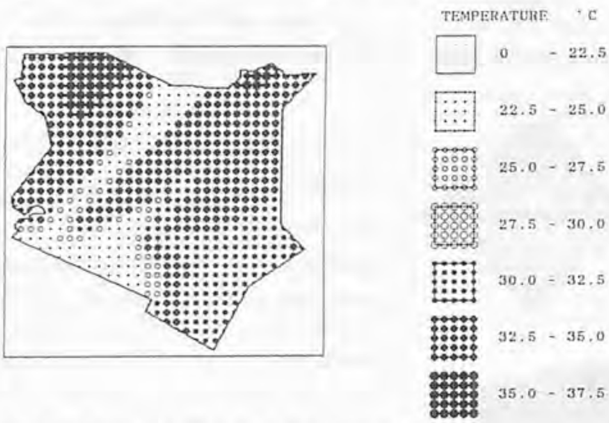

Fig. 8b Temperature distribution map of Kenya.

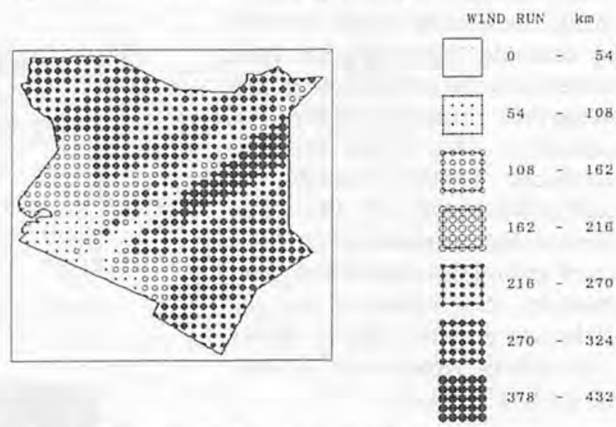

Fig. 8d Wind run distribution map of Kenya.

the calculated meteorological data with ones which were actually measured. As indicated in **Table 2**, the maximum error that resulted was 16% at the value for the wind run at Kitui (No. F). Most of the estimated values appear less than 10% in error. The performance of the neural network developed here was substantiated by the results.

Fig. 8 shows intensity distributions for each of the meteorological parameters plotted by the trained neural network. As indicated in **Fig. 8 (a)**, enough insolation for solar generation is available throughout the country. Especially in the western region, more than 270 W/m^2 of insolation is ready to be used for solar generation **Fig. 8(b)** shows that some care must be taken against the heat that reduces the efficiency of the solar cell significantly in most parts of the country. From **Fig. 8(c)** and **(d)**, it can be readily predicted that dry and windy weather conditions over the arid and semi-arid region create the dust problem.

Conclusions

The software developed in this research work can provide a quick and accurate means of gathering the vital information necessary for development, generation or installation and assessment of solar energy. The application of the knowledge-based system using the neural network made it possible to provide the most updated meteorological trend over the country by its keep-learning feature of the software.

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Cooperatives as a Solution to Small Farm Mechanization Problems in Cuba

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Abstract

Since 1977, Cuban farmers have benefitted from the central government's determination to encourage the substitution of small privately owned farms by agricultural production cooperatives (CPAs). This was a move toward more socialist forms of production while increasing agricultural productivity to fuel national development.

Agriculture in Cuba is dominated by state farms which include about 80% of the agricultural land (8.68 million ha), while CPAs cover 9% and the remainder is farmed by credit and service cooperatives (CCSs) and private small farmers (2%). Even the individual farmers who have not joined the CPAs recognize the value of credit and service cooperatives (CCSs) and over 60% are members.

Before the revolution in Cuba (in January 1959) the small farm sector consisted of nearly 80% of farms covering 15% of the land. Farms were highly specialised with export cash crops (sugar, tobacco and coffee) predominating at the expense of food crops. Renting and share cropping were common.

Exploitation of the small farm and rural proletarian sector was commonplace and is typical of many developing country farmers today.

The CPAs allow land to be exploited rationally, crop and livestock production can benefit from the economies of scale and, most importantly, modern inputs including tractors, agricultural machinery and irrigation can be justified and used efficiently.

CPAs are always formed voluntarily under the guidance of the National Small Farmers Association (ANAP). Individual farmers pool their resources and then work collectively. All decisions are made democratically and the management of the CPA is in the hands of elected representatives.

In addtion to the increased productivity and reduced drudgery afforded by the efficient use of mechanization, further advantages of the cooperatives are the provision of schools, clinics, running water and electricity which are not so easy to provide for individual scattered farmers.

Introduction

Land reform in Cuba was firmly on the agenda well before the launch of the revolution in 1959. During his spirited and erudite defence at his trial for the 26 July 1953 Moncada barracks assault, Fidel Castro drew attention to the sorry plight of the Cuban rural poor under the Batista regime.

In what has become to be considered as the fundamental document of the revolution (Szulc, 1986), Castro's speech, History will absolve me (Castro, 1953), made in October 1953, drew indignant attention to the 500,000 farm workers living in miserable conditions and only being able to work

Acknowledgement: I am grateful to Brian Pollitt, University of Glasgow, for his helpful comments on a draft of this paper. The British Council in London Helped financially with a travel grant to visit Cuba, their support is acknowledged with thanks.

for the months of the year during the cane harvest. He also exposed the situation of the 100,000 small farmers who live and die working land that is not theirs, fearing to invest in improvements because of their precarious position of not knowing when the landlord would dispossess them, and dreaming, like Moses, of The Promised Land, only to perish before owning it. For Castro said, "Cuba is a country whose most important industry is agriculture, with most of its population engaged in agricultural production and the cities dependent upon it. If the prosperity of Cuba depends on a healthy and vigorous agricultural sector then how is it possible that the state allows such inhuman exploitation of the vast majority of farmers and agricultural workers?"

He went on to anticipate the revolutionary government by guaranteeing ownership of the land by those that work it as renters or share croppers. He also foresaw legal limitation of maximum land holdings and state expropriation of areas in excess, and state support of farming cooperatives to allow investment in capital intensive technology.

The first Land Reform Law which was enacted in May 1959 (barely five months after the end of the war) and substantially implemented in 1960. It addressed itself to the fact that eight percent of landowners (including North American companies) owned 70% of the agricultural land and put a 402 ha ceiling on private land ownerhsip. It also gave free title to 100,000 small farm renters and share croppers. Large estates (mainly sugar and cattle) were expropriated by the state and were for the most part retained in large farming enterprises (Partido Comunista de Cuba, 1976), although some land in excess of the maximum was given in units of not more than 67 ha to landless agricultural workers (Stubbs, 1989).

A second Land Reform Law was passed in October 1963, to dismantle the agrarian bourgeoisie that had remained more or less intact after the first law (e.g., in tobacco production). The second law established a private ownership limit of 67 ha and all farms exceeding this were expropriated by the state. This new law affected at least 10,000 farms and raised the level of state ownership from 40% to 70%. By 1987 this had risen to 81% or 8.35 million ha (PCC, 1988), and it continues to increase steadily (Stubbs, 1989). During the first years of the agrarian reform movement the policy was to concentrate on state farms, although during this period, and up to 1977, simple cooperative forms were encouraged amongst individual producers (Mutual Assistance Brigades, Campesino Associations, Credit and Service Cooperatives). Since the first congress of the PCC in 1975 the formation of production cooperatives has been encouraged amongst the small farm sector. The catalyst had been a policy directive given by Fidel Castro in the Sierra Maestra in 1974 during the fifteenth anniversary of the first Agrarian Reform Law. It was pointed out that integration into state farms was not the only socialist route that small farmers had to follow, but in addition their collectivization in production cooperatives should be encouraged.

Key, in 1988, analyzed the reasons for the late adoption of the producer cooperative model by the Cuban government and offers five reasons:

- By the mid-1970s the Cuban economy was sufficiently robust to be able to divert resources to cooperatives without detracting from state farm investment.
- More attractive employment opportunities had led to an exodus of farm family children from the countryside. Farmers had no one to leave their land to and there is no private land market in Cuba. If no state farm existed nearby it was difficult to sell to the state and so joining a cooperative became an increasingly attractive option, especially in view of the retirement pension shcemes offered.
- Labour shortages in the rural sector meant that collectivization permitting mechanization became increasingly attractive.
- The government realised that those farmers politically committed to join state farms had largely done so and the nationalization process was frozen. As in the mid-1970s small farmers still owned about 30% of cultivable land, new incentives had to be found.
- Collectivization makes it far easier for the state to plant input/output levels and so fix quotas. It also greatly enhances the ease of providing health care, education and other benefits as scattered families concentrate in cooperatives.

Between 1959 and 1975 a small number of production cooperatives had been formed (PVV, 1980) but the predominant thrust in the cooperative movement had been for the simpler forms already mentioned. From 1977 on, as a logical extension of the policy decisions taken in the 1975 Communist Party Congress, reinforced by the V Congress of the National Small Farmers Association (Associación Nacional de Agricultores Pequeños -ANAP), a major effort was made to accelerate the formation of agricultural production cooperatives (Cooperativas de Producción Agropecuaria - CPAs)

Under the guidance of ANAP and the Ministeries of Agriculture (MINAG) and Sugar Industry (MINAZ) the cooperative move-

Table 1. Land Holdings by Sector in Cuba, 1986

Item	ha (× 1000)	%
State farms	8678.9	81.4
CPAs	1011.5	9.5
Individual small farmers	975.5*	9.1
Total agricultural land	10665.9	100.0

Sources: Comité Estatal de Estadísticas, 1987, except * Creagh Ortiz, 1986.

ment grew dramatically. In 1977 there were 201,715 small farmers in 137,635 farms on 2,020, 184 ha and in the first years of the CPA movement small cooperatives (in numbers of members and area) were the norm. At the end of 1977 there were 137 CPAs with 503 members on 2,533 ha and by December 1986 there was a total of nearly 1,400 CPAs covering a total of over 1 million ha with an average size of 740 ha and 49 members (Comité Estatal de Estadísticas, 1987). The importance of the cooperative sector relative to state and individual farms is shown in **Table 1**.

The promotion of CPAs as a superior form of production not only has technical, economic and social advantages which will be discussed later, but is also an important building block in the construction of socialism in Cuba (PCC, 1988). The goal is to elimiate individual private property in agricultural production by replacement with state and cooperatively owned land. It is always emphasized that participation by small farmers in the CPA movement is absolutely voluntary and it is epected that persuasion by example will continue to swell the CPA ranks at the expense of the individual ownership sector.

However, the state is able to influence the attractiveness of CPAs to indivudal producers. One way has been to eliminate the free small farm market (established in 1980) whereby individual farmers were able to sell produce on the open market which commanded prices in excess of the official parallel market which is itself much higher than the ration prices. The free market was abolished in 1986 as it was seen to be a disincentive to joining the cooperative movement and individual farmers and middlemen were making large profits at the expense of urban consumers who were becoming increasingly annoyed (Kay, 1987 and 1988). The free market was abolished in 1986 as part of the process of "rectification of erros and negative tendencies". Jean Stubbs (1989) maintains that, as a result of this aspect of rectification and with ANAP being more attentive to CPA needs, there is a reanimation within the cooperative movement. She reports that in 1987, 70 new CPAs were formed incorporating an additional 30,000 ha and 2,000 new members. The state sells inputs, including machinery, to cooperatives under very favourable interest rate terms. The provision of machinery which can be more efficiently used on the increased scale implicit in collectivized farming, has been a powerful incentive to form cooperatives.

Before the Land Reform Laws took effect the Cuban peasantry lived a wretched existence similar to that endured by large numbers of Third World small farmers today.

The Cuban experience in forming small farmer cooperatives may have relevance to many of these marginal producers and, if so, lessons can be learnt from Cuba's trial and error process. The remainder of this paper describes the CPAs and goes on to illustrate how the socialization of agriculture has resulted in greatly expanded farm mechanization while at the same time being the driving force behind the establishment of a flourishing national farm machinery industry.

Fig. 1 Small farmers in many developing countries farm their plots individually.

Organization and Structure of CPAs

When a group of individual farmers decides that it wants to form a CPA, the farmers apply to ANAP and MINAG (or MINAZ) who then conducts a feasibility study (Gómez, 1983). After full discussions with each potential member and after having established the economic viability of the proposed CPA the application is ratified and the cooperative is formed. All the land, livestock and machinery are pooled and the previous individual owners are compensated on an annual basis. Twenty-five to thirty percent of CPA profits are set aside for this purpose.

The CPA members democratically elect their president who has

Fig. 2 Production cooperatives (CPAs) allow specialization of the workforce, investment in capital intensive inputs like tractors and more rational use of the land according to crop and livestock requirements.

a fixed term and is responsible for directing the cooperative. He works with his appointed management committee (junta directiva).

The junta directiva is the executive and administrative body of the CPA. It reports to the general assembly and directs the organizational, financial, political, educational and cultural activites of the cooperative. It must comprise at least five and no more than 13 members according to the number of farmers in the cooperative, a typical structure would be: president and vice president with secretaries of: organization; production; education and culture; ideology and three to five ordinary members.

The farm manager (jefe de producción) is responsible for forming work brigades which are often permanent groupings attending specific areas of the CPA. Each worker works according to normas (production standards) and any over or under production is taken into account at the end of the year. Each working member is paid a "wage" (anticipo) on account and at the end of the year, when the accounts have been balanced, the net profits are distributed. Forty to fifty percent is paid to the members according to the normas and the number of days work accomplished. As already mentioned 25-30 percent is used to repay members' initial capital contributions. Ten percent each goes to a fund for the development of basic amenities and to a social fund which will pay for vacations and retirement pensions. Finally, five percent is allocated to recreation and sport.

When all members have been repaid for their original contributions this part of the annual distribution can be used for the remaining categories.

Benefits of Collectivization

The benefits, both to the nation and to individual members, of farming cooperatively are considerable when compared with the situation of isolated individual holdings unless these are unusually large or fertile. Increased agricultural production and improved social organization are the principal advantages for the state whereas farm families are increasingly able to benefit from improved educational and medical services and are able to enjoy the hitherto unknown comforts of paid vacations and old age pensions.

As each member of a cooperative benefits directly from increases in output, and as land can be farmed technically more efficiently, cooperatives are generally very profitable enterprises. Although input and product prices are determined by the state, production above the quotas (set by ANAP and MINAG or MINAZ in consultation with the CPA) can be sold at parallel market prices. CPA profitability is expressed in terms of the centavo cost of one peso (100 centavos) of production. Kay (1988) citing Rodríguez (1983) reports that a financial analysis of 761 CPAs (about 50 percent) showed that 674 were profitable with an average cost per peso of 67 centavos. Gómez (1983) reports a similar study done by ANAP in 1982 and suggests that the loss making CPAs (some 6%) were mostly tabacco producers and that their poor performance was due to excessive labour, incorrect normas and "little financial control". It is also the case that tobacco (and coffee) CPAs do not benefit so much from collectivization as cigar tobacco leaf and coffee are harvested by hand.

In recent years the production cost per peso has risen from 71 centavos in 1983 to 87 centavos in 1987. However, during 1988 and 1989 there was a decrease and it now stands at about 70 centavos. The cost factors which have most effect are salaries, materials and, above all, machinery and equipment.

The process of collectivization of individual small farms into CPAs is a manifestation of the socialist ideals of the Cuban state where planning is a replacement for market forces in development. It is easier for a CPA to be brought into the main stream of national development where it can not only contribute better to society, but the level of benefit derived from the state can also more easily be raised. ANAP is not only concerned with the technical aspects of CPA development but also the social and political welfare of its members, it runs two schools where CPA members are given classes in, for example, agrarian cooperation and accounting. It has also elaborated a national accounting and statistics system so that CPA control can be uniform across the country.

Case Study—CPA República de Chile

The CPA República de Chile in Pinar del Río Province was established in October 1973 and was the first CPA in Cuba. To some extent its shortcomings served as a lesson to improve the coming cooperative movement. It started with 577 ha of which 362 were cultivable. The main crop (shown on one-tird of the agricultural land) was tobacco with other minor crops shown on the remainder. From the outset,

1. This is unusually large (Stubbs, 1989 estimated that in 1987 some 1,400 CPAs had a total of 68,000 members, i.e. an average of a little under 50 members/CPA), and would have been expected to lead to problems of effective management and administration.

the CPA had financial problems and Gómez (1983) outlines some of the major teething problems:

-Most of the members, although owners of small plots of land, had worked as agricultural labourers. They were used to depending on wages for their livelihood and were not accustomed to relating productive work to agricultural output.

-Before the creation of the CPA there had existed a state agricultural production plan which had not produced conspicuously successful results either in terms of agricultural output or financial income. As most of the members had been part of this plan they started the CPA in a pessimistic frame of mind.

-At the outset there was little democracy in the CPA. Plans were imposed as a result of full participation of all the members. This tended to stiffle interest.

-The CPA inherited a large debt burden as a result of the state plan already referred to. The debt (several hundreds of thousands of pesos) was due to investment in tobacco curing houses and agricultural machinery. The members despaired of ever producing a surplus and so had their cooperative spirit further undermined.

-The members paid themselves high anticipos which did not correspond to their prooductivity. This irresponsible behaviour did not take into account the real concept of the anticipo as an advance on future surpluses but rather as a wage, which it is not. The absence of work normas made it impossible to gauge what the correct remuneration for each member should be.

-During the initial stages of the CPA the members were more concerned to building their houses than to produce. The consequence was a worsening debt situation

2. The Cuban peso is officially exchanged at fractionally less than $US 1. However, the shadow exchange rate approaches 10 pesos to $US 1.

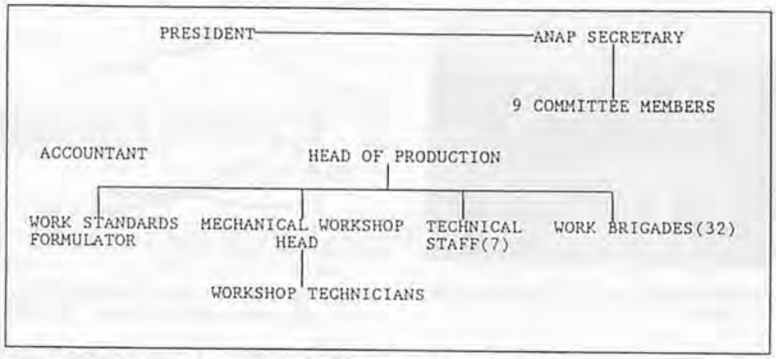

Fig. 3 Administrative structure of CPA Republica de Chile.

After three years the CPA owed approximately half a million pesos to the bank and was in danger of disintegration. It was at this stage that staff of the National Directorate of ANAP studied the situation and, in collaboration with the CPA members, formulated a package of measures to rescue the cooperative. These included:

-Collective decision making in general assemblies.

-Prioritizing the use of labour and giving precedence to productive agricultural work.

-Setting work normas in conjunction with realistic production plans.

-A reduction of the anticipo to reasonable levels.

-Diversification of crops and an increase in cattle production.

Improvement was slow but, with constant help from ANAP at provincial and national levels, the financial situation was turned around until, in 1983, each peso of production was calculated to cost only 71 centavos. Also in this year the CPA had no bank debts and was able to distribute 80,000 pesos among its members.

In 1989 the CPA República de Chile had 325 members and coverd 2,200 ha. As in the collectivization movement, in general, special emphasis is placed on improving the situation of women by weakening their social isolation and increasing their contribution to production (Pollitt 1982). República de Chile has 85 women members.

The members elect a president each 2-1/2 years who, in turn, forms the managing board of an accountant and a head of production or farm manager (**Fig. 3**). The head of production leads a team comprising of:

-The standards evaluator whose job is to calculate work norms for each farm task.

-The workshop head who in turn has his own team of mechanics, welders, blacksmiths.

-Seven technical staff who respond with solutions to technical problems that may present themselves. This group includes agronomists, pathologists, livestock and irrigation experts.

-The work brigades. There are 32 of these attending to their respective work areas which do not change. The members of each work brigade elect their own leader.

The ANAP secretary is also elected by the CPA members and he reports to the municipal and provincial ANAP authorities. He and his nine committee members are in charge of the social and political well being of the members which includes organizing the theatre group, games, dances and fiestas, as well as, for example, supervising the childrens' vegetable gardens which are seen as an essential training activity.

The CPA República de Chile is considered to be a vanguard cooperative. It boasts of modern housing for all its' members, a doctor and clinic, a primary

Fig. 4 The school at CPT Republica de Chile.

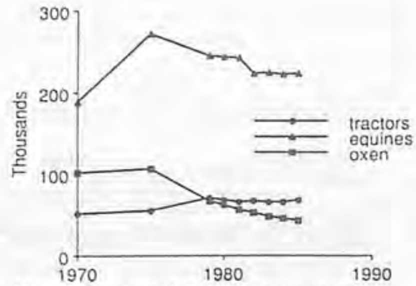

Fig. 5 Sources of Cuban state agricultural sector tractive power, 1970-85.

Fig. 6 The KTP3 cane harvester at EXPO Cuba.

school, a shop and even a bar! Lack of clean running water and electricity are of course, bad dreams from the past.

In the area covered by the cooperative there were still (in 1989) some 80 small farmers who have elected not to join. The majority of these are old farmers who do not wish to change their ways. The ANAP secretary reports that their sons say that they will join the CPA at the earliest opportunity and he expects them all to be members by the end of 1990 (Manuel Valdés, personal communication).

The Transition to Socialist Agriculture and Farm Mechanization

The CPA República de Chile has 21 wheeled and two tracked tractors as well as 25 ox teams (oxen are still regarded as a useful power source for mountainous areas inaccessible to wheeled tractors, small plots and intercultivation). It also has some 2070 kW irrigation pumps. This situation is in marked contrast to that which existed before the revolution. Before January 1959 Cuba had some 9,000 tractors and a substantial part of rural transport was by means of animal power. The agrarian reform process described in this paper has meant that, in 1989, and excluding the cane-sugar sector, MINAG has more than 34,200 tractors, 3,250 forest clearing and construction machines, 1,500 combine harvesters, and the number of associated agricultural implements is more than 71,500 (Expo Cuba information). The 1985 Census figures (Comité Estatal de Estadísticas, 1987) include machinery managed by both MINAG and MINAZ and show a total over 68,500 tractors in Cuba. The vast majority of these were wheeled Soviet Belarus tractors although tractors from other socialist countries (Romania, Bulgaria and Czechoslovakia) were also imported.

Draft animals are still important in Cuban agriculture as **Fig. 5** shows. Since 1982 the number of equines has remained fairly constant at over 222,000 head and the number of oxen has declined slightly to about 43,000 head. The average power of tractors imported into Cuba has risen from about 40 hp (1 kW = 1.34 hp) in 1959 to 75.5 in 1987. In 1985 they provided 84% of the 4.25 million hp available to state agriculture, the remainder being provided by animal power. The contribution made by animals to farm power needs in the private sector is likely to be much greater.

The effort to mechanize the sugar cane crop—especially the harvest—has been even more dramatic. In the mid-1960s there was a drive to increase sugar production and much voluntary labour was mobilized for the harvest. Meanwhile Cuban and Soviet engineers started to tackle the problem of mechanized cane cutting with no accumulated experience (Pollitt 1982). Up to 1970 no more than three percent of cane was cut mechanically, thereafter imported Massey-Ferguson cane cutters were used and these were gradually displaced by the Cuban Soviet KTP family of machines. The KTP1 initially imported from the USSR, was produced in Cuba from 1977. An improved version, the KTP2, is manufactured in Holguín at the rate of 600 units per year and a total of over 6,000 units had been manufactured by March 1989 with modest exports to Greece, Egypt, Nicaragua and Mexico (Expo Cuba information). By 1989, two-thirds of the cane crop was mechanically harvested and the national stock of active harvesters exceeded 4,000 units (Brian Pollitt, personal communication). The typical performance of these machines is in the region of 80-100 tonnes of green cane cut per day.

In 1989 a new cane harvester prototype (KTP3) was produced. It is claimed to be able to cut up to 40 tonnes per hour green cane and will have a retail price of $US 100,000 (**Fig. 6**).

This brief overview of the Cuban agricultural machinery industry serves to emphasise the dedication of the Cuban state to modernize agricultural production, exploiting the land to the maximum whilst at the same time improving labour productivity and reducing the drudgery in agricultural work—a far cry from the miserable conditions described by Fidel Castro back in 1953.

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Optimizing Production of Alcohol Using Bio-renewable Substrates

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Abstract

The influence of pH and temperature on the yield of alcohol from molasses in the presence of a proteoytic enzyme (papain) has been studied. A mathematical analysis of the substrate yield coefficient in the near optimal region led to an optimum pH of 4.87 and an optimum temperature of 32.47°C. At these conditions the alcohol yield was estimated to be 18.6% as compared to an average of 10% obtained in the absence of a proteoytic enzyme. The use of proteolytic enzymes can, therefore, lead to an increase in the production of alcohol which is now gaining great importance in agro-based industries.

Introduction

Nearly three quarters of the world's demand for industrial alcohol is met by fermentation processes, although in some oil producing countries like the United States, about 80% of their demand comes from synthetic processes. Even in the oil producing countries, however, increasing costs of crude oil may make it necessary to take another look at the classical fermentation route which uses renewable raw materials.

Apart from the conventional uses of alcohol, it is now being suggested for use as a solvent for vegetable oil extraction (Hron et al, 1982; Musonge, 1990) and for use as fuel for tractors, combines and other self-propelled machineries (Janius, 1988). The alcohol production industry is, therefore, likely to continue growing. Alcohol, especially ethanol, could be produced easily and the raw materials, being agricultural matter, are renewable, it is, therefore, necessary to search for means of transforming these raw materials economically into alcohol. Molasses, a by-product of the cane-sugar industry presents itself today as an inexpensive and abundant source from which a substantial percentage of the ever increasing demand for industrial alcohol can be derived. Under optimum fermentation conditions, the maximum concentration of alcohol obtainable within a reasonable time is between 8-12%. Such low concentrations of alcohol lead to high distillation costs, particularly in terms of capital investment. Above these concentrations, fermentation stops because of the inhibitory effect of alcohol on the growth of the yeast cells. It is, however, possible under special conditions, particularly using a yeast specie adapter to high alcohol tolerance, to continue the fermentation to about 20% after several months or years. This, of course, renders the process uneconomical.

Studies on alcoholic fermentation (Coates and Conde, 1963) at the Central Anehadora Guatemateca, Guatemala have shown that it is possible to obtain alcohol concentrations of the order of 20% by volume within 48 h or less in the presence of a proteolytic enzyme in their studies they employed the yeast *Saccharomyces cerevisiae* var. *ellipsoideus* (Amerine and Joslyn, 1970), because this yeast specie is capable of elaborating appreciable amounts of zymase, phosphatase as well as the proteolytic enzyme bromelain, it can also tolerate a medium of 20% alcohol concentration and above under special conditions.

In the study of the kinetics of alcoholic fermentation using two proteolytic enzymes; bromelain and papain in the presence of *Sac-*

Acknowledgement: The author wishes to express his profound gratitude to the Nigerian Sugar Industry at Bacita and Guiness Nigeria Ltd. for their willingness to supply samples of molasses and yeast, respectively. Thanks also go to the University Centre of Ngaoundere and the University of Lagos for their material and financial support.

caromyces cerevisiae (Susu and Ogunye, 1978), it was concluded that a better yield could be obtained in relation to the use of *Saccharomyces cerevisiae* alone. In the same study, it was demonstrated that under identical fermentation conditions, papain gave a better yield of alcohol.

The development of a microbial process for the formation of products is aimed at maximizing the yield and the rate of product formation. These qualities in the case of alcohol fermentation are often dictated or influenced by temperature, extent of aeration, acidity and alcohol concentration.

In order to achieve the above objectives, an observation of the important features of a fermentation process development has to be made. The present work is aimed at making a contribution in the determination of optimum values of temperature and pH, and the rate of product formation using *Saccaromyces cerevisiae* in the presence of the proteolytic enzyme papain.

Materials and Methods

Molasses

Molasses used in the present study was obtained from the Nigerian Sugar Industry at Bacita and had a composition as indicated in **Table 1**.

Solutions of the required Brix were prepared by making appropriate dilutions of molasses. The solutions were sterilized in an autoclave and then cooled to the required temperature. The pH of the various solutions was adjusted by the use of a 1N H_2SO_4 or a 1N NaOH solution. For each fermentation run, 1.6 litres of solution were measured into a 2 litre Multigen Fermentor before sterilization.

Table 1. Composition of Blackstrap Molasses

Component	Value
Brix	86°
Reducing sugar	23.5%
Protein	6.5%
pH	5.6

Yeast

The strain of yeast used in the work was obtained from Guiness Nig. Ltd. In the preparation of the yeast inoculum, the sample was first allowed to settle in a conical flask placed in a refrigerator. A 19° Brix solution of molasses was prepared and 1.5 litres of the solution were measured into a 2-litre multigen fermentor. One gm of $(NH)_2SO4$ was added as the nitrogen source in order to accelerate the growth rate of yeast cells. The solution was adjusted to a pH of 4.5 and sterilized in an autoclave at 121°C and 15 psig for a period of 15 min. The solution was then cooled to 30°C and after a re-adjustment of the pH to its initial level, a 5 ml paste of yeast was inoculated into the medium. An agitation speed of 600 rpm and an aeration rate of 240 ml/h were maintained for a period of 22 h under the above conditions. The yeast was then allowed to settle in a conical flask placed in a refrigerator. The yeast was acclimatized following the procedure outlined in (Susu and Ogunye, 1978), to ensure a tolerance of 20% alcohol.

Introduction of Proteolytic Enzyme Papain

To introduce the proteolytic enzyme papain, the yeast cells were suspended in a solution having the following composition: water (83%), spray dried papain (10%), and malt (7%). The solution was filtered of any impurities or some of the undissolved powdery papain after being allowed to stand for a day. Aeration and agitation were carried out as in the case of the growth of the yeast for a period of 18 h after which the proteolytic enzyme would have been introduced.

Experiments and Measurements

Experiments

Nine fermentation runs using molasses at a constant Brix of 37°, as substrate were carried out each lasting for a period of 16 hours. The yeast was used in the presence of the proteolytic enzyme papain. The temperature and pH co-ordinates were in the range 30-38°C and 4.5-5.5, respectively, in accordance with normal fermentation conditions. The choice of variables for each experiment permitted the use of a 3^2 factorial design method of analysis for the optimal policy evaluation the initial cell count was maintained at an average 51×10^7 cells/ml.

Measurements

For the optimal policy and kinetic studies, the variables monitored were the disappearance of sugar, the formation of ethanol and yeast growth. Sampling was carried out at a 2-hourly interval. The ethanol concentration was obtained by distillation of a 100 ml sample until the vapor attained a temperature of 95°C. The distillage was then made up to the original volume of the sample. The specific gravity was found and correlated with the relevant table in (Howitz, 1968) to obtain the concentration of alcohol in the sample. The Brix level was obtained by relating the specific gravity of various samples and correlation with Brix readings in

Table 2. Optimal policy

Factor	Level		
	+1	0	−1
Temperature (°C) = X_1	38	34	30
pH = X_2	5.5	5.0	4.5

(Meade, 1963). The yeast count was effected by direct microscopic method using a crystallite haemocytometer.

Results and Discussion

Optimal Policy Evaluation

A 3^2 factorial design aimed at determining the optimum values of temperature and pH was carried out. The design is shown in **Table 2**.

Nine sets of tests were carried out in a random manner to eliminate any possible trend in the yield. The yield is defined as:

$$Y = \frac{\text{Amount of alcohol x100}}{\text{Amount of sucrose initially present}} \quad (1)$$

It was assumed that in the neighbourhood considered, a second order polynomial adequately represented the data giving:

$$Y = B_0X_0 + B_1X_1 + B_2X_2 + B_{11}X_1^2 + B_{22}X_2^2 + B_{12}X_1X_2 \quad (2)$$

where Y = response (yield in this case) to changes in the variables X_1, X_2. The computation can, however, be conveniently implemented by expressing equation (2) in the form:

$$Y = Y_0X_0 + B_1X_1 + B_2X_2 + B_{11}(X_2^2 - \frac{2}{3}) + B_{22}(X_2^2 - \frac{2}{3}) + B_{12}X_1X_2 \quad (3)$$

with Y_0, denoting the mean values of the Y's given by

$$Y_0 = B_0 + \frac{2}{3}B_{11} + \frac{2}{3}B_{22}$$

noting that

$$\Sigma\frac{X_1}{n} = \Sigma\frac{X_2}{n} = \Sigma\frac{X_1X_2}{n} = 0$$

$$\Sigma\frac{X_1^2}{n} = \Sigma\frac{X_2^2}{n} = \frac{2}{3}$$

The values of the independent variables corresponding to equation (3) are given in **Table 3**.

Table 3. Values of Variables in Equation 3

Trial	X_0	X_1	X_2	$X_1^2-\frac{2}{3}$	$X_3^2-\frac{2}{3}$	X_1X_2	Y
1	1	−1	−1	1/3	1/3	1	36.57
2	1	0	−1	−2/3	1/3	0	37.68
3	1	1	−1	−1/3	1/3	−1	33.50
4	1	−1	0	1/3	−2/3	0	38.35
5	1	0	0	−2/3	−2/3	0	41.92
6	1	1	0	1/3	−2/3	0	33.00
7	1	−1	1	1/3	1/3	−1	34.11
8	1	0	1	−2/3	1/3	0	30.78
9	1	1	1	1/3	1/3	1	26.57

Table 4. Estimates of Constants and Regression Analysis for Equation 3

Constant (estimated)	X^2	YX	Estimate (3)/(2)	Component sum of squares = $(3)^2/(2)$
Y_0	9	312.48	34.72	10849.31
B_1	6	−15.96	−2.66	42.45
B_2	6	−16.29	−2.72	44.23
B_{11}	2	−6.22	−3.11	19.34
B_{22}	2	−9.11	−4.56	41.50
B_{12}	4	−4.47	−1.12	5.00

The orthogonality relation between the independent variables, provides a method of estimating their effects on the process as shown in **Table 4**.

The analysis of variance is shown in column (5) of **Table 4** which provides values for the sum of squares due to each term of the fitted equation. The difference between the computed total sum of squares and that calculated from the observed yields is 11.45 representing the deviation from regression. With the values in **Table 4** substituted in equation (3) the following correlation is obtained.

$$Y = 39.86 + 2.66X_1 - 2.72X_2 - 3.11X_1^2 - 4.56X_2^2 - 1.12X_1X_2 \quad (4)$$

where

$$X_1 = \frac{T - 34}{4} \text{ and } X_2 = \frac{pH - 5.0}{0.5}$$

Where T and pH represent optimum values deduced at the point where the response Y is stationary. If dY/dX_1 and dY/dX_2 are set to zero we obtain $X_1 = 0.3824$ and $X_2 = -0.2513$ giving an optimum temperature of 32.74°C and an optimum pH of 4.87. The calculated optimum yield becomes 40.1% corresponding to 18.6% alcohol by volume. Patterns of alcohol formation at the end of a 16-h period indicated that while at a constant pH of 4.5 and 5.0 the yield increased with increasing temperature from 30 to 34°C and dropped beyond 34°C; at a pH of 5.5: a rather continuous decrease in alcohol yield was observed. However, at constant temperatures, there was a continuous increase in product formation as the pH was raised from 4.5 to 5.0 with a subsequent decrease thereafter.

While this study has been concentrated on product formation patterns in order to obtain optimum operating parameters, the high level of alcohol could be due to the fact that in the process of hydrolysis of protein molecules additional sugars may be produced for subsequent fermentation, leading to an increased substrate level.

Conclusion

The optimal policy evaluations carried out by the 3^2 factorial experimental design technique in a batch fermentation led to an optimum temperature and pH of 32.47°C and 4.87, respectively. The product formation under these conditions was estimated at 18.6% by volume. The maximum concentration of alcohol attainable under optimum conditions of fermentations within a reasonable time lies in the range 8-12%. It can be concluded that the adaptation of the yeast to higher alcohol concentrations and the action of the yeast in the presence of the proteolytic enzyme papain enhanced the alcohol yield tremendously. Such higher concentrations of alcohol can then lead to lower production costs for industrial alcohol. The role of the proteolytic enzyme though not clear appears to be breaking the barrier that normally allows only limited utilization of reducing sugar content in molasses.

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Evaluation of Operator Noise Levels according to SAE and OECD

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Introduction

Noise is generally defined as unwanted or bothersome sound. It also influences the hearing acuity of humans when they are exposed to high enough levels for an extended amount of time. During the past 20 years noise reduction has become an important design component of industrial design and agricultural machinery.

Noise levels, to which an operator of a tractor or other self propelled equipment is exposed, have received great attention. The Nebraska Tractor Test Laboratory has been testing and reporting operator sound levels since 1970. The method used for sound measurement was in accordance with the SAE test code (1). This code defines the gears and engine speed and load conditions as well as the method for testing the sound levels.

Since 1986, the Nebraska Tractor test program has performed and published tests according to the OECD (Organization of Economic Cooperation and Development) test codes (2) in addition to SAE (Society of Automotive Engineers) tests and has also published some OECD tests results from test stations in other countries. In this article we will explain the differences in procedure and the problem in comparing the results of the two test types.

The OECD codes were developed by a group of industrial nations and has currently 24 members plus some affiliates. The US is an active member of the OECD whose headquarters is located in Paris.

Currently there is a concerted effort under way to unify the various test codes and standards into one International Standard. Because of the large number of countries invovled and their diverse regulations and interests this process will take considerable time.

Sound levels were first tested at Nebraska in 1970 and were first published in 1971. In the early years most tractors were without cabs or had cabs which were simply weather protection. These cabs often amplifeid the noise rather than reducing it. The testing of sound here and abroad prompted the development of quieter tractors, especially of well-insulated cabs.

General Procedures

Sound tests are conducted with a microphone and a signal conditioning system which converts the signals into a sound level expressed in decibels (dB(A)). The higher the dB(A) the higher the sound level. The microphone has a specified position in relation to the operator.

The Decibel [dB] is a logarythmic scale measure of sound pressure. Thus if the difference between two decibel levels is 10 dB, the sound power (in watts) of one is actually 10 times that of the other. The dB measured according to the so-called A-scale is called the dB(A). It is the most often used sound pressure definition for measuring sound levels which impact on the human operator. (3)

The test results from the SAE and the OECD codes are not directly comparable. The reasons are that:

a. The engine speeds required for each test code are different.
b. The loads imposed on the tractors during the tests are different.
c. The microphone location is different in each test code.

The last item is generally of minor importance for tractors with sound-insulated cabs.

The SAE Test

The operator sound level is measured during four tests and the result of each test is reported. The tests are:

1. During the maximum power test in a "Rated Gear". The throttle is set for maximum power and the drawbar load is adjusted to provide Rated Engine Speed. The Rated Gear is a gear usually specified by the manufacturer and is close to the actual speed of tillage operations.
2. In the same gear as test 1 and with the same throttle setting, but with a load equalling 75% of the pull obtained in test 1.
3. The same gear as test 1 and the same throttle setting are used, but the drawbar load equals 50% of the pull obtained in test 1.
4. The same load and speed as in test 3, but in a higher gear and with the throttle set back. This is the so-called "gear up and throttle down" test.

All tests are conducted with the same ballast used for the drawbar power tests. The manufacturer decides on the amount of ballast used during the drawbar tests.

Figs. 1, 2 and **3** show data points from the SAE tests of the past 20 years. The median values of tractors with cabs and without cabs are shown in **Fig. 1.** Since the dB(A) value is a logarithmic "weighted averrage" of the whole sound spectrum, it would be wrong to present an average, especially if the range of values is wide.

Figs. 2 and **3** show the median values and the ranges of the sound level values for tractors with and without cabs, respectively.

Tables 1 and **2** show how the data are reported in the standard Nebraska Tractor Test Reports and in the OECD test reports.

The graphs show clearly that there has been a marked improvement in the operator exposure level for the tractors with cabs. The tractors without cabs do not show such improvement, but the results from later years are based on a smaller number of tractors being tested without cabs.

The OECD Test

The first difference between the SAE and OECD tests is that the procedure requires the search for a maximum sound level in each gear. Since the measured sound is a composite of engine, gear, hydraulic noises and tractor body vibrations, the contribution of each part can differ at different

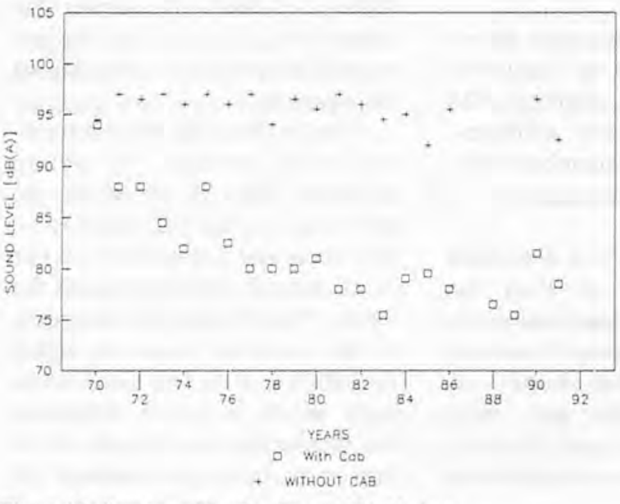

Fig. 1 Median sound level values, 1970-72 data.

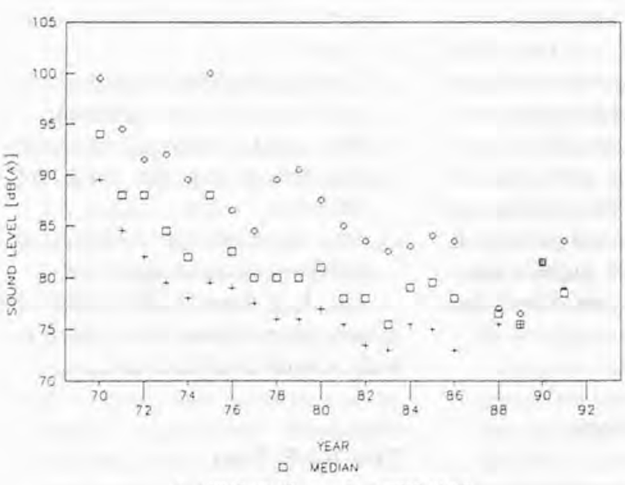

Fig. 2 Sound level [dB(A)] - with cab. Data from 1970 through 1991.

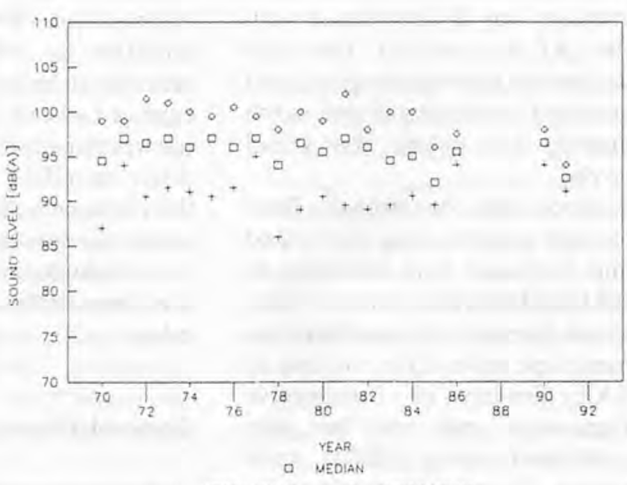

Fig. 3 Sound level [dB(A)] - without cab. Data from 1970 through 1991.

Table 1. Nebraska Sound Test Data

Tractor Sound Level with Cab	dB(A)
Maximum available power — two hours	81.5
75% of pull at maximum power — ten hours	82.5
50% of pull at maximum power — two hours	85.0
50% of pull at reduced engine speed — two hours	83.0
Bystander in 11th (3-3) gear	88.5

Table 2. OECD Sound Test Data (Front wheel assist tractor)

Gear and range	Drawbar pull kN	Forward speed km/h	Noise level dB(A) a	Noise level dB(A) b	Driving axles
Unloaded test in gear giving nominal speed nearest 7.5 km/h.					
4FT + S	0	7.98	69	81	1
4FT + S	0	8.07	69	81	2
Unloaded test in gear giving maximum speed.					
4FR + S	0	32.30	71	84	1
4FR + S	0	32.46	71	84	2
Test with drawbar pull for which tractor gives maximum sound level for gear giving nearest nominal speed to 7.5 km/h.					
4FT + S	26.2	6.92	75	87	1
4FT + S	30.5	7.19	76	88	2
Test with drawbar pull for which tractor gives maximum sound level for gears giving sound level at least 1 dB(A) above preceding test.					
No gears	—	—	—	—	—

Legend: a = All openings closed; b = Roof, rear and side windows open.

speeds. The engine speed at which maximum sound level occurs can, therefore, differ from gear to gear.

The second difference between the two tests is that some tests are performed with a drawbar load, others without.

The third difference is that the tractor is always tested without any ballast. The definition of a ballast includes the use of dual tires unless the manufacturer specifies that the tractor shall not be operated for field work without the dual tires.

Although the sound is tested in all the gears, only the following sound levels are reported:

1. The maximum sound level in the gear with a nominal speed nearest to 7.5 km/h and with a drawbar load. The maximum sound level can occur at any engine speed. The throttle is set for maximum power. Note that the maximum sound level does not necessarily occur at maximum power.
2. The sound level in a gear with a sound level higher by at least 1 dB(A) than the level found in test 1. This means that all gears have to be tested to determine which ones have to be reported.
3. The maximum sound level in the gear with a nominal speed nearest to 7.5 km/h without a drawbar load. The maximum may occur at any engine speed. The throttle setting can be changed to determine the maximum sound level but it usually turns out to be close to or at the maximum throttle setting.
4. The maximum sound level in the highest gear. The throttle can be changed to find the highest sound level. Usually, however, this turns out to be the maximum throttle setting.

The OECD codes are divided into two parts: the Full Code or Code I and the Restricted Code or Code II. Code II does not require a sound level test. Thus, when an OECD Code II test is performed at Nebraska an OECD Code I or an SAE sound test is sometimes added at the request of the manufacturer.

Table 2 shows an example of an OECD report. Note that the table shows data of a sound test with windows open and closed. This is an addition not required by OECD but by some national authorities. It is also required by the EEC. The OECD requires the test to be conducted with closed windows and doors. The numbers 1 and 2 in the last column of **Table 2** refer to the tractor being operated with the front axle disengaged and engaged, respectively.

Test Comparisons

It is not easy to compare the OECD tests of two different tractors, because the results are not obtained at comparable points on the engine curve. Some of the noise levels can occur at engine rpm's and drawbar loads which are not recommended for use or only for a short period.

The only time tests can be compared is when the engine revolutions in comparable gears are close. It would be incorrect to compare the sound level in a road gear with that of a gear in the tillage range.

Similarly, comparing OECD and SAE test results is difficult even if they were performed on the same tractor, unless the engine rpm differences for comparable gears are small and the loads on the drawbar are similar.

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ABSTRACTS

The ABSTRACT pages is to introduce the abstracts of the article which cannot be published in whole contents owing to the limited publication space and so many contributions to AMA. The readers who wish to know the contents of the article more in detail are kindly requested to contact the authors.

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A Computer Model for Sugarcane Transportation Incentive System: A.K.M. Shirin, Graduate Student, Div. of Agric. and Food Engg., Asian Institute of Technology, G.P.O. Box 2754, Bangkok, Thailand; Gajendra Singh, Professor, Div. of Agric. and Food Engg., Asian Institute of Technology, G.P.O. Box 2754, Bangkok, Thailand.

A general computer program has been developed for the sugarcane transportation incentive system. This incentive system model is able to compute the periodic benefit of an operator for his work beyond his normal duty period. The program written in Microsoft Quick Basic is an interactive one and should help the management of the mills in improving the total sugarcane hauling performance by increasing the number of trips per operator and quantity of sugarcane per trip up to the optimal level. This should also help the operators to increase their income.

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Comparison of Thermal Efficiencies of Different Types of Domestic Cooking Stoves: D.N. Sharma, Coordinator, Krishi Gyan Kendra, HAU, Hisar-125004; Binoo Sehgal, Assistant Professor, Department of FRM, College of Home Science, HAU, Hisar-125004; Asha Batra, Distt. Extension Specialist, Krishi Gyan Kendra, HAU, Hisar.

A study was conducted to compare the performance of eight different types of domestic cooking stoves, namely; Nutan Wick stove, Pressure stove, electric hot plate (500 & 1000 watts), electric heater (1000 watts), traditional mud stove (chulha), and improved Sahyog and Nada stoves under controlled conditions. Highest thermal efficiency was observed in LPG stove at slow burner setting (61.54%) and Nutan wick stove (61.35%) followed by LPG stove (high burner setting, 58.85%), electric heater (1000 watts), 50.75% electric hot plate (500 watts); 44.48% and electric hot plate (1000 watts). 30.47% Lowest thermal efficiency was recorded in traditional mud stove (14.14%). This efficiency could be improved to 18.24 and 17.48% in Sahyog and Nada improved mid stoves (without dampers), respectively. These can be further increased to 20.59 and 18.35%, respectively, with the use of damper in semi-open position. Higher thermal efficiencies in LPG stove and Nutan wick stoves were due to the formation of uniform blue flame and minimum radiation and convection losses during their use. In rural areas, firewood, crop residues and cow-dung are the main fuels used for domestic cooking/heating. Therefore, improved mud stoves of 20% thermal efficiencies can become popular in place of traditional mud stove among users.

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A Battery-powered Single-axle Tractor: Niaz Latif, Assistant Professor, Department of Technology, Northern Kentucky University, Highland Heights, Ky 41099, USA; Leslie Christianson, Professor, Agricultural Engineering, University of Illinois, Urbana, Illinois 61801, USA.

A single-axle battery-powered tractor is suggested for use in Lesser Developed Countries (LDC's). This tractor can be improved over the Internal Combustion Engine (ICE) powered tractors in: performance characteristics, variety of tasks performed, cost and simplicity of maintenance. Such a battery-powered tractor should pull 5 kN at a speed of .5 m/s for 3 hours/day, which requires a conventional lead-acid battery size of approximately 180 kg. Prospects for introducing battery-powered tractors in LDC's are also discussed.

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Development of Gorgon Nut Processing Machine: S.N. Jha, Res Scholar; Suresh Prasad, Assoc. Prof. Post Harvest Technology Centre, Indian Institute of Technology, Khargpur 721302, West Bengal, India.

A processing machine for gorgon nut was developed and tested. The machine consists of a roaster and a unit to impart centrifugal action to the hot nuts. The various processing conditions of nuts were investigated and the performance of the machine was tested.

Based on the expansion ratio, the kernels were classified into three categories, viz., grade 1 expanded kernels; grade 2 over-expanded or burst kernels; and grade 3 unexpanded kernels. The test results show that the machine works satisfactorily and can produce a maximum of 82% of grade 1 kernels at optimum processing conditions.

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Performance of a Compression Ignition Engine Using Ethanol as Supplementary Fuel: Anil Goswami, Ex-Graduate Student; Bachchan Singh, Prof.; T.K. Bhattacharya, Asst. Prof., Dept. of Farm Machinery and Power Engineering, College of Technology, G.B. Pant Univ. of

Agriculture and Technology, Pantnagar, 263145, U.P., India.

A stationary, 3.73 kW, constant speed, compression ignition engine was modified to run on diesel-ethanol fuel. The comparative performance of the engine on diesel and dual-fuel was studied at different loading conditions. The engine was tested on diesel fuel at the standard injection timing of 27°C BTDC. The engine on dual fuel was tested at the 0.08, 0.12 and 0.17 ml/s ethanol flow rate (at no-load and performance was observed on dual-fuel at 27, 30, 33 and 35° BTDC injection advance. The brake horsepower developed specific fuel consumption, diesel replacement and brake) thermal efficiency were studied.

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Energy Audit of Bagasse-fired Boilers of a Sugar Mill: C. Gopalarao, Asoc. Prof., Dept. of Agric. Eng., A.P. Agric, Univ , Tirupati, 517502, India; C.P. Singh, Prof.; A.K. Jain, Assoc. Prof., School of Energy Studies, Punjab Agric. Univ., Ludhiana 141004, India.

The energy audit of bagasse-fired boilers was conducted at the Dhampur Sugar Mills, Dhampur, Uttar Pradesh, India. The mill had seven boilers of different designs and capacities. Bagasse at average moisture content of 50% (wb) was used as fuel in all the boilers. All the boilers had balanced drought system. The thermo-chemical properties of bagasse was determined. The CO_2 concentration and temperature of flue gas was measured. Steam pressure, temperature and flow rate were also measured for all the boilers.

It was found that the boilers which operated at high percentage of excess air had a poor performance when compared to those operated at lower percentage of excess air. For a boiler operating at actual air to theoritical air ratio of 2.39, the heat loss through flue gas alone was 25% of the heat input.

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Design, Development and Evaluation of Pepper Cleaner: N. Varadharaju, Asst. Prof.; V.V. Sreenarayanan, Prof. and Head, Dept. of Agric. Processing, Tamil Nadu G.D.N. Agric, Univ., Coimbatore 3 India

A power-operated pepper cleaner was designed, developed and evaluated. The cleaner mainly consists of an endless flat canvas belt, feed hopper with fluted roller and separate outlets for pepper and foreign materials. The unit is powered by 0.5 hp electric motor. The cleaner was tested with different combinations of materials, slope, speed of the rollers and feed rate.

The best cleaning efficiency of 99.5% was achieved at an inclination of 20° and a roller speed of 100 rpm with the canvas belt. The optimum feed rate was 50 kg/hr and the cost of the unit is Rs.6000. The performance and cost of operation of the unit was evaluated and compared with those of the manual cleaning of pepper.

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Influence of System Parameters on Performance of Triangular-shaped Furrow Opener for Animal-drawn Seed Drills: S.M. Mathur, Asst. Prof., College of Tech. and Agric. Eng., Udaipur, Rajasthan 313001, India; K.P. Pandey, Prof., Indian Institute of Technology, Kharagpur 721302, India.

The reversible shovel type furrow openers used in the animal-drawn seed drills are not very suitable for sandy soils. A study was conducted in order to develop a triangular-shape furrow opener for such soils. The experiments were conducted in an indoor soil bin filled with lateritic sandy loam soil, (23% clay, 20% silt and 63% sand) at four levels of rake angle (20, 25, 30, 35 degrees), four working depths (50, 75, 100, 125 mm) and three forward speeds (0.36, 0.77 and 0.90 m/s). An octagonal ring transducer was used to measure the draft force experienced by the furrow opener. The depth of soil falling over the seeds that dropped in the furrow was measured.

The seed emergence test was also conducted in the soil bin. A multiple regression analysis was developed to study the influence of system parameters on specific draft requirement. Based on the heuristic approch, the optimum values of rake angle, working depth, and forward speed were found to have minimum specific draft for the triangular-shape opener of 29 degree, 85 mm, and 0.42 m/s, respectively. In terms of specific draft requirement and seed emergence, the performance of the triangular-shape furrow opener was better than traditional reversible shovel. it is expected that this type of furrow opener will have wide acceptability from farmers working with sandy soils.

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Development and Testing of a Laboratory Paddy Separator: J. Thajudhin Sheriff, Scientist, Post-harvest Technology Division, CTCRI, Trivandrum 695017, India; P.K. Chattopadhyay, Asst. Prof., Post Harvest Technology Centre, I.I.T., Kharagpur 721302, India.

At present time in the rice quality testing laboratories, the separation of paddy from brown rice mixture is done by hand-picking which is very laborious and time consuming. To overcome this problem a suitable laboratory paddy separator was developed. This separator consisted of a 440 mm × 237 mm oscillating deck with four mild steel zig-zags having 12 triangular flanks to form three compartments, rectangular grooved wooden frame, feed box and discharge outlet chutes.

This separator uses the principles of differences in specific gravity, buoyancy and surface texture of paddy and brown rice kernels. Provisions were made to change the feed rate, deck slope, stroke length and frequency of oscillations. Thirty two tests were conducted in the separator to determine the optimum combination of stroke length, frequency oscillation and deck slope.

The maximum effectiveness of separation of 0.914 was achieved at a slope of 1.0 degree, frequency of socillation of 160 cpm (cycles per minute), stroke length of 76 mm and feed rate of 7.05 kg/h.

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Effect of Drying Air Temperature and Duration on Germination of Rapeseed: B.G. Patil, Dept. of Civil and Agric. Eng., University of Melbourne, Parkville, Victoria 3052, Australia.

The effect of various drying parameters on the germination capacity of rapeseed was evaluated. The samples conditioned from 13.77% to 24.98% moisture contents (d.b.), were dried to equilibrium moisture content at air temperatures of 50°C and 60°C and at an airflow rate ranging from 0.21 to 0.53 $m^3 (s\ m^2)^{-1}$. For the moisture content range of 13.77% to 24.98% (d.b.), no significant effect on drying air temperature up to 60°C and duration of exposure to drying up to 7.5 hours on the germination of rapeseed was observed.

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Energy Requirements for Tillage Operations and a Dynamic Model of Mechanization: The Case of Bangladesh B.K. Bala; M.A. Satter; R.I. Sarker, Dept. of Farm Power and Machinery, Bangladesh Agric. Univ., Mymensingh, Bangladesh.

Energy requirements for tillage operations vary with crops, soil condition and availability of draft animals. But draft animals are in short supply which is why the mechanization of tillage operations is being encouraged by planners. A simple system dynamics model is presented in this paper to assess the mechanization requirements of tillage operations in order to supplement the draft power shortage in Bangladesh. The model was simulated using professional DYNAMO on a micro-computer. The potential implications of the model and its utility for the planning process are also discussed.

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Field Performance of Seed Metering mechanisms for Rapeseed and Mustard: T.R. Sharma, Res. Eng.; R.S.R. Gupta, Sr. Agric. Eng.; Satya Pal, Asst. Prof. (Agric. Eng.), Haryana Agricultural University, Hisar, India.

An Oblique cell type seed metering mechanism developed at HAU was compared with two openings of gravity feeds system, fluted roller system (used for wheat sowing) at zero setting and commonly used traditional sowing behind the plough for raya RH 30. Germination count of 5.8 plants/m length in lines was better than 4.4 plants length in 3 mm hole size gravity feed in quantity as well as uniformity of spacings. The other three methods resulted in higher seed rate leading to more germination counts of 11.2, 15 and 12 plants/m length in 4 mm opening in gravity fluted roller and traditional sowing, respectively. Plant to plant spacings are also irregular and unacceptable which need thinning.

The use of cell type metering system also resulted in 1416 kg/ha yield in comparison to 1292, 1258, 1168 and 921 kg/ha yields in fluted roller, gravity 4 mm opening, traditional plough sowing and gravity 3 mm, respectively. The operational cost of the cell type machine was Rs.74 per hectare in comparison to traditional sowing costing Rs.100 ha. If savings on operational costs seed saving and thinning costs are computed, the cost of the machine can be realized by sowing 1.4 hectare of farm land in one season. The cell type of metering mechanism, therefore, needs to be employed on seed drills and popularized for mustard and rape seed growing.

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Economics of Farm Mechanization in Developing Countries: K. Ohara, Prof., Faculty of Bioresources, Mie Univ., Tsu, Mie 514 Japan; V.M. Salokhe, Assoc. Prof., Agric. and Food Eng. Div., Asian Institute of Technology, Bangkok, Thailand.

The paper discusses ways to evaluate the economics of farm machine use with reference to developing countries. The impact of agricultural mechanization on the economics of agriculture in selected developing countries is reviewed in brief. The effects of demand and supply is also discussed.

The Royal Smithfield Show
Nov. 28-Dec. 1, 1993
Earls Court, London, U.K.

Tractor Multinationals Back

Three of the world's leading tractor manufactures - Massey Ferguson, New Holland Group and Case IH - have committed to exhibit at this year's Royal Smithfield Show in London's Earls Court. The Show recently commissioned a survey of farmers, 47% of whom said they expected to spend more money on capital goods this year than last.

The Agricultural Engineers Association now predicts that British farmers will buy around 16,000 tractors this year and the Royal Smithfield Show is the acknowledged shop window for the latest in agricultural tractors, machinery and equipment.

John Deere will be exhibiting at this year's Royal Smithfield Show. The support of the major manufacturers - John Deere, JI Case, Massey Ferguson and the New Holland Group means that Smithfield now offers farmers the opportunity to see the most comprehensive range of tractors, in one place.

To complete the range, Deutz, JCB, Valmet and Zetor, will also be displaying their tractors. Independent research, carried out by EAA shows farmers regard tractors as a major reason for visiting the Show.

1994 Postharvest Convention
March 23, 1994
Postharvest Dept. of Silsoe College
Cranfield University
Silsoe, Bedford MK45 4DT
United Kingdom

The Postharvest Department of Silsoe College will be holding their Fourth Convention on Wednesday, 23rd March 1994 and it will be entitled "Appropriate Postharvest Technology for Third World Development".

Further details can be obtained from the Postharvest Technology Department at the College.

Middle East Agriculture 94
April 17-20, 1994
Dubai, U.A.E.

Midle East Agriculture 94—the 5th in the series of trade exhibitions for the Arab Gulf's agriculture, irrigation and agri-industry sector, has attracted the support of the Commission of the European Communities (EC). The show will take place 17 to 20 April 1994 at the Dubai World Trade Centre.

All EC companies taking part within the EC pavilion are eligible for a 50% financial incentive towards their costs for space and stand construction.

Middle East Agriculture 94 is the only exhibition in the Middle East that has ben included in the EC's 1994 programme thereby confirming the status of the exhibition as one of the most important regional trade fairs in the international exhibition calendar.

Middle East Agriculture 94 is sponsored by the UAE Ministry of Agriculture and Fisheries which is taking a larger centrepiece stand at the show. Further information can be obtained from Overseas Exhibition Services Ltd of 11 Manchester Square, London, UK, W1M 5AB. Tel:- +44 71 1951. Fax:- +44 71935 8625

I.I.S.R. Sugarcane Cutter-planter with Tillage Disks—India

The IISR two row tractor mounted cutter planter is an improved and

innovative device as a complete planter. It consists of furrow opening tillage discs and sub units to perform sett cutting, fertilizer and chemical dispensing, soil covering and pressing operations in a single pass of the tractor.

While dragging type furrow openers may not work in hard, sticky and relatively dry soil and moisture conditions. These discs have been adjusted to yield a well tilled, pronounced and smooth V-shaped furrow. The cutting unit takes full seed cane of any shape and size. It cuts setts of defined length and guides them to the furrow. Fertilizer is length and guides them to the furrow. Fertilizer is despensed through a metering unit and gamma BHC is sprayed in the furrow through nozzles. All the units are powered through pto drive of a 35 H.P. tractor.

The slip is minimal and the utility index of a primmower is increased. The equipment has been tested extensively at IISR farm and the test data are as follows.

-Field capacity	0.25 ha/h
-Labour required	Six
-Length of sett	38 cm
-No. of setts in 10m	36
-Field efficiency	60%
-Price of the equipment	Approx. Rs.10,000/-(US$350)

For further details please contact, Director, Indian Institute of Sugarcane Research, Lucknow, India Telex: 535-309 Fax: 52073

BOOK REVIEW

Systems Approaches for Agricultural Development
(Philippines)

Edited by F.P. Vries, P.S. Teng, and K. Metselaar

During the coming decades, agriculture will have to cope with an ever-increasing demand for food and we have to do so without further degrading or exhausting the environment. The very dynamic framework of social and economic conditions is further complicating this task. Intensification, sustainability, optimizing scarce resources, and climate change are among the key issues. Organized thinking about future farming requires forecasting of consequences of alternative ways to farm and to develop agriculture. The complexity of the problems calls for a systematic approach in which many disciplines are integrated. Systems thinking and systems simulation are therefore indispensable tools for such endeavors.

About 150 scientists and senior research leaders participated in the symposium "Systems Approaches for Agricultural Development" (SAAD) at the Asian Institute of Technology (AID), Bangkok, Thailand, in December 1991. This book reports the proceedings of that symposium.

Kluwer Academic Publishers published this book in cooperation with IRRI. IRRI distributes the paperback edition worldwide; Kluwer distributes the hardcover edition.

1993. 543 pages. 15.24 × 22.86 cm. Paperback. HDC US$50.00, LDC US$13.00 plus (US$13.00) airmail or (US$2.00) surface postage.

The Literature of Agricultural Engineering
(U.S.A)

Edited by C.W. Hall and W.C. Olsen

The first book in English which had the words "agricultural engineering" in the title was published in England in 1852. The profession in the United States will soon be a century old A growing profession depends for the dissemination of its principles and standards on scholarly activities, the most important of which is the writing of documents that come to form the literature. The development of agricultural engineering in many countries of the world is thus chronicled, often initially in reports and articles, then later in books. After surveying nearly one hundred authors and users of the literature, the editors made judgements and compiled listings that identify the dominant works in the field. The Literature of Agricultural Engineering therefore lists, analyzes, and summarizes the books and journals that have made important contributions to the evolution of the subject.

A thorough assessment of this literature takes on added significance with the increasing glovalization of the economy. Books and journals originating in the developed countries are valuable sources of information for Third World countries, and those sources are identified in this book. But the Third World countries also have much to offer the rest of the world. Although their literature may not be voluminous and some of it is in languages not widely known, many of their books should be in the agricultural engineering libraries of the developed countries. Scholars and literature collectors throughout the world will find assistance here in evaluating their collection strengths, in measuring their journal holdings, and in making decisions about the preservation of pertinent historical literature.

The Literature of Agricultural Engineering builds on the traditional subject areas of power and machinery, soil and water, structures and environment, and electric power and processing. Sections I and III cover these traditional subject areas in detail. Although the names of these areas have endured over the years, the subject matter has changed tremendously, as new topics and techniques have been incorporated into their activities and publications. Thus, subjects such as erosion, soil transport, chemical drift, precision application, filtering pollutants, conservation, materials handling, waste management, and safety, to name a few, are now important aspects of the traditional areas.

The Literature of Agricultural Engineering is the second book in the literature of the Agricultural Sciences series. The first is Agricultural Economics and Rural Sociology: The Contemporary Core Literature. A total of seven books is anticipated. Volumes to follow are Animal Science and Health; Soil Science; Crop Protection and Improvement; Food Science and Human Nutrition; and Forestry and Agroforestry.

Members of the Steering Committee advising the Core Agricultural Literature Project on this volume, in addition to myself, were James Basselman, former manager of publications for the american Society of Agricultural Engineers; Joseph Campbell, Cornell University; Wiliam Chancellor, University of California, Davis; and Elizabeth Roberts, Washington State University.

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INSTRUCTIONS TO AMA CONTRIBUTORS

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

Criteria for Article Selection

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

a. are written in the English language ;
b. are relevant to the promotion of agricultural mechanization, particularly for the developing countries ;
c. have not been previously published elsewhere, or, if previously published are supported by a copyright permission ;
d. deal with practical and adoptable innovations by small farmers with a minimum of complicated formulas, theories and schematic diagrams ;
e. have a 50 to 100-word abstract, preferably preceding the main body of the article ;
f. are typewritten, double-spaced, under 4,000 words (approximately equivalent to 8 pages of AMA-size paper) ; and those that
g. are supported by authentic sources, reference or bibliography.

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a. As a rule, articles that are not chosen for AMA publication are not returned unless the writer(s) asks for their return and are covered with adequate postage stamps. At the earliest time possible, the writer(s) is advised whether the article is rejected or accepted.
b. When an article is accepted but requires revision/modification, the details will be indicated in the return reply from the AMA Chief Editor in which case such revision/modification must be completed and returned to AMA within three months from the date of receipt from the Editorial Staff.
c. "The AMA does not pay for articles published. However, the writers are given collectively 5 free copies (one copy air-mailed and 4 copies sent by surface/sea mail) of the AMA issue wherein their articles are published. In addition, a single writer is given 25 off-prints of the article and plural writers are given 35 off-prints (also sent by surface/sea mail)"
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a. Articles for publication (original and one-copy) must be sent to AMA through the Co-operating Editor in the country where the article originates. (Please refer to the names and addresses of Co-operating Editors in any issue of the AMA). However, in the absence of any Co-operating Editor, the article may be sent directly to the AMA Chief Editor in Tokyo.
b. Contributors of articles for the AMA for the first time are required to attach a passport-size ID photograph (black and white print preferred) to the article. The same applies to those who have contributed articles three years earlier. In either case, ID photographs taken within the last 6 months are preferred.
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Format/Style Guidance

a. Whether the article is a technical or popular contribution, lecture, research result, thesis or special report, the format must contain the following features :
   i) a brief and appropriate title ;
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   vi) bibliography
b. The pages must be numbered (Arabic numeral) successively at the top center. 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".
c. 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.
d. 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.
e. 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).
f. Indicate by footnotes or legends any abbreviations or symbols used in tables or figures.
g. Convert national currencies in US dollars and use the later consistently.
h. Round off numbers, if possible, to one or two decimal units, e.g., 45.5 kg/ha instead of 45.4762 kg/ha.
i. 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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